RAILROAD BRIDGE INSPECTION MANUAL

Connecticut Department Of Transportation Office of Rail

April, 2012

Version 1.0

CONNECTICUT DEPARTMENT
OF TRANSPORTATION

BUREAU OF PUBLIC TRANSPORTATION
OFFICE OF RAIL

RAILROAD BRIDGE INSPECTION MANUAL

April 2012

Version 1.0

Prepared by:

1. Connecticut Department of Transportation
   Bureau of Public Transportation
   Office of Rail
2. H.W. Lochner, Inc.

TABLE OF CONTENTS

CHAPTER 2 APPENDICES

CHAPTER 3: POLICIES

CHAPTER 6: CONDITION EVALUATION PROCEDURES

CHAPTER 6 APPENDICES

CHAPTER 7: LOAD RATINGS

CHAPTER 1
OVERVIEW OF THE CONNDOT RAILROAD BRIDGE INSPECTION MANUAL

Table of Contents

CHAPTER 1: OVERVIEW OF THE CONNDOT RAILROAD BRIDGE INSPECTION MANUAL

1.1. PURPOSE

The purpose of this Manual is to define the procedures and practices of the Connecticut Department of Transportation (ConnDOT) Office of Rail for determining the physical condition, load capacity and maintenance needs of railroad bridges in the State of Connecticut.

The provisions of this Manual are intended to:

- Establish policy and standard practices for the ConnDOT railroad bridge inspection, evaluation and load rating.
- Define responsibilities for operating units within the ConnDOT and for liaison with outside agencies.
- Provide bridge inspection, evaluation, load rating, and reporting procedures.
- Provide interpretation and set guidelines for the implementation of AASHTO, AREMA, FHWA, and FRA codes, publications, rules or standards that apply to railroad bridge inspection.
- Establish formal quality control and quality assurance procedures.
- Assist in training personnel to perform the tasks required for railroad bridge inspection.

1.2. INSPECTION OBJECTIVES

The objectives of the ConnDOT railroad bridge inspection manual are:

- To fulfill requirements of FRA 49 CFR Parts 213 and 237, Bridge Safety Standards.
- To establish and maintain the information necessary to meet the requirements for content of a Railroad Bridge Management Program (RBMP) as defined in FRA §237.33.
- To ensure prompt discovery of any deterioration, defect, or structural deficiency that could be hazardous to the traveling public.
- To provide a condition evaluation for qualifying railroad structures in the ConnDOT railroad bridge inventory.
- To determine the extent of minor deterioration and initiate routine maintenance and repair work.
- To determine the extent of major deterioration and select rehabilitation or replacement candidates.

1.3. BACKGROUND

The general requirements for the inspection, evaluation, and load rating of the nation's railroad bridges are defined in the Code of Federal Regulations,FRA 49 CFR Part 237. These regulations were effective on September 13, 2010 and each railroad track owner, as defined in FRA § 237.5, with qualifying structures is required to adopt and implement a Railroad Bridge Management Program (**RBMP**).

The Federal Regulations stipulate that each railroad track owner perform inspections, prepare reports, and determine safe load capacity for railroad bridges in accordance with their adopted **RBMP**. The regulations encourage owners to inspect, evaluate and load rate bridges using the general provisions of the AREMA "Manual for Railway Engineering" but allow owners the option to establish or adopt other appropriate criteria. In addition, the AREMA "Bridge Inspection Handbook" and AASHTO Manuals, Technical Advisories and AASHTO Specifications, Codes, and Guidelines serve as source material for track owners to conduct operations in compliance with the regulations.

The ConnDOT Office of Rail has established a **RBMP** to meet the requirements of the FRA 49 CFR Part 237. Certain procedures were contained in the ConnDOT Bridge Inspection Manual, and other practices have been established by the ConnDOT Office of Rail policy, written and unwritten, or by historic practices. This Manual has been developed to set down the formal ConnDOT Office of Rail policy for complying with FRA 49 CFR Part 237 requirements, and to define the organizational structure and assign responsibilities to carry out the stated policy. In addition, this Manual is intended to compile available information to produce state-of-the-art guidance on inspection, condition evaluation, and load rating of Railroad bridges in Connecticut for use on Railroad bridge inspections.

1.4. DEFINITIONS

RBMP (Railroad Bridge Management Program), February 2012, Version 1.0: A program designed to optimize the use of available resources for the inspection, evaluation, load rating, maintenance, rehabilitation, and replacement of Railroad bridges.

BIM: ConnDOT Bridge Inspection Manual (September 2001, version 2.1, with interims).

BRIM: FHWA Bridge Inspection Reference Manual

RBIM: ConnDOT Railroad Bridge Inspection Manual (2012).

AASHTO: American Association of State Highway and Transportation Officials, 444 North Capitol Street, N.W., Suite 225, Washington, DC 20001.

AREMA: American Railway Engineering and Maintenance-of-Way Association, 10003 Derekwood Lane, Suite 210, Lanham, MD 20706.

AREMA HANDBOOK: AREMA Bridge Inspection Handbook (2008)

RAILROAD BRIDGE (FRA §237.5): Any structure with a deck, regardless of length, which supports one or more railroad tracks, or any other undergrade structure with an individual span length of 10 feet or more, located at such a depth that it is affected by live loads.

QUALIFYING RAILROAD STRUCTURES: All railroad bridges, as defined by FRA §237.5, and all other undergrade railroad structures (other than pipes) with an individual span length of 5 ft or more, located at such depth that it is affected by live loads, owned by ConnDOT. This term and definition is specific to the ConnDOT owned railroad structures and reflects the Department policy of inspecting railroad culverts with individual span lengths in the range of 5 to 10 feet but recognizing these structures are not specifically addressed by the federal bridge regulations.

ACTIVE RAILROAD LINE: A railroad line or segment of a line that is connected to the general railroad system of transportation and over which trains may operate.

INACTIVE or ABANDONED RAILROAD LINE: A former railroad line or segment of a line that is or was connected to the general railroad system of transportation and over which trains do not operate but may in the future.

NBIS (National Bridge Inspection Standards): Federal regulations establishing requirements for inspection procedures, frequency of inspections, qualifications of personnel, inspection reports, and preparation and maintenance of bridge inventory records. The NBIS apply to all structures defined as bridges located on or over all public roads.

CFR: Code of Federal Regulation.

ConnDOT: Connecticut Department of Transportation.

DEPARTMENT: Connecticut Department of Transportation.

FHWA: Federal Highway Administration, U.S. Department of Transportation.

FRA: Federal Railroad Administration, U.S. Department of Transportation.

MUTCD: The Manual of Uniform Traffic Control Devices.

NHI: The National Highway Institute, 901 N. Stuart Street, Suite 300, Arlington, VA 22203

NICET: National Institute for Certification in Engineering Technologies.

1.5. STANDARD REFERENCES AND GUIDES

The primary references for use in conjunction with this Manual are the most current edition of the following Manuals along with any interims:

AREMA **MANUAL FOR RAILWAY ENGINEERING**

AREMA **BRIDGE INSPECTION HANDBOOK**

AASHTO **MANUAL FOR CONDITION EVALUATION OF BRIDGES**

FHWA **BRIDGE INSPECTORS REFERENCE MANUAL** (BIRM)

FHWA **RECORDING AND CODING GUIDE FOR THE STRUCTURE INVENTORY AND APPRAISAL OF THE NATION'S BRIDGES** (the ”FHWA Coding Guide”)

FRA **49 CFR Parts 213 and 237 Bridge Safety Standards**

This Manual provides interpretive and supplemental information to assist the user in performing bridge inspections, evaluations, and reporting findings in accordance with the above mentioned references.

Numerous other references provided by AREMA, AASHTO, ConnDOT, FRA and FHWA, including Technical Advisories, are part of the reference body of documents needed to conduct railroad bridge inspection in accordance with the ConnDOT guidelines and procedures. These documents include:

AREMA "**Bridge Inspection Handbook"**

AREMA "**Manual for Railway Engineering"**

AASHTO "**Standard Specifications for Highway Bridges"** with annual interim updated specifications

AASHTO "**Guide Specifications for Strength Evaluation of Existing Steel and Concrete Bridges"**

AASHTO "**Guide Specifications for Fatigue Evaluation of Existing Steel Bridges"**

AASHTO "**Standard Specifications for Movable Highway Bridges"**

AASHTO "**Movable Bridge Inspection Evaluation and Maintenance Manual 1st Edition"**

AITC ”**Timber Construction Manual"**

USDA Forest Service Publication **"Timber Bridges: Design, Construction, Inspection and Maintenance"**

ConnDOT **Railroad Bridge Management Program**

FHWA **"Manual for Inspection Bridges for Fatigue Damage Conditions" #FHWA-PA-89-022 + 85-02, January 1990**

FHWA **"Culvert Inspection Manual" #FHWA-IP-86-2, July 1986**

FHWA **HEC No. 18 "Evaluating Scour at Bridges" #FHWA-NHI 01-001, May 2001**

FHWA **HEC No. 20 "Stream Stability at Highway Structures" #FHWA-NHI 01-002, March 2001**

FHWA **"Underwater Inspection of Bridges" #FHWA-DP-80-1, November 1989**

1.6. CONDITION EVALUATION

The condition evaluation establishes the physical and functional condition of the bridge components, including the extent of deterioration and other defects. The evaluation forms the basis for load rating of the bridge, maintenance actions, and repair/rehabilitation programs. The annual inspection cycle provides a continuous record of bridge condition and rate of deterioration (See Section 5.2 of this manual for inspection types).

The bridge inspector's primary responsibility is public safety. If defects are discovered that present a hazard to safe passage across the structure, or endanger the bridge's normal performance, the Department's emergency response procedures as described in Section 3.2.7 of this manual must be initiated immediately.

The condition of each bridge member is to be evaluated in accordance with the 0-9 numeric coding system described in the “FHWA Coding Guide”. The ConnDOT Office of Rail guidelines for interpreting defects and deterioration and assigning a numeric rating to the structural element are contained in Chapter 9 of this Manual.

1.7. LOAD RATING

Load ratings are computed and updated as required as part of the Department's Railroad Bridge Management Program. Load rating is the determination of live load carrying capacity of an existing bridge using existing bridge plans and supplemented by information gathered during the field inspection. Engineering judgment is required to incorporate the effect of defects and deterioration in the load rating analysis.

The AREMA Manual for Railway Engineering recognizes load ratings at two levels, Normal and Maximum. The Normal Rating generally corresponds to the design level of stress, and results in a live load that can safely use the bridge for an indefinite period of time. The Maximum Rating describes the maximum permissible live load that should never be exceeded on the bridge.

The AREMA Manual for Railway Engineering provides general guidance and direction for load rating procedures. The ConnDOT Office of Rail's practices and procedures for conducting load rating analyses are contained in Chapter 7 of this manual.

1.8. QUALITY CONTROL AND QUALITY ASSURANCE

In order to maintain the accuracy and consistency of inspections and load ratings, ConnDOT is committed to a defined quality control, quality assurance program. Quality Control procedures are designed to maintain the caliber of bridge inspection and load rating at or above a specified standard. Quality Assurance measures are instituted to monitor the level of the overall program.

ConnDOT's Quality Control and Quality Assurance procedures and responsibilities are contained in Chapter 4 of this Manual.

CHAPTER 2
ORGANIZATION OF THE OFFICE OF RAIL FOR MANAGEMENT OF RAILROAD BRIDGES

Table of Contents

CHAPTER 2: ORGANIZATION OF THE OFFICE OF RAIL FOR THE MANAGEMENT OF RAILROAD BRIDGES

2.1. ORGANIZATION

The Connecticut Department of Transportation's Office of Rail is positioned within the Engineering Design and Construction Services of the Bureau of Public Transportation and is responsible for the Management of Railroad Bridges.

Charts detailing the organization of the Office of Rail for the inspection of Railroad Bridges, can be found in Appendix A2.1 of this manual.

2.2. ConnDOT JOB DESCRIPTION, QUALIFICATIONS, AND RESPONSIBILITIES

The FRA 49 CFR establishes minimum qualifications for the individual in charge of the unit responsible for bridge inspection, reporting, and inventory and for individuals in charge of inspection teams. The Department has developed more detailed qualifications for these positions, as well as, other positions required to complete the Railroad Bridge Management program. Additionally, qualifications for consultant inspection programs have been defined.

2.2.1. Transportation Principal Engineer

2.2.1.1. Description - Supervises the staff of the Office of Rail including bridge engineers, inspectors and other staff members as assigned.

2.2.1.2. Qualifications - In addition to those qualifications listed in the NBIS, the Department requires a minimum of two (2) years supervisory experience in bridge and structural design, bridge construction or bridge repair projects, or hydraulic design of highway structures. The Department requires that the Transportation Principal Engineer Maintain a Connecticut Professional Engineering License.

2.2.1.3. Responsibilities - Supervises the staff of the Office of Rail; schedules, assigns, oversees and reviews the work of staff; provides staff training and assistance; conducts performance evaluations; determines priorities and plans Section work; establishes and maintains Section procedures; develops or makes recommendations on the development of policies and standards; acts as liaison with other operating units, agencies and outside officials regarding Section policies and procedures; prepares reports and correspondence; administers and coordinates an effective Railroad Bridge Management Program for all Railroad bridges including both Metro-North and off system; acts as specialized consultant in all matters pertaining to design, construction and maintenance of bridges and structures; oversees maintenance of bridge inventories and inspection records; supervises; oversees review and appraisal of inspection reports; assists in determining which bridge repairs can be undertaken by State personnel and which require an outside contract; evaluates field reports of programs for bridge structure replacement or major repairs; provides information to Bridge Design for contract repairs; interprets Federal and State policy and briefs staff; represents State on Federal/State committees and panels; makes recommendations directly to the Rail Administrator on unsafe bridges and structures; performs related duties as required.

2.2.2. Transportation Supervising Engineer

2.2.2.1. Description- Directs Transportation Engineer III, II, and I, Lead Inspectors, and Bridge Inspectors in the performance of the bridge inspection process.

2.2.2.2. Qualifications - A minimum of eight (8) years' experience in the field of civil engineering (a bachelors degree may be substituted for four (4) of the eight (8) years' experience). Two (2) years as an engineer with individual or supervisory responsibility in bridge engineering projects, a minimum of one (1) year employment as a Transportation Engineer III (if a ConnDOT employee), and must maintain a Connecticut Professional Engineering License.

2.2.2.3. Responsibilities - Directs Engineers III, II, and I, Lead Inspectors, and Bridge Inspectors in the performance of bridge inspections; performs administrative duties utilizing communication skills, interpersonal skills, and problem solving; advises the Office of Rail and Evaluation on bridge and structure related topics; acts as liaison with consultants for inspection and special projects as assigned.

2.2.3. Transportation Engineer III (Senior Engineer)

2.2.3.1. Description - A Transportation Engineer III acts as a working lead that assists a Transportation Supervising Engineer by supervising an inspection team, numerous inspection teams, or other section employees or consultants in their daily activities.

2.2.3.2. Qualifications - Three (3) years of experience in civil engineering including one (1) year of supervisory experience are required for this position, with a Bachelors degree in civil or structural engineering.

2.2.3.3. Responsibilities - Determines schedules for inspection of bridges in their assigned area and assists in in-depth inspections of complex bridges, to research and investigate problems encountered during the inspection process, to review the reports prepared by the inspection teams or Consultant Firms, prepare maintenance memorandums, and other tasks required for the inspection program.

2.2.4. Transportation Engineer II and Transportation Engineer I

2.2.4.1. Description - Transportation Engineer II and I assist the Transportation Engineer III.

2.2.4.2. Qualifications - Three (3) years' experience for Transportation Engineer II and two (2) years' experience for Transportation Engineer I in civil engineering with a Bachelors degree in civil or structural engineering.

2.2.4.3. Responsibilities - Similar to those assigned to the Transportation Engineer III and other tasks as determined by the Transportation Principal Engineer of the Office of Rail.

2.2.5. Lead Inspector (Team Leader)

2.2.4.4. Description - Acts as Lead Inspector of a field inspection team responsible for technical inspection of bridges and related structures based on National Bridge Inspection Standards.

2.2.4.5. Qualifications - Five (5) years of experience in bridge inspection in a responsible technical capacity. College training in civil engineering may be substituted on the basis of fifteen (15) semester hours equaling one-half (1/2) year of experience to a maximum of two (2) years for an Associate's degree.

Has completed a comprehensive training course based on the BIRM.

2.2.4.6. Responsibilities - Plans work flow and determines priorities; schedules, assigns, oversees, and reviews work; establishes and maintains procedures; assists in conducting performance evaluations; acts as liaison with operating units, agencies, and outside officials regarding policies and procedures; inspects bridges in accordance with this and all other applicable manuals mentioned in Section 1.5.; prepares inspection notes and sketches covering all bridge defects noted; operates bridge inspection equipment as required; evaluates seriousness of bridge defects and makes on-the-spot decisions as required; prepares accurate reports of all bridge inspections; ensures on-site traffic protection; performs semi-final bridge construction inspections; performs related duties as required.

2.2.6. Bridge Inspector

2.2.4.7. Description - Independently performs a full range of tasks as a member of an inspection team assisting a Lead Inspector in the inspection of bridges and related structures in accordance with National Bridge Inspection Standards.

2.2.4.8. Qualifications - Four (4) years of experience in field construction inspection, field engineering survey work, or bridge maintenance work. College training in civil engineering may be substituted on the basis of fifteen (15) semester hours equaling one-half (1/2) year of experience to a maximum of two (2) years for an Associate's degree. For State employees, one (1) year of experience in bridge maintenance work at or above the level of Department of Transportation Maintainer 3 may be substituted. Will complete a comprehensive training course based on the BIRM at the earliest possible date.

2.2.4.9. Responsibilities - Reviews bridge plans and previous inspection reports; coordinates traffic control and equipment at inspection site; assists in the inspection of bridges; assists in the preparation of reports of all bridge inspections, including notes and sketches; operates bridge inspection equipment; performs related duties as required.

2.2.7. Consultant Inspection Teams

All consultants utilized for the inspection of bridges for the Department shall maintain a staff of competent field and office personnel that have qualifications meeting the requirements of the Department and the FRA and, as outlined below, with other stipulations as detailed in the individual scopes of work.

2.3. FRA JOB DESCRIPTION, QUALIFICATIONS, AND RESPONSIBILITIES

The FRA establishes minimum qualifications under FRA 49 CFR Part 237 Subpart C, for individuals responsible for the Railroad Bridge Safety Management Program that have been adopted by the Department as the minimum requirements for these positions.

2.3.1. Railroad Bridge Engineer (FRA §237.51)

2.3.1.1. Description - Person who is determined by the track owner to be competent to perform the responsibilities of the Railroad Bridge Engineer as listed in section 2.3.1.3 Responsibilities.

2.3.1.2. Educational Qualifications - (1) A degree in engineering, granted by a school of engineering with at least one program accredited by ABET, Inc. or its successor organization as a professional engineering curriculum, or a degree from a program accredited as a professional engineering curriculum by a foreign organization recognized by ABET, Inc. or its successor; or (2) Current registration as a professional engineer in the State of Connecticut.

2.3.1.3. Responsibilities - (1) Determine the forces and stresses in railroad bridges and bridge components; (2) Prescribe safe loading conditions for railroad bridges; (3) Prescribe inspection and maintenance procedures for railroad bridges; and (4) Design repairs and modifications to railroad bridges.

2.3.2. Railroad Bridge Inspector (FRA§237.53)

2.3.2.1. Description - Person who is determined by the track owner to be technically competent to perform the responsibilities of the Railroad Bridge Inspector as listed in section 2.3.2.3 Responsibilities.

2.3.2.2. Educational Qualifications - no stated minimum requirements.

2.3.2.3. Responsibilities - (1) View, measure, report and record the condition of a railroad bridge and its individual components; and (2) Authorize or restrict the operation of railroad traffic over a bridge according to its immediate condition or state of repair.

2.3.3. Railroad Bridge Supervisor (FRA§237.55)

2.3.3.1. Description - Person who is determined by the track owner to be technically competent to perform the responsibilities of the Railroad Bridge Supervisor as listed in section 2.3.3.3 Responsibilities.

2.3.3.2. Educational Qualifications - no stated minimum requirements.

2.3.3.3. Responsibilities - (1) Supervises the construction, modification or repair of a railroad bridge in conformance with common or particular specifications, plans and instructions applicable to the work to be performed; and (2) Authorize or restrict the operation of railroad traffic over a bridge according to its immediate condition or state of repair.

FRA Designation	ConnDOT Classification
Railroad Bridge Engineer	Transportation Supervising Engineer
Railroad Bridge Inspector	Transportation Engineer III
Railroad Bridge Supervisor	Supervisor Rail Officer or Transportation Engineer III

2.4. LIAISON WITH OTHER DEPARTMENT SECTIONS

Should a need arise that requires assistance from other Department sections such as Design, Maintenance, Rail Systems, and the Testing Lab, arrangements will be made by contacting the Transportation Supervising Engineer in charge of the inspection area.

2.5. CONSULTANT COORDINATION

The Office of Rail will assign the task of coordination of consultant inspection contracts to a Supervising Railroad Engineer. This person will be responsible for tracking the consultant's work, schedule, and billing. The Supervising Railroad Engineer will assign the day-to-day responsibilities of the coordination to a Railroad Engineer (liaison engineer) and other employees as necessary.

Consultants are responsible for notifying the Office of Rail of their proposed schedule and any changes to that schedule in a timely manner.

2.6. COORDINATION WITH OUTSIDE AGENCIES

Flagging protection shall be arranged by the Consultant Railroad Bridge Engineer or the Consultant Railroad Bridge Inspector with the Operating Railroad responsible for the rail line that the bridge is located on. The Consultant Railroad Bridge Engineer or the Consultant Railroad Bridge Inspector will send a copy of the inspection schedule with requested flagging protection to the Office of Rail Supervising Engineer or to the support section in charge for tracking the consultant's work, schedule, and billing. This process will insure consistency in record keeping and tracking of flag usage. Consultant requests for flagging will be submitted to the Operating Railroad at least two (2) weeks prior to need for Metro-North flagging protection and one (1) week prior to the need for off-system flagging protection.

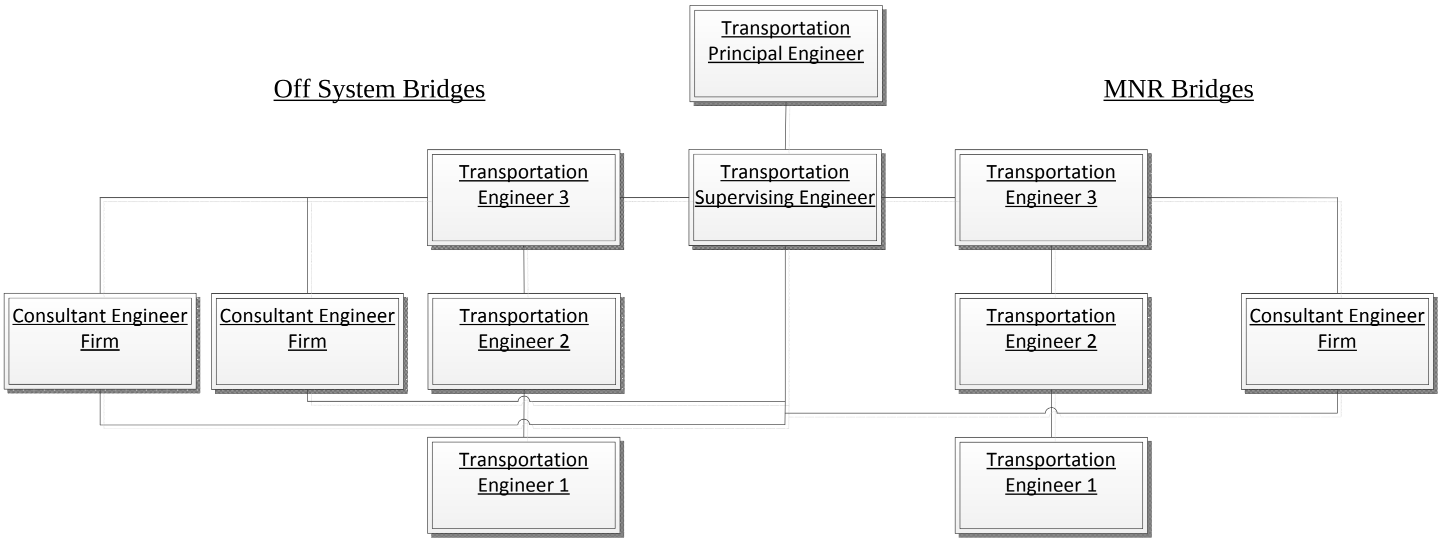
The Consultant is responsible for determining and obtaining the required local permits and following all local rules and regulations when performing inspections over local town roads.

Coordination with other agencies, such as outside testing laboratories, local town governments, local and state police, etc., is the responsibility of the Consultant.

2.7. DESIGNATION OF INDIVIDUALS

The FRA requires the Department to designate those individuals responsible for the Department's Railroad Bridge Management Program and qualified as railroad bridge engineers, railroad bridge inspectors and railroad bridge supervisors. This listing must include each individual designated including the basis for the designation and shall be recorded in the ConnDOT Office of Rail's Railroad Bridge Management Program.

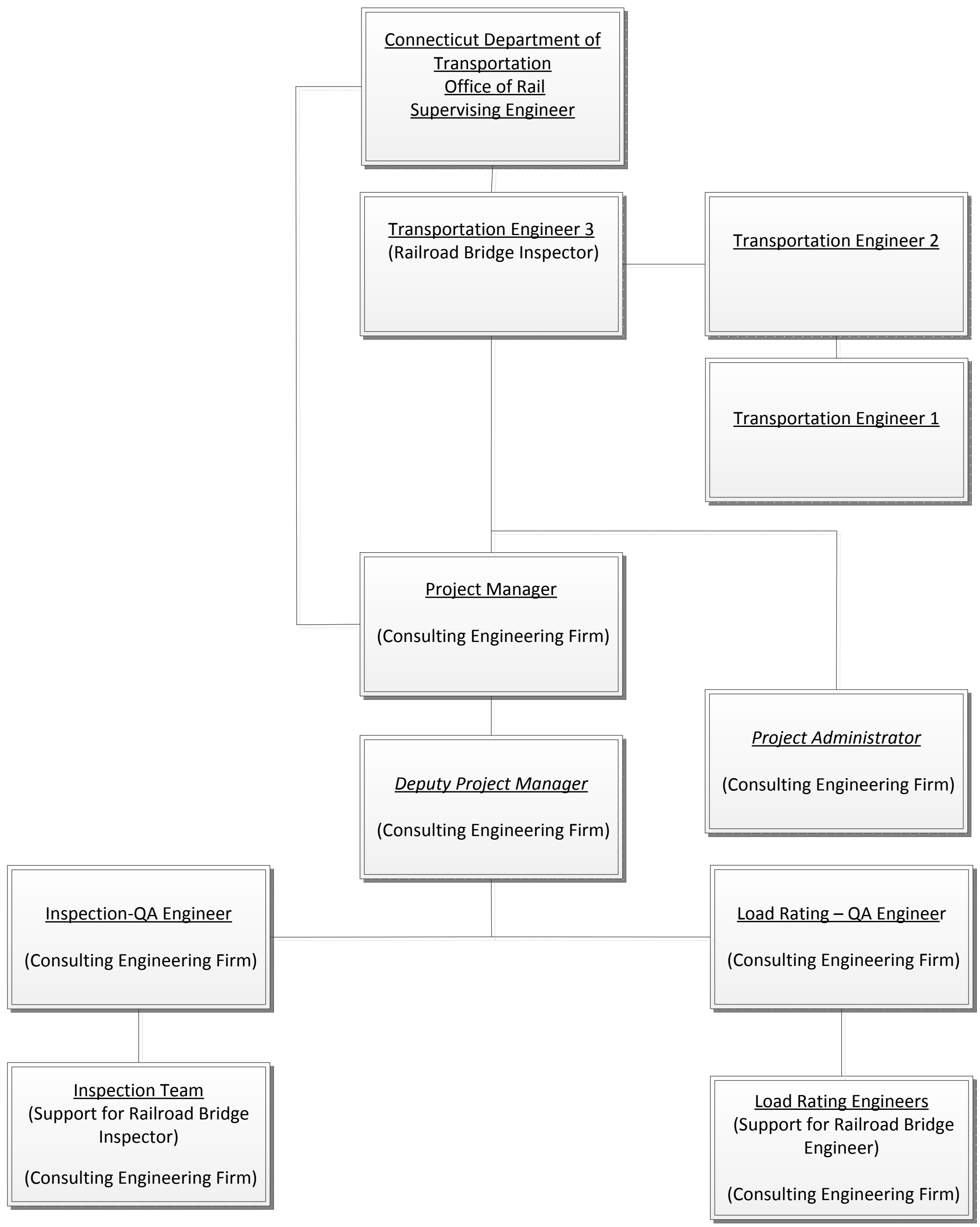
ORGANIZATION CHART FOR INSPECTION OF RAILROAD BRIDGES



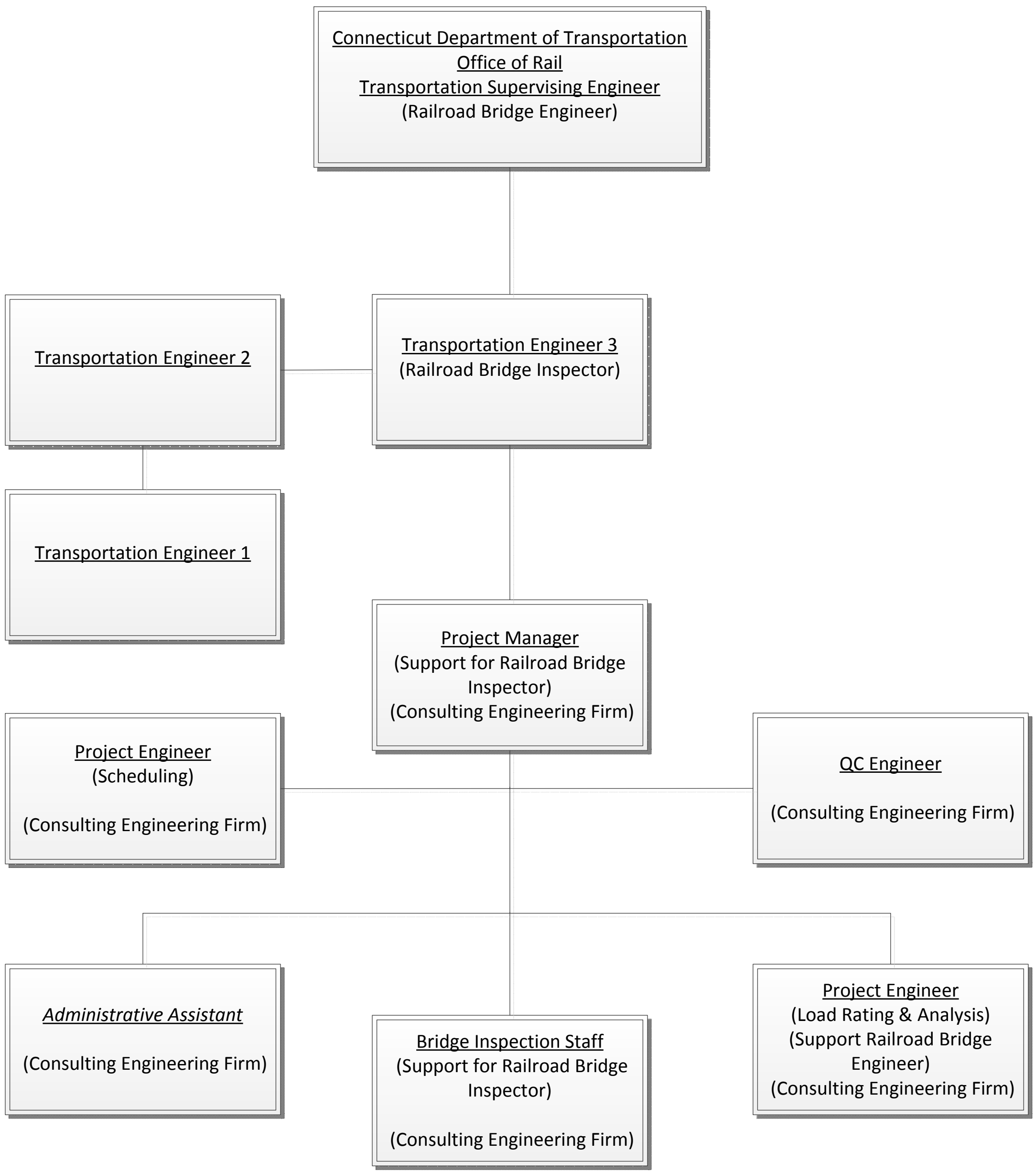
FRA Designation	CDOT Office of Rail Designation
Railroad Bridge Engineer –	Transportation Supervising Engineer with support from Consultant Engineering Firm
Railroad Bridge Inspector –	Transportation Engineer 3 with support from Consultant Engineering Firm
Railroad Bridge Supervisor –	Transportation Engineer 3 with support from Consultant Engineering Firm

See Page A2.2 Detailed Organization Charts for Inspection (Routine and Verification) of Metro-North Railroad Bridges
See Page A2.3 Detailed Organization Charts for Routine Inspection of Off-System Bridges
See Page A2.4 Detailed Organization Charts for Verification Inspection of Off-System Bridges

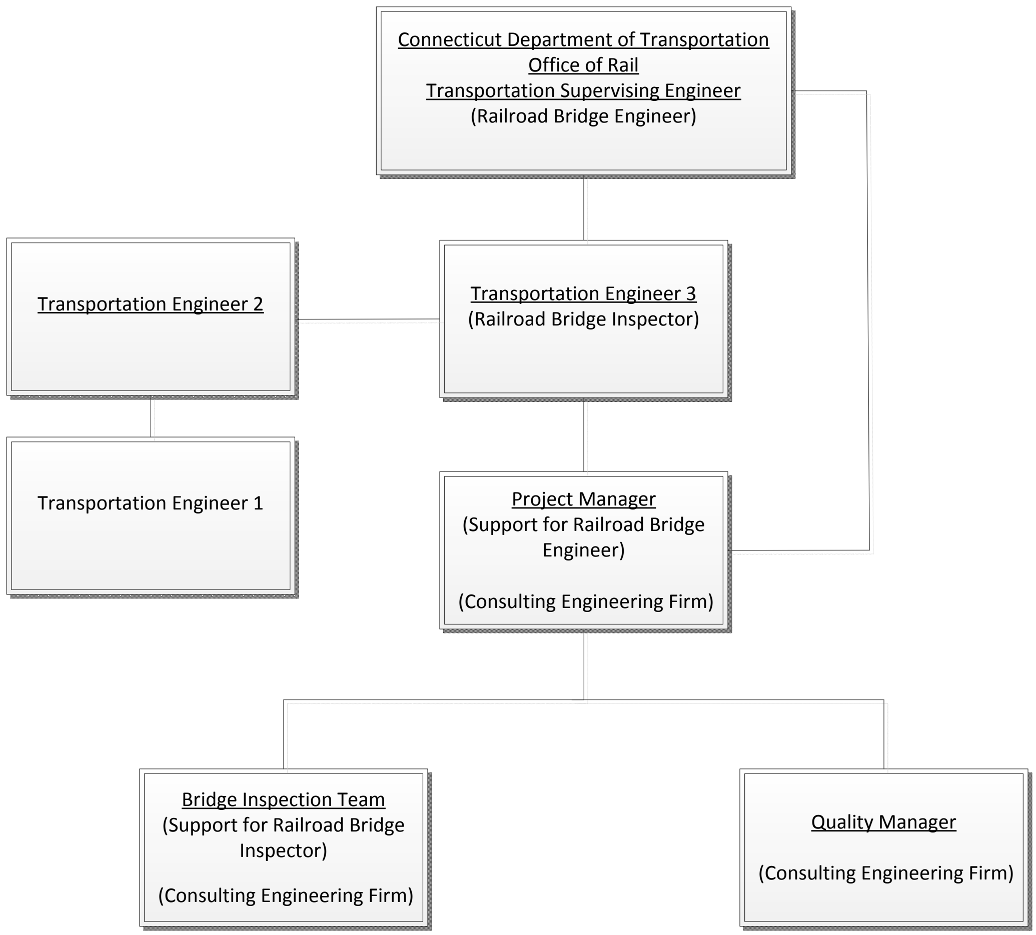
METRO-NORTH RAILROAD BRIDGE INSPECTION
(ROUTINE AND VERIFICATION)
ORGANIZATION CHART
CONNDOT – CONSULTING ENGINEERING FIRM



OFF SYSTEM ROUTINE INSPECTION
ORGANIZATION CHART
CONNDOT – CONSULTING ENGINEERING FIRM



OFF SYSTEM VERIFICATION INSPECTION AND EVALUATION ORGANIZATION CHART
CONNDOT – CONSULTING ENGINEERING FIRM



CHAPTER 3
POLICIES

Table of Contents

CHAPTER 3: POLICIES

CHAPTER 3: POLICIES

3.1. PERSONNEL

3.1.1. Work Rules

All personnel should be familiar with the Department's *"Employee Handbook*." All supervisors shall also be familiar with the *"Personnel Handbook for Supervisors at All Levels*." This handbook is available to assist all supervisors to become more aware of their role, function, and authority, and to assist them in dealing with common types of employee problems.

3.1.2. Safety

It is the responsibility of each person involved in the inspection process to be familiar with the Department's handbook entitled *"Guidelines for Safe Practice"* and all applicable Administrative Memorandums.

Railroad Bridge Inspectors should pay special attention to the following sections:

I. Accidents

III. General Safety for All Employees

IV. Clothing and Protective Wearing Apparel

V. Trucks and Passenger Cars

VI. Power Equipment
- 42 Rented Equipment and Trucks
- 43 Operators Qualifications
- 44 Condition of Equipment
- 45 Operation of Equipment
- 46 Gasoline Filling
- 47 Breakdown of Equipment

VII. Plants and Plant Operation
- 74 Movable Bridges and Electrical Repairs

IX. Use of Small Tools

93	General
94	Sharp Edge Tools
95	Tool Storage
98	Crowbars
910	Cold Chisels
102	Hand Hammers
103	Hand Shovels
105	Ladders
111	Wrenches

X. Job Protective Devices

XI. Operations - Field and Plant

120	Bridge Operation
121	Water Operations
125	Engineering Inspection and Survey
145	Traffic Status and Road Inventory
151	Bucket Truck Operations

Additionally, the OSHA publication *"Construction Industry OSHA Safety and Health Standards"* will be followed for those areas where it pertains to inspection work. A copy of the current OSHA Manual can be found in the office of the Transportation Principal Engineer of the Office of Rail. The sections pertaining to this type of work include (but are not limited to) the following:

1926.100	Head Protection
101	Hearing Protection
102	Eye and Face Protection
103	Respiratory Protection
104	Safety Belts, Lifelines, and Lanyards
106	Working Over or Near Water
107	Definitions Applicable to this Section
1926.300	General Requirements Hand and Power Tools
301	Hand Tools
302	Power Operated Hand Tools
303	Abrasive Wheels and Tools
1926.451	Scaffolding
452	Guardrails, Handrails, and Covers
1926.556	Aerial Lifts
1926.950	Power Transmission and Distribution
1926.1053	Ladders

The above listing is not all inclusive. OSHA regulations are comprehensive and many sections may apply in part. As the regulations are constantly revised, refer to the most recent OSHA manual for any updates and/or revisions.

3.1.3. Media/Public Relations

The Department maintains an Office of Communications, which has the responsibility of dealing with the media and other interested public agencies and/or parties. The field forces should respond to the public/media in a courteous manner. Any questions that arise during the course of an inspection should be referred to the Transportation Principal Engineer of the Office of Rail. It will be his responsibility to deal with the question or to refer the question to the Office of Communications.

3.2. INSPECTION

3.2.1. Intensity of Inspection

The intensity of the inspection will vary depending on the extent of available access to the structural elements and the type of inspection required (in-depth, routine, verification, special, underwater, etc.). The intensity is described in the appropriate sections of this manual.

3.2.2. Inspection Frequency

All railroad structures on active railroad lines will be inspected by qualified railroad bridge inspectors at least once in each calendar year, with not more than 540 days between successive inspections.

All Railroad Pedestrian overpass shall be inspected as a 24 month interval.

<u>The performance of all inspections and preparation of inspection reports shall meet the applicable requirements of Title FRA 49 part 237 subpart E of the Code of Federal Regulations.</u>

3.2.2.1. Report Preparation and Review Time Windows

The Inspection Report for a railroad structure shall be submitted to the ConnDOT within 30 calendar days of the completion of the inspection and shall be reviewed, revised when appropriate, distributed to the Railroad and filed as complete within 120 calendar days of the completion of the inspection.

An exception to the above schedule is allowed for complex structures including movable bridges where the amount of information and level of detail requires a greater period of time. In all cases, the goal is to issue final inspection reports in an expedient manner.

3.2.2.2. Increased Inspection Interval

Each qualifying railroad structure on inactive or abandoned railroad lines may be inspected by qualified railroad bridge inspectors at regular intervals of 24 months. Generally, the decision to conduct inspections at 24 month intervals will be proposed by the Transportation Supervising Engineer and submitted to the Transportation Principal Engineer for final approval.

Railroad bridges on inactive or abandoned lines shall not be placed in active service unless an inspection has been performed within the previous 540 days and the Transportation Supervising Engineer has reviewed the inspection report and load rating and determined it is safe to resume service

3.2.2.3. Decreased Inspection Interval

A railroad bridge shall be inspected more frequently than provided for in the BRMP when a Transportation Supervising Engineer determines that such inspection frequency is necessary considering conditions noted on prior inspections, the type and configuration of the bridge, or the weight and frequency of traffic carried on the bridge.

3.2.2.4. Underwater Inspections

Underwater inspections will normally be scheduled every two (2) years, one (1) month prior to the above water inspection. Diving inspection frequency can be increased or decreased to match the routine inspection frequency, up to a maximum of four (4) years.

3.2.2.5. Special Inspections

A special inspection shall be performed for any railroad bridge that might have been damaged by a natural or accidental event, including but not limited to a flood, fire, earthquake, derailment or vehicular or vessel impact.

The need for special inspections, timing for such inspections and the level of detail considered appropriate shall be determined by a Transportation Supervising Engineer.

3.2.2.6. In-Depth Inspections

Each qualifying railroad structure will have an in-depth inspection performed at a maximum interval of 10 years. The in-depth inspection shall be scheduled in accordance with the requirements of Section 3.2.2 and shall satisfy the annual requirement for inspection in the year performed.

3.2.3. Inspection Team

The FRA requires that bridge inspections be conducted under the direct supervision of a designated railroad bridge inspector, who shall be responsible for the accuracy of the results and the conformity of the inspection to the bridge management program. Bridge inspections can often require more than one person for safety and efficiency. The FRA permits others to assist the designated inspector, who remains responsible for the results of the inspection.

In Connecticut the Inspection Team shall, at a minimum, consist of personnel meeting the qualifications of a lead inspector and a bridge safety inspector. The makeup of the team can vary depending on the complexity of the bridge and the difficulty of the proposed inspection.

3.2.4. Working in the Railroad Right of Way

When working near or within the Railroad right-of-way it is necessary to obtain Flagging protection from the Operating Railroad for the safety of the inspection crew.

The Flagging protection shall be arranged by the Consultant Firm with the Operating Railroad responsible for the rail line that the bridge is located on. Consultant requests for flagging will be submitted to the Operating Railroad at least two (2) weeks prior to need for Metro-North flagging protection and one (1) week prior to the need for off-system flagging protection.

3.2.5. Maintenance and Protection of Traffic

During the course of the inspection it may be necessary to close lanes of roadways to gain access to important parts of the bridge. The signing patterns utilized for this work shall be in conformance with the Department's *Traffic Control Patterns for Highway Maintenance Operations* (as revised) and the current edition of the *Manual for Uniform Traffic Control Devices (MUTCD)*. The latest editions of these publications are available online.

There may be instances when due to on/off ramp locations or intersections, the standard traffic control plans will not fit the actual field conditions. In such cases, additional signs, cones, etc. may be required. Consultant Teams shall coordinate complex signing patterns with the Consultant's Project Engineer.

An impact attenuator truck shall be used to protect each workzone on all limited access highways.

For Consultant Teams, the signing pattern shall be installed by the Consultant, or an agent of the Consultant, based on the above noted standards.

Procedure for obtaining lane closures on State Routes:

1. Fill out the lane closure form for the following week's inspections. A line must be included for all closures, including shoulder closures on State Routes.
2. Submit the form to the Transportation Supervising Engineer in the Office of Rail for review.

Consultants shall provide a detailed two-week schedule of planned activities involving maintenance and protection of traffic to the following:

1. Transportation Principal Engineer of the Office of Rail (designated project representative)
2. First Elected Official of a town or city for local bridges
3. Other parties as identified by the Department

Generally, daytime lane closures are only permitted between the hours of 9:00 AM and 3:00 PM. The Department's *Structure Inspection Daytime Lane Closure Guide* shall be used as a guideline when scheduling lane closures. All lane closures will be terminated if extensive traffic backups occur, as ordered by the Maintenance Superintendent, or as ordered by the State Police. Additionally, the inspection team is responsible for monitoring traffic backups and having the traffic control signing patterns removed should the backups become excessive. Lane closures are not permitted to exceed two miles in length.

3.2.6. Entry on Private Property

Entry onto private property for the purpose of inspecting bridges and structures should not, for the most part, be required. Inspectors should, however, understand the rights of property owners and the restrictions on entering private property. The procedures for obtaining permission, should it be necessary, can be obtained by contacting the Office of Rail.

3.2.7. Critical Deficiency Reporting/Emergency Response

When a critical defect affecting the safety of the bridge structure or the safety of the traveling public is found during an inspection, it is imperative that the Transportation Principal Engineer of the Office of Rail be informed of the situation immediately. Some examples of critical defects include:

- Distress in primary members where the members may not be capable of safely carrying the imposed loads, and partial or total failure of the bridge is a possibility.
- Scour at or under a substructure unit is extensive enough that significant movement of the substructure unit is possible, which could cause the bridge to collapse.
- Substructure movement or distress that is so excessive that the substructure unit may not be capable of supporting the superstructure and partial or complete failure is a possibility.
- Suspected cracks in fracture critical members.
- Any situation where the structural integrity of the bridge is such that its safety is in question.

- Any situation that poses an immediate hazard to traffic on or under the bridge due to loose or broken components, severe deterioration of the bridge riding surface or materials that can drop to occupied areas below the bridge.

The following information should be noted for reporting critical defects:

1. Structure Number
2. Town
3. Route Number/Road Name
4. Features Crossed
5. Type of Bridge (i.e.: Thru Truss, 2 Girder, etc.)
6. Type of Defect Encountered
7. Location of Defect
   a. Span
   b. Girder/Floorbeam/Stringer No.
8. Other Pertinent Information

The above noted information is to be transmitted by the inspection team by telephone to the Transportation Engineer III (or above) who will in turn inform the Transportation Supervising Engineer for the Office of Rail. A written report accompanied by field sketches and photographs (if available) shall be forwarded to the Transportation Supervising Engineer within 24 hours of the initial report.

Consultant Teams that find critical defects shall immediately contact the Consultant's Project Engineer who will have the responsibility of assessing the problem and notifying the Office of Rail.

Critical deficiencies identified outside of normal working hours, when the Office of Rail office is not staffed, shall be reported to the Highway Operations Center in Newington at (860)-594-3447.

If it is deemed necessary, repair sketches and/or procedures may be required. Coordination with the Office of Rail will be performed by the Transportation Supervising Engineer.

3.3. LOAD RATING - QUALIFICATIONS & RESPONSIBILITIES

Load ratings for railroad bridges shall be performed in accordance with the AREMA Manual for Railway Engineering and the procedures outlined in Chapter 7 of this manual.

The individual in the Office of Rail charged with overall responsibility for load rating bridges will be a Transportation Supervising Engineer meeting the qualifications of a Railroad Bridge Engineer. The qualifications for the position may include a current Connecticut professional engineer's license and a minimum of five years bridge design and inspection experience. The distribution and assignment of bridges for load rating shall be the responsibility of the Transportation Supervising Engineer. Final, checked, load rating reports shall be reviewed by the Transportation Supervising Engineer or a person designated by the Transportation Supervising Engineer.

Load rating calculations shall be performed by Railroad Bridge Engineers. The engineering knowledge and skill needed to properly evaluate bridges varies depending on the complexity of the bridge. Specialized knowledge of other engineers or experts may be required in certain instances.

The determination of the actual load rating assigned to the bridge requires the judgment of an experienced engineer. Accordingly, the results of each analysis shall be reviewed by a qualified engineer. The engineer's judgment is needed to recognize special situations where routine, simplified analysis procedures are inadequate and a more sophisticated approach is required. In addition, the reviewing engineer shall be required to evaluate the bridge rater's decisions about the strength of materials, effects of deterioration and defects, stability, etc. The reviewing engineer may also recommend additional inspection and/or testing. Authorization by the Transportation Supervising Engineer in charge of load ratings is required prior to performing additional testing.

3.4. MAINTENANCE

The inspection report reviewer, with input from the inspection team, will prepare a list of possible maintenance items that should be performed to extend the useful life of the structure and to ensure its continued safety. These items shall be presented in a Railroad Maintenance Memorandum prioritized as indicated below:

Priority A - Critical - IMMEDIATE response.

Priority B - Urgent, but not critical - Response within 1 WEEK.

Priority C - Important, but not urgent - Response within 2 MONTHS.

Priority D - Of lesser importance, but needing attention - Response within 6 MONTHS.

Priority E - Routine repairs - scheduled by Office of Rail to coincide with other commitments of the same type or within the same general area. - Response within 2 YEARS.

For details and procedures regarding Railroad Maintenance activities see Chapter 8.

When reviewing a railroad maintenance memorandum, it is important that the repairs be meaningful to prolong the life of the structure (not cosmetic) and are cost effective when considering the life cycle costs of the structure.

3.5. DOCUMENT MANAGEMENT

The Rail Section will maintain a file for each railroad bridge in its inventory in accordance with the RBMP.

The files are to be organized into three sections as follows:

1. Inspection Reports (in reverse chronological order)

2. Correspondence (in reverse chronological order)

3. Computations and Plans

(for smaller bridge files, 1 & 2 may be mixed in chronological order)

3.5.1. Inspection Reports

The reports, including all pertinent forms, field notes, photographs, and miscellaneous notes, are submitted either in a digital format or in a hard copy format bound using a suitable, removable clip or binding. This will facilitate removal of portions of the report for reproduction.

Annual inspection reports and special inspection reports shall be retained in the file for a minimum period of 2 years from the completion of the inspection.

In-depth inspection reports shall be retained in the file until the completion and review of the next in-depth inspection of the bridge.

Underwater inspection reports shall be retained in the file until the completion and review of the next underwater inspection of the bridge.

3.5.2. Correspondence

This section shall include pertinent letters such as maintenance memos, letters to towns, letters to utility companies, permit information, etc. These documents should be arranged so that the order of documents is maintained. The correspondence shall be placed in reverse chronological order. For correspondence referring to multiple bridges, a reference sheet with the location of the complete document may suffice.

3.5.3. Computations and Plans

This portion of the file should contain the rating evaluation computations, special computations for deteriorated members, scour computations, etc. The first sheet of this package should contain a Rating Summary sheet with the results and dates of the latest rating or re-rating.

Plan sheets, preferably the as-built drawings, should be included in the file folder or the location of these plans referenced for easy retrieval.

3.5.4. Use of the Files

Since it is extremely important that the information contained in the inspection files be available in an emergency situation, the removal of the file from its assigned location or removal of portions of the individual file must be discouraged and monitored carefully.

To monitor the files, the following policy shall apply:

1. No original file or portion thereof may be removed from the files located in the Office of Rail Office without special approval from the Transportation Supervising Engineer. Bridge files shall be reviewed at the appropriate location within the office of the Office of Rail, with the file reviewer making copies of information they wish to keep.

2. Files shall be kept in chronological order, with all contents facing forward.

3. If it is necessary to separate or unbind any part of the file for making copies, you are expected to return this material to its original form and order.

4. When a folder is removed from a file, a reference card shall be filled out and inserted in place of the file. (Information on these cards shall include Name, Unit or Firm, Telephone Number, Date Taken, and Bridge No.)

5. File folders in poor condition shall be given to the designated staff member for repair or replacement.

3.5.5. Electronic Recordkeeping

An electronically generated record containing all, or a portion of the documentation required per the RBMP, shall be maintained by the Office of Rail but shall not be maintained as the sole recordkeeping method, unless the electronic recordkeeping system meets the system security requirements of FRA 49 CFR, Section 237, Part 155 - Documents and Records.

CHAPTER 4
QUALITY CONTROL/QUALITY ASSURANCE

Table of Contents

CHAPTER 4: QUALITY CONTROL/QUALITY ASSURANCE

4.1. GENERAL

The Connecticut Department of Transportation Office of Rail has instituted a Railroad Bridge Management Program (**RBMP**) to meet FRA 49 CFR Parts 213 and 237 requirements. Railroad Bridge inspectors collect inventory and condition information on each bridge for inclusion in the Department's database. The accuracy and consistency of the inspection and documentation are vital to public safety, and also impact programming and funding appropriations. In recognition of the importance of this information, ConnDOT has established quality control and quality assurance procedures.

To be effective, quality control/quality assurance procedures must be followed by all personnel and the procedures should be evaluated and updated regularly. This Manual defines the Office of Rail’s basic quality control/quality assurance program. The program shall be flexible and shall be updated routinely by memos and directives from the Manager of the Office of Rail.

4.2. DEFINITIONS

The terms quality control and quality assurance are not interchangeable. The following definitions describe the distinction between the terms as they are used in this Manual.

QUALITY CONTROL (QC) is the enforcement of procedures that are intended to maintain the caliber of bridge inspection, load rating, and documentation at or above the NBIS standard. Quality control is the responsibility of every person involved in the daily activities of the Office of Rail's bridge inspection program. Certain personnel shall be designated with specific responsibilities within the overall quality control procedures.

QUALITY ASSURANCE (QA) is a measurement of the level and consistency of the overall program. Quality assurance will be performed by a separate designated group within the Office of Rail or by an outside consultant. The QA group will perform an annual review in order to measure the quality and uniformity of the inspection and documentation, and to identify specific items or procedures in the program where clarification, revision, or additional training is needed.

4.3. QUALITY CONTROL PLAN

4.3.1. Supervisory Responsibility & Duties

Primary responsibility within the Office of Rail for Quality Control shall be assigned to the Transportation Supervising Engineer and the Transportation Engineer III in charge of each area.

Consultants performing inspections shall designate a Project Manager to have primary responsibility for quality control. The duties of the Consultant's QC Engineer shall be similar to the State's QC Engineer.

The Office of Rail Transportation Supervising Engineer and the Consultant's Project Manger are charged with the responsibility of implementing the Quality Control Plan by performing the following duties:

1. Oversee quality control of field operations and reports.

2. Coordinate and implement basic training programs for railroad bridge inspectors and specialized instruction on aspects of the work requiring special attention, e.g. fatigue and/or fracture critical details, scour evaluation, etc.

3. Provide railroad bridge inspectors with access to latest applicable standards and training in proper use of inspection tools.

4. Review the QC Engineer's field review reports for repeated problems, and meet with appropriate staff to remedy.

5. Coordinate the QC Plan with other Transportation Supervising Engineers.

6. Review a representative number of final inspection reports.

4.3.2. Quality Control of Field Inspection Operations

Inspection Procedures - The QC duties of the Inspection Team Leader during the field inspection shall include:

1. Assure that the inspection vehicle includes all required inspection tools, equipment and applicable manuals/references.
2. Observance of proper safety and traffic control procedures in accordance with the requirements of this Manual and references.
3. Proper recording of field conditions with clear, clean and complete field notes.
4. Photographing deficient areas in accordance with this manual.
5. Where photography is not adequate, develop sketches or marked-up drawings in sufficient detail to describe the conditions.
6. Cleaning of delaminated steel sections and measurement of remaining section to determine losses.
7. Sounding of concrete structures to locate delaminations.
8. Proper reporting of safety and structural flag conditions.
9. "Hands-on" inspection of nonredundant members, FCM's, and fatigue prone details.
10. Documentation of access required for inspection.
11. Updating of plans and inventory data based upon observed inspection conditions.
12. Documentation of section losses for load rating updates.
13. Documentation for further investigations and/or design services, if necessary, to identify and resolve observed deficiencies.

4.3.3. Quality Control of Documentation

The QC Engineer shall conduct office review of documents submitted by the field inspection team for conformance with the ConnDOT reporting requirements. The review shall address coding, documentation completeness and technical correctness, and shall accomplish the following general objectives:

1. Consistency between inspection data, photographs, sketches, notes, and if required, load rating data.
2. Correct and consistent interpretation of inspection items and inspection ratings in conformance with the ConnDOT Standards.
3. Adequate inspection documentation of items rated "5" or lower, major defects, repairs, and all unusual features.
4. Completeness of scour documentation.
5. Completeness of Fracture Critical Member documentation. (Refer to the requirements for Fracture Critical and Fatigue Sensitive Member Inspection in Section 5.2.4.4 of this manual.)
6. Proper cross-referencing of photographs to the inspection report.
7. Compliance with this manual in terms of required photographs, notes, and sketches.

4.3.4. Quality Control of Reports

4.3.4.1. **Report Review** - The QC Engineer shall review each inspection report for completeness and conformity to the Department's requirements. Special attention should be paid to load ratings, load or height postings, dates, clearances, fatigue details, fracture criticality, etc. Before making changes to any report, the QC Engineer may confer with the lead inspector responsible for preparation of the report. After a bridge file has passed the QC Engineer's check, and after all necessary corrections have been made, the QC Engineer shall sign and date the review, on the cover of the report or appropriate location on the BRI 39, as "Reviewed By."

4.3.4.2. **Review Summary** - The QC Engineer shall read through the summary and/or maintenance recommendations to assess the overall condition of the Railroad bridge. Any major defects should be highlighted in the summary and the approximate repair quantity noted. For major structural defects, a flagging memo should be included in the report. (Ref. Critical Deficiency Reporting, See Section 3.2.7). A review of the previous defects summary should also be made at this time.

4.3.4.3. **Review BRI-18 and Field Notes** - The QC Engineer shall read through the BRI-18 to obtain an overall view of the condition of the railroad bridge. Each item on the BRI-18 shall be compared to the previous report for consistency (it is unlikely that the bridge has "healed" since the last inspection unless repairs have been made). Special attention shall be given to items rated "5" or less - the referenced field notes shall be reviewed. The QC Review shall check clearance diagrams, bearing measurements, pin and hanger measurements (if applicable) and parapet joint measurements; then compare the measurements to the previous report. The QC Engineer shall provide the Transportation Supervising Engineer with a completed inspection report that can be used for the assessment of the bridge’s condition.

4.3.4.4. **Review Photos, Additional Notes, Etc.** - The QC Engineer shall check that the photographs and additional notes are referenced from the BRI-18. A representative photo should be present for each item of the BRI-18 that has a rating of "5" or below.

4.3.4.5. **Review BRI-25 & 39** - The QC Engineer's review is not limited to the items that have changed from that printed on the form. Special attention should be given to those items that cause the bridge to be classified as structurally deficient or functionally obsolete. The coding of each item should be consistent.

4.3.4.6. **Review Railroad Maintenance Memorandum** - This QC review is to ensure that the proper items are included in the memo as referenced to the defects and deficiencies summary and to suggested maintenance recommendations as submitted by the inspectors. The QC review should also ensure that the appropriate priority code is noted.

Previous maintenance memos should be reviewed to determine if the items are recurring, and to determine if repairs have been made.

4.3.4.7. **Check Evaluation (If Required)** - The QC Engineer shall review the rating summary sheet for completeness. If ratings have been calculated to account for deterioration of bridge members, the QC Engineer should review the calculations to determine if the deteriorations used in the calculations are representative of the actual field conditions.

4.3.4.8. **Form Completeness** - The completeness of documents shall be reviewed as part of the report review procedure. The forms to be reviewed include:

BRI-12
BRI-18
BRI-25
BRI-39
Railroad Maintenance Memorandum
Deficiencies and Recommendations Listing
Clearance Diagrams
Joint Measurements
Bridge Hit Data Sheet

It should be noted that this list is based on a typical Railroad bridge report and not all of the above forms will be included in every report, other Railroad bridge reports may contain more, less or different information.

Procedures for completing these forms can be found in Chapters 5, 6, 9 & 10 of this Manual.

4.3.4.9. **Supervisory Review** - The Transportation Supervising Engineer responsible for quality control shall review a number of the final reports. The sampling goal is to review 10% of the reports.

4.3.5. Quality Control of Bridge Load Ratings

The QC Engineer shall perform a review of the load rating calculations for completeness and conformance to the ConnDOT Standards, and to ensure that the calculations reflect the conditions recorded on the BRI 18, and to ensure that the rating loads have been accurately transferred to the BRI 39. In general, the QC review shall address the following areas:

1. Review adequacy of inspection data, sketches, plans, and other information used as the basis for the rating calculations.

2. Review analysis procedures for conformance with the ConnDOT Standards and appropriate design specifications. A detailed checking of calculations is not required by the QC Engineer.

3. Review whether age, condition, and quality of materials have been accurately addressed in the determination of material strengths. Review the treatment of section losses or member deficiencies in the rating calculations. Assumptions should be clearly stated.

4. Determine that the controlling member in the rating has been properly identified.

5. Determine that the method of analysis used produces a satisfactory result. Evaluate whether more sophisticated or more detailed analysis (e.g.: finite method analysis) would improve the load rating.

6. Determine if investigations into fatigue, scour, or other specialty areas are needed.

7. Evaluate whether additional measurements, materials testing, load testing, or other investigations are needed to refine the load rating.

The QC engineer shall confer with the load rating engineer responsible for preparation of the calculations to resolve any comments on the load rating procedures. After the load rating file has passed the QC Engineer's review, and after all necessary corrections have been made, the QC Engineer shall sign and date the review on the cover of the load rating, as "Reviewed By."

4.4. QUALITY ASSURANCE

4.4.1. Responsibility and Duties

The Transportation Principal Engineer of the Office of Rail has primary responsibility for quality assurance and shall oversee the QA initiative. QA shall be an independent function, prepared by a QA group (designated by the Transportation Principal Engineer).

The Transportation Principal Engineer shall assign a Transportation Supervising Engineer to be responsible for QA operations, a QA Engineer, and a QA inspection team. It is desirable that the assignees not routinely work together as a team. This QA group shall be selected on an annual rotating basis. The QA group's function is to monitor the inspection program by independently inspecting a representative sample of railroad bridges previously inspected by the ConnDOT teams or Consultant teams, and preparing a report comparing findings for consistency and accuracy.

Consultants performing inspection, design and load rating shall designate a Project Manager to have primary responsibility for quality assurance and a QA Engineer to carry out the program. The duties of the Consultant's QA Engineer shall be similar to the State's QA Engineer.

The report shall be presented to the Transportation Principal Engineer of the Office of Rail for overall evaluation of the program.

4.4.2. Quality Assurance Procedures

4.4.2.1. QA of Field Inspection, Documentation, and Reports - The general guidelines and procedures for administering the QA program shall include:

The Transportation Principal Engineer and Transportation Supervising Engineer will select specific inspection areas or procedures to be stressed in the annual QA program. The emphasis may change from year to year depending on general inspection results, observed problems or inconsistencies in reporting, or the desire to monitor new or critical evaluation items.

The Transportation Principal Engineer and Transportation Supervising Engineer will select a statistical sample of railroad bridges to be checked under the upcoming annual QA program.

The QA team conducts an inspection of the designated railroad bridges within 45 days of the actual inspection, and performs the following tasks:

- Verifies inventory data
- Verifies section loss measurements
- Verifies signage and posting
- Performs independent condition rating of specified members
- Lists and prioritizes maintenance needs

The QA group then compares findings with the actual inspection reports and identifies and explains deviations.

The Quality Assurance group prepares a report summarizing deviations in the selected items for evaluation by the Transportation Principal Engineer of the Office of Rail. The Transportation Principal Engineer and Transportation Supervising Engineer meet to discuss findings.

The Transportation Principal Engineer may make recommendations to improve the overall inspection program. This may include special training on specific items, issuance of clarifying memorandums or directives, or informal meetings with staff and/or consultant inspection teams.

4.4.2.2. **QA of Load Ratings** - The Transportation Principal Engineer of the Office of Rail and the QA Transportation Supervising Engineer will select a statistical sample of bridge load ratings to be reviewed under the upcoming annual QA program. The bridges selected may be a random cross-section of structures or may emphasize a particular type of structure or a combination of both.

The QA Transportation Supervising Engineer shall direct an independent load rating of the selected structures. The original load rating documents and calculations shall not be reviewed prior to the independent rating nor consulted during the load rating process. The independent load rating shall be based on the same bridge inspection findings used in the original rating.

Upon the completion of the independent ratings, the QA Transportation Supervising Engineer shall compare the findings of the original and independent ratings to identify and explain the differences. The QA Transportation Supervising Engineer shall prepare a QA Report summarizing the findings for evaluation by the Transportation Principal Engineer of the Office of Rail.

The Transportation Principal Engineer may then make recommendations for modification in the load rating program by issuance of memorandums of policy or procedures or meetings with staff and/or consultant representatives.

CHAPTER 5
GENERAL INSPECTION PROCEDURES

Table of Contents

CHAPTER 5: GENERAL INSPECTION PROCEDURES

The procedures outlined in this chapter are guidelines. Bridges vary too much for inspection procedures to be followed as you would a recipe in a cookbook. Defined procedures help prevent overlooking the inspection of any item, but they do not replace good judgement and a healthy curiosity. Inspect the bridges as though someone's life depends on you. **It does!**

5.1. PLANNING AND SCHEDULING

Proper planning and scheduling of bridge inspection activities promotes the effective and efficient completion of this monumental task. Without the proper preparation, it would be impossible to complete the thousands of bridge inspections that must be performed every year. Limited manpower and budgetary constraints make the efficient use of these resources paramount to the success of this program.

5.1.1. Document Review

The first step in preparing for a bridge inspection is to review the available information contained in the bridge file, such as:

- "As-Built" bridge plans and shop drawings, where available
- Any rehabilitation plans
- Previous inspection reports, including any special or interim reports (like underwater or "Bridge Hit" reports)
- Railroad Bridge maintenance memorandum
- Correspondence pertinent to any required work or work completed

Bridge Plans

The bridge plans contain information that shows the material the bridge is constructed of and how it was put together. Member types and sizes, connection details, intended bearing details or deck joint configurations and the presence (or absence) of piles in the substructure are all bits of information, useful to the inspector, which should be available on the plans. The inspector should be able to recognize and question details in the field that do not agree with what is shown on the plans.

Previous Inspection Reports

Previous inspection reports should make the inspector aware of any areas of concern on the bridge that might warrant special attention. They also provide a standard with which to gage the progress of previously noted deterioration. Special equipment or access requirements necessary to complete the inspection should be noted in previous reports. A thorough review of the last inspection report not only gives the inspector a "feel" for the bridge, but helps to ensure completeness in the inspection and consistency in the evaluation ratings.

Maintenance and Repair Records/Correspondence

Maintenance and repair records make the inspector aware of repairs requested or performed. The bridge inspection should confirm the completion and evaluate the quality of repair work that was previously requested.

Additional Data

Correspondence from towns, citizens reporting unusual noises, etc. may indicate problems to be reviewed or resolved. Accident reports or flood data may give information useful in understanding conditions found during the inspection. Construction memos may give information regarding past, present or future work being done on the bridge or in the vicinity of the structure.

5.1.2. Pre-Inspection

Pre-inspection visits to the bridge site, if appropriate, are useful for determining access requirements (or impediments to normal access), establishing the need for and type of any maintenance and protection of traffic required and observing the overall condition of the bridge to gage time requirements. These visits may be as simple as driving by a smaller bridge, to see that there is no construction activity in the area that might interfere with access or maintenance and protection of traffic patterns. The pre-inspections themselves can be effectively scheduled by performing them when the crew is in the vicinity of the bridge doing other work or by doing several pre-inspections in one geographic area at the same time. Another advantage of pre-inspection visits is that they may make the inspection team aware of more than one structure in a close proximity that may require similar special access equipment.

5.1.3. Coordination of Access and Equipment Needs

The document review process and pre-inspection are intended to familiarize the inspector with the bridge prior to actually arriving at the bridge site to perform the inspection. During these reviews, the equipment and access requirements necessary for the inspector to properly perform the inspection are identified.

- Will Railroad Flag Protection be needed?

  Coordination with the Operating Railroads is required in scheduling Flag Protection. Metro-North requires a minimum of 2 week notice to schedule Flagmen, provide the off system operating Railroads a 1 week notice to schedule Flagmen.

- Will a Town Permit be required?

  A letter shall be sent to the Town were the inspection is to be performed asking for a contact person for the coordination of the inspection. The Town contact will inform the consultant of the town's requirements for the consultant to be able to perform inspections at different locations in their town. Some of the items that the towns may require are a permit fee, insurance (with the town listed as payee), MPT plan and the use of a local police officer for traffic control.

- Will traffic control be required?

  The type of traffic pattern necessary for a state road should be submitted to the Office of Rail a minimum of 3 weeks prior to the anticipated inspection date. Indicate if police assistance will be required, and if an impact attenuator vehicle should be used in the traffic pattern.

- Will access to any locked or gated areas be required?

  Fenced in areas, and machinery pit areas on movable bridges, are both areas where a key may be required to gain access to the structural elements to be inspected.

- Will a bucket truck or snooper be required?

- Will special equipment be required?

  Special items that may be required are scaffolding, rigging, boats, rafts or other special equipment needs.

5.1.4. Weather Considerations

Considering the possible weather conditions when scheduling inspections can permit a more thorough and comfortable inspection. Large, open structures over water are most uncomfortable to inspect in the middle of the winter. Severe cold also impacts inspections involving climbing and snow/ice conditions preclude traffic control operations. Snow and ice on the structure also adds time to the inspection by hampering the ability to see important bridge components without removing the snow and ice.

Structures over water should be scheduled during periods of low water or coordinated at times of low tide to permit complete inspection of the substructure by wading, where possible.

5.2. TYPES OF INSPECTION

General

Each inspection must be conducted systematically so that all items are inspected with a minimum of duplication or lost motion.

Some bridges have areas to be inspected that are extremely difficult to reach and may be inaccessible by snooper or bucket truck. These areas may be viewed with binoculars on inspections that are not in-depth. Note on the report that normal access was not possible and record the distance from which the area was viewed. On in-depth inspections, or if any defects are found or suspected, closer access should be gained by using rigging, scaffolding, specialized equipment or free-climbing. (See chapter 6 for additional guidance on inspection distance requirements.)

Any area that cannot be inspected because of an accumulation of pigeon waste or other debris, and areas covered by poison ivy or heavy brush, should be reported to the Office of Rail so a request for cleaning can be made to Maintenance. Following the cleaning, the area must be re-inspected.

5.2.1. Routine Inspections

Routine bridge safety inspections are regularly scheduled bridge safety inspections that are conducted every two years on all qualifying railroad structures, defined by the Railroad Bridge Management Program. Typically, these are structures that have been assigned a bridge number and have spans of 5' or greater. The Office of Rail provides each Consultant Firm with a computer listing of the bridges assigned to the Consultant to be inspected during the upcoming contract period. The Consultant's team leader then schedules the individual inspections to comply with the appropriate inspection cycle.

The primary purpose of routine inspections is to identify any critical problems or deficiencies. Critical deficiencies identified during a Routine Inspection, that may present a hazard to the public, shall be reported to the Office of Rail immediately for their action. Non-critical deficiencies will also be noted and these deficiencies will be called to the attention of the Office of Rail for their attention.

While some variation in the inspection sequence may be necessary, or desirable for particular bridges, the following sequence is suggested for most bridges:

1. Inspect the deck from the top.
2. Inspect the bridge approaches.
3. Inspect the underside of the deck.
4. Inspect the bearings.
5. Inspect the beams/superstructure.
6. Inspect the abutments and wings.
7. Inspect the piers.
8. Inspect the waterway.

Specific requirements for various types of bridges and bridge components are contained in Chapter 6 of this manual. The AREMA "*Bridge Inspection Handbook"* shall be used as a supplemental reference, providing guidelines for inspections specific to railroad structures.

A complete photographic record of the bridge shall be taken at each routine inspection. The required photographs are the same that is required for the in-depth and a list of the required photographs are listed in Section 5.2.3.

5.2.2. Verification Inspections

Verification inspections are regularly scheduled bridge safety inspections that are conducted every two years on all qualifying railroad structures defined by the Railroad Bridge Management Program. These verification inspections are performed on alternating calendar years from the Routine Inspections (Section 5.2.1) to satisfy the FRA 49 CFR §237 Subpart E requirement for annual inspection of railroad bridges in service. The Office of Rail provides each Consultant Firm with a computer listing of the bridges assigned to the Consultant to be inspected during the upcoming contract period. The Consultant's team leader then schedules the individual inspections to comply with the appropriate inspection cycle; specifically meeting the §237.101 requirements for such inspections to be performed in the given calendar year and within 540 days of the previous inspection.

The primary purpose of Verification Inspections is to confirm the condition of the bridge components, as identified in the previous Routine or In-depth Inspection Report. For components where a change in condition is noted, a revision shall be made to the previous Inspection Report. Changes may include further deterioration of a bridge component or may reflect an improved condition based on the performance of maintenance or repair work since the previous inspection. Verification Inspections are not intended to confirm the accuracy of inventory type data including clearance measurements, however, if an obvious change has occurred in such data then the change shall be noted and included in the report.

It is not intended for underwater inspections to be performed annually as part of the Verification Inspection of railroad bridges over waterways, however, channel and related waterway conditions, that are observed to have changed since the prior report, shall be noted and included in the report.

Critical deficiencies identified during a Verification Inspection that may present a hazard to the public shall be reported to the Office of Rail immediately for their action. When an inspection identifies a change in the condition of a bridge or bridge component that might adversely affect the ability of the bridge to carry the traffic it is designed for, such condition shall be reported to the Office of Rail for assessment and possible revision of the Load Rating.

The general procedures for a Verification Inspection follow the guidelines for a Routine Inspection as defined in Section 5.2.1. The AREMA "*Bridge Inspection Handbook"* shall be used as a supplemental reference, providing guidelines for inspections specific to railroad structures. Routine photographic documentation of the bridge is not required except for those bridge components where the condition previously reported has changed, as noted above.

The Verification Inspection Report is not intended to be an independently produced document but rather is effectively a copy of the previous report with revisions made where the conditions identified during the verification inspection have changed. An updated Railroad Maintenance Memorandum will be generated at the time the Verification Inspection Report is prepared.

5.2.3. In-depth Inspections

In compliance with current Department practice, an in-depth inspection should be conducted on all qualifying structures every 10 years. The biennial routine inspection is not normally conducted in the year that the in-depth inspection is made. An in-depth inspection consists of a "hands-on" examination of all exposed parts of a bridge to assess and record the physical condition of the bridge, to ascertain that the bridge is functioning as shown on the original plans and to ensure that the bridge is adequate to safely carry the intended loads.

A Qualified Team Leader, knowledgeable in bridge design and inspection, should be present to assist the normal 2-person bridge inspection team during in-depth field inspections in accordance with the provisions of Section 3.2.3 of this manual.

For bridges with piers or abutments in water, underwater inspection is mandatory. Where the waterway is shallow enough to be waded safely, this work will be performed by the inspection team and will consist of probing the base of all substructure units in the waterway to locate any scour. In slow moving, clear water, where the bottom is clearly visible, the inspection team should attempt to perform the necessary probing and soundings using a raft. If any signs of scour or settlement, etc. are noted in water that is too deep to wade, then divers should be requested. A stream cross section is to be provided, showing water depths along the upstream bridge fascia and along each substructure unit located within the waterway. The intervals between measurement points should not exceed approximately 20'. Bridges over waterways that are too large or deep to be safely waded will have the underwater portion inspected by the underwater inspection team. Requirements for underwater diving inspections are included in Section 5.2.5.

Bridges over roadways shall have a new clearance diagram prepared for each span over a roadway and for any fixed obstructions above the inventory route. Specific directions for completing clearance diagrams are contained in Chapter 6.

A prepared set of drawings, representative of the entire bridge, or photocopies of the original construction plans should be used to delineate any and all deficiencies on the bridge. These drawings or photocopies will become part of the inspection report, and should include dimensions, descriptions and sizes of both the structure and the deficiencies. A blank copy of these drawings or photocopies should be kept in the bridge file to be used for future in-depth inspections or to have on hand as needed.

Prior to the inspection, parts of the bridge may require cleaning by means of hand tools, water blasting or other methods. Access to structural members may be gained by climbing the structure or by using ladders, rigging, scaffolding or mobile equipment, such as bucket trucks and snoopers.

A visual examination may identify signs of distress, distortions, latent defects, loss of section or deterioration. If these signs are found, further detailed examinations may be necessary. Such examinations include using non-destructive testing such as dye penetrant, ultrasonic, radiographic (x-ray) and magnetic particle tests; using a "D" meter to check the thickness of metal remaining; taking cores or drilling for laboratory testing and/or dismantling assemblies. This work should only be performed under the supervision of a Qualified Team Leader.

Every component and member of the structure must be physically inspected during an in-depth inspection. The use of binoculars to observe areas that are difficult to access is not permitted. Only in extenuating circumstances and with the prior approval of the Transportation Supervising Engineer shall these procedures be excused. If any pre-approved areas do not receive "hands-on" inspection, they shall be so noted in the inspection report.

A complete photographic record of the bridge shall be taken at each in-depth inspection. In addition to the bridge identification photo, a sufficient number of clear, color photographs shall be taken to illustrate the following:

a) Appearance of bridge from both approaches.

b) Appearance of both approaches from the bridge (omit these if the bridge is short enough for the bridge approaches to be viewed when looking through the bridge structure in "a" above)

c) Appearance of bridge in each elevation (several photos may be required to show bridges that cross a number of features).

d) Appearance of upstream and downstream channels on water crossings.

e) Typical condition and configuration of major superstructure and substructure types.

f) Typical utility installations.

g) Identification and description of any significant problem areas as described in Chapter 6.

5.2.4. Special Inspections

5.2.4.1. Interim Inspections

Interim inspections may be required to monitor a particular known or suspected deficiency such as: scour, settlement, deteriorated member condition, usage of a load posted bridge, bearing or joint measurements, etc.

5.2.4.2. Damage Inspections

Damage inspections are normally conducted immediately following any incident that may have an effect on the structural integrity of a bridge. The inspection is conducted by various personnel assigned by the Transportation Principal Engineer of the Office of Rail depending on the seriousness of the incident.

Bridge Hit:

1. Assess the damage. This may require requesting and/or implementing traffic control to allow access to the damaged area.
    - Inspect the damaged members to determine the extent and seriousness of the damage. Determine if the bridge is safe to carry traffic, if emergency repairs are needed or if the bridge should be closed.
    - Notify the Transportation Supervising Engineer if there is a safety problem.
    - Document the damage with diagrams and photographs.
2. Prepare a Bridge Hit Report (Use "Incident Report BRI-24" form in Appendix A).
    - Check and record if the bridge is posted for less than legal weight limits, for a vertical clearance restriction or for a reduced speed. Also check to verify that posting signs are in place and legible.
    - Record the date and time (if available) that the bridge was hit.
    - Record the name of the owner, the license plate number and type of vehicle that damaged the bridge. Note the length, height, estimated weight and number of axles of the vehicle. Attempt to determine if an overheight/overweight vehicle was involved and, if it was a vehicle requiring a permit, that the permits were obtained and current.
    - Check and record the direction the vehicle was traveling at the time of the accident. Request a copy of the police report or accident report. It may be necessary to check the accident report to determine the direction the vehicle was traveling.
    - Describe and document the damage with field sketches (including a plan view and details), verbal description and photographs.
    - Document any actions that were taken, such as closing the bridge or restricting speeds. Describe your recommendations for additional action to be taken by others.
    - Record the date that repairs are completed by maintenance forces. Repairs will likely not be completed while you are inspecting the damage, and it may require a follow-up visit to the bridge to answer this question.
    - Record any additional remarks concerning the damage.
    - Attach a copy of the accident report, if possible.

- Submit the Bridge Hit Report immediately after the initial inspection. Submit a supplemental report (a photocopy of the original) when repairs have been made. A clearance diagram should also be submitted for an overhead type collision.

5.2.4.3. Flood Surveys

Flood surveys are usually conducted by the ConnDOT's Hydraulics and Drainage Section and information collected kept in their files.

5.2.4.4. Fracture Critical and Fatigue Sensitive Member Inspections

For the most part, the fracture critical and fatigue sensitive member inspection will be performed with the annual inspections, as noted in the specific sections of Chapter 6. The following is a general list of what shall be inspected:

1. All exposed surfaces of metal, load path nonredundant superstructure elements shall receive a 100% close-up, "hands-on" visual inspection during each inspection. Areas to receive this "hands-on" inspection include areas subject to tension stress and stress reversal. Members may consist of riveted, bolted, or welded construction. For bridge inspection purposes, superstructures consisting of two girders (including box girders) or trusses are considered load path nonredundant. [Refer to the BIRM 8.1.8].

2. All exposed surfaces of metal, load path nonredundant pier caps (cap girders) shall receive a 100% close-up, "hands-on" visual inspection during each inspection. This includes areas subject to tension stress and stress reversal.

3. For bridges with redundant load path superstructures, all AREMA fatigue category D, E, or E' details [Refer to BIRM Section 8.1.7 and AREMA "MANUAL FOR RAILWAY ENGINEERING", Chapter 15] shall receive a 100% close-up, "hands-on" visual inspection as part of each inspection.

4. Tension and stress reversal zones of metal members shall be examined for the presence of tack welds, remaining original welded erection aids, remaining original groove weld back-up bars, plug welded holes, and other existing weld details, situations, or conditions not part of the original design. If any of these situations exist, they shall receive a 100% close-up, "hands-on" visual inspection during each inspection. This shall be done regardless of redundancy.

5. All fracture critical zones, all load path nonredundant members, fatigue prone weld details and all other areas identified as requiring a 100% close-up, "hands-on" inspection shall be clearly delineated in a specially prepared "BRI-12 Fracture Critical Data

Sheet" for each appropriate bridge inspection report. Whenever an inspection report has a "BRI-12 Fracture Critical Data Sheet" (See Appendix A) to highlight special items of inspection concern, the section shall be preceded by a title cover sheet boldly stating, "Details or Situations Requiring Special Attention During Inspection."

6. In general, all connections welded to a primary member shall be considered part of the primary member.

7. When a bridge element receives a 100% close-up, "hands-on" visual inspection under these provisions, a note shall be placed under Additional Notes on inspection form BRI-18 stating that the required 100% "hands-on" inspection was performed. This note shall specifically list those elements of the bridge that received the required 100% "hands-on" inspection.

8. Other details, situations, or conditions of special concern may be highlighted for special inspection emphasis, even if the specific situation is not itemized in this list of elements to be inspected.

5.2.5. Underwater Inspections

An underwater inspection shall generally be performed on any qualifying structure where the water depth around any of the substructure units is greater than 30 inches, and inspection using hip boots and/or a raft is impossible or impractical because of poor underwater visibility, swift current, soft bottom conditions, accumulated debris or low headroom.

Underwater inspections involve visually and tactually inspecting all the exposed underwater components of the structure. This includes, but is not limited to, abutments, piers, footings, piles, and fender systems. Also, soundings of the channel are taken to identify scour problems. This work shall be performed in conformance with all Federal and State regulations including Title 29 OSHA regulations Part 1910 Subpart T "Commercial Diving Operations" of the Code of Federal Regulations, Chapter 11 of the BIRM, and the FHWA's manual *Underwater Inspection of Bridges* (UIB).

Routine Underwater Inspections are performed along with the above-water inspections. (See Section 3.2.2.4.) These inspections will generally be 80% Level I and 20% Level II, as defined in the UIB. If deterioration is found or suspected, an inspection of the deteriorated areas shall proceed to higher levels depending on the seriousness of the deficiency and criticality of the component being inspected. In some cases, the underwater inspection team will be required to perform a *Full Inspection*, which involves inspecting the entire structure. (See Section 5.2.1.)

Interim Underwater Inspections are routine underwater inspections performed more frequently than every two years.

Special Underwater Inspections are performed in order to monitor known or suspected deficiencies such as scour, pile deterioration or foundation undermining, and to determine the impacts of flood conditions. This inspection will generally be focused only on a specific area or member. The inspection report should give an update of the condition that precipitated the special inspection. This type of report should contain Report Content Item Nos. 1, 3, and parts of 4 through 8.

Report Content

1. *Cover Sheet*: A cover sheet with the bridge number, feature carried, feature crossed, type and frequency of inspection performed (Routine Full, Routine Underwater, Verification or Interim), name of company performing the inspection, and date of inspection. The Project Manager, or an Engineer above the level of Project Manager, shall sign, date and affix his/her P.E. stamp to the cover.

2. *Table of Contents*

3. *Executive Summary:* This section shall list all recommended corrective actions and an estimate of repair quantities for significant or enumerated defects.

This section shall also summarize the scour history at the bridge including any maintenance work performed. The portions of the structure that are constructed on pile foundations or ledge shall be indicated. A statement shall be made of the susceptibility of the stream and/or the streambed to change, including past or potential horizontal stream migration and vertical stream degradation or aggradation. Information on all scour countermeasures present at the bridge, such as rip rap, spur dikes, protective walls, etc., shall be provided along with general construction dimensions and descriptions of current condition.

4. *BRI-59:* The Standard Bridge Inspection Form BRI-59 is the General Information Form. This form will be used to inventory the location of the structure and the site conditions.

5. *BRI-58*: The Standard Bridge Inspection Report Form BRI-58 is the Condition Rating Form. The ratings shall reflect the directions given in Chapter 6 of the RBIM and the FHWA "Coding Guide", as revised. Additionally, a narrative description shall be provided for each applicable item rated "7" or less.

6. *Drawings:* All drawings should be prepared/updated using the Department's current digital CADD file format. **In order to maintain historical data, new measurements and deficiencies should be plotted using existing sounding grids, cross sections, and plan and elevation views, when prior CADD files are available.** If existing drawings (grids) are not available, or there are major errors in the layout of the drawing (grid), a proposed drawing (grid) format, using the guidelines below, should be submitted to the Transportation Principal Engineer of Office of Rail for approval. The maximum size of the drawings should be 11 inches x 17 inches. The orientation of all substructure units should be referenced as previously established in prior inspection reports. Note that all dimensions shall be in English units.

A. **Stream Plan Views**

The plan views shall show the elevations of the stream bottom from a reference datum. Whenever possible, from the original plans or survey data, the reference datum shall be tied to a National Geodetic Vertical Datum (NGVD) or other established elevation datum. Elevations of the stream bottom shall be determined by sounding, fathometers, or other Department approved means. The datum from the previous report and the soundings from that datum shall be shown in English units, in parentheses, on the drawing so that comparisons can easily be made to the previous inspection cycle.

For structures with a span length of less than or equal to 50 feet, soundings shall be taken on a 10 foot by 10 foot grid around and between all substructure units, beginning with the vertical face of the substructure unit. The grid should extend 50 feet up stream and 50 feet downstream from the ends of the substructure units to show changes in the adjacent stream bottom. See Figure 5.2.5a. No grid is required through a box culvert unless there is debris or sediment buildup. However, a grid of the stream is required upstream and downstream of the box culvert.

For structures with span lengths greater than 50 feet, the grid shall consist of four parallel rows of soundings at 1 foot, 10 feet, 25 feet and 50 feet from the longitudinal face of the substructure units. Beyond this point, the grid intervals are 50 feet. Under the structure, the grid (starting at each end of the substructure unit) shall be 3 spaces at 10 feet then continue at 15-foot intervals. The spacing of the rows of the soundings upstream and downstream of the structure shall be at 1 foot, 10 feet, 25 feet, 50 feet, and 100 feet from the ends of the substructure units. See Figure 5.2.5b. Additional soundings should also be taken at the upstream and downstream centerline of the piers. Soundings shall be taken at each point where the grid intersects.

Additional soundings shall be taken if a non-linear surface profile greater than 1 foot /10 feet is identified. Furthermore, if the top of the footing is exposed, an additional row of soundings shall be taken at the face of the footing.

Bathymetric surveys are also performed on selected bridges in place of the above soundings. If this is required for a particular structure, a completed survey shall be included in the report. The contour interval shall not exceed 2 feet. The survey shall extend 175 feet upstream and downstream from the ends of the pier or abutment footings. The prior datum should always be maintained.

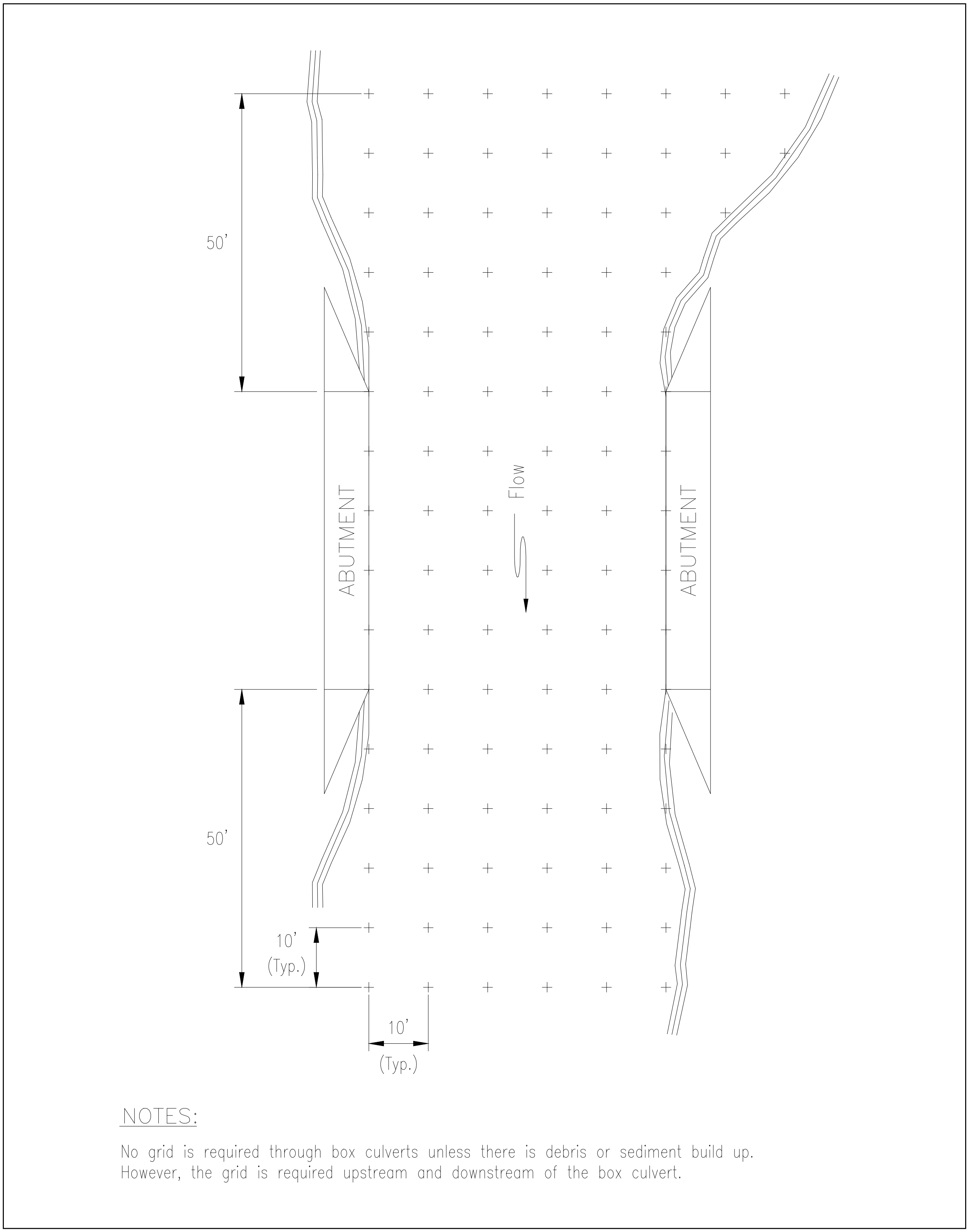
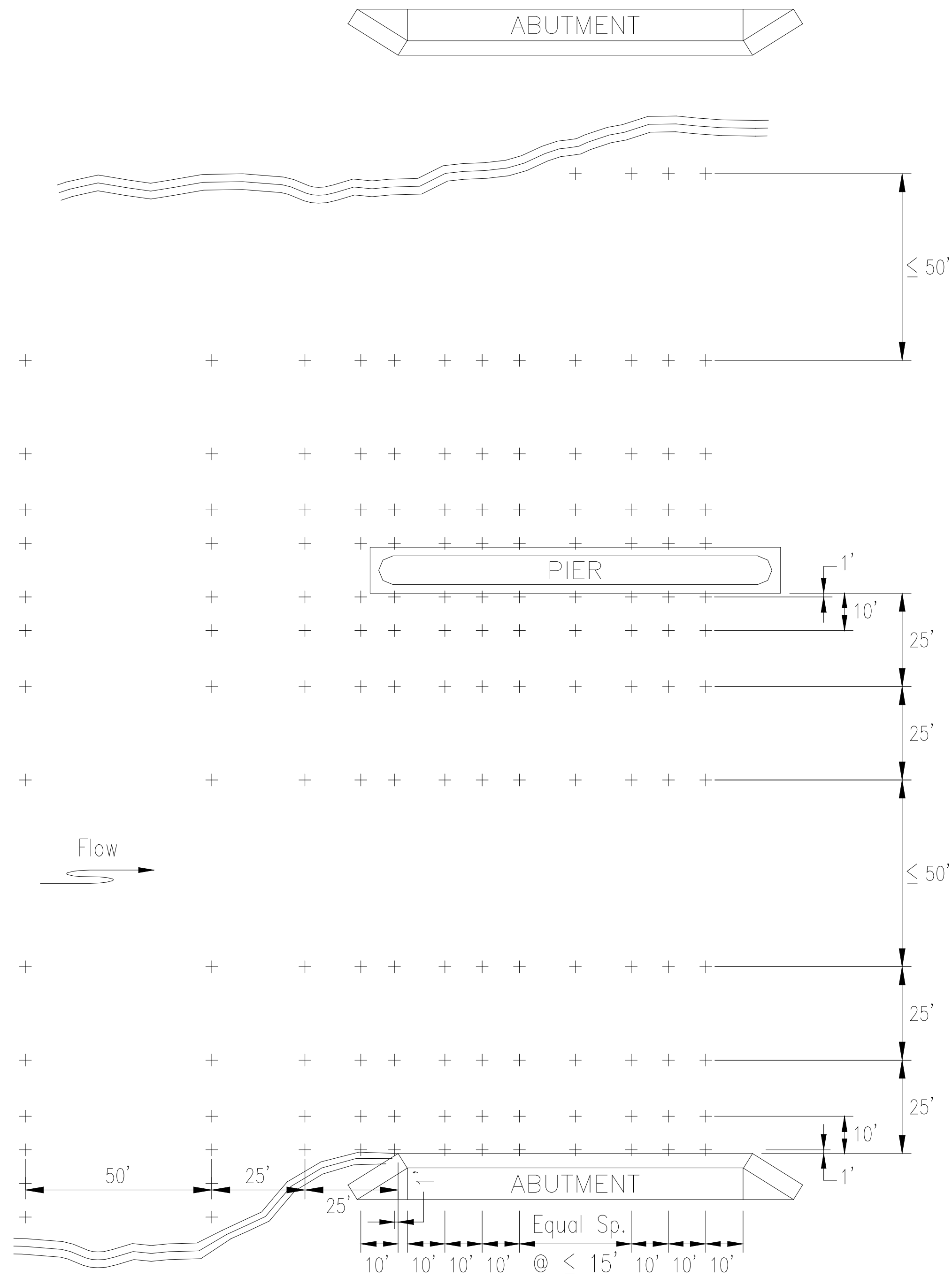


Figure 5.2.5a – Sounding Grid for bridges with span lengths ≤ 50 feet



NOTES:

1. The first row of soundings from the foundation footing should be referenced to the face of the column stem for future soundings.

2. Additional soundings shall be taken if the surface profile is greater than 10% slope to show irregularity and the results shall be shown in the drawings.

Figure 5.2.5b – Sounding Grid for bridges with span lengths over 50 feet

B. Stream Cross Sections

The cross section should be taken 1 foot from the upstream face of the substructure units, looking downstream. The limits of the cross section shall be the apparent high water mark.

The cross section shall contain the most recent stream cross section, as well as, all past stream cross sections in order to show a historical representation of the movement of the stream bottom over the life of the structure. (See Figure A-12-3 in Appendix 6.12.)

Where information is available from original construction plans or other investigations, the foundation type shall be given including the type, size and length of the piles, or note if founded on bedrock. When an undermining condition exists, cross sections of the undermined portion of the substructure must be provided with dimensions of the undermined area.

C. Substructure Plan and Elevation Views

The report shall contain plan and elevation views of each substructure unit inspected. All deficiencies found during the inspection shall be plotted on the drawings and described by their size (i.e. length, width, depth) and location. Approximate bottom of footing lines, below the mudline, should be shown as dashed, "hidden" lines, on the substructure elevation views.

7. *Photographs:* Photographs of upstream and downstream approaches, elevations of the bridge and typical substructure units, and any deterioration causing a rating of "5" or less shall be provided. Underwater photographs are generally not required but may be submitted if underwater visibility permits and the subject is of particular importance. All photographs shall be taken using digital cameras.

8. *Field Notes*: All field notes, field forms and other sketches actually prepared in the field at the time of the inspection shall be submitted with the report.

5.2.6. Semi-Final Construction Inspections

Semi-final bridge construction inspections are conducted as bridge construction operations near completion and the Contractor is still available to make corrections. The purpose of the Semi-final inspection is to prepare a "punch list" of items that need completion or correction. An in-depth inspection of the **newly completed construction** is performed to complete the "punch list" and to provide a condition and dimensional "bench mark" that will be referenced on future inspections. On new structures, the entire bridge will receive the in-depth inspection. This will include preparing all the required Structure Inventory and Appraisal information. On rehabilitation projects, only the repair areas require an in-depth level of inspection. Ideally, the entire bridge should receive its normally scheduled biennial inspection at the same time as the Semi-final construction inspection. Railroad Bridge inspectors should realize when preparing the "punch list" that the Contractor cannot be required to perform any work outside the scope defined in the construction contract, plans and specifications. This should not prevent the inspector from preparing a second, separate list of items on the bridge that might require attention. If it is deemed necessary, some repairs might be added as extra work to be completed by the Contractor on site.

Semi-final construction inspections require close attention to detail. The bridge is not only being inspected for safety, but also for consistency with the construction contract documents and for quality in the completed product.

It is imperative that the inspectors have access to the construction plans and specifications prior to performing the Semi-final inspection and that they make themselves thoroughly familiar with the work done.

The Railroad Bridge Inspector must coordinate the timing of the semi-final construction inspection with the Construction Inspector on the project. The Contractor should be aware of the Railroad Bridge Inspector's presence on the job site. Inspection access may be provided by the Contractor after arrangement with the project Construction Inspector.

5.3. RECORD KEEPING AND DOCUMENTATION

A good bridge inspection reporting system is essential in order to protect the lives of the public and to protect the public's investment in bridge structures. It is necessary to employ a uniform bridge inspection reporting system because of the requirements that must be fulfilled to satisfy the FRA 49 CFR §237 requirements. A uniform reporting system is essential in evaluating, correctly and efficiently, the condition of a structure. Furthermore, it is a valuable aid in establishing maintenance priorities and replacement priorities, and in determining structure capacities and the cost of maintaining the nation's bridges. The information necessary to make these determinations must come largely from the bridge inspection reporting system. Consequently, the importance of clear and complete inspection reports cannot be overemphasized.

5.3.1. Bridge Inspection Report Format

The bridge inspection report is a complete record of the bridge inspection. It contains the field notes and sketches completed during the inspection, completed standard inspection forms, supporting photographs, an executive summary, and possibly a Railroad Bridge Maintenance Memorandum, if required. Inspection reports may contain bridge plans, if they were not previously on file, or rehabilitation plans, if work has been done on the bridge. Load rating calculations may be submitted under separate cover if there has been deterioration, modifications or a change in the dead loads on the bridge since the last inspection.

The ConnDOT bridge inspection forms BRI-18, BRI-39, and BRI-25 (See Appendix A) form the core of a Railroad bridge inspection report. Form BRI-18 is a complete description of the condition of each component of the bridge. Field notes, sketches, and photographs that are used to more clearly describe or supplement the information recorded on form BRI-18 should be referenced on this form. Form BRI-39 gives all the Inventory data relative to the bridge, and form BRI-25 provides Inventory data on any state numbered routes that pass under the structure.

The intent for Routine and In-Depth inspections, is to generate a new report for each inspection.

In general, the format of the completed bridge inspection report will be:

1. Cover page with bridge identification, date of inspection, type of inspection, name of consulting firm and engineer's stamp.
2. Table of Contents (BRI-27).
3. Executive Summary.
4. Form BRI-18 with any attached sheets, such as mechanical or electrical reports, as necessary, to clarify items on the BRI-18.
5. Form BRI-11, Seismic Screening Data Sheet, or Form BRI-12, Fracture Critical Inspection Data Sheet, only if these are not already on file in the bridge record. New forms may be required, however, if the bridge has been rehabilitated or modified.
6. Field Notes/Sketches. Clearance diagrams, which are used for the BRI-39 and BRI-25 forms, are placed first. The remainders of the field notes are placed in the same order as the items they support on the BRI-18 (deck, superstructure, substructure, waterway, approaches).
7. Photographs.
8. Inventory Coding Forms BRI-39 and BRI-25 (if required). These forms are submitted with, but not bound into the inspection report, so that they can be separated for computer data entry

The intent for the verification inspection is not to recreate an inspection report, but while in the field, revise a copy of the previous inspection report for components where a change in condition is noted.

In general, the format of a verification inspection report will be:

1. The cover page, stamped with the type of inspection, date of inspection, name of the consulting firm and engineer's stamp.
2. The complete copy of the most recent inspection report with any condition changes noted on the report. If no changes were noted from the last inspection, it shall be noted on the report and the report included.
3. Photographs of any conditions that have changed.

Additional forms/information that is submitted with the inspection report:

1. Railroad Maintenance Memorandum (if required). See Chapter 8. The Railroad Maintenance Memorandum shall not be bound into the inspection report.
2. Bridge Plans or Rehabilitation Plans. These are submitted only if they are not already on file in the bridge record.

5.3.2. Executive Summary

An Executive Summary is required to be submitted with the inspection report. The Executive Summary, located in the beginning of the inspection report, should provide a general description of the structure and give the overall condition of the main components. Specific, serious deficiencies may also be highlighted in the summary to call attention to their presence.

The following information should appear in the first paragraph of the summary to describe a bridge: bridge number, feature carried, feature crossed, town, number of spans, type of construction, overall length of structure, date of construction, dates of any major rehabilitations and the current load capacity of the structure.

The overall condition rating of the structure should then be given, followed by the condition of each main structure component; deck, superstructure, substructure, channel, culvert and approach. A statement that reflects the **overall** condition of each main component should include minor deteriorations that do not require repair.

e.g.: "**Superstructure** The superstructure is in satisfactory condition (Overall Rating = 6) with areas of light rust along the bottom flanges."

Following the overall condition description for each component, should be a list of deficiencies that require repair or items that should be monitored on future inspections. Items that require repair should include an estimated quantity for the required repairs.

e.g.:

1.) There are 4 loose rivets in Diaphragm 1 at Girder G3, in the bottom vertical gusset plate. Replace the 4 rivets with high strength bolts.

2.) The bearing anchor bolts are missing at Girder G3 at the west abutment. Install bearing keeper angles at this bearing.

5.3.3. Field Notes and Field Forms

Field notes and field forms, including sketches, are completed at the bridge site to record conditions observed during the inspection. Field notes and sketches allow the inspector to describe the type, size, and location of defects observed more completely than the limited space on form BRI-18 allows. For this reason, it is important to cross reference the detailed statements contained in the field notes to the more general descriptions contained on the BRI-18.

All field notes should be neatly prepared and every effort should be taken during the inspection to keep sheets presentable during the course of the inspection. All field notes are part of the "historic record" of the inspection and must be submitted with the inspection report. Sheets that are neat do not need to be recopied. As a minimum, all field note sheets must be identified with the bridge number, date the sheet was prepaired in the field, and the inspection crew names.

5.3.4. Introduction to Condition Rating Coding System

The condition of an element, member, or component is an evaluation of its current physical state compared to the as-built (new) condition.

The inspector should evaluate each element of a given component and assign to it a broad descriptive condition rating of "good," "fair," or "poor," based on the deficiencies found on the individual element. The following guidelines should be used in establishing an element's condition rating:

- Good - element is limited to only minor problems.
- Fair - structural capacity of element is not affected by minor deterioration, section loss, spalling, cracking, or other deficiency.
- Poor - structural capacity of element is affected or jeopardized by advanced deterioration, section loss, spalling, cracking, or other deficiency.

To ensure a comprehensive inspection and as a part of the requirements of record keeping and documentation, an inspector should record the type, size, quantity, and severity of deterioration and deficiencies for each element in a given component.

The *FHWA "Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges"* uses a numerical condition rating system to evaluate the condition of various bridge components. These rating guidelines can be applied to the various items on the ConnDOT Structure Appraisal Form BRI-18.

Code	Description
N	NOT APPLICABLE
9	EXCELLENT CONDITION
8	VERY GOOD CONDITION - no problems noted.
7	GOOD CONDITION - some minor problems.
6	SATISFACTORY CONDITION - structural elements show some minor deterioration.
5	FAIR CONDITION - all primary structural elements are sound but may have minor section loss, cracking, spalling, or scour.
4	POOR CONDITION - advanced section loss, deterioration, spalling, or scour.
3	SERIOUS CONDITION - loss of section, deterioration, spalling, or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	CRITICAL CONDITION - advanced deterioration of primary elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	"IMMINENT" FAILURE CONDITION - major deterioration or section loss present in critical structural components, or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic, but corrective action may put bridge back in light service.
0	FAILED CONDITION - out of service; beyond corrective action.

The numerical condition ratings should characterize the general condition of the entire component being rated. They should not attempt to describe localized or nominally occurring instances of deterioration or disrepair. Correct assignment of a condition rating must, therefore, consider both the severity of the deterioration or disrepair and the extent that it is widespread throughout the component being rated. However, in some cases, a deficiency will occur on a single element or in a single location. If that one deficiency reduces the load carrying capacity or serviceability of the component, then the element can be considered a "weak link" in the structure, and the rating of the component should be reduced accordingly.

5.3.5. Structure Inventory and Appraisal Forms

Structure Inventory and Appraisal (SI&A) forms are a graphic representation of the data elements collected for each railroad bridge (qualifying structure) to comprise the ConnDOT Railroad Bridge Inventory database. The pertinent data needed to describe the type, size, location, condition, etc. of each Railroad bridge is collected and coded on these forms in accordance with the FHWA *"Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges."*

It is important to note that the SI&A sheet is not an inspection form. Rather, it is a summary sheet of bridge data used by the Office of Rail to effectively monitor and manage the Railroad Bridge Inspection Program and the Railroad Bridge Rehabilitation and Replacement Program.

The ConnDOT Forms BRI-39 and BRI-25 (See Appendix A) are used to code and record the necessary Bridge Inventory data as described in the FHWA "Coding Guide." Form BRI-39 contains the inventory data for the rail on the bridge plus the bridge structure itself. Form BRI-25 is used to code inventory information for routes that pass under the bridge, generally State numbered highways. While every structure has one (1) BRI-39 form associated with it, there may be no BRI-25 form (as for structures over water) or several BRI-25 forms for large structures in interchange areas.

The information contained on the forms is a compilation of both office data and field inspection results. Measurements and dimensions are normally taken from the original plans and verified in the field. Once a bridge has been inventoried, the majority of the SI&A items will remain unchanged. Only specific items, which are identified on the BRI-39 and 25 forms, need to be coded or verified on every inspection.

Inspectors should carefully explain changes in coded items when there is no obvious reason (e.g. a rehabilitation project) to explain why certain dimensions or coded values have changed. For example, a paving project or restripping of a roadway under a bridge might cause under clearance dimensions to change. Unless explained, it might not be obvious why these values are being changed on the form. Furthermore, coded dimensions may not coincide with original design plans since field measurements verify that a particular item has been repaired, replaced or not built according to plan. Office personnel should not adjust coded values based on plan information without confirming that field conditions match the plans.

5.3.6. Photographs

The old saying "a picture is worth a thousand words" is certainly applicable to bridge inspection reporting. Sometimes, no amount of written description can convey the same information as a simple photograph. For this reason, photographs form an important part of every bridge inspection report and all bridge inspectors should be familiar with basic camera operation and photographic techniques. Reading the operation manual supplied with the camera you are using will normally provide enough basic information and guidelines to allow you to take the commonly required photographs.

All inspection photographs shall be taken using digital cameras. Digital cameras shall have a minimum photo quality of 2048 x 1536 pixels (3 MP) with 24-bit color.

It is important to keep track of photos taken. For this reason, it is necessary to keep a photo log of the pictures taken at each structure (See Figure 5.3.6a). The structure identifier, date and description of what is in the photo (including exact location of detail shots) should appear next to the number of the photo. Photographs in the inspection report should be printed two to a page with both photos viewable from the same direction and individually labeled. Labels must be legible while viewing the mounted print.

Bridge No. ____________________________ Date

Town _______________________ Inspectors

Carried ______________________ Crossing

Photo #	Image Description
1	Bridge ID
2	East Elevation
3	Bridge from South Approach
4	Typical Underside (Span 4)
5	Span 3, Beam 4 Bearing Pedestal Spalled at Pier 3

Figure 5.3.6a - Sample Photo Log

Photographing the bridge:

Upon arrival at a bridge site, and before shooting bridge images, take a picture of the bridge number located on the bridge. If the number is known, but cannot be found or is not legible, photograph the number after writing it on a sheet of white paper. Use large text and a dark, thick tipped marker when writing numbers and letters to be photographed. This insures legibility, even if the photo is slightly out of focus.

After taking the ID photo, the following general descriptive photos should be taken:

1) An elevation (side view) of the bridge.

2) A picture of the bridge from the approach, showing the roadway on the bridge (preferably from the on-traffic side so that signs are readable and railing transitions are visible).

3) A typical underside photo showing the main superstructure.

There are other photos required for in-depth inspections that are discussed in Section 5.2.3.

Documentation photographs for an inspection should include photos of significant defects and photos necessary to describe deterioration conditions. As a minimum this should include photos of items rated "5" or less and items that will require maintenance repairs. Conditions found during the inspection that might cause an inspector to change a previously coded condition rating (up or down), may warrant photographs, to document changes in condition that justify the revised coding. Keep in mind, that it is always easier to take documentation photos during the inspection, rather than having to return to the site at a later point. This is especially true when special access equipment or traffic control is involved.

Hint In the course of photographing some details (e.g., steel or concrete cracking) there may be an inclination to get a close-up of a small detail. Sometimes this is necessary or desirable, but frequently it is more helpful to step back enough to show the overall picture, such that the significance of the defect can be related to its location on the bridge. For example, a close-up picture of a crack in a piece of steel may not give sufficient scale and may resemble other cracks. However, an overall picture that shows the whole connection detail, with the crack, provides a graphic description of its size and the criticality that it presents to the total connection. When it isn't possible to do this successfully, it may be desirable to take both the close-up detailed photo and the overall view.

When taking pictures of deterioration, cracks and other deficiencies, check the photo in the LCD display to make sure the item you are trying to photograph is depicted. If the deficiency does not show up in the photo, retake the photo varying the flash, camera angle and other camera settings to better capture the item that you are trying to document.

Be aware that while photos are important and can be a great help in clarifying conditions, they are **not** a replacement for good notes and sketches. The photograph will not give you the amount of steel section loss shown or otherwise quantify deteriorations being illustrated. One way to partially accomplish this is to include some type of ruler or measuring device in the photo to lend scale to the image. Another helpful technique to use when taking detail pictures is to label the detail being photographed. Draw an arrow to the defect, using keil or a marker, and label the location exactly on the member to be photographed.

5.3.7. Documentation For Items Rated "5" Or Less

All items with a condition rating of "5" or less should be documented with sketches, in sufficient detail, to allow for "as-inspected" rating calculations to be performed, and such that future inspections can determine if the condition has deteriorated. This documentation should include sketches and/or photographs of the deteriorated areas.

All sketches should be prepared in accordance with Section 5.3.3 *Field Notes and Field Forms*. Sketches should be drawn to scale as much as possible. Sketches should contain a North arrow, or other means of providing proper orientation (i.e. stream flow direction, geographic features, etc.). All members should be labeled using the nomenclature from the design plans (if it is known) or other nomenclature defined on the sketch (i.e. "Stringers numbered from North to South"). Documentation of deteriorated areas should include the size of the deterioration (i.e. height, width, length, depth, etc.) and location along the member (i.e. distance from nearest support, etc.). All dimensions should be labeled as either field measured (i.e. using ruler, calipers, etc.) or estimated.

All photographs should be taken in accordance with Section 5.3.6 *Photographs*. Sufficient photographs should be taken to show the full extent of the deteriorated area (i.e. close up views), and its location along the member receiving the condition rating (i.e. panoramic views). The location of each photograph should be noted in the field notes.

CHAPTER 6: CONDITION EVALUATION PROCEDURES

Table of Contents

CHAPTER 6: CONDITION EVALUATION PROCEDURES

CHAPTER 6 APPENDICES

CHAPTER 6: CONDITION EVALUATION PROCEDURES

6.0. GENERAL

References: AREMA BRIDGE INSPECTION HANDBOOK©(2008)
Bridge Inspector's Reference Manual Revised 2006 (**BIRM**)

6.0.1 Structure Identifier Requirements and Procedure

Procedure for Assigning Structure Numbers

The State of Connecticut assigns a structure number, usually a five or six alphanumeric character with "R" the last character identifying railroad structure.

Railroad Structures	*nnnnnR – nnnnnR & 08000R – 09999R

*Note: Some RR structures were numbered using existing bridge numbers and adding an R suffix.

*All bridges have milepost in addition to bridge numbers as identifier.

A new structure number will only be assigned to new structures in new locations or newly discovered structures. Bridge structures that are removed and completely replaced in the same location will retain the same structure number. Bridge structure numbers will be assigned to a structure in a new location and the number will be kept for that location even if the alignment has changed, provided that the structure is performing the same function. The Transportation Supervising Engineer will be responsible for archiving all information relating to the old structure in that location.

6.0.2 Bridge Component Labeling Systems for Inspection Reporting

When producing inspection reports, it is very important to establish a uniform system of identifying a structure, as well as, the components that make up that structure. The system should be consistent from structure to structure and should be known and understood by not only the inspectors, but also any other individual who may need to read, interpret, or further evaluate the information contained in the report.

Numbering of railroad bridge elements is based on the direction of increasing milepost. Numbering advances from the beginning to the end of the bridge, progressing in the direction of increasing milepost, as shown in **Figure 6.0.2a**. Girders and other longitudinal members are numbered from left to right facing the direction of increasing milepost. Refer to **Figure 6.0.2b** thru **Figure 6.0.2e** for bridge component labeling practices of different, typical railroad bridge superstructures.

Abutments should be referenced by compass direction, in addition to number, to allow easy orientation in the field (e.g. South Abutment (#1) and North Abutment (#2)). When establishing the bridge orientation, the original construction plans or a compass should be referenced for a North direction. Bridge orientation should be taken as either West to East or South to North (Do not use designations such as Southwest Abutment).

Please refer to, the AREMA Bridge Inspection Handbook chapter 5, for more specific structure nomenclature and labeling practices.

Once a bridge labeling system is determined, a key plan should be prepared that shows the labeling for all the bridge components. This key plan should remain a part of the permanent file and be referenced for all subsequent inspections. Changes to the key plan should not be made without the approval of the Transportation Supervising Engineer.

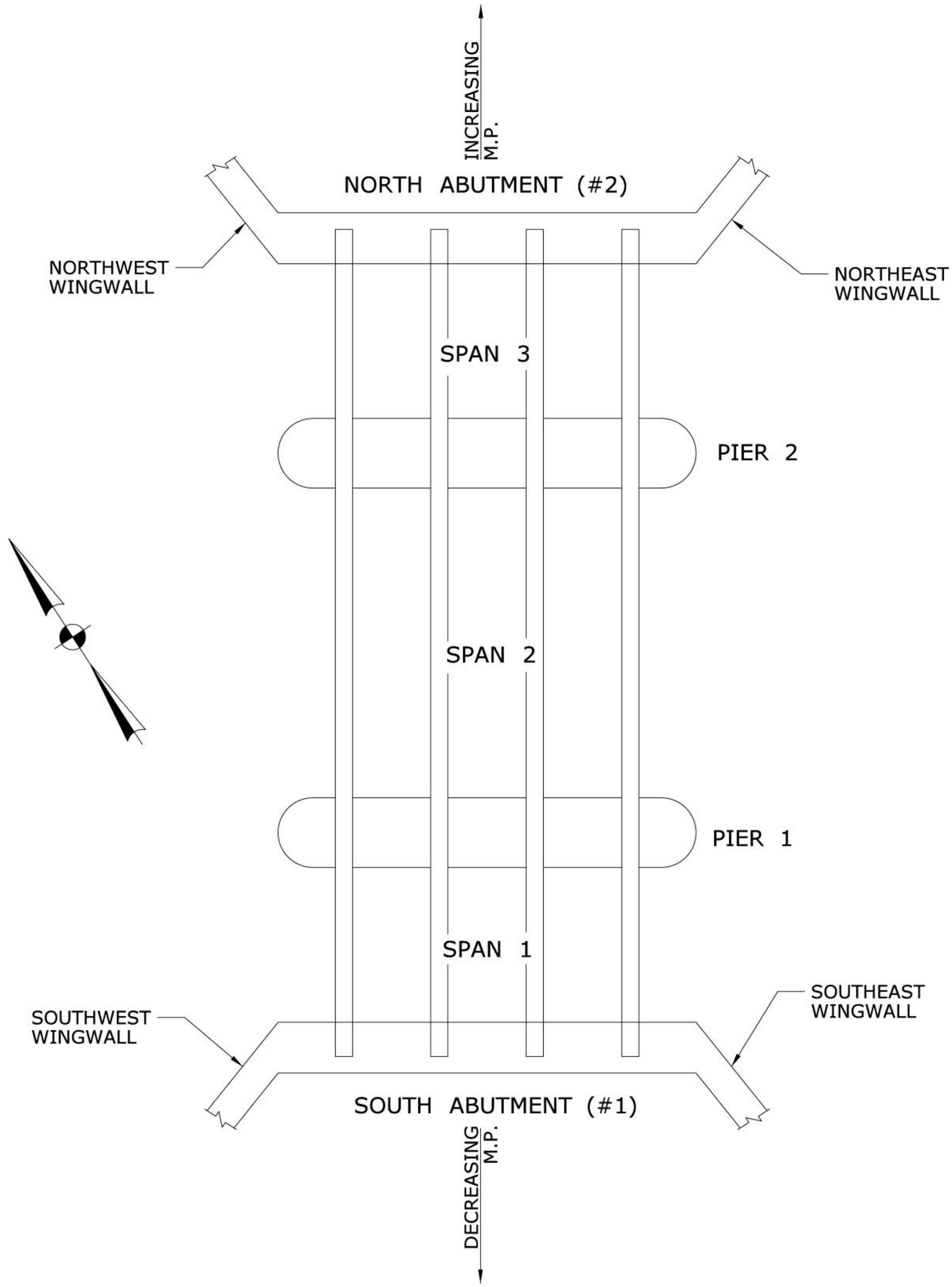


Figure 6.0.2a: Railroad Bridge Substructure Labeling System

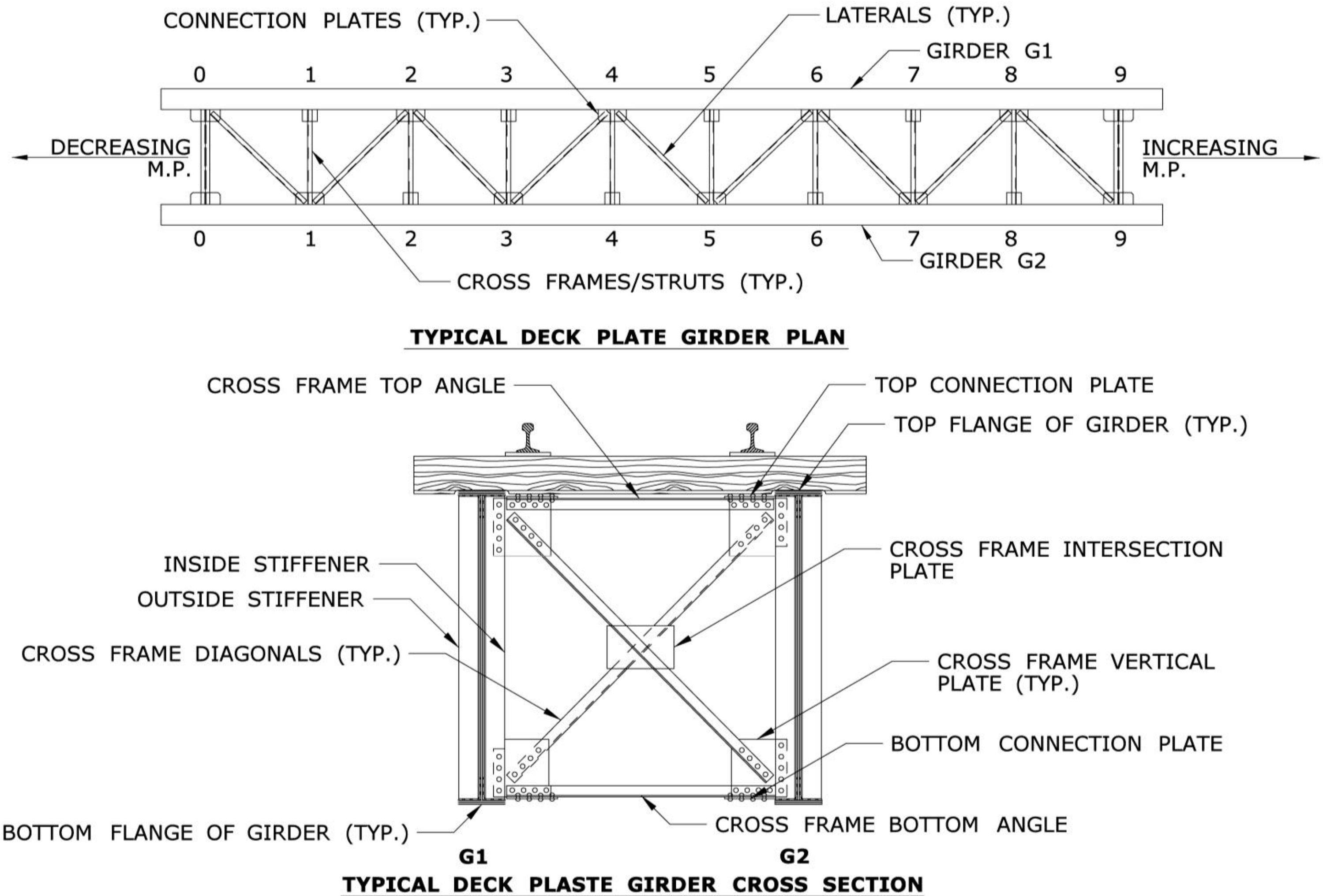


Figure 6.0.2b: Deck Girder Labeling System

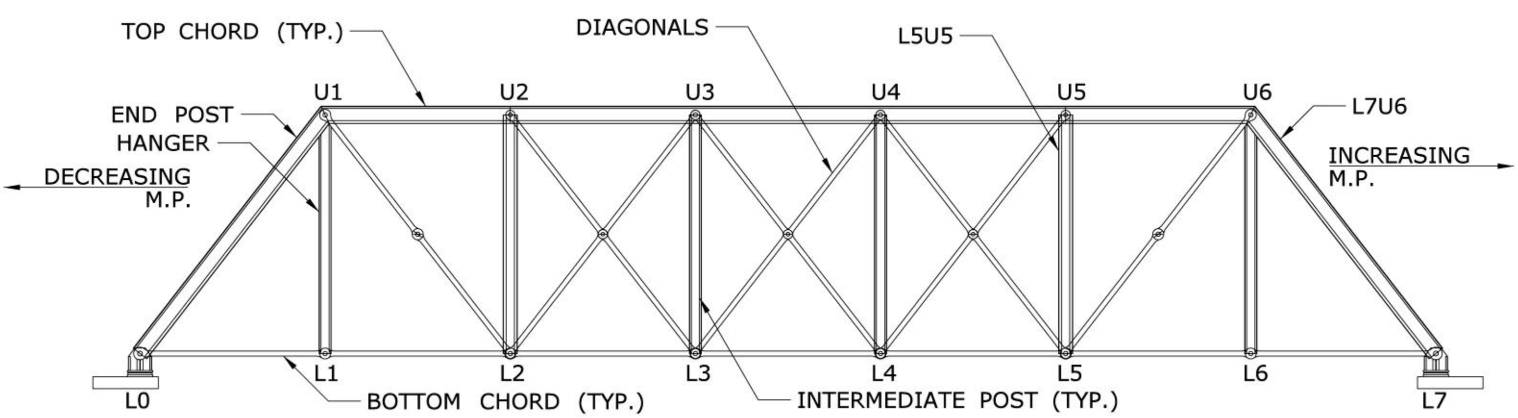
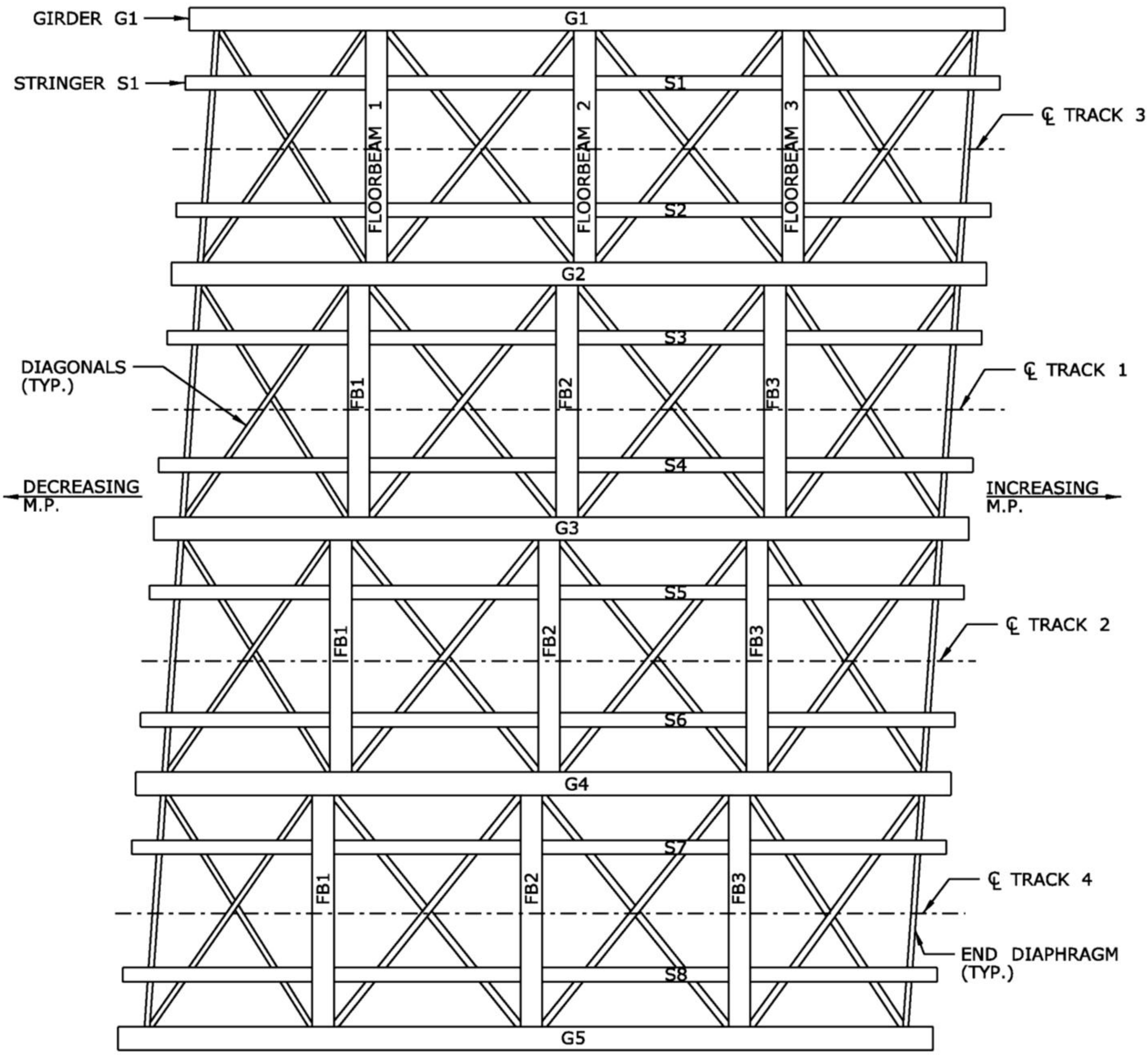
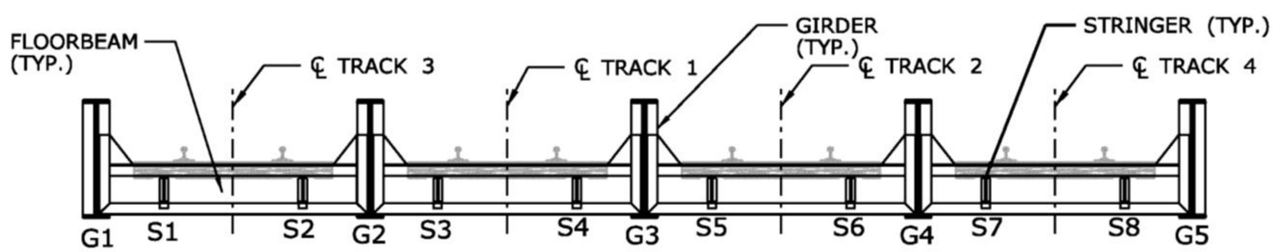


Figure 6.0.2c: Truss Labeling System



TYPICAL STRINGER FLOORBEAM SYSTEM PLAN



TYPICAL STRINGER FLOORBEAM SYSTEM CROSS SECTION

Figure 6.0.2d: Stringer Floorbeam Labeling System

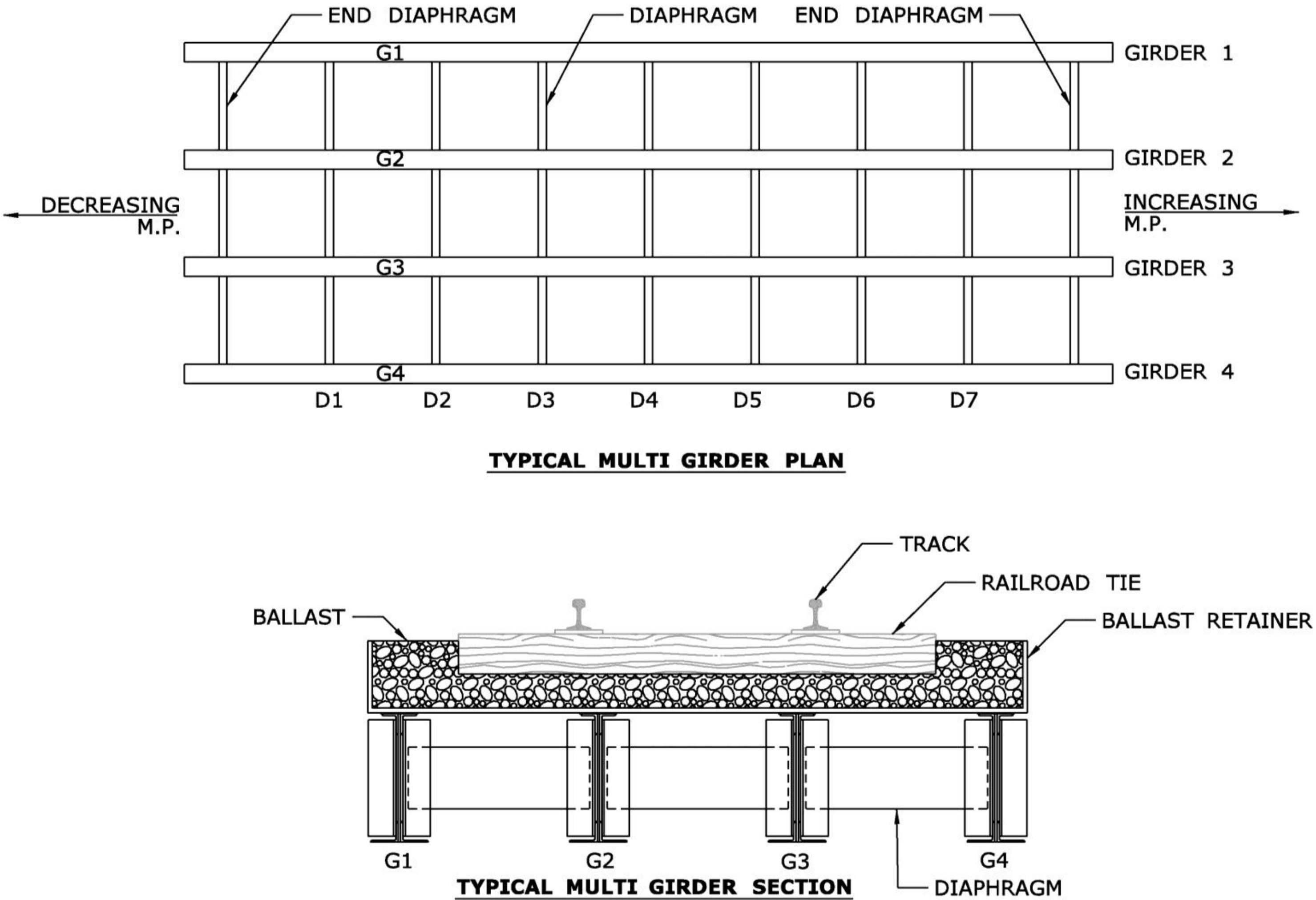


Figure 6.0.2e: Multi Girder Labeling System

6.0.3 Measuring Clearances and Preparing Clearance Diagrams

Reference: The Department's Policy on Posting Vertical Clearances

Clearance diagrams must be on file for all Railroad bridges over roadways. These diagrams give the necessary horizontal and vertical clearance information needed to complete the coding items required by the *FHWA Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges* (Ref. FHWA Coding Guide Items 53, 54, 55 and 56). These measurements provide important information on maximum size vehicles that can pass under or through the bridge structure. Where these measurements are less than legal minimums, they are used for establishing posted limits on the bridge.

Clearance diagrams should be drawn as a plan view of the bridge showing position of all lanes below. Trackside obstacles including substructure elements, top or toe of slopes steeper than 3:1, etc., should also be shown. Minimum dimensions should be labeled on the clearance diagram. See Figure 6.0.3a for an example Clearance Diagram.

A new clearance diagram shall be completed on each in-depth inspection and verified on each routine inspection. A new clearance diagram will also be required if there is not one currently on file or any time a change to the roadways at the bridge cause measurements to change. These changes could include the roadway being resurfaced or milled, lane positions being relocated /adjusted, the addition or relocation of guide rail or traffic barriers, etc.

On routine inspections, a copy of the clearance diagram from the last in-depth inspection shall be included in the inspection report. All minimum clearances shall be verified in each span of the bridge and enough additional measurements shall be checked to verify that changes to the roadway (i.e.: lane relocation, resurfaced, milled, etc.) have not taken place. The controlling vertical and horizontal clearances in each span shall be verified on every inspection. When verifying measurements, dimensions should not normally change unless there has been some work done to change the measurement. The minimum dimensions are what is desired. Do not change previously coded clearance measurements without documentation as to why they have changed.

Verification Inspections are not intended to confirm the accuracy of inventory type data including clearance measurements, however, if an obvious change has occurred in such data then the change shall be noted and included in the report.

6.0.3.1. Vertical Clearance Measurements

Reference: FHWA coding guide

For railroad spans over roadways, vertical clearance shall be measured at every painted line marking, curbline, edge of pavement, and all visible breaks in grade. These measurements are duplicated at both fascias in each span that crosses a roadway. When there are no pavement markings, vertical clearance should be measured at each curbline, at the center of the road, and the edges of each lane where traffic is expected to travel.

It is important to remember that the primary objective of these measurements is to locate the minimum vertical clearance. As such, it may be necessary to take different or additional measurements when it is suspected that minimum vertical clearance is not at the usual edge of lane or fascia locations.

Examples:

- The roadway beneath the bridge may have a cross slope with a crown that is not located right on a lane line. Take the clearance at the crown of the road.
- If the roadway beneath the bridge has a rise beneath the bridge or is on a vertical crest curve that peaks beneath the bridge, the minimum vertical clearance may be located near the middle of the bridge rather than at the fascias. Be aware of this possibility particularly on very wide bridges.
- If the road beneath the bridge dips significantly at the bridge, it may be possible for long vehicles to get wedged under the structure due to "bridging" of the truck chassis. If it is suspected that this potential exists, additional investigation should be requested. Surveying may be necessary to determine the effective vertical clearance.
- If the roadway beneath the bridge is on a grade, the vertical clearance to one side of a fascia beam may be less than the other. Check the fascia edge and interior edge. This will be more prominent on wide beams like box beams.
- If a bridge beam has a bolted splice or other attachment to the underside that protrudes from the bottom of the structure, the vertical clearance at this location should be checked.
- Always measure and record vertical clearance at locations of impact damage to the superstructure.

It is necessary to identify the largest (tallest) vehicle that can move beneath the structure within a 10' lane width. If the lane widths where measurements were taken are greater than the typical 12', then additional measurements should be taken to code Item #10. Locate the maximum vertical clearance at the largest (tallest) lane opening under the bridge. Take an additional vertical clearance measurement 10' to either side of this maximum clearance.

When measuring vertical clearances, only a direct reading vertical measuring rod should be used (bridges with clearances in excess of the normal 25' measuring rod are an exception). Survey leveling rods are not appropriate for this work. The rod must be held vertical to get the proper measurement. This should be checked using a bubble level on the rod or by having another inspection team member sight the rod to insure it is plumb. The rod should be swayed back and forth to ensure that the minimum clearance is obtained. Vertical measurements should be taken to the nearest inch with fractional inches truncated (i.e.: 14'-5 3/4" is recorded as 14'-5").

Currently, vertical clearances of less than 14'-3" require the structure to be posted for the low clearance. All clearances less than the posting limit should be carefully verified. Current policy is to post structures for 3" less than the minimum measured clearance to account for snowfall, vehicle bounce, etc.

6.0.3.2. Horizontal Clearance Measurements

Reference: FHWA coding guide

Lateral clearances must be measured in accordance with the FHWA coding guide items 55 and 56. All lane widths, shoulder widths, distances to guide rails, fences, and substructure units or toe/top of slope (greater than 3:1) should be measured and shown. Lateral clearance measurements from the edge of travel way to a roadside obstruction or substructure unit should be taken at each fascia of the bridge to locate the minimum, in case the roadway is skewed to the bridge or curved. When measuring clearances at railroad tracks, measure from the nearest trackside obstruction to the closest rail as well as distance between rails and distance to adjacent tracks. Caution: Do not lay metallic measuring tapes across railroad tracks, as they can affect rail signal systems.

When measuring lane widths, note that standard highway designs and normal paving equipment produce standard size lane widths such as the 12' lane. Minor deviations in lane stripping should not be used to show a typical lane configuration, if plans are available to indicate that standard sizes were intended. In general, indicate the typical lane widths if actual measurements are within ±3". Likewise, paved shoulder widths are normally intended to be in multiples of 6". Lateral clearance measurements from the edge of the traveled way (not the shoulder) to the nearest roadside or trackside obstacle should be recorded exactly as measured.

`

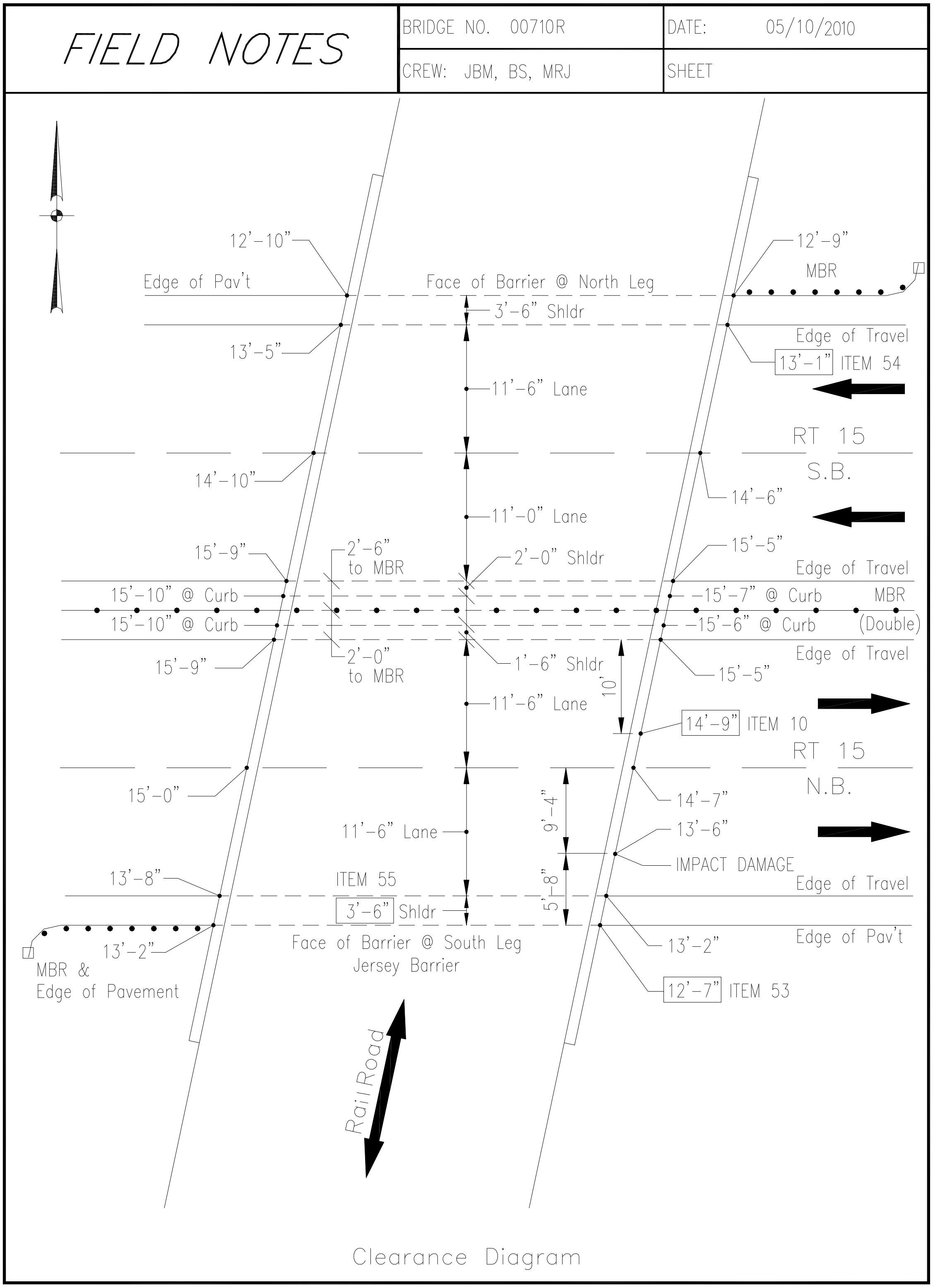


Figure 6.0.3a: Example Clearance Diagram

6.1. DECK INSPECTION

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 6

6.1.1 General

The three main categories of railroad bridge decks are:

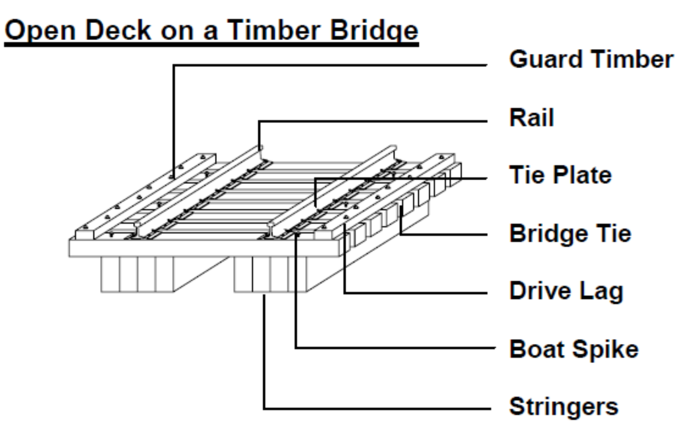
- Ballast Decks
- Open Decks
- Direct Fixation Decks

Of these three categories, the majority of bridges in the ConnDOT railroad bridge inventory have either an open deck or a ballast deck. With direct fixation decks only being used where there are tight clearances.

The deck plays a crucial role as the interface between the train and the superstructure. Subjected to the direct action of the train, railroad bridge decks often develop defects faster and require more maintenance than the rest of the bridge structure. Furthermore, less apparent defects in the main structure of the bridge often result in more apparent defects in the bridge deck. In this fashion, a deck defect may indicate a more critical condition in the main structure. For these reasons it is important that the deck of every railroad bridge be thoroughly inspected on a regular basis.

6.1.2 Open Decks

An open deck is a bridge deck where the rail and tie plate is fastened to timber bridge ties that rest directly on the main structure of the bridge. Open decks are typically used on steel or timber spans. Open deck concrete bridges are uncommon.



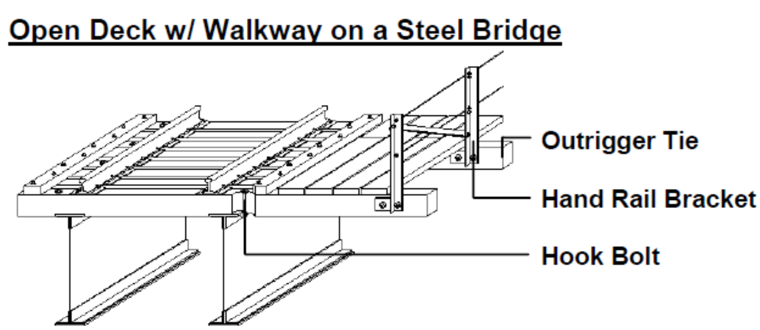


Figure 6.1.2a

Inspection Requirements

Inspections:

- During inspection, report any unusual condition of any element of the rail and timbers to the ConnDOT Office of Rail (Inspection of rail elements are done by Railroad personnel). Rail elements include the rail, spikes, tie plate, drive lags, guards and ties. In some situations a defect in the deck or main structure will result in unusual wear on the rail.
- From the underside, watch the deck system under live load and watch for pumping of the track and/or bridge ties.

Documentation for Routine Inspections:

- The location of the pumping track and/or bridge ties should be noted and special attention should be given to the superstructure directly beneath the pumping deck system for damage and signs of wear.
- The location of line and surface defects should be noted prior to inspecting the remainder of the structure.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- During the inspection, walk the deck and note the general tie condition, looking for split ties, broken ties or decayed ties. Note any derailment or fire damage, shifted or skewed ties and Horizontal shear cracks.

Documentation for In-Depth Inspections:

- If loose and missing rail components are found, their locations should be noted prior to inspecting the remainder of the structure. This is necessary to allow the inspector to search any additional damage due to impact from the loose components.

Figure 6.1.2b: Open deck on a Through Girder Bridge

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer should determine if the pattern, quantity and severity of the deteriorations found support the numerical condition ratings given. The reviewer should compare the present inspection report to past reports.
- Low condition ratings, which are caused by extensive widespread deterioration, should be sufficient reason to request supplemental testing to better determine the condition of deck components and whether rehabilitation or replacement is warranted.

Maintenance Concerns:

- Timber Decay – as timber decays the tie is crushed under the rail, the track spikes will loosen and the track surface and gauge may be affected.
- Fire Damage – Damage to the ties caused by fire can degrade the critical bearing areas for the tie to the bridge and the rail to the tie.
- Mechanical Damage – Mechanical damage can take several forms, such as plate cutting, broken ties, and derailment damage. Mechanical damage occurs when ties are subject to repeated overloading of large impact loads. Ties damaged should to be identified and replaced.
- Skewing and Sliding Ties – Skewing ties will affect track gauge and lead to mechanical damage to the ties, tie plates and the base of the rail.

6.1.3 Ballasted Decks

On a ballast deck bridge, the rail is fastened to standard track ties resting in a bed of ballast that is confined by a ballast pan or tub which is then connected to the bridge superstructure. There are three different material used for the ballast pan or tub; timber, concrete and metal.

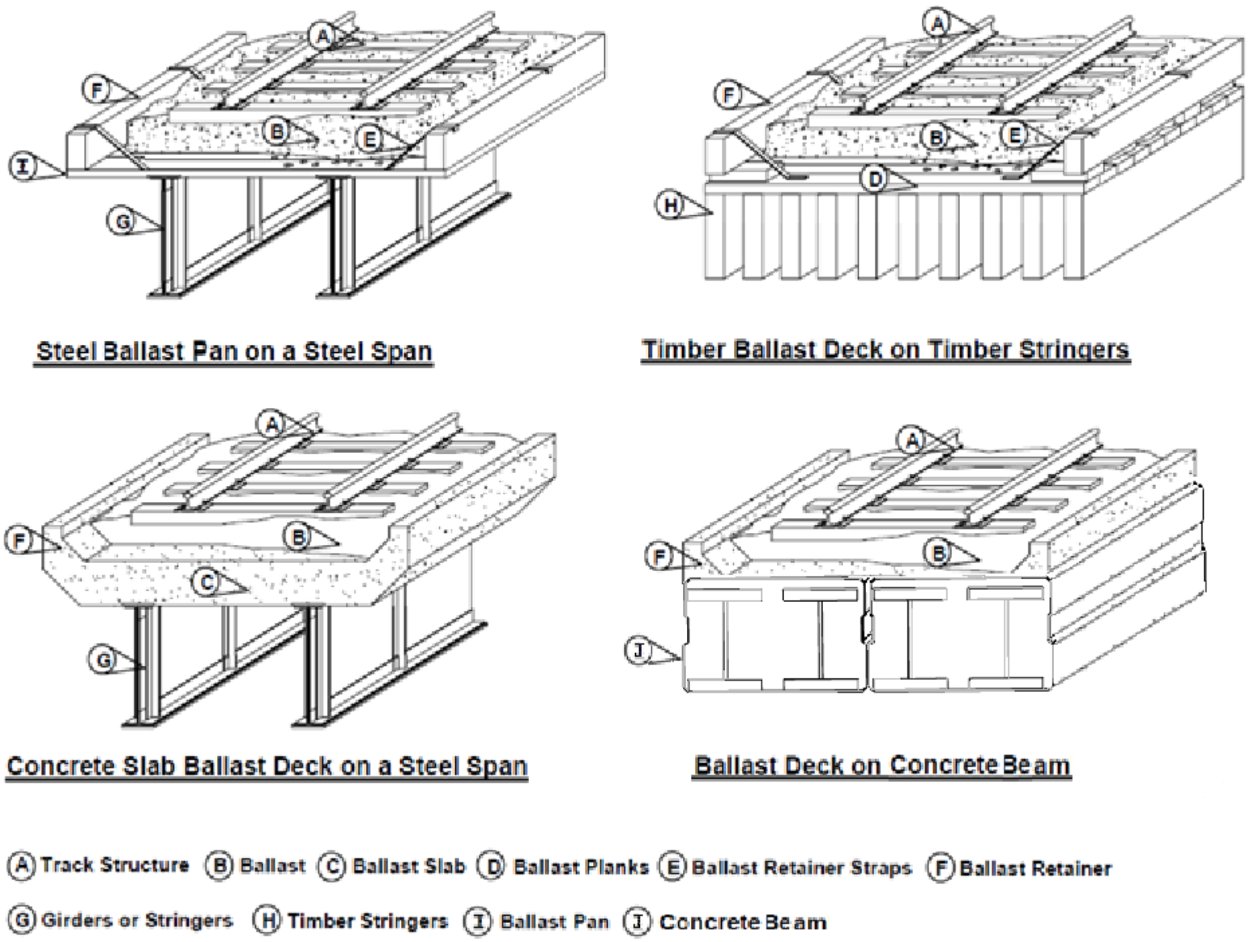


Figure 6.1.3a

6.1.3.1. Ballasted Timber Decks

Inspection Requirements

Inspections:

- During inspection, report any unusual condition of any element of the rail and ties to the ConnDOT Office of Rail (Inspection of rail elements are done by Railroad personnel). Rail elements include the rail, spikes, tie plate, drive lags, guards and ties. In some situations a defect in the deck or main structure will result in unusual wear on the rail.
- Inspect the top of deck, visually observing the condition of the top surface or overlay. Pay special attention to the condition of the ballast, look for fouled ballast, excessive ballast, ballast leaks and evidence of poor drainage. They are all signs of possible issues with the ballast planks. The entire top surface should be visually inspected.

- Inspect the entire underside of the ballast pan or floor, checking for signs of decay, weathering, and damage. Look for evidence of poor drainage or loss of waterproofing. Normally, observation of the decking during the course of the superstructure inspection will provide an adequate inspection distance.
- On the exposed surfaces of the timber decking, discolored areas and areas of suspected decay or parasite damage should be tapped with a hammer or probed with an ice pick in an effort to determine the presence of internal decay or voids. Be careful of frozen timber that may have internal deterioration but sounds solid due to water frozen in internal cavities.
- On laminated timber decks, the laminated surfaces should be examined for separation. Fasteners connecting the decking to the floor system should be examined for loosening.
- Approximately 20% of exposed surfaces of the timber decking shall be tapped with a hammer or probed with an ice pick to determine the presence of internal decay.

Documentation for Routine Inspections:

- Deck notes should be organized in a "span by span" manner.
- Note the size and location of splits, fungus decay and parasite damage. Also note the location of loose attachments to the floor system and the cause of this condition (wood shrinkage, decay, crushing). Where these cannot be simply described, a sketch shall be made showing the size and location of the deficiency.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements of routine inspections, "hands-on" access shall be provided to the entire underside of the deck.
- Measure the depth of the ballast along each track on the bridge and find the average ballast depth.
- 100% of exposed surfaces of the timber decking shall be tapped with a hammer or probed with an ice pick to determine the presence of internal decay.
- All exposed surfaces of the timber decking showing surface decay shall be probed with an ice pick to determine the depth of the decay.

Documentation for In-Depth Inspections:

- The thickness of the timber deck should be measured and recorded. Give the actual, not nominal, dimension.
- The average depth of ballast should be measured and recorded.
- Sketches of the underside of deck, on a span by span basis, are required with sizes and types of deteriorations noted.
- A good quality photograph of the deck that documents its overall condition and supports the condition rating should be included.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer should determine if the pattern, quantity and severity of the deteriorations found support the numerical condition ratings reported. The reviewer should compare the present inspection report to past reports.
- Low condition ratings, which are caused by extensive widespread deterioration, should be sufficient reason to request supplemental testing to provide a more in-depth evaluation of the condition of deck components and to determine whether rehabilitation or replacement is warranted.

Maintenance Concerns:

- Proper drainage should be maintained by removing any accumulations of sand or debris that might trap or hold water on the deck and promote decay.
- Any inspection bore holes created should be plugged.
- Loose or damaged planks should be repaired or replaced where possible. Also, loose or protruding hardware should be tightened, repaired or replaced.

Figure 6.1.3.1b: Underside of a Timber Ballasted Deck

6.1.3.2. Ballasted Concrete Decks

Inspection Requirements

Inspections:

- During inspection, report any unusual condition of any element of the rail and ties to the ConnDOT Office of Rail (Inspection of rail elements are done by Railroad personnel). Rail elements include the rail, spikes, tie plate, drive lags, guards and ties. In some situations a defect in the deck or main structure will result in unusual wear on the rail.
- Inspect the top of the deck, visually observing the condition of the top surface or overlay. Pay special attention to the condition of the ballast. Look for fouled ballast, excessive ballast, ballast leaks and evidence of poor drainage. These are all signs of possible issues with the ballast pan or floor. The entire top surface should be visually inspected.
- The underside of the deck should be inspected with sufficient lighting to detect cracks 1/32" wide and larger.
- Inspect the entire underside of the ballast slab, checking for signs of decay, weathering, and damage. Normally, observation of the decking during the course of the superstructure inspection will provide an adequate inspection distance.
- On the underside of the deck, all areas of suspected delamination and at least 10% of those areas showing cracking, scaling, wetness or staining shall be tapped with a hammer to determine soundness.
- For precast deck slabs, in addition to the normal concrete deck inspection, the deck panel anchorages and connections should be inspected (if possible).

Documentation for Routine Inspections:

- Note the size and location of cracks, spalls, delaminations, etc., along with any signs of efflorescence, rusting, leakage, etc. Where these cannot be simply described, a sketch shall be made showing the size and location of the deficiency.
- Deck notes should be organized in a "span by span" manner.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for routine inspections, "hands-on" access shall be provided to the entire underside of the deck and to all portions of bare concrete on the top of deck.
- Measure the depth of the ballast along each track on the bridge and determine the average ballast depth.

- On the underside of the deck, all areas of cracking, scaling, wetness or staining shall be sounded with a hammer. A random sampling of at least 25% of the areas showing no apparent signs of deterioration shall also be sounded using a frequency adequate to detect delaminations.
- For decks with metal stay in place forms, spot locations of heavily rusted forms may need to be removed to inspect the underlying concrete. It is not necessary to remove forms that show only minor deterioration.

Documentation for In-Depth Inspections:

- Sketches of the underside of the deck, on a "span by span" basis, are required with sizes and types of deteriorations noted.
- The average depth of ballast should be measured and recorded.
- A good quality photograph of the deck that documents its overall condition and supports the condition rating should be included.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer should determine if the pattern, quantity and severity of the deteriorations found support the numerical condition ratings reported. The reviewer should compare the present inspection report to past reports.
- Low condition ratings that are caused by extensive widespread deterioration should be reason to request supplemental testing to provide a more in-depth evaluation of the condition of deck components and to determine whether rehabilitation or replacement is warranted. The true condition of a ballasted bridge deck may not be apparent until removal of the ballast for rehabilitation.

Maintenance Concerns:

- Proper drainage should be maintained by removing any accumulations of sand or debris that might trap or hold water on the deck and promote decay.
- Repair of spalled areas on the underside of the deck is not normally necessary. At most locations, any loose or hollow concrete should be removed and the spalled area cleaned and coated with an appropriate material that will protect any exposed reinforcing steel and prevent further deterioration. Spalls that extend up past the bottom mat of reinforcing steel should be patched to cover the reinforcing steel.
- Beam haunches have shown a susceptibility to spalling. Loose haunch concrete, or any loose concrete, warrants immediate removal if it is located over areas of vehicular, navigation or pedestrian traffic.

Figure 6.1.3.2a: Typical Underside of Concrete Ballasted Deck

6.1.3.3. Ballasted Metal Decks

Inspection Requirements

Inspections:

- During inspection, report any unusual condition of any elements of the rail and ties to the ConnDOT Office of Rail (Inspection of rail elements are done by Railroad personnel). Rail elements include the rail, spikes, tie plate, drive lags, guards and ties. In some situations a defect in the deck or main structure will result in unusual wear on the rail.
- Inspect the top of deck visually observing the condition of the top surface or overlay. Pay attention to the condition of the ballast. Look for fouled ballast, excessive ballast, ballast leaks and evidence of poor drainage. These are all signs of possible issues with the ballast pan or floor. The entire top surface should be visually inspected.
- Inspect the entire underside of ballast pan, checking for signs of deterioration and damage.
- All areas suspected of deterioration or damage and all areas where water can be trapped should be observed "hands-on."
- At least 10% of the bearing areas and connections should be observed "hands-on." If this inspection reveals significant deteriorations, then additional "hands-on" inspection is required.

Documentation for Routine Inspections:

- Note the size and location of cracks. Where these cannot be simply described, a sketch shall be made showing the size and location of the deficiency.
- Deck notes should be organized in a "span by span" manner. Deck deficiencies should be located with sufficient detail to make correlation with the underside of the deck notes possible.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for routine inspections, "hands-on" access shall be provided to all deck bearing areas and connections.
- Measure the depth of the ballast along each track on the bridge and determine the average ballast depth.
- The thickness of the steel plate deck should be determined in several random locations and, in suspected areas of deterioration, from the underside with a D-Meter.
- An in-depth inspection of the deck surface should be performed whenever the ballast is removed for rehabilitation or replacement.

Documentation for In-Depth Inspections:

- The average depth of ballast should be measured and recorded.
- Sketches of the underside of the deck, on a span by span basis, are required with sizes and types of deteriorations noted.
- A good quality photograph of the deck that documents its overall condition and supports the condition rating should be included.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer should determine if the pattern, quantity and severity of the deteriorations found support the numerical condition ratings reported. The reviewer should compare the present inspection report to past reports.
- Low condition ratings that are caused by extensive widespread deterioration should be reason to request supplemental testing to provide a more in-depth evaluation of the condition of deck components and to determine whether rehabilitation or replacement is warranted. The true condition of a ballasted bridge deck may not be apparent until removal of the ballast for rehabilitation.
- If areas of severe rusting are noted that result in steel section loss, a structural evaluation may be warranted.

Maintenance Concerns:

- Proper drainage should be maintained by removing any accumulations of sand or debris that might trap or hold water on the deck and promote decay.
- Missing connections or broken attachments between the deck and the support system can permit deck "bouncing" under traffic and accelerate deterioration of the deck. Shimming, reattachment or other maintenance should be recommended. However, welding to support beams should not be undertaken without discussion with a Transportation Supervising Engineer.
- Fatigue cracks should be repaired to prevent crack propagation.
- Severely rusted areas of steel grid should have repair plates installed or be considered for replacement.

Figure 6.1.3.3a: Underside of Ballasted Metal Deck

6.1.3.4. Ballast Retainers

Ballast retainers are critical in maintaining the ballast section of a ballast deck bridge. Loss of the ballast retainer may lead to the undermining of the ballast shoulders and a decrease in track stability.

Inspection Requirements

Inspections:

- Inspect the ballast retainers for deterioration for each of the following materials:

Figure 6.1.3.4a: Steel Ballast Retainer

Timber: Check for fungus growth, parasite infestation, fire damage, weathering, warping, splitting, checking, crushed or displaced members and chemical damage. Check for adequate attachment to the deck.

Concrete: Inspect for cracked, scaled, spalled, delaminated, displaced, or crushed concrete.

Steel: Check for rust, section loss, cracks and loose, bent, or displaced members.

Stone Masonry: Inspect for crushed, spalled, weathered, chemically damaged, displaced, cracked stones, or lost joint mortar.

- Evaluate the ability of the ballast retainer to direct water runoff to the drainage system and determine if leakage occurs through the ballast retainer.
- Assess the buildup of ballast retained, note any overloading.

Documentation for Routine and In-Depth Inspections:

- Document any deterioration or deficiency found on the ballast retainers. These notes may be incorporated into the field notes for the deck. Documentation should include the size and relative location on the bridge for the noted deficiency and deterioration.
- Document the current condition of previously noted problems.
- Typical conditions as well as deteriorations causing a condition rating of less than or equal to “5”, should be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer should determine if the pattern, quantity and severity of the deteriorations found support the numerical condition ratings reported. The reviewer should compare the present inspection report to past reports.

Maintenance Concerns:

- Damaged or deteriorated ballast retainers warrant immediate repair if it is located over areas of vehicular, navigation or pedestrian traffic. This is required to prevent the loss of ballast from the bridge onto the surface bellow.
- Areas of built-up ballast at the retainers should be removed to avoid the loss of ballast onto the surface below.

6.1.4 Direct Fixation Decks

On a direct fixation deck, the rails are anchored directly to the main structure of the bridge.

Figure 6.1.4a: A Through Girder with a Directly Fixed Deck

Inspection Requirements

Inspections:

- During inspection, report any unusual condition of any element of the rail to the ConnDOT Office of Rail (Inspection of rail elements are done by Railroad personnel). Rail elements include the rail, spikes, tie plate, drive lags, guards and ties. In some situations a defect in the deck or main structure will result in unusual wear on the rail.

Documentation for Routine Inspections:

- Deck notes should be organized in a "span by span" manner.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.

A photograph shall be taken of those bridge components where the condition previously reported has changed.

6.1.5 Deck Joints

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 6
Reference: BIRM Section 5.4

The deck joints that are required to be inspected on Connecticut Railroad bridges are the joints between precast concrete beams. See Appendix A6.6.

Inspection Requirements

Inspections:

- Inspect all joints in accordance with BIRM, Section 5.4.
- All joint components should be inspected from the underside of the deck with adequate lighting to detect and defects. Any problem areas found will require closer inspection.
- Check all joints and supporting elements for deterioration due to cracks, excessive vibration, loose or missing mortar, etc. Remove sand and debris as required to properly inspect the joint and supporting elements.
- Check joints for loose, damaged or broken components. These may present hazards to the traveling public in the form of protrusions or loose debris that can damage vehicles or pedestrians.
- Check the joint for vertical displacement across the two halves of the joint in the direction of traffic.
- Check to see if joint sealant is in place and operating as designed or if there are signs of leakage through the joint or any other damage or deterioration. Also observe if water backs up around the joint on the deck due to the inadequacy or blockage of the primary drainage system.
- Inspect for any concrete deterioration adjacent to the joint supports or faces.
- Observe the joint when traffic passes over for excessive movement and deflection.

Documentation for Routine Inspections:

- Note any deterioration or deficiencies discovered during the inspection. Particularly note deterioration due to the infiltration of water through closed.
- Document all concrete losses by noting the area and depth of the loss as well as its relative location along the length of the joint measured from a fixed point.
- Document locations and lengths of all cracks found. Mark these locations on the joint with permanent marker or keel. Note the date found and the extent of the crack in such a manner that subsequent inspections may determine the extent of crack propagation.
- Particular care will be given to documenting any increased quantity or size of deteriorations that have changed since the last inspection. If the condition rating has changed from the last inspection, a photograph and explanation of why the rating has changed shall be included in the inspection report.
- Notes should be made describing the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to those requirements for a routine inspection, "hands on" access should be provided to the underside of all joint elements.
- Check for any signs that the deck joint may not be securely anchored to the superstructure or deck (deteriorated concrete).

Documentation for In-Depth Inspections:

- All documentation required for a routine inspection will be included in the in-depth documentation except as noted in this section.
- Documentation, as a whole, should clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph of the deck joint, that documents the overall condition as well as detail photographs of any deterioration, shall be provided.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- The inspection reviewer should determine if patterns of deterioration or progressive deterioration are taking place. Progression will be determined by comparing present to past inspection reports.

Maintenance Concerns

- Although the condition of the joints is not directly incorporated into the condition rating of the deck, superstructure and substructure, their condition and ability to perform their designed function can influence those ratings. Leaking or improperly draining joints can lead to excessive corrosion of the superstructure and bearings, or deterioration of the substructure below. Therefore, routine maintenance should be requested as necessary, to address deck joint problems, and prevent the need for major rehabilitation in the future.
- Routine maintenance should be requested as necessary to clear deck joints of debris, repair or patch waterproofing seals, replace or tighten fasteners and repair deteriorated concrete.

6.1.6 Walkways

Reference: BIRM, Section 5.1 thru 5.5

Inspection Requirements

Inspection:

- Inspect walkways in accordance with BIRM Section 5.1 thru 5.5.
- Walk the full length of the walkway.
- The condition of elements supporting the walkway should be documented as part of the walkway inspection.
- Note deterioration or decay of the decking material.

Documentation for Routine Inspections:

- Document deteriorations and deficiencies found on the walkways. These notes may be recorded directly on the BRI-18 or be incorporated into any sketches prepared as part of the top of deck inspection.
- Detail sketches shall be provided as necessary to adequately describe the deterioration or deficiencies noted.
- Document the current condition of all previously noted problems.
- Typical conditions as well as deteriorations causing a condition rating of less than or equal to "5", should be photographed as outlined in Chapter 5. If typical conditions are documented in the top of deck photo, this will be considered adequate for this purpose.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for routine inspections, “hands on” access shall be provided to the entire walkway.
- Bare concrete sidewalks should be sounded or chain dragged at an interval sufficient to detect delaminations greater than 1 foot in diameter.
- Timber sidewalks should be sounded, or probed with an ice pick to locate interior deteriorations.

Documentation for In-Depth Inspections:

- All documentation required for routine inspections shall be required for in-depth inspections. Sketches of the top and underside condition of walkways shall be included with the deck sketches.
- A good quality photograph of the walkway that documents the overall condition and supports the condition rating shall be provided.

Maintenance Concerns:

- Walkway deteriorations that present a safety hazard to users should be recommended for repair.
- Debris should be removed from the walkway to prevent standing water.

Figure 6.1.6a: Fiberglass Grate sidewalk

6.1.7 Bridge Railings

Reference: BIRM, Section 5.5

Railings will be defined as any barrier along the curb or along the fascia, constructed of timber, steel, aluminum or other metal, that is designed to function as a pedestrian barrier.

Inspection Requirements

Inspection:

- Inspect all railings in accordance with BIRM, Section 5.5.
- All rail components should be inspected for deficiencies. All problem areas shall be inspected "hands-on."
- Inspect components of the railing system for cracks, scaling, spalls, rust, section loss, loose or broken fasteners, cracked welds, parasite infestation, weathering, splitting, checking, impact damage or other deterioration.
- Inspect railing components for impact damage, missing components or displacement that present exposed, blunt ends or snagging hazards to passing vehicles and/or pedestrians.
- Observe rail post anchorages to determine if the railing is securely fastened to the deck or parapet.
- Inspect railing expansion joint devices or end treatments to see if they are in place and functioning properly. Note whether expansion joint or end treatment components are missing, exposing the blunt ends of the railing on either side of the joint.
- If accumulated snow, ice or sand obscure a significant portion of the railing or rail anchorage (more than approximately 30% of its length), this should be noted along with the condition of the visible portion. A supplement to the inspection report, describing the condition of the covered areas, will be required when the snow/ice has melted or the sand has been removed.

Documentation for Routine Inspections:

- Document deterioration or deficiencies found on the railings. These notes may be recorded directly on the BRI-18 form or be incorporated into the sketches made as part of the top of deck inspection. Documentation should include the size and relative location along the bridge of noted deficiencies.
- Document the condition of railing expansion joint devices and end treatments, and whether or not the joint opening appears appropriate for the ambient temperature.
- Detailed sketches may be provided, as required, to adequately describe the deterioration or deficiency noted.
- Document the current condition of all previously noted problems.
- Typical conditions as well as deteriorations causing a condition rating of less than or equal to "5", should be photographed as outlined in Chapter 5. If typical conditions are documented in the top of deck photo, this will be adequate for this purpose.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for a routine inspection, "hands-on" inspection should be provided to all railing elements.
- A random sampling of approximately 50% of rail post anchor bolts should be hammer tapped to determine if they are sound.

Documentation for In-Depth Inspection:

- All documentation required for routine inspection will be required for in-depth inspection.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive in their documentation.
- Review the inspection findings to determine if any deficiencies or deteriorations exist that present a safety hazard to users.

Maintenance Concerns

- Areas of severe deterioration, impact damage or impact displacement that diminish or negate the ability of the railing to achieve its design function should be repaired or replaced immediately.

Figure 6.1.7a: Decorative Fence along bridge walkway

6.1.8 Drainage Systems

Reference: BIRM, Section 5.4

Working drainage systems are important to the longevity of a structure. Inadequate drainage can accelerate deterioration of bridge elements exposed to water and cause structural damage.

It is advantageous to inspect bridge drainage systems during periods of rain or snow melt.

Inspection Requirements

Inspections:

- Inspect the drainage system in accordance BIRM, Section 5.4.
- All visible drainage system components shall be inspected. Use adequate lighting to detect corrosion, impacted rust, section loss, cracks, dings, gouges, impact damage, missing components, and other defects. Any problem areas found shall be inspected "hands-on".
- Evaluate the ability of the drainage system to effectively channel runoff away from the deck, superstructure, and substructure. Signs of an ineffective drainage system include deterioration around drainage components, water staining, and debris buildup.
- Inspect deck drains for clogging or sediment buildup. Note any vegetation growth in the drain.
- Inspect the downspouts or outlet pipes. Evaluate their effectiveness at directing water away from the structure.
- Inspect drainage troughs for debris buildup, section loss, perforations, and other deterioration. Evaluate the trough's overall effectiveness at directing water runoff to the drainage system.
- Drainage troughs under deck joints are to be inspected and rated as part of the drainage system.

Documentation for Routine Inspections:

- Note any deterioration or deficiency discovered during the inspection.
- Evaluate the drainage system's effectiveness as a whole.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements of the routine inspection, "hands-on" access shall be provided to the entire drainage system.

Documentation for In-Depth Inspections:

- All documentation required for the routine inspection shall be included in the in-depth documentation.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes, and photographs to ensure they are mutually supportive of their documentation.
- The inspection reviewer should determine if hazards exist to traffic both on the structure (due to ponding, etc.) and below the structure (due to falling water, etc.). Recommendations to correct these deficiencies should be included in the railroad Maintenance Memo (RMM).

Maintenance Concerns:

- Water leaking through faulty drainage can cause damage or injury to vehicles and pedestrians passing below the structure and should be considered during maintenance operations.
- Properly designed drainage systems that are prone to clogging should be scheduled for routine cleaning. Outdated or inadequate drainage systems that regularly clog should be recommended for redesign and replacement.

Figure 6.1.8a: A deck wheephole blocked by a piece of timber

6.1.9 Lighting and Utilities

Reference: BIRM, Section 5.4

Inspection Requirements

Inspection:

Lighting:

- Inspect lighting devices in accordance with BIRM, Section 5.4.
- Verify that lighting devices are operating properly and are in compliance with current ConnDOT standards and applicable U.S. Coastguard, Federal Aviation Administration (FAA), and U.S. Army Corps of Engineers guidelines and regulations.
- Aerial obstruction lights, or navigation lights that are not operational should be immediately reported in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in the Section 3.2.7 of this manual.
- Inspect all lighting devices for exposed wires and electrical shock danger.

Utilities:

- Visually inspect the grounding conductors (wire) of the grounding and bounding system.
- Visually inspect all grounding connections for proper connection.
- All utilities and utility supports shall be visually inspected, including grounding conductors (wires) for grounding and bonding railroad bridges.
- Inspect the utilities for cracks, breaks, sags, rust, deteriorated insulation and other deterioration.
- If pier or abutment settlement has occurred, look for adverse effects on the utility and utility supports.
- Note if the utilities reduce the vertical clearance or free board of the bridge.
- Inspect all utilities for any evidence of leakage. Inspect valves and drains. Where gas lines are carried on a bridge, the smell of gas should be considered evidence of leakage and a potential hazard. If an odor of gas is present, the inspector should immediately notify the Office of Rail in accordance with the Critical Deficiency Reporting/Emergency Response procedure outlined in the Section 3.2.7 of this manual.
- Visually inspect all electrical utilities for loose wires or poor insulation that might present a shock hazard.
- Visually inspect junction boxes. Note whether or not covers are in place and secure.
- Check the utilities for excessive vibration. If excessive vibration is noted, inspect the utilities and support connections for fatigue damage.
- Visually inspect the utilities for damage caused by lack of thermal expansion and contraction due to malfunctioning expansion devices.

Documentation for Routine Inspection:

- Document the location of all inoperable lighting devices.
- Describe deteriorations and/or deficiencies noted on utilities, lighting devices and/or support device components.
- Note if the condition of the lighting system appears to be in compliance with current ConnDOT, FAA, USCG, and USACOE specifications, standards and regulations as applicable.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- All the same requirements for routine inspections shall be inspected in the in-depth inspection.

Documentation for In-Depth Inspections:

- All documentation required for routine inspections shall be included in the in-depth inspection documentation.
- A good quality photograph that documents the overall condition and supports the condition rating of the lighting system or utility shall be provided.

Report Review:

- Review the inspection report and field notes for documentation of lighting devices that are inoperable or present hazardous conditions to traffic. Ensure that the procedures for "Critical Deficiency Reporting" have been followed, if applicable.
- Review the field notes for evidence that lighting systems are in compliance with current ConnDOT standards, Federal guidelines and/or USCG, FAA and USACOE regulations. Devices or systems that do not comply with applicable regulations should be documented as to the specific causes for noncompliance.
- Review the inspection findings for evidence of utility leakage or unsafe conditions. If leakage or serious deteriorations are noted, ensure that the responsible utility company or department is notified. If unsafe conditions were found, ensure that the procedures for "Critical Deficiency Reporting" have been followed.
- Review the inspection report for changes in vertical clearance or freeboard due to utilities. If any changes are noted, verify that the field measured vertical clearance is still within the limits of the current posting (if posted) or still meets the ConnDOT standards for exemption from posting (if not posted).

- Review the inspection field notes for evidence of malfunctioning utility expansion joint devices. If expansion joint devices are not functioning the utility owner should be notified.

Figure 6.1.9a: Typical Bridge Utility Installation

Maintenance Concerns:

- It is important for the safety of pedestrian, highway, air and waterway traffic that damaged, deteriorated or inoperable lighting devices are repaired or replaced and obstructed lights be moved or cleared of obstructions so adequate visibility is maintained.
- Lighting systems that do not comply with current standards, guidelines or regulations should be upgraded as required. Maintenance will be responsible for evaluating lighting systems.
- Utility owners should be made aware of deficiencies to correct unsafe conditions, prevent unnecessary bridge deterioration and to avoid utility service outages.

6.2. SUPERSTRUCTURE INSPECTION

6.2.1 Bearings

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 9
Reference: BIRM, Section 9

Bearings are designed to resist longitudinal braking and traction forces, wind, and other forces besides the dead load and live load of the span. Fixed bearings must be able to resist longitudinal forces while the expansion bearings must be able to resist transverse forces.

Some bearings have no inherent resistance to lateral movement and require separate lateral restraint to transmit lateral forces from the superstructure to the foundation. Similarly, some bearings have no inherent resistance to uplift and require separate hold down devices to prevent uplift or separation during earthquakes.

For a simple span, bearings at one end will be fixed or stationary bearings with expansion accommodating bearings at the other end. Some exceptions may be noted on short spans such as those atop towers or piers where both ends are fixed.

In the field, the inspector is going to see several different bearing types. The overall appearance of the bearings for a span will be somewhat similar, i.e., if flat plates are used at one end, flat plats will be used at the other end, with the only difference being for the accommodation of thermal movement. The bearings that are common on Railroad brides are as follows:

Fixed Bearings	Expansion Bearings
Fixed Position Sole Plate	Sliding Plates
Fixed Shoes	Cylindrical rollers (nested)
Bolsters	Segmental rollers (nested)
(See Figure 6.2.1b)	Rockers
	Pot Bearings
	Rubber/Neoprene Bearings
	(See Figure 6.2.1a)

See Figures 6.2.1G thru 6.2.1V for photos of bearings

The most common bearing on Connecticut Railroad Bridges is a Plate Type Bearing. Review the **AREMA Bridge inspection Handbook**, Chapter 9, Section 3 for further information on the different types of bearings and their common defects.

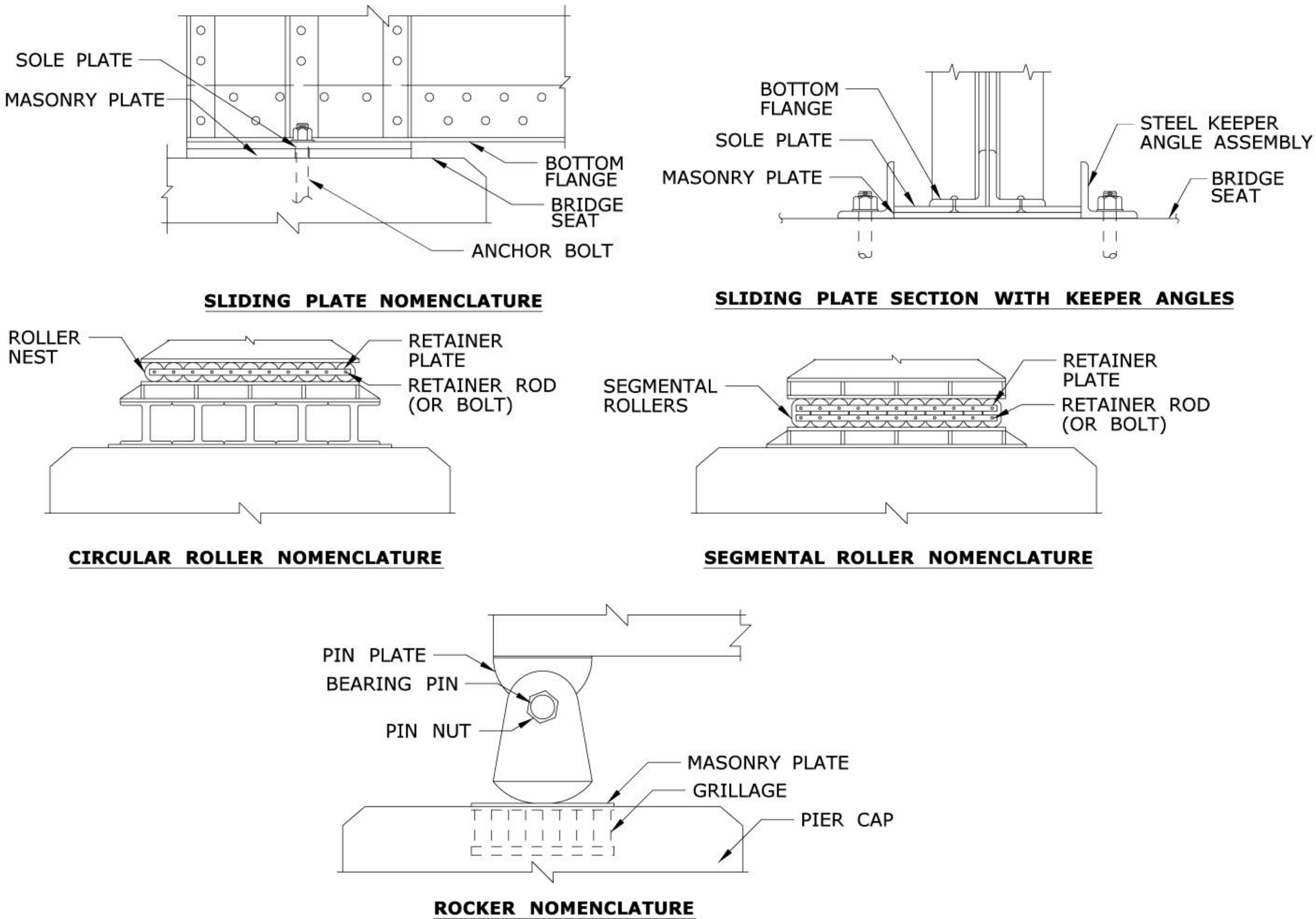


Figure 6.2.1a: Expansion Bearings

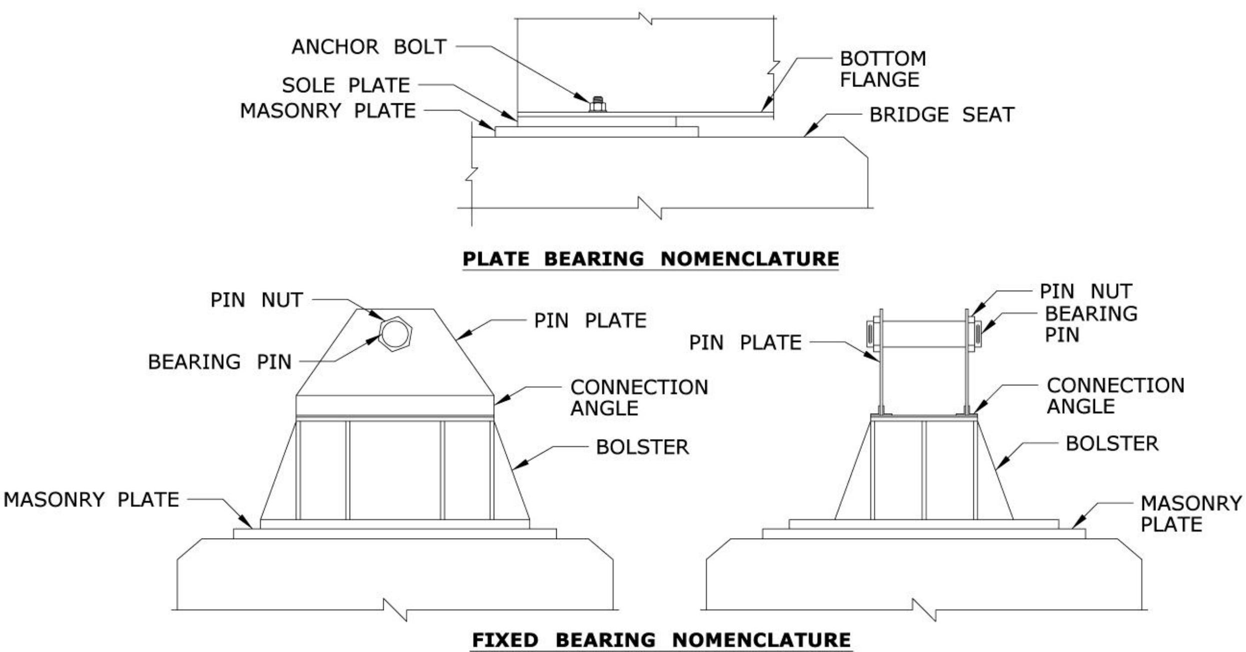


Figure 6.2.1b: Fixed Bearings

Inspection Requirements

Fixed bearings should be examined for their ability to function as designed. The plates, rockers, grillage and anchor bolts should be evaluated as a system for their ability to continue transmitting loads from the superstructure to the substructure.

In addition to the criteria mentioned for fixed bearings, functioning expansion bearings need to allow movement. In general, the longer the span, the more important the ability to allow movement becomes. Frozen (malfunctioning) expansion bearings do not allow the superstructure to move as intended, and can cause large and unwanted forces to be transmitted into the substructure.

Inspections:

- Inspect all bearings in accordance with BIRM, Section 9.
- Bearing areas must be cleaned, as necessary, to permit an adequate inspection of the bearings.
- Check that the bearing is free of debris and corrosion, that it is uniformly supported on base material, that the anchor bolts and nuts are present without section loss and the anchor nut is tight to bearing, the central bearing pin is not deteriorated and will allow for span deflection/rotation and the fasteners to the superstructure are present without section loss and tight.
- A random sampling (approximately 25%) of the bearing anchor bolts should be tapped with a hammer to determine if they are intact and solidly anchored to the substructure. The frequency of sampling should be increased if defective bolts are found.
- A random sampling (approximately 25%) of the bearings shall be observed for pumping under live load.
- For expansion bearings check that they have unrestricted lateral movement, that their position is correct given the temperature and that a keeper system is in place.
- "Hands-on" inspection of all bearings will be required to determine if expansion bearings are operating as intended. Bearings and surrounding areas must be clean for "hands-on" inspection.
- Check the connection of the bottom flange to the sole plate. Inspect for cracked welds.
- A random sampling (approximately 25%) of the bearing joints should be measured. The distance between the end of the beam and the backwall or the joint between a non continuous beam shall be recorded. Section 6.2.1.1 describes joint measurements.
- Measurements of steel expansion bearings will be required to complete the bearing measurement forms. Typically, the fascia beam bearings and one beam near the center of the bridge should be measured in each span. Measurements will not be required for spans under 50'.

Documentation for Routine Inspections:

- The condition of fixed bearings and expansion bearings may be described on the inspection forms or framing plans. Special or unusual problems should be sketched.
- Any pumping of the bearings under live load should be measured and noted on the framing plans.
- Unsupported bearings shall be recorded with any special or unusual problems being sketched.
- Record any bottom flange/sole plate weld cracks on the framing plan.
- Expansion bearing conditions may be described directly on the BRI-18 form unless the bearings have a condition rating of “5” or less. When the bearings are rated “5” or less, and the span length is greater than 50’, the measurements shown in, Figure 6.2.1d, Figure 6.2.1e or Figure 6.2.1f shall be taken at the fascia beam bearings and at least one additional bearing near the center of the bridge. Also, any bearing that appears “frozen” should be measured.
- Frozen bearings and typical conditions and deteriorations causing a condition rating of less than or equal to “5” shall be photographed as outlined in Chapter 5.
- A random sampling (approximately 25%) of the bearing joints should be measured. The distance between the end of the beam and the backwall or the joint between a non continuous beam shall be recorded. Section 6.2.1.1 describes joint measurements.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- All bearing anchor bolts will be tapped with a hammer to determine if they are firmly anchored to the substructure.
- The bearings shall be observed for pumping under live load.

Documentation for In-Depth Inspections:

- In addition to the documentation required for routine inspections, bearing measurement forms will be completed for steel expansion bearings.
- Any pumping of the bearings under live load shall be noted and measured.

Report Review:

- Expansion bearing measurements should be compared to those in the previous report. Comparison of bearing measurements could identify malfunctioning bearings.

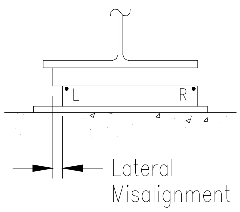
Maintenance Concerns:

- If the inspector discovers a bridge condition that affects the integrity of the bridge under train loads, the inspector should immediately notify the Office of Rail in accordance with the Critical Deficiency Reporting/Emergency Response procedure outlined in Section 3.2.7 of this manual to halt all train traffic and arrange for immediate repairs.
- Bearings must be clean to function properly. Debris on a bridge seat that interferes with a bearing's movement or holds moisture around the bearing should be removed.
- Frozen bearings can develop irregularities along their movement surfaces that cause mechanical binding and prevent movement. As a result, cleaning rarely fixes a frozen bearing.
- When a large number of bearings appear to be frozen, replacement of the bearings should be considered. However, thermal movement in bridge spans less than 100' may be accommodated in the superstructure and, If there are no signs of distress, replacement of frozen bearings in spans less than 100' may not be justified.

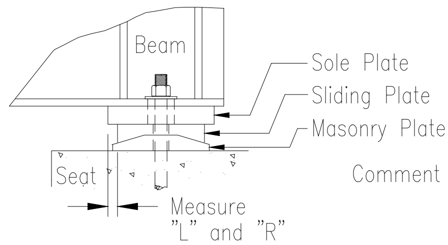
FIELD NOTES	BRIDGE NO.	DATE:
	CREW:	SHEET

SLIDING BEARING MEASUREMENTS

Form BRI-14, Rev. 9/01



FRONT VIEW



SIDE VIEW

Span No. = ______

Substructure Unit = ____________________

Temperature = _____°F

Comment On:
- Presence of keepers or work done on bearings.
- Undermining of bearing. Attach sketch with dimensions.
- Cracking of plates or welds.
- Condition of anchor bolts.

Beam	Movement				Condition			Comments
	"L"	"R"	Mode Exp. or Contr.	Lateral Misalign.	Bearing Frozen?	Normal Mov't?	Rust ? H/M/L	

Figure 6.2.1d: Sliding Bearing Measurement Form

FIELD NOTES	BRIDGE NO.	DATE:
	CREW:	SHEET

ROCKER BEARING MEASUREMENTS

Form BRI-15, Rev. 9/97

Span No. = ______

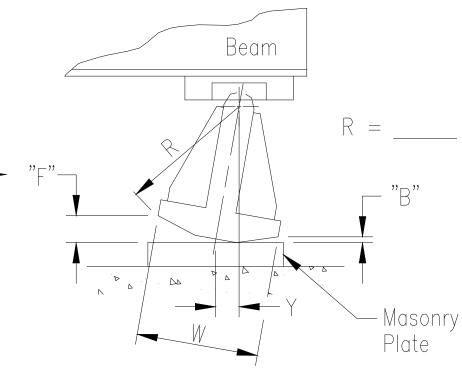
Substructure Unit = ________________________

Temperature = _____°F

$\theta = \sin^{-1}(F-B)/W$

$Y = R \tan \theta$

The "Front" of the bearing is the side facing the fixed bearing.



R = ______

W = ______

NOTE:

"F" & "B" should be measured at the left side corners of the rocker or on the side closest to to the front face of the substructure on skewed bridges.

Beam	"F"	"B"	Y	Cont. or Exp.	Comments

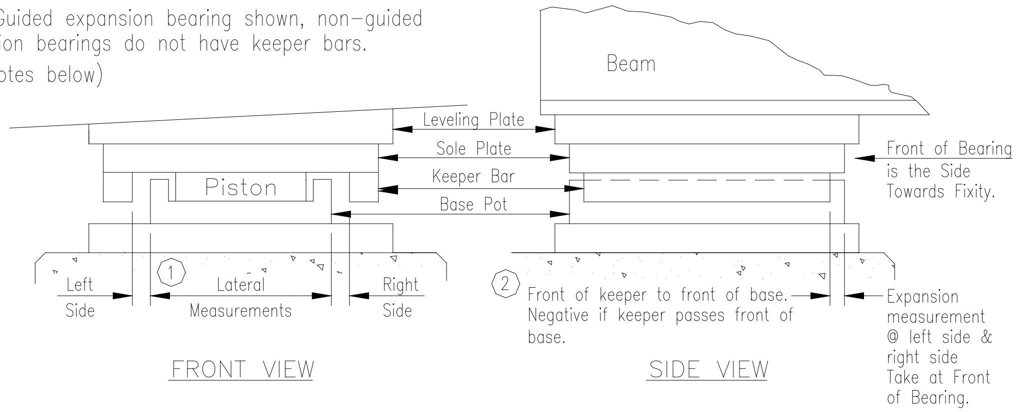
Figure 6.2.1e: Rocker Bearing Measurement Form

FIELD NOTES	BRIDGE NO.	DATE:
	CREW:	SHEET

POT BEARING MEASUREMENTS

Form BRI-16, Rev. 9/97

Note: Guided expansion bearing shown, non-guided expansion bearings do not have keeper bars.
(see notes below)



(1) -Left & Right are determined when facing the Front of the Bearing.
-For non-guided bearings, measure from side of sole plate to side of piston @ center line of piston.

(2) -For non-guided bearings, measure expansion from front of sole plate to front of piston @ center line of bearing.

Span No. & Substructure Unit = ______________________ Temperature = ____°F

Beam	Expansion			Lateral		Comments
	Exp. Measurement		Side of Brg.	Left	Right	
	L	R	(N,S,E,W)			

Figure 6.2.1f – Pot Bearing Measurement Form

Figure 6.2.1g - Fixed pin bearing with bolster

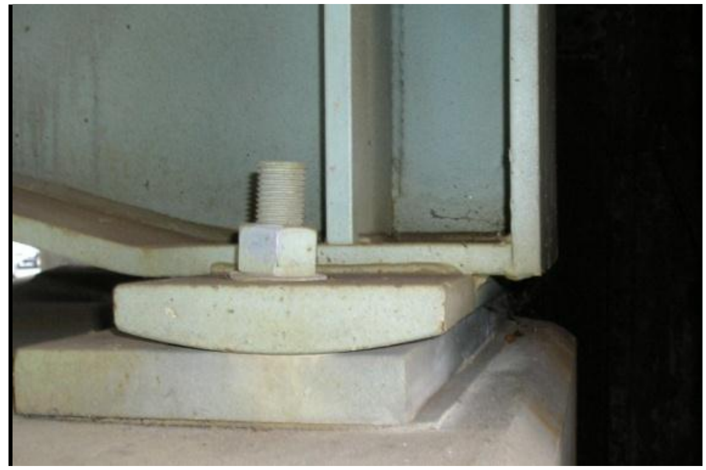


Figure 6.2.1h - Fixed rocker bearing

Figure 6.2.1i - Fixed plate bearing

Figure 6.2.1j - Expansion sliding plate bearing

Figure 6.2.1k - Expansion sliding plate bearing

Figure 6.2.1l - Expansion elastomeric bearing

Figure 6.2.1m - Expansion roller bearing

Figure 6.2.1n - Fixed bearing on top of a pier cap

Figure 6.2.1o - Fixed bearing on top of a pier column

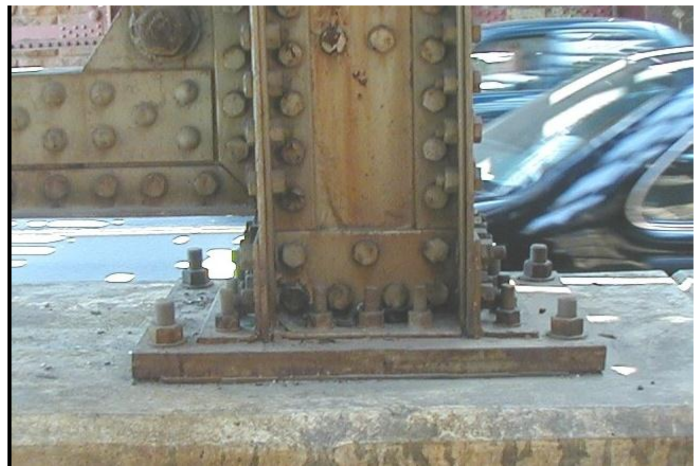


Figure 6.2.1p - Typical pier column bearing

Figure 6.2.1q - Bearing with sole plate no longer in contact with masonry plate, needs to be shimmed and grouted

Figure 6.2.1r - Bearing worn into the bridge seat, needs to be shimmed and grouted

Figure 6.2.1s - Bearing shimmed and prepped for grouting

Figure 6.2.1t - Shimmed and grouted bearing

Figure 6.2.1u - Expansion bearing with deteriorated anchor bolt, replaced with steel angle keeper system

Figure 6.2.1v - Expansion bearing with cracked bottom flange to sole plate weld

6.2.1.1. Joint Measurements

Measuring the joint between the end of the beam and the backwall or the joint between non continuous beams, and comparing the measurement to others taken at the same location at different temperatures, provides a quick and easy method of determining whether the superstructure bearings are responding (as intended or otherwise) to changes in temperature and allowing movement of the superstructure. Measurements that show a predictable change based on a known temperature difference, give confidence that bearing devices are functioning to permit superstructure expansion/contraction.

Joint opening measurements will be taken at every inspection and the temperatures at the time of the measurements recorded. At structures where the operation of the bearing devices is in question, additional measurements at a more frequent interval, may be required at different extremes in temperature. All measurements will be taken to the nearest 1/16" and recorded using the form shown in Figure 6.2.1.1b. For Railroad Bridges, record the beam designation were the measurement was taken in the deck joint location column.

The joint opening to be recorded will be the perpendicular opening at the joint, measured at a point approximately 6" up from the top of the bottom flange. The location where the measurement is taken should be marked with a chisel and a small spot of orange paint. Figure 6.2.1.1a illustrates how the measurement is taken at various configurations.

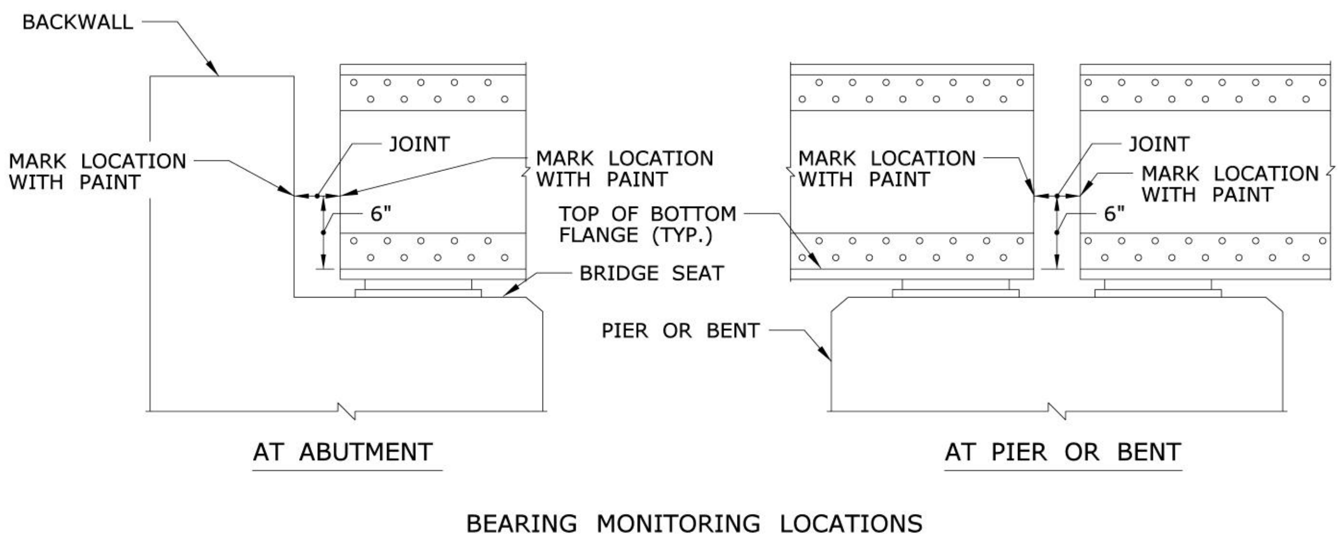


Figure 6.2.1.1a

JOINT MEASUREMENT

Form BRI-17, Rev 6/99

Bridge #: Location: Town 0f:

Deck Joint Location	Deck Joint Type	Effect Span (ft.)	Winter Measurement			Summer Measurement			Differential Movements			Comment	Difference between Actual & Calc. Movements	
			TEMP	Date..		TEMP	Date..		Actual		by			
			deg	Left (in)	Right (in)	deg	Left (in)	Right (in)	Left	Right	Formula		Left (in)	Right (in)
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0
									0	0	0		0	0

* Note: Place the higher temperature measurements to the right side of the table.
A negative differential movement indicates possible abnormal movement.
The "Effective Span" is the length contributing to expansion at the joint. This should be 0 at fixed joints.

Figure – 6.2.1.1b: Joint Measurement Form

6.2.2 Concrete Superstructures

6.2.2.1. Reinforced Concrete Slabs

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 6, CHAPTER 8
Reference: BIRM, Section 2.2, 7.1 and 13.2.

Inspection Requirements

Inspections:

- Inspect the slab in accordance with BIRM, Section 7.1.
- The underside of the slab should be viewed using adequate lighting to detect cracks 1/32" wide and larger.
- All areas of suspected delamination and at least 25% of those areas on the bottom of the slab showing cracking, scaling, wetness or staining shall be tapped with a hammer to determine soundness.
- The ends of cracks that are 1/8" wide or larger and any cracks that appear to be tension or shear cracks shall have their ends marked with a permanent marker or chisel mark and spot of paint so that extension may be monitored on subsequent inspections.

Documentation for Routine Inspections:

- The size and location of cracks, spalls, delaminations, etc., shall be noted. Where these cannot be simply described, a sketch of the slab underside shall be made that shows the size, location and orientation of deficiencies found. Cracks with rust staining should be documented as such, since they may be indicative of leakage through the slab and deterioration of the reinforcing steel. Spalls that expose reinforcing steel should be specifically noted and any deterioration or section loss on the exposed steel documented.
- Particular care shall be paid to document increased quantity or size of deteriorations that have changed since the last inspection. If the condition rating has changed from the last, a photograph or explanation of why the rating has changed should be included.
- Notes should be made describing the current condition of any previously discovered item that was being monitored.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for routine inspections, "hands-on" access shall be provided to the entire slab underside.
- All areas of cracking, scaling, wetness or staining shall be sounded with a hammer. A random sampling of at least 50% of the areas showing no apparent signs of deterioration shall be sounded using a frequency adequate to detect deficiencies.

Documentation for In-Depth Inspections:

- A sketch of the underside of the slab depicting all deteriorations found is required.
- A good quality photograph of the underside of the slab that documents its overall condition and supports the condition rating shall be included.

Report Review:

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer should determine if patterns of deterioration or progressive deterioration is taking place. Progression will be determined by comparing present to past inspection reports.
- The sudden or progressive appearance of flexure or shear cracks may indicate the need for a new structural evaluation and/or posting of the bridge structure for a weight restriction.
- Low condition ratings, which are caused by extensive widespread deterioration, should be reason to request supplemental testing to better determine the condition of the slab and whether rehabilitation or replacement is warranted.

Maintenance Concerns:

- Due to the difficulty inherent with overhead concrete patching and the non-structural nature of the bottom surface concrete in typical simple span slabs, repair of spalled areas on the undersides of slabs is not normally necessary, except in slab bearing areas. At most locations, loose or hollow concrete should be removed and the spalled area cleaned and coated with an appropriate material that will protect exposed reinforcing steel and prevent further deterioration.
- Waterproofing methods can be the best way to prevent or slow the deterioration of reinforced concrete members. Care must be taken, in the application of waterproofing systems, to ensure that they are not applied in such a way as to prevent existing moisture in the slab from exiting.

Figure 6.2.2.1a: Typical Concrete Slab Bridge

6.2.2.2. Prestressed and Post Tensioned Concrete Superstructures

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 8
Reference: BIRM, Sections 2.2 and 7.8 Thru 7.10

Inspection Requirements

Inspections:

- Inspect the superstructure in accordance with BIRM, Sections 7.8 Thru 7.10.
- Bearing areas, and anchorages should be viewed using adequate lighting to detect hairline cracks. The remainder of the superstructure should be viewed from as close as practical, using binoculars, where appropriate, with adequate lighting to detect cracks 1/32" and larger. See Appendix A6.4.
- All areas of suspected delamination, scale, cracks with efflorescence, wetness, rust staining, and cracks 1/32" and larger, shall be tapped with a hammer to determine soundness. Cracks less than 1/32" shall be tapped with a hammer at sufficient intervals to detect patterns of delamination.
- The ends of cracks greater than 1/32" shall have their ends marked with a chisel or permanent marker so that extension may be monitored on subsequent inspections. Cracks, that were found and marked on previous inspections, shall be checked for extension beyond the previous end mark. If extension is noted, the new end of the crack should be marked and the amount of extension noted in the inspection report.
- The interiors of box beams/girders should be inspected whenever possible. Documentation/monitoring of deterioration/cracking will be done primarily from the interior of the boxes. Inspection of the interiors of box beams requires additional safety precautions. Refer to the section on inspection of steel box girders for comments on safety.

Documentation for Routine Inspections:

- The size and location of cracks, spalls, delaminations, etc., shall be noted. Where these cannot be simply described, a sketch of the superstructure element shall be made that shows the size, location, and orientation of deficiencies found.
- Flexure and shear cracks larger than 1/32" shall be measured and accurately located. Smaller, nonstructural cracks need not be measured, but their general size, length, direction, location, and quantity should be noted in the inspection report. Where cracking is extensive, the amount of documentation required should be discussed with the Office of Rail's Transportation Supervising Engineer.
- Particular care shall be paid to documenting increased quantity or size of deteriorations that have changed since the last inspection. If the condition rating has changed from the last inspection (up or down), a photograph and explanation of why the rating has changed should be included.
- Notes should be made describing the current condition of any item previously discovered and noted for monitoring.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for routine inspections, "hands-on" access shall be provided to the entire superstructure.
- All areas of suspected delamination, scale, cracking, and a random sampling of at least 25% of the areas (showing no apparent signs of deterioration) shall be sounded to locate delaminations using a frequency adequate to detect deficiencies.

Documentation for In-Depth Inspections:

- A simple framing plan shall be drawn or a copy of the plans made and all deficiencies referenced to that framing plan. All deterioration shall be sketched noting the size, length, direction, depth, etc., of deterioration. If the deterioration is limited, placing the information on the framing plan will usually be sufficient, however, in most cases sketches of individual members that show all exposed faces will be required.
- In some cases the quantity of cracks will preclude measurement and documentation of all cracks within a reasonable length of time. In this case, it is important that the significant cracks and deterioration are fully documented, and that the pattern and quantity of other deterioration is noted.
- The notes as a whole should clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph of the superstructure that documents its overall condition and supports the condition rating shall be included.

Report Review:

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection reviewer should determine if patterns of deterioration or progressive deterioration is taking place. Progression will be determined by comparing present to past inspection reports.
- The sudden or progressive appearance of flexure or shear cracks may indicate the need for a new load rating analysis and/or posting of the bridge structure for a weight restriction.

Maintenance Concerns:

- Repairs to prestressed concrete members will generally be structural in nature and may have an effect on their load carrying capacity. Repairs should be detailed and performed under the direction of a Transportation Supervising engineer. Only very loose concrete, that is in danger of falling onto traffic, should be removed with a light (less than 15 pound) jackhammer prior to consultation with the Transportation Supervising engineer. <u>At no time should drilling or the use of powder actuated fasteners be permitted on prestressed members.</u>
- Certain structural cracks may be repaired using chemical repair techniques. Engineering judgement and discussion with the Transportation Supervising Engineer are required for specific applications.

6.2.2.3. Concrete Encased Steel Deck Beams

Reference: AREMA Bridge Inspection Handbook© Chapter 8
Reference: BIRM, Sections 2.2, 7.1, 8.2, 13.2, and 13.3

This is a railroad specific precast beam made up of multiple built up steel beams encased in concrete. The deck units are placed side by side, grouted and then post tensioned together.

Inspection Requirements

Inspections:

- Inspect the superstructure in accordance with BIRM, Sections 7.1 and 8.2.
- The entire superstructure will be inspected using adequate lighting to detect corrosion, impacted rust, section loss, cracks, dings, gouges, impact damage and other defects. Particular emphasis will be placed on areas of maximum moment (midspan) and bearing areas.
- Suspect areas shall be inspected "hands-on" to determine the extent of deterioration or deficiency.
- Areas of heavy rusting shall be inspected "hands-on" to establish the depth of any section loss. Rust scale or "laminated rust" shall be removed with chipping hammers, scrapers or wire brushes, as necessary, in order to measure the minimum remaining thickness of steel or maximum depth of section loss. This will be most critical on beam flanges in high moment areas. Refer to the procedures in Appendix A6.2 for documenting steel section losses.
- Impact damaged areas should be inspected "hands-on" for the presence of tears or cracks.
- Any suspected crack should undergo Nondestructive Testing (NDT) to confirm its existence and determine the extent of the crack. All confirmed fatigue cracks shall be immediately reported in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 3.2.7.
- When defects are found in a particular detail or location on a member, all other similar details or member locations need to be inspected "hands on" for similar defects.
- Inspect tension zones for deteriorating concrete (delaminations, spalls, and cracks with efflorescence, etc), which could cause debonding of the tension reinforcement.
- The tension areas should be examined for flexure cracks. Check for flexure cracks on the bottom of the beam stem near mid-span and, for continuous spans, in the top of the beam stem near the intermediate supports (See Appendix A6.4 for typical locations).
- Check longitudinal beam joints for signs of active leaks.
- Inspect for spalled, missing or delaminated concrete at the edges of the steel bottom flanges.
- Examine repaired areas to determine if repair materials are in place and functioning as designed. Hammer tap patched areas to determine if the patch is sound and adhering to the base material.

Documentation for Routine Inspections:

- A simple framing plan shall be provided showing locations of deteriorations and other noted problems. Elevations, cross sections and other detail sketches shall be drawn, as required, to clearly show the locations and extent of noted deterioration, spalled and missing concrete and active leaks.
- Particular care shall be paid to documenting increased quantity or size of deteriorations that have changed since the last inspection. If the condition rating has changed from the last inspection (up or down), a photograph and explanation of why the rating has changed should be included.
- Note the extent and severity of all rusting. Significant loss, whether from past or current rusting, should be noted in sufficient detail for a load rating analysis to be performed. Engineering judgment is required in the field to determine the significance of areas with loss but, as a guideline, specific notes are required when greater than 15% (typically 1/8") of the flange thickness is lost in areas of high moment.
- Less significant losses (typically <1/8") should be noted, but exact measurements are not required.
- Document steel losses by noting the area and depth of the loss as well as its relative location along the length of the beam, measured from a fixed point (e.g. 12" H x 12" W x 1/8" deep loss on girder web at the bottom flange, beginning 3' from the west bearing on girder G1). Whenever possible, where deterioration is noted, a D meter shall be used to measure the remaining section instead of estimating the loss. Notes should clearly indicate whether an "estimated loss" or "measured remaining thickness" is being given. See Appendix A6.2 for typical examples of documenting steel section loss.
- Note the location and condition of all significant (deeper than a paint scrape) impact damage.
- Document locations and lengths of all cracks found. Mark these locations on the bridge with a permanent marker or a lumber crayon. Note the date found and the limit of crack propagation in such a manner that subsequent inspections may determine additional crack propagation. The method of inspection should also be noted as the crack may have propagated farther than may show visually. If any retrofit has been made to an old crack or holes drilled to arrest existing cracks, evaluate the effectiveness of the retrofit and note whether or not the crack has propagated past the arresting hole.
- Notes should be made describing the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for routine inspections, "hands-on" access shall be provided to the entire superstructure.
- All areas of suspected delamination, scale, cracking, and a random sampling of at least 25% of the areas (showing no apparent signs of deterioration) shall be sounded to locate delaminations using a frequency adequate to detect deficiencies.

Documentation for In-Depth Inspections:

- A simple framing plan shall be drawn or a copy of the plans made and all deficiencies referenced to that framing plan. All deterioration shall be sketched noting the size, length, direction, depth, etc., of deterioration. If the deterioration is limited, placing the information on the framing plan will usually be sufficient, however, in most cases sketches of individual members that show all exposed faces will be required.
- In some cases the quantity of cracks will preclude measurement and documentation of all cracks within a reasonable length of time. In this case, it is important that the significant cracks and deterioration are fully documented, and that the pattern and quantity of other deterioration is noted.
- The notes, as a whole, should clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph of the superstructure that documents its overall condition and supports the condition rating shall be included.

Report Review:

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection reviewer should determine if patterns of deterioration or progressive deterioration is taking place. Progression will be determined by comparing present to past inspection reports.
- The sudden or progressive appearance of flexure or shear cracks may indicate the need for a new load rating analysis and/or posting of the bridge structure for a weight restriction.

Maintenance Concerns:

- Only very loose concrete, which is in danger of falling onto traffic, should be removed with a light (less than 15 pound) jackhammer prior to consultation with the Transportation Supervising Engineer.
- Areas of section loss, gouges, dings, and impacted rust are all stress risers in steel members and should be monitored closely or repaired.

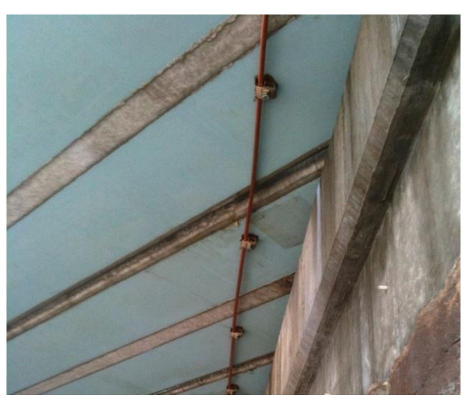


Figure 6.2.2.3a: Concrete Encased Steel Deck Beam

6.2.2.4. Concrete Rigid Frames and Closed Spandrel Arches

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 8

Reference: BIRM, Sections, 7.1, 7.5 and 7.6

Inspection Requirements

Inspections:

- Inspect the concrete rigid frame or closed spandrel arch in accordance with BIRM, Sections 7.1, 7.5, and 7.6.
- Check the ballast mat for low spots or “leaks”.
- The entire superstructure shall be inspected use adequate lighting to detect cracking, scaling, spalling, exposed reinforcing (with or without corrosion loss), delamination, impact damage or other defects.
- Suspect areas should be inspected “hands-on” to determine the type and extent of deterioration or deficiency.
- Inspect the area of the arch ring/skew back interface for deterioration. See Appendix A6.9 for sketches and nomenclature.
- Inspect the arch or frame intrados for longitudinal cracks that may indicate differential vertical movement across the transverse section. Look for transverse tension cracks near the crown that may indicate an overload/overstress condition.
- Inspect the arch ring/spandrel wall interface for cracks and spalls that may indicate deflection of the wall or differential movement of the arch ring.
- Inspect the spandrel walls for bulging, tilting, or other signs of deterioration and signs of fill material exfiltration.

Special Note:

In closed spandrel arch structures that are earth filled, the spandrel walls are primary members. They act as retaining walls and serve to resist the lateral earth pressures that develop in the fill material during transfer of dead and live loads to the arch ring. Cracks and spalls, which are large enough to allow exfiltration of fill material, reduce the effective transfer of load and can cause voids to develop below the railroad ballast. They should be sealed to prevent further exfiltration and monitored for recurrence.

Because ballast and/or fill material is porous, water can easily penetrate to the inside surfaces of arch rings, spandrel walls and frame legs. If weepholes are ineffective and water is retained, deterioration may take place on the inside face, long before water seepage, staining, or other signs of deterioration are noticeable on the outside face. Once cracks or spalls penetrate to the outside surface, water can accelerate the exfiltration of fill material.

- Check all are as exposed to drainage for concrete spalling and scaling. T his may be particularly evident around weepholes.
- Check weepholes to see if they appear clear to permit proper drainage of the backfill.
- Check for shear cracks that initiate at the intersection of the frame leg and intrados and propagate upward into the frame slab toward midspan or downward into the leg.
- Check the tension zones in frames for flexure cracks, cracks with rust stains or efflorescence, exposed or corroded tensile reinforcement, or deteriorated concrete that could cause debonding of the tension reinforcement.
- Check the frame legs for horizontal cracks that could indicate excessive backfill pressure and for loss of section due to spalling or scaling that would increase the compressive stresses. Check for exposed reinforcement.

- Investigate areas that have been damaged, due to impact, for resulting concrete damage (compression zones) and reinforcement damage (tensile zones).
- Inspect repaired areas to determine if repair materials are in place and functioning as designed. Hammer tap patched areas to determine if the patch is sound and adhering to the base material.
- Look for spalling, scaling or delaminated concrete that is located above roadway travel lanes that could cause a hazard if it were dislodged and fall to the roadway below.

Documentation for Routine Inspections:

- Document deficiencies and deteriorations observed. Dimensions should include the length, width, height, depth of loss, orientation, and location relative to a fixed point.
- Elevation and plan drawings may be provided to show the layout of the arch ring, frame, spandrel walls and foundation, along with all noted deteriorations. If required, additional sectional views and detail drawings shall be provided as necessary to adequately describe the extent of deficiencies noted. Sketches should always be provided if significant deterioration is found.
- Notes shall be made describing the current condition of all previously noted problems so that a rate of deterioration can be established for monitoring purposes. If a condition rating has changed from the previous inspection due to increased quantity or size of deterioration, or if the deterioration has been repaired, photographs, documentation and an explanation of why the condition rating has changed shall accompany the report.
- All shear cracks in the spandrel walls, frame slab or frame legs and any transverse cracks in the arch ring or frame legs that are greater than 1/8" in width shall have their ends marked on the structure with a permanent marker or chisel and paint mark along with the date they were found. This will allow subsequent inspections to determine the extent and rate of crack propagation.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements of the routine inspection, "hands-on" access shall be provided to the entire superstructure.
- Elevation and plan drawings shall be provided to show the layout of the arch ring, frame, spandrel walls and foundation along with all deteriorations noted. Section views and detail drawings shall be provided as required to adequately describe the extent of deficiencies noted.
- All areas of cracking, scaling, spalling, wetness, or staining on the spandrel walls shall be sounded with a hammer to determine the extent and limits of deterioration.
- At least 50% of the areas of the arch or frame intrados, spandrel walls, and frame legs showing no apparent signs of deterioration shall be initially inspected using hammer sounding to locate delaminated areas. If delaminations are found, additional areas shall be sounded.

Documentation for In-Depth Inspections:

- All documentation required for the routine inspection shall be included in the in-depth documentation except as noted in this section.
- Documentation, as a whole, shall clearly describe the structural condition and serve as a benchmark to which all future inspections can be compared.
- A good quality photograph of the superstructure, that documents the overall condition as well as detail photographs that support the condition rating, shall be provided.

Report Review:

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Check to ensure the inspection report, inspection field notes, and photographs are cross referenced and mutually supportive of their documentation.
- The inspection reviewer should determine if patterns of deterioration or progressive deterioration is taking place. Progression will be determined by comparing present and past inspection reports.
- Transverse cracking in the arch ring may indicate possible differential deflection of the arch ring and can seriously affect the ability of the arch ring to carry load. If these cracks are noted, further investigation as to the cause and effects should be considered.
- Rigid frames rely on the integrity of the moment connection between the slab and leg to transfer dead and live load moments to the footings. Cracking, spalling, exposed rebar or other deterioration noted in this area, particularly in the tension area, should be monitored closely and further investigation as to the cause and effects should be considered.

Maintenance Concerns:

- Spalls noted during the inspection should be patched utilizing approved materials and details. If exposed reinforcing bars are present, they should be cleaned of all rust and coated with an approved protective coating prior to patching operations. Consideration should be given to replacing severely corroded sections of reinforcing bars and/or utilizing wire mesh to reinforce the patch.
- Weepholes should be cleaned as needed to insure proper drainage.

Figure 6.2.2.4-a: A Closed Spandrel Reinforced Concrete Arch Bridge

6.2.3 STEEL SUPERSTRUCTURES

6.2.3.1. Steps To Follow When Fatigue Cracks Are Observed

Fatigue cracks are most detrimental to the safety and performance of a structure or component when they are orientated in a direction perpendicular to the applied stress. See Appendix A6.1 and Figures 6.2.3.1a to Figure 6.2.3.1f. If a crack is detected, the following steps are recommended:

For the Inspector:

1. Report the fatigue crack immediately in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 3.2.7. A sketch and photographs shall be prepared so that the crack location, size and orientation can be evaluated. The Inspector is urged to be aware of fatigue prone and fracture critical members within the structure.

2. Determine the locations of the ends of the crack visually. The crack tip will, in general, extend beyond the crack in the paint film and beyond any oxide indication.

3. Examine any other identical details on the bridge. Additional fatigue cracks are likely to occur at any time in similar details at the same relative location within the detail.

4. When examining other similar details, check carefully for breaks in the paint and the formation of oxide dust at the location where the first crack originated.

5. If a suspect area is located in a detail found in many areas throughout the bridge, a more detailed examination of all such details should be carried out, such as having the paint removed in the area and applying dye penetrant or a visual examination with a 10X power magnifier.

For the Railroad Bridge engineer:

1. Evaluate the significance of the crack on the load-carrying capacity of the bridge, considering the crack size, known material characteristics, and temperature. Steel is much more brittle during periods of extreme low temperature, and brittle fracture is more likely to occur in cold weather than during warm weather.

2. If the crack is moving perpendicular to the stress field in the member, it is desirable to arrange to have holes drilled, at the crack ends, immediately. The holes should be 3/4” to 1” in diameter. The edge of the holes should be placed at the presumed end of the crack. After holes are drilled, it is desirable to check the hole to insure that the crack tip has been removed and does not pass through the hole (see Appendix A6.3 for typical example). This is generally a temporary retrofit pending development of a permanent repair.

4. Determine if special nondestructive tests are desirable at other locations (i.e. dye penetrant, mag-particle, ultrasonic testing or a more thorough visual examination).

5. Review results of examination of other locations on the bridge. Determine if a pattern develops related to truck traffic lanes and geometry of the structure.

6. Determine if the crack or cracks have developed from normal fabrication conditions or as a result of an unusual flaw.

7. Develop a repair and retrofit scheme for the fatigue damaged area(s).

8. Determine whether or not other structures exist with similar details and conditions.

Figure 6.2.3.1a - Fatigue crack in a diaphragm web

Figure 6.2.3.1b - Fatigue crack in a connection angle

Figure 6.2.3.1c - Fatigue crack in a connect angle

Figure 6.2.3.1d - Fatigue crack top flange angle

Figure 6.2.3.1e - Fatigue crack top flange angle with stop holes drilled and repair stiffeners installed

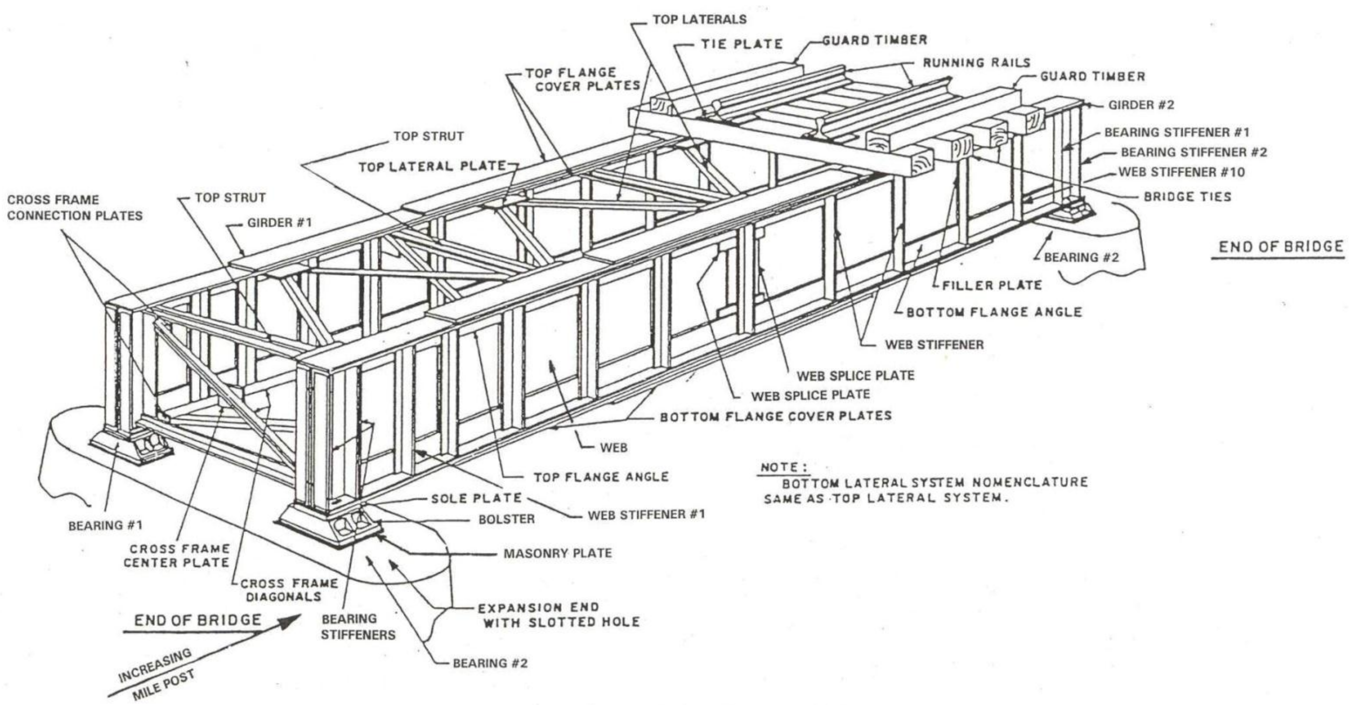
Figure 6.2.3.1f - Fatigue crack in a secondary member

6.2.3.2. Girder Systems

Girder system bridges are bridge were the deck is supported directly by the longitudinal girder itself. For inspection purposes the Girder systems are divided into two categories, the Deck Plate Girder Bridge and the Multi Girder Bridge. Box girders are not common in railroad practices. The Deck Plate Girder Bridge is made up of two built up girders generally supporting an open deck. The Multi Girder Bridge is made up of 4 or more rolled or built up girders supporting an open or ballasted deck. The Deck Plate Girder is separated from the Multi Girder because, with only two girders, each girder is Fracture Critical and the required inspection is different than the Multi Girder Bridge without any Fracture Critical members.

6.2.3.2.1. Deck Plate Girders

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 9
Reference: BIRM, Sections 2.3, 8.1, 8.3, and 13.3



DECK PLATE GIRDER SPAN

Inspection Requirements

Inspections:

- Inspect the superstructure in accordance with BIRM, Sections 8.1, 8.3 and 13.3.
- All exposed surfaces of metal load path nonredundant superstructure elements shall receive a 100% close-up, “hands-on” visual inspection during each inspection. Areas to receive this “hands-on” inspection include areas subject to tension stress and stress reversal. Members may consist of riveted, bolted, or welded construction.

- Check for section loss at the top flange under the ties. Check for section loss of the bottom flange at mid-span.
- Check cover plates attachment to the top and bottom flanges, look for missing fasteners, worn fasteners. Look for cracked welds, longitudinally and at plate butt welds, transitional flange.
- Look for cracks in flange angle fillets and/or moon-shaped cracks in the flange from tie deflection to the gage side of the girder and/or pulling up on the field side from the hook bolts rising as the ties deflect. Generally the cracks occur when the flange is only a pair of angles and less than 3/4 in. thick.
- Sight along the flanges of beams for evidence of compression flange buckling or dead load deflection ("negative camber").
- Girder/beam webs should be checked for signs of web crippling (out-of-plane bending) or beam tipping at all support locations from lack of stiffness. A plumb bob may be used for this purpose.
- Check for significant section loss and shear cracks in the web within the end “d” distance.
- Look for out-of-plane cracks in web at girder ends from lateral movement, at cross-frames and at partial depth stiffeners.
- Tension and stress reversal zones of metal members shall be examined for the presence of tack welds, remaining original welded erection aids, remaining original groove weld back-up bars, plug welded holes, and other existing weld details, situations, or conditions not part of the original design. If any of these situations exist, they shall receive a 100% close-up, “hands-on” visual inspection during each inspection. This shall be done regardless of redundancy.
- All fracture critical zones, all load path nonredundant members, fatigue prone weld details, and all other areas identified as requiring a 100% close-up “hands-on” inspection shall be clearly delineated in a specially prepared “Fracture Critical Data Sheet” for each appropriate bridge inspection report. Whenever an inspection report has a “Fracture Critical Data Sheet” (See Appendix A6.1) to highlight special items of inspection concern, the section shall be preceded by a title cover sheet boldly stating, “Details or Situations Requiring Special Attention During Inspection.”
- In general, all connections welded to a primary member shall be considered part of the primary member.
- When a bridge element receives a 100% close-up, “hands-on” visual inspection under these provisions, a note shall be placed under Additional Notes on inspection form BRI-18 stating that the required 100% “hands-on” inspection was performed. This note shall specifically list those elements of the bridge that received the required 100% “hands-on” inspection.
- Areas of heavy rusting shall be inspected "hands-on" to establish the depth of any section loss. Rust scale or "laminated rust" shall be removed with chipping hammers, scrapers or wire brushes, as necessary, in order to measure the minimum remaining thickness of steel or maximum depth of section loss. This will be most critical on beam flanges in high moment areas and beam webs in the vicinity of supports. Refer to the procedures in Appendix A6.2 for documenting steel section losses.

Some Pointers to Remember
About Weld Inspection

- *Visual inspection is the best tool. However, locations of ends of cracks may be erroneous as sub-surface crack propagation may be more extensive than surface propagation.*
- *Radiographic inspection permits looking into the weld for defects that fall within the sensitivity range of the process. It provides a permanent record of the results.*
- *Magnetic-particle inspection is outstanding for detecting surface cracks and is used to advantage on heavy weldments and assemblies.*
- *Dye-penetrant is easy to use in detecting surface cracks. Its indicators are readily interpreted.*
- *Ultrasonic inspection is excellent for detecting subsurface discontinuities, but requires expert interpretation.*

- Impact damaged areas should be inspected "hands-on" for the presence of tears or cracks.
- Welded repairs, diaphragm or utility connections, and any miscellaneous welds in the tension zones of beams that can be accessed without special equipment should be inspected closely for fatigue cracks or other defects (See Appendix A6.1 for typical details.). If defects are found, arrangements should be made to permit a "hands-on" inspection of all similar details on the structure.
- All suspected cracks should undergo Nondestructive Testing (NDT) to confirm their existence and determine the extent of crack. All confirmed fatigue cracks shall be immediately reported in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 3.2.7.
- The Secondary Members will be inspected from a distance of not greater than 15' using adequate lighting to detect corrosion, impacted rust, section loss, cracks, dings, gouges, impact damage and other defects.
- Bolts and rivets should be visually checked for tightness and section loss. Broken paint or bleeding rust around a bolt or rivet may indicate a loose or broken fastener. Suspect fasteners should be tapped with a hammer to confirm their integrity.
- Other details, situations, or conditions of special concern may be highlighted for special inspection emphasis even if the specific situation is not itemized in this list of elements to be inspected.

Documentation for Routine Inspection:

- Note the extent and severity of all rusting. Significant loss, whether from past or current rusting, should be noted in sufficient detail for a load rating analysis to be performed. Engineering judgment is required in the field to determine the significance of areas with loss, but as a guideline, specific notes are required when:

  a) Greater than 15% (typically 1/8”) of the flange thickness is lost in areas of high moment.

  b) Greater than 30% (typically 1/8”) of the web thickness is lost in areas of high shear.

  Less significant losses (typically <1/8”) should be noted, but exact measurements are not required.

- Document steel losses by noting the area and depth of the loss as well as its relative location along the length of the beam measured from a fixed point (e.g. 12" H x 12" W x 1/8" deep loss on girder web at the bottom flange, beginning 3' from the west bearing on girder G1). Whenever possible, where deterioration is noted, calipers or other measuring devices shall be used to measure the remaining section instead of estimating the loss. Notes should clearly indicate whether an "estimated loss" or "measured remaining thickness" is being given. See Appendix A6.2 for typical examples of documenting steel section loss.
- Note locations and condition of all welded repairs or connections and other miscellaneous welds in the tension zones of the beams if they were not detailed on the construction plans or noted in the last in-depth inspection.
- Note the location and condition of all significant (deeper than a paint scrape) impact damage.
- Document in the field notes, the locations of all loose bolts/rivets, and also mark locations on the bridge with a permanent marker or lumber crayon along with the date they were found.
- Document locations and lengths of all cracks found. Mark these locations on the bridge with permanent marker or lumber crayon. Note the date found and the limit of crack propagation in such a manner that subsequent inspections may determine additional crack propagation. The method of inspection should also be noted as the crack may have propagated farther than may show visually. If any retrofit has been made to an old crack or holes drilled to arrest existing cracks, evaluate the effectiveness of the retrofit and note whether or not the crack has propagated past the arresting hole.
- Particular care shall be given to documenting any increased quantity or size of deteriorations that have changed since the last inspection. If the condition rating has changed from the last inspection, a photograph and explanation of why the rating has changed shall be included in the inspection report.
- Notes should be made describing the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes.
- A simple framing plan should be provided showing locations of deteriorations and other noted problems. Member elevations and cross sections should be provided, as required, to adequately describe deterioration found.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for a routine inspection, "hands-on" access shall be provided to the entire superstructure.
- All secondary members should be inspected "hands-on" regardless of extent of damage or deterioration.
- Check cross frames and struts for section loss to angles, particularly back-to-back angles with excessive fastener spacing.
- Look for cracks in cross frame and strut connections to the girders.
- Check the connection plates for section losses
- Check for section loss in the bottom and top laterals angles adjacent to connection plates and swelling between back-to-back angles.

Documentation for In-Depth Inspections:

- All documentation required for a routine inspection will be included in the in-depth documentation except as noted in this section.
- A simple framing plan, and elevations (as required), of all primary members should be provided. All deterioration or deficiencies found should be noted on these sheets to include size, length, direction, depth, etc. Sections and other detail sketches should be drawn, as required, to clearly show the locations and extent of deterioration or deficiencies noted.
- Documentation as a whole should clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph of the superstructure that documents the overall condition, as well as, detail photographs that support the condition rating shall be provided.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- The inspection reviewer should determine if patterns of deterioration or progressive deterioration are taking place. Progression will be determined by comparing present to past inspection reports.
- The reviewer should verify that the current structural evaluation on file for the bridge is valid based on conditions found during the inspection.
- The appearance of new or sudden propagation of existing fatigue cracks may warrant a new load rating or fatigue analysis, and/or posting of the bridge structure for a weight restriction. The reviewer should insure that all new fatigue cracks found were reported in accordance with the established procedures for "Critical Deficiency Reporting."

Maintenance Concerns

- Most repairs to steel members will be structural in nature and may have an effect on the load carrying capacity of the structure. Repairs should be detailed and performed under the direction of a Transportation Supervising Engineer.
- Fatigue cracks that show little or no crack propagation for extended periods can suddenly resume propagation, possibly resulting in member failure. Therefore, all cracks found shall be immediately reported and corrective action should be taken as soon as possible to ensure the integrity of the structure and safety of the public.
- Areas of section loss, gouges, dings, and impacted rust are all stress risers in steel members and should be monitored closely or repaired.
- Areas of severe rusting should be cleaned and coated to prevent further deterioration.

Figure 6.2.3.2.1-a: Typical Deck Plate Girder Superstructure

6.2.3.2.2. Multi-Girders Systems

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 9

Reference: BIRM, Sections 2.3, 8.1, 8.2, and 13.3

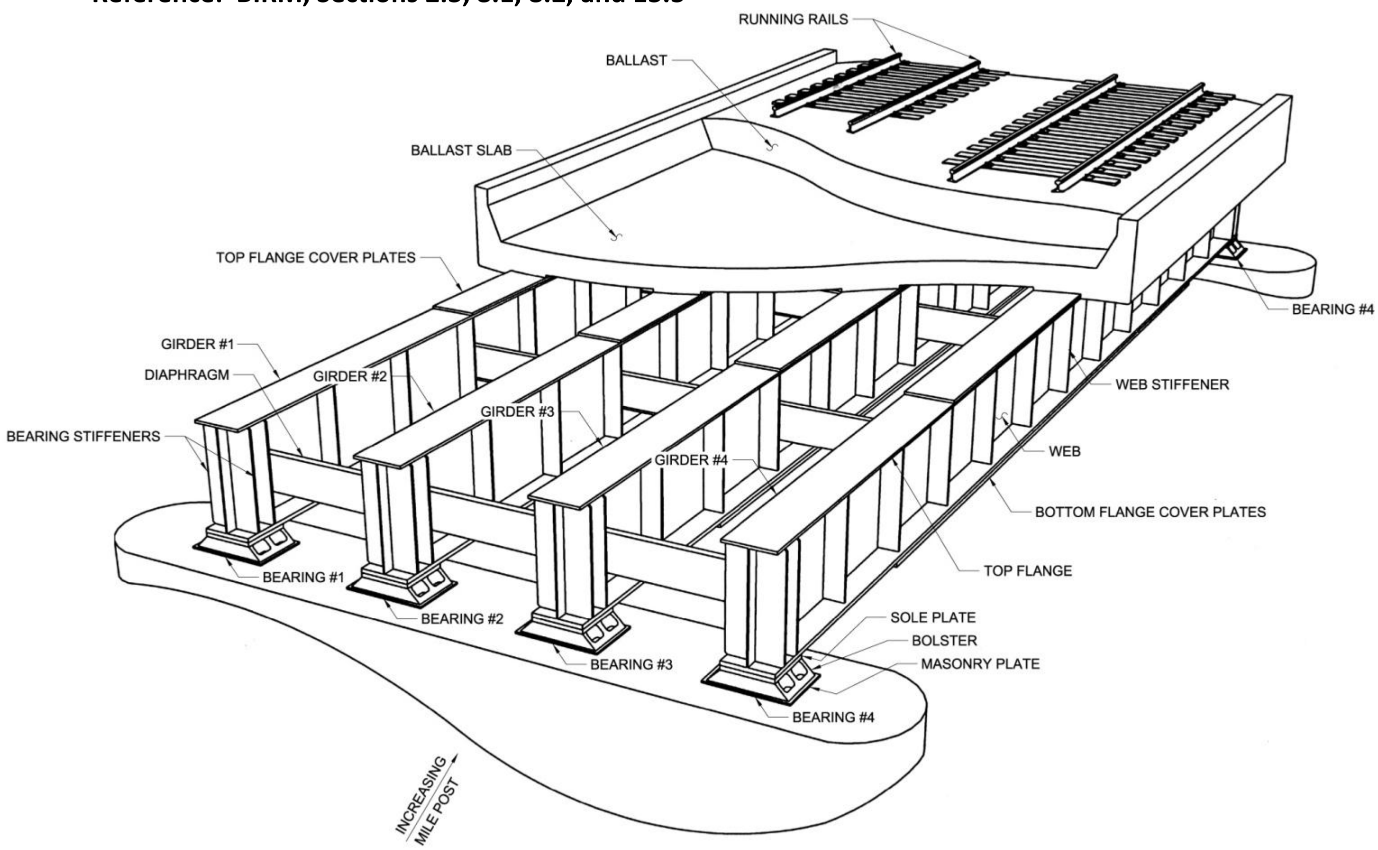


Figure 6.2.3.2.2a: Concrete Slab Ballast Deck on Steel Span Nomenclature

Inspection Requirements

Inspections:

- Inspect the superstructure in accordance with BIRM, Sections 8.1, 8.2 and 13.3.
- The entire superstructure will be inspected using adequate lighting to detect corrosion, impacted rust, section loss, cracks, dings, gouges, impact damage and other defects. Particular emphasis will be placed on areas of maximum moment (midspan for simple span beams and the area over the piers for continuous beams), ends of cover plates (or other locations of abrupt change in member cross section), bearing areas and diaphragm connections.
- Suspect areas shall be inspected "hands on" to determine the extent of deterioration or deficiency.
- Areas of heavy rusting shall be inspected "hands-on" to establish the depth of any section loss. Rust scale or "laminated rust" shall be removed with chipping hammers, scrapers or wire brushes, as necessary, in order to measure the minimum remaining thickness of steel or maximum depth of section loss. This will be most critical on beam flanges in high moment areas and beam webs in the vicinity of supports. Refer to the procedures in Appendix A6.2 for documenting steel section losses.

- Impact damaged areas should be inspected "hands-on" for the presence of tears or cracks.
- Sight along the flanges of beams for evidence of compression flange buckling or dead load deflection ("negative camber").
- Girder/beam webs should be checked for signs of web crippling (out-of-plane bending) or beam tipping at all support locations. A plumb bob may be used for this purpose.
- Partial length welded cover plates should be inspected "hands on" for fatigue cracks or other defects.
- Welded repairs, diaphragm or utility connections, and any miscellaneous welds in the tension zones of beams that can be accessed without special equipment should be inspected closely for fatigue cracks or other defects (See Appendix A6.1 for typical details.). If defects are found, arrangements should be made to permit a "hands-on" inspection of all similar details on the structure.
- All suspected cracks should undergo Nondestructive Testing (NDT) to confirm their existence and determine the extent of crack. All confirmed fatigue cracks shall be immediately reported in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 3.2.7.
- Bolts and rivets should be visually checked for tightness and section loss. Broken paint or bleeding rust around a bolt or rivet may indicate a loose or broken fastener. Suspect fasteners should be tapped with a hammer to confirm their integrity.
- Check the girder webs at approximately 25% of the welded diaphragm connection plates for fatigue cracks due to out-of-plane bending. See Appendix A6.1 for typical locations of fatigue cracks.
- Twenty-five percent (25%) of all welded girder web to lateral bracing gusset plate connections in the area of maximum bending moment shall be inspected "hands-on" for fatigue cracks due to out-of-plane bending in the girder web. See Appendix A6.1 for typical locations of fatigue cracks.
- When defects are found in a particular detail or location on a member, all other similar details or member locations will be inspected "hands on" for similar defects.

Some Pointers to Remember
About Weld Inspection

- *Visual inspection is the best tool. However, locations of ends of cracks may be erroneous as sub-surface crack propagation may be more extensive than surface propagation.*
- *Radiographic inspection permits looking into the weld for defects that fall within the sensitivity range of the process. It provides a permanent record of the results.*
- *Magnetic-particle inspection is outstanding for detecting surface cracks and is used to advantage on heavy weldments and assemblies.*
- *Dye-penetrant is easy to use in detecting surface cracks. Its indicators are readily interpreted.*
- *Ultrasonic inspection is excellent for detecting subsurface discontinuities, but requires expert interpretation.*

Documentation for Routine Inspection:

- Note the extent and severity of all rusting. Significant loss, whether from past or current rusting, should be noted in sufficient detail for a load rating analysis to be performed. Engineering judgment is required in the field to determine the significance of areas with loss, but as a guideline, specific notes are required when:
  - a) Greater than 15% (typically 1/8") of the flange thickness is lost in areas of high moment.
  - b) Greater than 30% (typically 1/8") of the web thickness is lost in areas of high shear.

  Less significant losses (typically <1/8") should be noted, but exact measurements are not required.
- Document steel losses by noting the area and depth of the loss as well as its relative location along the length of the beam measured from a fixed point (e.g. 12" H x 12" W x 1/8" deep loss on girder web at the bottom flange, beginning 3' from the west bearing on girder G1). Whenever possible, where deterioration is noted, calipers or other measuring devices shall be used to measure the remaining section instead of estimating the loss. Notes should clearly indicate whether an "estimated loss" or "measured remaining thickness" is being given. See Appendix A6.2 for typical examples of documenting steel section loss.
- Note locations and condition of all welded repairs or connections and other miscellaneous welds in the tension zones of the beams if they were not detailed on the construction plans or noted in the last in-depth inspection.
- Note the location and condition of all significant (deeper than a paint scrape) impact damage.
- In the field notes, document the locations of all loose bolts/rivets. Mark the locations on the bridge with a permanent marker or lumber crayon, along with the date they were found.
- Document locations and lengths of all cracks found. Mark these locations on the bridge with a permanent marker or lumber crayon. Note the date found and the limit of crack propagation in such a manner that subsequent inspections may determine additional crack propagation. The method of inspection should also be noted as the crack may have propagated farther than may show visually. If any retrofit has been made to an old crack or holes drilled to arrest existing cracks, evaluate the effectiveness of the retrofit and note whether or not the crack has propagated past the arresting hole.
- Particular care shall be given to documenting any increased quantity or size of deteriorations that have changed since the last inspection. If the condition rating has changed from the last inspection, a photograph and explanation of why the rating has changed shall be included in the inspection report.
- Notes should be made describing the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes.

- A simple framing plan should be provided showing locations of deteriorations and other noted problems. Member elevations and cross sections should be provided as required to adequately describe deterioration found.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for a routine inspection, "hands-on" access shall be provided to the entire superstructure.
- All primary and secondary members should be inspected "hands-on" regardless of extent of damage or deterioration.

Documentation for In-Depth Inspections:

- All documentation required for a routine inspection will be included in the in-depth documentation except as noted in this section.
- A simple framing plan and elevations, as required of all primary members, should be provided. All deterioration or deficiencies found should be noted on these sheets to include size, length, direction, depth, etc. Sections and other detail sketches should be drawn as required to clearly show the locations and extent of deterioration or deficiencies noted.
- Documentation, as a whole, should clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph of the superstructure, that documents the overall condition, as well as, detail photographs that support the condition rating, shall be provided.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- The inspection reviewer should determine if patterns of deterioration or progressive deterioration are taking place. Progression will be determined by comparing present to past inspection reports.
- The reviewer should verify that the current structural evaluation on file for the bridge is valid based on conditions found during the inspection.

- The appearance of new or sudden propagation of existing fatigue cracks may warrant a new load rating or fatigue analysis, and/or posting of the bridge structure for a weight restriction. The reviewer should insure that all new fatigue cracks found were reported in accordance with the established procedures for "Critical Deficiency Reporting."

Maintenance Concerns

- Most repairs to steel members will be structural in nature and may have an effect on the load carrying capacity of the structure. Repairs should be detailed and performed under the direction of a Transportation Supervising Engineer.
- Fatigue cracks, that show little or no crack propagation for extended periods, can suddenly resume propagation, possibly resulting in member failure. Therefore, all cracks found shall be immediately reported and corrective action should be taken as soon as possible to ensure the integrity of the structure and safety of the public.
- Areas of section loss, gouges, dings, and impacted rust are all stress risers in steel members and should be monitored closely or repaired.

Figure 6.2.3.2.2b: Typical Multi-Girder Superstructure

6.2.3.3. Steel Through Girder Floorbeam Systems

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 9
Reference: BIRM, Sections 8.1, 8.3 & 13.3

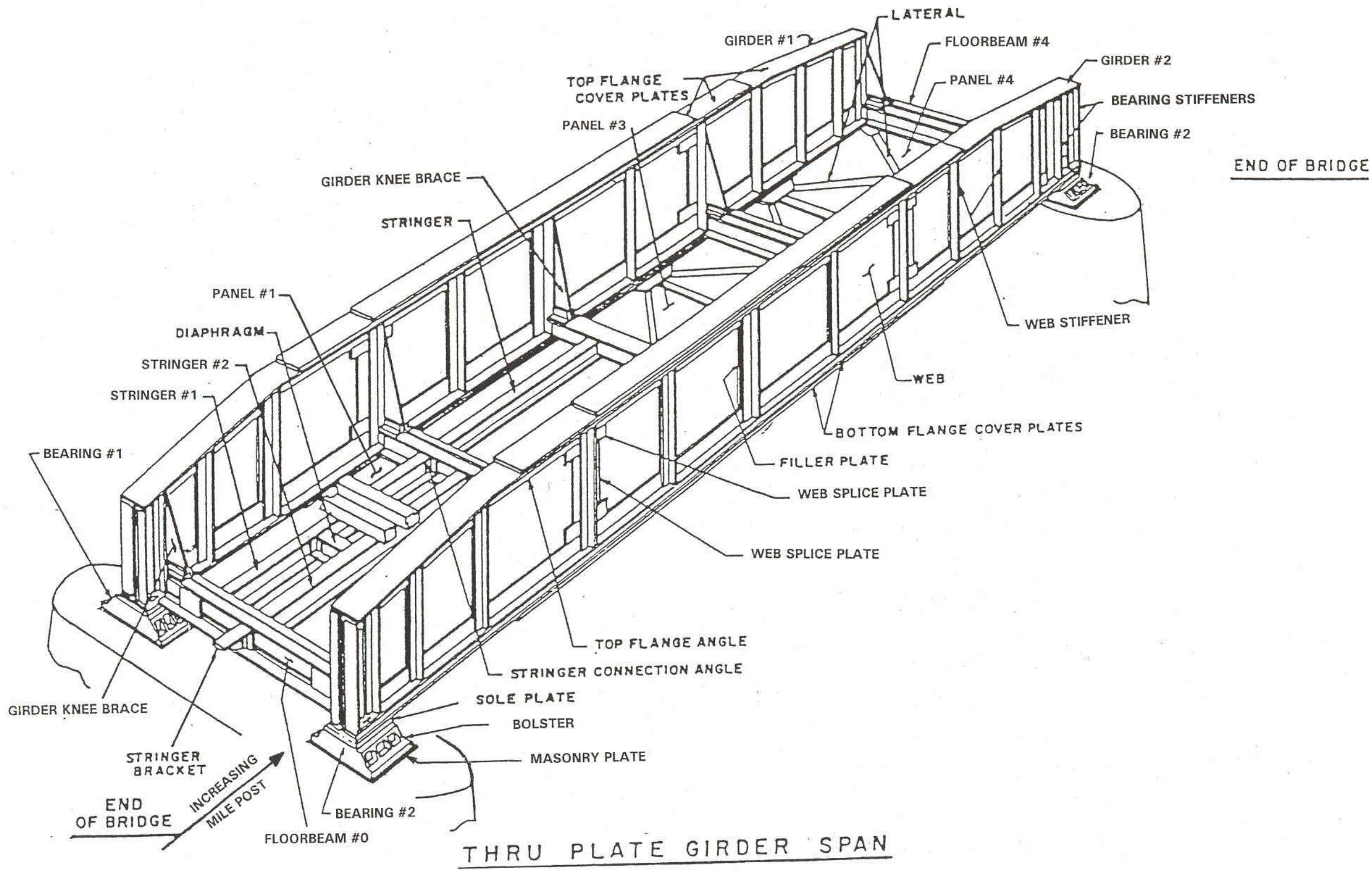
Steel Through Girders support two different floorbeam systems; stringers and floorbeams (Stringer-Floorbeam System) and closely spaced floorbeams with diaphragm spacers (Floorbeam-Diaphragm System). The floorbeam systems may support an open deck with ties placed directly on the stringer tops or there may be ballasted decks of concrete or steel construction atop the stringer and floorbeams.

In Connecticut, the Stringer-Floorbeams Systems tend to mainly support an open deck, while closely spaced floorbeams with the diaphragm spacers generally support a steel ballasted deck. On multi track bridges the stringer floorbeam system will share common girders between tracks while the closely spaced floorbeams will have two girders supporting each track carried by the bridge.

Some Pointers to Remember
About Floorbeam Systems

- *A two stringer per track span system, either framing into the web of a floorbeam or supported atop floorbeams, is fracture critical.*
- *Floorbeams of a conventional floor system are fracture critical.*
- *A four beam per track stringer span between floorbeams is redundant and not fracture critical.*
- *A stringer or a floorbeam built-up of a web plate and angle flanges is internally redundant.*
- *A stringer or a floorbeam built-up of a web plate and angle flanges with bolted or riveted cover plates is internally redundant.*
- *A stringer or a floorbeam built-up of a web plate and angle flanges with WELDED cover plates is NOT internally redundant.*
- *A floorbeam-diaphragm floor system of closely spaced floorbeams is not fracture critical and is generally considered redundant.*
- *A composite floor system follows the same designations as if it were not a composite system.*

6.2.3.3.1. Stringer-Floorbeam System



Inspection Requirements

Inspections:

- Inspect the superstructure in accordance with BIRM, Sections 8.1 and 8.3.
- Depending on the number of steel girders that make up the superstructure and the spacing of the floorbeams, the girders and floorbeams may be Fracture Critical. A detailed study of the structure shall be conducted prior to initiation of the inspection to confirm the existence and locations of fracture critical members (FCM's), as well as identifiable fatigue sensitive details. All FCM's shall be inspected in accordance with the guidelines established in this section and Chapter 5, Fracture Critical Member Inspection.
- Walk the top side of the deck and look for tears in the knee bracing from train impacts.
- The entire superstructure will be inspected from a distance of not greater than 10 ft. using adequate lighting to detect corrosion, impacted rust, section loss, cracks, dings, gouges, impact damage and other defects. Particular emphasis will be placed on areas of maximum moment (midspan for simple span girders and the areas over the piers for continuous girders), ends of cover plates (or other locations of abrupt change in member cross section), bearing areas and floorbeam connections.

- Suspect areas shall be inspected "hands-on" to determine the type and extent of deterioration or deficiency.
- Compression flanges shall be inspected for flange buckling due to overloads.
- Check for section loss in the stringer top flanges under the ties.
- Section loss, gouges, dings, and impacted rust are all stress risers in steel members and shall be monitored closely.
- Look for cracks in stringer flange angle fillets and/or moon-shaped cracks in the flange from tie deflection to the gage side of the stringer and/or pulling up on the field side from the hook bolts rising as the ties deflect. Generally the cracks occur when the flange is only a pair of angles and less than 3/4 in. thick.
- Check for shear cracks in the stringer web near the floorbeam connection.
- Look for out-of-plane cracks that may occur at copes, at stringer or floorbeam ends, at stringer diaphragms or in the floorbeam over stringer connection.
- Check for cracks in stringer web-to-floorbeam web connection angles, in the fillet at either end or in line with the fasteners in the floorbeam.
- Look for loose and/or broken fasteners at the top or bottom of connection angles.
- Girder webs shall be checked for signs of web crippling (out-of-plane bending) at all support locations. Where visual observation indicates the possibility of distortion in the web, the web should be checked with a plumb bob.
- All welded repairs, connections, cover plates, utility connections and any other miscellaneous welds in the tension zone of the girders and floorbeams shall be inspected "hands-on" for fatigue cracks or other defects. See Appendix A6.1 for typical details.
- All suspected cracks should undergo Nondestructive Testing (NDT) to confirm their existence and determine the extent of the crack. All suspected fatigue cracks, that are not definitively dismissed after NDT, shall be immediately reported in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 3.2.7.
- Bolts and rivets shall be visually checked for tightness and section loss. Broken paint or bleeding rust around the bolt or rivet may indicate a loose or broken fastener. Suspect fasteners shall be tapped with a hammer to confirm their integrity.
- Check the top and bottom of the girder webs at the floorbeam connections for fatigue cracks due to out-of-plane bending. See Appendix A6.1 for typical locations.
- Welded girder web to lateral bracing gusset plate connections shall be inspected for fatigue cracks due to out-of-plane bending in the girder web. This is more prevalent where the gusset plate is welded to the girder web but not to the floorbeam.
- When defects are found in a particular detail or location on a member, all other similar details or member locations will be inspected "hands-on" for the presence of similar defects.

Documentation for Routine Inspection:

- A simple framing plan shall be provided showing locations of deteriorations and other problems noted. Member elevations and cross sections shall be provided, as required, to adequately describe deterioration found.
- Note the extent and severity of all rusting. Significant loss, whether from past or current rusting, should be noted in sufficient detail for a load rating analysis to be performed. Engineering judgment is required in the field to determine the significance of areas with loss, but as a guideline, specific notes are required when:
  a) Greater than 15% (typically 1/8”) of the flange thickness is lost in areas of high moment.
  b) Greater than 30% (typically 1/8”) of the web thickness is lost in areas of high shear.
- Less significant losses (typically <1/8”) should be noted, but exact measurements are not normally required.
- Document steel losses by noting the area and depth of the loss as well as its relative location along the length of the girder, floorbeam or stringer, measured from a fixed point (e.g. 12” H x 12” W x 1/8” deep loss on girder web at the bottom flange, beginning 3’ from the west bearing on the north face of girder G1.) Whenever possible, where deterioration is noted, calipers or other measuring devices shall be used to measure the remaining section instead of estimating the loss. Notes should clearly indicate whether an “estimated loss” or “measured remaining thickness” is being given. See Appendix 6.2 for typical examples of documenting deterioration.
- Note locations and condition of welded repairs, connections, cover plates, utility connections and other miscellaneous welds in the tension zones of the girders, floorbeams and stringers.
- Determine the approximate percentage of bolts/rivets with section losses in the head/bolt and document extent of loss (e.g. 20% of rivets exhibit 10% head loss or all rivets at deck joints exhibit 50% head loss).
- Document, in the field notes, locations of loose bolts/rivets found and mark the locations on the bridge with a permanent marker or lumber crayon along with the date found.
- Document locations and lengths of all cracks found. Mark these locations on the bridge with a permanent marker or lumber crayon. Note the date found and the extent of the crack in such a manner that subsequent inspections may determine additional crack propagation. The method of inspection shall also be noted as the crack may have propagated farther than may show visually. If any retrofit has been made to an old crack or holes drilled to arrest existing cracks, evaluate the effectiveness of the retrofit and note whether or not the crack has propagated past the arresting hole.
- Particular care should be given to documenting the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes. If increased quantity or size of deteriorations causes the condition rating to change from the last inspection, a photograph and explanation of why the rating has changed shall be included in the inspection report.

- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for a routine inspection, "hands-on" access shall be provided to all primary and secondary superstructure elements.
- All welded connections shall receive a close visual inspection.
- The following details shall be inspected using ultrasonic non-destructive testing procedures:
  1. All transverse, full penetration groove welds found in the tensile zones of fracture critical members.
  2. If any welded detail on the bridge has experienced fatigue cracking in the past, all similar details shall be considered for testing. The need for additional NDT shall be determined by the Transportation Supervising Engineer.

Documentation for In-Depth Inspections:

- All documentation required for a routine inspection shall be included in the in-depth documentation except as noted in this section.
- A simple framing plan shall be provided showing locations of deteriorations and other problems noted. Member elevations and sections of all fracture critical members shall be provided showing all deteriorations found as well as the location and classifications of all AREMA fatigue category D, E, or E' details. Member elevations and cross sections of other members shall be provided, as required, to adequately describe deteriorations found.
- Documentation, as a whole, shall clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph of the superstructure that documents the overall condition, as well as detail photographs that support the condition rating, shall be provided.

Report Review:

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- The inspection reviewer shall determine if fatigue problems have been noted and whether or not patterns of deterioration or progressive deterioration are taking place. If fatigue cracks are noted, the reviewer shall ensure that procedures for reporting critical deficiencies have been initiated. Rate of deterioration progression will be determined by comparing present to past inspection reports.

- The appearance of new, or the sudden propagation of existing, fatigue cracks may warrant a new load or fatigue analysis and/or load posting of the bridge structure. A note should be placed in the file stating that fatigue problems are evident and that they should be monitored closely.

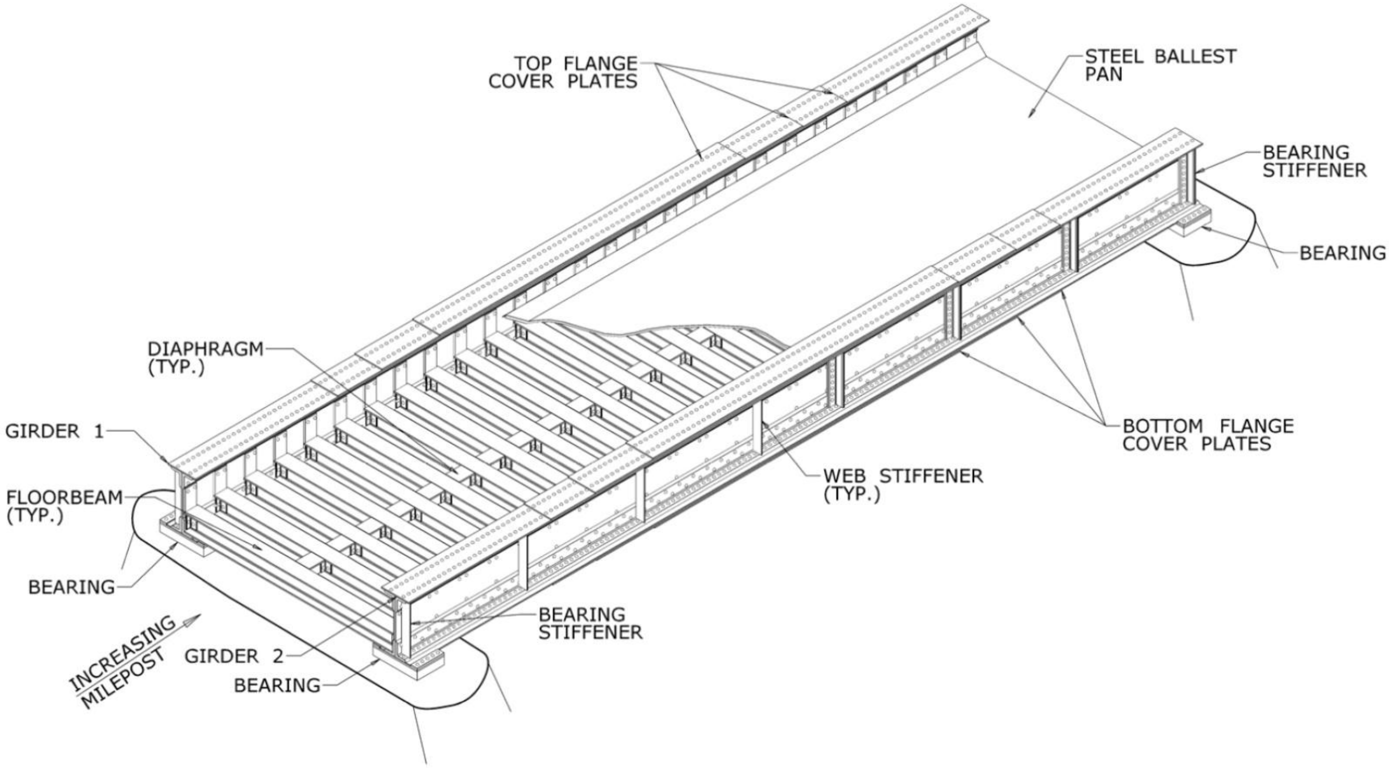
Maintenance Concerns:

- Most repairs to steel members will be structural in nature and may have an effect on the load carrying capacity of the structure. Repairs should be detailed and performed under the direction of a Transportation Supervising Engineer.
- Fatigue cracks, that show little or no crack propagation for extended periods, can suddenly resume propagation possibly resulting in member failure. Therefore, all cracks found shall be immediately reported and corrective action should be taken as soon as possible to ensure the integrity of the structure and safety of the public.
- Areas of section loss, gouges, dings, and impacted rust are all stress risers in steel members and should be monitored closely or repaired.

Figure 6.2.3.3.1a: Through Plate Girder with a Stringer Floorbeam System from the top, with the track removed

Figure 6.2.3.3.1b: Through Plate Girder with a Stringer Floorbeam System, from the bottom

6.2.3.3.2. Floorbeam-Diaphragm System



FLOORBEAM-DIAPHRAGM THROUGH GIRDER

Inspection Requirements

Inspections:

- Inspect the superstructure in accordance with BIRM, Sections 8.1 and 8.3.
- Depending on the number of steel girders that make up the superstructure and the spacing of the floorbeams, the girders and floorbeams may be fracture critical. A detailed study of the structure shall be conducted prior to initiation of the inspection to confirm the existence and locations of fracture critical members (FCM's), as well as identifiable fatigue sensitive details. All FCM's shall be inspected in accordance with the guidelines established in this section and Chapter 5, Fracture Critical Member Inspection.
- The entire superstructure will be inspected from a distance of not greater than 10 ft. using adequate lighting to detect corrosion, impacted rust, section loss, cracks, dings, gouges, impact damage and other defects. Particular emphasis will be placed on areas of maximum moment (midspan for simple span girders and the areas over the piers for continuous girders), ends of cover plates (or other locations of abrupt change in member cross section), bearing areas and floorbeam connections.
- Suspect areas shall be inspected "hands-on" to determine the type and extent of deterioration or deficiency.
- Check the floorbeam to ballast pan connection, making sure the pan is tight to the top flange.

- Look for cracks in the diaphragms and connection angles.
- Floorbeam web shall be checked for signs of out-of-plane cracks at the diaphragm connections.
- Compression flanges shall be inspected for flange buckling due to overloads.
- Section loss, gouges, dings, and impacted rust are all stress risers in steel members and shall be monitored closely.
- Look for loose and/or broken fasteners at the top or bottom of connection angles.
- Girder webs shall be checked for signs of web crippling (out-of-plane bending) at all support locations. Where visual observation indicates the possibility of distortion in the web, the web should be checked with a plumb bob.
- All welded repairs, connections, cover plates, utility connections and any other miscellaneous welds in the tension zone of the girders and floorbeams shall be inspected "hands-on" for fatigue cracks or other defects. See Appendix A6.1 for typical details.
- All suspected cracks should undergo Nondestructive Testing (NDT) to confirm their existence and determine the extent of the crack. All suspected fatigue cracks, that are not definitively dismissed after NDT, shall be immediately reported in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 3.2.7.
- Bolts and rivets shall be visually checked for tightness and section loss. Broken paint or bleeding rust around the bolt or rivet may indicate a loose or broken fastener. Suspect fasteners shall be tapped with a hammer to confirm their integrity.
- Check the top and bottom of the girder webs at the floorbeam connections for fatigue cracks due to out-of-plane bending. See Appendix A6.1 for typical locations.
- Welded girder web to lateral bracing gusset plate connections shall be inspected for fatigue cracks due to out-of-plane bending in the girder web. This is more prevalent where the gusset plate is welded to the girder web but not to the floorbeam.
- When defects are found in a particular detail or location on a member, all other similar details or member locations will be inspected "hands-on" for the presence of similar defects.

Documentation for Routine Inspection:

- A simple framing plan shall be provided showing locations of deteriorations and other problems noted. Member elevations and cross sections shall be provided, as required, to adequately describe deterioration found.
- Note the extent and severity of all rusting. Significant loss, whether from past or current rusting, should be noted in sufficient detail for a load rating analysis to be performed. Engineering judgment is required in the field to determine the significance of areas with loss, but as a guideline, specific notes are required when:
  a) Greater than 15% (typically 1/8") of the flange thickness is lost in areas of high moment.
  b) Greater than 30% (typically 1/8") of the web thickness is lost in areas of high shear.
- Less significant losses (typically <1/8") should be noted, but exact measurements are not normally required.
- Document steel losses by noting the area and depth of the loss as well as its relative location along the length of the girder, floorbeam or stringer, measured from a fixed point (e.g. 12" H x 12" W x 1/8" deep loss on girder web at the bottom flange, beginning 3' from the west bearing on the north face of girder G1.) Whenever possible, where deterioration is noted, calipers or other measuring devices shall be used to measure the remaining section instead of estimating the loss. Notes should clearly indicate whether an "estimated loss" or "measured remaining thickness" is being given. See Appendix A6.2 for typical examples of documenting deterioration.
- Note locations and condition of welded repairs, connections, cover plates, utility connections and other miscellaneous welds in the tension zones of the girders, floorbeams and stringers.
- Determine the approximate percentage of bolts/rivets with section losses in the head/bolt and document extent of loss (e.g. 20% of rivets exhibit 10% head loss or all rivets at deck joints exhibit 50% head loss).
- Document, in the field notes, locations of loose bolts/rivets found and mark locations on the bridge with a permanent marker or lumber crayon along with the date found.
- Document locations and lengths of all cracks found. Mark these locations on the bridge with a permanent marker or lumber crayon. Note the date found and the extent of the crack in such a manner that subsequent inspections may determine additional crack propagation. The method of inspection shall also be noted as the crack may have propagated farther than may show visually. If any retrofit has been made to an old crack or holes drilled to arrest existing cracks, evaluate the effectiveness of the retrofit and note whether or not the crack has propagated past the arresting hole.
- Particular care should be given to documenting the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes. If increased quantity or size of deteriorations causes the condition rating to change from the last inspection, a photograph and explanation of why the rating has changed shall be included in the inspection report.

- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for a routine inspection, "hands-on" access shall be provided to all primary and secondary superstructure elements.
- All welded connections shall receive a close visual inspection.
- The following details shall be inspected using ultrasonic non-destructive testing procedures:

  3. All transverse, full penetration groove welds found in the tensile zones of fracture critical members.
  4. If any welded detail on the bridge has experienced fatigue cracking in the past, all similar details shall be considered for testing. The need for additional NDT shall be determined by the Transportation Supervising Engineer.

Documentation for In-Depth Inspections:

- All documentation required for a routine inspection shall be included in the in-depth documentation, except as noted in this section.
- A simple framing plan shall be provided showing locations of deteriorations and other problems noted. Member elevations and sections of all fracture critical members shall be provided showing all deteriorations found, as well as, the location and classifications of all AREMA fatigue category D, E, or E' details. Member elevations and cross sections of other members shall be provided, as required, to adequately describe deteriorations found.
- Documentation, as a whole, shall clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph of the superstructure, that documents the overall condition, as well as, detail photographs that support the condition rating, shall be provided.

Report Review:

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.

- The inspection reviewer shall determine if fatigue problems have been noted and whether or not patterns of deterioration or progressive deterioration are taking place. If fatigue cracks are noted, the reviewer shall ensure that procedures for reporting critical deficiencies have been initiated. Rate of deterioration progression will be determined by comparing present to past inspection reports.
- The appearance of new, or the sudden propagation of existing, fatigue cracks may warrant a new load or fatigue analysis and/or load posting of the bridge structure. A note should be placed in the file stating that fatigue problems are evident and that they should be monitored closely.

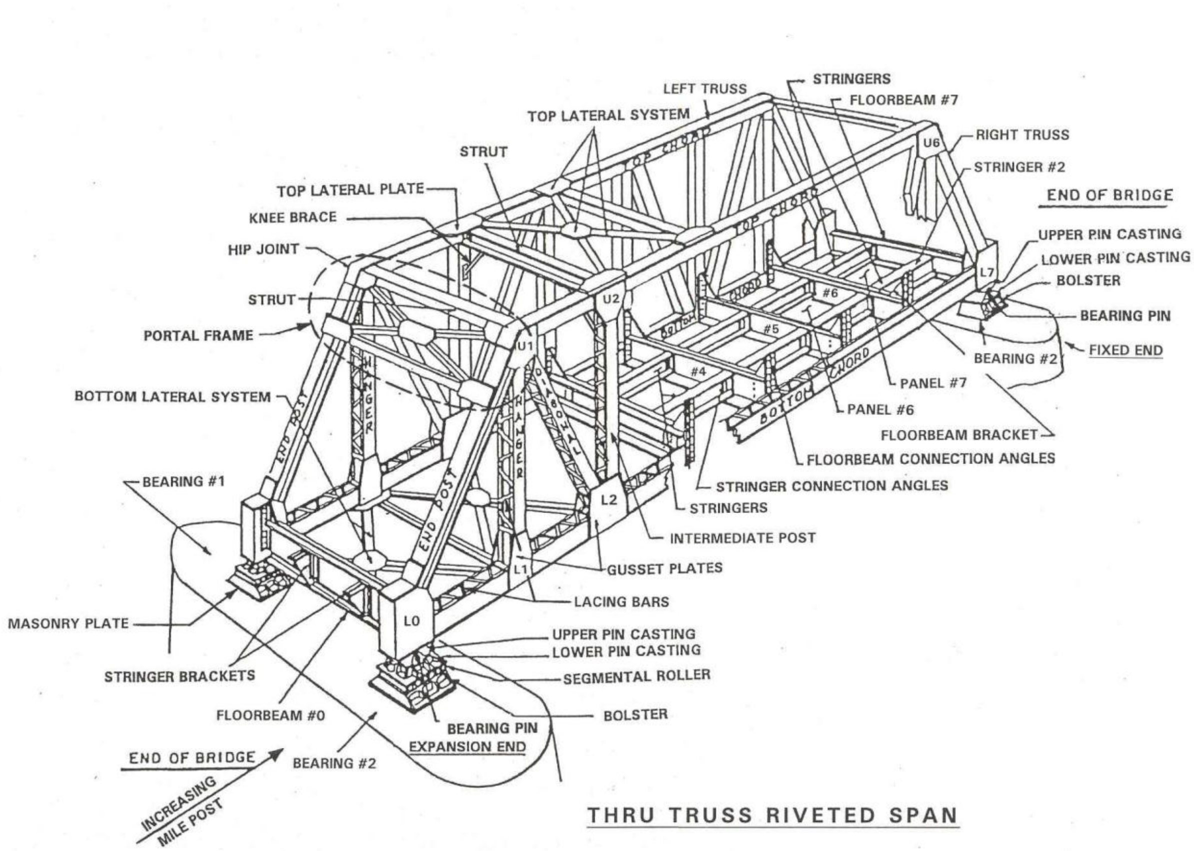
Maintenance Concerns:

- Most repairs to steel members will be structural in nature and may have an effect on the load carrying capacity of the structure. Repairs should be detailed and performed under the direction of a Transportation Supervising Engineer.
- Fatigue cracks, that show little or no crack propagation for extended periods, can suddenly resume propagation possibly resulting in member failure. Therefore, all cracks found shall be immediately reported and corrective action should be taken as soon as possible to ensure the integrity of the structure and safety of the public.
- Areas of section loss, gouges, dings, and impacted rust are all stress risers in steel members and should be monitored closely or repaired.

Figure 6.2.3.3.2a: Typical multi-track through girder with a floorbeam diaphragm system

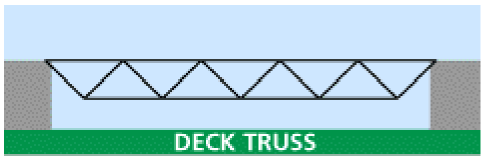
6.2.4 Trusses

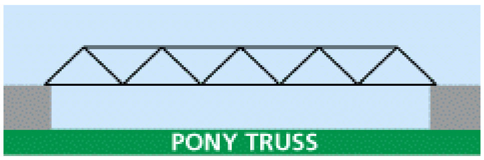
Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 9 SECTION 5, 9
Reference: BIRM, Sections 2.3, 8.1, 8.3 and 8.6 Thru 8.8
Reference: Cridlebaligh, B. S. "Bridge Basics – A spotter's guide to bridge design" <http://pghbridges.com/basics.htm> (June 24, 2011)

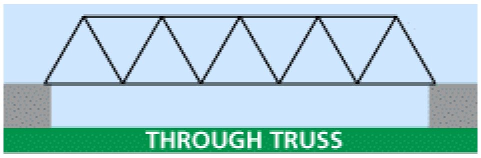


Truss Types

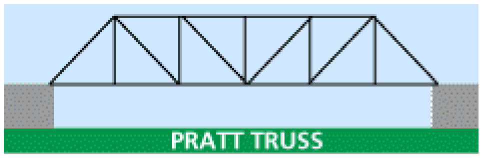
Primarily truss bridges can be classified under 3 broad categories depending on the location of the travel surface relative to the main structure. A Deck Truss is one in which the train travels on top of the main structure. In a Pony Truss the train travels between parallel superstructures that are not cross-braced at the top and in a Through Truss configuration the train travels through the superstructure.

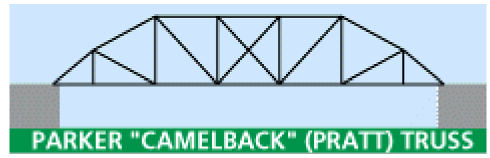


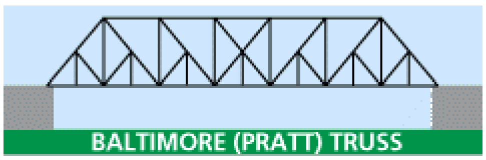


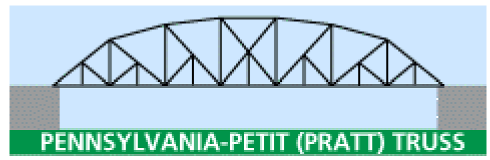


The Pratt truss is a very common type. It was originally designed by Thomas and Caleb Pratt in 1844. This design was later modified by Charles H. Parker to create the Camelback truss. This truss has a top chord which is not parallel with the bottom chord, which creates a stronger structure; however the design is more complicated to build.

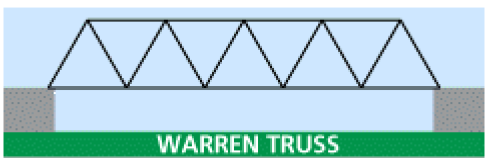


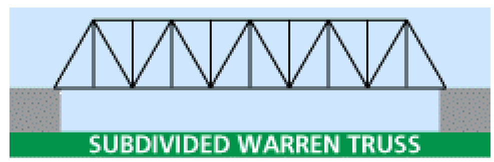


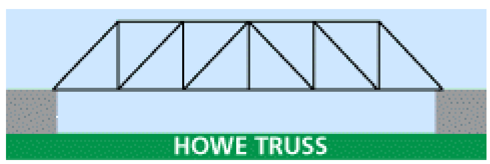




The Warren truss was patented by James Warren and Willoughby Monzoni of Great Britain in 1848.







The Howe Truss contains diagonal members that are in compression exactly opposite to the structure of a Pratt truss. This design was patented in 1840 by William Howe. (See Appendix A6.11)

Inspection Requirements

Inspections:

General:

- Inspect the trusses and metal arches in accordance with BIRM, Section 8.3 and 8.6 thru 8.8.
- Before the inspection begins, a study of the structure shall be done to determine the locations of all Fracture Critical Members (FCMs) and Fatigue Sensitive Details (FSDs). All FCMs shall be marked for inspection in accordance with the guidelines given in Chapter 5 for Fracture Critical Member Inspection. Unless otherwise shown by detailed analysis, all built up, rolled and eyebar type tension members, as well as all cable hangers, shall be considered to be FCMs and inspected as such. Girders, floorbeams or stringers may be identified as FCMs based on detailed analysis, engineering judgment and appropriate federal guidelines.
- All superstructure elements shall be inspected on all sides (Fracture Critical Members will always be inspected "hands-on") using adequate lighting to detect

corrosion, impacted rust, section loss, cracks, dings, gouges, impact damage and other defects. Particular emphasis shall be placed on truss member connections, areas of maximum moment, maximum shear, maximum axial load, locations of fatigue sensitive details (FSDs) as outlined in Appendix A6.1, bearing areas and floor system connections.

- Suspect areas shall be inspected “hands-on” to determine the type and extent of deterioration or deficiency.
- Bolts and rivets shall be visually checked for tightness and section loss. Broken paint or bleeding rust around the fastener may indicate a loose or broken fastener. Suspect fasteners shall be tapped with a hammer to confirm their integrity.
- When defects are found in a particular detail or location on a member, all other similar details or member locations will be inspected “hands-on” for similar defects.
- Section loss, gouges, dings, and impacted rust are all stress risers in steel members and shall be monitored closely.

Floor System:

- Girders, floorbeams and stringers that comprise the floor system of trusses, deck arches and through arches shall be inspected in accordance with the guidelines outlined in Section 6.2.3.3 Steel Through Girder Floorbeam Systems.

Pins:

- Inspect the pins in accordance with BIRM, Section 8.4.
- All pin assemblies should be treated as fracture critical, regardless of whether or not the girders they support are redundant. All pins or assemblies will be inspected in accordance with the guidelines established in this section and in Chapter 5 for Fracture Critical Member Inspection.

Special Note:

- *Pins are normally designed for shear and bearing on the full thickness of the connected members. In pins that have "shoulders" (changes in pin diameter at the threads), the pin can be subjected to excessive bearing stress if the hanger shifts off the pin shoulder and onto the threaded area. Pins can also see very high torsional forces if corrosion inhibits or prevents their ability to rotate freely.*

- Pin assemblies shall be inspected "hands-on" using adequate lighting to detect corrosion, impacted rust, section loss, hairline cracks (external), impact or collision damage or other deterioration. This should be done in conjunction with the inspection of the superstructure elements.
- Visually inspect the pin to the extent that it is visible and tap the pin with a hammer to check for gross looseness of the pin, nut and/or retainer cap. Measure the amount of any negative thread noted on each pin nut (the amount that the pin is recessed into the nut). Check the retainer cap to see if it is bent or deformed in any way. Verify that the face of the cap is flat with a straight edge. Verify that the nuts that hold retainer caps in place are tight and that a cotter pin or tack weld between the pin and nut are present and not bent or broken.

- Inspect spacer plates, nuts, cotter pins and keys for proper positioning, alignment and installation.
- Inspect all pins for signs of rotation. Abrasion dust around the nut or spacer plates is an indicator that rotation occurs. Cracked paint around pin nuts may indicate rotation or may indicate the nut is loose. If this condition is noted, the nut should be tapped with a hammer to determine tightness.
- Inspect all panel point pins for corrosion, impacted rust and signs of scoring and wear (abrasion dust). Ultrasonic testing will be performed on a rotating 20% of the truss pins at each biennial inspection to detect internal flaws not visible to the inspector. The pins to be tested will be selected and pre-approved by the Transportation Supervising Engineer prior to performing any testing. Pins that exhibit excessive deterioration or wear shall be considered for additional Nondestructive Testing.
- Inspect the webs and flanges of the connected beams at all pin assemblies for proper alignment. This may be checked with a straight edge or plumb bob. Misalignment may indicate lateral movement caused by impacted rust.
- Inspect components for signs of rotation that may be evidenced by cracked and/or worn paint between the connected members. Differential movement between the connected members may also be noted during live load passage.
- When defects or deteriorations are found in a particular location on a pin assembly, all other pin assemblies shall be inspected for the presence of similar defects.

Special Note:

- *If differential movement around the pin is excessive or if there is significant vertical movement with live load passage, the pins or pin holes may be excessively worn.*

- Inspect all rotating components for signs of movement and wear at the interface with other components. This may be evidenced by the presence of red or orange abrasion dust ("bleeding" rust).
- Inspect the connected members closely for signs of fatigue cracking. The critical areas most likely to develop cracks are outlined below and shown in Figure 6.2.4a:
  - at welds, used to connect plates.
  - at welds, used to connect web doubler plates.
  - in the base metal, at the ends of connected members adjacent to pin holes.
  - in the base metal, at the juncture between heads and shanks of eyebars.

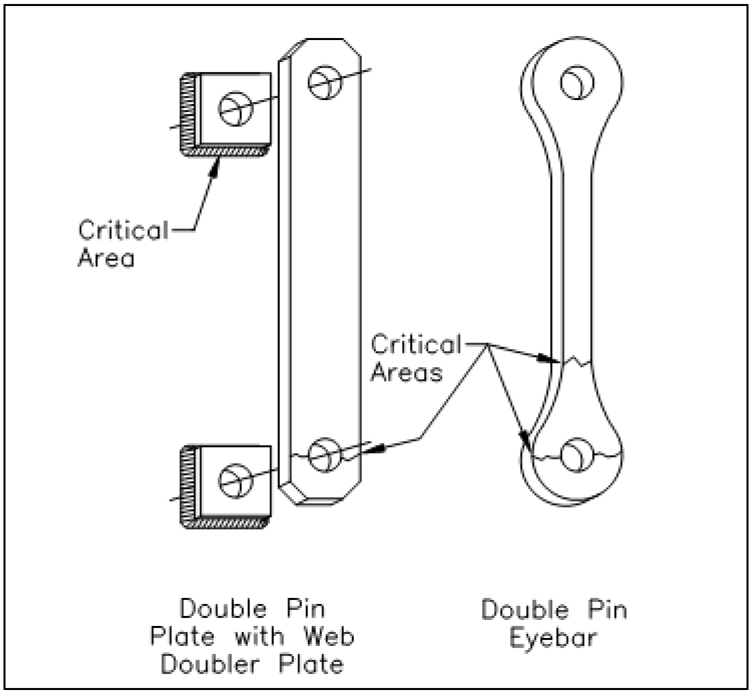


Figure 6.2.4a: Fatigue Cracks in Pin Assemblies

- All suspected cracks shall undergo Nondestructive Testing (NDT) to attempt to confirm the existence and extent of the crack. All confirmed fatigue cracks shall immediately be reported in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 3.2.7.

Special Note:

Disassembly of pin assemblies for inspection:

- ***No portion of any pin assembly should ever be disassembled by bridge inspection personnel.*** *Partial or total disassembly of a pin joint shall be undertaken only by approved personnel after proper engineering design is performed with auxiliary support supplied.*
- *Removal of the retainer nuts or caps should not be attempted unless an alternate means of retaining the connected members on the pin is in place.*
- *Pins are generally difficult to remove even after the retaining assemblies are taken off. This is not always true, however, and a pin that is subjected to high torsional stresses due to impacted rust can rotate or fail suddenly, if the nut is loosened. Connected members that are subjected to bending stress, due to impacted rust, may slip off the "shoulder" or pin itself once the nut is loosened.*
- *Partial or full disassembly of pin assemblies shall never be undertaken until all live load is removed from the structure. Live load shall remain off the structure until reassembly is complete.*

Nondestructive Testing:

- *Ultrasonic testing is currently the best means available for checking pins in place for internal flaws. However, the presence of "dead spaces" within the pin (locations where sound waves can not reach due to the geometry of the pin surface relative to the transducer) may skew test results.*
- *Only trained, certified technicians, knowledgeable in the theory and limitations of ultrasonic testing should perform and evaluate the test results.*

Truss Tension Members:

- This section shall cover all truss tension members.
- Members that experience force reversal shall be inspected as tension members.
- Inspect all tension members for signs of corrosion, section loss, wear, impacted rust, fatigue induced cracks, impact damage, signs of misalignment, debris build up, loose, missing or deteriorated fasteners, and other deterioration.
- Check alignment of tension members. Buckling or bowing due to causes other than impact, may be indicative of permanent force reversal, and may be caused by settlement, tilting or other displacement of the substructure elements. If bowing or buckling is observed, a thorough investigation as to the causes and effects shall be conducted.
- Check that all diagonals are full engaged and that they are tight to their connections.
- Inspect all pin holes for signs of wear.
- All welded repairs, connections, cover plates, utility connections and any other miscellaneous welds on tension members shall be inspected "hands-on" for fatigue cracks or other defects. See Appendix A6.1 for typical details. Particular attention shall be placed on inspection of welds that are transverse to the direction of applied stress.
- All suspected cracks shall undergo NDT to confirm their existence and determine the extent of the crack. All confirmed fatigue cracks shall be immediately reported in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 3.2.7.
- Inspect counter members to ensure that they are laterally movable by hand. Counters are designed to be stressed during live load application only. Inability to move counters during dead load application is an indicator that unanticipated loads are being applied to the member.
- Inspect counter eyebars within a panel for contact, abrasion dust or wear between the eyebars at the cross over.
- Inspect eyebars for corrosion and cracks along their entire length. Particular attention shall be paid to forged joints between rolled bars and their cast eye.
- Inspect threaded rod eyebars and turnbuckles for corrosion, impacted rust, tack welds and cracks. Inspect the threaded portion of the rod for signs that the turnbuckle is loosening.

Truss Compression Members:

- This section shall cover all truss compression members.
- Inspect all compression members for signs of buckling, web crippling, corrosion, section loss, impacted rust, collision damage, wrinkles or waves in flanges, welds, misalignment, debris buildup, loose, missing or deteriorated fasteners or other deterioration. Buckling, warping, wrinkling, etc., may indicate member overstress. Section loss, tears, misalignment, etc., may result in possible loss of load capacity. Both conditions warrant analysis to determine the effects on the structure.

- Inspect the condition of lacing bars, stay plates and batten plates. Note that the condition of these items will not normally be considered when assigning a condition rating to the compression member. However, if deterioration extends into the compression member base metal or if the alignment of compression member components is affected (impacted rust causing bent flanges, web plates, etc.), sound judgement shall be used to determine if and to what extent the condition rating should be adjusted.
- Truss top chord members that are integral with the bridge deck or that support portions of the floor system between panel points, shall be inspected as both axially loaded and bending members.
- Check for cracks at the top chord splices, primarily at hip connections.
- Inspect for wear at the pin holes.
- Inspect all splice plates for loose, missing or deteriorated fasteners, cracks and impacted rust.

Spandrel Members:

Cable Hangers:

- In addition to the inspection requirements of this section, cable hangers shall be inspected in accordance with the guidelines given for Truss and Metal Arch Tension Members, and in Chapter 5 for Fracture Critical Members.

Secondary Members:

- Inspect the top chord, bottom chord, Gusset Plates and floor system lateral bracing, sway bracing and knee braces for cracks, corrosion, impacted rust, loose, missing or deteriorated fasteners, proper alignment, debris buildup, impact damage and other deterioration.

Documentation for Routine Inspections:

- Document all steel losses by noting the area and depth of the loss, as well as, the relative location along the length of the member measured from a fixed point (e.g. 12" H x 12" W x 1/8" deep loss on the north web plate of member U3L4, North truss, beginning 3"). Whenever possible, where deterioration is noted, calipers or other measuring devices shall be used to measure the remaining section instead of estimating the loss. Notes should clearly indicate whether an "estimated loss" or "measured remaining thickness" is being given. See Appendix A6.2 for typical examples of documenting deterioration.
- Document whether rotation within the pin assembly was observed.
- Document the location and amount of any impacted rust found at pin assemblies and whether rotation of the connected members is affected.
- Note the locations and condition of all welded repairs, connections, cover plate ends, utility connections and other miscellaneous welds on all truss and metal arch tension members and in tension zones of all girders and beams.
- Determine the approximate percentage of bolts/rivets with section loss in the head/bolt and document the extent of the loss (e.g. 20% of rivets exhibit 10% section loss).

- Document, in the field notes, locations of all loose bolts/rivets. Mark locations on the bridge with a permanent marker or lumber crayon, along with the date found.
- Document locations and lengths of all cracks found. Mark these locations on the bridge with a permanent marker or lumber crayon. Note the date found and the limit of crack propagation in such a manner that subsequent inspections may determine additional crack propagation. The method of inspection shall also be noted as the crack may have propagated farther than may show visually. If any retrofit has been made to an old crack or holes drilled to arrest existing cracks, evaluate the effectiveness of the retrofit and note whether the crack has propagated past the arresting hole.
- Particular care shall be given to documenting the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes. If increased quantity or size of deteriorations causes the condition rating to change from the last inspection, a photograph and explanation of why the rating has changed shall be included in the inspection report.
- The results of all NDT performed shall be included in the inspection report.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.
- A simple framing plan shall be provided showing locations of deteriorations and other problems noted. Member elevations and cross sections shall be provided as required to adequately describe deteriorations noted.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for a routine inspection, "hands-on" access shall be provided to all primary and secondary superstructure members.
- All welded connections shall receive a close visual inspection.
- The following details, with the approval of the Transportation Supervising Engineer, shall be inspected using ultrasonic NDT procedures:
    1. All transverse, full penetration groove welds, found in the tensile zones of fracture critical members.
    2. All pin and hanger assemblies.
    3. If any welded detail on the bridge has experienced fatigue cracking in the past, all similar details shall be considered for testing. The need for additional NDT shall be determined by the Transportation Supervising Engineer.

Documentation for In-Depth Inspections:

- All documentation required for a routine inspection will be included in the in-depth documentation except as noted in this section.
- A simple framing plan shall be provided showing locations of deteriorations and other problems noted. Member elevations and cross sections of all FCMs shall be provided showing all deteriorations found, as well as, the location and classification of all fatigue sensitive details as defined by AREMA fatigue category D, E, or E' details. Member elevations and cross sections of all other members shall be provided, as required, to adequately describe deteriorations found.
- Documentation, as a whole, shall clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph that documents the overall condition of the superstructure shall be provided. Detailed photographs, that support the condition reported, shall be provided.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure that they are mutually supportive of their documentation.
- The inspection reviewer shall determine if fatigue problems have been noted and whether patterns of deterioration or progressive deterioration are taking place. If fatigue cracks are noted, the reviewer shall ensure that procedures for reporting critical deficiencies have been initiated. Rate of deterioration progression will be determined by comparing present to past inspection reports.
- The appearance of new, or the sudden propagation of existing, fatigue cracks may warrant a new load or fatigue analysis and/or load posting of the bridge structure. A note should be placed in the file stating that fatigue problems are evident and that they should be monitored closely.

Maintenance Concerns

- Most repairs to steel members will be structural in nature and may have an effect on the load carrying capacity of the structure. Repairs should be detailed and performed under the direction of a Transportation Supervising Engineer.
- Fatigue cracks, that show little or no crack propagation for extended periods, can suddenly resume propagation, possibly resulting in member failure. Therefore, all cracks found shall be immediately reported and corrective action should be taken as soon as possible to ensure the integrity of the structure and safety of the public.
- Areas of section loss, gouges, dings, and impacted rust are all stress risers in steel members and should be monitored closely or repaired.

Figure 6.2.4b – Through Truss Bridge.

Figure 6.2.4c – Deck Truss Bridge.

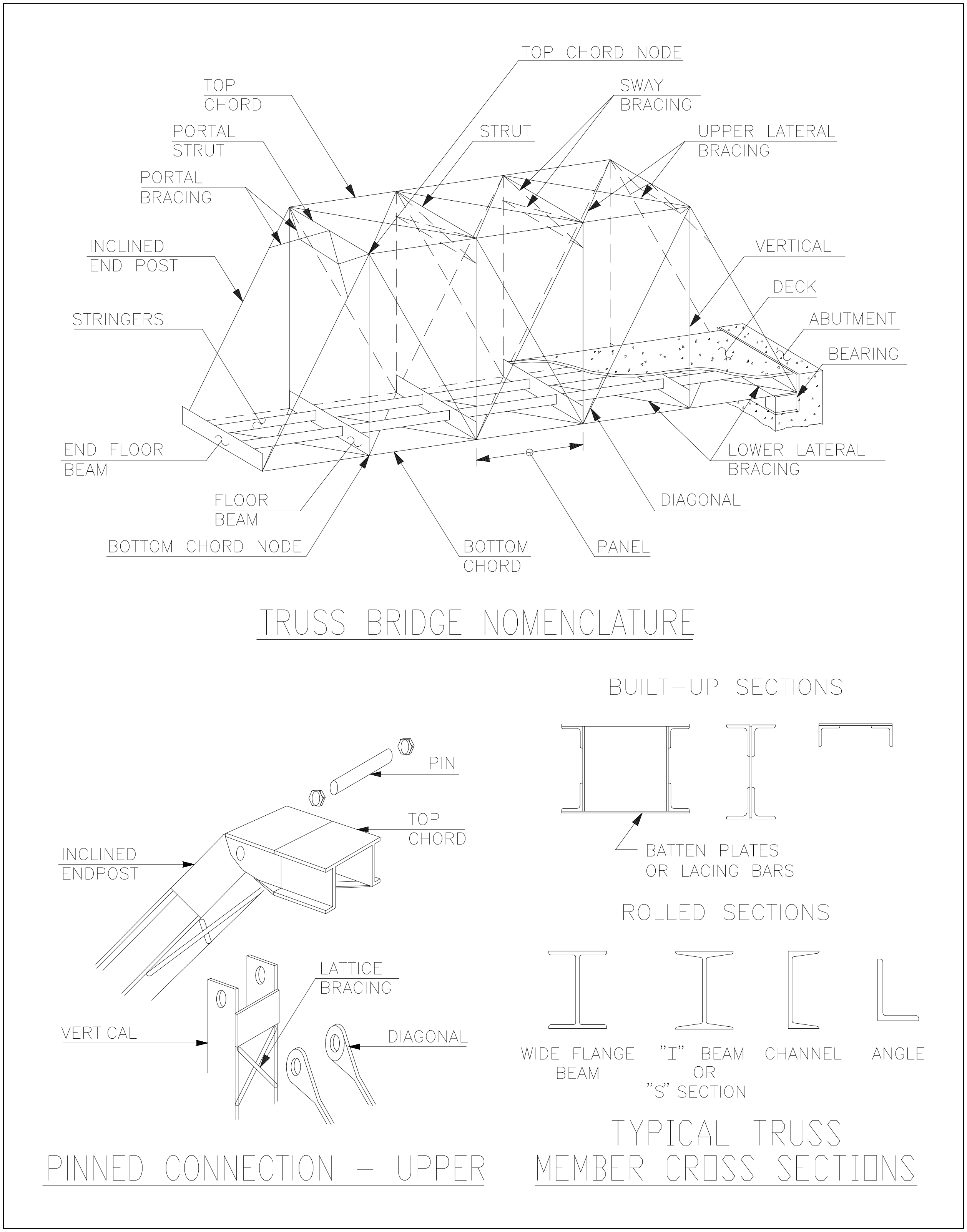


Figure 6.2.10c – Truss Bridge nomenclature and details.

6.2.5 Pin-Connected Pratt Trusses

Reference: AREMA BRIDGE INSPECTION HANDBOOK©
Reference: BIRM, Sections 2.3, 8.1, 8.6 and 8.7

General:

This special section is provided to illustrate that pin-connected Pratt trusses are unique and have many fracture critical members with significant maintenance problems. Below are a few characteristics of a Pratt truss.

The Pratt truss is a unique truss, bearing the name of its originators, Thomas and Caleb Pratt.

The interior diagonal members are all tension members and commonly consist of two or more eyebars and are fracture critical members. If the diagonal consists of more than two eyebars, it has internal redundancy.

The primary diagonal members are all orientated from top to bottom pointing towards the truss bottom-center.

The single diagonal eyebars, orientated from bottom to top towards the end, are called counters. Counters are tension members which become involved when loads on the span are in certain positions.

The end diagonals, or end posts, are compression members.

The first interior vertical member is commonly called a “hip hanger”, as it connects to the hip joint on the span. This member is a tension member, highly prone to fatigue damage and may be an H-shape which can be pinned or rigidly connected to the truss top connection.

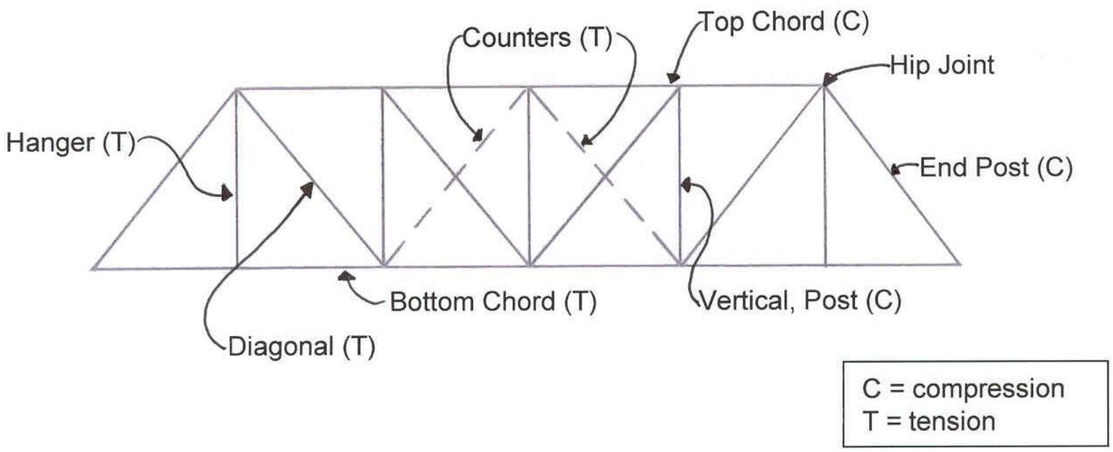
The remaining interior vertical members are generally all box members, as they are compression posts, usually pinned at both top and bottom.

The top chords are compression members and are generally composed of an open bottom box member with a solid top cover plate and a laced bottom.

The bottom chords, other than the end two panels, are tension members usually of two or more eyebars.

The bottom chord end two panels are usually a box member and, although they are tension members (due to braking and the possibility of compression in the end two panels), they are shaped to carry compress loads.

The Pratt truss has both top and bottom bracing systems and usually a conventional floor system. Most Pratt trusses have all truss connections pinned, except that some hanger members may be rigidly connected to the bottom chord.



Pratt Truss

Pratt Truss Deterioration – Scenario:

It has been observed that there is a typical scenario for the deterioration of pin-connected Pratt trusses. At first, there is light wear at the pin joints typified by a rust halo between the pin and connecting members. As the wear continues, primarily in the vertical compression members at the pin joints, there is actually a small change in the geometric distance between the top and bottom chords which results in a change in length for the diagonal eyebars. This change allows the eyebars to become slack. As the pin hole wear continues to increase in the top chord and in the vertical members, when a live load crosses the bridge, the floor system deflects excessively under each wheel load and rebounds between wheels. This results in flexing of the stringer-floorbeam joints and causes cracks to form in the connection angels. By the time there is significant wear in the pin joints (⅜ in. to ½ in. gaps or more), the truss hip plate flexes and retrofit patch plates, over the joint, crack shortly after being installed. The cracks are due to flexing caused by the sway in the upper connection.

With extreme wear in the pin holes, the truss becomes quite vulnerable to lateral sway and speed restrictions become necessary. At the top chord, vertical movement is noted in the chords, as the wheel loads pull downward on the verticals. The appearance resembles a wave occurring at the speed of the train.

With extensive wear in the pin holes, there is also concern that the pins will have stress concentrations at the grooves that could wear into the pins and possibly cause a fracture.

Inspection Requirements

Inspections:

General:

- Inspect the trusses in accordance with BIRM, Section 8.3 and 8.6.
- Before the inspection begins, a study of the structure shall be done to determine the locations of all fracture critical members (FCMs) and fatigue sensitive details (FSDs). All FCMs shall be marked for inspection in accordance with the guidelines given in Chapter 5 for Fracture Critical Member Inspection. Unless otherwise shown by detailed analysis, all built up, rolled and eyebar type tension members, as well as all cable hangers, shall be considered to be FCMs and inspected as such. Girders, floorbeams or stringers may be identified as FCMs based on detailed analysis, engineering judgment and appropriate Federal Guidelines.

- All superstructure elements shall be inspected on all sides (fracture critical members will always be inspected "hands-on") using adequate lighting to detect corrosion, impacted rust, section loss, cracks, dings, gouges, impact damage and other defects. Particular emphasis shall be placed on truss member connections, areas of maximum moment, maximum shear, maximum axial load, locations of FSDs as outlined in Appendix A6.1, bearing areas and floor system connections.
- Suspect areas shall be inspected "hands-on" to determine the type and extent of deterioration or deficiency.
- Bolts and rivets shall be visually checked for tightness and section loss. Broken paint or bleeding rust around the fastener may indicate a loose or broken fastener. Suspect fasteners shall be tapped with a hammer to confirm their integrity.
- When defects are found in a particular detail or location on a member, all other similar details or member locations will be inspected "hands-on" for similar defects.
- Section loss, gouges, dings, and impacted rust are all stress risers in steel members and shall be monitored closely.

Floor System:

- Inspect the floor system's hangers for fatigue cracking at the top connection.
- Look for section losses at the top pin hole.
- Girders, floorbeams and stringers that comprise the floor system of trusses, deck arches and through arches shall be inspected in accordance with the guidelines outlined in Section 6.2.3.3 Steel Though Girder Floorbeam Systems.

Pins:

- Inspect the pins in accordance with BIRM, Section 8.4.
- All pin assemblies should be treated as fracture critical, regardless of whether or not the girders they support are redundant. All pins will be inspected in accordance with the guidelines established in this section and in Chapter 5 for fracture critical member inspection.

Special Note:

Pins are normally designed for shear and bearing on the full thickness of the connected members. In pins that have "shoulders" (changes in pin diameter at the threads), the pin can be subjected to excessive bearing stress, if the hanger shifts off the pin shoulder and onto the threaded area. Pins can also see very high torsional forces, if corrosion inhibits or prevents their ability to rotate freely.

- Pin assemblies shall be inspected "hands-on" using adequate lighting to detect corrosion, impacted rust, section loss, hairline cracks (external), impact or collision damage, or other deterioration. This should be done in conjunction with the inspection of the superstructure elements.
- Visually inspect the pin to the extent that it is visible and tap the pin with a hammer to check for gross looseness of the pin, nut and/or retainer cap. Measure the

amount of any negative thread noted on each pin nut (the amount that the pin is recessed into the nut). Check the retainer cap to see if it is bent or deformed in any way. Verify that the face of the cap is flat with a straight edge. Verify that the nuts that hold retainer caps in place are tight and that a cotter pin or tack weld between the pin and nut are present and not bent or broken.

- Inspect spacer plates, nuts, cotter pins and keys for proper positioning, alignment and installation.
- Inspect all pins for signs of rotation. Abrasion dust around the nut or spacer plates is an indicator that rotation occurs. Cracked paint around pin nuts may indicate rotation or may indicate the nut is loose. If this condition is noted, the nut should be tapped with a hammer to determine tightness.
- Inspect all panel point pins for corrosion, impacted rust and signs of scoring and wear (abrasion dust). Ultrasonic testing will be performed on a rotating 20% of the truss pins at each biennial inspection to detect internal flaws not visible to the inspector. The pins to be tested will be selected and pre-approved by the Transportation Supervising Engineer prior to performing any testing. Pins that exhibit excessive deterioration or wear shall be considered for additional Nondestructive Testing.
- Inspect the webs and flanges of the connected beams at all pin assemblies for proper alignment. This may be checked with a straight edge or plumb bob. Misalignment may indicate lateral movement caused by impacted rust.
- Inspect components for signs of rotation that may be evidenced by cracked and/or worn paint between the connected members. Differential movement between the connected members may also be noted during live load passage.
- When defects or deteriorations are found in a particular location on a pin assembly, all other pin assemblies shall be inspected for the presence of similar defects.

Special Note:

If differential movement around the pin is excessive or if there is significant vertical movement with live load passage, the pins or pin holes may be excessively worn.

- Inspect all rotating components for signs of movement and wear at the interface with other components. This may be evidenced by the presence of red or orange abrasion dust ("bleeding" rust).
- Inspect the connected members closely for signs of fatigue cracking. The critical areas most likely to develop cracks are outlined below and shown in Figure 6.2.5a:

  - at welds, used to connect plates.
  - at welds, used to connect web doubler plates.
  - in the base metal, at the ends of connected members adjacent to pin holes.
  - in the base metal, at the juncture between heads and shanks of eyebars.

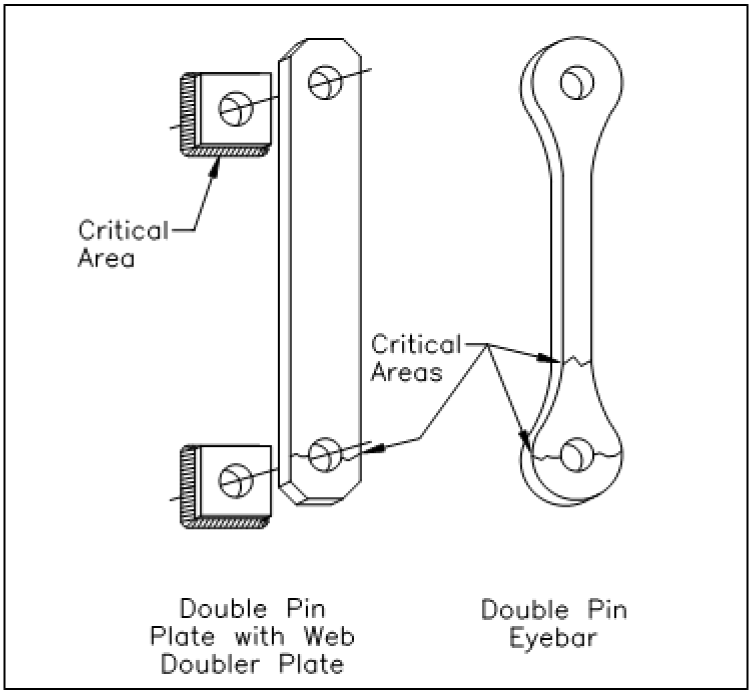


Figure 6.2.5a: Fatigue cracks in pin assemblies

- All suspected cracks shall undergo Nondestructive Testing (NDT) to attempt to confirm the existence and extent of the crack. All confirmed fatigue cracks shall immediately be reported in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 3.2.7.

Special Note:

Disassembly of pin assemblies for inspection:

- ***No portion of any pin assembly should ever be disassembled by bridge inspection personnel.*** *Partial or total disassembly of a pin joint shall be undertaken only by approved personnel, after proper engineering design is performed with auxiliary support supplied.*
- *Removal of the retainer nuts or caps should not be attempted unless an alternate means of retaining the connected members on the pin is in place.*
- *Pins are generally difficult to remove even after the retaining assemblies are dismantled. However, this is not always true and a pin that is subjected to high torsional stresses, due to impacted rust, can rotate or fail suddenly if the nut is loosened. Connected members that are subjected to bending stress due to impacted rust, may slip off the "shoulder" (or pin itself) once the nut is loosened.*
- *Partial or full disassembly of pin assemblies shall never be undertaken until all live load is removed from the structure. Live load shall remain off the structure until reassembly is complete.*

Nondestructive Testing:

- *Ultrasonic testing is currently the best means available for checking pins, in place, for internal flaws. However, the presence of "dead spaces" within the pin (locations where sound waves can not reach due to the geometry of the pin surface relative to the transducer) may skew test results.*
- *Only trained, certified technicians, knowledgeable in the theory and limitations of ultrasonic testing should perform and evaluate the test results.*

Truss Tension Members:

- This section shall cover all truss tension members.
- Members that undergo force reversal shall be inspected as tension members.
- Inspect all tension members for signs of corrosion, section loss, wear, impacted rust, fatigue induced cracks, impact damage, signs of misalignment, debris build up, loose, missing or deteriorated fasteners, and other deterioration.
- Check alignment of tension members. Buckling or bowing due to causes other than impact, may be indicative of permanent force reversal and may be caused by settlement, tilting or other displacement of the substructure elements. If bowing or buckling is observed, a thorough investigation as to the causes and effects shall be conducted.
- Check that all of the diagonals are fully engaged and that they are tight to their connections.
- Inspect eyebars for scoring from contact with the verticals and worn heads.
- Check for unequally tensioned eyebars.
- Inspect all pin holes for signs of wear.
- All welded repairs, connections, cover plates, utility connections and any other miscellaneous welds on tension members shall be inspected "hands-on" for fatigue cracks or other defects. See Appendix A6.1 for typical details. Particular attention shall be placed on inspection of welds that are transverse to the direction of applied stress.
- All suspected cracks shall undergo NDT to confirm their existence and determine the extent of the crack. All confirmed fatigue cracks shall be immediately reported in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 3.2.7.
- Inspect counter members to see if they are laterally movable by hand. Counters are designed to be stressed during live load application only. Inability to move counters during dead load application only indicates that unanticipated loads are being applied to the member.
- Inspect counter eyebars, within a panel, for contact, abrasion dust or wear between the eyebars at the cross over.
- Inspect eyebars for corrosion and cracks along their entire length. Particular attention shall be paid to forged joints between rolled bars and their cast eye.
- Inspect threaded rod eyebars and turnbuckles for corrosion, impacted rust, tack welds and cracks. Inspect the threaded portion of the rod for signs that the turnbuckle is loosening.

Truss Compression Members:

- This section shall cover all truss compression members.
- Inspect all compression members for signs of buckling, web crippling, corrosion, section loss, impacted rust, collision damage, wrinkles or waves in flanges, welds,

misalignment, debris buildup, loose, missing or deteriorated fasteners or other deterioration. Buckling, warping, wrinkling, etc., may indicate member overstress. Section loss, tears, misalignment, etc., may result in possible loss of load capacity. Both conditions warrant analysis to determine the effects on the structure.

- Inspect the condition of lacing bars, stay plates and batten plates. Note that the condition of these items will not normally be considered when assigning a condition rating to the compression member. However, if deterioration extends into the compression member base metal or if the alignment of compression member components is affected (impacted rust causing bent flanges, web plates, etc.), sound judgment shall be used to determine if and to what extent the condition rating should be adjusted.
- Truss top chord members, that are integral with the bridge deck or that support portions of the floor system between panel points, shall be inspected as both axially loaded and bending members.
- Check for cracks at the top chord splices, primarily at hip connections.
- Inspect for wear at the pin holes.
- Inspect all splice plates for loose, missing or deteriorated fasteners, cracks and impacted rust.

Secondary Members:

- Inspect the top chord, bottom chord and floor system lateral bracing, sway bracing and knee braces for cracks, corrosion, impacted rust, loose, missing or deteriorated fasteners, proper alignment, debris buildup, impact damage and other deterioration.
- Look for section losses to the lateral bracing at the end connections and between “back to back” angles.
- Inspect the portal frame for fatigue cracks in the upper connections.

Documentation for Routine Inspections:

- Document all steel losses by noting the area and depth of the loss, as well as, the relative location along the length of the member measured from a fixed point (e.g. 12” H x 12” W x 1/8” deep loss on the north web plate of member U3L4, North truss, beginning 3”. Whenever possible, where deterioration is noted, calipers or other measuring devices shall be used to measure the remaining section instead of estimating the loss. Notes should clearly indicate whether an “estimated loss” or “measured remaining thickness” is being given. See Appendix A6.2 for typical examples of documenting deterioration.
- Document whether rotation within the pin assembly was observed.
- Document the location and amount of any impacted rust found at pin assemblies and whether rotation of the connected members is affected.
- Note the locations and condition of all welded repairs, connections, cover plate ends, utility connections and other miscellaneous welds on all truss and metal arch tension members and in tension zones of all girders and beams.

- Determine the approximate percentage of bolts/rivets with section loss in the head/bolt and document the extent of the loss (e.g. 20% of rivets exhibit 10% section loss).
- Document, in the field notes, locations of all loose bolts/rivets. Mark locations on the bridge with a permanent marker or lumber crayon along with the date found.
- Document locations and lengths of all cracks found. Mark these locations on the bridge with a permanent marker or lumber crayon. Note the date found and the limit of crack propagation in such a manner that subsequent inspections may determine additional crack propagation. The method of inspection shall also be noted as the crack may have propagated farther than may show visually. If any retrofit has been made to an old crack or holes drilled to arrest existing cracks, evaluate the effectiveness of the retrofit and note whether the crack has propagated past the arresting hole.
- Particular care shall be given to documenting the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes. If increased quantity or size of deteriorations causes the condition rating to change from the last inspection, a photograph and explanation of why the rating has changed shall be included in the inspection report.
- The results of all NDT performed shall be included in the inspection report.
- Typical conditions and deteriorations causing a condition rating of less than or equal to “5” shall be photographed as outlined in Chapter 5.
- A simple framing plan shall be provided showing locations of deteriorations and other problems noted. Member elevations and cross sections shall be provided, as required, to adequately describe deteriorations noted.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for a routine inspection, “hands-on” access shall be provided to all primary and secondary superstructure members.
- The following details, with the approval of the Transportation Supervising Engineer, shall be inspected using ultrasonic NDT procedures:

    1. All transverse, full penetration groove welds, found in the tensile zones of fracture critical members.

    2. All pin and hanger assemblies.

    3. If any welded detail on the bridge has experienced fatigue cracking in the past, all similar details shall be considered for testing. The need for additional NDT shall be determined by the Transportation Supervising Engineer.

Documentation for In-Depth Inspections:

- All documentation required for a routine inspection will be included in the in-depth documentation except as noted in this section.
- A simple framing plan shall be provided showing locations of deteriorations and other problems noted. Member elevations and cross sections of all FCMs shall be provided showing all deteriorations found, as well as, the location and classification of all Fatigue Sensitive Details as defined by AREMA fatigue category D, E, or E' details. Member elevations and cross sections of all other members shall be provided as required to adequately describe deteriorations found.
- Documentation, as a whole, shall clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph that documents the overall condition of the superstructure shall be provided. Detailed photographs, that support the condition reported, shall be provided.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure that they are mutually supportive of their documentation.
- The inspection reviewer shall determine if fatigue problems have been noted and whether patterns of deterioration or progressive deterioration are taking place. If fatigue cracks are noted, the reviewer shall ensure that procedures for reporting critical deficiencies have been initiated. Rate of deterioration progression will be determined by comparing present to past inspection reports.
- The appearance of new, or the sudden propagation of existing, fatigue cracks may warrant a new load or fatigue analysis and/or load posting of the bridge structure. A note should be placed in the file stating that fatigue problems are evident and that they should be monitored closely.

Maintenance Concerns

- Most repairs to steel members will be structural in nature and may have an effect on the load carrying capacity of the structure. Repairs should be detailed and performed under the direction of a Transportation Supervising Engineer.
- Fatigue cracks, that show little or no crack propagation for extended periods, can suddenly resume propagation, possibly resulting in member failure. Therefore, all cracks found shall be immediately reported and corrective action should be taken as soon as possible to ensure the integrity of the structure and safety of the public.
- Areas of section loss, gouges, dings, and impacted rust are all stress risers in steel members and should be monitored closely or repaired.

Figure 6.2.5b Pratt Truss – side view

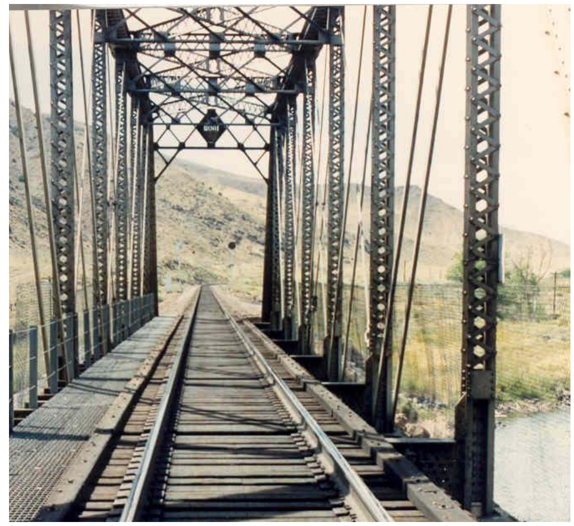


Figure 6.2.5b Pratt Truss – end view

Figure 6.2.5c Joint U1 – hip joint patch plates over crack in bent plate joint movement

Figure 6.2.5d Bottom chord – loose eyebars (note bow in bars)

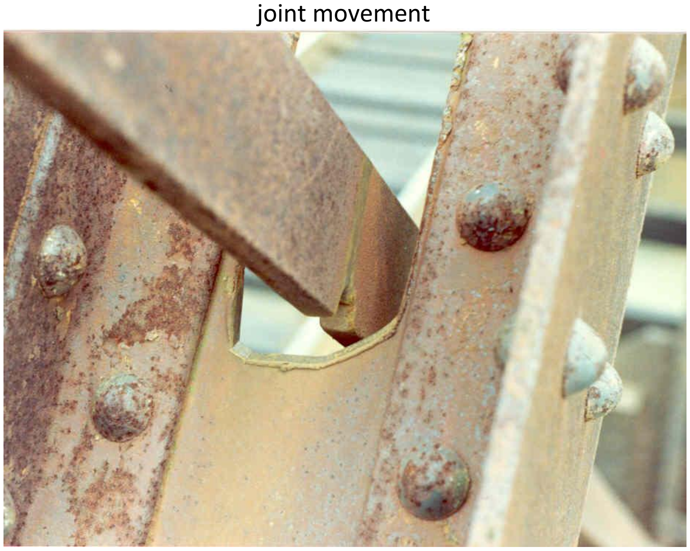


Figure 6.2.5e Pratt Truss – loose counter with section loss

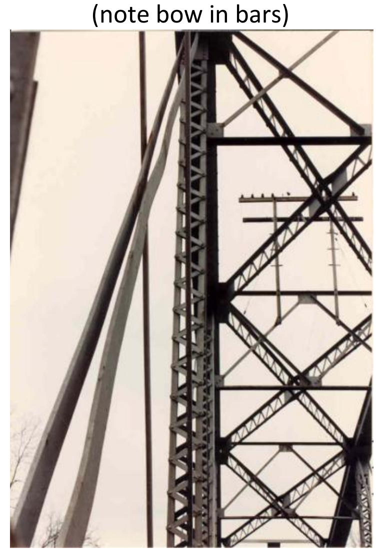


Figure 6.2.5f Pratt Truss – loose diagonal eyebars

Figure 6.2.5g Slippage mark indicates amount of wear in joint

Figure 6.2.5h Pin and counter wear

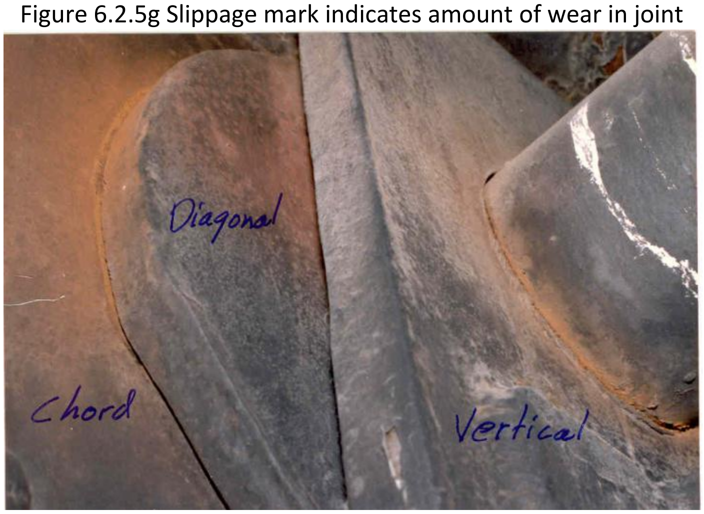


Figure 6.2.5i Interior of upper chord joint
(note wear at pin and slippage between diagonal and chord)

Figure 6.2.5j Lower pin joint slippage marks indicate wear in components

Figure 6.2.5k Reinforced stringer – floorbeam connection due to movement in truss members

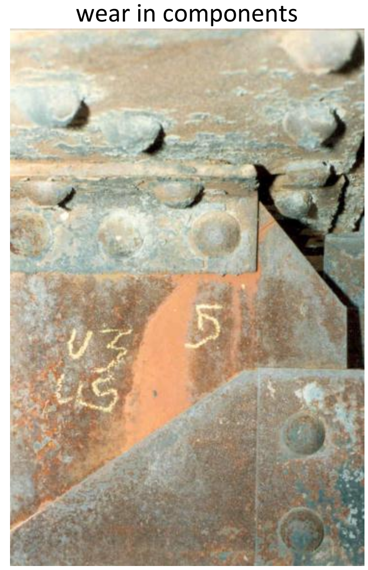


Figure 6.2.5l Sway frame connection plate crack

6.2.6 Moveable Bridges

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 10
Reference: AREMA Manual for Railway Engineering© CHAPTER 15 PART 6
Reference: BIRM, Sections 12.2
Reference: AASHTO Movable Bridge Inspection Evaluation and Maintenance Manual 1st Edition

General:

Movable bridges are complex structures involving multiple disciplines for their design, maintenance and inspection. By their very nature of being movable, these bridges require structural, mechanical and electrical attention. Often these bridges are located in harsh environments, over waterways of either fresh or salt water. Generally, they are built close to the water level and are therefore subject to constant moist conditions and exposure to marine collisions. All of these conditions require above normal maintenance needs. Of paramount importance, these bridges must operate reliably.

Movable bridges are constructed over navigable waterway, if the bridge cannot be opened to prescribed clearances, the Coast Guard should be immediately notified and efforts taken to restore the clearance. Likewise, should the bridge electrical mechanical system experience a failure, the Coast Guard needs to be advised of the problem and the time to restore operations.

Today the surviving types of movable bridges are the swing, bascule and vertical lift. The AREMA *Manual for Railway Engineering*, Chapter 15, Part 6 - Movable Bridges provides information concerning specific design and detail elements of these bridges, both for items common to all types of movable bridges, as well as, for items specific for each type bridge.

The format for this Section is divided into general inspection information, followed by structural inspection information specific to swing bridge, bascule bridge, vertical lift bridge, operator's house and fenders & dolphins. Other aspects of moveable bridge inspection, such as mechanical and electrical, need to be completed by specialists in each discipline and should follow the AASHTO *Movable Bridge Inspection Evaluation and Maintenance Manual* for their inspection. The track & signal and communication inspection will be performed by the Railroad.

Inspection

A complete inspection of a movable bridge generally requires a team of inspectors; one for each discipline - structural, mechanical and electrical. It is important that all inspectors be familiar with the operations of each bridge type to be inspected and the general functioning of each major component. Railroad Personal need to be present at the time of the mechanical and electrical inspections. It is important that the mechanical and electrical inspections for all major components be performed at the same time.

A movable bridge inspection generally may include all or most of the following elements, depending on the level of inspection requested:

- System Operational Reliability - all disciplines.
- Structural Inspection - the bridge structural components and supports, special movable bridge structural elements (for example: bascule segmental girders, counterweights), bridge balance and seating during operation, the operator's house, machinery house, and bridge protective fenders and dolphins.
- Mechanical Inspection - mechanical components - gearing (open and closed), shafts, couplings, bearings, trunnions, trunnion bearings, sheaves, pivot bearings, balance wheels,

tracks, counterweight ropes and chains, locks, toggles and wedges, wire rope, brakes and lubrication.

- Electrical Inspection - commercial power, standby power, power transfer switches, motors and motor control centers, lighting, control system, interlocks, navigation and aerial lights, conduit, wiring, control desk, panel boards and cabinets, relays, limit switches and indicator lights.
- Safety Inspection - operations, lockout during inspections/maintenance, walkways, ship ladders and platforms.

Prior to starting any movable bridge inspection, the inspector should consult with the bridge tender and maintenance personnel concerning the operational qualities of the bridge. Any changes in the performance of the bridge, any known problems, including those of an intermittent nature, and other information should be discussed. These personnel have the first-hand knowledge of the bridge. Log books may be kept by the bridge personnel who may give insight to repetitive problems, as well as, document the efforts being made in maintaining the bridge.

Moveable bridges present a number of hazards to the inspector due to energized electrical equipment, moving machinery and crushing hazards when the bridge operates. Coordination with the bridge operator and appropriate lock-out/tag-out procedures are imperative to protect inspectors working around the machinery and to prevent unexpected movement of the bridge.

The inspection should conduct trial openings to allow the inspector to observe the various functions of the bridge. Trial openings that have frequent starts and stops lend to better observation of gearing, bearings and other items. Safety during the operation of the bridge, with teams of inspectors, must include procedures for proper activation/de-energizing of the bridge.

Structural Inspection - The structural inspection should follow normal bridge inspection procedures as described in the other Sections of this chapter for superstructure and substructure inspection that apply to movable bridges. In addition, as presented later in this Section, there are specific elements of each type movable bridge that have special structural features. Of primary importance is the finding of defects, damage, and deterioration to primary elements. Fatigue considerations and fracture critical members likewise require the same attention as for other bridges. Certain elements of movable bridges may have complete reversals in stress which should be closely observed for potential crack development.

Additional structural items include the inspection of control houses, machinery houses, walkways, ladders, platforms, stairways and elevators. Most movable bridges also have fender and dolphin systems, which require close inspections.

Mechanical Inspection - The mechanical inspection is often performed by a mechanical specialist with years of experience in the proper operations and functioning of mechanical systems and their components, such as: gearing, shafts, couplings, bearings, brakes, locks, linkages, hydraulic components, and other component parts of equipment that transmit mechanical power. Observations are made for alignment, noise, vibration, damage, wear, heat, proper functioning, lubrication and needs for maintenance or repair.

Most mechanical systems on movable bridges are built for rugged operation and, even with some degree of wear, components generally have long life expectancy. Older mechanical systems often are upgraded by eliminating long line shafts and installing either hydraulic components to power end items or electric motors with gear boxes.

Electrical Inspection - The electrical inspection is often performed by an electrical specialist with years of experience in power and control systems. The inspector should observe the functional operation of the bridge, look for abnormal performance of the equipment, and identify items that do not conform to current National Electric Code standards. Items of interest include: incoming commercial power, standby power sources, power transfer switching, cabling (submarine, conduit and aerial), navigation lighting, motors, brakes, control panels, control systems, programmable logic controllers (PLC) computer control systems and the remote control equipment. Included in inspections should be a review of available spare components at the bridge site. The review of log book entries, indicating faults or other problems, should be reviewed with the bridge tender and others.

Inspection Techniques:

In addition to the visual condition and measuring techniques available to the inspector, signs of distress may become apparent to the inspector by:

Looking for telltale signs of wear in moving parts such as:

- Orange abrasion dust from the rubbing together of unlubricated ferrous metals.
- Lubricant accumulations full of metal particles or grit.
- Sloppy fit, evidenced by relative motion in machine parts during operation.

Assessing unusual odors that can provide useful information as follows:

- Hot brake lining odor from a thrust or solenoid brake may indicate it is improperly adjusted and drags.
- Wire insulation has a distinctive odor when overheated.
- Fluids such as leaking hydraulic oil, diesel, or gasoline can be identified and/or located by odor.

Assessing excessive vibration through bridge parts can assist the inspector to:

Trace a noise through the structure by feeling the parts with the fingertips to detect the vibrations associated with the particular noise. The vibrations increase as the fingers move closer to the source of noise. Probing with the finger can help locate defects that are not visible. (Do not perform this inspection while the parts are moving).

Riding the structure can give a “seat of the pants” feel for any operational defects.

Assessing unusual sounds that can help the inspector to:

Focus on problem areas. A mild power hum from the motors is expected as the span accelerates. Each individual bridge will have some chronic sounds that may be acceptable, but a noise is acceptable only after the inspector identifies and assesses it. If an adjustment can be made to reduce the noise, it should be considered. Unnecessary sounds interfere with hearing the important noises that could detect distress.

Determine the type of problem. Groaning or squealing noises during operation generally indicate poor lubrication of moving parts. Snapping, banging, clicking or clanging noises generally indicate “stick-slip” of moving parts and/or advanced wear and damage that may be a potential hazard.

Special Note:

It is important that inspectors and maintainers understand the purpose of each functional system and are able to evaluate the operation of each system, as well as, assess the condition of individual components. An experienced inspector should be able to identify a component problem, evaluate the impact on the functional system, and extend the findings to determine the impact on bridge operations. Without understanding the functional systems, it would be difficult for an inspector, observing an operational problem, to diagnose the possible cause. The ability to view a movable bridge, as a series of functional systems, will assist the inspector in better understanding movable bridge operation.

6.2.6.1. Swing Bridges

Reference: AREMA Bridge Inspection Handbook©, Chapter 10 Section 3
Reference: BIRM, Sections 12.2.2, 12.2.6, 12.2.9 thru 12.2.11 and 12.2.13
Reference: AASHTO Movable Bridge Inspection Evaluation and Maintenance Manual 1st Edition

General

Swing bridges consist of two-span trusses or continuous girders which rotate horizontally about a center pivot. Turntables are similar to swing bridges. The swing spans are usually symmetrical about the pivot but can be unequal in length (bob-tailed) with counterweights provided to equalize the balance. When in the closed position (ready for rail traffic) all swing span ends are wedged for support, sufficient to offset any negative reaction (uplift).

The swing bridge offers unlimited vertical clearance but has generally half the horizontal clearance of a vertical lift bridge of comparable length span. The swing bridge offers the lowest profile. The swing bridge generally is operated in one direction, or 90 degrees in either direction or to a skew of the waterway alignment. However some can be positioned end-to-end for 360 degrees, if there are special needs and there are special electrical connections.

Swing bridges are classified by type:

• Center-bearing or pivot support swing.

• Rim-bearing.

The center-bearing type swing spans carry the entire weight of the bridge on a central pivot and are balanced against tipping by generally 4 to 8 balance wheels. The balance wheels are attached to the span underside, in a circular pattern, to ride on a circular track anchored to the pier. Commonly a circular rack is attached to the track, or integral with the track, to which drive pinion(s) engage for movement of the bridge. The center-bearing type span is typically fitted with six wedge assemblies, two at each end and a pair at the center of the bridge. It is intended that the end wedges engage the wedge supports sufficient to take the drop out of the span and raise the ends to a plan elevation. The center wedges stabilize the center and are driven snug so that they support live loads rather than the pivot bearing but they are not intended to lift the swing span off the center-bearing.

Center-bearing is usually a large casting or housing that holds a multi-stack of bearing elements called discs or lenses. Traditionally the bearing "sandwich" consists of an upper and a lower steel disc or lens fixed by pintles to the housing and with concave inner surfaces to which a central bronze disc, or lens with convex surfaces, mate. Oil/grease grooves are cut into the steel lens to distribute the lubricant uniformly across the entire bearing elements interfaces.

The rim-bearing swing span carries the entire weight of the bridge through a circular girder, to a ring of tapered rollers (wheels), then to a circular track. Their position is held constant by the use of spider rods connecting the rollers to the center pivot. A center pivot is provided only for maintaining the swing span concentric with the track and circular rack. Typically, no loads are passed vertically through the center pivot. The rim-bearing swing span has only four wedge assemblies, a pair at each end. The bridge live load is transmitted through the end wedges and the center ring of rollers.

Both types of swing bridges have end latch assemblies to assist in proper positioning of the bridge in the closed position. A positioning variation for swing bridges that rotate in only one direction is the use of an end bumper for alignment. Swing bridges with center fenders may also be fitted with either wedge supports or a bumper for the bridge to swing against while holding the open position.

For both types of swing bridges there is a circular track for the wheels/rollers to move on as the bridge is operated. A circular rack is attached or often integral with the track for the bridge. Typically, span mounted machinery drives a pinion(s) that engages the rack to power the bridge open and closed. Depending on the size of the swing bridge, there may be from one to four drive pinions needed for turning the bridge. For the multiple drive pinion arrangement, machinery is provided to assure that the load is shared among the multipinions.

Operational Sequence:

To close the bridge from an open position:

1. Sound the horn to close the bridge; assure it is safe to operate the bridge; no marine vessels approaching; and all maintenance workers are clear per railroad safety procedures.
2. Swing the bridge closed: electrical/mechanical system controls/powers the drive pinion until the swing span is closed. With the bridge barely moving, the end latch raises up a ramp and drops into a slot to assist in proper span alignment. With the bridge in the closed position, the center navigation light facing the marine channel is showing red to mariners.
3. The drive system is then used to engage the wedges, while the miter rails are lowered into their mating components.
4. The drive system is deactivated.
5. The signal system is activated and, if all functions are properly complete, the signal light will turn to "green".

To open the bridge from a closed position:

1. Reverse process – when complete, the navigation lights facing mariners will be green and the signal lights for the rail traffic will be red.

Inspection Requirements:

Support System:

- Observe support system components under typical loading conditions for unusual movement, vibration or sound. (***Riding the span as it moves may be necessary in some cases to properly accomplish this task. If inspectors are to ride the movable span, the operator must be so informed. The inspectors should carefully select tie-off locations to be clear of moving parts at all times, and should utilize required personal and fall protection equipment.***)
- Evaluate smoothness of swing span motion. (*Span drive motor amperage draw should be consistent with the motors operated at constant speed, in the absence of outside forces such as wind*).

- Watch the span arms for any up and down movement.
- On rim-bearing swings, all rim bearing wheels should turn synchronously. (*One wheel moving slower than the others, skidding, or not moving at all, means that it is not carrying its full share of the load.*)
- Center bearing swing balance wheels should not snap, crunch, grind or wobble in motion.
- Inspect the center bearing, look for section loss, warpage, or other deterioration which would impact bridge structural capacity, alignment and operation of the pivot machinery and/or wedges.
- Watch the rim-bearing to ensure the rim wheel is not frozen.
- Inspect the rim wheel for cracks.
- Inspect the spider rod at center connection plate for deterioration.
- Check for component deterioration under miter rails.
- Look for broken teeth on the circular rack.
- Note the condition of lens or discs, look for gummed surfaces due to poor lubrication/dirt.
- Inspect the pinion shaft bearings for wear and note the condition of the bearing fastener preload.
- Check the bearing and machinery support fasteners for section loss.

Balance System:

- Inspect asymmetric swing spans for the correct amount and placement of balance components.
- Inspect symmetric swing spans for alterations that may have changed span balance from its initially balanced condition.
- Consult available design and rehabilitation plans to determine the basic design configuration of the counterweight system and the locations of all adjustment pockets or trays. (*Often loose balance adjustment blocks are placed in closed spaces constructed into the counterweight assembly.*)
- Inspectors should determine how many balance adjustment blocks are present and where they are grouped. (*A large number of blocks or an asymmetric placement may indicate the span was difficult to balance when it was built or balance was adjusted to correct an operating problem. The presence, in one pocket, of multiple types of blocks may indicate balancing has been required more than once during the life of the bridge.*)
- Check for new ties, paint or railings that can significantly affect span weight and span balance. (*Span balance should be checked during every inspection of a movable bridge*)
- Observe the balance system at rest and during span motion.

- Inspect balance system for localized corrosion or other defects that could cause balance blocks or counterweights to break loose from their support.
- Inspect for signs of previous rebalancing efforts.
- Inspect the interface of concrete counterweights and steel support members embedded in the counterweight for line corrosion at the interface. (*Steel members, especially the counterweight support links, should be carefully inspected for corrosion losses. A failure of one of the structural counterweight support members could initiate collapse of the counterweight, or could create unbalance, binding, interference, or other operational problems.*)
- Watch when the structure brakes to ensure that the brake actuators are not set to engage too rapidly to decelerate high inertial load which can damage machinery or fasteners.

Structural Components:

Typical structural components (such as floorbeams, trusses, stringers, etc.), which are common to fixed and movable bridges, shall be inspected in accordance with Sections 6.1, 6.2 and 6.3 of this manual.

Inspection of unique structural components that occur primarily on movable bridges, and special considerations of typical structural components due to the nature of movable bridge operations, shall be covered in the following sections.

Swing bridges feature unique structural systems for transferring loads from the main structural members (girders or trusses) to the supporting pivot machinery. Typically a pivot girder connects the girders or trusses to the top of the pivot bearing assembly for center-bearing type swing bridges. This may be supplemented by a rim girder to support balance wheels. For rim bearing type swing bridges, a heavy circular rim girder transfers the main structural members' (girders or trusses) loads to the roller assemblies. In either case, this supporting structure must be in good condition, free of major section loss, warpage, or other deterioration which would impact bridge structural capacity, alignment and operation of the pivot machinery and/or wedges.

Special Note:

Lubricants and other coatings will tend to accumulate under movable bridge machinery on structural members. These coatings interfere with the inspection of the members they coat and should be removed to permit close inspection.

- Before the inspection is commenced, a study of the structure shall be done to determine the locations of all fracture critical members (FCM's) and fatigue sensitive details (FSD's). The study shall include identification of all force reversal members due to opening and closing operations. All FCM's shall be marked for inspection in accordance with the guidelines given in Chapter 5 for Fracture Critical Member Inspection. Unless otherwise shown by detailed analysis, all built up, rolled and eyebar type tension members shall be considered to be FCM's and inspected as such. Girders, floorbeams or stringers may be identified as FCM's based on detailed analysis, engineering judgment and appropriate Federal Guidelines.

- Certain structural components are most heavily loaded during span opening and closing operations. The critical design load of such members often does not include vehicle live load. The inspection of such components should be based upon the knowledge that distress may be present due to loads resulting from span operation, which are not necessarily vertical loads in all cases.

Substructure:

- Inspect piers for rocking or other movement when the leaf or span is opened. (*This is an indicator of a serious deficiency and should be reported immediately in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in* *Section 3.2.m.*)
- Check the braces, bearings and all housings for cracks, especially where stress risers would tend to occur.
- Inspect concrete and masonry for cracks in areas where machinery bearing plates or braces are attached. (*Note the tightness of bolts and the tightness of other fastening devices used. Loose anchorages can cause movement of machinery and result in misalignment and accelerated deterioration of the substructure elements.*)
- Inspect the substructure elements during opening and closing operations for span or counterweight contact. (*Contact between these elements is an indication of unbalance or misalignment. Interference between substructure and bridge elements during operations can also effect the horizontal and vertical clearances within the navigational channel limits.*)

Superstructure:

- Inspect the live load bearings and span lock bars for proper fit, alignment and if applicable, the amount of lift. When span locks are provided to hold the span in the open position, check for movement under wind load. (*Alignment is a critical item for the proper operation of a swing bridge and often is one of the more problematic items for this type movable bridge.*)
- Check that the wedges properly engage. Look for sticking, operation difficulties and end lifting. (*Failure to engage will cause a far end lifting when a train first enters the near end.*)
- Inspect all joints between fixed and movable portions of the structure for adequate longitudinal clearance that provides for thermal expansion and allows for vertical movement under heavy loads.
- Inspect for defects usually found on fixed bridges, such as loss of section of structural members, fatigue, and wear. (*Often cracks and loose fasteners are noted on structural elements in near proximity of the miter rail joints which can emit excessive vibration and impact from passing rail cars.*)
- Check the superstructure for signs of span warpage. (*A span can warp from being heated by the sun on one side, causing wear of the bearing surfaces of the wedge assemblies.*)

Ship Ladders, Walkways and Platforms:

- Inspect ship ladders, walkways, platforms and all support connections for loose or missing fasteners, cracked welds or fatigue cracks and other deficiencies.
- Inspect stair treads and walkway surfaces for loose or missing components and adequate connection to their supports. Check surfaces for traction deficiencies or accumulation of lubricants or debris that may create a slipping or tripping hazard.
- Inspect all railing connections for loose or missing fasteners, cracked welds, fatigue cracks or other deterioration.
- Inspect all bridge structural components that support ship ladders, walkways and/or platforms for evidence of distress or deterioration.

Counterweights:

- Inspect counterweights to determine if they are sound and are properly affixed to the structure. Also check temporary supports for the counterweights that are intended for use during bridge repair and bumpers that prevent bascule leaf overtravel.
- Where steel members pass through, or are embedded in concrete, check for corrosion of the steel member and for rust stains on the concrete.

Electrical:

- Visual inspect the power pole, weather head, and transformers.
- Flex cables connecting power on the pivot pier with the swing span must be checked for wear and any evidence of kinks or pinch points.
- Check the power transfer switch.
- Check that the engine-generator set works properly and has a proper fuel supply.
- Check that the batteries are in good condition and that the battery charger is working properly.
- Visual inspect conduit runs, note their condition and look for any broken connections.
- Visual check for proper termination of wires in cabinets.
- Check that the wire identifications are correct.
- During operation, inspect for noises, smells and heat build-up in the electrical system.
- Visual inspect the panel boards and circuit breakers, look for proper connections, neatly run wires and condition of the breakers and panel box.
- Note any disconnect switches.

Mechanical:

- Inspect the pivot shaft and bearings for wear.
- Inspect the span end machinery for proper function and wear.
- Check the wheel spider rods for wear.
- Inspect the wedge assemblies, checking for proper function.

Lubrication:

- Inspect the pivot bearing, line shaft bearings, differential, clutch, worm gear box, linkages, wedges, circular rack and track, balance and rim-bearing wheels, open gearing/enclosed gear boxes, hydraulic brakes, motor bearings and latch assembly parts for proper lubrication.

Common Problems:

- span not operating concentric with circular track, resulting in drive pinion bearing failure and poor pinion engagement.
- wedge engagement - sticking, difficult to operate, end lifting.
- span warpage.
- rim wheel frozen, cracked.
- spider rod deterioration at center connection plate.
- component deterioration under miter rails.
- broken circular rack teeth at ends of operation from rough bridge operations.
- lens or discs gummed due to poor lubrication/dirt.
- pivot bearing wear causing the span to sit lower – often reducing the needed clearance between the balance wheels and track.
- excessive wear of pinion shaft bearings or failure of bearing fastener preload.
- fatigue of bearing supports and machinery support fasteners.
- improper balance wheel clearance allowing swing span ends to strike the rest piers during operation.
- brake actuators set too rapidly to decelerate high inertial load, damaging machinery or fasteners.

Documentation for Routine Inspections:

- The typical structural components (such as the deck, floorbeams, trusses, stringers, etc.), which are common to fixed and movable bridges, shall be documented in accordance with Sections 6.1, 6.2 and 6.3 of this manual.
- Typical conditions as well as, deteriorations causing a condition rating of less than or equal to "5" should be photographed as outlined in Chapter 5.
- A good quality photograph of each of the bridge components that documents its overall condition and supports the condition rating should be included.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for a routine inspection, "hands-on" access shall be provided to the entire superstructure.

Documentation for In-Depth Inspections:

- All documentation required for a routine inspection will be included in the in-depth documentation except as noted in this section.
- A simple framing plan, and elevations (as required), of all primary members should be provided. All deterioration or deficiencies found should be noted on these sheets to include size, length, direction, depth, etc. Sections and other detail sketches should be drawn as required to clearly show the locations and extent of deterioration or deficiencies noted.
- Documentation as a whole should clearly describe the condition and serve as an accurate benchmark to which future inspections can be compared.

Report Review:

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer should determine if the pattern, quantity and severity of the deteriorations found support the numerical condition ratings given. The reviewer should compare the present inspection report to past reports.

Maintenance Concerns:

- Proper lubrication of all moving parts must be performed on a regular basis. Excess lubricant should always be removed when new lubricant is added.
- The operation of each of the functional systems should be reviewed and appropriate steps taken to correct or adjust system deficiencies.

Figure 6.2.6.1a Swing span – truss closed position

Figure 6.2.6.1b Swing span – truss Operator/Control House with good vision of channel

Figure 6.2.6.1c Swing span- girder closed position

Figure 6.2.6.1d Swing span – girder open position

Figure 6.2.6.1e Turntable

Figure 6.2.6.1f Swing span – rim support(load thru all wheels)

Figure 6.2.6.1g Rim support - new assembly of wheels spider rods and center plate

Figure 6.2.6.1h Rim support spider rod - section loss at center connection plate

Figure 6.2.6.1i Rim support arrow – crack in wheel(note warp in upper track)

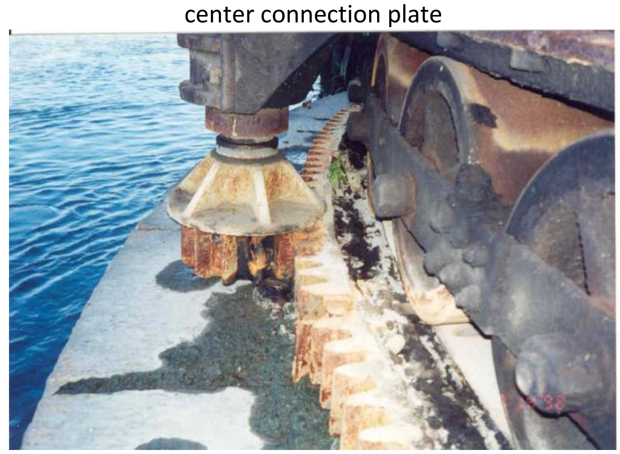


Figure 6.2.6.1j Rim support Rack/Drive Pinion - good alignment wheel protruding

Figure 6.2.6.1k Poor pinion alignment

Figure 6.2.6.1l Journal bearings (top and bottom) - support for drive pinion assembly

6.2.6.2. Bascule Bridges

Reference: AREMA BRIDGE INSPECTION HANDBOOK©, CHAPTER 10 SECTION 4

Reference: BIRM, Sections 12.2.2, 12.2.6, 12.2.9 thru 12.2.11 and 12.2.13

Reference: AASHTO Movable Bridge Inspection Evaluation and Maintenance Manual 1st Edition

General:

The bascule bridge is a movable bridge consisting of either a truss or girder span that is rotated vertically about a horizontal axis. The span may be rotated on a rolling segment, pivoted and pulled to a vertical position through linkages or pivoted about a fixed point. The bascule span is counterbalanced such that the span is approximately balanced in all positions of travel. The bascule span generally rotates through about 85 degrees. In the lowered or closed position (ready for rail traffic) the bridge is locked by span locks and for safety, rails are often locked. In the operation of the bridge, the electrical/mechanical system normally has a drive pinion that engages either a stationary rack or a stationary pinion that is engaged by a moving rack.

The bascule movable type bridge, particularly the rolling lift type, offers a nearly full open vertical clearance (85 degrees) and a good length horizontal opening, but typically less than that provided by a vertical lift bridge. It is primarily used where the channel is not very wide and where vertical height of an open bridge is a significant concern.

There are three common type bascule bridges:

- rolling lift bascule (Scherzer type)
- multi-trunnion, folding parallelogram (Strauss type)
- simple trunnion (Chicago type)

The rolling lift bascule bridge, developed by Scherzer, rolls back on a circular segment girder atop a track girder. It is kept in alignment through the engagement of pintles. The advantage of this type bascule is that as it rolls back, it moves away from exposure to the channel. The Scherzer bascule bridge has a characteristic vertical counterweight in the air above track clearance that rotates to the horizontal position, just above the track, when the bridge is fully opened. The rolling bascule machinery normally is mounted on the movable span at the center of the rolling radii and the drive pinion engages a stationary rack mounted on an independent stationary frame. Air buffers are mounted on the span end to cushion the span as it comes to rest on the bearing pads and span locks secure the bridge in the down position. The bridge is balanced so that the span is slightly toe heavy when seated to give the span a positive end reaction and to prevent end flutter or uplift as live load passes over the span.

The multi-trunnion Strauss bascule consists of a four-sided folding parallelogram bounded by trunnion joints at its corners. The tower front inclined leg is one side of the parallelogram and is stationary. The bascule span heel is jointed to the tower base portion of the inclined leg. An overhead truss, which pivots on a trunnion joint atop the tower inclined leg, balances the span to one side and a counterweight to the other side. An operating strut with an attached rack connects to the hip joint of the span and pulls to fold the parallelogram to raise the bridge and extends the parallelogram to lower the bridge. A characteristic feature of the Strauss trunnion bridge is the swinging of the counterweight from vertical to near horizontal, tucked into the tower. The bridge is balanced so that the toe end is slightly span heavy to give the span a positive end reaction and to prevent end uplift under the passage of live loads. The Strauss bascule also has air buffers to cushion seating and span locks.

The simple trunnion bascule commonly called the Chicago type bascule bridge, pivots on a line of stationary supported bearings. To the rear of the bearing pivot is a counterweight which rotates downward as the bridge is raised. A rack is attached to the bascule span with stationary machinery usually mounted on the pier. This type bascule span typically has live load bearings ahead of the trunnions and rear or tail locks to block live loads to the rear side. Air buffers and span locks are also used on this type bascule.

There remain several Abt type bascule bridges in service. With the bridge in an open position the counterweight hangs down from an A-frame tower top bearing. As the bascule span is lowered, the counterweight rotates and the entire machinery floor rolls up the rear tower legs on a track, while engaging pinions on an adjacent stationary rack.

Although there remain several double-leaf bascule railroad bascule bridges, due to the enormous size shear locks between leafs and other problems in the transfer of live loads, double-leaf railroad bridges are no longer in favor. The inspection of double-leaf bascules is the same as single-leaf bascule spans with special attention to the shear locks or compression/tension connections at the center.

In all bascule bridges, the track structure rotates from horizontal to nearly vertical, thus the need for very good anchorage to the floor system. Bascule bridges that remain in the open position for long periods of time may experience gravitation of the track resulting in crowding of the heel rail joints.

Operational Sequence

To close the bridge from an open position:

1. Sound the horn to close the bridge, assure it is safe to operate the bridge; no marine vessels approaching, all maintenance workers clear, per railroad safety procedures.
2. Lower the bridge: activate the electrical/mechanical system; controls power the drive pinions which engage the racks. With the bridge nearly closed, the lowering speed is reduced to barely moving. The air buffers assist in a soft landing while side guides assist in centering the span. Upon full seating, the span locks are engaged to assure the bridge is seated properly. The navigation light marking the center of the channel turns from green to red, facing the mariners. Rail locks are inserted.
3. The drive system is deactivated.
4. The signal system is activated and if all functions are properly complete, the signal light will turn to "green".

To open the bridge:

1. Reverse process – when complete, the navigation lights facing mariners will be green and the signal lights for the rail traffic will be red.

Inspection Requirements

Support System:

- Evaluate the uniform motion of bascule operation.

Special Note:

Sudden changes in span drive motor amperage should not occur except in response to wind or other external effects. A smooth rise or fall in motor current can be caused by the motion of the span center of gravity through an arc, during span motion. Current AASHTO standards require a small positive toe reaction on bascules. This code requirement means that the true span center of gravity (c.g.) must be forward of the center of rotation (c.r.). If the c.g. is vertically located higher than the c.r., it may go over center or move rotationally with the span upward and backward until it moves to a point above and to the rear of the c.r. during the latter part of span motion. This type of structure would then decrease load on the span motors as it opened until it went over center, at which time, the span should begin to accelerate slightly at constant power.

Balance System:

Special Note:

A poorly balanced span or bascule leaf puts excessive loads on drive system components that are designed to work in conditions of near perfect balance. Machinery, from the drive motor through the final drive pinion and rack, may fail unexpectedly and without warning due to these loads. Poor balance can also cause tipping, binding and failure of structural elements. All possible steps should be taken to correct the unbalanced span once the condition is discovered. Many factors can cause an unbalanced condition. Wind, rain, and snow-loading cause temporary imbalance, but are unavoidable. Other conditions, such as accumulation of several coats of paint, removal or addition of counterweight blocks, and trunnion shaft misalignment cause a continuing unbalanced condition to persist.

The balance system is one of the most important design features and is often overlooked or not fully understood by inspectors. Inspectors should be aware of the function of balance in the continued safe operation of a movable bridge.

- Inspect gear teeth to determine if one side of the tooth is more worn than the other. If there is a fairly consistent pattern of teeth wearing more on one side than the other, the span is probably not well balanced.
- Inspect gear teeth to see if the face of the teeth that make contact during the opening cycle are more worn than the face that are in contact during the closing cycle. This indicates the bridge is "span-heavy." If the latter faces of the gear teeth are more worn, the leaf is counterweight heavy .
- Consult available design and rehabilitation plans to determine the basic design configuration of the counterweight system and the locations of all adjustment pockets or trays. (Often loose balance adjustment blocks are placed in closed spaces constructed into the counterweight assembly.)
- Inspectors should determine how many balance adjustment blocks are present and where they are grouped. (A large number of blocks or an asymmetric placement may indicate the span was difficult to balance when it was built or balance was adjusted to correct an operating problem. The presence, in one pocket, of multiple types of blocks may indicate balancing has been required more than once during the life of the bridge.)
- Check for new ties, paint or railings that can significantly affect span weight and span balance. (Span balance should be checked during every inspection of a movable bridge)
- Observe the balance system at rest and during span motion.
- Inspect balance system for localized corrosion or other defects that could cause balance blocks or counterweights to break loose from their support.
- Inspect for signs of previous rebalancing efforts.
- Inspect the interface of concrete counterweights and steel support members embedded in the counterweight for line corrosion at the interface. (*Steel members, especially the counterweight support links, should be carefully inspected for corrosion losses. A failure of one of the structural counterweight support members could initiate collapse of the counterweight, or could create unbalance, binding, interference, or other operational problems.*)

Structural Components:

Typical structural components (such as floorbeams, trusses, stringers, etc.), which are common to fixed and movable bridges, shall be inspected in accordance with Sections 6.1, 6.2 and 6.3 of this manual.

Inspection of unique structural components that occur primarily on movable bridges, and special considerations of typical structural components due to the nature of movable bridge operations, shall be covered in the following sections.

The inspection of items peculiar to bascule type bridges are segmental girders, track and treads, pintles, rack frame supports, live load bearings, tail locks, counterweights, bridge balance and track droop.

Bascule bridges by nature of pivoting and tilting allow for the accumulation of debris and development of corrosion on the floorbeam side, facing upward, upon bridge opening. Additionally, if a bascule bridge is normally held in the open position, the weight of the track section, about the weak axis of the floorbeams, may show signs of bending.

Special Note:

Lubricants and other coatings will tend to accumulate under movable bridge machinery on structural members. These coatings interfere with the inspection of the members they coat and should be removed to permit close inspection.

- Before the inspection is commenced, a study of the structure shall be done to determine the locations of all fracture critical members (FCM's) and fatigue sensitive details (FSD's). The study shall include identification of all force reversal members due to opening and closing operations. All FCM's shall be marked for inspection in accordance with the guidelines given in Chapter 5 for Fracture Critical Member Inspection. Unless otherwise shown by detailed analysis, all built up, rolled and eyebar type tension members shall be considered to be FCM's and inspected as such. Girders, floorbeams or stringers may be identified as FCM's based on detailed analysis, engineering judgment and appropriate federal guidelines.
- Rolling bascule segmental girders are faced with either castings or long curved tread plates. The casting rarely have problems but the tread plates are known to crack, roll the edges of the girder webs and often have loose fasteners particularly at tread plate joints. Pintle wear can cause difficulties in proper "tracking" of the bascule as the bridge is lowered.
- The Strauss bascule bridge counterweight truss members, adjacent to the counterweight, have a full reversal in loading during each bridge cycle. Fatigue cracks may be found in these members. These bascule bridges additionally may have a problem with the breakage of retainer bolts in the trunnion joints and wear between the trunnion sleeve and supporting gusset plates. Cracks have also been found in the rear hip gusset plates, at the interface with the counterweight concrete. A combined structural-mechanical problem often occurs in this type bascule bridge in the operating strut guide assembly. The assembly bottom castings have a tendency to crack adjacent to the drive pinion. Wheel bushings wear, which affects the mesh of the pinion with the rack and fasteners, are difficult to tighten in the castings/wheel blocks due to the lack of access.

- Bascule bridges with live load bearings commonly have a problem with the bearings being pounded into the pier concrete and, as a result, not being effective. The tail locks also are exposed to heavy impact loads and require regular maintenance.
- The counterweight concrete must be inspected for deterioration. The counterweight pockets for fine adjusting the balance, should be closed to weather, as well as, to prohibit the entrance of birds. Plugged drains within counterweights have been known to affect balance and in cold regions have caused the cracking of the counterweight concrete walls.

Substructure:

- Inspect piers for rocking or other movement when the leaf or span is opened. (*This is an indicator of a serious deficiency and should be reported immediately in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in* *Section 3.2.m.*)
- Check the braces, bearings and all housings for cracks especially where stress risers would tend to occur.
- Inspect concrete and masonry for cracks in areas where machinery bearing plates or braces are attached. (*Note the tightness of bolts and the tightness of other fastening devices used. Loose anchorages can cause movement of machinery and result in misalignment and accelerated deterioration of the substructure elements.*)
- Inspect the substructure elements during opening and closing operations for span or counterweight contact. (*Contact between these elements is an indication of unbalance or misalignment. Interference between substructure and bridge elements during operations can also affect the horizontal and vertical clearances within the navigational channel limits.*)

Superstructure:

- Inspect the live load bearings and span lock bars for proper fit, alignment and if applicable, the amount of lift. When span locks are provided to hold the span in the open position, check for movement under wind load.
- Inspect all joints between fixed and movable portions of the structure for adequate longitudinal clearance that provides for thermal expansion and allows for vertical movement under heavy loads.

Ship Ladders, Walkways and Platforms:

- Inspect ship ladders, walkways, platforms and all support connections for loose or missing fasteners, cracked welds or fatigue cracks and other deficiencies.
- Inspect stair treads and walkway surfaces for loose or missing components and adequate connection to their supports. Check surfaces for traction deficiencies or accumulation of lubricants or debris that may create a slipping or tripping hazard.
- Inspect all railing connections for loose or missing fasteners, cracked welds, fatigue cracks or other deterioration.
- Inspect all bridge structural components that support ship ladders, walkways and/or platforms for evidence of distress or deterioration.

Counterweights and Counterweight Pits:

- Inspect counterweights to determine if they are sound and are properly affixed to the structure. Also check temporary supports for the counterweights that are intended for use during bridge repair and bumpers that prevent bascule leaf overtravel.
- Where steel members pass through, or are embedded in concrete, check for corrosion of the steel member and for rust stains on the concrete.
- Check the strut connecting the counterweight trunnion to the counterweight for fatigue cracks. (*Cracks may develop in the webs and bottom flange near the gusset connection at the end nearest the counterweight. This crack will be most noticeable when the span is open.*)
- Inspect the counterweight pits for standing water. Buoyancy forces on the counterweight can affect span balance and overload machinery and motors, causing unexpected movements of the bridge. Check sump pumps, if present, for proper function.

Electrical:

- Visual inspect the power pole, weather head, and transformers.
- Flex cables connecting power on the pivot pier with the swing span must be checked for wear and any evidence of kinks or pinch points.
- Check the power transfer switch.
- Check that the engine-generator set works properly and has a proper fuel supply.
- Check that the batteries are in good condition and that the battery charger is working properly.
- Visual inspect conduit runs, note their condition and look for any broken connections.
- Visual check for proper termination of wires in cabinets.
- Check that the wire identifications are correct.
- During operation, inspect for noises, smells and heat build-up in the electrical system.
- Visual inspect the panel boards and circuit breakers, look for proper connections, neatly run wires and condition of the breakers and panel box.
- Note any disconnect switches.

Mechanical:

- Inspect the shafts for signs of warpage, distortion or cracks in keyways and loss from corrosion.
- Check that the collars are properly positioned and tight on the shafts to hold the shafts in postion.
- Inspect shaft bearings for even wear.
- Inspect breaks checking that the drum surface true and not glazed, the brake pad thickness, pads fit drum, release and set correctly, proper torque settings, fluid levels, alignment of pads to drums

- Check gears for tooth breakage, alignment, mesh and wear.

Lubrication:

- Inspect the line shaft bearings, differential, racks and pinions, span locks, centering devices, hydraulic brakes, motor bearings, open gearing/enclosed gear boxes, track and tread plates, pintles, and air buffers. for proper lubrication.

Common Problems

- maintaining bridge balance, holding the toe end down
- span lock engagement tolerance
- rails crowding at the heel of the span
- air buffers, sticking plunger and bent plunger
- the cone gear in the differential gear set is subject to extreme wear and deformation
- journal lining wear
- pinion bearing support fasteners fail
- brake actuators stick
- counterweight deterioration

Scherzer Type

- tracking (worn pintles)
- loose tread plate fasteners
- cracked tread plate connection angles/worn web plates
- corrosion of embedded steel grillages/track/rack frame

Strauss Type

- broken trunnion retainer bolts
- fatigue cracks in counterweight truss
- operating strut guide assembly loose fasteners, poor gear mesh, casting cracks

Chicago Type

- poor live load bearing pads
- poor tail lock conditions
- worn trunnion bearing bushings

Documentation for Routine Inspections:

- The typical structural components (such as the deck, floorbeams, trusses, stringers, etc.), which are common to fixed and movable bridges, shall be documented in accordance with Sections 6.1, 6.2 and 6.3 of this manual.
- Typical conditions as well as deteriorations causing a condition rating of less than or equal to "5", should be photographed as outlined in Chapter 5.

- A good quality photograph of each of the bridge components that documents its overall condition and supports the condition rating should be included.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for a routine inspection, "hands-on" access shall be provided to the entire superstructure.

Documentation for In-Depth Inspections:

- All documentation required for a routine inspection will be included in the in-depth documentation except as noted in this section.
- A simple framing plan, and elevations (as required), of all primary members should be provided. All deterioration or deficiencies found should be noted on these sheets to include size, length, direction, depth, etc. Sections and other detail sketches should be drawn as required to clearly show the locations and extent of deterioration or deficiencies noted.
- Documentation as a whole should clearly describe the condition and serve as an accurate benchmark to which future inspections can be compared.

Report Review:

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer should determine if the pattern, quantity and severity of the deteriorations found support the numerical condition ratings given. The reviewer should compare the present inspection report to past reports.

Maintenance Concerns:

- Proper lubrication of all moving parts must be performed on a regular basis. Excess lubricant should always be removed when new lubricant is added.
- The operation of each of the functional systems should be reviewed and appropriate steps taken to correct or adjust system deficiencies.

Figure 6.2.6.2a Scherzer type bascule - rolling bascule span truss

Figure 6.2.6.2b Scherzer type bascule - rolling bascule span girder

Figure 6.2.6.2c Strauss trunnion bascule - lowered position

Figure 6.2.6.2d Strauss trunnion bascule - partially raised(note member parallelogram)

Figure 6.2.6.2e ABT type bascule - lowered position

Figure 6.2.6.2f ABT type bascule - raised position

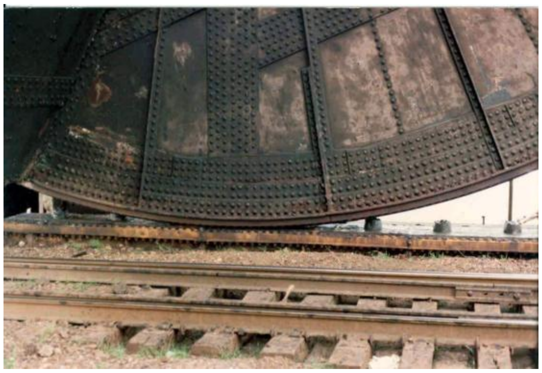


Figure 6.2.6.2g Rolling bascule - segment girder track

Figure 6.2.6.2h Rolling bascule - segment girder tread plate, worn pintles

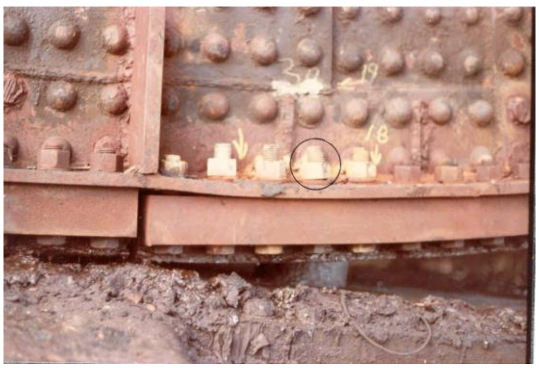


Figure 6.2.6.2i Rolling bascule - segment girder tread plate deflection

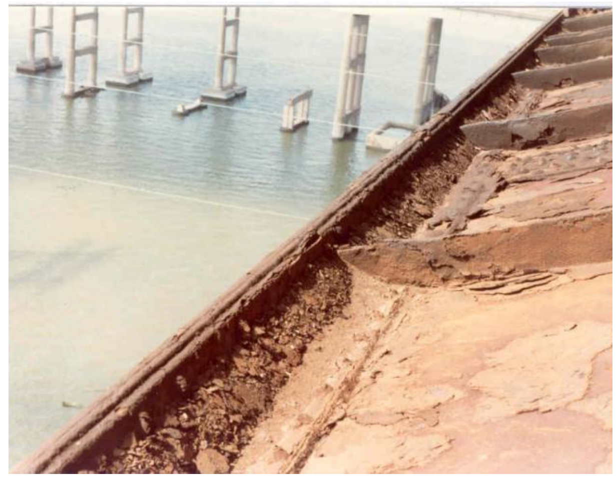


Figure 6.2.6.2j Rolling bascule - floorbeam debris collection and section loss

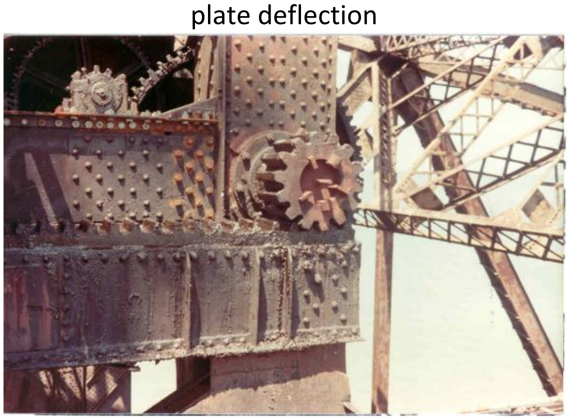


Figure 6.2.6.2k Rolling bascule - pinion and rack

Figure 6.2.6.2l Rolling bascule - cracked rack section through bolt holes

Figure 6.2.6.2m Strauss type bascule - counter weight trunnion joint, worn pin-gusset hole

Figure 6.2.6.2n Strauss type bascule - broken retainer bolt, common with joint wear

Figure 6.2.6.2o Strauss type bascule - counter weight hip connection, crack due to interface corrosion

Figure 6.2.6.2p Strauss type bascule - operating strut with rack operating strut guide

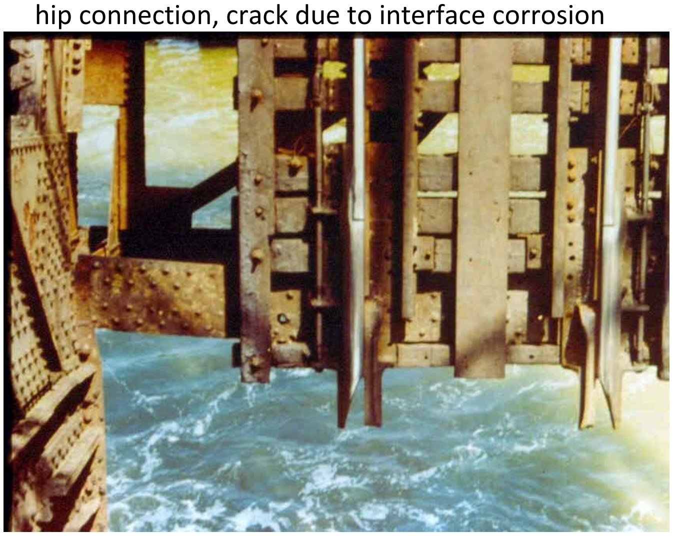


Figure 6.2.6.2q Bascule span – raised position Floorbeam – bowed from track load

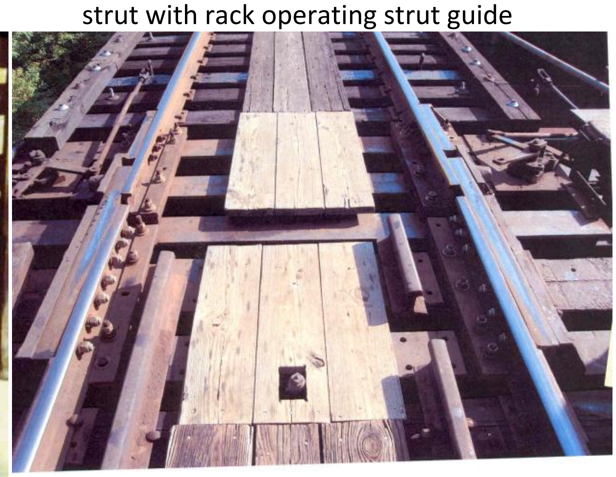


Figure 6.2.6.2r Bascule span - toe end miter rail joint

6.2.6.3. Vertical Lift Bridges

Reference: AREMA BRIDGE INSPECTION HANDBOOK©, CHAPTER 10 SECTION 5
Reference: BIRM, Sections 12.2.4, 12.2.8 thru 12.2.11 and 12.2.13
Reference: AASHTO Movable Bridge Inspection Evaluation and Maintenance Manual 1st Edition

Vertical lift bridges consist of a movable truss or girder span between fixed lifting towers. The lift span is counterbalanced by counterweights, located in the towers, with wire ropes running over tower top sheave assemblies connected to the span and counterweight. The manner in lifting the span determines the type of a vertical lift bridge. Vertical lift bridges provide a wide horizontal channel opening but limit vertical clearance. The requirements for the opening are determined by the Coast Guard.

Vertical Lift Bridge Types
- tower drive
- span drive

The tower drive type vertical lift bridge operates by mechanically turning the tower top sheaves which move the counterweight ropes attached to the span and counterweight. A complete set of mechanical drive equipment is located atop each tower. Drive pinions engage circular rack sections that are attached to each sheave. Electronically, both towers must be synchronized to keep the span level, as the span is raised and lowered. The inability to keep the span level is called "skew" and can be a significant problem with this type bridge.

The span drive bridge is operated from the lift span through a central mechanical system that powers an independent system of wire ropes called "operating ropes or haul cables." There are two types of span drive bridges; cable operated and those operated by rope drums connected to drive shafts at span ends. The operating rope ends are attached to the top and bottom of the tower with ropes, spooled on the drums in several turns that cross the drum in spiral grooves. There are two advantages to the span drive type vertical lift bridge: the operation is controlled by one set of machinery and span skew is less likely to occur.

The vertical lift bridge is set to be balanced, or in equilibrium, when the bridge is in the raised position and to be “span-heavy” in the lowered position. This is accomplished by the passage of the counterweight ropes from one side of the tower sheaves to the other side. When the lift span is down, the counterweight ropes are long on the span side and short on the counterweight side. When the span is in the up position, the opposite occurs. For bridges with lifts over 40 feet, there usually is an auxiliary counterweight system, or balance chains, connected between the bottom of the counterweight and tower to make further weight adjustments, as the span travels, without causing excessive changes in power requirements.

Operational Sequence

To close the bridge from an open position:

1. Sound the horn to close the bridge, assure it is safe to operate the bridge, no marine vessels approaching; all maintenance workers are clear, per railroad safety procedures.
2. Vertical lift span lowers, while the counterweight rises in tower guides.
3. The channel center navigation light turns from green to red, indicating closure.
4. The span slows in speed, as it approaches the pier top, and is cushioned by air buffers located at each span corner.
5. The span guides and a span centering pin position the span into correct position so that the rails properly engage a mating section, mounted on the span end.
6. Upon seating, span locks are engaged and the span operating equipment is deactivated.
7. The signal system is activated and, if all functions are properly complete, the signal light will turn from red to green.

To open the bridge from a closed position:

1. Reverse process – when complete, the navigation lights facing mariners will be green and the signal lights for the rail traffic will be red.

Inspection Requirements

Support System:

- Evaluate the uniform motion of the lift span operation. (*This may vary somewhat due to the fact that span motion is strongly affected by guide track alignment and lubrication conditions. Slight variation, from perfect parallel guide track alignment or dry spots where lubrication is absent, can cause some oscillation of span drive motor power.*)
- Check the alignment of the towers (*The towers can lean due to foundation movement, and can cause major jamming and/or power fluctuation. If it is suspected that tracks are misaligned or out-of-plumb, a survey should be done to check the towers for plumb and alignment.*)

Balance System:

> *Special Note:*
> *The balance system is one of the most important design features and is often overlooked or not fully understood by inspectors. Inspectors should be aware of the function of balance in the continued safe operation of a movable bridge.*

- Inspect gear teeth to determine if one side of the tooth is more worn than the other. If there is a fairly consistent pattern of teeth wearing more on one side than the other, the span is probably not well balanced.
- Inspect gear teeth to see if the face of the teeth that make contact during the opening cycle are more worn than the face that are in contact during the closing cycle. This indicates the bridge is “span-heavy.” If the latter faces of the gear teeth are more worn, the leaf is counterweight heavy.
- Consult available design and rehabilitation plans to determine the basic design configuration of the counterweight system and the locations of all adjustment pockets or trays. (*Often loose balance adjustment blocks are placed in closed spaces constructed into the counterweight assembly.*)

- Inspectors should determine how many balance adjustment blocks are present and where they are grouped. (*A large number of blocks or an asymmetric placement may indicate the span was difficult to balance when it was built or balance was adjusted to correct an operating problem. The presence, in one pocket, of multiple types of blocks may indicate balancing has been required more than once during the life of the bridge.*)
- Check for new ties, paint or railings that can significantly affect span weight and span balance. (*Span balance should be checked during every inspection of a movable bridge*)
- Observe the balance system at rest and during span motion.
- Inspect balance system for localized corrosion or other defects that could cause balance blocks or counterweights to break loose from their support.
- Inspect for signs of previous rebalancing efforts.
- Inspect the interface of concrete counterweights and steel support members embedded in the counterweight for line corrosion at the interface. (*Steel members, especially the counterweight support links, should be carefully inspected for corrosion losses. A failure of one of the structural counterweight support members could initiate collapse of the counterweight, or could create unbalance, binding, interference, or other operational problems.*)

Structural Components:

Typical structural components (such as floorbeams, trusses, stringers, etc.), which are common to fixed and movable bridges, shall be inspected in accordance with Sections 6.1, 6.2 and 6.3 of this manual.

Inspection of unique structural components that occur primarily on movable bridges, and special considerations of typical structural components due to the nature of movable bridge operations, shall be covered in the following sections.

The inspection of items peculiar to vertical lift bridges are counterweights, bridge balance, guides (counterweight and span), machinery house or tower enclosures, counterweight and operating ropes, sheaves, and centering devices.

Special Note:

Lubricants and other coatings will tend to accumulate under movable bridge machinery on structural members. These coatings interfere with the inspection of the members they coat and should be removed to permit close inspection.

- Before the inspection is commenced, a study of the structure shall be done to determine the locations of all fracture critical members (FCM's) and fatigue sensitive details (FSD's). The study shall include identification of all force reversal members due to opening and closing operations. All FCM's shall be marked for inspection in accordance with the guidelines given in Chapter 5 for Fracture Critical Member Inspection. Unless otherwise shown by detailed analysis, all built up, rolled and eyebar type tension members shall be considered to be FCM's and inspected as such. Girders, floorbeams or stringers may be identified as FCM's based on detailed analysis, engineering judgment and appropriate federal guidelines.

- Certain structural components are most heavily loaded during span opening and closing operations. The critical design load of such members often does not include vehicle live load. The inspection of such components should be based upon the knowledge that distress may be present due to loads resulting from span movement operation, which are not necessarily vertical loads in all cases.

Substructure:

- Inspect piers for rocking or other movement when the leaf or span is opened. (*This is an indicator of a serious deficiency and should be reported immediately in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in* *Section 3.2.m.*)
- Check the braces, bearings and all housings for cracks especially where stress risers would tend to occur.
- Inspect concrete and masonry for cracks in areas where machinery bearing plates or braces are attached. (*Note the tightness of bolts and the tightness of other fastening devices used. Loose anchorages can cause movement of machinery and result in misalignment and accelerated deterioration of the substructure elements.*)
- Inspect the substructure elements during opening and closing operations for span or counterweight contact. (*Contact between these elements is an indication of unbalance or misalignment. Interference between substructure and bridge elements during operations can also affect the horizontal and vertical clearances within the navigational channel limits.*)

Superstructure:

- Inspect the live load bearings and span lock bars for proper fit, alignment and if applicable, the amount of lift. When span locks are provided to hold the span in the open position, check for movement under wind load.
- Inspect all joints between fixed and movable portions of the structure for adequate longitudinal clearance that provides for thermal expansion and allows for vertical movement under heavy loads.

Ship Ladders, Walkways and Platforms:

- Inspect ship ladders, walkways, platforms and all support connections for loose or missing fasteners, cracked welds or fatigue cracks and other deficiencies.
- Inspect stair treads and walkway surfaces for loose or missing components and adequate connection to their supports. Check surfaces for traction deficiencies or accumulation of lubricants or debris that may create a slipping or tripping hazard.
- Inspect all railing connections for loose or missing fasteners, cracked welds, fatigue cracks or other deterioration.
- Inspect all bridge structural components that support ship ladders, walkways and/or platforms for evidence of distress or deterioration.

Counterweights and Counterweight Pits:

- Inspect counterweights to determine if they are sound and are properly affixed to the structure. Also check temporary supports for the counterweights that are intended for use during bridge repair and bumpers that prevent bascule leaf overtravel.
- The counterweight and operating ropes should be carefully examined for broken wires, excessive surface wear, tightness and sharing of load, end attachments, and indications of core collapse. As the ropes age, they elongate and/or stretch. For operating ropes, it becomes necessary to adjust the ends of the ropes which have devices for making these adjustments. Counterweight ropes should only be checked for individual loose ropes only and adjusted, as necessary. However, loose ropes are uncommon after initially being adjusted.
- A careful inspection is needed to check for possible crack development in the sheave webs. The sheave shafts commonly have a reduction in diameter at the interface with the sheave hub. An in-depth inspection is needed, at a determined interval based on age, details and bridge cycles, to ultrasonically look for cracks in the shaft. The shaft should be found tight within the hub of the sheave. No fretting corrosion should be evident. The sheave grooves should be checked to ensure that conditions are not present that would cause nicks to or score the wire ropes. The grooves should cradle the ropes.
- Where steel members pass through, or are embedded in concrete, check for corrosion of the steel member and for rust stains on the concrete.
- Check the strut connecting the counterweight trunnion to the counterweight for fatigue cracks. (*Cracks may develop in the webs and bottom flange near the gusset connection at the end nearest the counterweight. This crack will be most noticeable when the span is open.*)
- Inspect the counterweight pits for standing water. Buoyancy forces on the counterweight can affect span balance and overload machinery and motors, causing unexpected movements of the bridge. Check sump pumps, if present, for proper function.

Electrical:

- Visual inspect the power pole, weather head, and transformers.
- Flex cables connecting power on the pivot pier with the swing span must be checked for wear and any evidence of kinks or pinch points.
- Check the power transfer switch.
- Check that the engine-generator set works properly and has a proper fuel supply.
- Check that the batteries are in good condition and that the battery charger is working properly.
- Visual inspect conduit runs, note their condition and look for any broken connections.
- Visual check for proper termination of wires in cabinets.
- Check that the wire identifications are correct.

- During operation, inspect for noises, smells and heat build-up in the electrical system.
- Visual inspect the panel boards and circuit breakers, look for proper connections, neatly run wires and condition of the breakers and panel box.
- Note any disconnect switches.

Mechanical:

- Check that the motors are applying equal force to the lift system.
- Inspect breaks checking that the drum surface true and not glazed, the brake pad thickness, pads fit drum, release and set correctly, proper torque settings, fluid levels, alignment of pads to drums.
- Inspect the journal bearings for lining wear, galling, worn or packed grease grooves, shaft smoothness, housing and supporting group.
- Inspect the bearing housing anchorage, lubrication and general alignment.
- Inspect the roller bearings, checking the roller and raceway surfaces, contamination, lubrication, seals and housings.
- Inspect the idler and deflector sheaves.
- Inspect the air buffers, checking for clean and smooth cylinder and plunger rod, proper functions (pressure), free drop, and tolerances
- Check that the span locks bar engages slots, inspect the gear box conditions.

Lubrication:

- Inspect the line shaft bearings, differential, span locks, centering devices, hydraulic brakes, motor bearings, open gearing/enclosed gear boxes, guide wheels and guide contact surfaces, operating and counterweight ropes, sheave and idler wheel bearings and air buffers for proper lubrication.

Common Problems

- span balance and bounce upon seating
- span skew for tower drive bridges
- loose operating ropes for span drive bridges
- span warpage and uneven support at the span bearings
- Sticking air buffer plunger rods
- lack of lubrication on counterweight ropes
- counterweight sheave trunnion cracking – particularly at the fillet
- Accelerated wear on the counterweight sheave bearing and drum pinion bearing
- counterweight deterioration

Documentation for Routine Inspections:

- The typical structural components (such as the deck, floorbeams, trusses, stringers, etc.), which are common to fixed and movable bridges, shall be documented in accordance with Sections 6.1, 6.2 and 6.3 of this manual.
- Typical conditions as well as, deteriorations causing a condition rating of less than or equal to "5", should be photographed as outlined in Chapter 5.
- A good quality photograph of each of the bridge components that documents its overall condition and supports the condition rating should be included.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for a routine inspection, "hands-on" access shall be provided to the entire superstructure.

Documentation for In-Depth Inspections:

- All documentation required for a routine inspection will be included in the in-depth documentation except as noted in this section.
- A simple framing plan, and elevations (as required), of all primary members should be provided. All deterioration or deficiencies found should be noted on these sheets to include size, length, direction, depth, etc. Sections and other detail sketches should be drawn as required to clearly show the locations and extent of deterioration or deficiencies noted.
- Documentation as a whole should clearly describe the condition and serve as an accurate benchmark to which future inspections can be compared.

Report Review:

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer should determine if the pattern, quantity and severity of the deteriorations found support the numerical condition ratings given. The reviewer should compare the present inspection report to past reports.

Maintenance Concerns:

- Proper lubrication of all moving parts must be performed on a regular basis. Excess lubricant should always be removed when new lubricant is added.
- The operation of each of the functional systems should be reviewed and appropriate steps taken to correct or adjust system deficiencies.

Figure 6.2.6.3a Vertical lift – lowered position tower drive

Figure 6.2.6.3b Vertical lift – raised position tower drive

Figure 6.2.6.3c Vertical lift – lowered position span drive

Figure 6.2.6.3d Vertical lift – raised position span drive

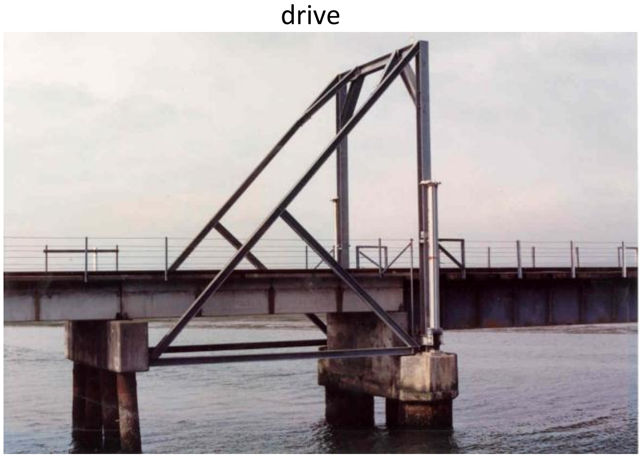


Figure 6.2.6.3e Vertical lift – hydraulic lift - infrequent openings

Figure 6.2.6.3f Vertical lift – screw jack lift

Figure 6.2.6.3g Sheave – bearing assembly tower drive Roller bearings

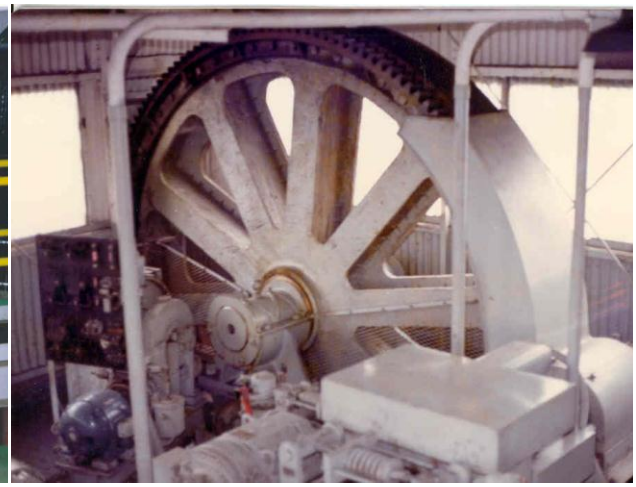


Figure 6.2.6.3h Sheave-bearing assembly tower drive trunnion bearings

Figure 6.2.6.3i Sheave- trunnion shaft surface condition inspection

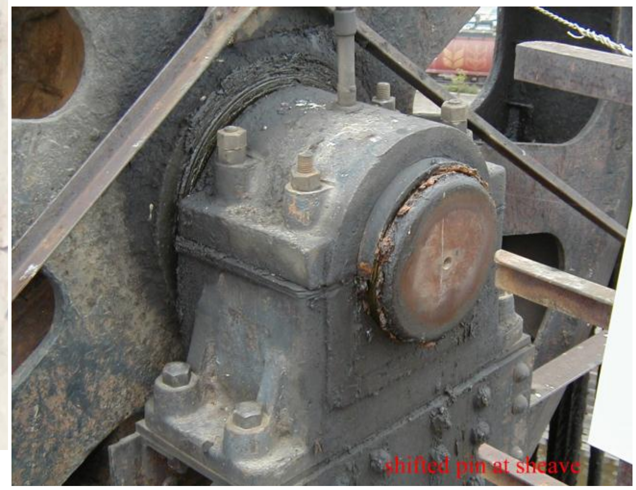


Figure 6.2.6.3j Sheave- trunnion bearing assembly

Figure 6.2.6.3k Lift span - centering device

Figure 6.2.6.3l Sheave - trunnion bearing assembly

Figure 6.2.6.3m Counterweight ropes - cable splay at counterweight

Figure 6.2.6.3n Counterweight ropes - fiber core being expelled

Figure 6.2.6.3o Counterweight ropes - broken strand

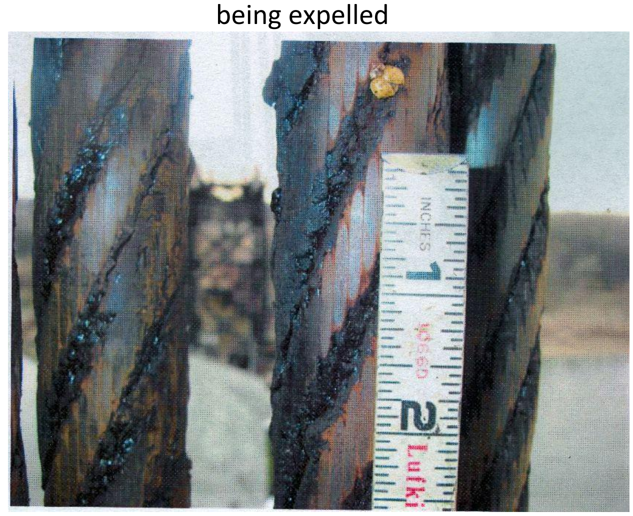


Figure 6.2.6.3p Counterweight ropes - severe crown wear

Figure 6.2.6.3q Counterweight ropes - raised spelter at socket - normal conditions

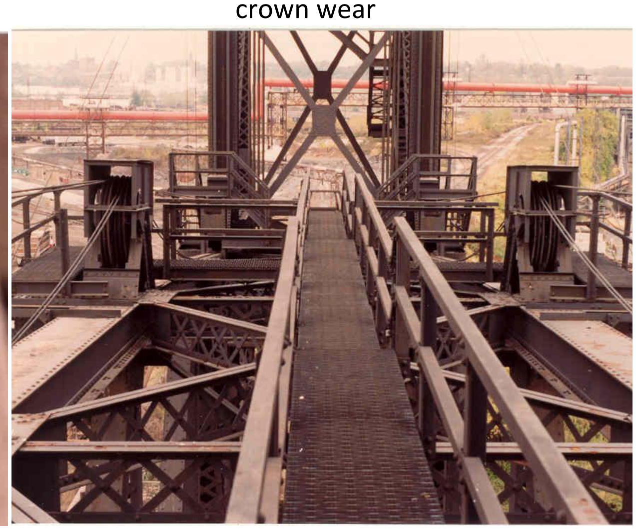


Figure 6.2.6.3r Operating ropes-idler wheels - excessive looseness in ropes

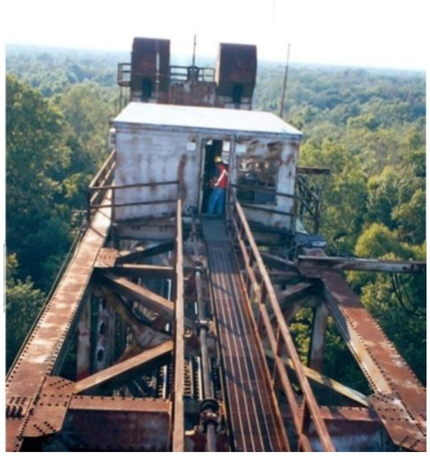


Figure 6.2.6.3s Span drive – bridge raised hood over sheaves (background) machine house and drive shaft (foreground)

Figure 6.2.6.3t Counterweight balance pockets – weights not uniformly distributed

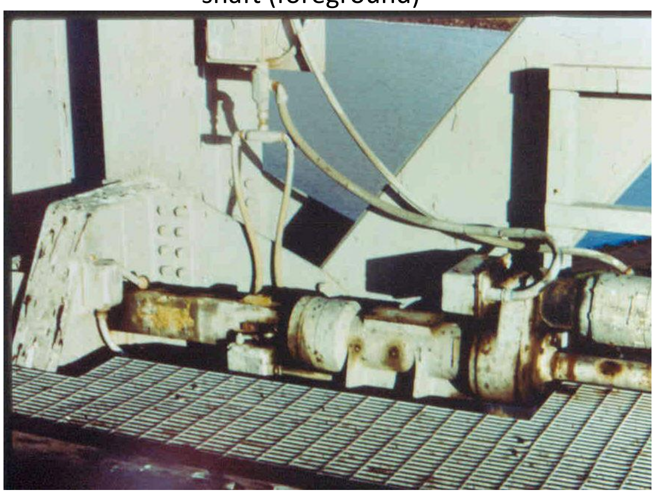


Figure 6.2.6.3u Span lock

Figure 6.2.6.3v Tower access caged ladder and elevator

Figure 6.2.6.3w Two-piece miter rail worn points

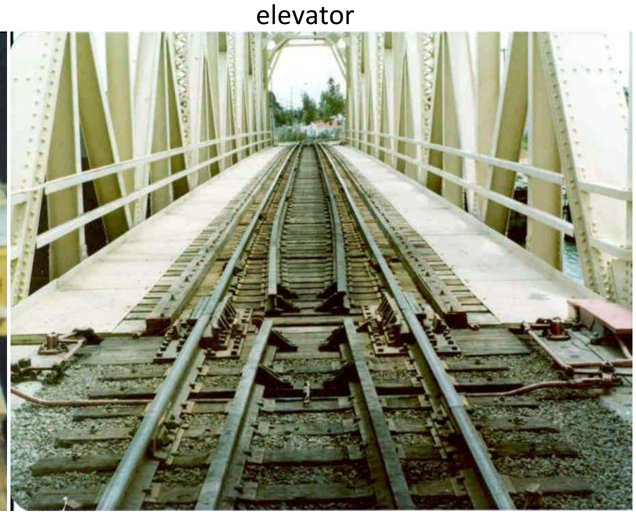


Figure 6.2.6.3x Two-piece miter rail and signal equipment

6.2.6.4. Operator's House

Reference: AREMA BRIDGE INSPECTION HANDBOOK©, CHAPTER 10 SECTION 2
Reference: BIRM, Sections 12.2 and 12.2.12

General:
The Control House may be located on the bridge, adjacent to the bridge or at some nearby designated location.

The Operator's House is the central location for the control of the bridge and related functions. As such, the operator needs to have good visibility of the waterway, be able to see the track in both directions and have easy access to the house.

In older facilities, a review should be made for operator safety as related to open electrical panels or moving machinery in near proximity to the operator's surroundings. Additionally, an alternate means for escape from the house should be available in case a fire occurs in or near the house. Houses, in some remote locations that are not manned, require vandal-proof measures. Bulletproof windows may be required.

Inspection Requirements

Inspection:

- Check that the control house has an unobstructed view of the navigation channel and approach roadways during all phases of the bridge movement cycle.
- Visually inspect the roof and walls for signs of water infiltration.
- Visually check that the pumping (if any) is in good shape and not leaking.
- Inspect for proper installation and function of smoke alarms, fire extinguishers and fire fighting systems, as required by current federal, state and local regulations.
- Check that the house includes a working two-way radio for communications with vessels.
- Check to determine if the house is equipped with alternate signaling equipment, including flags, lanterns, or other devices.
- Check to insure that the house is equipped with means to clean the exterior side of windows.
- Inspect the bridge machinery controls for adequate support and that they are securely installed.
- Inspect the foundation or supports for growth of marine life and plants.

Documentation for Routine Inspections:

- Typical conditions as well as, deteriorations causing a condition rating of less than or equal to "5", should be photographed as outlined in Chapter 5.
- A good quality photograph of each side of the building that documents its overall condition and supports the condition rating should be included.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements of the routine inspection, "hands-on" access shall be provided to the entire structure.

Documentation for In-Depth Inspections:

- All documentation required for routine inspections shall be included in the in-depth documentation, except as noted in this section.
- Documentation, as a whole, should clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph of the structure, which documents the overall condition, as well as, detail photographs that support the condition rating, shall be provided.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer should determine if the pattern, quantity and severity of the deteriorations found support the numerical condition ratings given. The reviewer should compare the present inspection report to past reports.

Maintenance Concerns:

- The Control House needs to protect the control systems for the bridge. It is important that the building be maintained and that it is sealed from the exterior elements. Any issues with leaking, damaged doors and windows should be address to help protect and prolong the life of the building and the bridge’s controls inside.

Figure 6.2.6.4a Metal building on shore


Figure 6.2.6.4b House - adjacent to bridge


Figure 6.2.6.4c Operator’s House 1st floor – electrical - no alternative escape

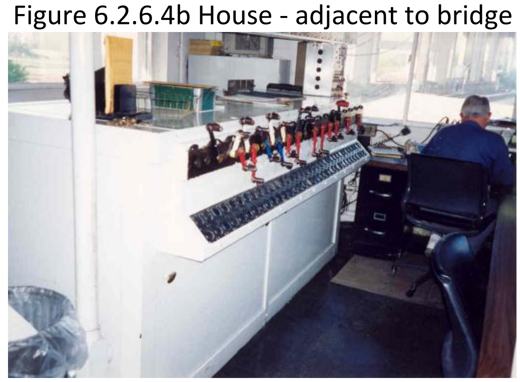


Figure 6.2.6.4d Operator’s House interior

6.2.6.5. Fenders, Dolphins and Navigation Guidance Systems

Reference: AREMA BRIDGE INSPECTION HANDBOOK©, CHAPTER 10 SECTION 10
Reference: AREMA *Manual for Railway Engineering*, Chapter 8, Part 23
Reference: BIRM, Sections 12.2

General:
The inspection of fenders and dolphins protecting a movable bridge should be a part of the bridge inspection. The inspector should view the protection system from two standpoints – do the fendering and dolphins protect the bridge adequately and, do any components of the fenders and dolphins pose a threat to the safety of passing marine vessels. The answer to adequacy of protection an analysis, as required by the Office of Rail, based on the type and size of vessels using the waterway. Such methods of analyses are available in the AASHTO Manual published by FHWA.

The inspection should include a review of adequate access and functioning of navigational guidance system.

The navigation guidance system directs the travel path of an approaching vessel from the open channel through the bridge opening and allows for controlled passage of vessels through a movable bridge site.

The navigation guidance system includes numerous separate communication, lighting, vessel guidance, navigation and channelizing devices, functioning to allow controlled passage of vessels through a movable bridge site.

The guidance systems should be in conformance with USACOE, USCG, and CFR requirements. This system also requires provisions for efficient communication, by audible and visual signals, between the bridge operator and vessels.

A partial list of the components of this system includes:

Marine Radio Communication
Lights, Whistles, Horns
Retroreflective Panels
Radar Reflectors and/or Racons (radar signal emitters)
Fog Signals
Fender systems and other substructure protection devices
White/Red Flags at control tower
Underclearance Gauges and Tide Gauges
Permit drawings showing legal channel width and underclearance
NOAA Navigation Charts
Navigation Lighting

Inspection requirements:

Fenders and Dolphins

- The field inspection of the protection system should look for loose and/or missing components such as timber rubbing strips or wales, exposed bare steel supports which could damage a vessel, and deteriorated components, including fasteners and wraps, that could not withstand a vessel impact.

Navigation Guidance System

- Review the procedure for passage of vessels though the bridge opening. This includes, but is not limited to, bridge operation signals, fixed markings in the channel and on the structure, channel alignment and control markings, radio communications, presence, placement, adequacy and condition of pier protection devices, navigational lighting and other aspects relating to safe passage of a vessel.
- Inspect visual and audible signals required by current regulations. They should be effective during daytime, nighttime and inclement weather conditions from the perspective of, not only an approaching vessel, but also from other vessels in the vicinity of the bridge. Signals should be distinct and recognizable to multiple vessels on either side of the bridge and should clearly indicate which approaching or waiting vessel should traverse first and when the next is to proceed.
- Determine if the bridge site has an adequate holding area in which approaching vessels may safely await the bridge opening, and are clear of the bridges range of motion. If there is no holding area, evaluate the radio communication/bridge opening timing sequence to determine if it is adequate and consistent with current navigation rules for the structure. Determine if the vessel is properly signaled to proceed by the bridge operator via radio, light or other signal once the bridge has completed its opening sequence and brakes have been set.
- Inspect the navigation guidance lighting to determine if it is in coordination with the bridge motion; i.e. red span lights should not change to green (signaling vessels to begin passage) until the bridge has completed its motion and the brakes are set.
- Verify that the superstructure is clear of the horizontal and vertical channel clearance envelope in the open position. Some existing structures exhibit full open positions that do not clear the navigation envelope. Bascules should be checked by climbing the leaf in the open position and dropping a plumb line, or by other means if climbing is not feasible. It is also vital that the span be securely locked in the open position by the brakes, or other means, to ensure that it cannot drift during vessel transit. Swing bridges, with inoperative brakes, present a potential hazard if a wind gust causes the span to move during vessel transit.
- Determine if bascule or lift span brakes are fully operational. Holding the span open, by stalling the drive machinery against the stops, is a dangerous practice and is not acceptable for any reason, except dire emergency involving other overriding threats to public safety.
- Determine whether navigational guidance system adequately recognizes when the transiting vessel, as well as any other vessel in the bridge proximity, are well beyond the bridge range of motion so that the bridge may return to closed position. If this is done through "visual observation" by the bridge operator, determine if there are areas that are obstructed from the operators view and large enough to hold a vessel. If this is the case, recommendations for additional detection methods should be made to cover these areas.

Documentation for Routine Inspections:

- Typical conditions and deteriorations, causing a condition rating of less than or equal to "5", should be photographed as outlined in Chapter 5.
- A good quality photograph of each of the components that documents its overall condition and supports the condition rating should be included.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements of the routine inspection, "hands-on" access shall be provided to the entire superstructure.
- All primary and secondary members shall be inspected "hands-on" regardless of extent of damage or deterioration.
- Severe internal decay may be taking place even though the surface condition appears good. Therefore, random probing of 50% of the structural members shall be conducted with an ice pick or awl to locate voids or areas of internal deterioration. Emphasis shall be placed on locations of wetness or staining. Be careful of frozen timber that may have internal deterioration but sounds solid due to water frozen in the internal cavities.

Special Note:

All destructive testing shall have prior approval of the Transportation Supervising Engineer.

Documentation for In-Depth Inspections:

- All documentation required for routine inspections shall be included in the in-depth documentation except as noted in this section.
- Documentation, as a whole, should clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph of the superstructure, which documents the overall condition as well as detail photographs that support the condition rating, shall be provided.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- The inspection report reviewer should determine if the pattern, quantity and severity of the deteriorations found support the numerical condition ratings given. The reviewer should compare the present inspection report to past reports.

Maintenance Concerns:

- Any infringement of the protection system into the authorized waterway channel should be promptly corrected.

Figure 6.2.6.9a Fender system lining the channel

Figure 6.2.6.9b Fender system lining the channel

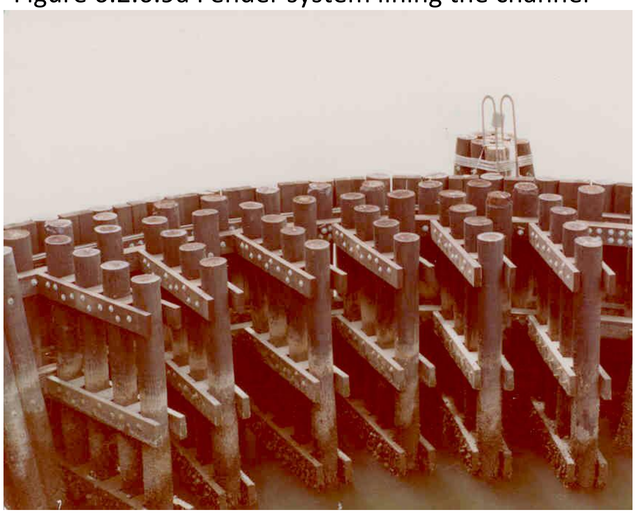


Figure 6.2.6.9c Timber fendering/dolphin

Figure 6.2.6.9d Fender/dolphin system

Figure 6.2.6.9e Dolphins without fender

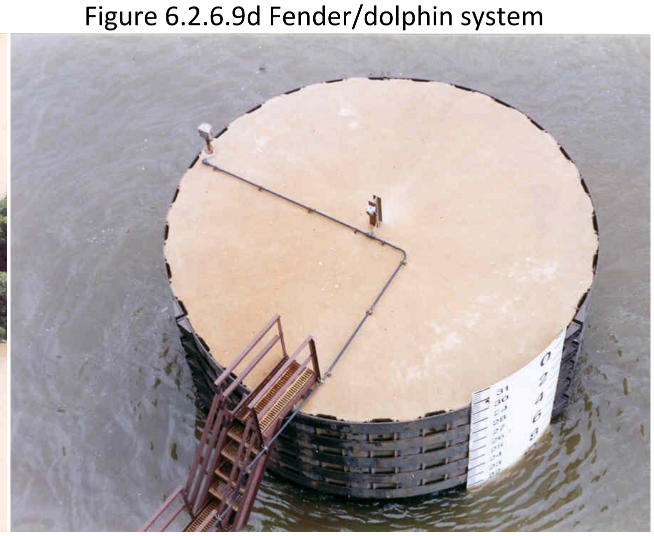


Figure 6.2.6.9f Typical dolphin

Figure 6.2.6.9g Typical fender system

Figure 6.2.6.9h Failed fender system

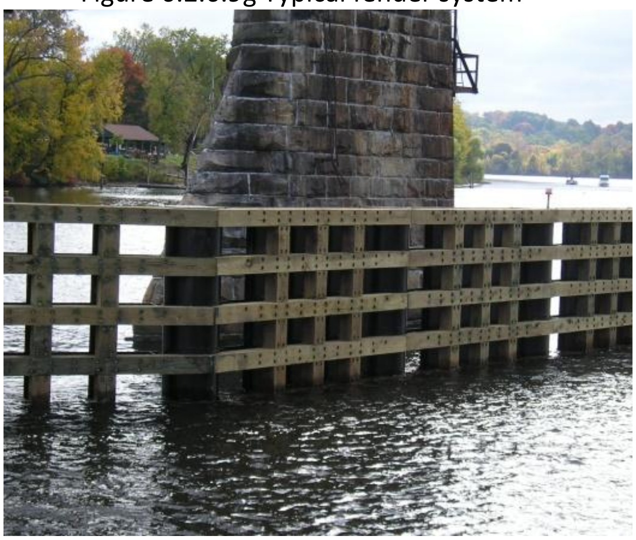


Figure 6.2.6.9i Newly installed fender system

Figure 6.2.6.9j Donut fender

Figure 6.2.6.9k Typical fender system

Figure 6.2.6.9l Timber fendering dolphin

6.2.7 Timber Superstructures

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 7

Reference: BIRM, Sections 2.1 and 6.1 Thru 6.3

Reference: USDA Forest Service Publication "Timber Bridges: Design, Construction, Inspection and Maintenance"

Inspection Requirements

Inspections:

- Inspect the timber superstructure in accordance with BIRM, Chapter 6, and Sections 2.1 and 13.1.
- The entire superstructure shall be inspected using adequate lighting to detect fungus growth, parasite infestation, fire damage, impact or collision damage, weathering or warping, splitting, cracking, checking, signs of overstress or chemical damage.
- All areas found to be deteriorated or deficient during the visual inspection survey will be subsequently inspected "hands-on" to determine the type and extent of deterioration or deficiency.
- Check timber members for signs of crushing at bearing areas and at stringer/floorbeam connections. Look for signs of overstress in areas of maximum bending stress.
- Check for signs of decay and parasite damage at ends of members where dirt, debris, and moisture tend to accumulate and at the superstructure/ deck interface. Deteriorated areas may also occur at locations of field constructed connections where the paint or preservative system has been damaged or disrupted. (See Appendix A6.8 for types of decay and deterioration.) Areas that have evidence of serious deterioration, decay or infestation should be discussed with the Railroad Bridge Engineer to determine the need for possible further investigation by Non-Destructive Testing (NDT) and Destructive Testing (DT) methods (such as Increment Boring).
- 25% of all surface areas showing no apparent deterioration shall be hammer tapped or probed with an ice pick to determine soundness of member. If the preservative treatment of the member is damaged by probing it should be "touched-up" with new preservative. Be careful of frozen timber that may have internal deterioration but sounds solid due to water frozen in the internal cavities.
- Note all fire damaged areas and whether or not the damage is superficial (scorched) or if loss of effective section has occurred. Note the depth of char.
- Check for horizontal shear cracks in solid sawn members and delamination between laminas in glue-laminated members. Cracks and delaminations at mid-height of the member are more critical than those nearer the top or bottom surface. Horizontal cracks will cause the member to act as two smaller members, independent of each other, in the vicinity of the crack or delamination.

- Secondary members may be timber or steel members. For timber, check for deterioration, proper fit, cracked or split members and corroded, loose or missing fasteners. For steel members, check for section loss, loose or missing fasteners and bowing or buckling of the member.
- Timber members are best connected with seated, bearing type connections. Check bolted, framed, or nailed connections for member deterioration or connection failure.
- Areas on the underside of the deck that are below repaired or deteriorated areas of the wearing surface or overlay shall be inspected "hands-on" to evaluate the condition of the repair or limits of deterioration.
- Check primary members for excessive deflection, sagging and vibration as well as for proper alignment.
- Evaluate the condition and effectiveness of the roof and siding of covered bridges, as well as, the protective coating (paint or pressure treatment).

Documentation Required for Routine Inspections:

- Document all deterioration such as debris build-up, fungus growth, parasite infestation, fire damage, impact or collision damage, weathering and warping, splitting, cracking, checking, chemical damage and signs of overstress. All deteriorations noted shall include the size and relative location on the member. Where possible, measurements will be taken to determine the remaining effective section of the member.
- Document any horizontal shear cracks, splits, or delaminations in bending members. Note whether the cracks, splits, or delaminations pass entirely or partially through the member and measure the depth of the crack, if possible. Also dimension the height of the member halves above and below the crack, as well as, the member base and the amount that the crack has opened.
- A simple framing plan shall be provided showing locations of deteriorations and other noted problems. Member elevations and sections shall be provided, as required, to adequately document the deterioration or other problems found.
- Particular care shall be given to documenting any increased quantity or size of deteriorations that have changed since the last inspection. If the condition rating has changed since the last inspection, a photograph and explanation of why the rating has changed shall accompany the inspection report.
- Notes should be made, describing the current condition of all previously noted problems, so that a rate of deterioration can be established for monitoring purposes.
- Typical conditions and deteriorations, causing a condition rating of less than or equal to "5", shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements of the routine inspection, "hands-on" access shall be provided to the entire superstructure.
- All primary and secondary members shall be inspected "hands-on" regardless of extent of damage or deterioration.
- Severe internal decay may be taking place even though the surface condition appears good. Therefore, random probing of 50% of the structural members shall be conducted with an ice pick or awl to locate voids or areas of internal deterioration. Emphasis shall be placed on locations of wetness or staining. *Be careful of frozen timber that may have internal deterioration but sounds solid due to water frozen in the internal cavities.*

> ***Special Note:***
>
> *All destructive testing shall have prior approval of the Transportation Supervising Engineer.*

Documentation for In-Depth Inspections:

- All documentation required for routine inspections shall be included in the in-depth documentation except as noted in this section.
- Documentation, as a whole, should clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph of the superstructure, which documents the overall condition as well as detail photographs that support the condition rating, shall be provided.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- The inspection reviewer should determine if patterns of deterioration or progressive deterioration are taking place. Progression will be determined by comparing past and present inspection reports.
- Review all field notes to determine if further non-destructive testing and/or destructive testing is warranted.

Maintenance Concerns

- The most common type of preventive maintenance for wood structures is to deny the food source to the fungus or parasite. This is done through application of preservative treatment, paint or other protective coatings.
- Pressure treatments typically do not penetrate through the entire cross-section of the member. Therefore, as with non-treated members, interior deterioration due to parasite infestation may still occur, despite the solid appearance of the exterior.
- Loose connections may occur due to timber shrinkage, cracking, checking, decay or crushing around the connector. These connectors may need to be tightened or replaced with larger connectors over time.
- Clean debris to avoid moisture accumulation.
- Cut vegetation from around wet areas and areas prone to debris buildup to better allow air circulation for drying action.

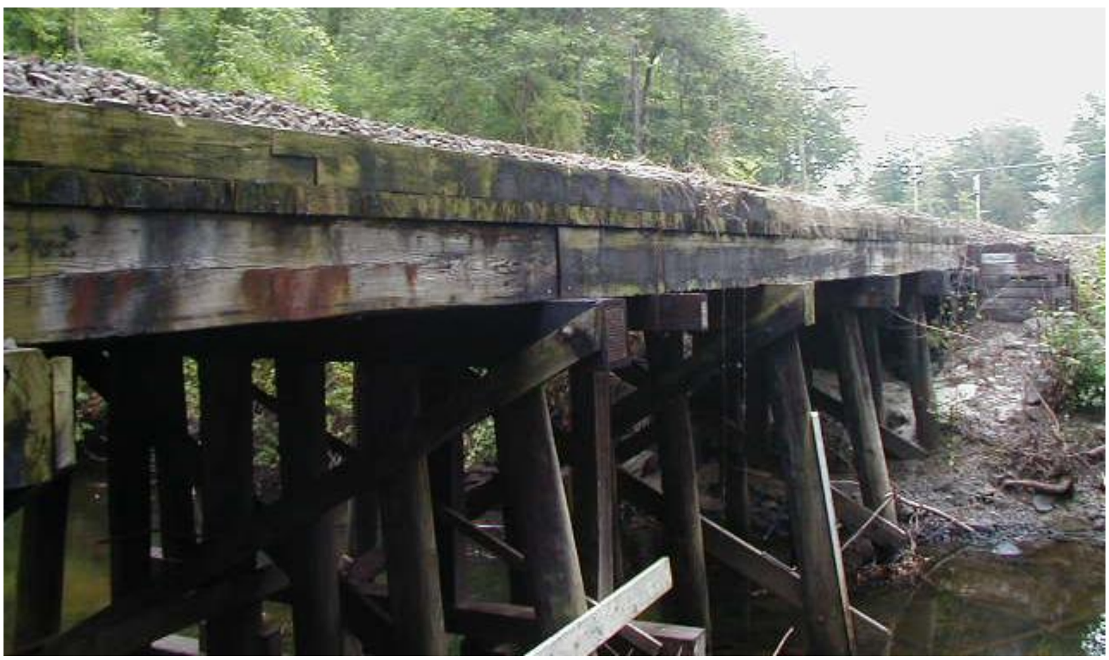


Figure 6.2.7a - Timber multi stringer bridge with timber bent substructure.

6.2.8 Stone Masonry Arches

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 12
Reference: BIRM Section 2.4, 7.5 and 12.4.6

Inspection Requirements

Stone masonry arches may have concrete, stone or other type of construction for the spandrel portion of the arch structure. Spandrels that are comprised of stone masonry shall be inspected in accordance with this section. Spandrels constructed of concrete shall be inspected according to the guidelines outlined in Section 6.2.2.4, Concrete Rigid Frames and Closed Spandrel Arches.

Inspections:

- Inspect the superstructure in accordance with BIRM, Section 2.4 and 12.4.6.
- The entire stone masonry arch superstructure shall be inspected to detect crushed, spalled, disintegrated, weathered, chemically damaged, displaced, missing or cracked stones, missing joint mortar, efflorescence, deformations in the arch ring or spandrel walls or other defects. All problem areas observed shall be subsequently inspected "hands-on" to determine the extent of the deterioration.
- Inspect the arch stones for signs of possible failure from any of the following failure modes:
    1. Crushing of stones (See the special note below).
    2. The Capstones Break.
    3. Sliding of one arch stone on another.
    4. Rotation of an arch stone, or series of arch stones, about an edge of a joint, creating an opening at the joint.
    5. Undermining of the sidewalls.

    (See Appendix A6.7 for a greater description of these failure modes)

- Probe areas where joint mortar is missing to determine the average depth of loss and the location of maximum loss.
- Stones adjacent to joints with missing mortar shall be inspected for displacement, tilting, cracking, heaving, spalling, and crushing due to the freeze/thaw effects of penetrating water and the effects of non-uniform bearing pressure.
- Check stones that have experienced cracking to determine whether the pieces are in tight contact with the adjacent stones and are providing adequate stability to the arch.
- Where visible, inspect the footing areas for signs of displacement due to the horizontal forces induced by the arching action in the structure.
- Inspect the arch spandrel walls for distress (large shear cracks, initiating from the arch stones) or deterioration (spalls, map cracking, delamination, loss of joint mortar, etc.)
- Check to determine if the arch and spandrel walls are plumb. Visually sight along the walls and through the arch barrel to detect bulges or deformations.
- Inspect the top side for depressions in the ballast; this may indicate loss of backfill material.

Documentation Required for Routine Inspections:

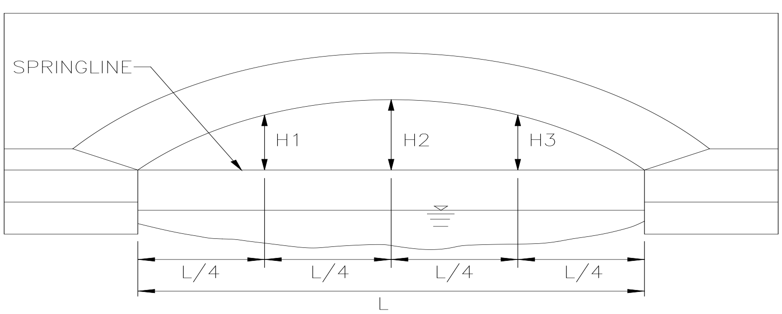
- Document all deficiencies and deteriorations observed. Dimensions shall include the length, width, height, depth of loss, orientation and location relative to a fixed, identifiable point.
- When deficiencies cannot be easily described or if the condition rating is a "5" or less, elevation drawings, as well as topside and underside plan drawings, shall be provided to show the layout of the stone masonry joints and noted deterioration. Sectional views and detail drawings shall be provided, as required, to adequately describe the extent of noted deficiencies.
- Note areas of water leakage (infiltration and exfiltration).
- Notes shall be made describing the current condition of all previously noted problems so that a rate of deterioration can be established for monitoring purposes. If the condition rating has changed from the previous inspection, due to increased quantity or size of deterioration or if the deterioration has been repaired, documentation shall accompany the inspection report that includes photographs and an explanation of why the condition reported has changed.
- Typical conditions and deteriorations, causing a condition rating of less than or equal to "5", shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements of the routine inspection, "hands-on" access shall be provided to the entire superstructure.
- Measure the clear waterway opening at the spring line. Also measure the vertical dimension from the spring line to the bottom of the arch ring at the quarter points along the spring line of each fascia (See Figure 6.2.8a). The first time this is done on a structure, it may be necessary to drill holes or use a "Ram-Set" to install anchors that the ends of the string line can be tied to. If practical, permanent marks should be made on the arch ring where the measurements are taken so that future measurements can be taken at the same location.



Stretch a string accross the waterway from abutment to abutment face to approximate the springline length (L) and location. Measure the height from the springline to the Arch Ring at the quarter points (H1, H2 & H3) as shown.

Figure 6.2.8a – Arch Measurements

Documentation for In-Depth Inspections:

- All documentation required for the routine inspection shall be included in the in-depth documentation except as noted in this section.
- Elevation drawings, as well as topside and underside plan drawings, shall be provided to show the layout of the stone masonry joints and noted deterioration. Sectional views and detail drawings shall be provided as required to adequately describe the extent of deficiencies noted.
- Documentation, as a whole, shall clearly describe the structural condition and serve as an accurate benchmark to which future inspection can be compared.
- A good quality photograph of the superstructure, that documents the overall condition as well as detail photographs that support the condition rating, shall be provided.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- Crushing or spalling of the arch ring stones may be an indication that the stone is being overstressed and is deteriorating. This may be caused by an increased loading condition or a shifting of the neutral axis within the stone. Crushing or spalling of any one arch ring stone approaching 1/3 of its total height means that large localized stresses are being applied to that stone. This can lead to a sudden total failure of the stone. Subsequent total failure of the arch is then possible. All field notes should be reviewed closely for indications that this condition exists. Any arch ring stone crushing warrants close monitoring and thorough consideration of more detailed analysis to determine any adverse effects on the integrity of the arch.
- Low condition ratings caused by extensive or widespread deterioration should be reasons to request supplemental testing or analysis to better determine the condition and stability of the stone masonry arch and whether rehabilitation or replacement is warranted.
- The inspection reviewer should determine if patterns of deterioration or progressive deterioration are taking place. Progression will be determined by comparing present to past inspection reports.
- The sudden or progressive appearance of cracks or movements in the arch stones may indicate the need for a new load analysis and/or weight restriction of the bridge.

Maintenance Concerns

- Arches originally constructed without mortar between the stones ("dry laid") do not need to be pointed. Arches originally constructed with mortared joints however, should normally have missing or deteriorated mortar repaired.
- The object of joint mortar, when incorporated into the design, is to furnish a cushion for adjacent stones. This helps to distribute the pressure uniformly and relieve the stone of transverse stresses and the stresses from concentrated crushing pressures to which the projecting points are subjected, when they are in contact with other stones. Therefore, loss of joint mortar can increase the stresses in the stone, to the point, where crushing or cracking may occur. Lost joint mortar should be replaced with approved mortar utilizing approved procedures.
- Cracks in stones or cracks in joint mortar and openings in joints provide access to water seepage that can further deteriorate the stone or joint through freeze/thaw action or allow exfiltration of fill material. All cracks and joint openings shall be considered for injection, or other repair, depending on their location and proximity to the arch ring. Engineering judgment and discussion with the Transportation Supervising Engineer is required prior to conducting repair work to determine the extent and criticality of the problem, effects on public safety and cost/benefit ratio of the repair.

Figure 6.2.8b – Stone Masonry Arch

6.3. SUBSTRUCTURE INSPECTION

6.3.1 Concrete Substructures

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 8
Reference: BIRM Sections 2.2, 10, 11 and 13.2

Inspection Requirements

Inspections:

- Inspect the substructure in accordance with BIRM Section 10.
- Abutments, wingwalls and piers should be carefully observed from the ground on all sides, using binoculars where appropriate (non-critical areas).
- "Hands-on" access will be required for all bearing seat areas, the front faces of abutments and piers in the vicinity of bearings.
- "Hands-on" access will be required to the faces of pier caps in areas of high tension or shear stresses (typically over columns).
- Areas of cracking, scaling, wetness or staining should be tapped with a hammer to determine if the concrete is sound.
- Spalling or scaling of bearing seats, that has caused (or may cause) a loss of bearing area for a superstructure member, should be measured.
- The length and width of tension or shear cracks, found in pier caps, should be measured.
- Where movement (tipping or settlement) of an element is suspected, plumb bob measurements and joint opening or misalignment measurements should be taken. The location where measurements were taken should be clearly marked (with chisel and paint spot) so that measurements can be made in a similar manner at the same location during follow-up inspections. (See Figure 6.3.1a)
- All substructure elements in, or adjacent to, waterways shall be checked for the presence of scour and undermining. Scour shall be checked by wading and probing around the entire base of every element exposed to potential scour. Areas that cannot be accessed with available equipment should be referred for underwater inspection (See Appendix A6.12).

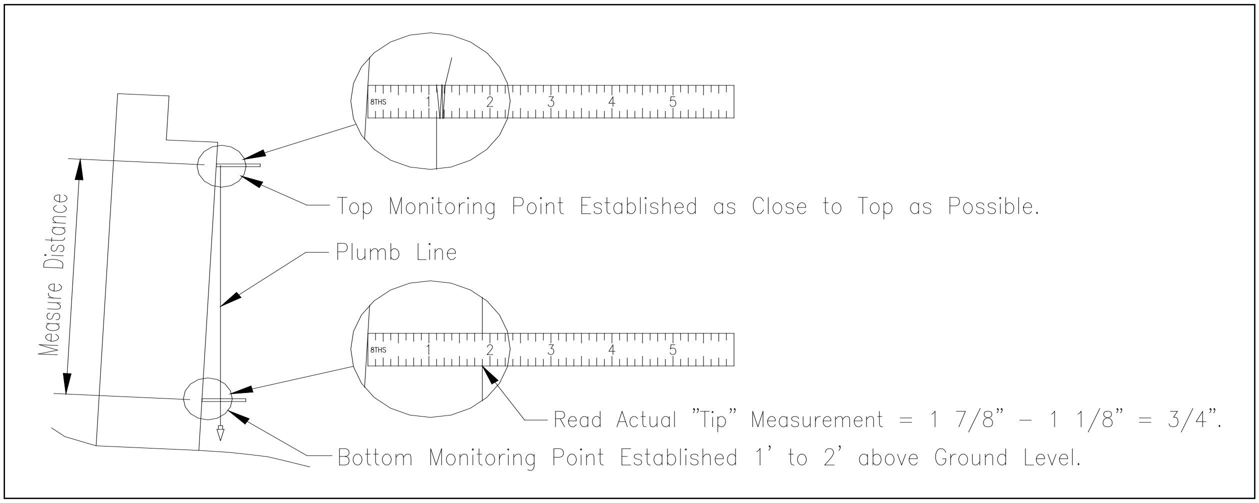


Figure 6.3.1a – Recommended Method for Measuring Substructure Tipping Using a Plumb Line. ("Hold-Off" Method illustrated for use where face of substructure interferes with free movement of plumb bob)

Documentation for Routine Inspections:

- A narrative description of defects found will be adequate when it is possible to fully describe them.
- Sketches will be required if any of the following situations exist:
    1) The bridge is more than 3 spans and the individual substructure unit rating would be "5" or less.
    2) There is a loss of bearing, due to spalling or scaling (or potential loss).
    3) Scour under a footing.
    4) The defects found cannot be simply described as to size, orientation and location.
    5) Structural cracks (tension or shear cracks) are found in a pier cap. Additionally, it may be desirable to set-up a "crack inventory" to monitor the lengths and widths of cracks in a specific area or at a specific element.

Note: Whenever possible, make a good quality "original" sketch before going to the field. Then make a photocopy of the original to record information on and save the original sketch in the file to be copied for use on the next inspection.

- If stream scour condition exists that could influence the substructure at some time in the future, a reference should be made to conditions described under Channel & Channel Protection.
- Photographs should be taken of any defect causing a condition rating of "5" or less. Photographs and/or explanations should also be provided when conditions warrant changing a rating number from a previous inspection (either up or down).
- Sketches indicating measurements for monitoring purposes should be made or copied from the previous inspection report. If a previously used sketch is copied, a revision block should clearly show the date and crew using the copied sketch. Do not re-use a sketch to the point where the difference between new and old notes is no longer discernable.

Note: When working on large structures, a photocopy of the General Plan & Elevation of the bridge can be helpful for shading in areas on the bridge that have been inspected, when it is necessary to track progress over several days.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the above requirements for routine inspections, "hands-on" access shall be provided for all substructure elements.
- All suspected areas of deterioration (cracked, scaled, wet, or displaying efflorescence) and a random sampling over at least 20% of those areas without apparent defects shall be tapped with a hammer using a reasonable frequency to determine soundness. If defects are found in an area that appeared sound, then the sampling rate and area to be hammered should be increased.

Documentation for In-Depth Inspections:

- A sketch of each substructure element will be required. All defects found should be documented.
- Detailed sketches of specific problem areas should be made.
- Representative photographs should be taken that document the overall condition of the substructure and support the condition rating used.
- Similar to routine inspections, monitoring measurements, and explanations or photographs of items that cause ratings to change, will be required.

Report Review

- Findings should be reviewed in accordance with the established Quality Control and Quality Assurance procedures.
- The inspection report reviewer should determine if the pattern, quantity or severity of the deteriorations found support the numerical condition ratings.
- Verify that critical defects (evidence of movement, presence of scour, structural cracks) have been measured for comparison with previous measurements or that adequate monitoring points have been established. Progression of these defects may be cause for a lower rating and/or the need for stabilization work.
- Bridges with large or ongoing settlement/movement problems should be referred to the ConnDOT's Soils and Foundations section for their review.
- Scour problems, other than simple run-off erosion, should be referred to the ConnDOT's Hydraulics section for their review.

Maintenance Concerns

- Concrete deterioration is, most commonly, the result of a leaking deck joint or defective drainage system. The cause of the deterioration (joint or drainage) should always be repaired before, or in addition to, any recommended concrete repairs.
- Certain structural cracks may be repaired using chemical repair techniques. Engineering judgment and discussion with the Transportation Supervising Engineer are required for specific applications.
- Waterproofing methods can be the best way to prevent or slow the deterioration of reinforced concrete members. Care must be taken in the application of waterproofing systems to insure that they are not applied, in such a way, as to prevent entrapped moisture in the concrete from exiting.

- A determination by a Transportation Supervising Engineer, as to what is a structural repair and what is a "cosmetic" or non-essential repair, may help to limit repair quantities to a manageable level. Typically, spalls on massive concrete elements like abutments and solid shaft piers may not need repair if structural reinforcing steel is not exposed and aesthetics are not a concern.
- Repair of scour problems, other than simple run-off erosion, should not be proposed without discussion with the ConnDOT's Hydraulics section.
- Addressing movement of substructure elements is normally beyond the scope of maintenance repairs and will require individual attention.
- When removing deteriorated concrete for repair of pier columns, generally the reinforcing steel should not be exposed for more than 6 ft. on one face at a time.

Figure 6.3.1a: Concrete Pier with sheet piling cofferdam footing

Figure 6.3.1b: Concrete Abutment

Figure 6.3.1c: Concrete Wingwall with decorative form liner

Figure 6.3.1d: Concrete Hammer head pier

6.3.2 Masonry Substructures

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 8
Reference: BIRM Section 10

Inspection Requirements

Inspections:

- Inspect the substructure in accordance with BIRM, Section 10.
- The entire stone masonry substructure shall be for crushed, spalled, disintegrated, weathered, chemically damaged, displaced, missing or cracked stones, missing joint mortar, efflorescence, vegetation growth, deformations, impact damage due to ice, debris or marine or vehicular traffic, and other deteriorations or deficiencies. Problem areas observed should be inspected, "hands-on", to determine the extent of the deterioration or deficiency.
- Inspect the substructure elements for tilting, settlement, rotation or other movement. If any of the following are noted, further investigation may be warranted:
    1. Check to determine if the substructure elements are plumb (Note: check to determine if the design calls for a battered or sloped face).
    2. Note whether the horizontal mortar joints appear parallel with the surface of the water, if applicable.
    3. Inspect abutment weepholes, if present, to see if they are clogged. A build up of water behind the abutments can generate hydrostatic pressures that can cause lateral movement.
    4. Inspect abutments for signs of hydrostatic piping. This is caused when perforated drain pipes or weepholes become clogged, forcing water to seep through the embankment material or under the abutment footing, and discharge through the fill in front, possibly bringing with it, sizable amounts of backfill material. Check for deep ruts in the fill in front of the abutment, resulting in possible exposure of the footing. The roadway or the approach slab may also show settlement.
    5. Visually sight along the faces of the substructure elements to try to detect bulges, tilting, settlement or other deformation.
    6. Inspect the masonry stones for vertical cracks through several courses of stone in the same general area.
    7. Evaluate the following items from the bearing, approach and joint inspections that may indirectly indicate substructure movement:
        - Gaps between the bearings and the pedestals.
        - Positioning of the bearing elements on the pedestals, i.e. longitudinal or transverse misalignment, lack of full contact in the bearing area between the sole plate, bent or broken anchor bolts.
        - Gaps between the superstructure elements and abutment backwalls that are significantly greater or less than the design value or that expected for the ambient temperature.
        - If the superstructure is in contact with the backwall, it may indicate that the abutment is moving.

> ***Special Note:***
>
> *If movement of a substructure element occurs, the effects of that movement on bearings, joints, etc., may be visible at adjacent substructure elements, not at the element where the movement occurred. For example, over rotation of rocker bearings at a pier may be caused by movement of an adjacent abutment or pier with fixed bearings.*

- Probe areas where joint mortar is missing to determine the average depth of loss and the location of maximum loss.
- Stones with missing mortar below deck joints should be inspected for displacement, tilting, cracking, heaving, spalling, and crushing due to the freeze/thaw effects of penetrating water.
- Check stones that have experienced cracking to determine whether the pieces are in tight contact with the adjacent stones and are providing adequate stability to the substructure element.
- Inspect the substructure stones for signs of possible failure from crushing. Particular attention to crushing should be paid in the vicinity of bearings.
- All substructure elements, in or adjacent to waterways, shall be checked for the presence of scour and undermining. Scour shall be checked by wading and probing around the entire base of every element exposed to potential scour. Areas that cannot be accessed with available equipment should be referred for underwater inspection (See Appendix A6.12).

> ***Special Note:***
>
> *After maximum local scour has occurred during peak flow periods, sediment may backfill the scour hole during low flow periods giving a false indication to the inspector as to the actual extent of the scour problem. Probing through the soft surface sediment to the hard packed substrate with a probing rod will help to a limited degree, but only by performing soil borings will the actual scour depth be found.*

Documentation Required for Routine Inspections:

- Document deficiencies and deteriorations observed. Dimensions of deteriorations should include the length, width, height, depth of loss, orientation and location relative to a fixed, identifiable point.
- When deficiencies cannot be easily described, or if the condition rating is a "6" or less, elevation drawings shall be provided of the substructure elements to show the layout of the stone masonry joints and deteriorations noted. Sectional views and detailed drawings should be provided, if necessary, to adequately describe the extent of noted deficiencies.
- Document all scour, as well as, all signs of undermining of the substructure elements. Excessive scour conditions and any undermining condition, regardless of extent, shall be brought to the attention of the Transportation Supervising Engineer in accordance with the established procedures for critical deficiency reporting. Depths of scour holes shall be measured, utilizing probing rods, survey rods, sonic equipment or other measuring device and the presence of any backfilled sediment should be noted.

- Document any impact damage on the substructure elements due to ice, debris and marine or vehicular traffic.
- Document any signs of crushing of the stones in the area of bearings.
- Notes should be made describing the current condition of all previously noted problems so that a rate of deterioration can be established for monitoring purposes. If the condition rating has changed from the previous inspection, due to increased movement or quantity or size of deterioration or if a deteriorated area has been repaired, documentation shall accompany the inspection report that includes photographs and an explanation of why the condition reported has changed.
- Typical conditions and deteriorations, causing a condition rating of less than or equal to "5", shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements of the routine inspection, "hands-on" access shall be provided to the entire substructure.
- A plumb bob should be used to check the vertical alignment on all substructure units.

Documentation for In-Depth Inspections:

- All documentation required for the routine inspection shall be included in the in-depth documentation, except as noted in this section.
- Elevation drawings shall be provided to show the layout of the stone masonry joints and deterioration noted. Sectional views and detailed drawings shall be provided, if necessary, to adequately describe the extent of deficiencies noted.
- Documentation, as a whole, shall clearly describe the structural condition and serve as an accurate benchmark to which future inspection can be compared.
- A good quality photograph of the substructure, that documents the overall condition as well as detail photographs that support the condition rating, shall be provided.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- Review the inspection field notes for signs of tilting, settlement or rotation of any substructure elements. The reviewer shall also check for signs of contraction and local scour around substructure elements. If either of these conditions are noted for the first time, or if additional movement or scour is noted from the previous inspection, or if movement or scour is having serious adverse effects on the stability of the substructure element, the reviewer shall make recommendations to correct the observed deficiencies.

- Review the inspection field notes for signs of crushing of the substructure stones, particularly in the area of bearings, that may indicate the stone is being over stressed. If crushing is noted for the first time or if additional crushing is noted from the previous inspection, the reviewer should investigate the need for a revised load rating or make recommendations to correct the observed deficiencies.
- Low condition ratings that are caused by extensive or widespread deterioration should be reasons to request supplemental testing or analysis to better determine the condition and stability of the substructure element and whether rehabilitation or replacement is warranted.
- The inspection reviewer should determine if patterns of deterioration or progressive deterioration are taking place. Progression will be determined by comparing present to past inspection reports.
- The sudden or progressive appearance of cracks or movements in the substructure stones may indicate the need for a new load analysis and/or weight restriction of the bridge structure.

Maintenance Concerns

- The object of joint mortar, when incorporated into the design, is to furnish a cushion for the stones that helps to distribute the pressure uniformly across the stone surface. It also relieves the stone of transverse stresses and concentrated crushing pressures to which the projecting points are subjected when they are in contact with other stones. Therefore, loss of joint mortar can increase the stresses in the stone to the point where crushing or cracking may occur. Lost joint mortar should be replaced with an approved material utilizing approved procedures.
- Stone masonry set without mortar (dry laid) does not need to have joints mortared as a maintenance repair. In some cases, to do so may actually complicate the situation. For example, by preventing water from draining through an abutment, a build-up of hydrostatic pressure behind the abutment may cause tipping.
- Cracks in stones or cracks in joint mortar and openings in joints provide access to water seepage that can further deteriorate the stone or mortar joint through freeze/thaw action. Cracks and open joints should be considered for sealing, injection or other repair depending on their location and severity. Only cracks that are allowing water to enter should be sealed. Cracks that are allowing water from behind the abutment to exit should not be sealed unless it is determined that this is causing a larger problem. Engineering judgement and discussion with the Transportation Supervising Engineer is required prior to conducting repair work in order to determine the extent and criticality of the problem, effects on public safety and cost/benefit ratio of the repair.
- Settlement or tipping of substructure elements may be caused by erosion of the foundation material caused by scour. If the waterway at the bridge site has a history of scour problems, consideration shall be given to the design and construction of waterway protection devices such as rip rap, gabions, cofferdams, check dams, etc., to reduce the adverse effects of scour. However, if a train station is located at one end of the bridge, movement of the substructure elements may occur due to the longitudinal forces induced by locomotives accelerating and decelerating at the station.

- If the substructure elements are regularly impacted by ice and debris, consideration shall be given to the design and construction of protection devices to divert or absorb the impact forces. This will have a secondary benefit of moving waterway blockages and turbulence away from the substructure elements. However, this should also require a hydraulic analysis to be sure the hydraulic capacity of the structure is not compromised.
- All substructure impact protection devices (guardrail, fender system, ice breaker, etc.) shall be routinely checked to ensure that adequate protection is maintained. All damaged protection devices should be repaired, in a timely manner, to maintain the integrity of the system.

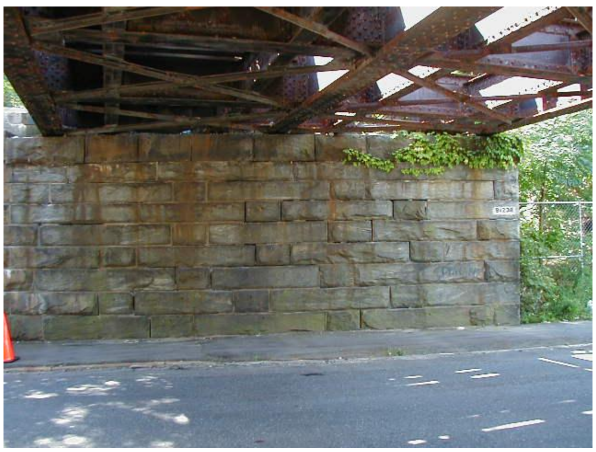


Figure 6.3.2a: Typical Masonry Abutment

Figure 6.3.2B: Typical Masonry Wingwall

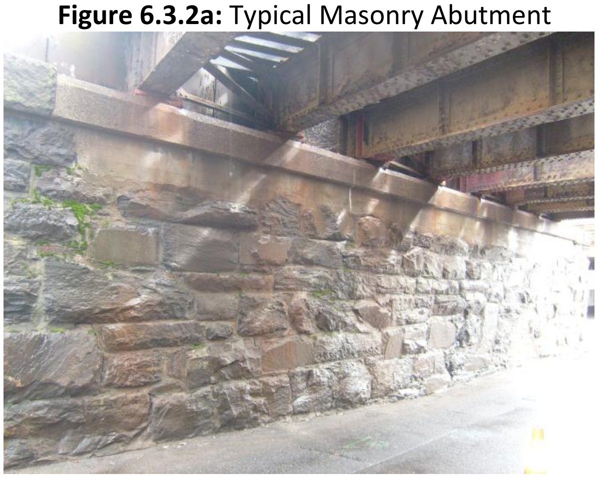


Figure 6.3.2c: Masonry abutment with concrete bridge seat

Figure 6.3.2d: Typical Masonry Piers

6.3.3 Steel Substructures

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 9
Reference: BIRM Section 10

General:
Steel piers and columns are a common feature in Connecticut, with a majority of the multi span Railroad Bridges having steel piers or columns for supports.

Inspection Requirements

Inspections:

- Inspect the substructure in accordance with BIRM, Sections 10.
- All exposed surfaces of metal, load path nonredundant substructure elements shall receive a 100% close-up, "hands-on" visual inspection during each inspection. Areas to receive this "hands-on" inspection include areas subject to tension stress and stress reversal. Members may consist of riveted, bolted, or welded construction.
- Check for section loss of the bottom flange of the pier cap at midway between columns.
- Check cover plates attachment to the top and bottom flanges of the pier cap, look for missing fasteners, worn fasteners. Check for cracked welds, longitudinally and at plate butt welds, transitional flange.
- Sight along the flanges of the cap beams for evidence of compression flange buckling or dead load deflection ("negative camber").
- Cap beam webs should be checked for signs of web crippling (out-of-plane bending) or beam tipping, at all support locations, from lack of stiffness. A plumb bob may be used for this purpose.
- Tension and stress reversal zones of metal members shall be examined for the presence of tack welds, remaining original welded erection aids, remaining original groove weld back-up bars, plug welded holes, and other existing weld details, situations, or conditions not part of the original design. If any of these situations exist, they shall receive a 100% close-up, "hands-on" visual inspection during each inspection. This shall be done regardless of redundancy.
- All fracture critical zones, all load path nonredundant members, fatigue prone weld details, and all other areas identified as requiring a 100% close-up "hands-on" inspection shall be clearly delineated in a specially prepared "Fracture Critical Data Sheet" for each appropriate bridge inspection report. Whenever an inspection report has a "Fracture Critical Data Sheet" (See Appendix A6.1) to highlight special items of inspection concern, the section shall be preceded by a title cover sheet boldly stating, "Details or Situations Requiring Special Attention During Inspection."
- In general, all connections welded to a primary member shall be considered part of the primary member.
- Check the pier columns and pier caps for cracks.

- When there are any significant changes in clearance, visually inspect and measure for pier movement.

- When a bridge element receives a 100% close-up, “hands-on” visual inspection under these provisions, a note shall be placed under “Additional Notes” on inspection form BRI-18 stating that the required 100% “hands-on” inspection was performed. This note shall specifically list those elements of the bridge that received the required 100% “hands-on” inspection.

- Areas of heavy rusting shall be inspected "hands-on" to establish the depth of any section loss. Rust scale or "laminated rust" shall be removed with chipping hammers, scrapers or wire brushes, as necessary, in order to measure the minimum remaining thickness of steel or maximum depth of section loss. This will be most critical on beam flanges, in high moment areas, and beam webs, in the vicinity of supports. Refer to the procedures in Appendix A6.2 for documenting steel section losses.

- Impact damaged areas should be inspected "hands-on" for the presence of tears or cracks.

- Welded repairs or utility connections, and any miscellaneous welds in the tension zones of the cap beams that can be accessed without special equipment, should be inspected closely for fatigue cracks or other defects (See Appendix A6.1 for typical details.). If defects are found, arrangements should be made to permit a "hands-on" inspection of all similar details on the structure.

- All suspected cracks should undergo Nondestructive Testing (NDT) to confirm their existence and determine the extent of crack. All confirmed fatigue cracks shall be immediately reported in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 3.2.7.

- The secondary members will be inspected from a distance of not greater than 15' using adequate lighting to detect corrosion, impacted rust, section loss, cracks, dings, gouges, impact damage and other defects.

- Bolts and rivets should be visually checked for tightness and section loss. Broken paint or bleeding rust around a bolt or rivet may indicate a loose or broken fastener. Suspect fasteners should be tapped with a hammer to confirm their integrity.

- Check for debris around the column or pier bases; debris will retain moisture and promote corrosion.

- Examine the cap beam for rotation due to eccentric connections.

- Other details, situations, or conditions of special concern may be highlighted for special inspection emphasis, even if the specific situation is not itemized in this list of elements to be inspected.

Documentation for Routine Inspection:

- Simple elevation drawings should be provided showing locations of deteriorations and other noted problems. Member elevations and cross sections should be provided, as required, to adequately describe deterioration found.

- Note the extent and severity of all rusting. Significant loss, whether from past or current rusting, should be noted in sufficient detail for a load rating analysis to be performed. Engineering judgment is required in the field to determine the significance of areas with loss, but as a guideline, specific notes are required when:

  a) Greater than 15% (typically 1/8") of the flange thickness is lost in areas of high moment.

  b) Greater than 30% (typically 1/8") of the web thickness is lost in areas of high shear.

  Less significant losses (typically <1/8") should be noted, but exact measurements are not required.

- Document steel losses by noting the area and depth of the loss as well as its relative location from a fixed point (e.g. 12" H x 12" W x 1/8" deep loss on cap beam at the bottom flange, beginning 3' from the west of Column 1). Whenever possible, where deterioration is noted, calipers or other measuring devices shall be used to measure the remaining section instead of estimating the loss. Notes should clearly indicate whether an "estimated loss" or "measured remaining thickness" is being given. See Appendix A6.2 for typical examples of documenting steel section loss.

- Note locations and condition of all welded repairs or connections and other miscellaneous welds in the tension zones of the beams, if they were not detailed on the construction plans or noted in the last in-depth inspection.

- Note the location and condition of all significant (deeper than a paint scrape) impact damage.

- Document in the field notes, the locations of all loose bolts/rivets, and also mark locations on the bridge with a permanent marker or lumber crayon, along with the date they were found.

- Document locations and lengths of all cracks found. Mark these locations on the bridge with a permanent marker or lumber crayon. Note the date found and the limit of crack propagation in such a manner that subsequent inspections may determine additional crack propagation. The method of inspection should also be noted as the crack may have propagated farther than may show visually. If any retrofit has been made to an old crack or holes drilled to arrest existing cracks, evaluate the effectiveness of the retrofit and note whether the crack has propagated past the arresting hole.

- Particular care shall be given to documenting any increased quantity or size of deteriorations that have changed since the last inspection. If the condition rating has changed from the last inspection, a photograph and explanation of why the rating has changed shall be included in the inspection report.

- Notes should be made describing the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes.

- Typical conditions and deteriorations, causing a condition rating of less than or equal to "5", shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for a routine inspection, "hands-on" access shall be provided to the entire substructure.
- All secondary members should be inspected "hands-on" regardless of extent of damage or deterioration.
- Check cross frames and struts for section loss to angles, particularly back-to-back angles with excessive fastener spacing.
- Look for cracks in cross frame and strut connections to the columns.
- Check the connection plates for section losses
- Check for section loss in the bottom and top laterals angles, adjacent to connection plates, and swelling between back-to-back angles.

Documentation for In-Depth Inspections:

- All documentation required for a routine inspection will be included in the in-depth documentation except as noted in this section.
- Simple elevation drawings of all primary members should be provided. All deterioration or deficiencies found should be noted on these sheets and should include size, length, direction, depth, etc. Sections and other detail sketches should be drawn, as required, to clearly show the locations and extent of deterioration or deficiencies noted.
- Documentation, as a whole, should clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph of the substructure, that documents the overall condition as well as detail photographs that support the condition rating, shall be provided.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- The inspection reviewer should determine if patterns of deterioration or progressive deterioration are taking place. Progression will be determined by comparing present to past inspection reports.

- The reviewer should verify that the current structural evaluation on file for the bridge is valid, based on conditions found during the inspection.
- The appearance of new or sudden propagation of existing fatigue cracks may warrant a new load rating or fatigue analysis, and/or posting of the bridge structure for a weight restriction. The reviewer should insure that all new fatigue cracks found were reported in accordance with the established procedures for "Critical Deficiency Reporting."

Maintenance Concerns

- Most repairs to steel members will be structural in nature and may have an effect on the load carrying capacity of the structure. Repairs should be detailed and performed under the direction of a Transportation Supervising Engineer.
- Fatigue cracks, that show little or no crack propagation for extended periods, can suddenly resume propagation, possibly resulting in member failure. Therefore, all cracks found shall be immediately reported and corrective action should be taken, as soon as possible, to ensure the integrity of the structure and safety of the public.
- Areas of section loss, gouges, dings, and impacted rust are all stress risers in steel members and should be monitored closely or repaired.

Figure 6.3.3a: Typical three span over road bridge with two steel piers

Figure 6.3.3b: Steel Column Supported Deck Plate Girders

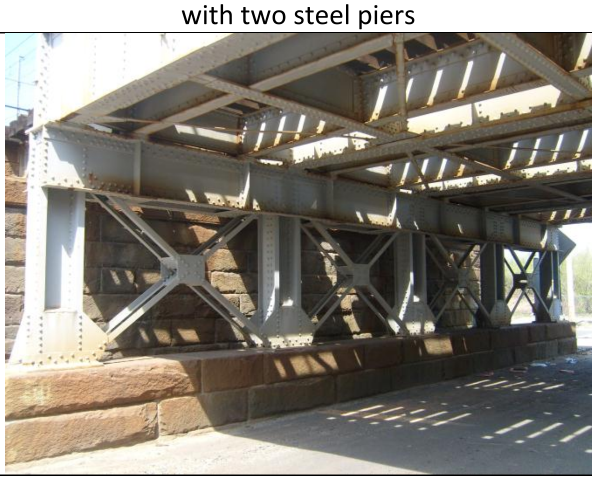


Figure 6.3.3c: Typical steel pier

Figure 6.3.3d: Typical steel columns

6.3.4 Timber Substructures

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 7
Reference: BIRM, Sections 2.1, 10, 11.3 and 13.1
Reference: USDA Forest Service Publication "Timber Bridges: Design, Construction, Inspection and Maintenance"

Inspection Requirements

Inspections:

- Inspect the timber substructure elements in accordance with BIRM, Section 10.
- The entire substructure shall be using adequate lighting to detect fungus growth, parasite infestation, fire damage, impact or collision damage, weathering or warping, splitting, cracking, checking, signs of over stress, chemical damage or other deterioration.
- Areas found to be deteriorated or deficient during the visual inspection will be inspected, "hands-on", to determine the type and extent of deterioration or deficiency.
- Check timber members for signs of crushing at timber pile/concrete footing interface (if exposed), pile/bent cap interface, or other bearing areas. Look for buckling, cracking and other signs of over stress along the length of axially loaded piles and in areas of maximum bending stress on pier bent caps.
- Check for signs of decay and parasite damage in the tidal area of timber piles or in areas frequently exposed to wetting/drying cycles for non-tidal waterways. Deterioration may also occur at locations of connections where the paint or preservative system has been damaged or disrupted. (See Appendix A6.8 for types of decay and deterioration.) Areas that have evidence of serious deterioration, decay or infestation should be brought to the attention of the Transportation Supervising Engineer to determine the need for further investigation by Non-Destructive Testing or Destructive Testing methods (such as Increment Boring).
- A representative sample of the timber surface area, showing no surface deterioration, shall be hammer tapped or probed with an ice pick in an attempt to locate internal deterioration. If deterioration is found, additional probing shall be performed. Be careful of frozen timber that may have internal deterioration but sounds solid, due to water frozen in the internal cavities.
- Inspect the substructure elements for tilting, settlement, rotation or other movement.

> ***Special Note:***
>
> *If movement of a substructure element occurs, the effects of that movement on bearings, joints, etc., may be visible at adjacent substructure elements, not at the element where the movement occurred. For example, over rotation of rocker bearings at a pier may be caused by movement of an adjacent abutment or pier with fixed bearings.*

- The area around the base of timber piles should be inspected for signs of contraction or local scour as outlined in Appendix A6.10 & A6.12.
- Suspected areas of local scour shall be probed with a probing rod to attempt to determine the limits of scour.

> ***Special Note:***
>
> *After maximum local scour has occurred during peak flow periods, sediment may backfill the scour hole during low flow periods giving false indication to the inspector as to the actual extent of the scour problem. Probing through the soft surface sediment to the hard packed substrate with a probing rod will help to a limited degree, but only by utilizing core samples or other methods will the actual scour depth be determined.*

- Note all fire damaged areas and whether the damage is superficial (scorched) or if loss of effective section has occurred. Note the depth of char.
- Check for shear cracks parallel to the longitudinal axis of piles and pier caps. If there are any glue-laminated members (pier caps), look for shear cracks between the laminas. For bending members, horizontal shear cracks will cause the member to split and act as two smaller members, independent of each other. Therefore, horizontal cracks and delaminations at mid-height of the member are more critical than those nearer the top or bottom surface.
- Secondary bracing members may be constructed of timber or steel members. For timber, check for deterioration, proper fit, cracked or split members and corroded, loose or missing fasteners. For steel members, check for section loss, loose or missing fasteners and bowing or buckling of the member.
- Timber members are best connected with seated, bearing type connections. Check bolted, framed, or nailed connections for member deterioration or connection failure.
- Check bent caps for excessive deflection, sagging and vibration, as well as, for proper alignment.

Documentation for Routine Inspections:

- When deficiencies cannot be easily described, or if the condition rating is a "6" or less, provide elevation drawings of substructure elements to show the layout of the timber members and noted deteriorations. Sectional views and detailed drawings shall be provided as required to adequately describe the extent of noted deficiencies.
- Document deterioration such as debris build-up, fungus growth, parasite infestation, fire damage, weathering and warping, splitting, cracking, checking, chemical damage and signs of overstress. All deteriorations noted shall include their size and relative location on the member. Where possible, measurements will be taken to determine the remaining effective section on the member.

- Document horizontal cracks, splits, or delaminations in bending members. Note whether the cracks, splits, or delaminations pass entirely or partially through the member and measure the depth of the crack, if possible. Dimension the height of the member halves (above and below the crack), the member width and the amount the crack has opened.
- Document signs of substructure settlement, tilting or other misalignment and whether adverse effects on the superstructure elements were noted.
- Document areas of water staining and deterioration due to water leakage from deck joints.
- Document conditions of contraction and local scour. Excessive scour conditions shall be reported immediately in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 3.2.7. Depths of scour holes and the presence of backfilled sediment shall be noted.
- Document impact damage on the substructure elements due to ice, debris and marine or vehicular traffic.
- Particular care shall be given to documenting any increased quantity or size of deteriorations that have changed since the last inspection. If the condition rating has changed since the last inspection, a photograph and explanation of why the rating has changed shall accompany the inspection report.
- Notes should be made describing the current condition of all previously noted problems so a rate of deterioration can be established for monitoring purposes.
- Typical conditions and deteriorations causing a condition rating of less than or equal to "5" shall be photographed as outlined in Chapter 5.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements of the routine inspection, "hands-on" access shall be provided to the entire substructure.
- All primary and secondary members shall be inspected "hands-on" regardless of extent of damage or deterioration.
- Severe internal decay may be occurring despite the solid appearance of the exterior. Therefore, random probing of 50% of the structural members shall be conducted with an ice pick or awl to locate voids or areas of internal deterioration. Emphasis shall be placed in tidal zones, areas of wet/dry cycles or areas of water staining.

Documentation for In-Depth Inspections:

- All documentation required for routine inspections shall be included in the in-depth documentation except as noted in this section.
- Elevation drawings shall be provided to show the layout of the timber members and deterioration noted. Sectional views and detailed drawings shall be provided, as required, to adequately describe the extent of deficiencies noted.
- Documentation, as a whole, should clearly describe the structural condition and serve as an accurate benchmark to which future inspections can be compared.
- A good quality photograph of the substructure, that documents the overall condition as well as detail photographs that support the condition rating, shall be provided.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.
- The inspection reviewer should determine if a pattern of deterioration or progressive deterioration is taking place. Progression shall be determined by comparing past and present inspection reports.
- Review the inspection field notes for signs of tilting, settlement or scour, splitting, cracking or impact damage. Determine if conditions require additional analysis or immediate repair.
- Low condition ratings, that are caused by extensive or widespread deterioration, should be reasons to request supplemental non-destructive or destructive testing or analysis to better determine the condition and stability of the substructure element, and whether rehabilitation or replacement is warranted.

Maintenance Concerns

- The most common type of preventive maintenance for wood structures is the application of preservative treatment, paint or other protective coatings to protect the timber from fungus or parasites and the elements. Preservative treatment or paint shall be applied as required to protect the timber elements. It should be noted that preservative treatments typically do not penetrate through the entire cross-section of the member. Therefore, as with non-treated or painted members, interior deterioration due to parasite infestation may still occur despite the solid appearance of the exterior.
- Loose connections may occur due to timber shrinkage, cracking, checking, decay or crushing around the connector or deterioration of the fastener itself. Loose fasteners should be tightened, and broken, missing or deteriorated fasteners (exhibiting greater than 20% section loss) should be replaced.
- Remove debris to avoid moisture accumulation.

- Cut vegetation from around wet areas and areas prone to debris buildup to allow better air circulation for drying action.
- If the substructure elements have been properly designed and show little deterioration, movement of substructure elements may likely be caused by scour. If substructure elements at a particular bridge site have a history of, or high susceptibility to the effects of contraction and local scour, consideration shall be given to the design and construction of waterway protection devices such as rip rap, gabions, cofferdams, check dams, etc., to reduce the adverse effects of scour.
- If the substructure elements are regularly impacted by ice and debris, consideration shall be given to the design and construction of protection devices to divert or absorb the impact forces. This will have a secondary benefit of reducing waterway blockages and turbulence around the substructure elements.
- Substructure impact protection devices (guardrail, fenders, dolphins, ice breakers, etc.) shall be routinely checked to ensure adequate protection is maintained. All damaged protection devices should be repaired to maintain the integrity of the system.

Figure 6.3.4a: Timber Bent with a pile – note decay damage

6.4. CULVERTS

Reference: AREMA BRIDGE INSPECTION HANDBOOK© CHAPTER 12
Reference: BIRM Sections 2, 7.12, 11 and 13
Reference: FHWA Report #FHWA-IP-86-2, Culvert Inspection Manual

General:

A culvert is a transverse drain or waterway under a road or railroad; a conduit, typically underground. Structures that are defined as culverts vary from railroad to railroad. Most often the determination is based on span length and, occasionally, on the type of construction. The common feature of culverts is that they are usually smaller structures, built to handle storm water runoff, intermittent streams or small waterways.

There are three typical culvert configurations

- boxes
- circular structures
- arches

All three types are constructed from a variety of materials. The primary materials used for culverts are:

- Cast Iron Pipe
- Concrete Pipe
- Corrugated Wall Steel Pipe
- Concrete
- Masonry, Cut Stone or Brick
- Timber
- Rail
- Clay Pipe

A culvert may consist of any one of the materials listed, or it may be a combination of materials and configurations.

Safety
Before considering inspection procedures, the inspector must first consider worker safety. Culverts are most often located in hard to access areas. Some may be considered to be confined spaces. The inspector must determine the safest access to each location. If the work site is a confined space, the inspector must be completely familiar with all the rules and regulations that impact the work area. Personal safety and the safety of those working at the inspection site must be first and foremost concern.

Inspection Requirements

Inspection:

Track Level:

- Inspect the ballast surface for settlement, due to culvert flattening, and for signs of erosion or failure of the side slope over the culvert. Check for signs of sink holes over the culvert that may be due to "piping" of the fill material through joints in the culvert.
- Inspect the approach embankments for erosion protection, such as slope paving or vegetation. Note the overall adequacy of this protection and note any vegetation near the culvert where roots may damage the culvert.

Waterway:

- Note any observed changes in stream/culvert horizontal or vertical alignment that might affect the hydraulic adequacy of the culvert or cause scour. Note whether the stream bed fluctuates between high and low flow volumes.
- Note any observed changes in the ground cover or land use that might change the volume of water passing through the culvert.
- Document any changes in the amount, type or location of any channel erosion and streambed aggradation/degradation.
- Document any observable high water mark relative to the culvert barrel.
- Measure and document the velocity of the water flow upstream, downstream and through the culvert (if possible). Simple methods for approximating water flow velocity are outlined in Appendix A6.10, Waterways.
- Document any debris buildup or other obstructions in the waterway upstream and downstream from the culvert and any effects the obstruction is having on the hydraulic adequacy.

Culvert Barrel and End Treatments:

- Check the culvert headwall, wingwalls, cutoff walls, slope protection and energy dissipaters for any deficiencies and deterioration, undermining, scour, piping, tipping settlement and slope failure.
- Check the culvert barrel for deformations, settlement (either a smooth slope over the length of the culvert or an abrupt change at a joint), leaking or distressed joints and other deficiencies or deteriorations. Check for evidence that lateral earth pressure is causing bulging, flattening, peaking, sliding or rotation in the barrel or barrel components as outlined in Appendix A6.5 and Appendix A6.7.
- Document any debris or sediment build-up within the barrel.
- Verify the minimum required measurements of the culvert as outlined in Appendix A6.5. Dimensions should be taken at the inlet, outlet, mid-length and at 24 ft. intervals (maximum), as applicable, if access to the interior of the culvert is possible. Locations of sagging, bulging, flattening or peaking should also be measured.
- Check the barrel walls for scour and undermining (typically found in culverts that pass the natural streambed through the culvert) and around the inlet and outlet of closed barrel sections.
- Probe all areas of scour, undermining and joint mortar loss and note the average depth at each location and maximum depth overall.
- Check to see if the culvert barrel has separated from the headwalls or cutoff walls.
- Check to ensure that headwalls and wingwalls are adequately retaining the embankment material and protecting it against erosion.
- Where practical, the floors of metal pipe culverts should be sounded with a metal rod in an attempt to locate voids due to undermining.

- Check bottom flanges of rail ceiling for section losses; check for loss of concrete between rails.

Special Note About Corrugated Metal Culverts:

- *Culverts with mitered ends (ends cut to match the embankment slope) and ends of skewed culverts (where the end is cut parallel to the centerline of the roadway) have reduced strength in these areas and have increased susceptibility to buckling. Therefore, even minor deformations are significant.*
- *Projections of culvert ends beyond the embankment lead to increased probability of erosion and piping around the culvert barrel.*

Aprons, Energy Dissipaters and Flumes:

- Check the apron, which reduces erosion at the inlet and outlet (typically a concrete slab or rip-rap), for deterioration, missing stones, undermining of slab, movement of stones due to scour and deterioration of the joint between the apron slab and headwall. Deterioration of the apron allows leakage of water to the soil behind the headwall.
- Check the energy dissipaters, which reduce out flow velocity and downstream erosion (typically rip-rap or concrete basin), for missing stones, movement of stones, scour, undermining, deterioration of the basin and overall effectiveness of the dissipater.
- Check the flumes (typically concrete, bituminous material or rip-rap) for deterioration, erosion, debris and signs of water bypass.

Documentation Required for a Routine Inspection:

- Document all observed deficiencies and deteriorations. Dimensions should include length, width, height, depth of loss, orientation and location relative to a fixed, easily identifiable point.
- Estimate and record the depth of fill over the culvert.
- Draw a site plan that shows the orientation of all the culvert elements relative to the roadway. Sketch and dimension the boundaries of the waterway for the length necessary to show the alignment with the culvert (100 ft. minimum). The sketch shall include both the inlet and outlet sides of the culvert, and dimensions for the typical width, depth, estimated velocity and direction of flow of the waterway, as well as, all major changes in waterway cross section. All obstructions, deficiencies, changes in land use, changes in topography, sediment buildup, erosion, etc., shall be noted on the sketch (see Figure A-5-1 in Appendix A6.5 for an example sketch).
- Particular care shall be given to documenting any increase in quantity or size of deteriorations, erosion, sediment buildup, changes in waterway centerline, etc., which have changed since the last inspection. If the condition rating has changed since the last inspection, a photograph and detailed explanation of why the rating has changed shall be included in the report.

- Document any recent construction activity in the area that may affect the water flow through the culvert (i.e. changes in drainage area, land use, topography, etc.)
- Photographs taken shall include, but not be limited to the following:
  - View of the track above the culvert, taken from each approach toward the culvert.
  - View of the culvert inlet and outlet taken from the waterway centerline or edge upstream and downstream of the culvert. The distance at which these photographs are taken shall be the distance sufficient to give, a clear and accurate view of the culvert and waterway at the culvert.
  - View looking upstream from the culvert inlet and downstream from the culvert outlet.
  - Typical views of all major components where deficiencies, erosion, sediment buildup, obstructions, etc., were noted. Include detailed photographs, as necessary.

  (Note: Pictures taken of the track from the approaches and detail photos of deficiencies, erosion, deterioration, etc., may be omitted if photos from previous inspections adequately reflect the current condition. However, all photos taken of the waterway approaches and culvert openings should be updated during each inspection so that lateral movement and changes in alignment, over time, can be documented.)

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for routine inspections, all exposed surfaces of concrete culverts should be tapped with a hammer to locate delaminations.

Documentation for In-Depth Inspection:

- Same requirements as for routine inspection.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes and photographs to ensure they are mutually supportive of their documentation.

- The inspection reviewer should determine if a pattern of deterioration or progressive deterioration is taking place. Progression will be determined by comparing present and past inspection reports.
- Special attention shall be given to field note documentation indicating changes in the culvert shape, the presence of scour, piping or other problem that may warrant further investigation.
- Culverts are usually designed to use the vertical and horizontal earth pressures to maintain their stability and increase their live load capacity. Therefore, any change in the "As-Built" condition of the soil surrounding the culvert (addition or removal) should be noted and possibly analyzed for effects on the stability and capacity of the culvert.
- Changes in drainage area, land use and topography, which increase the depth or velocity of the waterway, should be assessed to determine if they may affect the long term waterway stability (i.e. lateral movement, aggradation, degradation, etc.) and hydraulic adequacy of the culvert.

Maintenance Concerns

- By the nature of their construction, culverts constrict the flow of water in the waterway. This constriction increases the potential for waterway blockage with debris and sediment, and increases the probability of scour around the culvert, especially if high outlet velocity or high inlet turbulence exist. Therefore, any blockages noted should be removed as soon as possible (during the inspection if possible).
- The addition of cut-off walls should be considered where "piping" or seepage around the outside of the culvert structure is found or suspected.
- Severely deteriorated culverts may be reviewed for repair by relining the culvert barrel.

Figure 6.4a: Twin corrugated plastic pipe culvert

Figure 6.4b: Concrete pipe culvert

Figure 6.4c: Masonry arch culvert

Figure 6.4d: Rail top box culvert

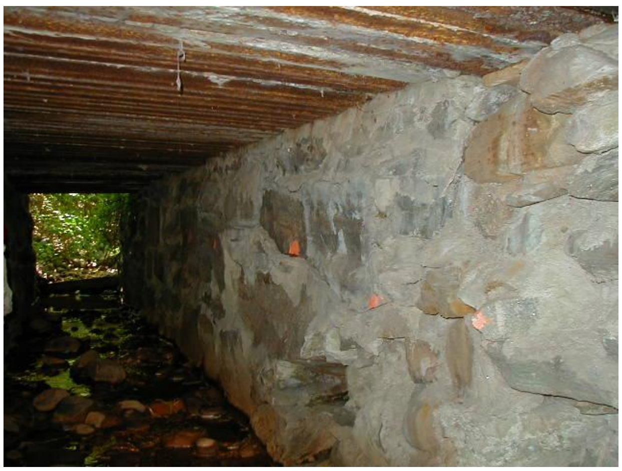


Figure 6.4e: inside a typical rail top box culvert

Figure 6.4f: Obstructed twin cell box culvert

Figure 6.4g: Deteriorated bottom of a corrugated pipe culvert

Figure 6.4h: Loss of concrete from slab above rail

6.5. WATERWAY

Reference: BIRM, Section 11

6.5.1 Channel And Channel Protection

Inspection Requirements

Inspections:

- Inspect the channel and all channel protection devices in accordance with BIRM, Section 11.
- All rip-rap, gabions, spurs, spur dikes and other types of channel and flood plain protection devices shall be inspected for signs of joint separation, broken or deteriorated retention cages, missing or displaced stones, cracked, spalled or deteriorated concrete, impact damage, erosion, loss or lack of vegetated cover, tilting, displacement and other deterioration.
- If the channel is navigable, see Section 6.2.6.5, protection devices such as timber, rubber, concrete or steel fender systems, dolphins, protective islands, etc., shall be inspected for deteriorations, deficiencies or impact damage and evaluated, as to their effectiveness, in providing adequate impact protection to the bridge structure from marine vessels. Navigation guidance systems (signs, lights, etc.) shall be inspected for deteriorated or broken devices, adequate visibility to marine vessels and compliance with current Coast Guard standards.
- Evaluate the overall effectiveness of the channel protection devices at redirecting or absorbing the energy of the water flow by estimating the flow velocity (fast or slow) and observing the flow characteristics (calm, turbulent, swirling, above normal flow depths, etc.), upstream, downstream and through the hydraulic opening.
- Inspect all rigid protection devices in the channel, such as gabions and concrete walls, for signs of local or contraction scour as defined in Appendix A6.10. Inspect non-rigid protection devices, such as riprap or earthen dikes, for local scour of the base material (look for sloughing of the construction material) or erosion of the construction material itself.
- Probe all areas of suspected local scour to determine the limits of scour.
- The problem of accurately determining maximum local scour and rate of change of local scour over time is one of the most difficult aspects of bridge inspection, yet it is one of the most important aspects of evaluating bridge safety. In order to effectively evaluate the scour potential of a structure, it is essential to develop a bridge diary dealing with scour. By referring and updating this document with each inspection, (which should also contain information about general and contraction scour and any lateral movement of the waterway), a clear picture of the extent and rate of scour development can be determined. This is essential to plan the proper maintenance efforts required to arrest scour damage (See Appendix A6.10 & A6.12).

> ***Special Note:***
>
> *After maximum local scour has occurred during peak flow periods, sediment may backfill the scour hole during low flow periods giving false indication to the inspector as to the actual extent of the scour problem. Probing through the soft surface sediment to the hard packed substrate with a probing rod will help to determine actual scour depth.*

- Look for irregularities in the surface slope of the protective devices (dips, depressions, sink holes, etc.), which can be an early indication of erosion or scour of the base material.
- Inspect the channel for signs of general scour (degradation) and aggradation as defined in Appendix A6.10.
- Inspect the banks of the channel for signs of erosion and sloughing of the bank material or vegetation.
- Inspect the channel for misalignment with the bridge substructure elements. If misalignment is observed, estimate the degree of misalignment.
- Inspect the channel for debris accumulation from ice, vegetation, etc. that constricts the water flow through the hydraulic opening. This accumulation may accelerate contraction or local scour, due to increased water flow velocity and development of water vortices.
- Inspect the channel for signs of lateral movement since the last inspection.

Documentation for Routine Inspections:

- Document deficiencies and deteriorations found in the channel protection devices. A site plan, that shows the location and orientation of the channel and channel protection devices, shall be provided. A bridge plan and channel cross section drawing will be required in accordance with Appendix A6.12.
- Estimate and record the flow characteristics of the channel (fast, slow, high, low, turbulent, etc.), at the time of inspection.
- Record the direction and distribution of flow between piers and between piers and abutments.
- Document all conditions of general, contraction and local scour as well as any signs of undermining of the protective device elements. Excessive scour conditions and any undermining condition, regardless of extent, shall be reported in accordance with the Critical Deficiency Reporting/Emergency Response procedures outlined in Section 3.2.7. Depths of all scour holes shall be measured utilizing probing rods, survey rods or sonic equipment and the presence of any backfilled sediment shall be noted.
- Document accumulation of any ice, debris, vegetation, etc., which constricts or disrupts the water flow through the hydraulic opening or around the protection devices.
- Document any recent construction activity in the area that may affect the stream flow under the bridge (i.e., changes in drainage area, land use, topography, etc.).

- Document the presence of sediment buildup, immediately downstream of the bridge structure, that may indicate the presence of contraction scour.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for a routine inspection, the actual water flow velocity shall be measured upstream, downstream and through the hydraulic opening. If flow meters are not available, the velocity may be estimated using the method outlined in Appendix A6.10 or similar approved method.

Documentation for In-Depth Inspections:

- All documentation required for routine inspections shall be provided for in-depth inspections.
- Record the actual water flow velocity upstream, downstream and through the hydraulic opening.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Cross reference the inspection report, inspection field notes, and photographs to ensure they are mutually supportive of their documentation.
- If excessive debris build-up or degradation of the channel is noted, check to see if any adverse effects, due to scour, were noted in the substructure section of the report.
- Review the inspection report for signs that a pattern of deterioration or progressive deterioration is occurring in the channel or with the channel protection devices. Progression shall be determined by comparing present and past inspection reports.

Maintenance Concerns

- Misalignment between the channel and substructure elements of the bridge and high water flow velocities can cause serious scour problems with the substructure elements. Channel protection devices are designed to reduce this scour potential by redirecting the flow, improving alignment and absorbing energy from the flow. Periodic maintenance may be required to repair damaged or deteriorated channel protection devices or replace scoured or eroded materials so that adequate protection for the bridge substructure remains in place. If misalignment or water velocity contribute to local scour of the substructure elements, despite the presence and good condition of the channel protection devices, a study may be required to determine the need for redesigning the channel protection system (moving existing devices or building new devices).

- Debris accumulation in the channel or at the bridge opening will constrict the water flow around protective devices or through the hydraulic opening of the bridge and potentially contribute to localized scour due to vortex development. Debris removal may be required as part of regular maintenance of the structure.

Figure 6.4.1a – Timber Fender System with navigation lights.

Figure 6.4.1b – Stone and tree debris in the channel.

6.5.2 Waterway Adequacy

Inspection Requirements

Inspections:

- Observe whether the lowest elevation of any component of the bridge superstructure is higher than the lowest point in the approach roadway. This gives indication that the approach roadways will be topped by flood water before the bridge superstructure is subjected to lateral forces due to the flood water.
- Observe whether waterborne debris is hung up in the bridge superstructure or around bearings. This indicates that the maximum hydraulic opening has been exceeded or that past flooding has approached the maximum hydraulic opening.
- Observe the location of any high water mark. This may be indicated by displaced vegetation, deposited debris, water staining on the bridge elements, etc.
- Observe whether significant aggradation or degradation has occurred that affects the hydraulic opening of the structure.
- Observe whether the superstructure has moved laterally in the direction of flow on the bearing plates or pedestals. This may indicate displacement during past flood conditions.

Documentation for Routine Inspections:

- Document the high water mark, the presence of vegetation or debris deposited on substructure elements or snagged on superstructure elements or any other indication that flooding has approached or has exceeded the maximum hydraulic opening.
- Evaluate the adequacy of the waterway, based on observed site conditions and the history of flooding at the site.

Documentation for Verification Inspections:

- A copy of the previous inspection report will be revised, noting any components with a change in condition from the report.
- A photograph shall be taken of those bridge components where the condition previously reported has changed.

In-Depth Inspections:

- In addition to the requirements for routine inspections, the hydraulic opening shall be estimated using the procedure outlined in Appendix A6.10.

Documentation for In-Depth Inspections:

- All documentation required for routine inspections shall be provided for in-depth inspections.
- Record the hydraulic opening as outlined in Appendix A6.10.

Report Review

- Review the inspection findings in accordance with established Quality Control and Quality Assurance procedures.
- Investigations should be considered for bridges that have experienced flow rates exceeding their maximum design flood value or for bridges that are at high risk for having their maximum design flood exceeded. Conclusions drawn from such investigations may indicate the need to employ preventative measures, as described above, or the need to rehabilitate existing protective devices meant for use during flood conditions. If new design or rehabilitation is warranted, detailed analysis to determine the backwater effect caused by these devices shall be conducted. Detrimental effects caused by diversion or back-up of water (i.e. increased flooding in town/cities, etc.) may mitigate the implementation of the preventive maintenance measures.

Maintenance Concerns

- High flow volumes and velocities during flood conditions can have serious detrimental effects on bridges, if the hydraulic opening is exceeded. Bridges that have had their roadway “overtopped” should be inspected after flooding recedes.

Appendix 6.1: FATIGUE SENSITIVE DETAILS

The following is a compilation of common fatigue sensitive details found on steel superstructure bridges that are most susceptible to fatigue cracking. They are taken from the Manual for Inspecting Bridges for Fatigue Damage Conditions written for the Pennsylvania Department of Transportation. The location of the fatigue crack shown in each detail represents the location where the crack is most likely to occur. This does not mean, however, that it is the only possible location. Inspectors should scrutinize the entire area prone to fatigue for the existence of cracks. For a more in-depth discussion on inspection techniques, AREMA categories of fatigue strength, fatigue damage at welded, riveted and bolted details, and estimation of fatigue life, the Penn-DOT and AREMA manuals should be reviewed.

General Notes About Fatigue Cracks:

- Fracture of steel members due to fatigue is a three step process that involves fatigue crack initiation, crack propagation (slow growth) and brittle fracture (rapid growth).

- High residual tensile stresses can develop in the weld metal due to the rapid heating and subsequent cooling during the welding process. These residual stresses can often exceed the service stresses due to dead and live load. As a result, the net tensile stress in the weld metal of tension members or in tension zones can exceed the net tensile stress in the base metal. In compression members or in compression zones, weld metal can have net tensile stress even though adjacent base metal is in compression.

- Fatigue cracks in welds on compression members or in compression zones, generally do not propagate by fatigue crack growth. Their presence, however, should not be overlooked or ignored.

- Fatigue cracks generally initiate at an internal flaw within the weld or weldment produced during the welding process. Welds that are perpendicular to applied bending or axial stress are more susceptible to fatigue cracking than those parallel to applied stress.

- Oxide dust (bleeding rust) forms within the fatigue crack due to abrasion of adjacent sides of the crack during flexure action. The presence of oxide dust in a line along a connection or around a fastener is a general indicator of the presence of a fatigue crack.

- The absence of paint cracks does not preclude the presence of fatigue cracks. Fatigue cracks can propagate from 1/4 to 1/2 of the plate thickness before the paint film cracks.

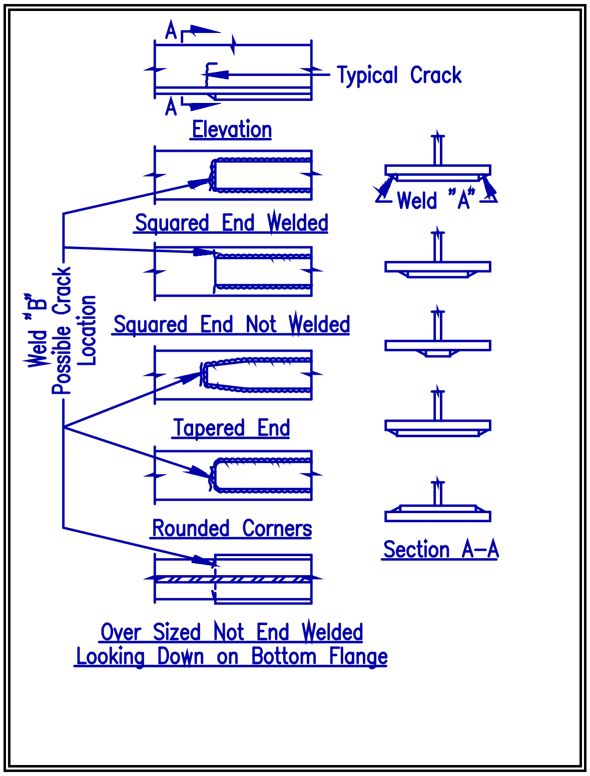
- Cleaning a suspect area by means of grinding or sand blasting may result in smearing the surface of the crack giving erroneous evidence as to the presence or extent of the crack. Care should be exercised when cleaning the area under investigation to avoid smearing.

Fatigue Damage in Welded Details

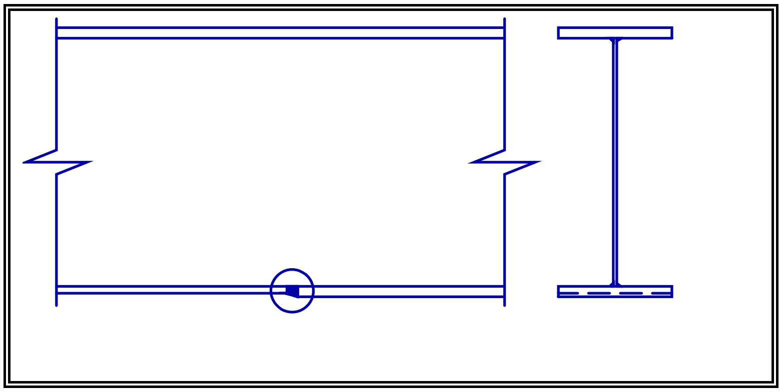
1) Fatigue Cracks in Main Members

1.1 Ends of Welded Cover Plates

- Cracks typically occur at the toe of the fillet weld where it attaches the cover plate to the flange.
- Details with flange thicknesses of greater than 0.8" are more prone to fatigue cracking.
- In transverse end welds (weld "B"), multiple cracks may initiate and join to become one large crack increasing the possibility of brittle fracture.
- In details without transverse end welds, cracks typically develop and propagate from the end of the longitudinal weld (weld "A") into the flange plate.

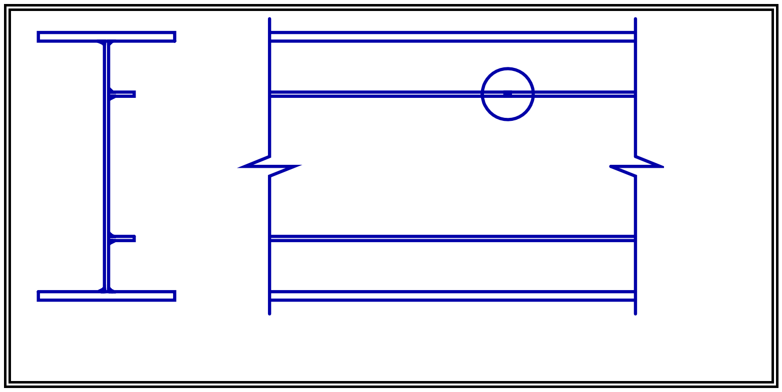


1.2 Transverse Groove Welds in Flange Plates



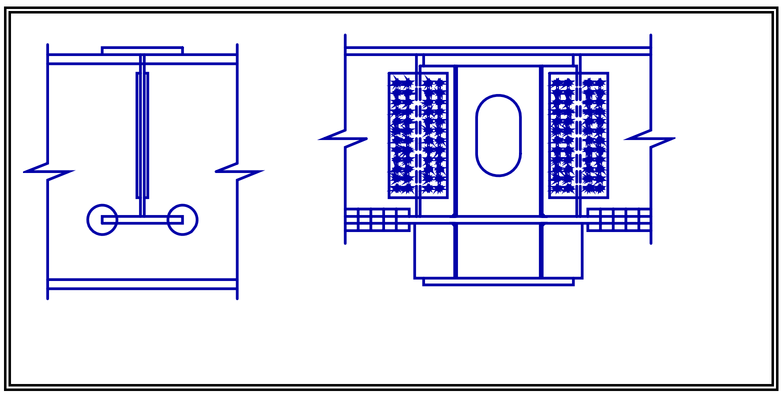
- Cracks at these locations are often not detectable through visual methods prior to brittle fracture. Other forms of NDT, such as Ultra-sonic testing, may have to be employed to evaluate these details.
- Due to improved methods of non-destructive testing during fabrication, fatigue problems are not expected at this location on newer structures (1980+).
- Tension flanges fabricated with this detail prior to 1970 or by electroslag methods are highly susceptible to fatigue cracking.

1.3 Butt welds in Longitudinal Stiffeners



- Cracks may initiate in the butt weld between the plates or at the intersection of the butt weld and stiffener longitudinal fillet weld.
- Cracks may propagate through the longitudinal stiffener fillet weld into the girder web or longitudinal stiffener plate.
- Longitudinal stiffeners in compression zones of girders have low fatigue susceptibility.

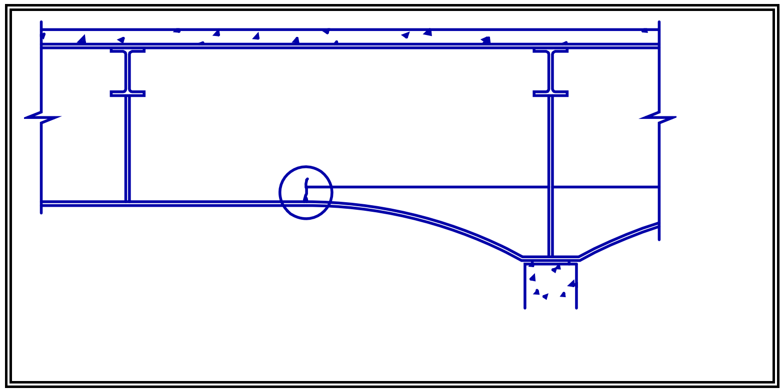
1.4 Web Plates with Cutouts and Filler Welds



- Girder bottom flanges from adjacent spans connected via splice plate through the web of the transverse cross girder may be welded on one or both sides of the web of the cross girder.
- Fatigue cracks may occur in the cross girder web at the toe of the fillet weld connecting the splice plate to the cross girder. Both sides of the cross girder web should be checked.
- Found primarily on newer bridges (1970+), this detail is likely to develop fatigue cracks.

1.5 Intersecting Groove Welds in Insert Plates

- Insert plates may occur over large areas, such as over piers, to increase haunch depth or as web repair plates (any size) occurring at any location on the girder.



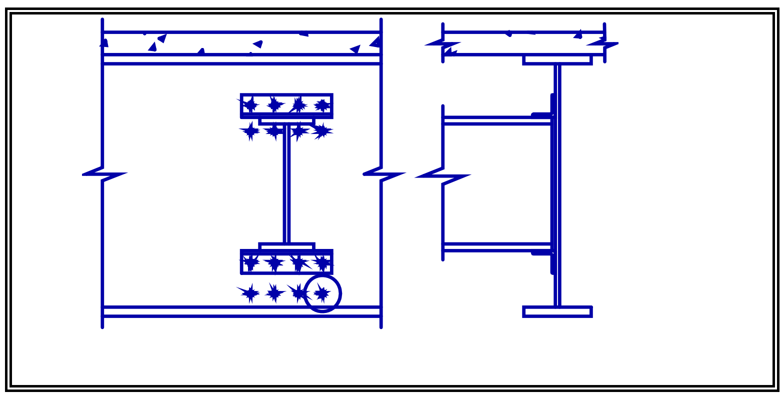
- Cracks may initiate at the intersection of the longitudinal and transverse groove weld and may propagate into the web or flange of the girder.

- Particular attention should be paid to welds that are perpendicular to the applied bending or axial stress.

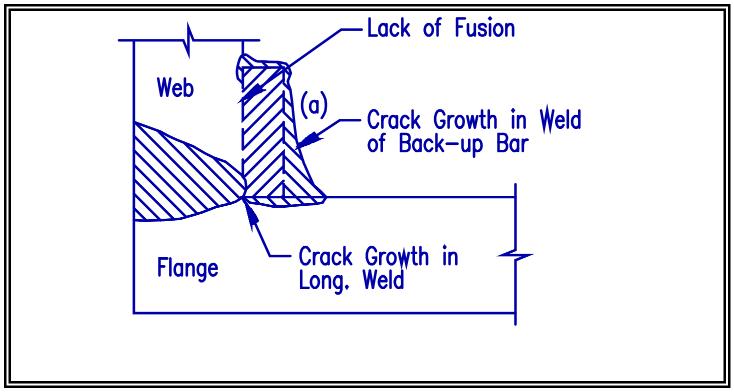
1.6 Mis-drilled Holes Filled with Weld Material and Plug Welds

- Misplaced holes in the tension zone of superstructure members that are filled with weld metal or plug welded serve as potential fatigue crack locations.

- Rough, un-ground welds are indicators that weld quality is poor and fatigue crack probability is high.



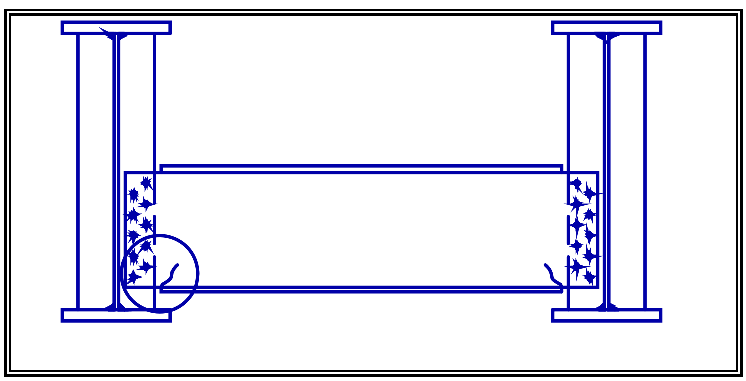
1.7 Butt welded and Tack Welded Backup Bars



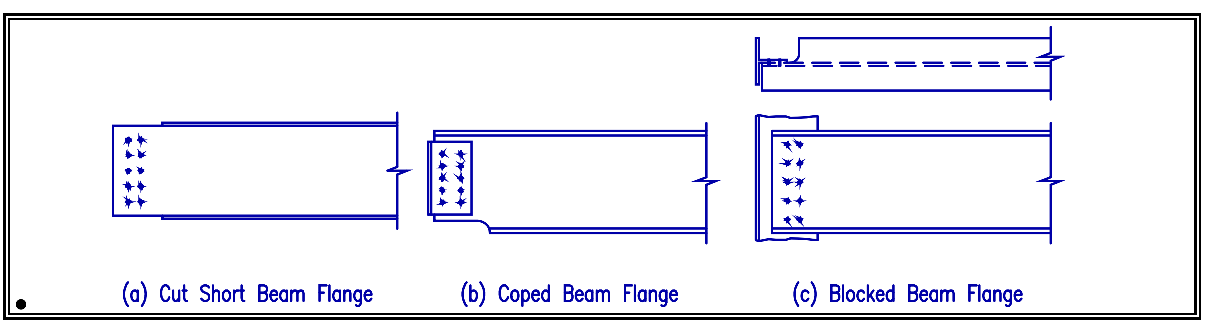
- Backup bars used in the groove weld process are often made continuous through butt welds and are usually held in place during the welding process using tack welds. These butt welds and tack welds are sources of low quality welds and the possibility of fatigue cracks at these locations is high.
- Fatigue cracks that initiate at butt welds or tack welds can propagate into the main member base metal via the full penetration groove weld. These cracks may be transverse to the direction of computed stress, which significantly increases the potential for brittle fracture of the member.
- If back up bars are orientated transversely to the direction of computed stress and not removed after the welding process, the probability of fatigue crack initiation is increased.

2) Fatigue Cracks in Members at Connections and Attachments

2.1 Cut Short Flanges, Coped Beam Ends and Blocked Flange Plates

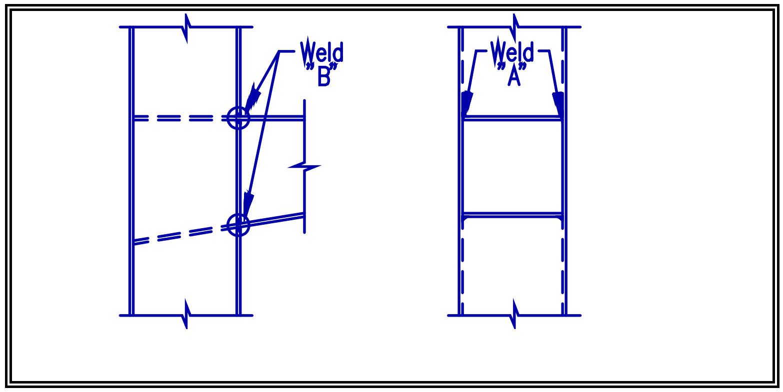


- Coping, blocking and shortening of member flanges, can cause a significant reduction in member stiffness and the process of flame cutting may induce high residual tensile stresses.
- Rough surface finish, dings, and gouges as well as sharp re-entrant corners without transitions at the copes or blocks make these areas highly susceptible to fatigue cracking. Fatigue cracks in these details are most likely to initiate at the re-entrant corner.



2.2 Welded Rigid Connections of Cross Girders at Bents

- Cross girder top and bottom flanges pass through the column web plate and are welded to the column walls parallel to the cross girder (weld "A").



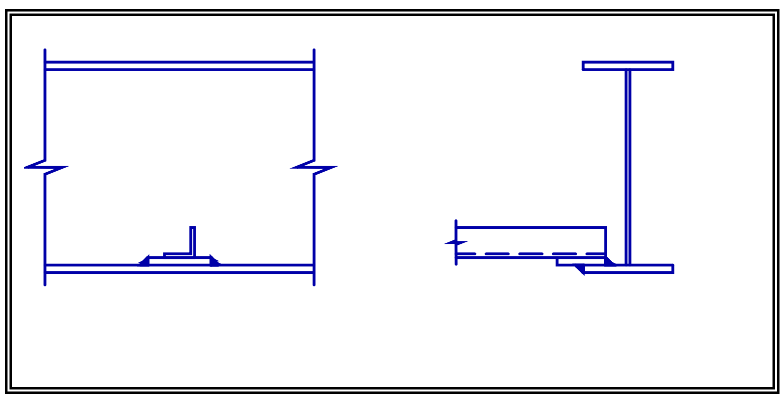
- The cross girder flanges are also connected to the transverse column web plate with welds that often incorporate backup bars (weld "B"). These welds and backup bars are transverse to the direction of stress in the cross girder and are highly susceptible to fatigue cracking.

- Cracks are most likely to form at the intersection of welds "A" and "B".

- Similar welds connecting the compression flange with the column web plate should also be checked for fatigue cracks.

2.3 Welded Flange Attachments

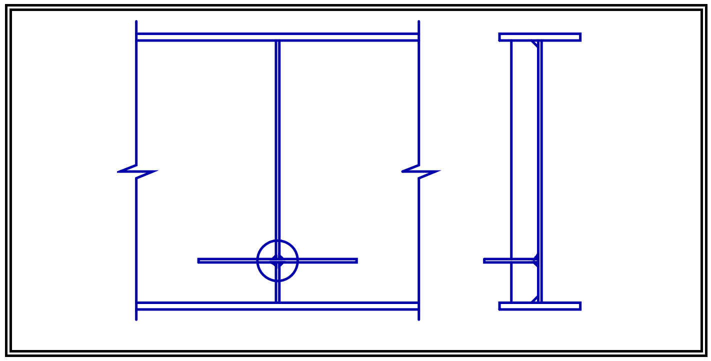
- Attachments may be butt welded to the edge of the flange or overlap the top or bottom surface of the flange and be attached with fillet welds.



- Unless the detail provides for a gradual change in geometry at the flange to plate intersection, it is highly prone to fatigue cracks. Cracks typically initiate at the weld terminations.

- All welds to tension flanges, such as brackets for anchoring catwalk hangers, drainage pipes, utilities, etc., should be examined closely.

2.4 Intersecting Welds at Gussets and Diaphragms

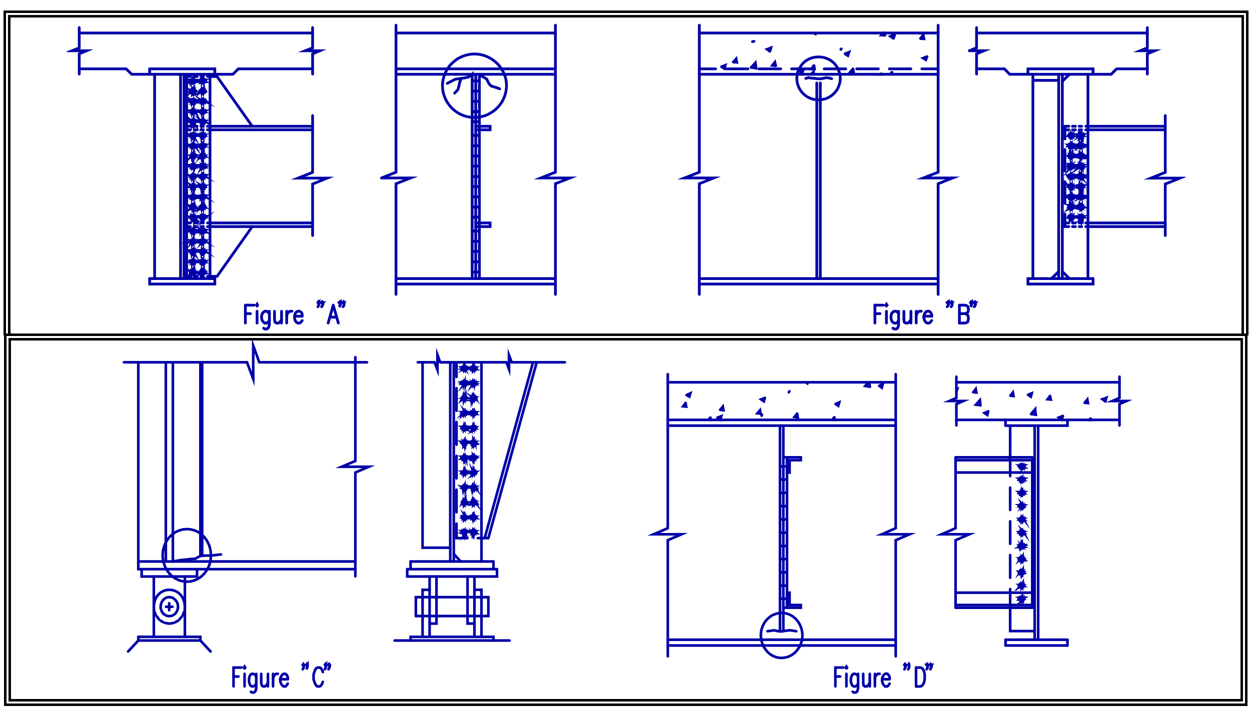


- The longitudinal horizontal weld between the gusset plate and the web, and the transverse horizontal weld between the gusset plate and the diaphragm connection plate, intersect the vertical weld between the diaphragm connection plate and the web, creating a detail highly prone to fatigue cracking.
- Defects generally originate in the weld between the gusset plate and diaphragm connection plate.
- Other possible locations where intersecting welds may cause fatigue problems are at interior plate diaphragms of box girders, intersections of longitudinal and transverse stiffener plates, diaphragm connection plates on girder webs, floorbeam end bracket connections to girder web and flanges etc.

3) Fatigue Damage due to Out-Of-Plane or Transverse Forces and Deflection

3.1 Girder Webs at Floorbeam and Diaphragm Connections

- In negative moment regions, where the top flange is rigidly embedded in the concrete deck and the floorbeam or diaphragm connection plate is not connected to the top flange, out-of-plane fatigue cracks may develop in the web gap region between the longitudinal flange to web weld and the top of the floorbeam or diaphragm connection plate.
- Look for horizontal cracks in the web of the girder at the top of the floorbeam connection plate. These cracks may propagate as an upside down "U" along the upper ends of the fillet welds of the connection plate (figure "A"). Cracks may also show in the girder web along the toe of the



flange to web fillet weld on the opposite side of the floorbeam connection (figure "B")

- In areas of positive moment where the floorbeam or diaphragm connection plate is not connected to the bottom flange, fatigue problems as described above may develop. The flange in these areas is not restrained against lateral movement. This reduces, but not eliminate, the effects of out-of-plane bending (figure "D").

- Floorbeam and diaphragm connections at bearing areas may experience this fatigue problem as the bottom flange is restrained against lateral movement by its connection to the bearing (figure "C").

- Highly skewed bridges with diaphragms and floorbeam connections perpendicular to the girders and bridges with staggered diaphragms, have increased probability of developing fatigue cracks because of large differential deflections between adjacent girders.

3.2 Ends of Diaphragm connection plates

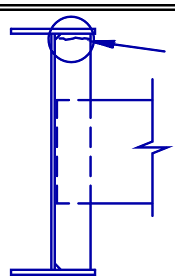


Figure "A"

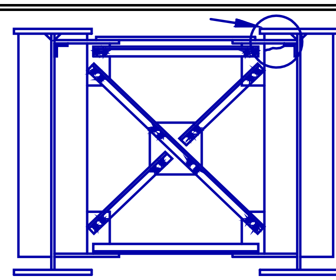


Figure "B"

- When the diaphragm connection plate is welded to the flange of the girder, fatigue cracks may develop along the weld to the flange (figure "A").
- This fatigue crack may propagate along the weld through the connection plate and completely sever the connection plate creating a detail like that described in section 3.1.

- Where diaphragms are connected to the connection plate via small gusset plates (figure "B"), fatigue cracks may develop in the ends of the weld connecting the gusset plate to the connection plate.

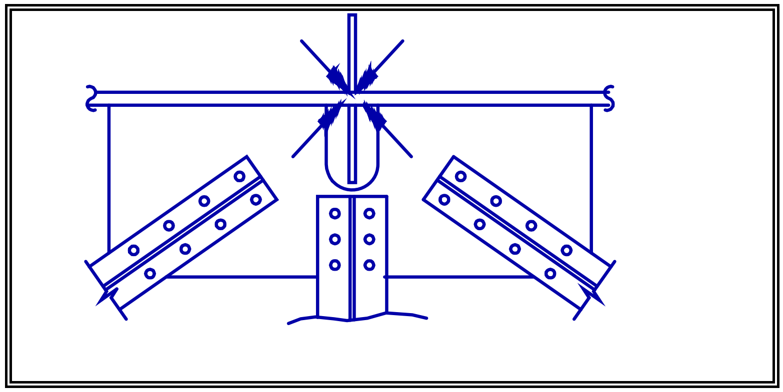
3.3 Box Girder Webs

- Webs of box girders at unattached ends of diaphragm connection plates are susceptible to the same kind of out-of-plane deflections and fatigue cracking that occurs in longitudinal girder webs.

- The occurrence of fatigue cracks at locations described for longitudinal girders are expected to be higher in all box girder types, especially curved box girders and those subject to torsional forces.

3.4 Lateral Gusset Plate Connections at Floorbeam or Diaphragm Connections

- Unequal lateral forces from bracing members introduces lateral deflection and twisting in the girder web in the direction perpendicular to the web.



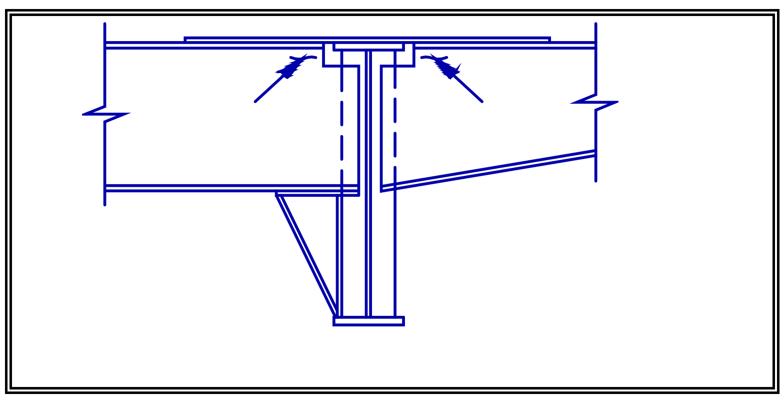
- When the gusset plate is not rigidly attached to the floorbeam or diaphragm connection plate, fatigue cracks may develop as described below:

  - At either end of the weld connecting the gusset plate to the web. However, the crack is more likely to develop at the end closest to the web gap.

  - Along the girder web at the toe of the fillet weld connecting the transverse stiffener to the girder web on the opposite side of the floorbeam or diaphragm connection.

3.5 Floorbeam and Cantilever Bracket Connections to Girders

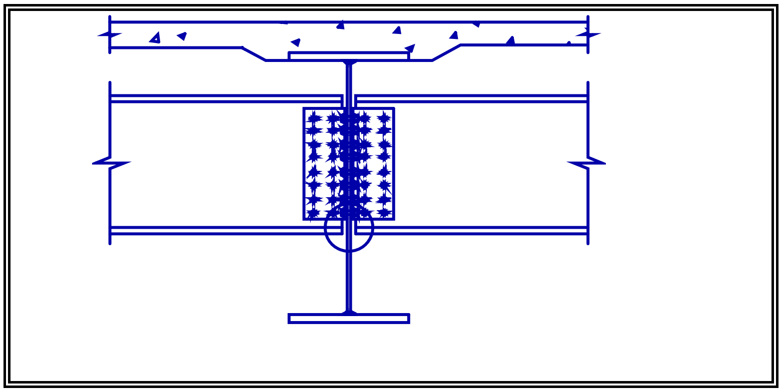
- Where stringers are supported on top of the floorbeam and tie plates connect the floorbeam and cantilever bracket top flanges, displacement induced fatigue cracks may develop in the floorbeam or cantilever bracket webs along the top flange fillet at the connection with the girder.



- Displacement induced fatigue cracks may develop in similar types of details at connections to tied arch girders and to truss bridge lower chord panel points when the stringers are placed above the floorbeams and cantilever brackets.

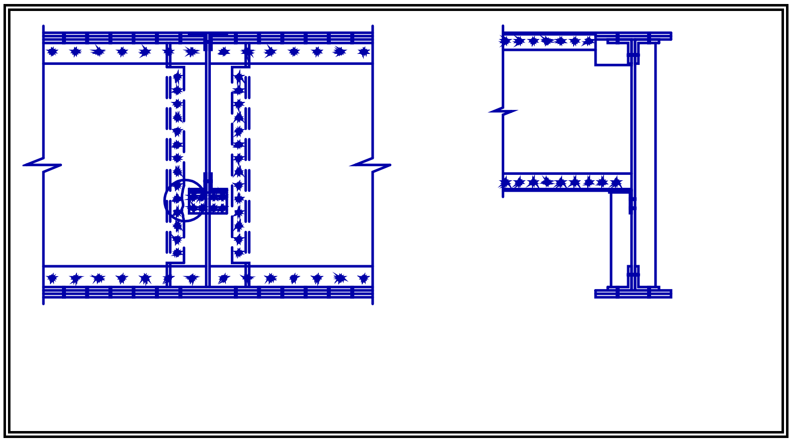
4) Fatigue Damage to End Connections

4.1 Cracking (Prying) of Rivets and Bolts



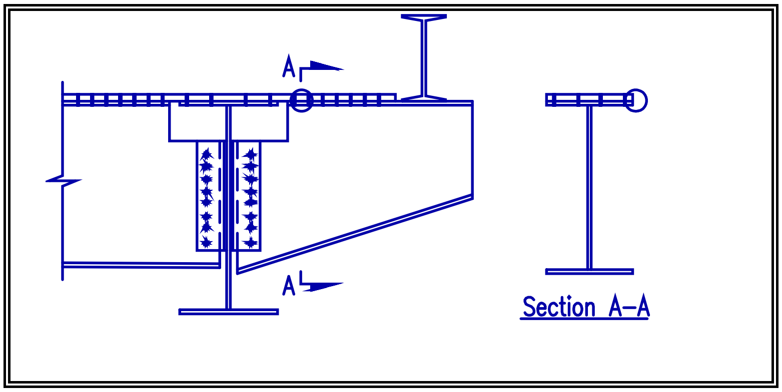
- In simple connections, rivets and bolts are subject to prying action. Those furthest away from the centroid of the connection are most susceptible to fatigue cracking.
- Missing bolt or rivet heads, oxide dust around the bolt or rivet head, a small gap between the fastener and the connection angle and a dull sound when the head is tapped are evidence of fatigue damage.
- Fatigue cracking may occur along the fillet of the connection angle generally initiating at the bottom end of the connection angle and propagating upward along the fillet.

4.2 Girder Webs at Floorbeam Connections



- Girder webs are susceptible to fatigue cracking when girder stiffeners on the opposite side of the floorbeam connection are offset from the connection.
- Fatigue cracking may occur in the unstiffened region between the floorbeam seat angle or clip angle and the girder stiffener due to out-of-plane bending caused by the floorbeam end moment.
- Bridges with relatively deep girders, subject to frequent heavy loads are more susceptible to fatigue cracking in this area.

4.3 Floorbeam and Cantilever Bracket Connections to Girders

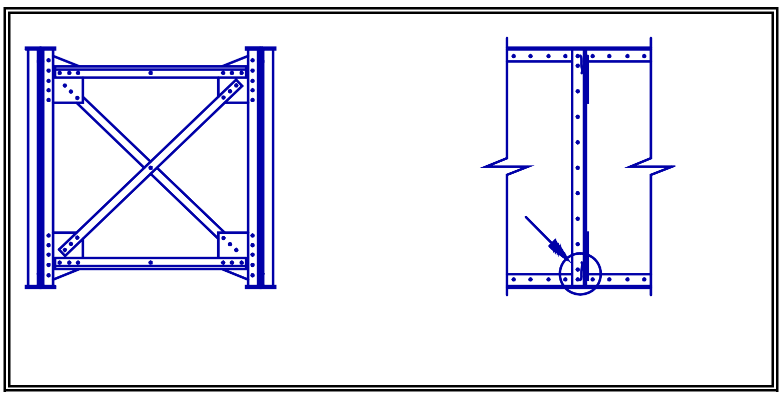


- Similar fatigue cracks as described in the section for welded members, may develop in riveted or bolted floorbeam and cantilever bracket connections.

- Tie plates that are rigidly attached to a girder flange are subject to significant horizontal bending stresses due to the relative displacement between the girder and floorbeam and cantilever bracket. Fatigue cracks may develop at the rivets or bolts closest to the girder.

- Tack welds used to aid construction in this area increase the likelihood of fatigue damage.

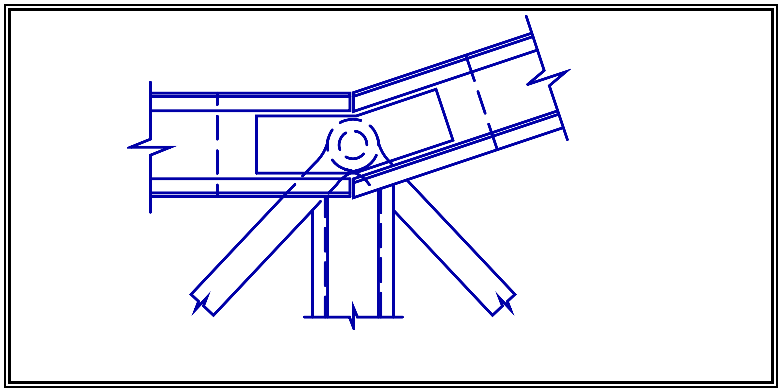
4.4 Diaphragm Connections to Girders



- Differential deflections between girders produces forces within the diaphragm that pull or push the diaphragm member against the connection angle.
- Fatigue cracks may develop in the leg of the connection angle that is parallel with the girder in the area between the fillet of the angle and the first line of fasteners, or in the fastener below the head.

- If the connection angle does not overlap the flange angle and there is a small gap between the two angles, a fatigue crack may develop in the web of the girder in this gap.

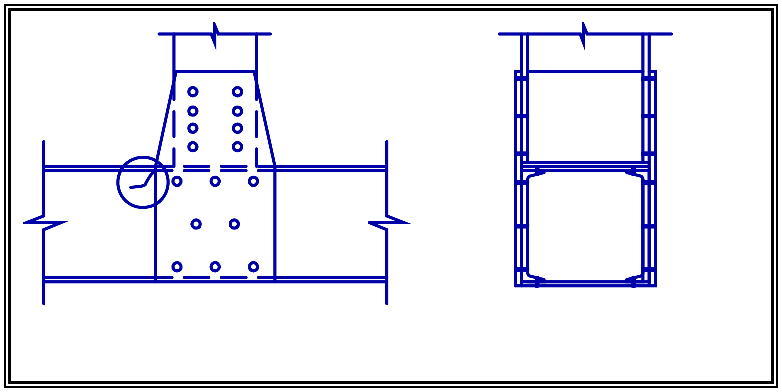
4.5 Truss Tension Members



- One of the primary accelerants of fatigue damage in truss members, such as built up lower chord members, vertical hangers, or diagonal eyebars, is the build up of corrosion that prevents rotation of pinned connections.

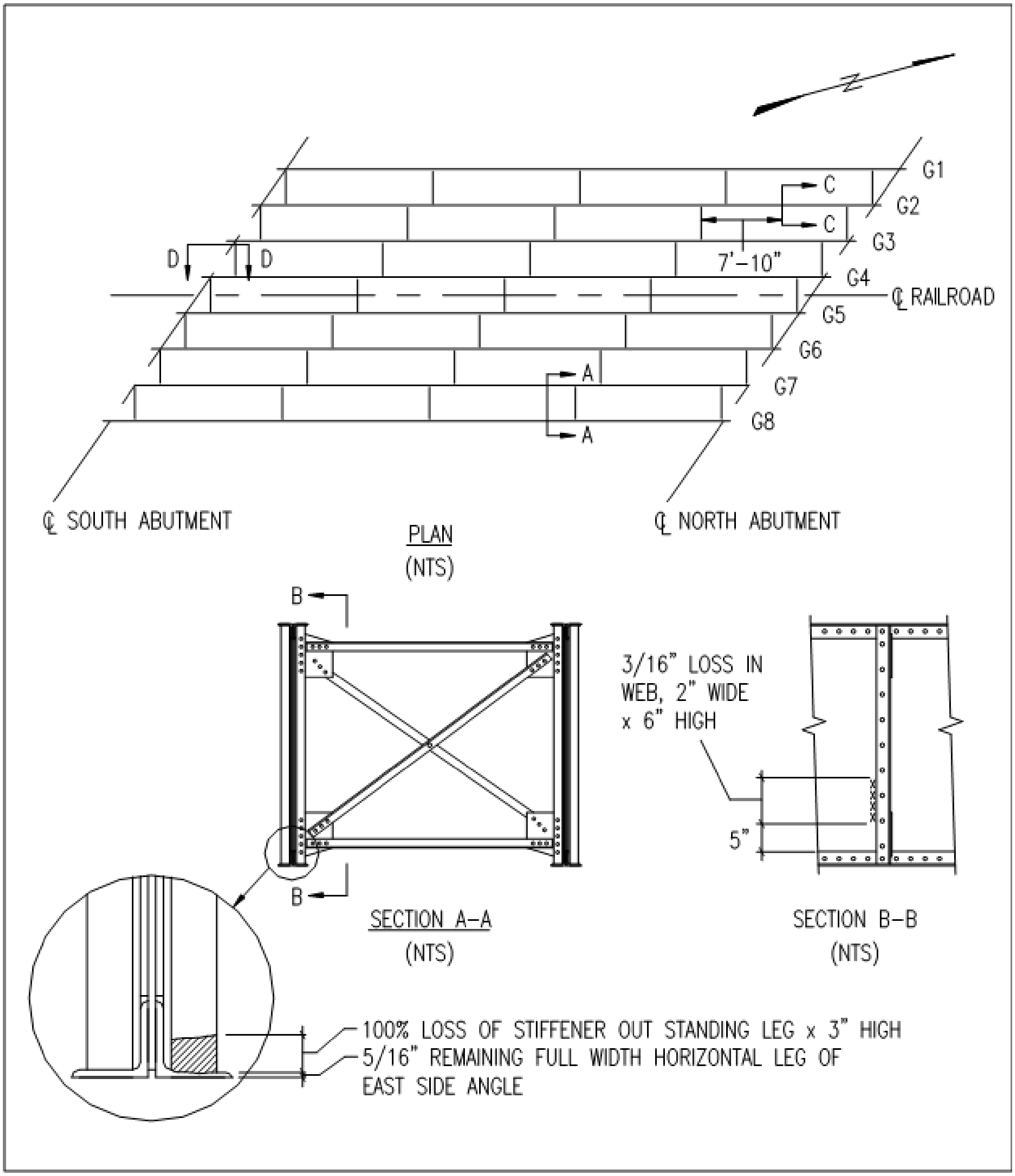
- "Frozen" pin connections prevent the chord members, hangers and eyebars from rotating properly, and bending stresses are introduced into the members.

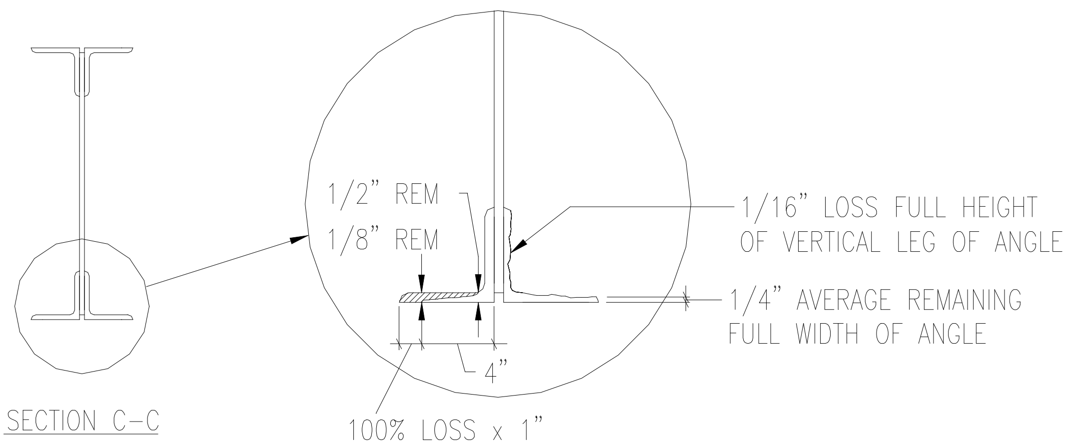
- Fatigue cracks may develop at rivet holes or other points of stress concentration.



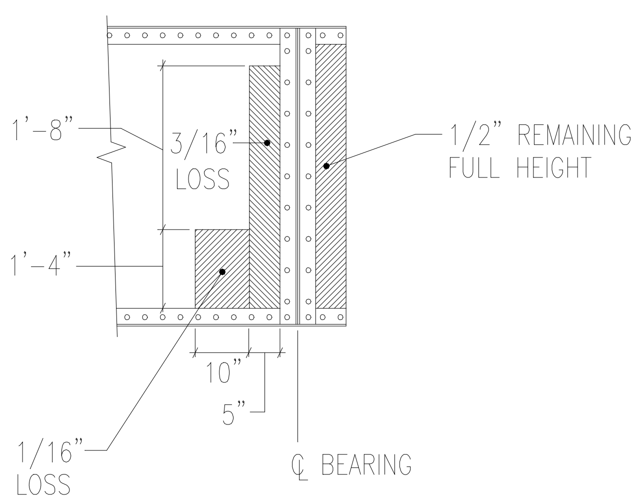
- Tack welds used to position and align elements during construction, create weld defects and residual stresses. All tack welds on tension members should be examined closely.

Appendix 6.2: SECTION LOSS MEASUREMENTS



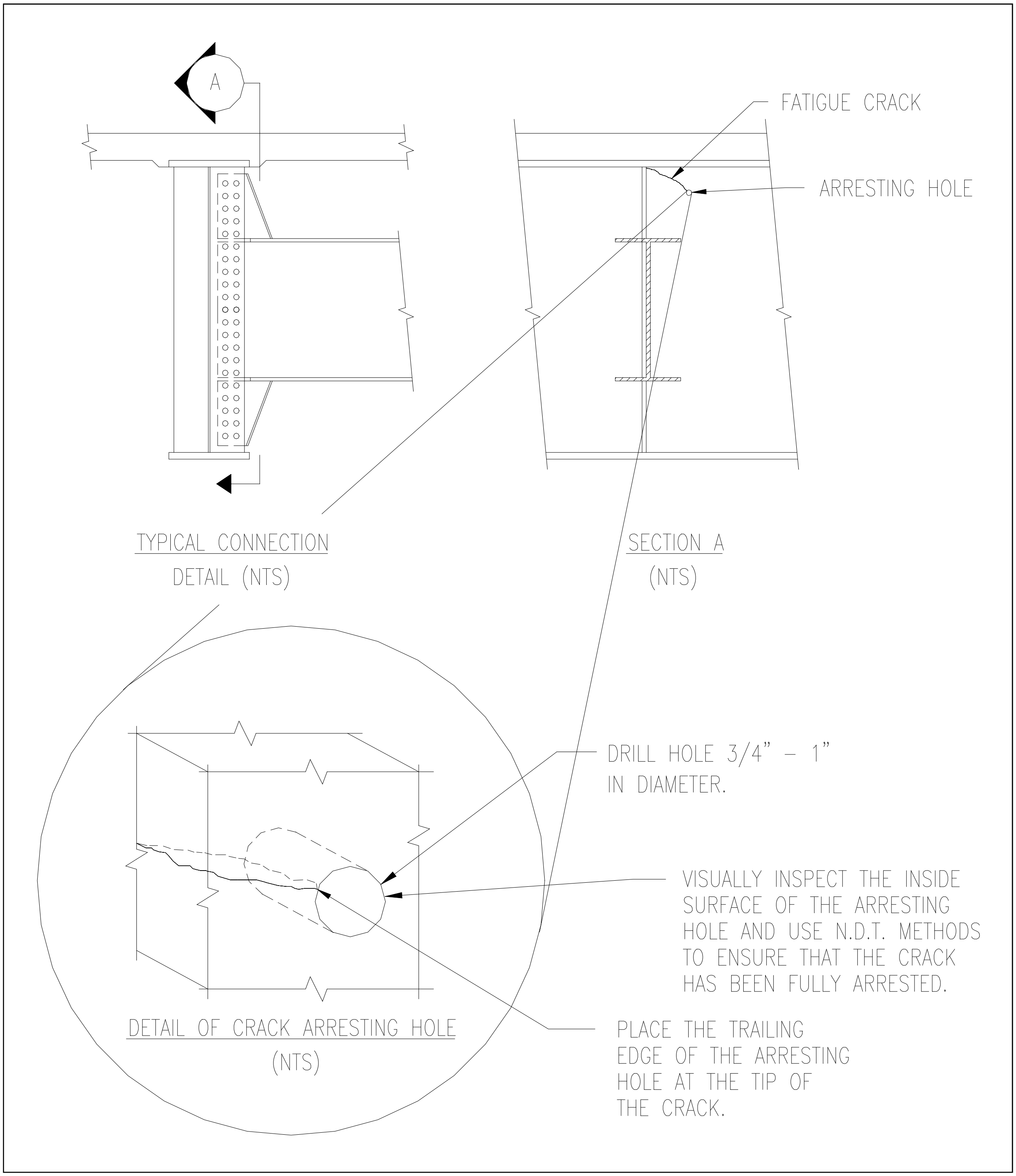


SECTION C-C
(NTS)



SECTION D-D
(NTS)

Appendix 6.3: CRACK ARRESTING DETAIL



Appendix 6.4: CONCRETE DETERIORATION AND CRACKING

ADVANCED CONCRETE INSPECTION TECHNIQUES

Non Destructive Testing:

- Acoustic wave sonic/ultrasonic velocity measurements
- Delamination detection machinery
- Electrical methods
- Flat jack testing
- Ground-penetrating radar
- Impact-echo testing
- Infrared thermography
- Laser ultrasonic testing
- Magnetic field disturbance
- Neutron probe for detection of chlorides
- Nuclear methods
- Pachometer
- Rebound and penetration methods
- Ultrasonic testing

Destructive Testing:

- Carbonation
- Concrete permeability
- Concrete strength
- Endoscopes
- Moisture content
- Reinforcing steel strength

Figure A-4-1. *Advanced Concrete Inspection Techniques*

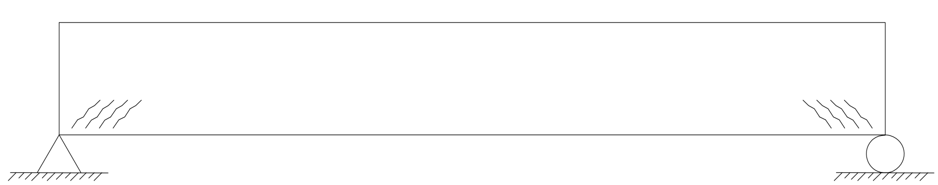


Figure A-4-2. *Typical Shear Crack Locations and Orientation.*

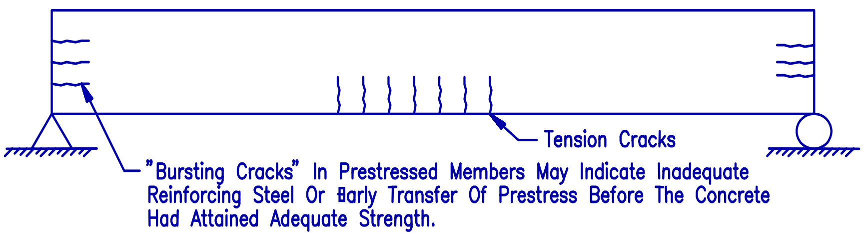


Figure A-4-3. *Typical Flexure Crack Locations*

Crack Width Defined*:

Hairline:	Less than 1/32 in.
Fine:	1/32 in. to 1/16 in.
Medium:	1/16 in. to 1/8 in.
Wide:	Greater than 1/8 in.

* Cracks which are categorized as fine or hairline, unless widespread or very concentrated, usually are caused by the curing process of the concrete (shrinkage temperature change, etc.) and pose no real threat to the integrity of the concrete component. When noted in field notes or a report, it is sufficient to express their presence by calling out the type of crack and not the actual width. However, when the crack has visibly opened (medium and wide cracks), the actual crack width should be noted in the field notes and the maximum size called out in the report (i.e. numerous wide cracks, up to ¼ in. noted.)

Scaling Classification:**

Light:	0 in. to ¼ in. in depth with no coarse aggregate exposed.
Medium:	¼ in to ½ in. in depth with coarse aggregate exposed.
Heavy:	½ in. to 1 in. in depth with coarse aggregate projecting from surface.
Severe:	Over 1in. in depth with loss of coarse aggregate.

** Most reinforced concrete members in service for any time and exposed to weather will show some light scale. This condition need not be considered a serious deterioration and its presence can be documented in a general note. Individual areas of light scaling do not need to be measured or called out.

Figure A-4-4. *Cracking and Scaling Definitions.*

Appendix 6.5: INSPECTION MEASUREMENTS REQUIRED FOR VARIOUS CULVERT SHAPES

The following information is condensed from the Federal Highway Administration report number FHWA-IP-86-2, Culvert Inspection Manual.

This information is presented in order to allow the inspector to become familiar with the various types of culverts that may be encountered in the field, to understand how culverts function hydraulically and structurally, and to understand those factors that affect the durability of the culvert.

This appendix reviews the most common culvert shapes, sizes and materials such as corrugated steel and aluminum, pre-cast concrete and cast-in-place concrete. The behavioral characteristics of stone masonry culverts are discussed in Appendix 6.7, Stone Masonry Arches and Culverts.

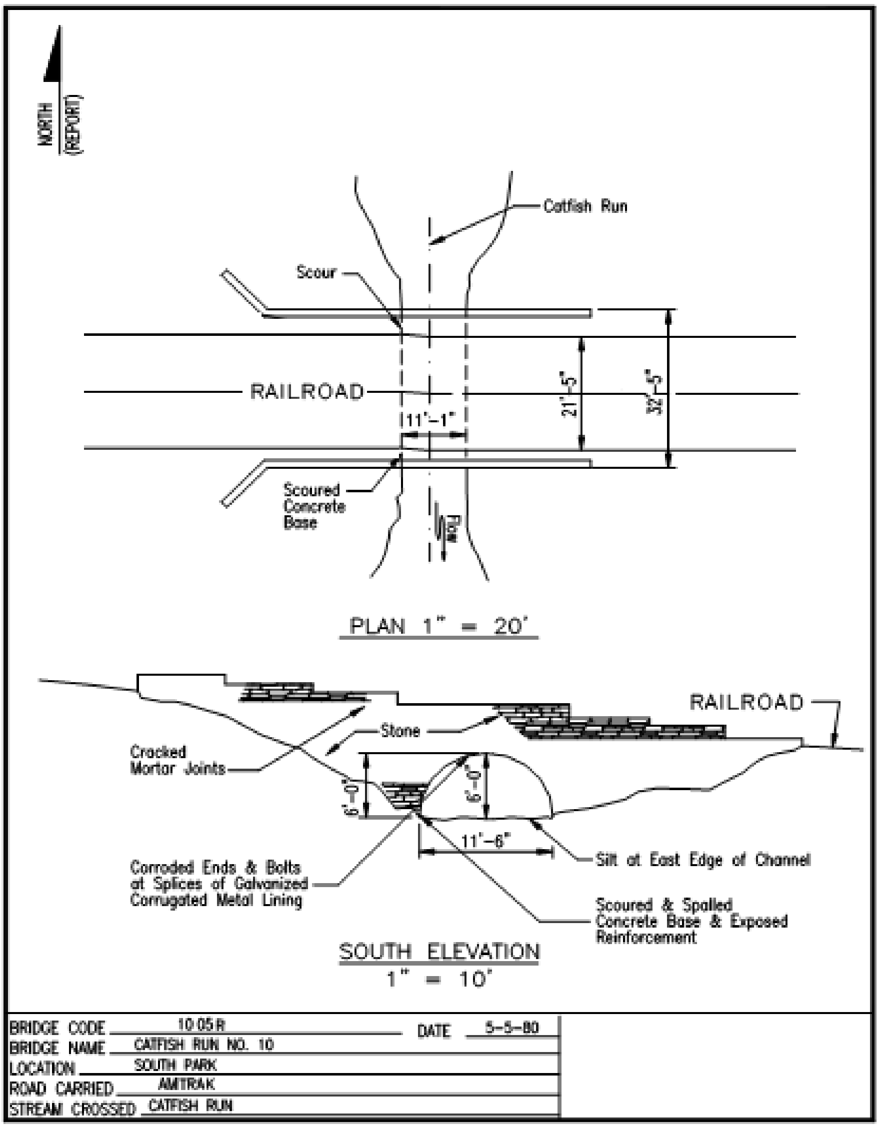


Figure A-5-1. *Example Field Note: Inspection Site Layout*

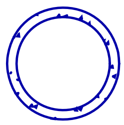
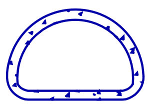
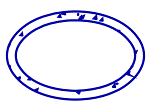
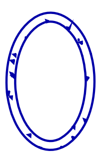
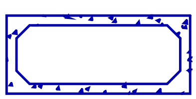
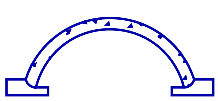
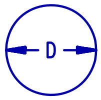
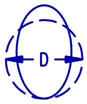
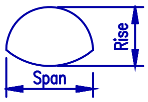
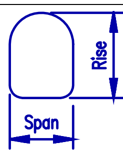
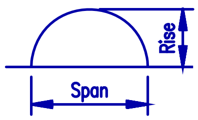
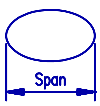
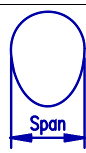
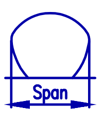
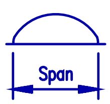
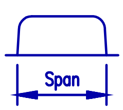
SHAPE	RANGE OF SIZES	COMMON USES
 Circular	1' to 16' reinforced 4" to 3'-0" non-reinforced	Culverts, storm drains and sewers.
 Pipe Arch	1 ½" to 11'-2" equivalent diameter	Culverts, storm drains and sewers. Used where vertical clearance is limited.
 Horizontal Ellipse	Span x Rise 1'-6" to 13'-0" equivalent diameter	Culverts, storm drains and sewers. Used where vertical clearance is limited.
 Vertical Ellipse	Span x Rise 3'-0" x 13'-0" equivalent diameter	Culverts, storm drains and sewers. Used where lateral clearance is limited.
 Rectangular (Box Section)	Span 3'-0" to 13'-0"	Culverts, storm drains and sewers. Used for wide openings with limited vertical clearance.
 Arch	Span 23'-0" to 42'-8"	Culvert and storm drains. For low, wide waterway enclosures.

Table A-5-1. *Standard Concrete Pipe Shapes*

SHAPE	RANGE OF SIZES	COMMON USES
Round 	6” to 26’-3”	Culverts, subdrains, sewers, service tunnels, etc. All plates have the same radius. For medium and high fills or trenches.
Vertically Elongated (Ellipse) 5% elongation is common 	3’3” to 23’-0” nominal; before elongating	Culverts, sewers, service tunnels and recovery tunnels. Plates of varying radii, shop fabrication. For appearance and where backfill compaction is only moderate.
Pipe Arch 	Span x Rise 1’-6” x 1’-0” to 20’-8” x 17’-9”	Where headroom is limited. Has hydraulic advantages at low flows. Corner plate radius: 1’-6” or 2’-8” mm for structural plate.
Underpass* 	Span x Rise 5’-7” x 5’-11” to 20’-4” x 17’-9”	For pedestrian, livestock or vehicle passage (structural plate).
Arch 	Span x Rise 5’-11” x 1’-6” to 24’-11” x 12’-6”	For low clearance large waterway openings and aesthetics (structural plate).
Horizontal Ellipse 	Span 19’-8” to 39’-4”	Culverts, grade separations, storm sewers and tunnels.
Pear 	Span 23’-0” to 29’-6”	Grade separations, culverts, storm sewers and tunnels.
High Profile Arch 	Span 19’-8” to 45’-11”	Culverts, grade separations, storm sewers, tunnels, ammunition magazines, and earth covered storage.
Low Profile Arch 	Span 19’-8” m to 49’-2”	Low-wide waterway enclosures, culverts and storm sewers.
Box Culverts 	Span 9’-10” to 21’-0”	Low-wide waterway enclosures, culverts and storm sewers.
Special	Various	For lining old structures or other special purposes. Special fabrication.

* For equal area or clearance, the round shape is generally more economical and simpler to assemble.

Table A-5-2. *Standard Corrugated Steel Culvert Shapes*

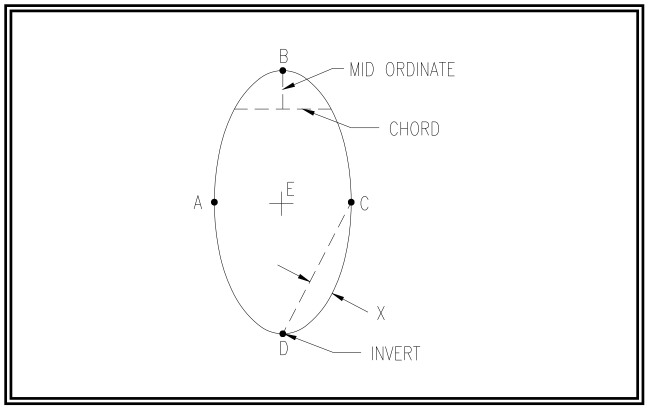


Figure A-5-2. *Vertical Elongated Corrugated Metal Pipe*

Circular or Vertical Elongated Corrugated Metal Pipe

- Inspector notes:

1. Minimum required measurements:
   Span = AC
   Rise = BD
2. If flattening is observed, measure the chord and mid ordinate (X) of the flattened area.
3. If horizontal span AC exceeds design value by more than 10%, measure vertical diameter = BD.

- Vertical deflection is expected during construction, slightly increasing the as-built horizontal span (AC).

- Barrels with shallow cover tend to have the sides pushed inward due to high lateral-to-vertical pressure ratios, decreasing the as-built horizontal span (AC). Barrels with deep cover tend to have sides pushed outward due to low lateral-to-vertical pressure ratios, increasing the as-built horizontal span (AC).

- Flattening of the top arc of the pipe is caused by unstable backfill. This may be compounded by the barrels reduced ability to transmit compressive forces when deteriorated.

- Flattening of the top arc is more serious than flattening of the invert as long as flattening of the invert is not excessive.

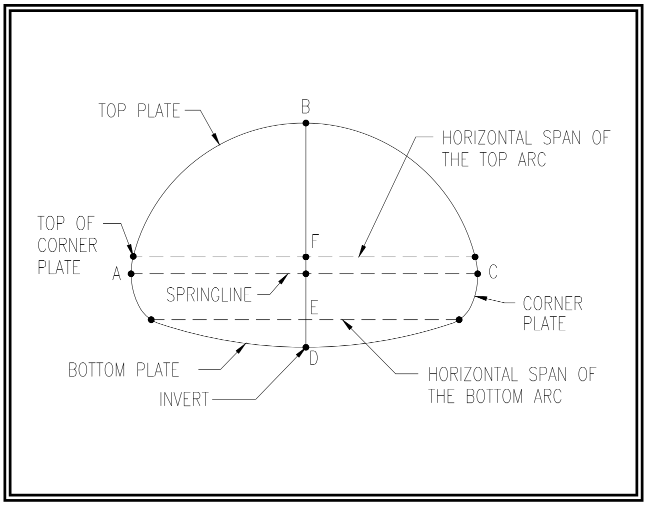
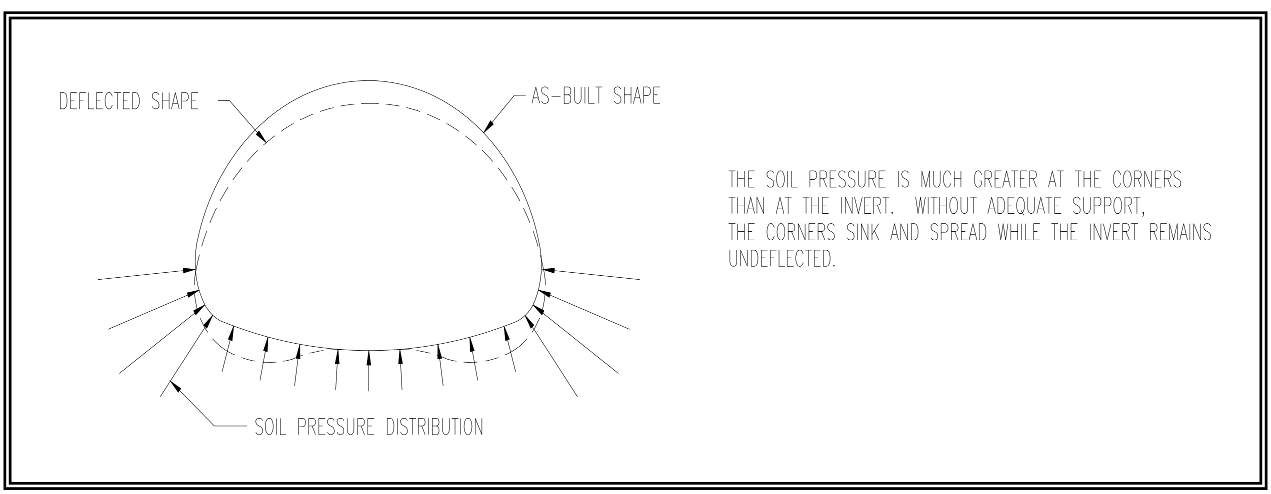


Figure A-5-3a. *Corrugated Metal Pipe Arch*

Corrugated Metal Pipe Arch

- Inspector notes:
  1. Minimum required measurements:

     Span = AC
     Rise = BD
  2. If AC exceeds the design value by 3% or more, measure BF, ED, the horizontal span of the top arc, and the horizontal span of the bottom arc.
- The load is transmitted to the foundation primarily at the connection of the corner plates to the bottom plate. Soil pressure at the invert is relatively small.
- Inadequate soil support under the exterior portions of the bottom plate may cause the ends of the bottom plate to push down while the center of the bottom plate stays in place. This may give the appearance that the bottom plate has been pushed up relative to its ends.
- The bottom plate should be inspected for flattening and the side plates should be inspected for spreading.



1.1.1.1. **Figure A-5-3b.** Culvert Soil Distribution and Typical Deflected Shape

- The top plate should be inspected for flattening.

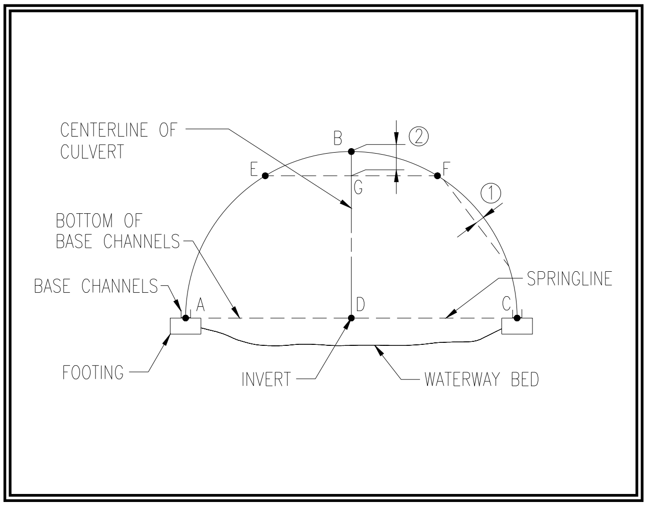


Figure A-5-4. *Structural Plate Arch*

Structural Plate Arch

- Inspector notes:

1. Minimum required measurements:
   Span = AD + DC
   (AD should = DC)
   Rise = BD
   (Measured at the culvert centerline)
2. Minimum required elevation:
   Point B.
3. If BD is greater than design by 5% or more, check side curvature for flattening.
4. If AD and DC are not equal, racking has occurred and the side curvature on both sides should be checked by measuring the half arc-mid-ordinates (point 1). Record the chord length used.
5. If BD is less than design by 5% or more, check the top curvature at the centerline of the arch (point 2) by measuring the mid-ordinate BG of chord EF. Record the chord length (EF) used.

- Flattened sides and peaked crown indicate lateral forces due to backfill are much greater than vertical forces due to cover fill. Flattening of the top arc indicates high vertical forces and possible unstable backfill on the sides of the arch.

- Racking of the arch (tilting of the arch to one side giving a nonsymmetrical X-section about the centerline), indicates a poor job of backfilling or erosion of the backfill material on one side adjacent to the culvert barrel.

- If dimension AD differs from DC by 10” or 5% of the span length (which ever is less), racking has occurred and measurements as described in item #4 , should be taken to determine the extent of arch flattening on the side opposite the racking.

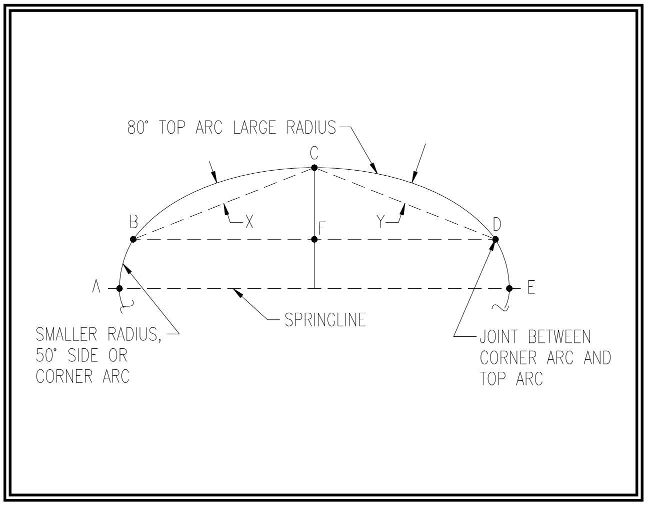


Figure A-5-5. *Typical Crown Section*

Crown Section of Long Span Culverts
(Low Profile, High Profile, Pear Shaped, Horizontal Ellipse)

- Inspector notes:

1. Minimum required measurement:
   Span = AE
2. Minimum required elevations:
   Points B, C, and D
3. Calculate the value of CF:

$$CF = Elev.C - \frac{(Elev.B + Elev.D)}{2}$$

4. If CF is greater than or less than the design value by 10% or more, measure the top arc chord = BD.
5. If BD differs by more than 3% from the design value, measure, for each half of the top arc, the chord length and half top arc mid-ordinate = X & Y.

- The critical shape factor for the crown section of long span culverts is the top arc geometry.

- Top arc and side arcs should appear to be smooth in curvature (no distortion, flattening, peaks or cusps) and symmetrical (no racking) about the centerline of the culvert.

- Elevation measurements are required to monitor the rate of settlement, if settlement has occurred or is continuing.

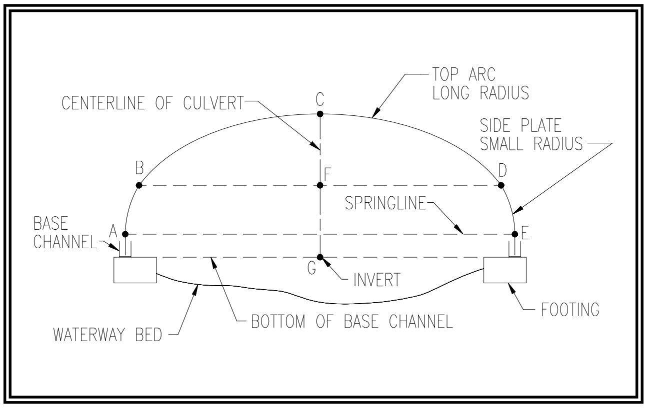


Figure A-5-6. *Low Profile Arch, Long Span Culvert*

<u>Low Profile Arch Long-Span Culvert</u>

- Inspector notes:
  1. Minimum required measurements:
     Span = AE
     Rise = CG
     Top Arc Chord = BD
     (Note: BD is measured at the joint between top plate and side plates.)
  2. Minimum required elevations:
     Points B, C, and D.
  3. Calculate the value of CF:

$$CF = Elev.C - \frac{(Elev.B + Elev.D)}{2}$$

- Because of the arch configuration, lateral soil pressures will attempt to flatten the sides and raise the top.

- If the base channels into which the ends of the culvert barrel are fitted and anchored, are not parallel to the centerline of the structure, or if the backfill is not placed symmetrically during construction, racking may occur during erection.

- If racking has occurred, the crown (point C) will move laterally causing the curvature on one side to flatten while the curvature of the other side increases. Backfill pressures may cause this condition to worsen.

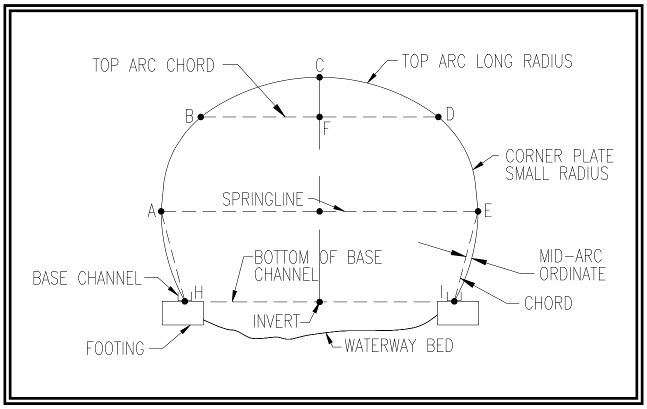


Figure A-5-7. *High Profile, Long Span Culvert*

High Profile Arch Long-Span Culvert

- Inspector notes:

    1. Minimum required measurements:
       Span = AE
    2. Minimum required elevations:
       Points B, C, D, H, and I.
    3. Calculate the value of CF:

$$CF = Elev.C - \frac{(Elev.B + Elev.D)}{2}$$

- High profile arches are similar to low profile arches except the radius of curvature of the portion of the culvert barrel below the springline is significantly increased.

- Shallow fills or minimum cover over the crown may cause the lateral soil pressure on the side walls to exceed the loads over the culvert. This condition will cause the side wall to flatten or buckle inward or cause the crown to peak.

- Racking may occur if the soil pressures are not symmetrical around the culvert or if the backfill was not placed symmetrically during construction.

- If flattening of the sidewalls is observed, the mid-ordinate shall be measured at the location of flattening.

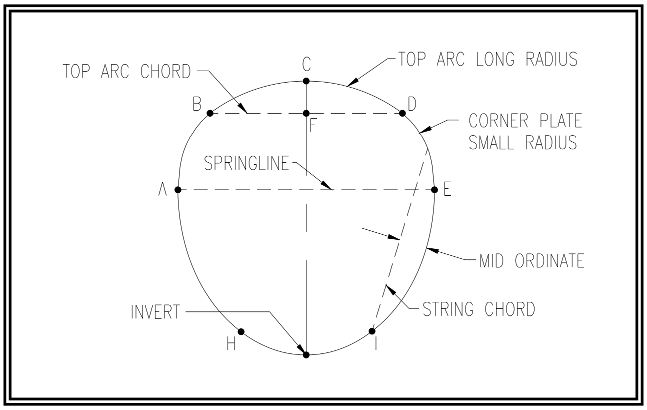


Figure A-5-8. *Pear Shape Long Span Culvert*

Pear Shape Long-Span Culvert

- Inspector notes:

  1. Minimum required measurements:
     Span = AE.
  2. Minimum required elevations:
     Points B, C and D.
  3. When flattening is observed in the side plates, check the mid-ordinate of the flattened area. Record the chord length used.

- Crown sections of pear shaped culverts differ from that of other long span culverts in that the small radius corner arcs stop above the spring line and the large radius side plates extend above the plane of the horizontal span. Therefore, when measuring for flattening of the side plates, the entire arc section should be used as indicated above.

- Side flattening, particularly in shallow fill situations, is the most critical shape factor.

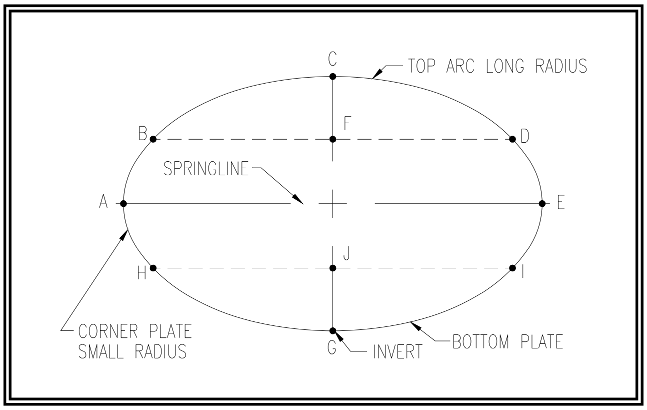


Figure A-5-9. *Horizontal Ellipse Long-Span Culvert*

Horizontal Ellipse Long-Span Culvert

- Inspector notes:

  1. Minimum required measurement:
     Span = AE
  2. Minimum required elevations:
     Points B, C, D and G
     (if possible).
  3. When bottom flattening is observed, Measure bottom plate curvature:
     a. Bottom arc chord = HI
     b. Bottom arc middle ordinate = JG

- Adequate curvature in the crown section is the critical shape factor.

- Soil pressure distribution is similar to that of the pipe arch with the greatest pressures occurring at the 4 o'clock and 8 o'clock positions. Pressure at the invert is relatively minor.

- The ends of bottom plate tend to push down into the soil while the center of the bottom plate does not move. This will give the appearance that the bottom plate has been pushed up.

- Look for differential settlement between the sides and bottom of the culvert barrel.

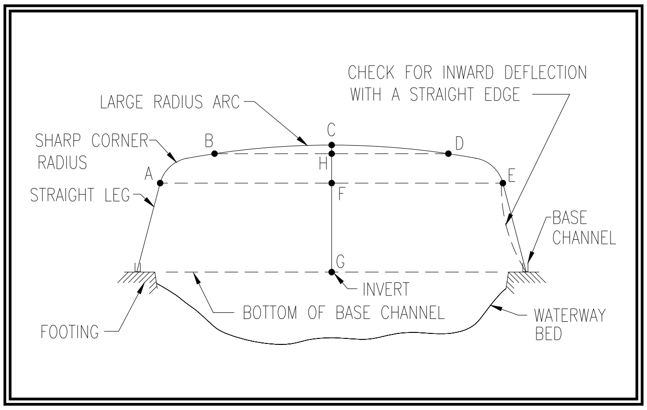


Figure A-5-10. *Corrugated Metal Box Culvert*

<u>**Corrugated Metal Box Culvert**</u>

- Inspector notes:

  1. Minimum required measurements:
     Span = AE
     Rise = CG
  2. If it is not possible to measure CG, measure BD and CH.
  3. If CG differs from design by more than 12% or AE differs from design by more than 3%, measure:
     a. Top arc chord = BD
     b. Top arc middle ordinate = CH

- This structure type relies more on its own internal structural capacity in shear and moment to carry the vertical loads than it does on the lateral earth pressure as with other culvert shapes.

- The geometry of the top arc is very flat to begin with and cannot withstand significant deflections before partial or total failure occurs.

- An inward deflection of the side walls is more critical than an outward deflection as the latter would be restrained by the soil pressure.

Appendix 6.6: DECK JOINTS

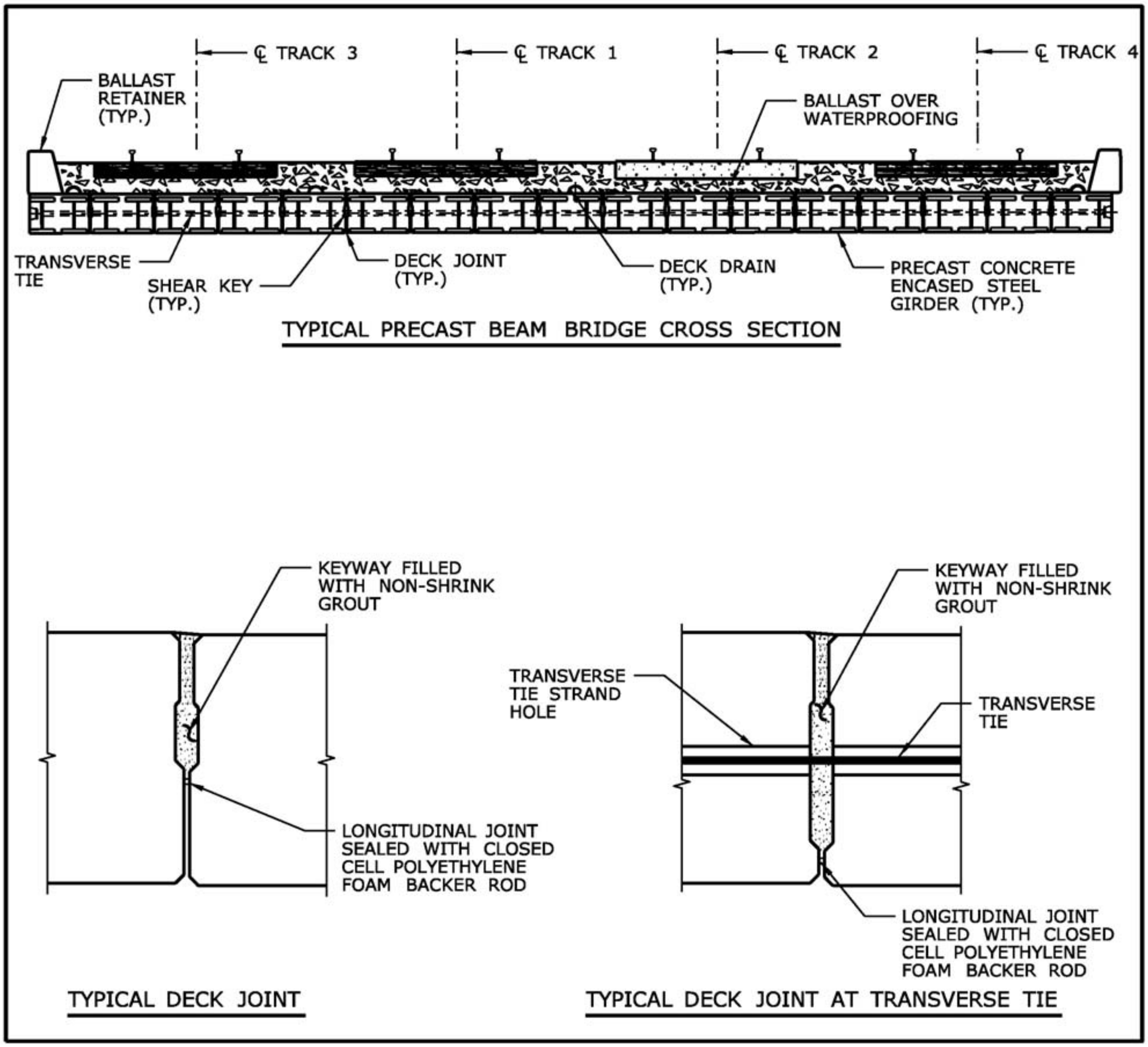


FIGURE A-6-1

Appendix 6.7: STONE MASONRY ARCHES AND CULVERTS

The following description of failure modes for stone masonry arches and culverts was taken from A Treatise on Masonry Construction by Barker, Chapter 18. It is intended to give the field inspector a better understanding of the masonry arch and culvert behavior so that field observations can be more accurately assessed as to their possible cause and criticality. This information however, does not cover all cause and effect conditions, nor should they be considered the only cause and effect conditions possible for stone masonry arches or culverts. As required, a thorough detailed investigation and analysis should be conducted to determine actual cause and effect conditions.

Figure A-7-1 illustrates the nomenclature used throughout this appendix.

Construction Techniques:

Stone masonry culverts, arch rings and spandrel walls are constructed using one of two methods of construction. The first method is called "dry laid." In this method, the stones are placed against one another with no joint filler material and rely totally on the friction forces developed between adjacent stones to keep the stones from sliding. The advantage of this construction is that the stability of the joint does not rely on the presence and integrity of the joint material. Only the percentage of surface area in contact is of importance and is usually adversely affected only over long periods of time. The disadvantage of this method is that the large voids between stones are readily susceptible to freeze/thaw action due to penetrating water. The second method utilizes joint material that conforms to the surface contours of the stone. The joint material may be either pointed mortar or concrete. The use of joint material provides an even stress distribution across the joint and increases sliding resistance by increasing the surface area that resists displacement forces. The joint relies on the presence and integrity of the joint material to function properly. Missing or ineffective joint material can serve to increase bearing and frictional stresses to the point where the stone may crush or displace.

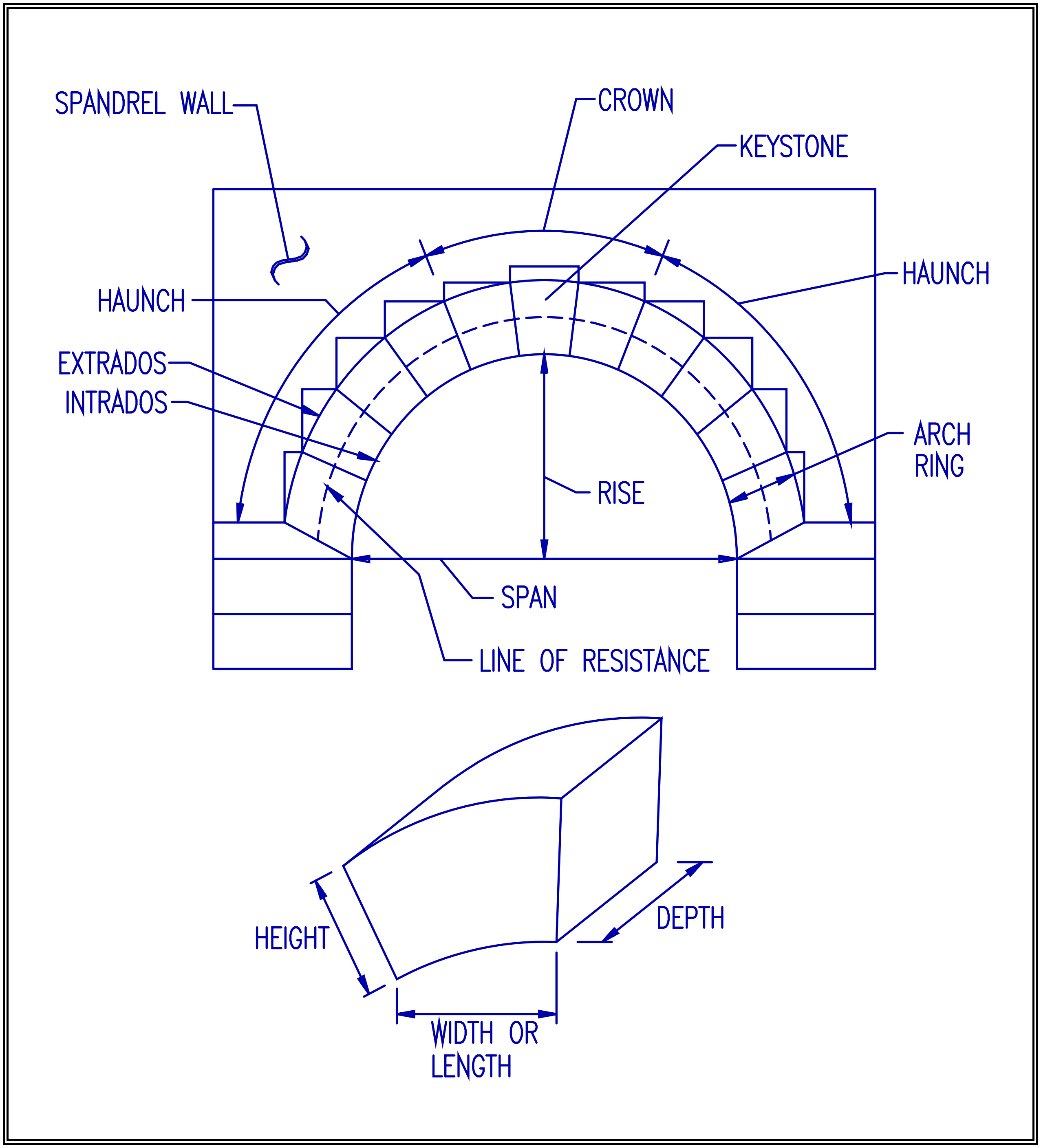


Figure A-7-1. *Typical Arch/Culvert Nomenclature*

Crushing:

To illustrate the effects of crushing of stone masonry, the following example is used. Figure A-7-2(a) shows the stress distribution on the end of a stone in reaction to applied Force P. The compressive stress in the extreme fiber of the stone (point B) has not yet reached the ultimate crushing strength of the stone (represented by the dashed line). Figure A-7-2(b) represents the same stone in which the location of the applied Force P has shifted, or the magnitude of the force has increased, resulting in the edge of the stone reaching the ultimate crushing strength of the stone. In Figure A-7-2(c), force P has further increased or shifted such that a portion of the stone cross section has reached ultimate crushing strength and has failed (represented by the hatched area). Figure A-7-2(d) represents the stress distribution just prior to total failure of the stone in which the location where Force P is applied approaches the inner limit of the portion of the cross section which has reached ultimate crushing strength (point A'). When the location where Force P is applied becomes coincidental with point A', total failure of the stone will occur resulting in serious reduction in capacity and potential failure of the arch or culvert superstructure.

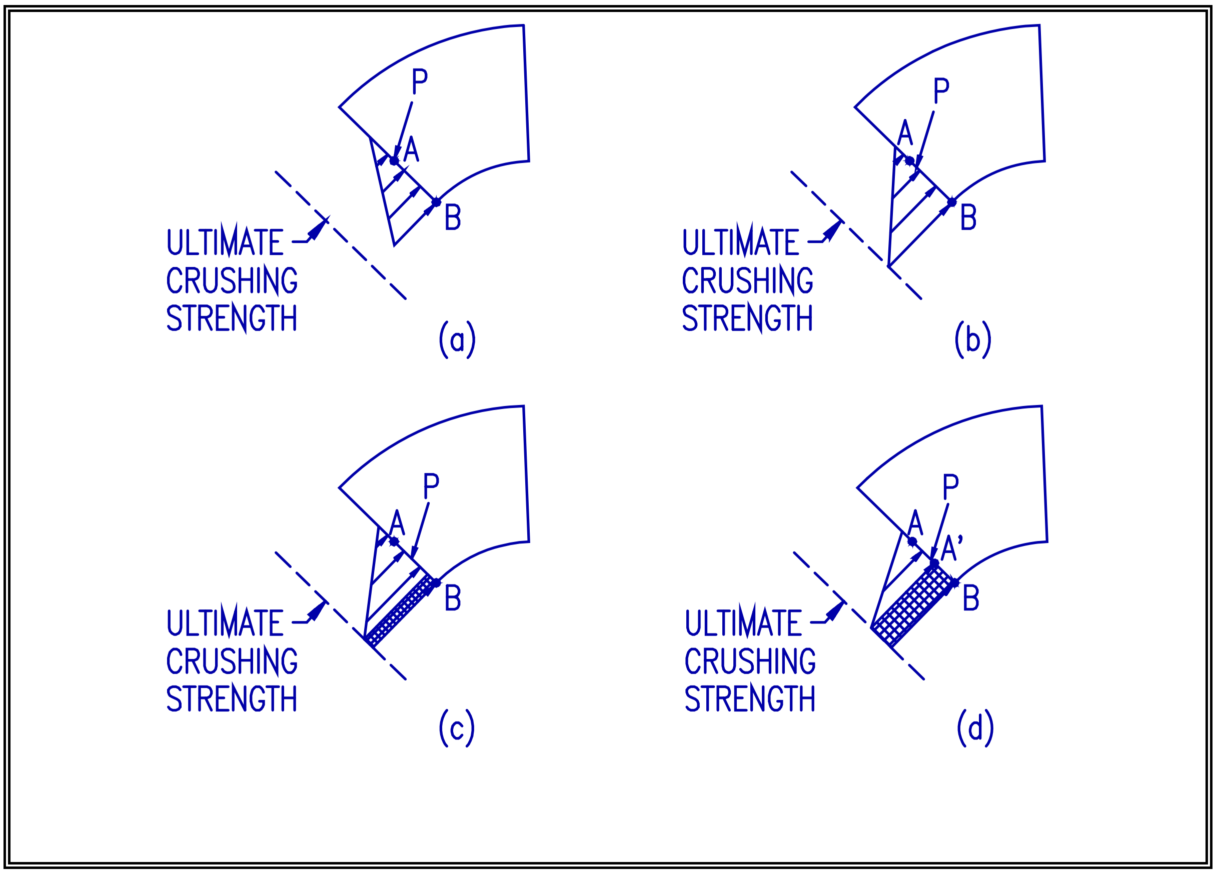


Figure A-7-2. S*tress Distribution on Arch or Culvert Ring Stones*

Sliding:

Sliding of one arch or culvert ring stone against another is resisted by the friction force (Force F) that exists between surfaces at a joint (see Figure A-7-3). The ring stone is stable against sliding when the line of resistance makes with the normal an angle less than the angle of friction between the joint mortar and the stone. If this angle is exceeded, due a shifting of the line of resistance or an increase in load, the component of the reaction resultant force parallel with the joint (Force X) will exceed the frictional force between the stone and mortar and sliding may occur.

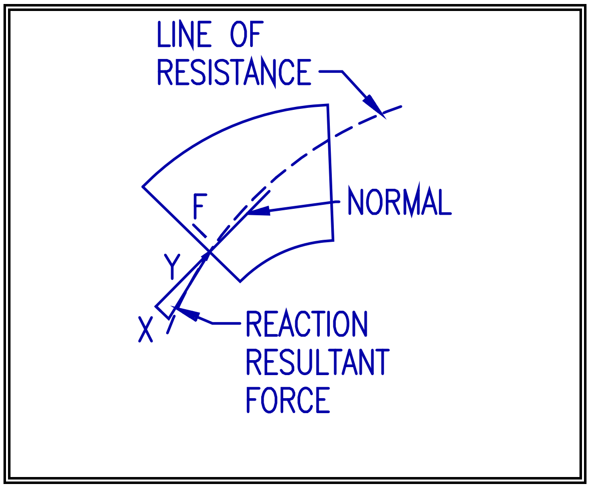


Figure A-7-3. *Friction Force Model for Arch and Culvert Ring Stones*

Figure A-7-4(a) and (b) represents the two possible failure modes due to sliding. Figure (a) shows the haunches of the arch sliding out and the crown slipping down and represents the situation where the rise is less than the span. In Figure (b), the rise is greater than the span and the crown will tend to push up and the haunches push in.

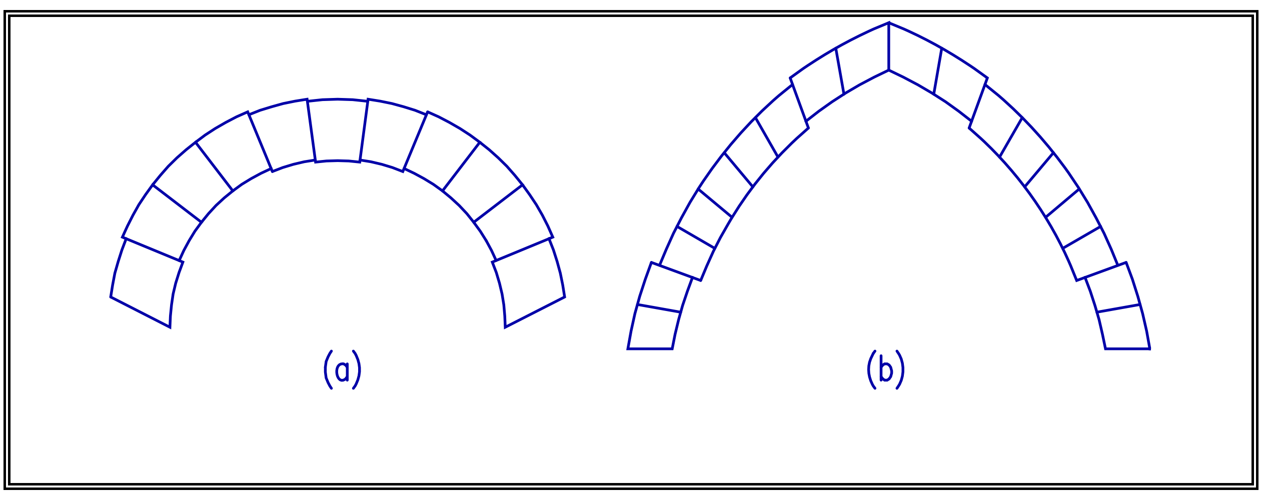


Figure A-7-4. *Sliding of Arch or Culvert Ring Stones Due to Overstress*

Rotation:

It is frequently prescribed that the line of resistance shall pass through the middle third of each joint. If the line of resistance departs from the middle third, the remote edge of the joint will be in tension. If the joint is unable to resist tension, it will open on the side farthest from the line of resistance. The figures below represent two possible methods by which the arch may give way due to rotation. Figure A-7-5(a) represents the failure mode most frequent for flat arches and Figure A-7-5(b) represents the failure mode most frequent for pointed arches. Openings along the extrados are more serious than those along the intrados because the former allows for the infiltration of water and possible increased deterioration due to freeze/thaw action.

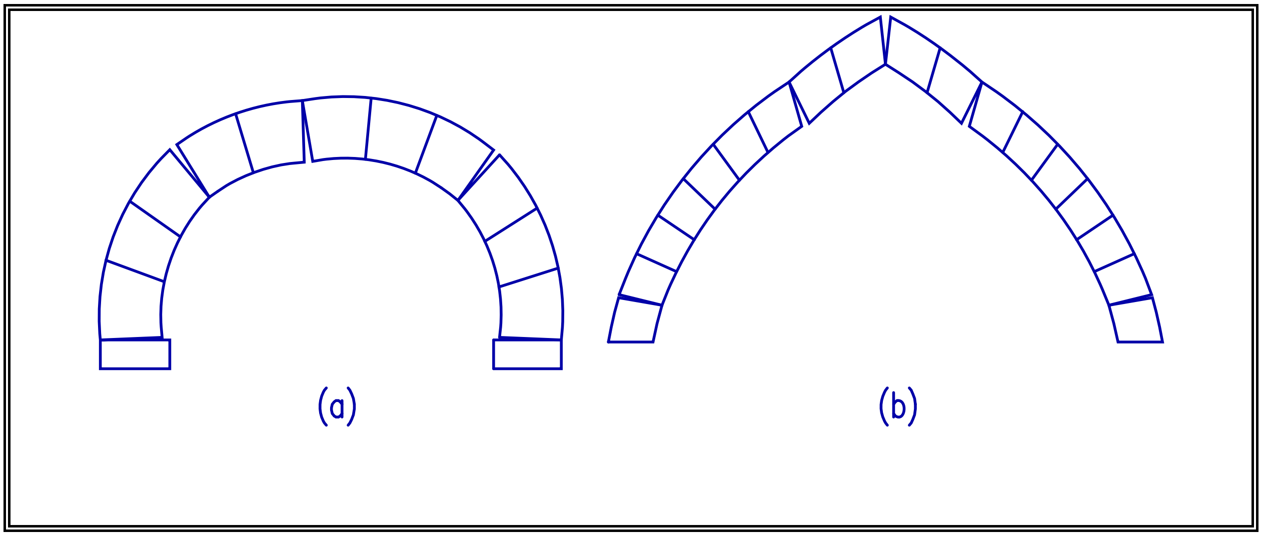


Figure A-7-5. *Rotation of culvert or arch ring stones due to a shifting of the line of resistance.*

Appendix 6.8: TIMBER DECAY AND DETERIORATION

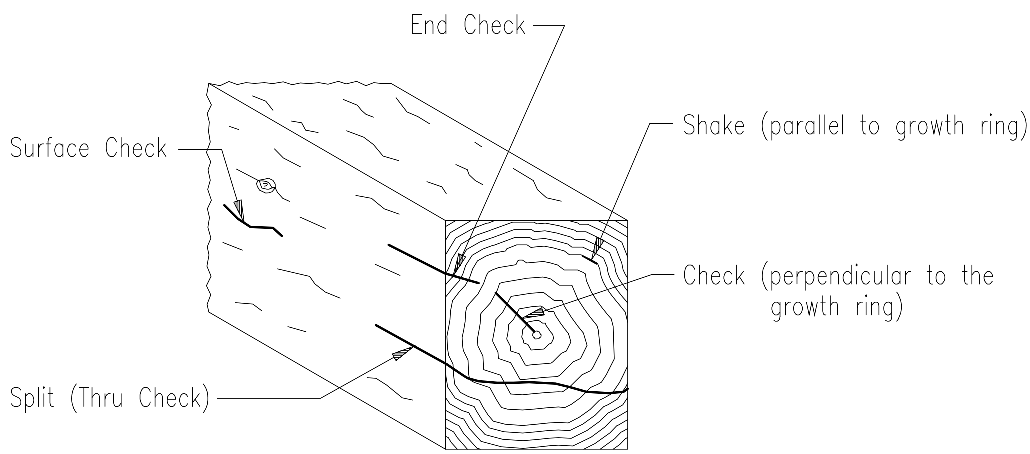


Figure A-8-1. *Timber Defect Nomenclature*

FUNGI TYPES:

- Molds and Stains: Superficial discoloration with no decay. Their presence, however, creates favorable conditions for other destructive fungi growth.
- Soft Rot: Only the surface of the wood is attacked. Therefore, the member is not normally significantly weakened.
- Brown Rot: Fungi feeds on the cellulose of the wood cells turning them brown in color and crumbly in texture. The result of their presence may reduce the load carrying capacity of the member.
- White Rot: Fungi feeds on the cellulose and lignin of the wood cells turning the wood white in color and stringy in texture. The result of their presence may reduce the load carrying capacity of the member.

[Note: Look for fruiting bodies (Concs) that release fungus spores and promote timber decay; typically fan shaped growing horizontal to the timber surface.]

CONDITIONS FAVORABLE TO FUNGI GROWTH:

- Sufficient Oxygen (≥ 20%)
- Favorable Temperature Range (01C (321F) to 321C (901F))
- Adequate food supply (the wooden structure itself)
- Adequate supply of moisture (30% minimum)

PARASITE TYPES:

- Termites: Pale colored, soft bodied parasites that eat and digest the wood. All damage is to the interior of the timber member and is therefore not noticeable on the surface. Look for long white mud shelter tubes or runways extending up from the ground.

- Marine Borers: Water-borne parasites that do not occur in fresh water. Damage is most extensive between mean high and mean low tide levels, although damage may extend down to the mudline. Borers may use the wood for nourishment creating relatively small holes on the surface while excavating the interior (Figure A-8-2), or burrow small excavations into the wood for shelter. As waves and tidal action breakdown the thin covering of wood fiber over the burrow, the borers dig deeper into the member resulting in progressive deterioration over time. Look for the typical hour glass shape of the timber member between tidal zones (Figure A-8-3).

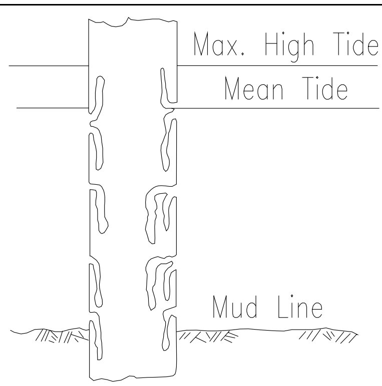


Figure A-8-2. *Timber Damage by Marine Borers - Type 1*

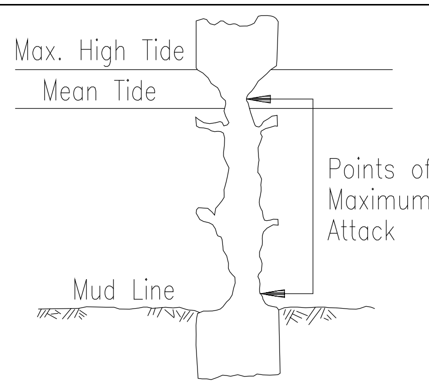


Figure A-8-3. *Timber Damage by Marine Borers Type 2*

- Carpenter Ants: Large black ants that hollow out the interior of timber members to make nests. Look for sawdust piles at the base of the timber and ants in the vicinity of, or moving in or out of, access holes.

- Powder Post Beatles: Small beetles that burrow into the timber and leave the timber surface pot-marked with holes. A powdery dust is usually dislodged from the holes and the entire interior of the timber may be excavated.

- Caddis flies: Insects, which while in the larva and pupa stages, burrow under the surface of the wood for protection. Found in fresh or brackish water.

ADVANCED TIMBER INSPECTION TECHNIQUES

Non-Destructive Testing

- Pol-Tek
- Spectral Analysis
- Ultrasonic Testing
- Hammer Tapping

Destructive Testing

- Boring, Coring, or Drilling
- Moisture Content
- Probing
- Shigometer

Appendix 6.9: CONCRETE CLOSED ARCHES AND FRAME

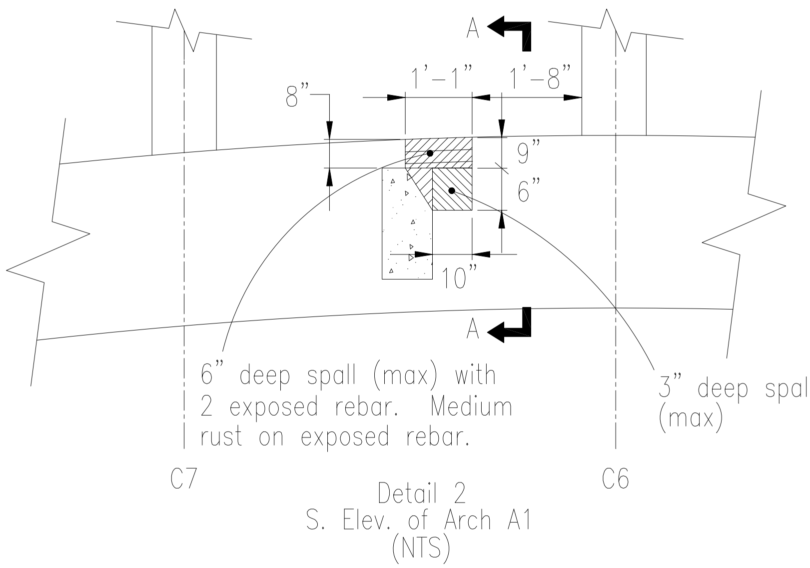


Figure A-9-1 *– Documentation of Inspection Deterioration*

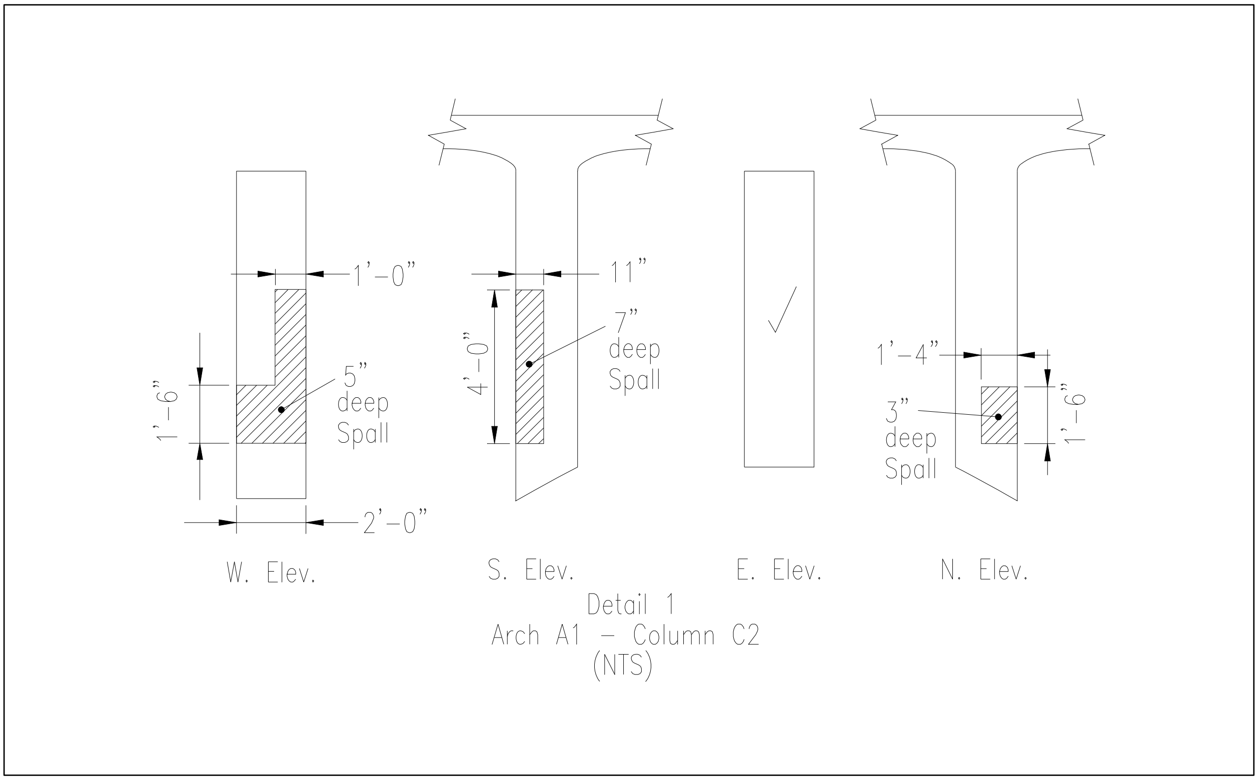


Figure A-9-2 *– Documentation of Inspection Deterioration*

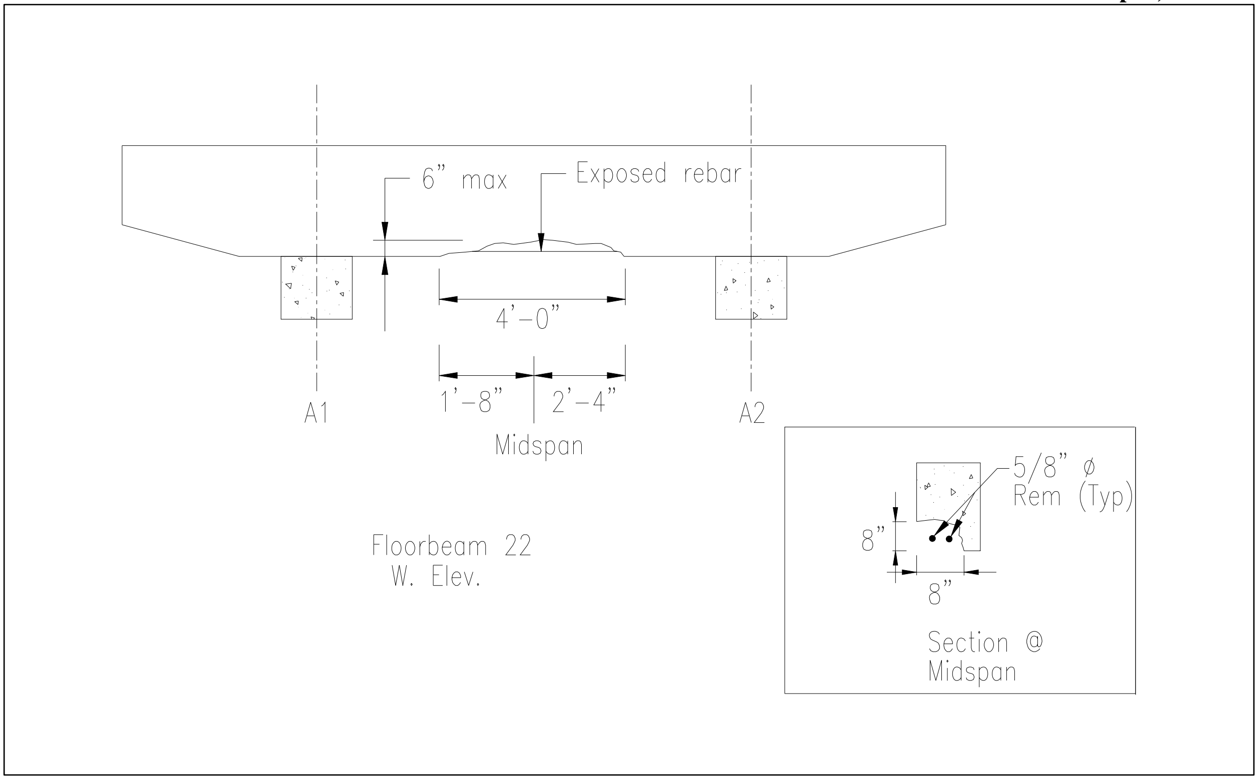


Figure A-9-3 *– Documentation of Inspection Deterioration*

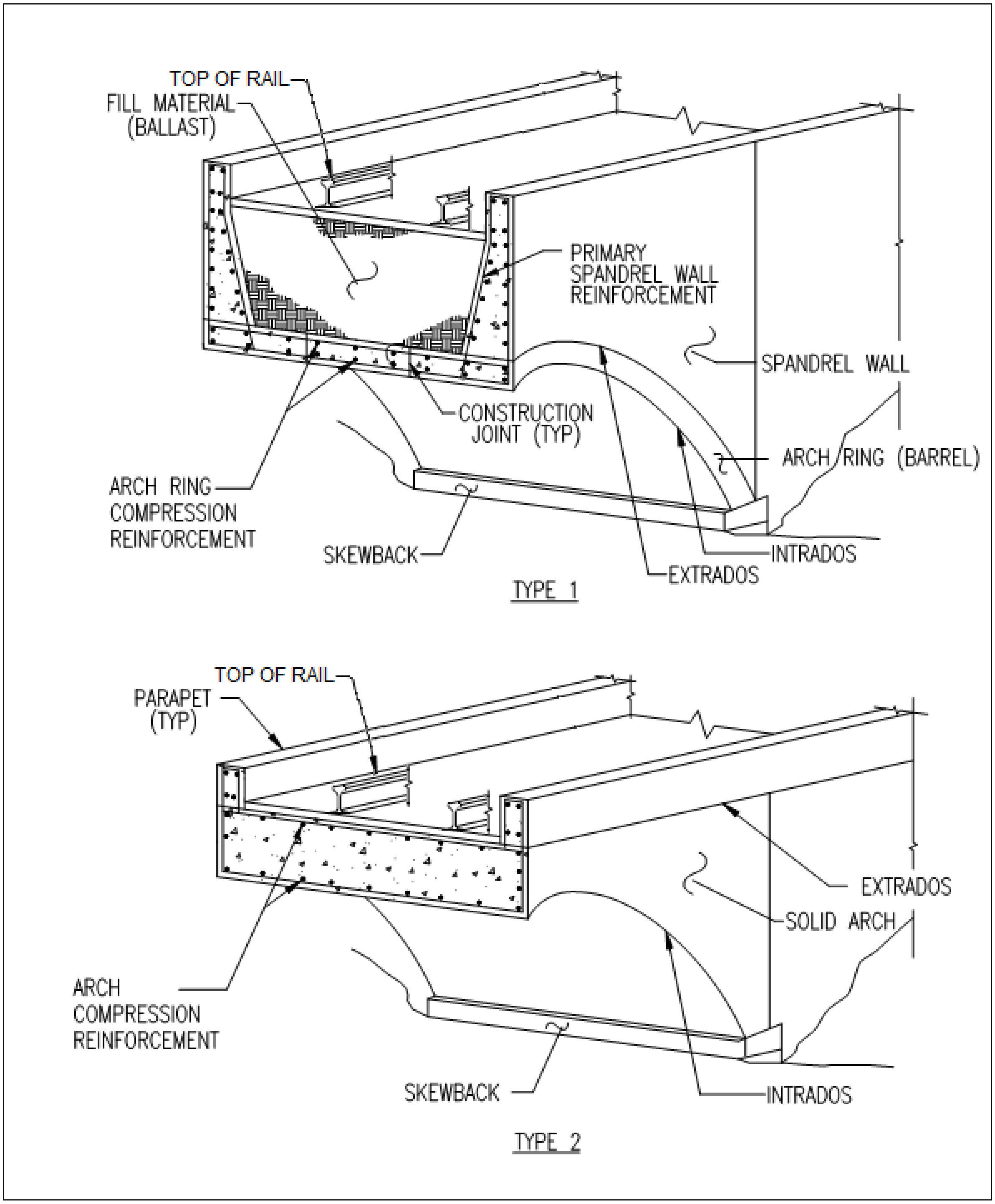


Figure A-9-4 *– Closed Spandrel Arch Configuration and Nomenclature*

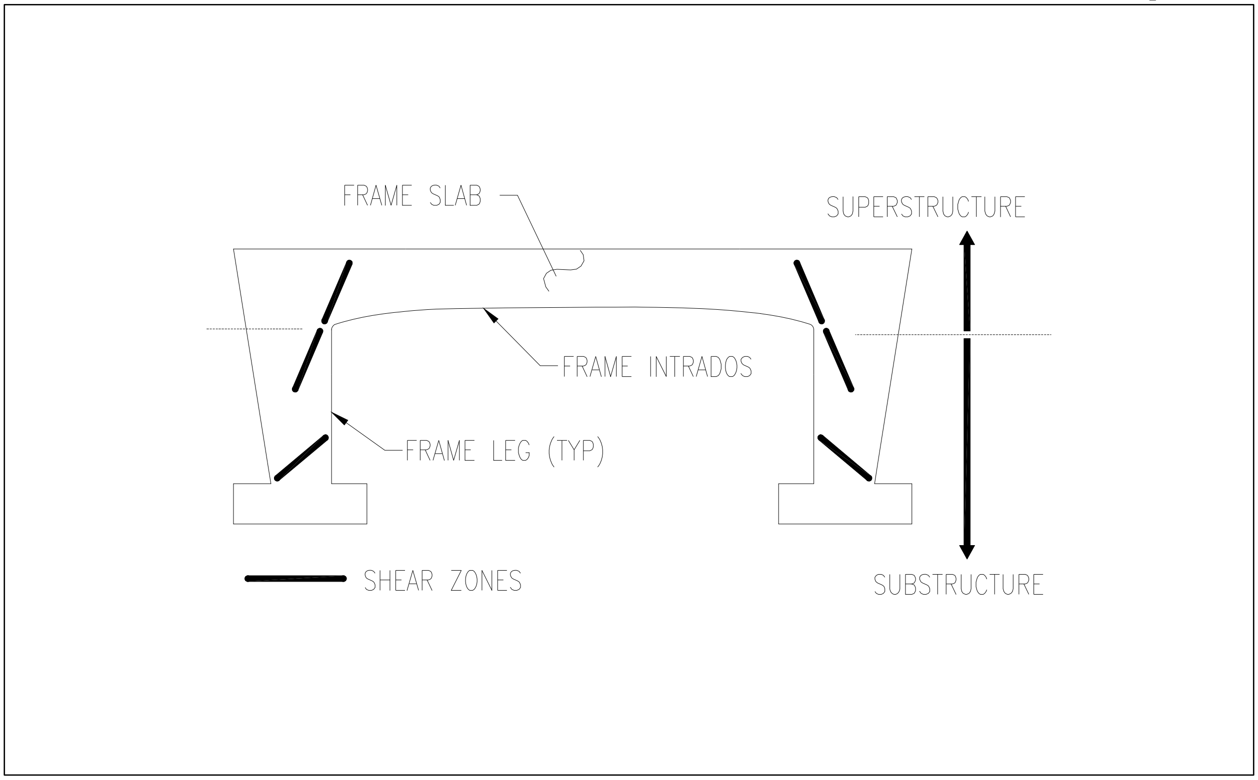


Figure A-9-5*– Single Span Rigid Frame Nomenclature and Shear Zones*

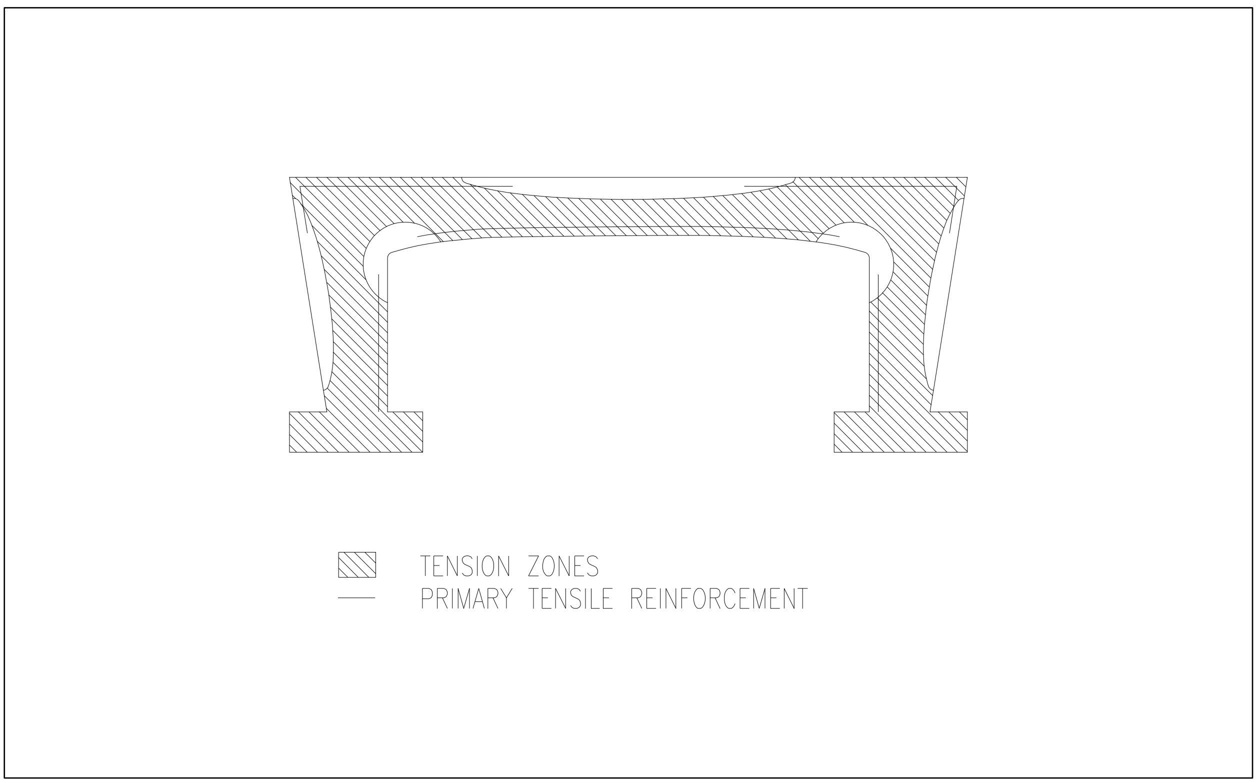


Figure A-9-6 *– Single Span Rigid Frame Tension Zones*

Appendix 6.10: WATERWAYS

A.10.1 CHANNEL AND CHANNEL PROTECTION

Rivers are the most geomorphic system engineers must cope with in the design and maintenance of bridges. The geomorphic features of the river can change dramatically with time. During normal flow conditions lateral movement, aggradation and degradation of the channel can disrupt the water flow in such a way that the long term stability of the bridge or approach roadways may be affected. During major floods, significant changes can occur in short periods of time. The increased flow rates and volumes associated with flood conditions can create conditions in which the capacity of the hydraulic opening is exceeded. While waterway channels are dynamic, bridges are not usually designed to move other than in keeping with planned structural movements and deflections due to thermal forces and anticipated static and dynamic loadings of the structure. Therefore, it is very important for the inspector to understand the nature of slow changes over time as well as rapid changes that may occur in waterways and the impact of these changes on the bridge's stability.

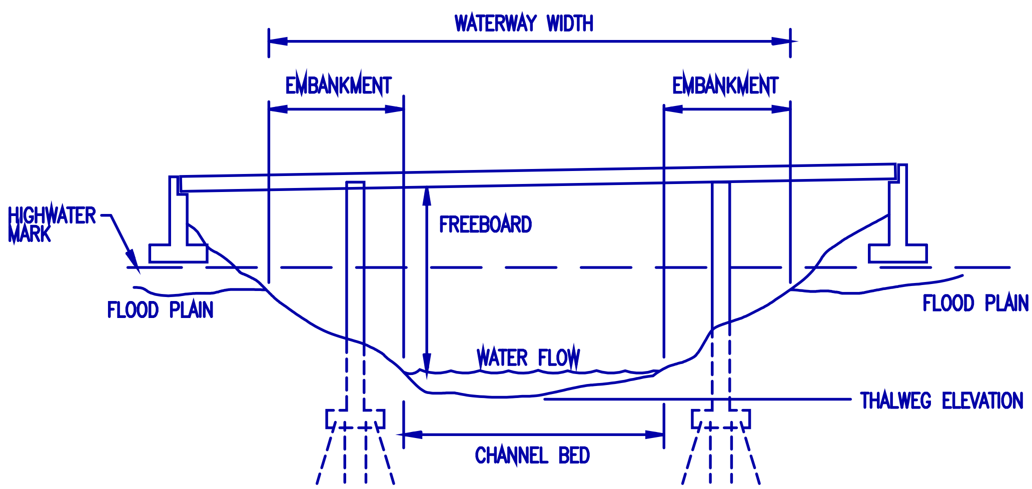


Figure A-10-1. *Typical waterway layout and nomenclature.*

A.10.1.1 Channel Protection

Channel protection for waterways is designed to protect the bridge from the detrimental effects of aggradation, scour, bank erosion, degradation and lateral movement of the waterway bed. Typical types of channel protection, as shown in Figure A-10-2, are designed to re-direct the flow of the waterway in a direction away from an endangered slope or bridge element, or dissipate the energy of the flow, which results in a reduction of the flow velocity. Channel protection may also be used to redirect the upstream water flow to reduce misalignment between the water flow and the substructure elements.

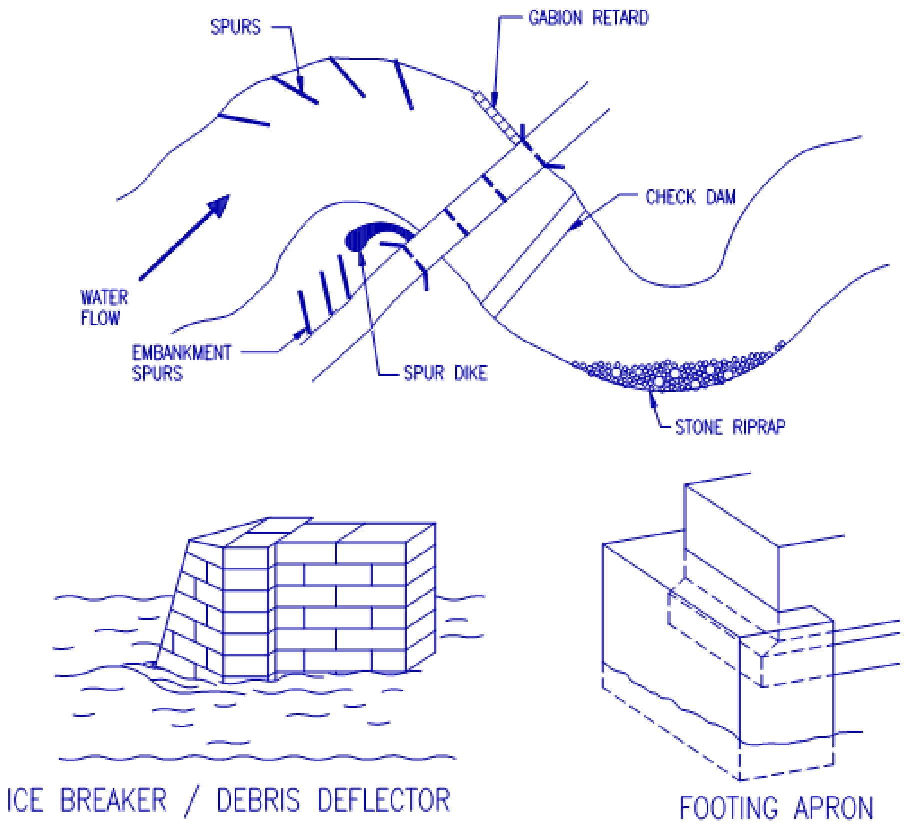


Figure A-10-2. *Types of waterway protection devices.*

A.10.1.2. Waterway Misalignment:

Waterway misalignment, generally caused by lateral movement of the waterway over time due to significant bank erosion during flooding or high velocity flows, describes the condition where the alignment of the flow has changed relative to the bridge abutments and piers. Generally, this means the direction of the water flow is no longer parallel with the piers and abutment faces. As the angle of attack (ι) increases, a greater surface area of the pier or abutment is being impacted by the flowing water, producing increased vortex action in the water and greater potential for local scour. However, to accurately assess if channel misalignment has occurred, a review of past inspection reports, review of the alignment at the time of construction, or review of aerial photographs over time is necessary.

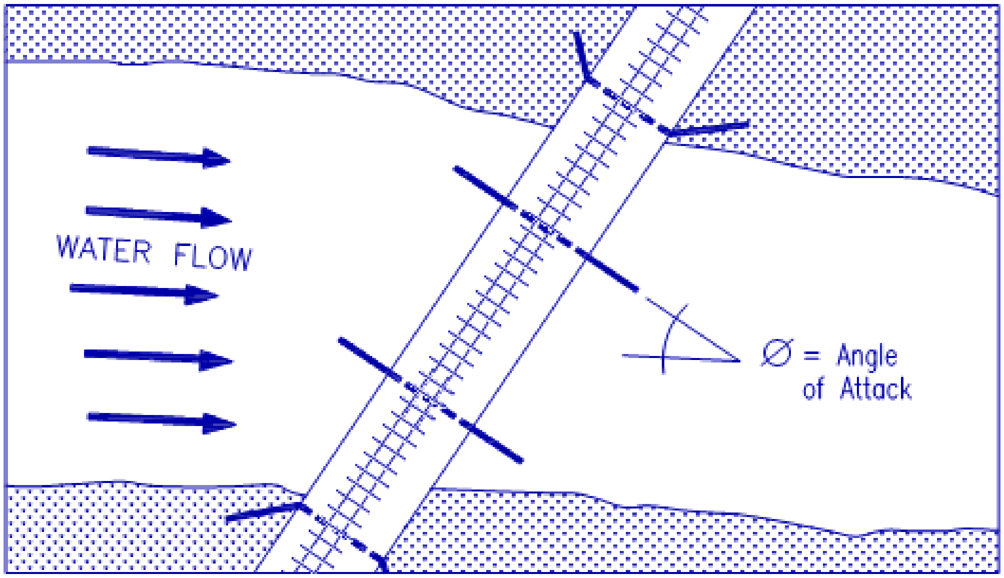


Figure A-10-3. *Misalignment between water flow and substructure elements.*

A.10.1.3 Scour:

Scour is the removal of material from the riverbed due to normal movement of the water through the hydraulic opening or due to localized vortices created by movement of the water around piers, abutments, or other obstacles in the water. See Appendix 6.12 for examples of required documentation to describe stream cross sections and scour at substructure elements. Three types of scour that require evaluation during inspection are as follows:

1. **General Scour:**

   General scour is the natural erosion of the riverbed that occurs over a period of years. It usually occurs over long lengths in a river and is accelerated by natural cutoffs that steepen the gradient of the waterway increasing the velocity and flow volume. However, human influences may cause or accelerate general scour. Upstream water developments, river diversions, dam outlets, changes in waterway alignment, changes in waterway dimensions or urbanization of a watershed all may affect the riverbed downstream.

2. **Contraction Scour:**

Contraction scour is scour that occurs only in the riverbed or flood plain below the structure. It is caused by the hydraulic opening having less width than the upstream waterway, or the hydraulic opening being substantially reduced by debris build-up. As a result, the water flow is constricted by the bridge abutments, intermediate piers and/or debris as it passes through the structure. Because the volumetric flow rate must remain constant, the velocity of the water increases as it passes through the structure. This increase in velocity causes increased scour of the waterway bed below the structure. Immediately downstream of the bridge, if the waterway widens to its upstream configuration or if debris no longer blocks the channel, the velocity will slow to its original speed allowing the scoured material to settle. The presence of downstream aggradation in conjunction with contraction conditions indicates the existence of contraction scour.

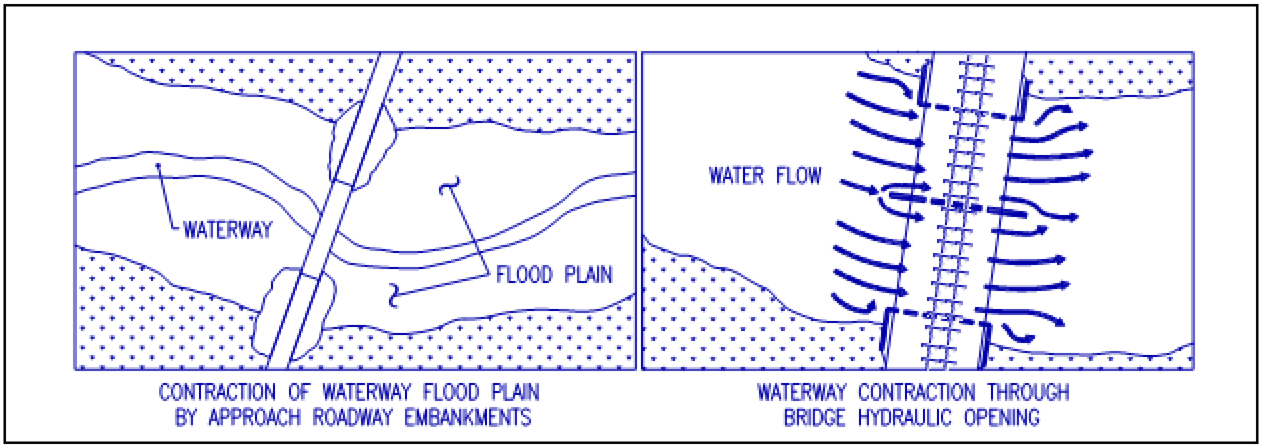


Figure A-10-4. *Waterway contraction*

3. **Local Scour:**

Local scour occurs at substructure elements that are within the channel or flood plain limits. They are created when constrictions of the water flow, caused by abutments, piers and debris build-up, as well as misalignment between the water flow and substructure elements, cause vortices or turbulence to develop along the faces of the substructure elements. These vortices remove sedimentary particles from the sides of the substructure elements and may eventually begin to undermine the elements. Scour depths caused by local scour, which are greatly influenced by the velocity of the water flow and configuration of the constriction, can be up to ten times greater than the depths caused by general scour.

Bridges in tidal zones are particularly vulnerable to local scour. The periodic reversal of the tide typically has imbalances between the input and output sediment transport rates. This, combined with complex vortices created by the tidal currents, produces large scour holes that can have a negative affect the stability of the bridge.

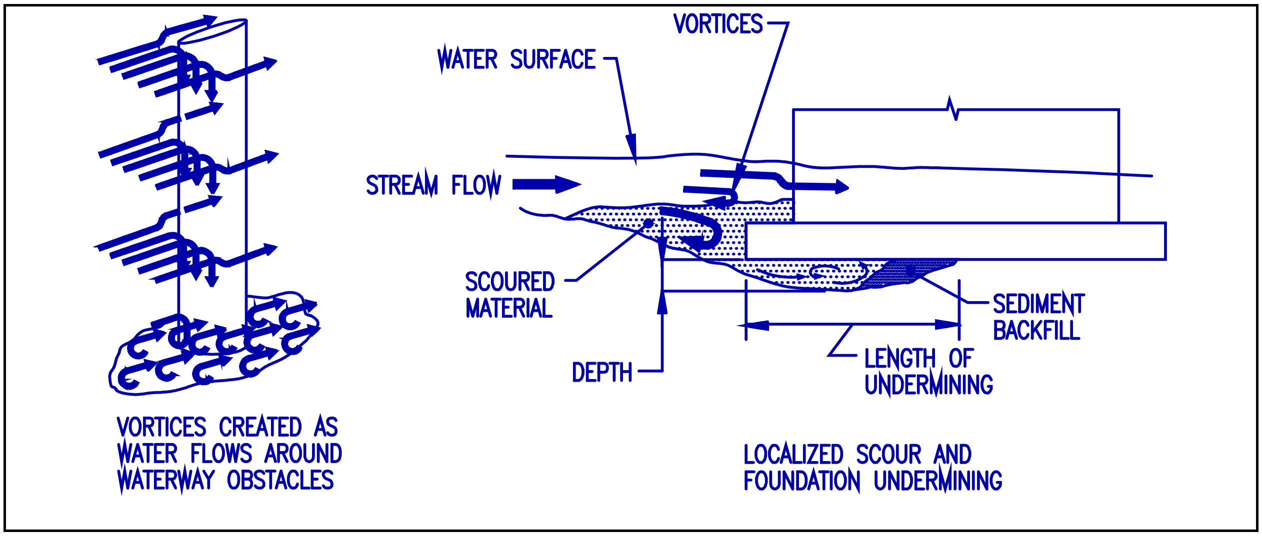


Figure A-10-5. *Local Scour*

A.10.2 Waterway Adequacy:

Waterway adequacy is an appraisal of the ability of a bridge to pass the water flow through the bridge during maximum and seasonal flood conditions. The appraisal considers all movement of the water regardless of path taken (i.e. through the hydraulic opening, around the structure or over the structure). The hydraulic opening is defined as the maximum cross-sectional area at the bridge opening through which water may pass, and is calculated as shown in figure A.10.6. Special care should be taken when choosing the locations where h_1, h_2, etc. are measured. They should be recorded in the field notes and bridge diary so future inspections will use the same points and maintain consistency between inspections. This will also aid in determining whether or not aggradation or degradation of the riverbed is occurring (See Appendix 6.12 for additional information).

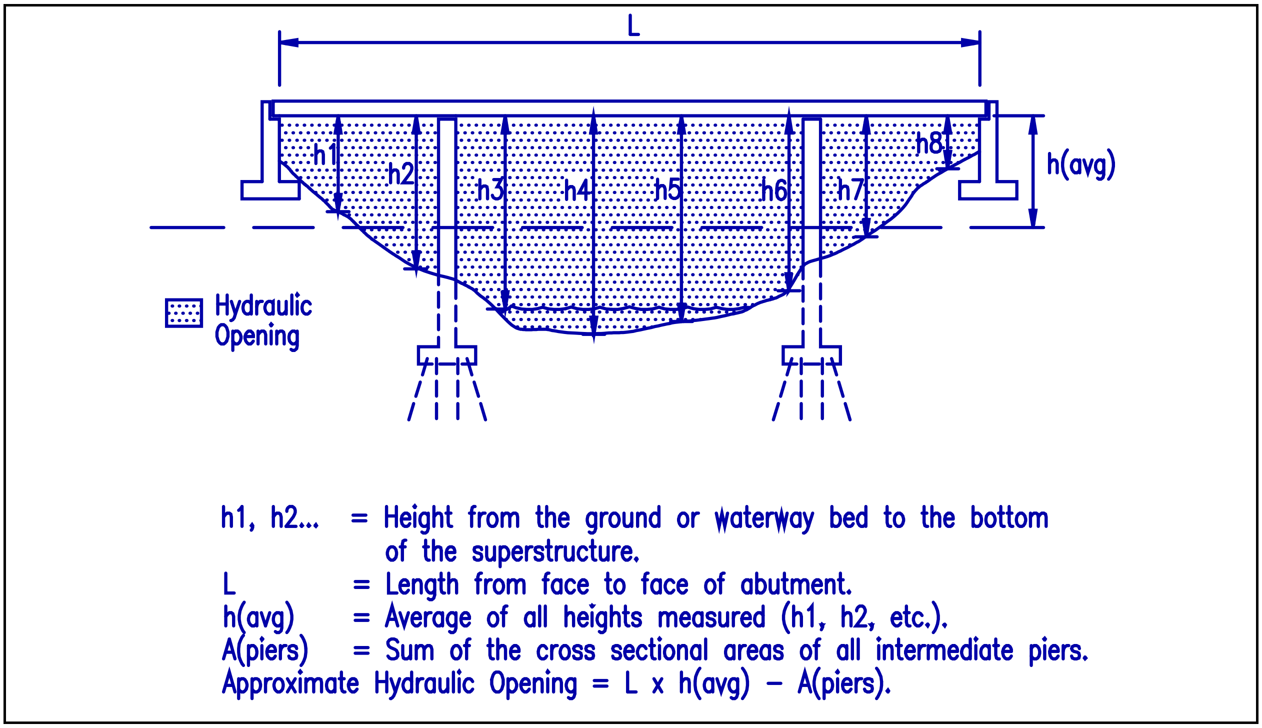


Figure A-10-6. *Hydraulic Opening*

In order to accurately appraise waterway adequacy, accurate knowledge of the maximum flood design value and actual history of flooding in the waterway must be known. This information can be gathered from historical files that document past flood limits, previous inspection reports and the first hand knowledge of residents who have lived in the area for long periods of time. Information regarding the classification of the road, volume of traffic and detour routes must also be known. Un less documentation gathered by the inspector shows a clear pattern of flooding, the appraisal of waterway adequacy is left up to the subjectivity of the inspection.

The following things should be considered during the appraisal:

- The presence of debris hanging in the superstructure or on the substructure elements indicating that the hydraulic opening has been exceeded or has come close to being exceeded during past flood conditions.

- The size and shape of the flood plain, and whether the cross sectional area of the maximum design or documented flood flow, whichever is greater, exceeds the value of the hydraulic opening. This indicates that the bridge superstructure may be, or may have already been, subjected to lateral forces that it was not designed to withstand.

- Whether the lowest point of the approach railways is higher, lower or equal to the lowest elevation of the bridge superstructure. This gives indication as to whether the approach railways will be topped by flood water before the bridge is topped. If these elevations are relatively even or if the approach railway is at a higher elevation than the bridge, the bridge will be subjected to buoyancy forces once the superstructure begins to become submerged. These buoyancy forces counteract the dead load of the bridge and will increase to a maximum once the entire bridge structure becomes submerged. As buoyancy forces increase, the net downward force the structure applies to the substructure will be reduced. This in-turn will reduce the frictional forces between the superstructure and substructure elements that resist the lateral forces applied to the bridge by the water flow. The combination of these two actions may displace the structure off the bearing pedestals or off the substructure elements entirely.

- The potential for flash aggradation or degradation during flood conditions that can diminish the hydraulic opening and create instability of the bridge structure.

SPECIAL NOTE:

Inspectors should be aware that riverbeds that are experiencing active aggradation and degradation, or that are stable, have both positive and negative effects associated with them as noted below and that all aspects should be evaluated when inspecting the waterway.

Aggradation:	• *Reduces the potential for scour and undermining of the substructure elements.*	• *Reduces the Hydraulic Opening of the bridge and affects flow patterns.*
Degradation: (General Scour)	• *Increases the Hydraulic Opening of the bridge.*	• *Increases the potential for scour and undermining of the substructure elements.*
Stable:	• *Hydraulic opening remains constant.*	• *Potential for scour and undermining of substructure elements during abnormal flow conditions.*

Appendix 6.11: TRUSSES

Trusses are normally designed so that members experience axial loads only and that no bending occurs in any member. In order to properly inspect a truss, the inspector must know the typical layout, nomenclature and function of the various truss members (see Figure A-11-1).

Trusses come in three basic types as shown in Figure A-11-2. Each type may be constructed as simply supported (as shown), continuous or cantilevered. Note the advantages and disadvantages for each truss type. Knowledge of these (particularly the disadvantages), helps to highlight causes of potential problems and identify areas that require special attention.

Through Truss:

Advantages: Long spans, greater freeboard (under clearance).

Disadvantages: Limited vertical and horizontal clearance for the roadway, members susceptible to impact damage, members susceptible to corrosion particularly at roadway/sidewalk level.

Pony Truss:

Advantages: Unlimited vertical clearance, greater freeboard (under clearance).

Disadvantages: Limited horizontal clearance for the roadway, short spans (under 120 ft. (36.5m)), members susceptible to impact damage, members susceptible to corrosion particularly at sidewalk/ roadway level.

Deck Truss:

Advantages: Unlimited vertical and horizontal clearances, members are not susceptible to vehicular impact damage, required substructure heights are reduced.

Disadvantages: Less freeboard (under clearance), more susceptible to the damaging effects during flooding and marine traffic impact damage.

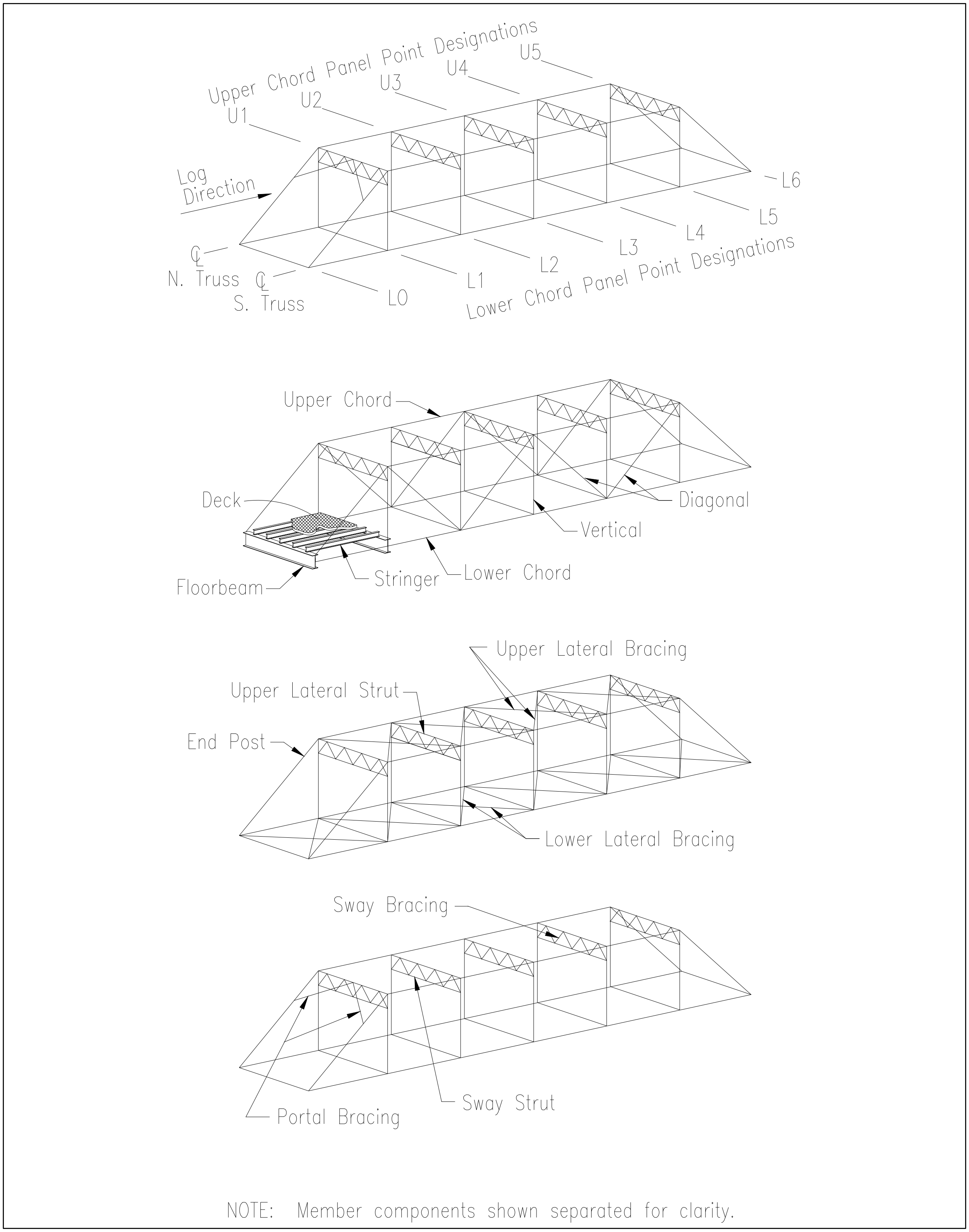


Figure A-11-1 – Truss layout and nomenclature

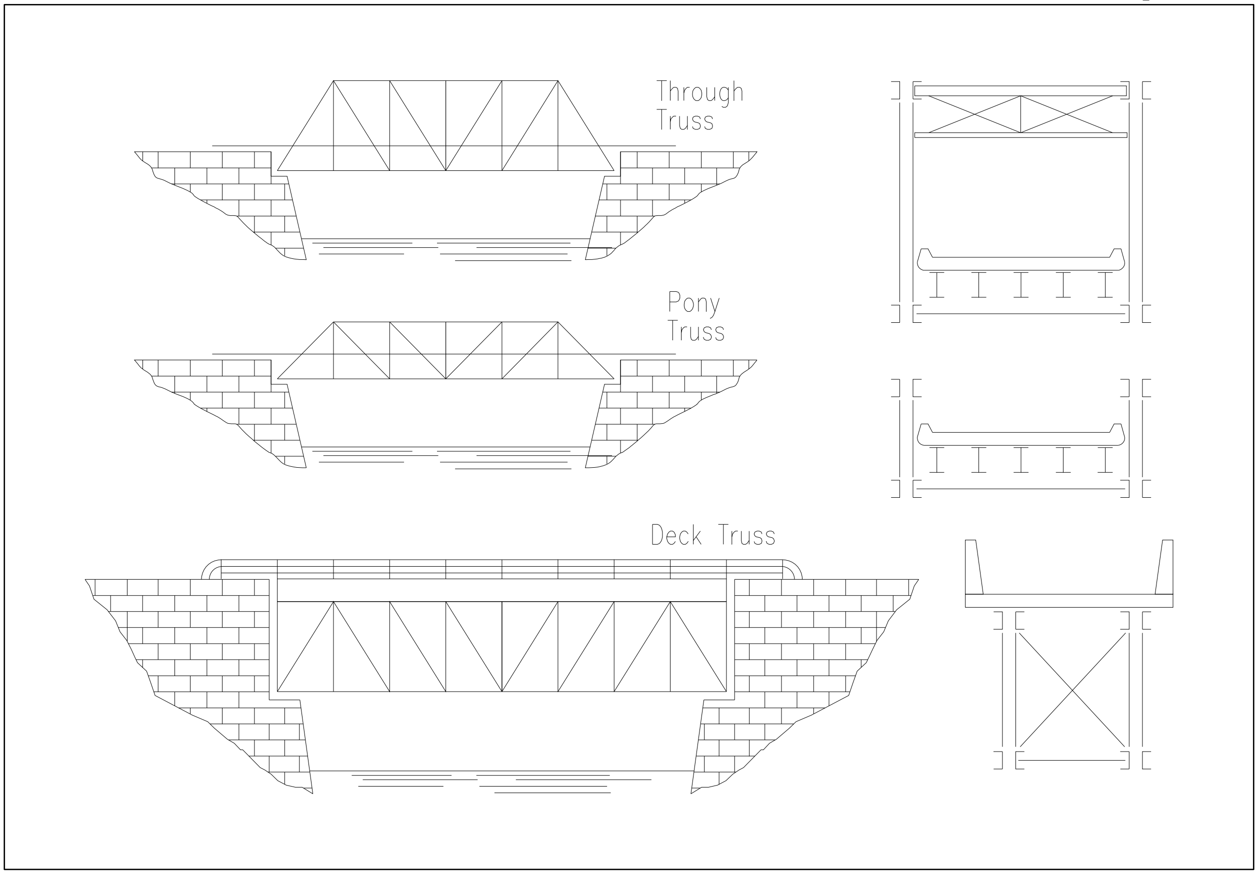


Figure A-11-2 *– Truss type comparisons*

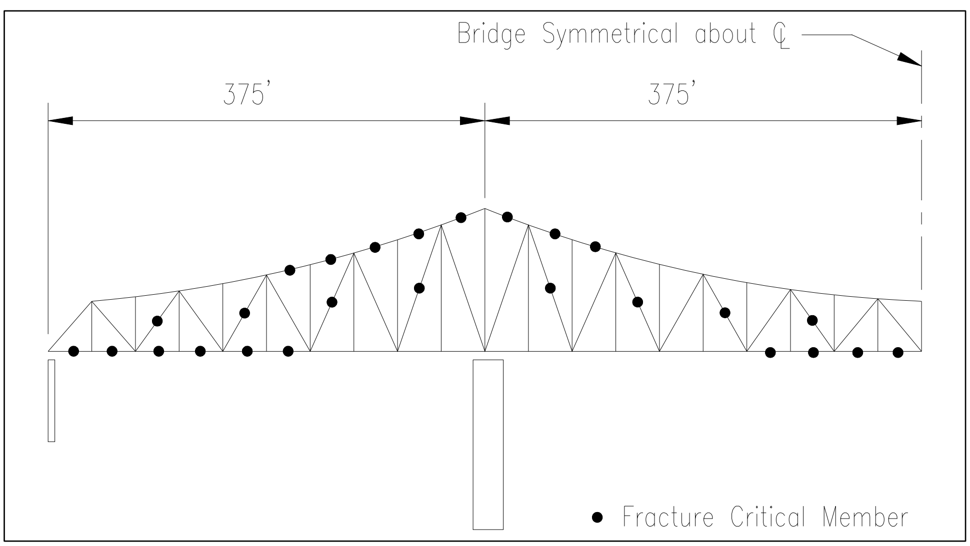


Figure A-11-3 *– FCM location identification*

Truss Member Force Prediction

Trusses are considered non-redundant because there are typically only two load paths to the substructure elements. The failure of certain critical members will usually result in the failure of the truss and the subsequent collapse of the structure. Even in the case where there are three or more trusses per span, the spacing of the trusses may be large enough so that loss of one truss will result in partial or total failure of the structure. Only detailed analysis by a competent Railroad structural engineer can determine if loss of one member within a truss will cause failure of the truss and whether loss of one truss will result in the loss of the entire structure. In lieu of detailed analysis, all tension members should be considered fracture critical members. Tension members may be chords, diagonals or verticals depending on the member arrangement and should be identified and marked for "hands-on" inspection prior to inspection initiation (see Figure A-11-3). If a detailed analysis cannot be performed, field expedient methods for stress prediction can be employed. In figure A-11-4, force prediction in truss diagonals is predicted by connecting pairs of diagonals with imaginary arches or cables depending on their downward or upward slope toward midspan. Member pairs that

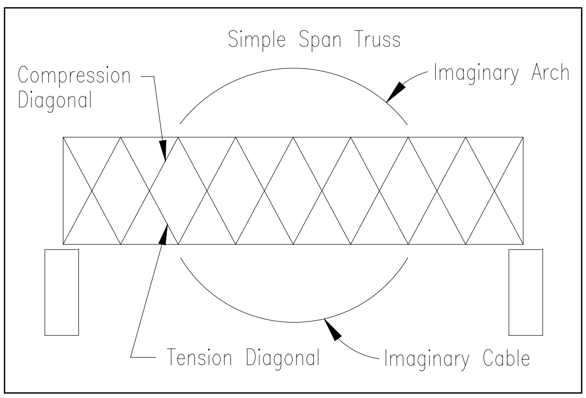


Figure A-11-4 *– Method for predicting Type of Force in Truss Diagonals*

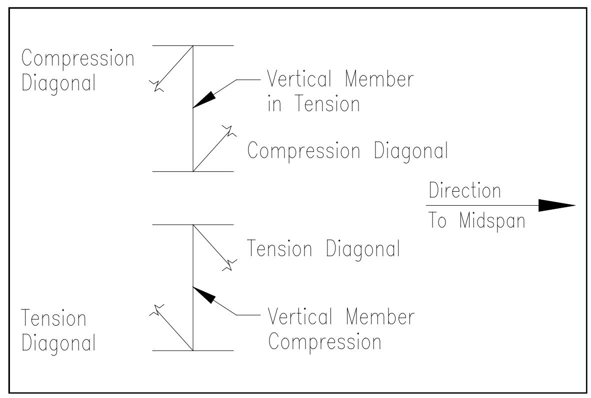


Figure A-11-5 *– Method for predicting Type of Force in Truss Verticals*

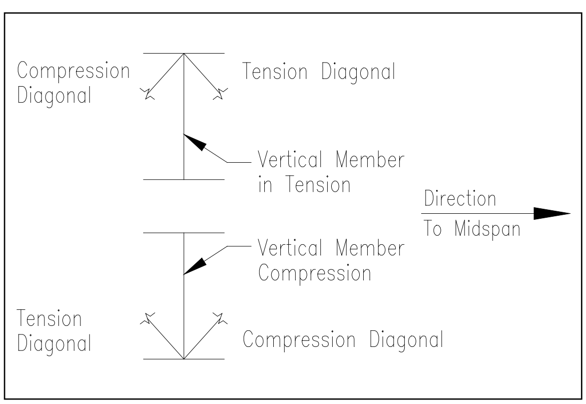


Figure A-11-6 *– Method for predicting Type of Force in Truss Verticals*

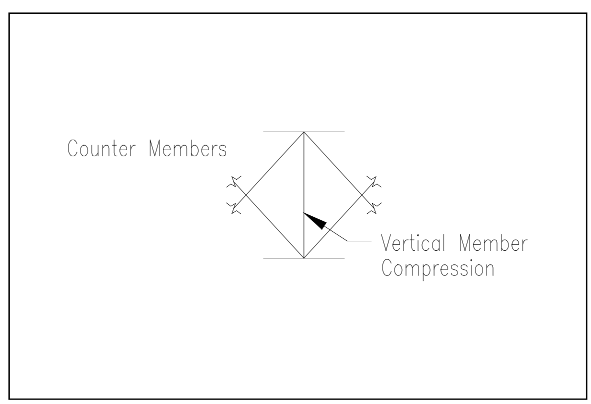


Figure A-11-7 *– Method for predicting Type of Force in Truss Verticals* form "arches" are said to be compression members and pairs that form "cables" are said to be in tension. Figures A-11-5, -6 and -7 predict force type in truss verticals based on the forces in diagonals that frame into it. Note, however that these field expedient methods are only valid for simply supported trusses.

Riveted or Bolted Built Up Truss Members

Redundancy within the tension member itself plays an important roll in determining susceptibility to fatigue crack propagation. Common fatigue crack locations for various truss details are outlined in Appendix 6.1, Item 4.5.

Riveted or bolted truss members have the advantage of being internally redundant (see Figure A-11-8). A crack initiating in one component of a truss member such as the flange angle, can not readily propagate into another component of that member. This configuration offers the greatest degree of internal redundancy and the least degree of susceptibility to failure due to fatigue.

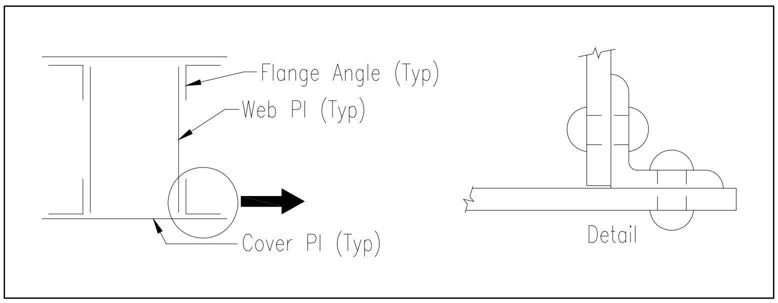


Figure A-11-8 *– Riveted or built-up member*

Welded Built Up Truss Members

Welded members, however, do not have this internal redundancy and a crack initiating at any portion of the cross section may propagate to any other point through the weld (see Figure A-11-9). The weld itself has high susceptibility to fatigue crack initiation if good quality control measures are not used during the fabrication of the member. Excessive porosity (pitting), rollovers and arc strikes,

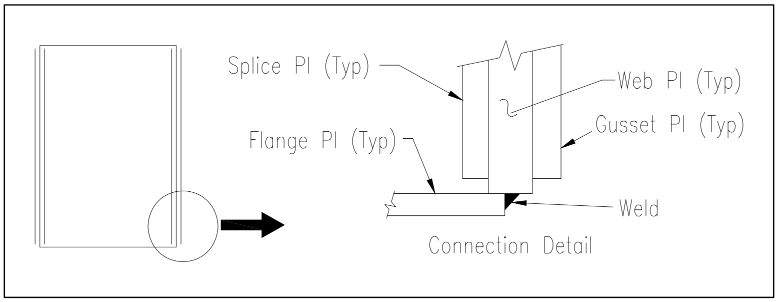


Figure A-11-9 *– Welded built-up member at connection*

unequal leg fillet welds, excessive convexity, excessive concavity, undersize welds, undercutting of the base metal, weld spatter and excessive reinforcement, lack of penetration, underfill, unfilled craters, uneven weld profile and slag are typical weld defects that increase susceptibility to fatigue crack initiation. The type of weld (groove, fillet, plug etc.) and where it is placed also plays an important roll in fatigue crack development. Appendix 6.1 of this manual details many common fatigue sensitive details that apply to truss members.

One unusual problem with welded, built up members results in the cracking of welds not from fatigue stress but rather corrosion stress. The detail shown in figure A-11-9 shows a welded built up member configured for a panel point connection. In this detail, if there is a gap between the interior splice plate and the bottom flange plate, dirt, debris and moisture can pack in the gap and accelerate deterioration until impacted rust fills the gap and begins to force the bottom flange plate down. When this occurs, as shown in figure A-11-10, the weld that connects the web plate and flange plate is subjected to tensile stresses that can lead to cracking of the weld.

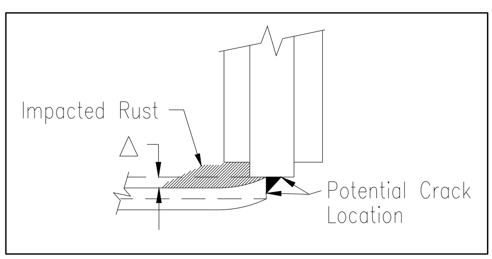


Figure A-11-10 *– Corrosion induced weld crack*

Eyebar Truss Members

Eyebar members are usually rectangular bars that have enlarged ends that have a hole in them. They are found in trusses that are pin connected and are used exclusively for tension members or members designed to primarily resist tension forces. Eyebar members are normally fracture critical although there may be some internal redundancy in members that are composed of a number of eyebars.

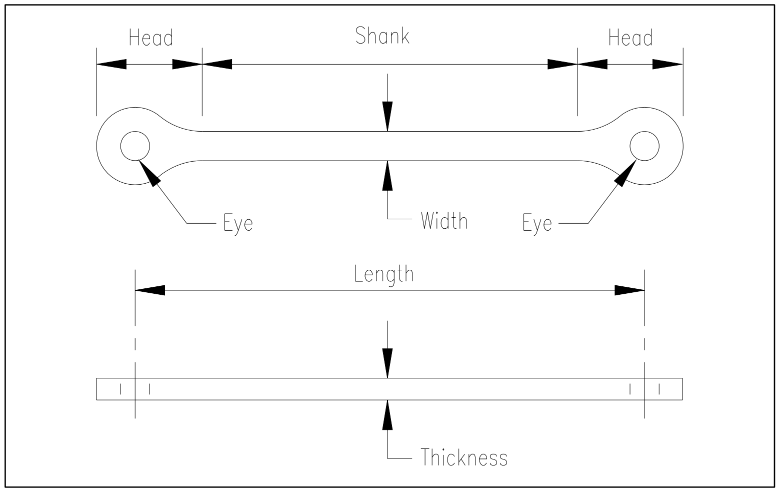


Figure A-11-11 *– Eyebar dimensions and nomenclature*

Appendix 6.12: SCOUR AND STREAM DOCUMENTATION

Bridge inspectors should accurately record the present condition of the bridge, including channel cross section measurements, pier or abutment protection, and existence of rip rap. Conditions indicative of potential problems with scour or stream stability should be identified. Original structure design plans that show substructure details and bottom of foundation elevations should be available to inspectors and inspectors should be aware of the stream bed elevation that will cause a bridge to become unstable. Inspectors are referred to FHWA Publication HI-96-018, *Stream Stability and Scour at Highway Bridges* for a more detailed discussion on this topic.

Elevations of the stream bottom shall be determined by sounding or other means when appropriate. The inspection team shall establish a datum that can be referenced and tied into the bridge structure. The same datum used in previous inspections should be used unless there is a need for a change that should be approved by the Senior Engineer.

Soundings shall be taken at a minimum of 5 points along the upstream fascia in each span. The distance between measurement locations should not exceed approximately 25'. Choose an interval that allows the channel to be accurately defined. The interval may be varied or unequal if site conditions warrant. The horizontal position at which the vertical elevations are taken should be clearly indicated. Whenever possible, these measurements should be taken at landmark positions on the bridge, such as diaphragm or rail post locations so that they can be easily duplicated in the future. The edges of the waterway should also be located and elevation measurements must be taken across the entire span opening to describe the embankment slopes. Whenever there is evidence of scour around a substructure element, soundings shall also be taken at a minimum of three (3) points (spacing not to exceed approximately 25') along the face of each substructure element. Bridges that are inspected by the Underwater Inspection Team shall be inspected in accordance with the requirements of the Underwater Inspection Contract and the guidelines outlined in Chapter 5 of this manual.

Examples of required documentation are shown on the following pages. The stream cross section measurements shown in Figure A-12-1 must be taken in the field on each inspection. These elevation measurements will be used to plot the stream cross section profiles as shown in Figure A-12-3. This cross section should be drawn in the office using CADD (which can be reused on subsequent inspections) or plotted as a scale drawing, showing foundation types and bottom of foundation elevations from as-built drawings. Where information is available, the estimated top of rock profile should also be shown. It is important that the stream cross section clearly and accurately show the position of the waterway with respect to the bottom of foundation positions. This historic record will be monitored over time to detect long term channel change trends.

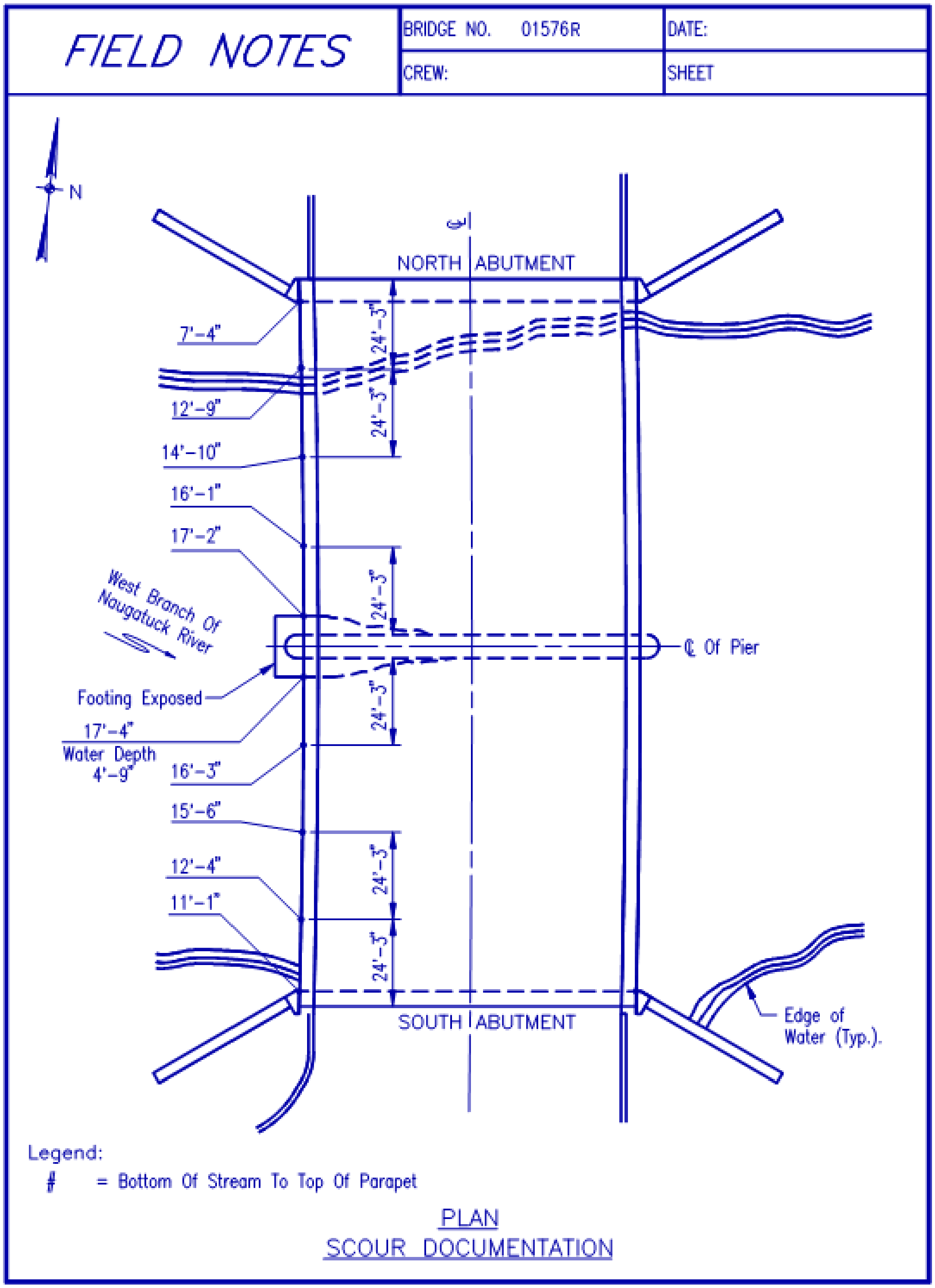


Figure A-12-1. Example of required field measurements for plotting stream cross section.

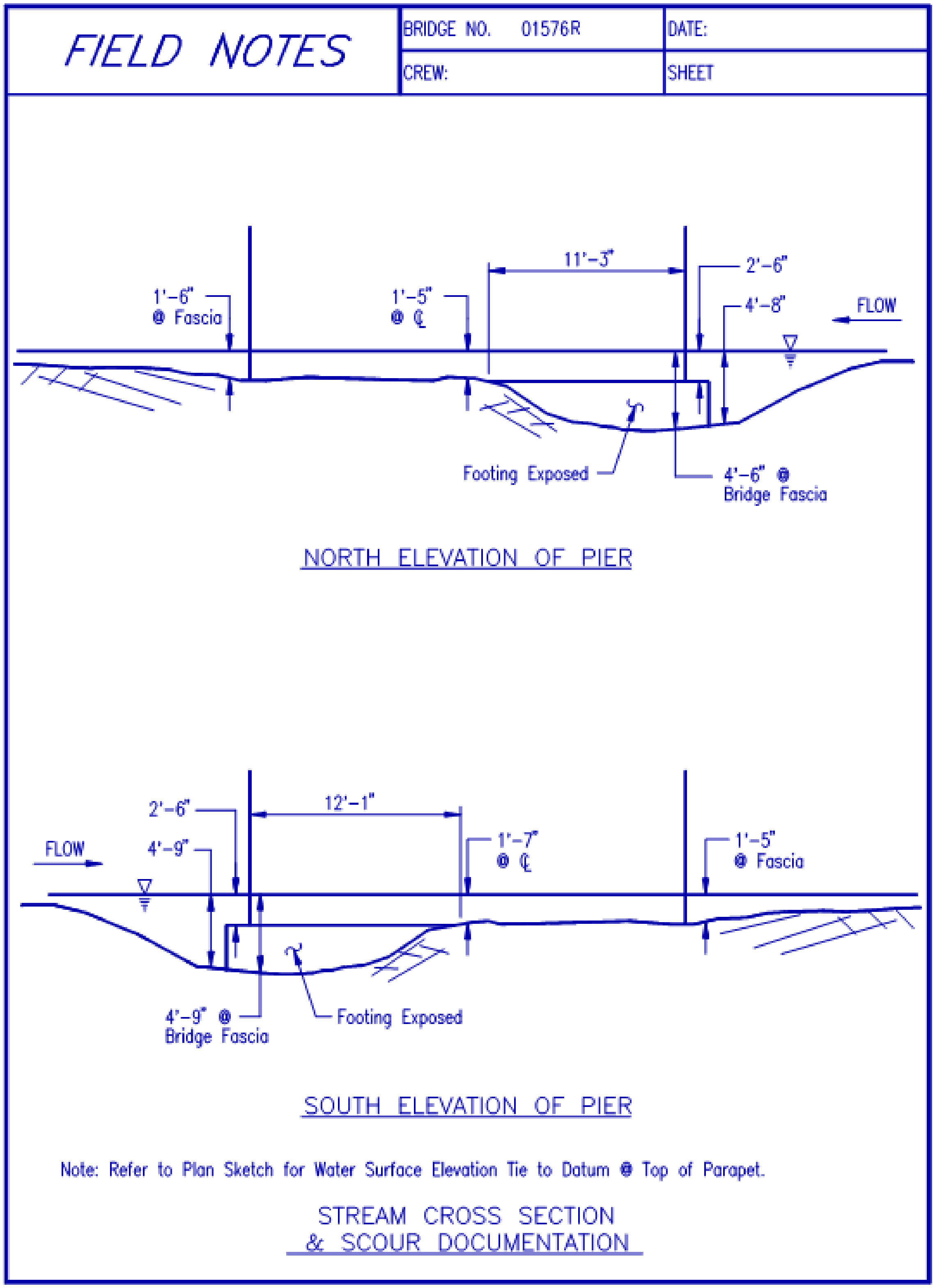


Figure A-12-2. Example documentation for scour at a substructure element.

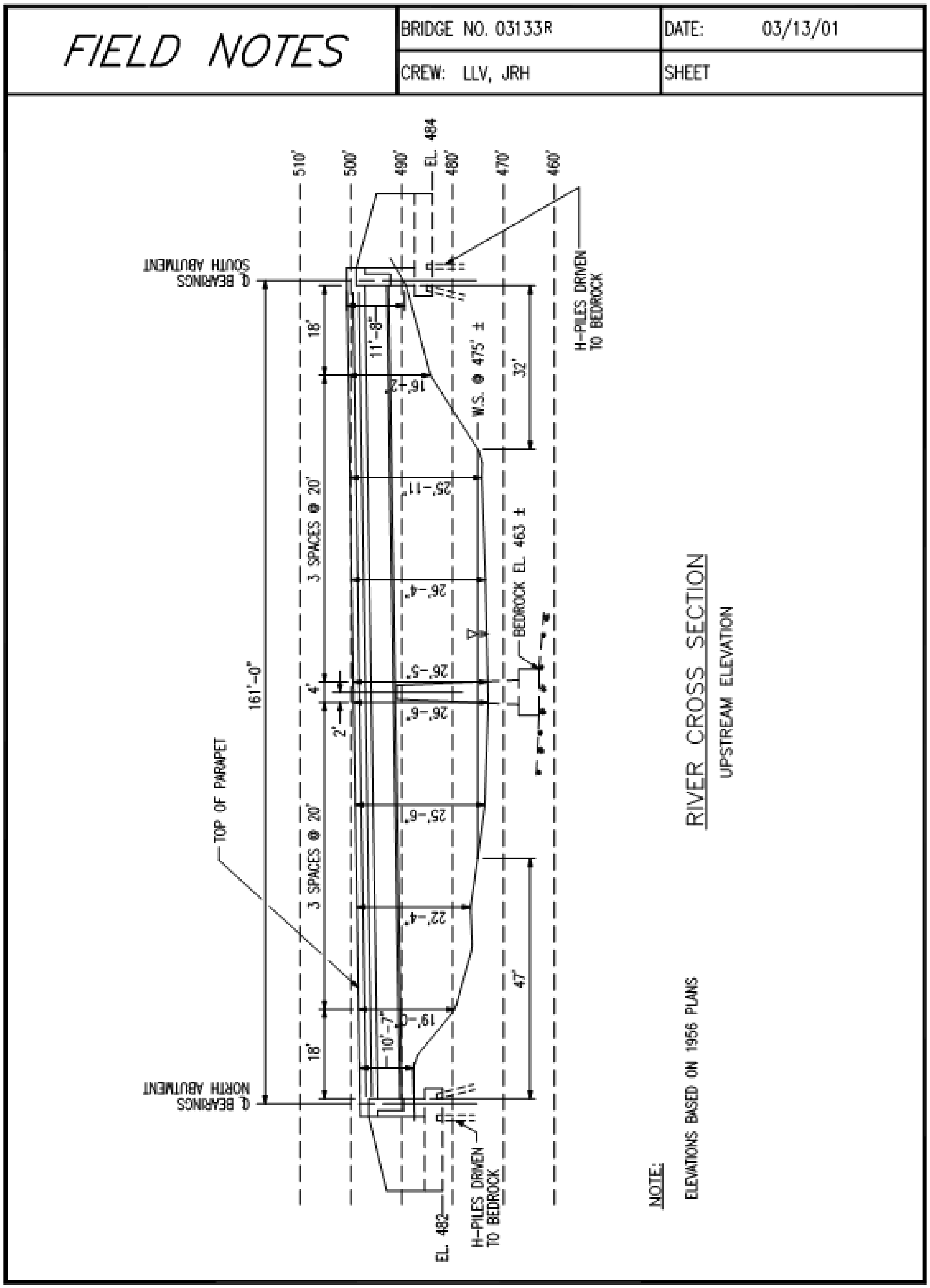


Figure A-12-3. Example River Cross Section.

Stream Cross Section Measurement

How Often?

Scour Susceptible /Critical Bridges: Every inspection and at each flood event as requested by The Supervising Engineer.

(Scour Susceptible is Item 113 = 4 or 5; Scour Critical is Item 113 = 3 or less)

All other bridges over water: At each in-depth inspection.

New bridges: A benchmark cross section at first inspection.

What is required?

Datum for all required structures: A datum line should be clearly marked on the diagram as to where it is located. A statement as to how it is being used should also be included, as necessary.

Scour Susceptible/Critical Bridges: An upstream cross section facing downstream is required for each span over the flood plain. A minimum of five shots per span is required. The shots do not need to be evenly spaced but should be located as required to accurately portray the cross section of the stream bed (i.e. a shot at each significant change in slope).

If exposed footings/undermining: Provide an elevation view along the entire face of the substructure unit where the problem is noted. Elevations should be taken as necessary to accurately portray the scour conditions. In the case of undermining, a plan view and/or cross section of the abutment/pier footing should be provided to clearly illustrate the extent of the undermining.

Box Culverts: Provide an elevation view of the cutoff walls at the inlet and outlet only showing distances from the top to the channel bottom. If the cutoff walls are not exposed, no measurements are necessary.

Please note that if a bridge is on the list for underwater inspection, the diving team will be required to provide the stream cross section information.

How to gather the data?

Datum Line: Datum line should be measured from a point where access is easiest and can easily be duplicated.

Stream Cross Sections: This information may be obtained from the bridge deck by suspending a weighted line over the parapet and reading the distance from the top of the parapet to the channel bottom at various locations. The horizontal distance from the abutment/pier face should be noted at each sounding location.

The other method may utilize a rod such as a vertical clearance pole to obtain water depths. When soundings are required at locations which are above water, the rod may be sighted using a lock level by the other inspector to obtain elevations relative to the benchmark. At each inspection the waterline should be carefully referenced to the benchmark, which can be any easily accessible fixed point on the structure (i.e. the beam underside or the top of parapet). Again, each measurement taken should be referenced horizontally to a substructure unit.

Sounding Grid Measurement

How Often ?

Scour Critical Bridges: Every inspection

Scour Susceptible Bridges: As requested by the Supervising Engineer

(Scour Susceptible is Item 113 = 4 or 5; Scour Critical is Item 113 = 3 or less)

All other bridges over water: At each in-depth inspection.

New bridges over water: A benchmark sounding grid at first inspection.

What is required?

Datum for all required structures: A datum line should be clearly marked on the diagram as to where it is located. A statement as to how it is being used should also be included, as necessary.

Scour Critical bridges: A sounding grid (plan view) is required at each inspection as outlined in the Underwater Inspection and Reports section of the RBIM (5.2.5).

For structures with a span length of less than or equal to 50 feet, soundings shall be taken on a 10 foot by 10 foot grid around and between all substructure units beginning with the vertical face of the substructure unit. The grid should extend 50 feet up stream and 50 feet downstream from the ends of the substructure units to show changes in the adjacent stream bottom. See Figure 5.2.5a. No grid is required through a box culvert unless there is debris or sediment buildup. However, a grid of the stream is required upstream and downstream of the box culvert.

For structures with span lengths greater than 50 feet, the grid shall consist of four parallel rows of soundings at 1 foot, 10 feet, 25 feet and 50 feet from the longitudinal face of the substructure units. Beyond this point, the grid intervals are 50 feet. Under the structure, the grid (starting at each end of the substructure unit) shall be 3 spaces at 10 feet then continue at 15-foot intervals. The spacing of the rows of the soundings upstream and downstream of the structure shall be at 1 foot, 10 feet, 25 feet, 50 feet, and 100 feet from the ends of the substructure units. See Figure 5.2.5b. Additional soundings should also be taken at the upstream and downstream centerline of the piers. Soundings shall be taken at each point where the grid intersects.

If, when completing the soundings, a non-linear surface profile of greater than 1 foot/10 feet (10%) is identified then additional sounding shall be taken to show the irregularity and the results shall also be shown in the drawings. Furthermore, if the top of the footing is exposed, an additional row of soundings shall be taken at the face of the footing.

Box Culverts: No grid is required through box culverts unless there is debris or sediment builds up. However, a grid should extend upstream and downstream 50 Feet from the box culvert.

Please note that if a bridge is on the list for underwater inspection, the diving team will be required to provide the sounding grid information.

How to gather the data?

Datum Line:	Datum line should be measured from a point where access is easiest and can easily be duplicated.
Sounding Grid:	When a grid is required, the inspection team should start by laying out the grid pattern on the shore. At each upstream or downstream location one inspector should remain on the shore while the other obtains the soundings at the required locations. At times there may be the need for a three-person team to obtain all the necessary measurements. The person doing the sounding should determine his location by using a 100’ tape with the help of the person on the shore. Soundings that are above the water level should be obtained using a lock level as described above. Additional points should be provided if there is a drastic elevation change located between fixed grid points. In the case where there is not a constant water surface elevation, care must be taken that all stream bottom elevations are referenced to the same datum. This may involve using a lock level to obtain some of the soundings or by measuring the waterline elevations at each different location.

Appendix 6.13: INSPECTING MOVEABLE BRIDGES

SUPERSTRUCTURE INSPECTION:

Inspect in accordance with Chapter 6, as applicable.

Inspect for stress reversal during opening and closing operations (cantilevered spans from piers for both bascule and swing types)

Girders and Beams: Look for segmental girder fatigue cracking (fillets of bottom flange angle and between rivet/bolt holes in horizontal leg of bottom flange angle). Are vertical stiffeners buckled (typically at bottom flange)? Is curved tread plate wear excessive? Are there loose bolts that hold the segments of curved tread plate together? Is there corrosion?

Are tread plates excessively worn or cracked at lugs?

Bearings: Are live load shoes in full bearing (possibly due to malfunctioning of buffer cylinder)? Is there a gap between the live load shoe and masonry plate that does or does not close under live load application? Are there signs of rotation (frozen)? Is there good alignment with the strike plates?

Floor System: Check for potential corrosion and section loss due to an open deck that allows water and deicing chemicals to fall onto superstructure. Is there debris buildup? Check for fatigue cracking.

Rivets and Bolts: Check for potential corrosion and section loss due to an open deck (see Floor System). Are the rivets and bolts that hold sections of the tread plate together loose, missing or broken? Are the rivets and bolts that hold sections of the curved segmental girder tread plates to the segmental girder loose?

Welds: On FCM's, inspect the utility connections, drain supports, electrical conduits, access ladder supports, etc., in tension zones of beams and girders (remember force reversal during opening and closing sequences) and on tension members in trusses? Inspect the tack welds, repair welds and plug welds. Check for fatigue cracking. Inspect the quality of the welds. Check for weld defects such as undercutting and porosity?

Member Alignment: Check the alignment between members in one leaf and between leaves, i.e. counterweight scrapes against the rack support when bridge opens and closes and tread plate teeth are worn unevenly. Check alignment between the moving portions of the bascule and adjacent stationary portions, i.e. leaf members rub against adjacent sidewalk during opening and closing operations.

Paint: Inspect the paint’s ability to protect the steel base metal. Is the paint peeling? Check for rust (heavy, medium, light).

Collision Damage: Are there bends in flanges or chord members, with resulting cracks, loss of connections or loss of counterweight material?

Load Deflection/Load Vibration: Is there excessive deflection or vibration, i.e. shear lock condition?

SUBSTRUCTURE:

General: Check for spalls, cracks, efflorescence, delaminations, exposed rebar, water staining, trunnion pedestals, scour.

Pier Caps: Is there deterioration under the bearings?

Swing Pier: Inspect for general deterioration under track girder.

Piles: Check for timber deterioration.

Fender System: Asses the general condition and evaluate the system's ability to protect the bridge. Check for previous impact or fire damage.

DECK:

Inspect in accordance with Section 6.1.1 through 6.1.3. Check for purlin condition.

Lighting: Is the lighting system in conformance with current ConnDOT and USCG standards and regulations? Refer to section 6.1.11 Lighting.

Safety Devices: Are crash barriers present? Inspect the traffic control signals and traffic gates. Check the guide rails that protect the superstructure elements (trusses). Are they in conformance with current CONNDOT and USCG standards and regulations? Refer to sections 6.1.5 to 6.1.9 as applicable.

MECHANICAL COMPONENTS:

General: Observe the opening and closing sequence several times from different vantage points (safety first!). Listen and look for "out of place" movements, noises, grinding or slippage. Observe any misalignment and wear caused by misalignment.

Note the condition of machinery casings and anchor bolts

Shear Locks (Bascule): Observe the action of the shear locks. Are there loose/missing bolts? Is there a gap between the shear key and shear lock saddle? Look for wear of components. Do the spans translate transversely or vertically during engagement and disengagement of locks (Could be because of misalignment)?

Lubrication: Check that a lubrication chart is maintained and adhered to by the maintenance crew. This should include specifics about what component gets how much of what kind of lubrication and at what interval.

Look for good lubrication of components. Check for contamination from shavings and abrasion particles or roadway debris. Should the lubrication be replaced? Inspect for oil leaks (ruptured seals). Is there enough lube and is the correct lubrication being used for specific components per component specification and lubrication chart? Are lubrication fittings in place?

Gears: Look for tooth wear, finning(?) and/or scouring on gears. Check for plastic deformation of teeth. Is the deformation uniform or non-uniform (on either side of the tooth or from one end to the other end of the tooth)?

Rack and Rack Pinions (similar to gears): Inspect to see if the root clearance between the teeth and rack is zero, such that vertical dead load is being transferred through the rack pinion to the rack and the rack support system. Adjustments need to be made to relieve this stress (make adjustments at the tread plate).

Buffers: Look for loose buffer screws

Buffer Cylinders: Inspect to see if the buffer cylinder rods are bent, preventing proper function of cushioning the closure forces.

Reducers: Is the oil level in the reducers at the appropriate levels? Check for leaking oil.

Bearings (trunnion, center, rim, rack pinion, live load): Check to see if the bearing bushings are protruded from the bearings. Are there keeper devices in place to prevent protrusion? Check welded connections. Are spacer devices being used? Are they supposed to be in place? Do the bushings rotate along the perimeter of the bearing in the bearing when the bridge operates? Check the corrosion level on components

Strike Plates (Swing): Check for wear from contact with live load shoes and for proper alignment with lifting devices.

Live Load Shoe Machinery: Check condition of hydraulic actuators and rods that seat live load shoes for corrosion, and proper alignment. Check for presence of interior bumpers or cushions that soften the impact during live load shoe placement.

Shafts: Note rust and corrosion on shafts.

Centering Guides and Latch Bar Machinery: Note proper function and whether clearances is within tolerance.

Rollers or balance wheels(swing): Note alignment, wear, contact with upper and lower tread plates, lubrication, attachment to radial shafts.

ELECTRICAL COMPONENTS:

General: Check for operator's manual that outlines step by step instructions for operating the bridge. Is this manual being used by the operator?

Motors: Check if motors are properly housed and protected from the elements (especially those below the deck {toe lock motors, live load shoe motors, centering device motors, etc.}).

Check the leaf span balance by checking voltage at main drive motors during opening and closing operations (difference in voltage indicates unbalanced span). Are voltage readings for this test and for tests of all electrical components within acceptable +/- tolerances? Evaluate variances.

Test the ability to begin opening and closing operations at different levels of openness. The test should require the same voltage at all stages (if not, unbalance has occurred).

Check that dead man switches are in place and functioning?

Check for presence and function of manual release levers, limit switches, functioning indicator lights at operator console (brake release, etc.).

Check that all operator switches operate as designed, and that sequential switches operate correctly.

Are proper operating sequences used (right switch/motor used to do the correct function, i.e. using the lift motor to slow down the bridge during closing operations instead of using the brakes for what ever reason)?

Note the presence and type of back up system for opening and closing the bridge. If the back up system is pneumatic or manual, note if there are step by step instructions to follow to manually close/open the bridge in case of power failure. Are all items required to open/close the span by back up systems present on site (i.e. compressor for pneumatic operations)? If emergency power is the back up, is there a back up to that?

Brakes: Inspect for proper operation, pitting or scouring of the brake drum or worn pads.

Traffic Signals and safety devices: Outline sequence used and note whether it functions properly. Are devices within guidelines of current ConnDOT code? Do switches at console indicate steps (i.e. a lamp that indicates the lights are green, yellow or red) so that the operator knows at what point the sequence is.

MISCELLANEOUS ITEMS:

Counter Weight Pit Sump Pumps: Inspect the pump's operation and function. Check the system's ability to handle the water load.

CHAPTER 7
LOAD RATINGS

Table of Contents

CHAPTER 7: LOAD RATINGS

7.0. GENERAL LOAD RATING REQUIREMENTS

The load capacity for each qualifying railroad structure shall be on file, as required by FRA 49 CFR Part § 237.71. The determination of load capacity shall be made by a Transportation Supervising Engineer, using appropriate engineering methods and standards.

Load rating calculations shall be updated whenever a field inspection reveals the condition of the bridge or a bridge component might adversely affect the ability of the bridge to carry the traffic being operated. Bridge conditions that warrant an updated rating include: a reduction in a member's load-carrying strength due to deterioration, track modifications that increase dead load, changes in track geometry, damage to members from collision and structural modifications.

A new load rating calculation for each qualifying railroad structure shall be performed as part of the in-depth inspection at a maximum interval of ten (10) years.

Load ratings are based on the "as-inspected" condition of the bridge and are performed in accordance with the *AREMA, "Manual for Railway Engineering."* The ratings are used to determine the safe load capacity of the bridge.

Normal and Maximum ratings shall be determined for the Cooper E 80 load defined by AREMA and actual equipment, when required by Office of Rail. The Normal rating level corresponds to the usual design load level, but reflects the existing bridge conditions with regard to age, deterioration and loss of section. This analysis is comparable to that used for design and, therefore, results in an allowable live load that can be carried by the existing structure for its expected service life. The rating is dependent on a specified speed, as impact reductions are allowed for reduced speeds. The Maximum rating is the load level which the structure can support at infrequent intervals, with any applicable speed restrictions. Unlimited usage of the bridge by rail vehicles at the Maximum level will shorten the useful life of the structure.

Generally, the rating factor for a structure is obtained by subtracting the dead load effect on the member from the overall capacity of the member and dividing the results by the effect of the live load and impact induced by rail equipment with known weight and configuration. Allowable stress levels for the Normal and Maximum ratings shall be in accordance with AREMA guidelines. The capacity of a member, in relationship to the Cooper E series live load configuration, can be obtained by multiplying the rating factor by the 80 kip maximum axle load associated with the Cooper E 80 load used in determining the live load effect. The resulting ratings are considered to represent the "equivalent Cooper" rating for the member under consideration.

Railroad structures supporting multiple tracks require load ratings to be determined for each track, considering the effect of concurrent track loading in accordance with AREMA guidelines.

7.1. APPROACH FOR LOAD RATING ANALYSES

1. Review Bridge Inspection File.

   The bridge inspection files contain recent and older field inspection reports, photos, maintenance memorandums and other relevant information for load rating an existing structure. For existing bridges, the load carrying capacity should be based on a recent field inspection. The extent of deterioration and damage will determine if the structural member should be considered for analysis. The review should include items that may not be shown on the as-built plans. The presence of utilities, walkways, sign supports and other relevant appurtenances must be considered in the computation of member capacity. Documentation regarding maintenance repairs, section loss, added utilities or other relevant information that may affect the load ratings should be included in the analysis package.

2. Gather Information During Field Inspection.

   If a bridge analysis and a bridge inspection are scheduled to be performed concurrently, the engineer who will perform the analysis should thoroughly review the file to ensure that all required information is present. The inspectors should then gather any data required to complete the analysis, such as section properties, depth of ballast, track eccentricity or other necessary information.

3. Review Bridge Plans {As-Built (if available) and Rehabilitation Plans}.

   A copy of all relevant details from the as-built and rehabilitation plans, including the general plan, framing plan, deck plan, cross sections and other relevant details, should be submitted with the evaluation. If bridge plans are not available and the bridge's components are unknown, follow the instructions under "Bridges with Unknown Component Details" in this chapter.

4. Review AREMA and Other Relevant Specifications.

   All equations and specifications used in the analysis should have a reference number from AREMA or other applicable codes clearly stated in the analysis. Any textbook material used as a reference for an analysis procedure must include: the textbook name, author, year, chapter name and page numbers.

5. Analysis Methodology

   Clearly state all analysis methodology concerning dead and live loading conditions, construction procedures, specifications and other relevant information used for load ratings.

6. Perform Analysis.

   An accurate load rating analysis is required by the Office of Rail. Select a software package that will best represent the loading, construction conditions and other relevant factors used to obtain the load ratings. Structural analysis computer software must be pre-approved by the Office of Rail. Any bridge that cannot be analyzed by one of the pre-approved software packages may be analyzed by other suitable methods, as approved.

   The determination of load capacity shall be made by a Transportation Supervising Engineer.

7. Review Load Ratings.

   The Office of Rail requires that a Transportation Supervising Engineer, other than the engineer who performs the analysis, check the load rating. Any low load rating, which may require a restriction, should be reported immediately to the Office of Rail.

8. Assemble the Analysis.

   The analysis should be arranged in a neat and orderly fashion as described in the "Format for Submission" section.

7.2. FORMAT FOR SUBMISSION

Each load rating package should contain the following, as applicable:

1. A cover sheet should be completed for every evaluation. The cover sheet must indicate the bridge number, railroad line and milepost, feature crossed, town, date, name of preparer, structure type, and controlling rating.
2. A table of contents.
3. A framing plan and cross section of the member.
4. A Rating Summary that includes the controlling Normal and Maximum ratings by track number and span for both the as-built and as-inspected conditions. All ratings shall indicate whether the controlling rating is due to shear, flexure, tension or compression.
5. A listing of all assumptions or parameters pertinent to the load rating calculation.
6. Rating calculations by span.
7. A copy of plans and sketches providing details relevant to the analysis.

General.

a. When analyzing for steel section loss or concrete deterioration, include sketches from the bridge inspection report. All relevant details from the pages of the bridge inspection report should be included.

b. MathCad or other software may be used in calculating dead loads, live load distribution factors (bending or shear), and for any other required calculations. If hand written calculations, drawings and statements are submitted, they must be neat and legible. Also, all calculations and drawings should clearly indicate the applicable units of measurement involved {inches, feet, kips, etc.}.

c. The Microsoft Excel program may be used for spreadsheet type analyses. Steel section properties, steel truss member analyses and other cases are examples where a spreadsheet could be helpful to perform the analysis. Any calculations performed using a computer spreadsheet must include an example to demonstrate how the procedure works. This is not necessary for steel section properties.

7.3. SELECTION OF MEMBERS FOR EVALUATION

For multiple span structures, a good representation of the spans must be selected for analysis. Also, a good representation of the bridge components for each span should be selected. To determine the selection of the bridge components for each span, the factors that should be considered include girder size, spacing, span length, dead load and positioning of live loads. Performing an analysis on one bridge component in a multiple member varying span structure will not be sufficient, even if the bridge component selected controls the load ratings.

The following is a list of the bridge components to be analyzed:

- Superstructure:
  - Girders and Stringers {Fascia and Interior} {Steel, Concrete and Timber}
  - Concrete encased steel girders and stringers {Fascia and Interior}
  - Concrete encased steel rail section
  - Steel Floor Beams {End and Interior}
  - Steel Truss {Tension and Compression Members, Floor Beam Hangers}
  - Prestressed Concrete Adjacent Box Beams and Deck Units {Interior}
  - Reinforced Concrete Slabs
  - Reinforced Concrete Tee-Beams
  - Concrete Rigid Frames and Arches {Deck, Knees and Legs}

  No analysis is required for bearing devices, connections and pin & hangers unless directed by the Office of Rail.

  The need for analysis of gusset plates for trusses shall be determined by the Office of Rail on an individual basis.

- Substructure:
  - Pier Caps {Steel and Timber}
  - Columns {Steel and Timber}
  - Bents {Steel and Timber}

  No analysis is required for concrete abutment stems, piers, footings and piles unless directed by the Office of Rail.

- As determined by the Office of Rail on an individual basis the rating can be performed for the Culverts:
  - Concrete Box Culverts {Roof, Walls and Floor}
  - Slab {Roof }
  - Concrete {Roof and Walls}
  - Masonry {Roof and Walls}

7.4. MISCELLANEOUS RATING PROCEDURES & REQUIREMENTS

- No fatigue analyses are required unless directed by the Office of Rail.

- Timber structures should be analyzed for bending moment and horizontal shear. The timber components to be analyzed should include stringers and floor beams of glue-laminated, nail laminated or sawn timber. Any timber deck "overhang" must be analyzed for bending moment and horizontal shear, if a wheel load can be placed on it. The allowable unit stress in bending and shear shall be the tabulated stress, modified by the applicable adjustment factors: wet service factor, load factor, size factor and other relevant factors, as applicable.

- For multiple longitudinal girder structures with wide sidewalks or station platforms, no analysis is required for girders directly under the sidewalk or platform, including fascia and interior girders. Girders should only be analyzed if they carry rail traffic directly over them, or if a wheel load may be placed between adjacent girders. An exception to this rule would be girders with section loss or collision damage.

From time to time, the Office of Rail will send out load rating procedural memorandums to provide additional guidance or directions for obtaining uniform results.

7.5. USING DESIGN CALCULATIONS FOR LOAD RATINGS

If there are design calculations in the bridge file, or they are readily available from a convenient source {Office of Rail, Bridge Design Section, etc.}, they may be used as a supplement for the evaluation. Any or all of the useful information from the design calculations can be used in the evaluation, provided a thorough review is made to ensure that the calculations match the existing structure. The design information used in the analysis must be attached to the evaluation. Load ratings performed with design calculations should be arranged as described in the format section.

7.6. COMPUTER SOFTWARE

All structural analysis computer software must have prior approval by the Office of Rail. Bridges that cannot be analyzed with these programs may be analyzed by other suitable methods. The following list has been approved by the Office of Rail (current versions of each program should be used):

- PENNDOT BAR7, PS3 and BOX5
- STAAD
- MathCad
- Excel {Spread Sheets}
- C-Bridge {Curved Steel I-Beams and Box Girders}

Any "in-house" program used by a consultant engineering firm must have prior approval by the Office of Rail.

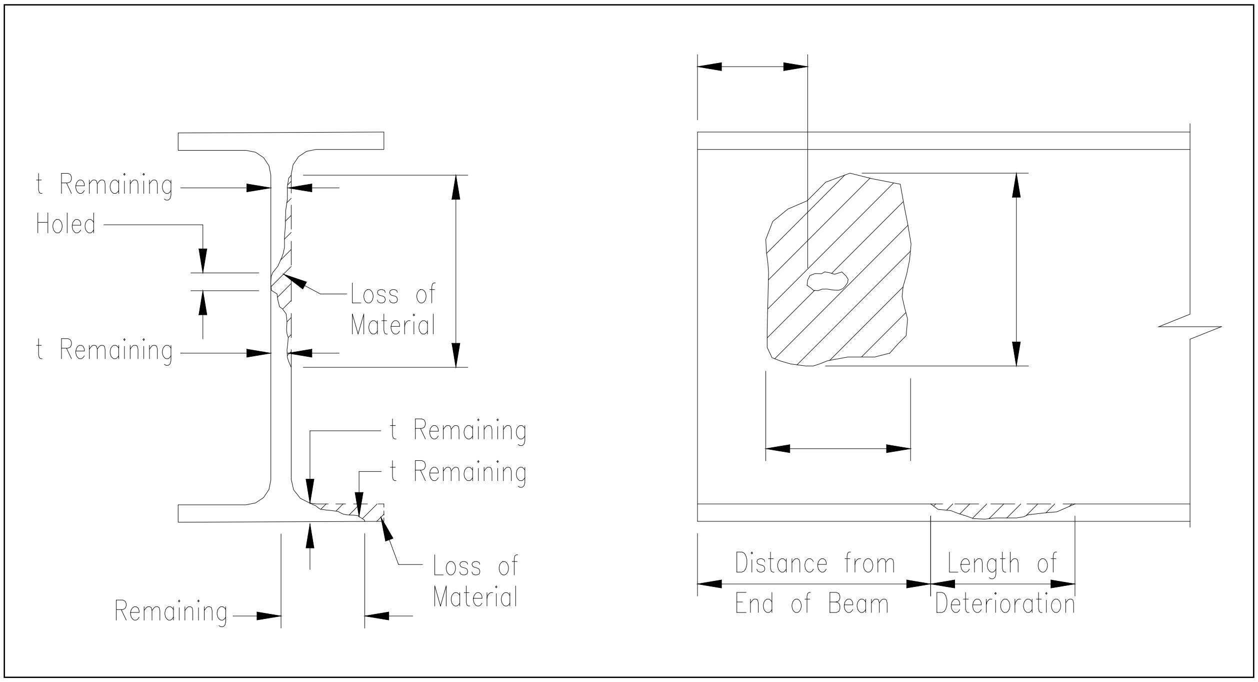
7.7. SPECIFICATIONS

All load ratings shall be performed in accordance with the provisions of the AREMA, "Manual for Railway Engineering." The following specifications, as revised, may also be referenced as necessary:

- Manual for Condition Evaluation of Bridges, AASHTO.
- Standard Specifications for Highway Bridges, AASHTO.
- Guide Specifications for Distribution of Loads for Highway Bridges, AASHTO.
- Guide Specifications for Alternate Load Factor Design Procedures for Steel Beam Bridges Using Braced Compact Sections, AASHTO.
- Guide Specifications for Horizontally Curved Highway Bridges, AASHTO.
- Guide Specifications for Design and Construction of Segmental Concrete Bridges, AASTHO.
- Guide Specifications for Strength Design of Truss Bridges, AASHTO.
- Guide Specifications for Moveable Highway Bridges, AASHTO.
- Manual for Steel Construction {ASD, LRFD}, AISC.
- National Design Specification for Wood Construction, NDS.
- Timber Construction Manual, AITC.
- PCI Bridge Design Manual.
- Timber Bridges “Design, Construction, Inspection and Maintenance”, USDA.
- Reinforced Concrete Design, ACI.

7.8. DOCUMENTATION OF LOSSES

The amount of material remaining and the location and extent of losses on steel members must be recorded for use in the analysis.



Additionally, the size, number and relative location of bolts or rivets that affect the "net area" in tension members should be accounted for in the analyses. For compression members, misalignments, bends and kinks that may result in eccentric loading or possible buckling should be carefully located and measured, since these defects may have a great effect on the load carrying capacity of the member.

7.9. RE-EVALUATION

If during the course of an inspection it is determined in the field that considerable deterioration is present, the inspector should notify the Transportation Supervising Engineer of the conditions found. The Transportation Supervising Engineer shall determine if the deterioration will affect the current load rating of the structure. If the deterioration does affect the current load rating of the structure the Transportation Supervising Engineer will then inform the Transportation Principal Engineer. The Transportation Principal Engineer will determine the need for a re-evaluation and deliver the request to the appropriate office personnel.

Inspectors can reference the guidelines presented in Section 6.2.3 for assistance in determining the severity of deterioration and the possible need for a re-evaluation.

7.10. BRIDGES WITH UNKNOWN COMPONENT DETAILS

For load path redundant bridges, where the details of the structure are hidden from view and no structural plans are available, an inspection by a Railroad Bridge Inspector and an evaluation by a Transportation Supervising Engineer may be adequate to determine the safe load capacity for the Normal and Maximum operating levels. This determination shall be discussed with the appropriate Transportation Supervising Engineer from the Office of Rail and the final rating determination made by the Transportation Principal Engineer.

It should be the practice of the inspection team to determine the dimensions and details of the necessary components, if possible (i.e.: reinforcement steel size and spacing can be determined by measurement in spalled areas; depths of steel beams may be determined by measuring up from the bottom of encasement and down from the top of deck, etc.). If these dimensions and properties are not measurable, sufficient sketches and photographs should be taken to adequately document the conditions for the purpose of providing an evaluation of load capacity.

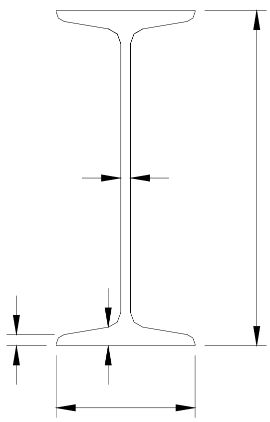
In some instances it will be possible to gain further insight into the makeup of the structural elements of the bridge by using non-destructive testing methods. A "D" Meter will show the thickness of steel sections when one surface is exposed. Pachometers can be utilized to determine spacing of reinforcement steel, as well as, some indication of concrete cover, if the bar size is known or bar size, if the cover is known. Prior to requesting any specialized NDT procedure, the Transportation Supervising Engineer from the Office of Rail shall be notified and the process discussed.

7.11. FIELD INVESTIGATION FORMS FOR LOAD RATING EVALUATIONS

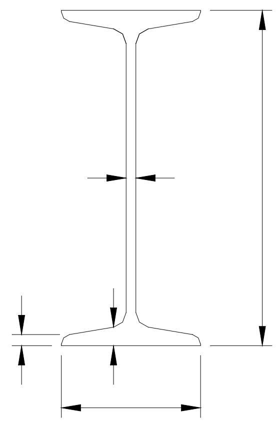
The field forms on the following pages may be used to document structure dimensions for use in performing load rating evaluations and to document deterioration of steel members.

FIELD NOTES	BRIDGE NO.	DATE:
	CREW:	SHEET

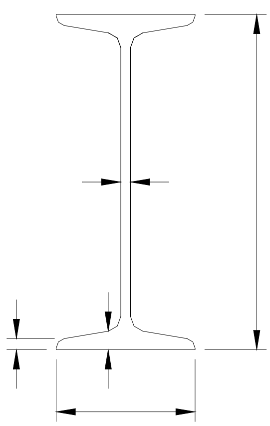
S-SHAPE BEAM



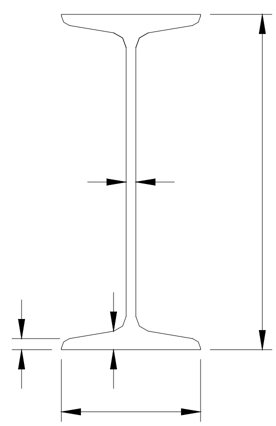
Beam No. ______



Beam No. ______



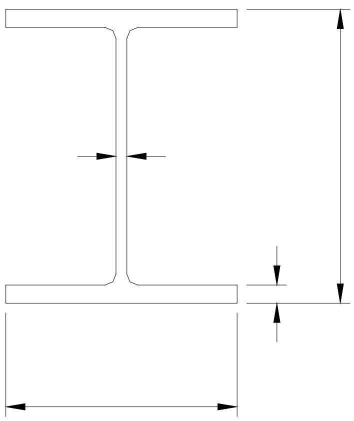
Beam No. ______



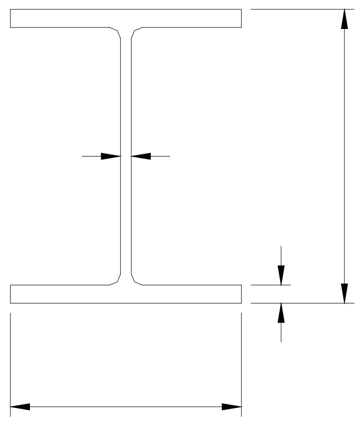
Beam No. ______

FIELD NOTES	BRIDGE NO.	DATE:
	CREW:	SHEET

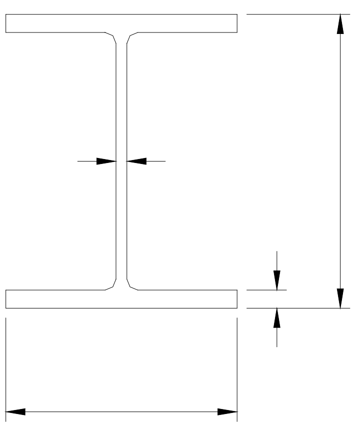
W–SHAPE BEAM



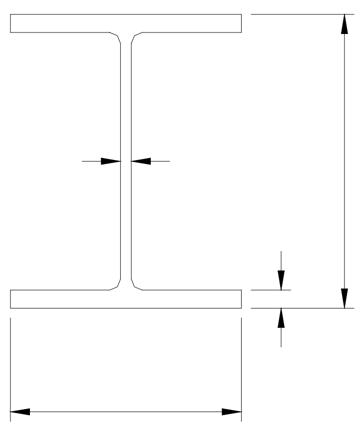
Beam No. ______



Beam No. ______



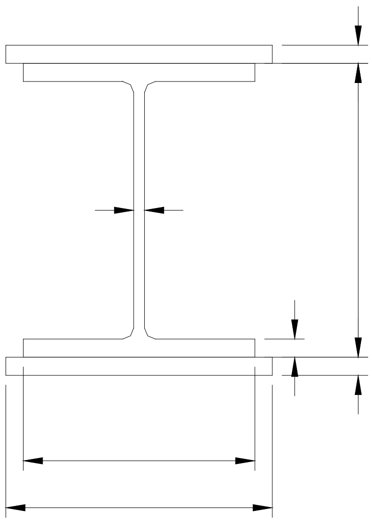
Beam No. ______



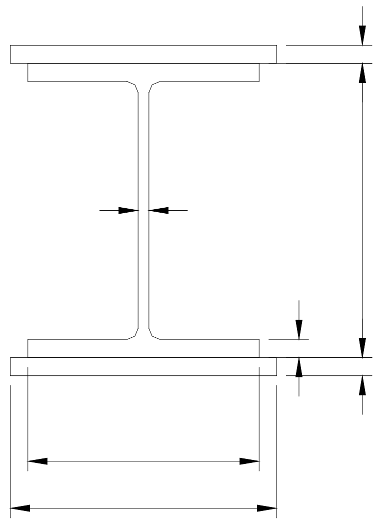
Beam No. ______

FIELD NOTES	BRIDGE NO.	DATE:
	CREW:	SHEET

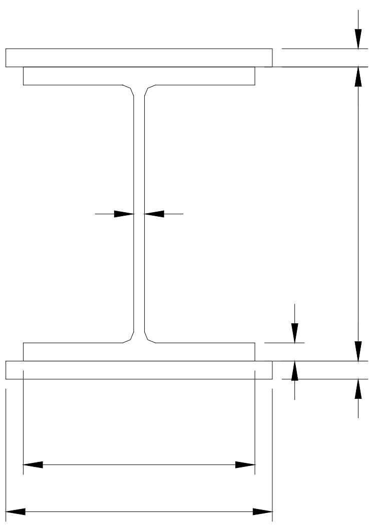
W–SHAPE BEAM WITH COVER PLATE



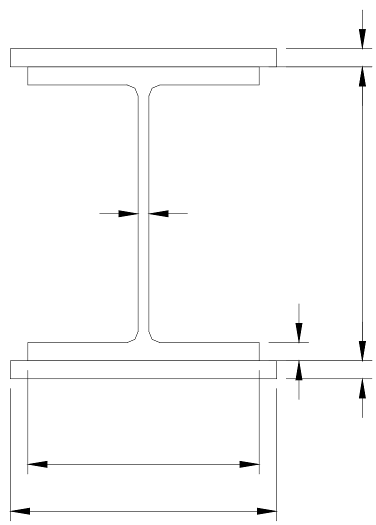
Beam No. ______



Beam No. ______



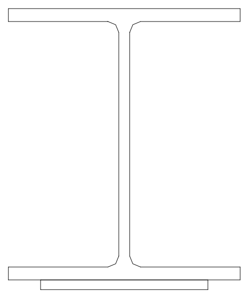
Beam No. ______



Beam No. ______

FIELD NOTES	BRIDGE NO.	DATE:
	CREW:	SHEET

SECTION LOSS NOTES



W–Shape Beam
With Cover Plate

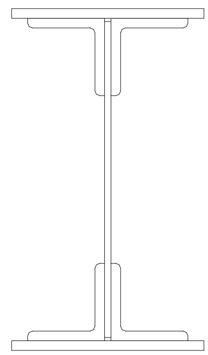
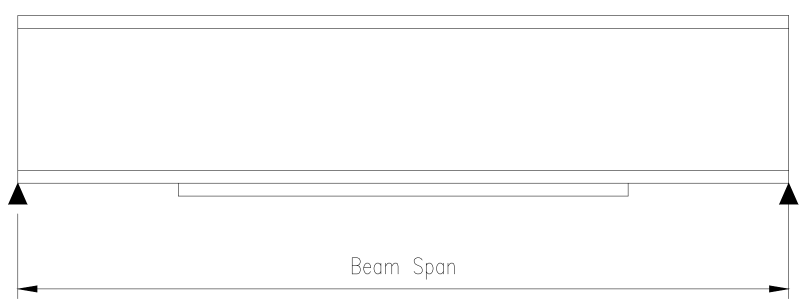


Plate Girder

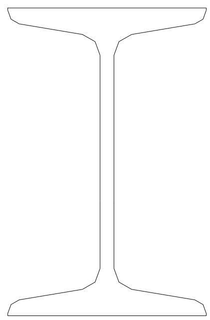


Elevation View

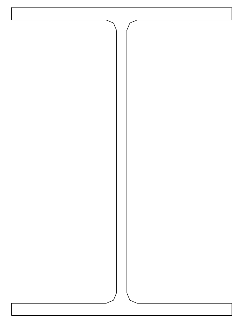
Beam No. ______ Span No. ______

FIELD NOTES	BRIDGE NO.	DATE:
	CREW:	SHEET

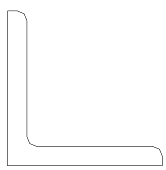
SECTION LOSS NOTES



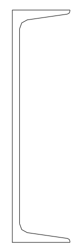
S–Shape Beam



W–Shape Beam



Angle



Channel

Elevation View

Beam No. ______ Span No. ______

7.12. OPERATING RESTRICTIONS

The Office of Rail has developed Equivalent Cooper load charts for railroad equipment running on Connecticut's rail lines. These charts are to be used to determine if a particular Railroad bridge's calculated Normal Load Rating is adequate to support the demand of the equipment regularly loading the bridge. When Railroad bridges that have been determined to have Normal Load Ratings lower than the demand placed on such structure by the equipment regularly loading the bridge, The Office of Rail shall determine whether restrictions on the operations of equipment over the structure are required.

CHAPTER 8
MAINTENANCE ACTIVITIES

Table of Contents

CHAPTER 8: MAINTENANCE ACTIVITIES

8.0. TYPICAL MAINTENANCE ACTIVITIES

One of the most important objectives of the bridge safety inspection program is to identify deficiencies and areas of deterioration for maintenance repairs in order to extend the useful life of the structure.

There are two types of deficiencies that should be noted; critical and noncritical.

Critical deficiencies are those that, if left unattended, will create a hazard to the traveling public or severely limit the use of the structure. Examples of critical deficiencies are:

- Cracked steel members
- Holes in decks
- Bearing pads not supporting bridge bearings
- Severely damaged or missing ballast retainers
- Minor distortion/bowing/buckling of steel members
- Obvious scour or undermining of substructure elements
- Deteriorated rivets
- Loose concrete above travel lanes
- Damaged and deteriorated sidewalk shields
- Deteriorated timber planks on stairs and walkways
- Broken and missing Navigational lighting
- Built up debris

If critical deficiency items are discovered during the inspection process, they should be immediately reported in accordance with Section 3.2.7 - Critical Deficiency Reporting.

A written Railroad Maintenance Memorandum (RMM) shall be prepared, with priority code A or B (see section 8.1), as a follow up to the phone notifications.

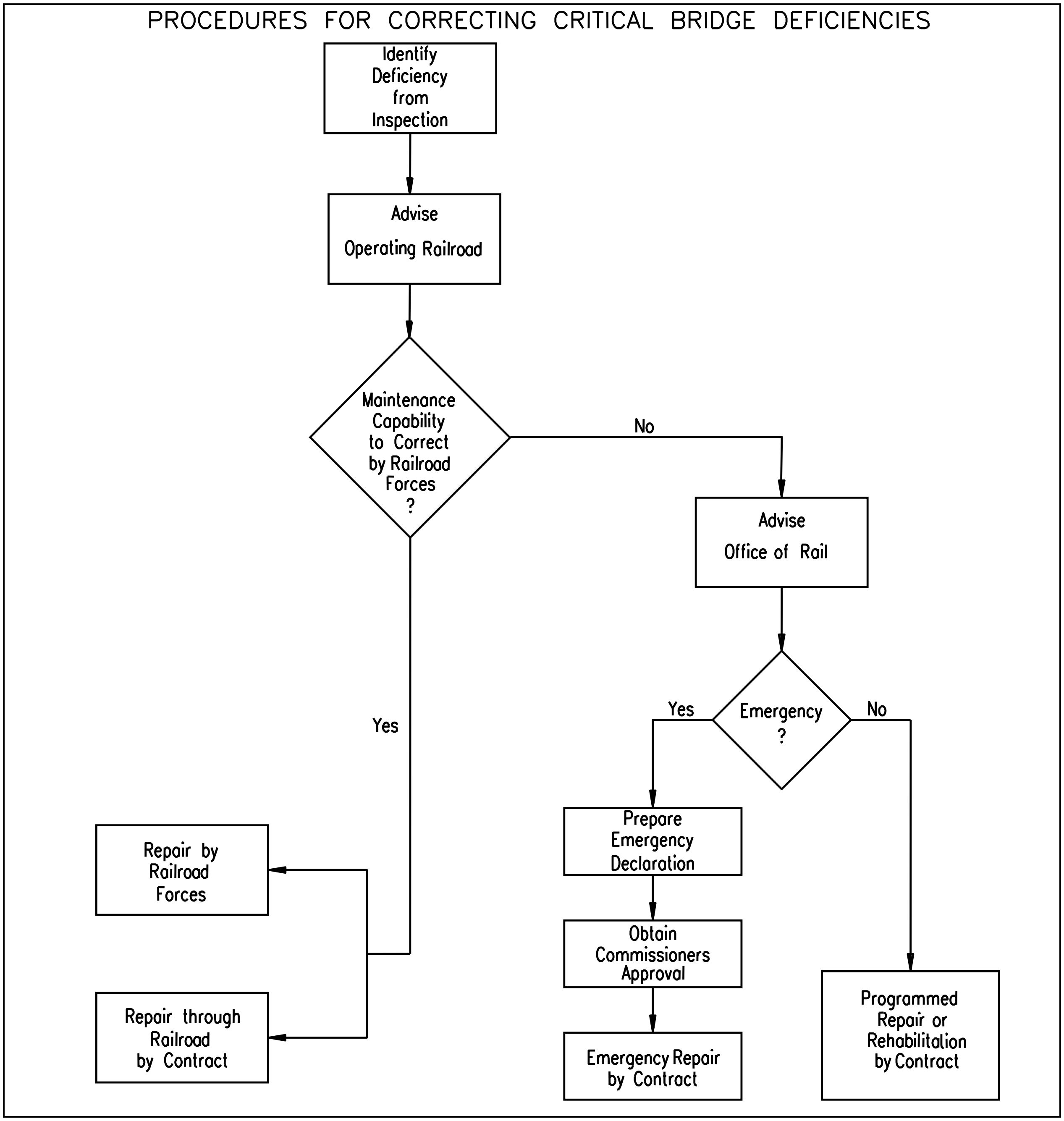
Noncritical deficiencies are those that, if left unattended, will lead to further deterioration of the bridge. These deficiencies are to be submitted in a Railroad Maintenance Memorandum, with priority code (see section 8.1), that outlines the problem areas and gives the scope of the required remediation. These repairs will be performed by the Operating Railroad's maintenance forces, or programed for inclusion of the bridge in a bridge rehabilitation/replacement project through the Office of Rail.

It is imperative that the correspondence sent to the Office of Rail fully identifies the size and location of the required repairs and that the priority of each repair is indicated.

The attached flow chart indicates the procedures for correcting deficiencies found during the inspection.

A system to monitor the completion of the repairs shall be in place. The Office of Rail notifies the Operating Railroad of the repair items performed, as well as, informing them of those items that they did not perform. The site will be re-visited, in an inspection, to verify the repairs and provide an initialed and dated copy of the Railroad Maintenance Memorandum to be filed with the latest inspection report.

It is not the intention of Office of Rail to enumerate basic and routine maintenance items in Railroad Maintenance Memorandums. These items may be included in the inspection report, but will not be identified for repair, if they do not have a significant effect on the bridge structure or public safety.



8.1. PRIORITY CODES FOR RAILROAD MAINTENANCE MEMORANDUMS

The following priority codes and respective response times will be used when specifying required repairs in Railroad Maintenance Memorandums (RMM). The examples listed are for illustration purposes only and should not be considered a complete listing. The criticality of any defect should be reviewed on a case-by-case basis and may require that the repairs be performed in a more timely fashion or allow them to be programmed as routine maintenance.

Priority A: Critical - IMMEDIATE response by Railroad Maintenance forces.

Examples of Priority A deficiencies:

- Cracks in main steel members
- Substantial section loss on steel members requiring immediate strengthening
- Major distortion/bowing/buckling of primary steel members
- Loose concrete above travel ways
- Significant undermining of substructure elements

Priority B: Urgent, but not critical - Response within 1 WEEK.

Examples of Priority B deficiencies:

- Substantial section loss on steel members requiring urgent strengthening
- Navigation lights not functioning

Priority C: Important, but not urgent - Response within 2 MONTHS.

Examples of Priority C deficiencies:

- Missing structural fasteners. Provide location quantity and size (i.e. diameter, length and grade).
- Exposed strands on prestressed concrete members
- Weep pipes draining onto structural members
- Debris in a waterway that affects hydraulic capacity

Priority D: Of lesser importance, but needing attention - Response within 6 MONTHS.

Examples of Priority D deficiencies:

- Defective bridge expansion bearings
- Dents/gouges in beams

Priority E: Routine repairs - scheduled by Maintenance to coincide with other commitments of the same type or within the same general area. - Response within 2 YEARS.

Examples of Priority E deficiencies:

- Leakage between adjacent deck units
- Minor debris in waterways
- Exposed concrete reinforcing steel on superstructure (slabs and tee-beams) members

8.2. NON-RAILROAD MAINTENANCE MEMORANDUMS ITEMS

Phone Call Items: These items require a phone call to the Office of Rail. A RMM is not required nor is a Priority attached.

Examples of Phone Call Items:

- Missing vertical clearance sign on the street or road
- Cutting back vegetation that impedes vertical clearance sign

Preventive Maintenance: Items considered preventive maintenance do not require a RMM.

Examples of Preventive Maintenance:

- Cutting back brush and vegetation around substructure

CHAPTER 9
CONDITION RATING GUIDELINES

Table of Contents

CHAPTER 9: CONDITION RATING GUIDELINES

CHAPTER 9: CONDITION RATING GUIDELINES

9.1. SUPERSTRUCTURE ITEMS

9.1.1. BEARINGS

The following have been developed as the condition rating guidelines for bearings. In order to determine the most appropriate condition rating for the bearings, the evaluator should be knowledgeable of both the physical condition of the bearing components, (cracks, section loss, impacted rust, etc.), as well as, the functional condition of the bearing. When considering functional condition, the evaluator shall look at expansion, contraction and rotation and evaluate both the degree to which these are occurring and whether the observed position of expansion, contraction and rotation is within the range expected for the ambient temperature. The evaluator shall also observe whether noted deficiencies and deteriorations occur at multiple bearings at one particular substructure element (i.e. all bearings at an abutment or pier).

Under certain circumstances, the evaluator may consider the condition of the substructure when assigning the condition rating to the bearing. If deterioration of the substructure elements is severe, specifically in the area of the bearings (such as severe undermining of the bearing plate), engineering judgment shall be used to determine the degree to which the functional capacity of the bearing is affected and the condition rating adjusted accordingly. In a similar manner, the condition of the bearings could influence the condition rating assigned to the superstructure. If the condition of the bearings is such that the superstructure is being adversely affected by imposed forces resulting from the failure of the bearings to perform their design function, the condition rating for the superstructure should be affected.

These rating guidelines shall apply to all types of fixed and expansion bearings. The rating condition should be assigned based on the condition of the worst line of bearings on the bridge.

Definitions:

Deficiency - Lack or shortage of a structural component (i.e. fasteners, under sizing, etc.) from the quantity specified in design.

Deterioration - Areas exhibiting corrosion, shavings, pitting, impacted rust, section loss, cracks, dings, gouges, impact damage, fire damage, loose fasteners or any other defect that affects the ability of the structural component to function in its design capacity.

Code	Description
9	Excellent Condition - No maintenance or rehabilitation concerns.
	• No noticeable deficiencies or deterioration.
8	Very Good Condition - No maintenance or rehabilitation concerns.
	• No noteworthy deficiencies or deterioration, minor surface rust may be present.

7 Good Condition - Potential exists for minor maintenance.

- Light to medium rust on less than 25% of the steel surface area. No section loss observed.
- Minor surface cracking observed in elastomeric pads.
- Minor accumulation of debris on and/or around bearings.
- Bearing is centered on both the masonry and sole plates with no signs of unexpected lateral movements, shifting or extrusion of bearing elements.
- Expansion, contraction and rotation are within the limits expected for the ambient temperature.
- Impacted rust between bearing elements is showing signs of impeding the normal expansion, contraction and rotation of the bearing (span length < 100’).
- Light to medium rust observed on bearing anchor bolts. Anchor bolts are firmly embedded in the substructure elements.
- Anchor bolt nuts are in place.

6 Satisfactory Condition - Potential exists for major maintenance.

- Light to medium rust on greater than 25% of the steel surface area.
- Severe rust on less than 25% of the steel surface area. Minor section loss (<5%) noted on bearing elements.
- Moderate cracking observed in elastomeric pads or minor shaving accumulation from pot bearings.
- Moderate accumulation of debris on and/or around bearings. Debris accumulation has the potential to interfere with normal expansion, contraction or rotation of the bearing or provides wet conditions that may accelerate deterioration of the bearing elements.
- Minor unexpected transverse movement, shifting or extrusion of bearing elements noted. There may be up to 5% loss of bearing area.
- Impacted rust is showing signs of forming and impeding the normal expansion, contraction and rotation of the bearing (span length > 100’).
- Moderate impacted rust between bearing elements with partial range of bearing expansion, contraction and/or rotation impeded (span length < 100’).
- Bearings exhibit minor over/under expansion, contraction or rotation for the ambient temperature.
- Anchor bolts are firmly embedded in the substructure, but have some minor deterioration noted. Nuts are in place.

5 Fair Condition - Potential exists for minor repair or rehabilitation

- Severe rust on greater than 25% of the steel surface area. Moderate section loss (5% to 10%) noted on a recurrent basis throughout the bearing elements.
- Severe cracking or exposed shim plates noted on elastomeric pads.
- Moderate accumulation of elastomer or PTFE shavings from pot bearings.
- Moderate to heavy accumulation of debris on and/or around bearing elements that is interfering with the normal expansion, contraction or rotation of the bearing. Wet conditions attributed to debris buildup are accelerating deterioration of the bearing elements.
- Moderate unexpected transverse movement, shifting or extrusion of bearing elements noted. Between 6% and 10% loss of bearing area.
- Moderate impacted rust between bearing elements with partial range of bearing expansion/contraction and/or rotation impeded (span length > 100').
- Bearing elements appear frozen with no evidence of normal movement or rotation observed (span length < 100') and no damage to the substructure noted.
- Bearings exhibit moderate over/under expansion, contraction, or rotation for the ambient temperature.
- Up to 15% of all anchor bolts are bent, sheared, loose, or are severely deteriorated. Minor loss in ability to supply anchorage to the bearing elements.

4 Poor Condition - Potential exists for major repair or rehabilitation.

- Severe rust with advanced section loss (10% to 20%) on bearing elements.
- Elastomeric pads are heavily deteriorated with section loss on exposed shim plates.
- PTFE sliding surface is loose or peeling.
- Heavy accumulation of debris on and/or around bearing is severely impeding the normal expansion, contraction or rotation of the bearings and causing heavy deterioration of the bearing elements.
- Severe transverse movement, shifting or extrusion of bearing elements noted between the masonry plate and sole plates (i.e. 25% of the sliding plate is extruded or one roller in a roller nest is off the masonry plate). Between 11% and 25% loss of bearing area.
- Severe impacted rust between expansion elements prevents the bearing from expanding or contracting.
- No evidence of normal movement and/or rotation of bearing elements discernable.
- Bearings are in a state of advanced over expansion or contraction for the ambient temperature.
- 15% to 25% of all anchor bolts are bent, sheared, loose, or are severely deteriorated. Moderate loss in ability to supply anchorage to the bearing.

3 Serious Condition - Repair or rehabilitation required.

- Heavy rust with severe section loss (>20%) on bearing elements. No evidence of normal movement or rotation noted. Localized failure of bearing elements possible.
- 25% to 33% of all anchor bolts are bent, sheared, loose, have loose nuts or are severely deteriorated at any one pier or abutment. Severe reduction in ability to supply anchorage to the bearings as designed.
- 50% of the anchor bolts at any one line of bearings, are bent, sheared, loose, or are severely deteriorated so as to prevent their ability to supply anchorage to the bearing as designed.
- Bearing elements are severely misaligned and/or extruded (i.e. more than one roller in a roller nest type bearing is off the masonry plate) with 26% to 50% of loss of bearing area.
- Bearing elements are severely over expanded or contracted for the ambient temperature and are in danger of rotating or sliding off the masonry plate.
- Minor effects of increased stress noted in other superstructure elements due to lack of expansion and/or contraction.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Heavy rust with severe section loss. Complete failure of one or more bearing elements. No normal expansion, contracting, or rotation of bearing elements noted.
- Greater than 33% of all anchor bolts are bent, sheared, loose, have loose nuts or are severely deteriorated at any one pier or abutment, so as to prevent their ability to supply anchorage to the bearings, as designed.
- Greater than 50% of the anchor bolts at any one bearing location, are bent, sheared, loose, have loose nuts or are severely deteriorated so as to prevent their ability to supply anchorage to the bearing as designed.
- Bearing elements are severely misaligned or extruded with greater than 50% loss of bearing area.
- Increased stress in other superstructure elements due to the lack of expansion, contraction, rotation or failure of bearings is readily apparent.

1 "Imminent" Failure Condition - Bearings are non-functional and/or failed.

- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Bearings are non-functional and/or failed.

- Bearings are beyond repair or rehabilitation.

9.1.2. REINFORCED CONCRETE DECKS

The following guidelines have been developed for the condition rating of Reinforced Concrete Decks. They are intended to supplement the FHWA Recording and Coding Guide to make it easier to determine the most appropriate condition rating to be assigned to the reinforced concrete deck (See Item 58 of the FHWA Recording and Coding Guide) used for data entry into forms BRI-18 and BRI-39.

These rating guidelines shall apply to cast in place concrete decks, as well as, precast concrete deck panels. The condition of the overlay, railings, joints, etc., shall not influence the overall rating of the reinforced concrete deck.

Definitions:

Deficiency - Lack or shortage of a structural component from the quantity specified in design, (i.e. missing concrete components such as haunches or reinforcing bar spacing or size other than that specified by design, etc.). Construction defects such as honeycombing.

Deterioration - Areas exhibiting cracks (Reference Appendix A6.4), spalls, impact damage, map cracking, efflorescence, exposed reinforcing bars (with or without corrosion), delaminations, scaling, abrasion or any other defect, on the underside of the deck, which affects the ability of the reinforced concrete deck to function in its design capacity.

% Deterioration - Coincident areas are counted only once and superficial defects, such as light scale, hairline shrinkage or temperature cracks (parallel to slab reinforcement), tight map cracked areas without efflorescence or dry areas of efflorescence that do not appear to have active leakage, shall generally not be included in this calculation. Repaired areas, as defined below, should not be included unless they are of a temporary nature (bituminous concrete patches) or are themselves deteriorated (hollow patches).

Contamination - Intrusion of chlorides or other contaminants into the concrete. The extent of contamination is measured by laboratory tests. Generally, a deck is considered contaminated if it contains greater than 2.0 lbs of chlorides/per cubic yard of concrete. Efflorescence is not an indication of contamination.

Repaired Area - Areas of the deck that have been repaired using an approved concrete mix (including Duracal, Set45, etc.), and approved repair details, which are sound and functioning as designed. Pop-outs on the underside of a deck that do not extend above the lower layer of reinforcement, and are coated with a protective epoxy type coating, should be considered permanent repairs. Any nonpermanent repairs are not considered a repaired area.

Code	Description

9 Excellent Condition - No maintenance or rehabilitation concerns.

- No noticeable deficiencies or deterioration.

8 Very Good Condition - No maintenance or rehabilitation concerns.

- No spalls, scaling or delamination noted.
- Isolated hairline cracks noted with no effect on serviceability of the deck.
- None of the electrical potential readings are above 0.35 volts, if half-cell testing was conducted.
- None of the chloride test results indicate over 2.0 lbs./CY, if test was conducted.
- Less than 5% of the deck is deteriorated.

7 Good Condition - Potential exists for minor maintenance.

- Isolated hairline cracks noted on bottom of the deck with no negative effect on the serviceability of the deck.
- Minor efflorescence bleeding from cracks in concrete may be present.
- Isolated spalls up to 1" with no exposed reinforcing steel noted on the bottom of the deck.
- None of the electrical potential readings are greater than 0.35 volts, if half-cell testing was conducted.
- None of the chloride test results indicate more than 2.0 lbs./CY, if test was conducted.
- Light surface scaling, abrasion and/or minor honeycombing noted.
- Less than 10% of the deck is deteriorated.

6 Satisfactory Condition - Potential exists for major maintenance.

- Random fine cracks noted on bottom of the deck may have minor efflorescence bleeding from them.
- Areas of map cracking may be present on the underside but without heavy efflorescence or wetness.
- Random spalls up to 1" deep with no exposed mild steel reinforcing bars or isolated spalls deep enough to expose the mat of steel reinforcing bars closest to the surface on the underside of the deck. Light surface corrosion on the reinforcing bars with no section loss.
- Less than 15% of the electrical potential readings are greater than 0.35 volts.
- Less than 15% of the chloride test results indicate greater than 2.0 lbs./CY.
- Less than 20% of the deck is deteriorated.
- Medium surface scaling, abrasion and/or medium honeycombing may be present.

5 Fair Condition - Potential exists for minor repair or rehabilitation.

- Widespread hairline to fine cracking on bottom of the deck.
- Moderate efflorescence bleeding from cracks in concrete may be present.
- Widespread spalls up to 1” deep with no exposed mild steel reinforcing bars or random spalls deep enough to expose the mat of steel reinforcing bars closest to the surface. There may be corrosion on the reinforcing bars with minor section loss.
- Less than 30% of the deck is deteriorated.
- Less than 30% of the electrical potential readings are greater than 0.35 volts.
- Less than 30% of the chloride test results indicate over 2.0 lbs./CY.
- Heavy surface scaling and/or significant honeycombing noted (up to 1/2” in depth) over up to 25% of the deck surface area.
- Widespread discoloration or wet staining on concrete surfaces.

4 Poor Condition - Potential exists for major repair or rehabilitation.

- Widespread fine to medium cracking noted on the bottom of the deck.
- Heavy efflorescence may be noted bleeding from cracks in concrete.
- Spalls on the bottom of the deck are widespread enough and/or deep enough to significantly affect the serviceability of the element. Moderate section loss on exposed steel reinforcing bars.
- Less than 40% of the deck is deteriorated.
- Up to 40% of the electrical potential readings are greater than 0.35 volts.
- Up to 40% of the chloride test results indicate greater than 2.0 lbs./CY.
- Severe surface scaling and/or significant honeycombing noted (between 1/2” and 1” in depth) over up to 25% of the deck surface area.
- Active water leakage through cracks and/or spalls in the deck.

3 Serious Condition - Repair or rehabilitation required.

- Widespread cracking of greater than 1/8” noted on the deck.
- Heavy efflorescence may be noted bleeding from cracks in concrete.
- Spalls on the bottom of the deck are widespread enough and/or deep enough to significantly affect the serviceability of the deck. There may be advanced section loss on exposed steel reinforcing bars.
- More than 40% of the deck is deteriorated.
- More than 40% of the electrical potential readings are greater than 0.35 volts.
- More than 40% of the chloride test results indicate greater than 2.0 lbs./CY.
- Severe surface scaling and/or significant honeycombing noted (over 1”in depth).
- Heavy water leakage through cracks and/or spalls in the deck.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Severe cracking or spalling makes local "punch-throughs" possible.
- Structural capacity of the deck is severely reduced.
- Closure of the bridge to traffic may be required until corrective action is taken.

1 "Imminent" Failure Condition - Concrete deck is in danger of failing.

- Local failures have occurred.
- Deck is closed and studies are required to see if rehabilitation is feasible.

0 Failed Condition - Concrete deck has failed.

- Deck is closed and beyond repair.

9.1.3. REINFORCED CONCRETE

The following guidelines have been developed for the condition rating of reinforced concrete members. They are intended to supplement the FHWA Recording and Coding Guide to make it easier to determine the most appropriate condition rating to be assigned to reinforced concrete members. These guidelines should be used in conjunction with the FHWA Recording and Coding Guide, Item 59 used for data entry into forms BRI-18 and BRI-39.

These rating guidelines apply to reinforced concrete girders, arch ribs, arch spandrels, floorbeams and other concrete members reinforced with mild steel.

The condition of the joints, waterproofing etc., will not normally influence the rating of reinforced concrete superstructure members. Deteriorations noted on previous inspection reports, which have been repaired, should not be considered in assigning condition rating unless the repairs are temporary or inadequate.

Definitions:

Deficiency - Lack or shortage of a structural component from the quantity specified in design, (i.e. reinforcing bar spacing or size other than that specified by design, etc.). Construction defects such as honeycombing or irregularities caused by defective formwork.

Deterioration - Areas exhibiting cracks, spalls, scaling, impact damage, map cracking, efflorescence, exposed reinforcing bars (with or without corrosion and section loss), delaminations (hollow areas), abrasion or any other defect that reduces the ability of the structural component to function in its design capacity.

Critical Cracks - Cracks, other than temperature and shrinkage cracks, which depending on their location, length, width and orientation to the member being rated, indicate the possibility of one or more of the following:

- an over stressing condition of the concrete and/or reinforcing steel.
- a reduction in the structural integrity of the member.
- an immediate need for further investigation.

These cracks may allow water and contaminant infiltration with subsequent corrosion of the reinforcing steel and delamination of the concrete, possibly reducing the capacity of the member. The width of the cracks may indicate the progressive level of the over stress condition. Cracks that form in member compression zones or at bearing interfaces, indicating excessive compressive stresses, may be accompanied by crushing of the concrete around the cracks and may lead to non-ductile failure of the member. Cracks in tension zones, indicating excessive tensile stresses, may visibly open and close with application of live load. Cracks that are diagonal in orientation to the member indicate over stress in shear.

Non-critical Cracks - Cracks caused by temperature changes or shrinkage and other cracks that do not pose an immediate threat to the structural integrity of the member but allow penetration of water, corrosion producing agents and other contaminants. They may cause further deterioration of the concrete, reinforcing steel, anchor bolts, etc., and negatively affect the structure over the long term. Spalling, due to freeze/thaw action and bleeding efflorescence may be noted around these cracks.

> ***Special Note:***
>
> - *Sections 6.2.2.4, 6.3.1, 6.4, as well as Appendices 6.4 and 6.9 detail some of the areas that should be inspected for critical cracks.*
> - *Reference Appendix A6.4 for definitions of crack width and scaling classifications.*

Code	Description
9	Excellent Condition - No maintenance or rehabilitation concerns.

- No noticeable deficiencies or deterioration.

8 Very Good Condition - No maintenance or rehabilitation concerns.

- Very minor construction or fabrication defects that do not affect the capacity or function of the member.

7 Good Condition - Potential exists for minor maintenance.

- Non-critical, hairline cracks (up to 1/32”) noted that do not affect the serviceability of the member.
- No critical cracks noted.
- Isolated small spalls up to 1” deep with no exposed reinforcing bars.
- A few small locations of concrete delamination are possible in non-critical areas.
- Light surface scaling, abrasion and/or minor honeycombing noted.
- Minor discoloration or wet staining on concrete surfaces that indicates porous concrete.

6 Satisfactory Condition - Potential exists for major maintenance.

- Non-critical hairline or fine cracks (up to 1/16” wide) noted to an extent that they may have minor effects on the serviceability of the member.
- No critical cracks noted.
- Minor efflorescence bleeding from cracks in concrete may be present.
- Random small spalls up to 1” deep with no exposed reinforcing bars or isolated small spalls from 1” to 2” deep, or deep enough to expose the mat of reinforcing bars closest to the surface. Light surface corrosion on the exposed reinforcing bars with no section loss.
- Small areas of medium to heavy scaling, abrasion and/or honeycombing noted with no exposed reinforcing steel.

- Moderate discoloration or wet staining on concrete surfaces noted. Concrete surface sounds solid when struck with a hammer.
- Concrete may be delaminated (concrete surface sounds hollow when struck with a hammer) on less than 10% of any individual structure unit (i.e.: 10% of one beam).
- Impact damage, which is not structurally significant, may be present.

5 Fair Condition - Potential exists for minor repair or rehabilitation.

- Non-critical cracks up to 1/8" wide noted to an extent that may moderately affect the serviceability of the member. Minor deterioration or section loss of the concrete reinforcing bars or anchor bolts in the vicinity of the cracks may be present.
- Isolated, hairline critical cracks may be present, but no consistent pattern of overload or over stress is observed.
- Moderate efflorescence bleeding from cracks.
- Widespread spalls up to 1" deep with no exposed reinforcing bars or random spalls from 1" to 2" deep, or deep enough to expose the mat of reinforcing bars closest to the surface. Minor section loss may be present on exposed reinforcing bars.
- Severe surface scaling, abrasion and/or significant honeycombing noted.
- Delaminations (concrete surface sounds hollow when struck with a hammer) may be more wide spread, up to 25% of the surface area on any individual structure element.
- Widespread discoloration, efflorescence or wetness on concrete surfaces noted.
- Impact damage that exposes reinforcing steel.

4 Poor Condition - Potential exists for major repair or rehabilitation.

- Non-critical cracks greater than 1/8 in wide noted to an extent that may significantly affect the serviceability of the member. Moderate deterioration of the concrete, reinforcing bars or anchor bolts in the vicinity of the cracks.
- Critical cracks (up to 1/16") noted on one or more members.
- Heavy efflorescence bleeding from cracks may be noted.
- Spalls are widespread enough and/or deep enough so as to significantly affect the serviceability of the element. Moderate section loss on exposed reinforcing bars.
- Severe surface scaling, abrasion and/or significant honeycombing noted. Large areas are involved with exposed reinforcing steel.
- Active water leakage through cracks and/or spalls in concrete members noted.
- Extensive concrete delaminations in areas that are not structurally critical.
- Impact damage to a large area of a member, causing damage to reinforcing steel.

3 Serious Condition - Repair or rehabilitation required.

- Non-critical cracks greater than 1/8" wide noted to an extent that may severely affect the serviceability of the member. Advanced deterioration of the concrete, reinforcing bars or anchor bolts in the vicinity of the cracks.

- Critical cracks up to 1/8” wide noted creating significant affects on the structural integrity of the member.
- Spalls are widespread enough and/or deep enough so as to affect the strength of the member or significantly affect the serviceability of the member. Advanced section loss on exposed reinforcing bars is noted.
- Heavy leakage of water through cracks and/or spalls noted on concrete members.
- Widespread concrete delaminations are present in structurally significant areas or delaminated concrete that is loose and poses a potential hazard to pedestrian, vehicular or marine traffic.
- Impact damage noted with heavy damage or distortion of the structural member.
- Partial failure of member is possible due to a deficiency or deterioration.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Severe deterioration of the concrete, reinforcing bars or anchor bolts in the vicinity of cracks.
- Failure of the member is possible due to deficiency or deterioration.
- Critical cracks greater than 1/8” wide, creating a severe effect on the structural integrity of the member.
- Severe, widespread deterioration of concrete and reinforcing bars in the vicinity of spalls. Possible localized failure of element possible.
- Large spalls or severe scale are severely affecting the strength and/or serviceability of the member or an adjacent member.
- Extensive concrete delamination is present, leading to spalling in structurally significant locations and/or loose concrete is dropping to areas where it may cause damage or injury to people or property below.
- Impact damage, with severe effects on member strength or serviceability is noted.
- Closure of the bridge or a portion of the structure may be necessary until repairs are made.

1 "Imminent" Failure Condition - Reinforced Concrete element is non-functional and/or failed.

- Structure is closed.
- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Reinforced Concrete element is non-functional and/or failed.

- Member is beyond rehabilitation.

9.1.4. PRESTRESSED CONCRETE

The following guidelines have been developed for the condition rating of prestressed concrete members. They are intended to supplement the FHWA Recording and Coding Guide to make it easier to determine the most appropriate condition rating to be assigned to prestressed concrete members. These guidelines should be used in conjunction with the FHWA Recording and Coding Guide, Item 59 used for data entry into forms BRI-18 and BRI-39.

These rating guidelines shall apply to prestressed and post-tensioned closed web box girders (slab beams and box beams), open web girders (I-beams), arches, floorbeams and other prestressed or post-tensioned concrete members. In the case of "integral deck" superstructures, the condition of the top surface of the deck shall not be considered in the rating of the superstructure (See Section 9.1.2). Normally, the condition of the bearings, joints, etc., shall not influence the rating of the prestressed concrete superstructure members.

Due to the design characteristics of prestressed concrete members, deteriorations in the superstructure, noted on previous inspection reports that have since been retrofitted, must be evaluated using sound engineering judgment. Once a prestressed member has lost load capacity, due to concrete and/or steel tendon section loss, it is difficult to restore the member to its original capacity. Repairs undertaken may be cosmetic in nature, intended only to prevent further deterioration of the concrete and/or steel tendons, or they may be intended to restore lost load capacity by rehabilitation of the member incorporating either internal or external post-tensioning details. In the case of cosmetic repairs, the ability of the repair material to protect the base materials (concrete and/or prestressing tendons) from further deterioration shall be noted in the condition evaluation report, but shall not be considered in assigning the condition rating. Repairs designed to restore the member to its original capacity, and have documentation as such, shall be evaluated considering the condition of the repair and its continued ability to add strength to the member. In either case, sound engineering judgment must be employed when assigning a condition rating to the member.

The quantities given in the following guidelines for the number of exposed prestressing tendons and/or broken strands are intended to give the inspector a guide for assigning the condition rating to the member. A greater or lesser degree of deterioration on a single member, or on a series of members, may prove to be more or less critical than indicated in these guidelines. The degree to which it is critical can only be determined through engineering analysis, knowledge of the as-built section(s) and understanding of the prestressing system behavior.

Definitions:

Reinforcing Bar -	Mild steel (non-prestressed) reinforcing steel. Most commonly placed transverse to the longitudinal centerline of the prestressed member for use as shear reinforcement
Tendon -	A high strength cable, strand, wire or bar used for prestressing or post-tensioning.
Strand -	Fabricated by twisting wires together, the seven-wire strand is the most common type of prestressing steel in the United States.
Wire -	Single wires or parallel wire cables. Parallel wire cables are commonly used in post-tensioning.

Deficiency - Lack or shortage of a structural component from the quantity specified in design, (i.e. missing concrete components, tendon spacing or size other than that specified by design, etc.). Construction defect such, as honeycombing.

Deterioration - Areas exhibiting cracks, spalls, impact damage, map cracking, efflorescence, exposed reinforcing bars or prestressing tendons with or without corrosion and section loss, delaminations, water staining, scaling, abrasion or any other defect that affects the ability of the structural component to function in its design capacity.

Critical Cracks - Cracks, other than temperature and shrinkage cracks, that depending on their location, length, width and orientation to the member being rated, indicate the possibility of one or more of the following:

- a reduction in prestressing force within the steel tendons
- an over stressing condition of the concrete and/or mild reinforcing steel
- a reduction in the structural integrity of the member
- an immediate need for further investigation.

These cracks may allow water and contaminant infiltration that may cause an increased rate of deterioration of the prestressing tendons and debonding of the concrete, possibly reducing the capacity of the member. The width of the cracks may indicate the progressive level of the over stressing condition. Cracks that form in member compression zones or at bearing interfaces, indicating excessive compressive stresses, may be accompanied by crushing of the concrete around the cracks and may lead to nonductile failure of the member. Cracks in prestressed tension zones, indicating a relaxing of the prestressing tendons or excessive tensile stresses in the concrete, may occur at tendon anchorages and/or locations of maximum live load bending moment. They may be “hairline to fine” in width, and under extreme conditions, may open and close with vehicular live load application. Cracks that are diagonal in orientation to the member indicate over stress in shear.

Non-critical Cracks - Cracks caused by temperature, shrinkage and other cracks that do not pose an immediate threat to the structural integrity of the member but allow penetration of water, corrosion producing agents and other contaminants. They may cause further deterioration of the concrete, mild reinforcing steel, anchor bolts, etc., and affect the structure over the long term. Spalling, due to freeze/thaw action and bleeding efflorescence may be present around these cracks.

Critical Spalls - Spalls that, depending on their location, surface area and depth, could affect the strength, serviceability and stability of the member. Spalls in pre-prestressing tension areas may expose the prestressing tendons which are highly susceptible to corrosion due to the high stress state and relatively small cross sectional area of the tendons and individual wires. The presence of these spalls may indicate a decrease in bond between the concrete and the prestressing tendons, and/or increase in localized concrete and mild steel stresses, that could lead to a nonductile failure of the member, with possible partial failure of the structure. A critical spall condition may also exist if the presence of non-critical spalls is widespread enough, on a particular member, so that the combined effect of the spalling action constitutes a serious situation requiring a large degree of repair or rehabilitation.

Code	Description
9	Excellent Condition - No maintenance or rehabilitation concerns.

- No noticeable deficiencies or deterioration.

8	Very Good Condition - No maintenance or rehabilitation concerns.

- Very minor construction or fabrication defects that do not affect the capacity or function of the member.

7	Good Condition - Potential exists for minor maintenance.

- Non-critical, hairline cracks (up to 1/32" wide) that do not affect the serviceability of the member.
- No critical cracks present.
- No exposure of prestressing tendons noted.
- Light surface scaling, abrasion and/or minor honeycombing present.
- Minor discoloration or wetness on concrete surfaces.

6	Satisfactory Condition - Potential exists for major maintenance.

- Non-critical cracks up to 1/16" wide noted to an extent that may have minor effects on the serviceability of the member.
- No critical cracks present.
- Minor efflorescence bleeding from cracks in concrete may be present.
- Isolated, small spalls up to 1" deep with no exposed mild steel reinforcing bars noted.
- No exposure of prestressing tendons noted.
- Medium surface scaling, abrasion and/or moderate honeycombing present.
- Moderate discoloration or wetness on concrete surfaces. Concrete surface sounds solid when struck with a hammer.
- Small isolated areas of delaminated concrete may be present.
- Impact damage noted with minor effects on member serviceability. No exposed reinforcing steel.

5 Fair Condition - Potential exists for minor repair or rehabilitation.

- Non-critical cracks up to 1/8" wide noted to an extent that may moderately affect the serviceability of the member. Minor deterioration or section loss of the concrete, mild steel reinforcing bars or anchor bolts in the vicinity of the cracks may be present.
- Isolated, hairline critical cracks may be present on a small number of members, but no consistent pattern of overload or over stress is observed.
- Moderate efflorescence bleeding from cracks.
- Spalls present up to 1" deep with no exposed mild steel reinforcing bars or random non-critical spalls from 1" to 2" deep, or deep enough to expose the mat of mild steel reinforcing bars closest to the surface. Minor section loss may be present on these reinforcing bars. Moderate effect on member serviceability. No more than one (1) prestressing tendon per beam may be exposed with no section loss or broken wires present.
- Heavy surface scaling, abrasion and/or significant honeycombing present.
- Widespread discoloration or wetness on concrete surfaces. Concrete sounds hollow when struck with a hammer.
- Impact damage that exposes reinforcing steel or up to two (2) prestressing tendons with no corrosion or damage to the tendons is noted.

4 Poor Condition - Potential exists for major repair or rehabilitation.

- Non-critical cracks greater than 1/8" wide noted to an extent that may significantly affect the serviceability of the member. Moderate deterioration of the concrete, mild steel reinforcing bars or anchor bolts in the vicinity of the cracks.
- Critical cracks up to 1/16" wide present. Moderate effects on the structural integrity of the member.
- Heavy efflorescence bleeding from cracks may be present.
- Non-critical spalls are widespread enough and/or deep enough so as to significantly affect the serviceability of the member. Moderate section loss on exposed mild steel reinforcing bars.
- Critical spalls that moderately affect the strength and/or serviceability of the member are noted. Few (< 3 per unit) exposed prestressing tendons with moderate surface corrosion and up to one (1) wire broken are present.
- Severe surface scaling, abrasion and/or significant honeycombing present.
- Active water leakage through cracks and/or spalls in concrete members.
- Locations within the pre-prestressed compression zone of the member exhibit advanced delaminations of the concrete.
- Locations within the pre-prestressed tension zone of the member exhibit moderate delaminations of the concrete.
- Impact damage with up to two (2) prestressing tendons damaged.

3 Serious Condition - Repair or rehabilitation required.

- Non-critical cracks greater than 1/8" wide noted to an extent that may severely affect the serviceability of the member. Advanced deterioration of the concrete, mild steel reinforcing bars or anchor bolts in the vicinity of the cracks.
- Critical cracks up to 1/8" wide noted, creating significant effects on the structural integrity of the member.

- Non-critical spalls are widespread enough and/or deep enough so as to significantly affect the serviceability of the member. Advanced section loss on exposed reinforcing bars is noted.
- Critical spalls significantly affecting the strength and/or serviceability of the member. Prestressing tendons are exposed with minor section loss and few broken wires (< 2 wires per unit).
- Heavy, active water leakage through cracks and/or spalls noted on concrete members.
- Impact damage with up to two (2) wires of one (1) tendon broken or one (1) wire on each of two (2) tendons broken.
- Delaminated concrete is widespread or structurally significant.
- Delaminated concrete has the potential to drop to areas below the structure, causing a risk of injury or property damage.
- Partial failure of member is possible due to a deficiency or deterioration.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Severe deterioration of the concrete, mild steel reinforcing bars or anchor bolts in the vicinity of the non-critical cracks.
- Critical cracks of greater than 1/8" noted creating a severe effect on the structural integrity of the member.
- Severe, widespread deterioration of concrete and reinforcing bars in the vicinity of non-critical spalls. Critical spalls severely affect the strength and/or serviceability of the member or an adjacent member. Prestressing tendons are exposed with moderate section loss. Several tendons are broken.
- Locations within the pre-prestressed compression zone of the member exhibit severe delaminations of the concrete.
- Locations within the pre-prestressed tension zone of the member exhibit severe delaminations of the concrete.
- Delaminated concrete is dropping to areas below the structure, causing a risk of injury or property damage.
- Impact damage noted with severe effects on member serviceability.
- Closure of the bridge or a portion of the structure may be necessary until corrective action is taken.

1 "Imminent" Failure Condition-Prestressed Concrete element is non-functional and/or failed.

- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Prestressed Concrete element is non-functional and/or failed.

- Member is beyond rehabilitation.

9.1.5. STEEL

The following guidelines have been developed for the condition rating of steel superstructures. They are intended to supplement the FHWA Recording and Coding Guide to make it easier to determine the most appropriate condition rating to be assigned to the superstructure and should be used in conjunction with the FHWA Recording and Coding Guide, Item 59 used for data entry into forms BRI-18 and BRI-39.

These rating guidelines shall apply to steel multi-girder, girder-floorbeam, truss, arch, and movable bridge superstructures. In the case of composite superstructures, the condition of the deck normally will not influence the condition rating of the superstructure. However, deck condition should be considered if deterioration affects the ability of the superstructure to act compositely with the deck, as designed. (See Item 59 of the FHWA Recording and Coding Guide.) The condition of the bearings, joints, paint system, etc., generally will not influence the rating of the superstructure. Deficiencies in the superstructure noted in previous inspection reports, that have since been retrofitted, shall only consider the condition of the retrofit when establishing the condition code.

The percentages of loss presented in the following condition coding guide, represent estimates for the purposes of aiding the inspector in applying a condition code rating to the member. It does not, however, relieve the inspector of the responsibility of using sound engineering judgment when dealing with elements with excessive section loss.

Definitions:

Deficiency - Lack or shortage of a structural component (i.e. missing fasteners, lattice bars, stiffener plate, under sizing, etc.) from the quantity specified by design that affects the ability of the structural component to function in its design capacity.

Deterioration - Areas exhibiting corrosion, pitting, impacted rust, section loss, cracks, dings, gouges, impact or construction damage, fire damage, loose fasteners or any other defect that detracts from the "As-Built" condition of the member.

Critical Section - That component of a structural element whose integrity is vital to the success of the element carrying out its design intent. For bending members, the critical section at the bearing areas is the area of the web. For bending members in areas of maximum moment, the critical section is the area of the flanges. For axially loaded members, the critical section is the adjusted gross area as defined in AASHTO Manual for Condition Evaluation of Bridges.

Code	**Description**
9	Excellent Condition - No maintenance or rehabilitation concerns. • No noticeable deficiencies or deterioration
8	Very Good Condition - No maintenance or rehabilitation concerns. • Very minor construction or fabrication defects that do not affect the capacity or function of the member.
7	Good Condition - Potential exists for minor maintenance. • Minor deficiencies, such as missing fasteners in isolated locations of secondary member connections. • Minor deterioration, such as loose fasteners in isolated locations. • Light to medium rust on less than 25% of the steel surface area. (No section loss.)
6	Satisfactory Condition - Potential exists for major maintenance. • Deficiencies noted on reoccurring basis and/or discernible pattern. • Light to medium rust on greater than 25% of the steel surface area. • Severe rust (< 1/16" section loss) on less than 25% of the steel surface area of a critical section.
5	Fair Condition - Potential exists for minor repair or rehabilitation. • Deficiencies noted on a regular basis and/or regular pattern. • Severe rust on greater than 25% of the steel surface area and/or section loss (up to 5% of the total flange cross sectional area or up to 25% of the total web cross sectional area) noted in a critical section on one or more members. • Fatigue, or out-of-plane distortion, cracks may be present in secondary members with no means of propagation into a primary member.
4	Poor Condition - Potential exists for major repair or rehabilitation. • Deficiencies are beginning to affect the ability of primary structural components to safely function in their design capacity. • Severe rust with advanced section loss (5% to 25% of total flange cross sectional area, 25% to 50% of total web cross sectional area) noted in a critical area on one or more members. • Fatigue, or out-of-plane distortion, cracks may be present in secondary members where there is means of propagation into the primary member. • Pin & hangers or hinges are frozen due to impacted rust. • Load carrying capacity of primary structural members may be affected.

3 Serious Condition - Repair or rehabilitation required.

- Deficiencies significantly affect the ability of structural components to safely function in their design capacity.
- Severe rust throughout the member and severe section loss (25% to 35% of the total flange cross sectional area or 50% to 75% the total web cross sectional area) in a critical area on one or more members.
- Fatigue, or out-of-plane distortion, cracks may be present in primary members.
- Local failures of structural components may have occurred in secondary members.
- Significant weakening of primary members evident.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Severe deterioration of the primary structural elements (>35% of the total flange cross sectional area or >75% of the total web cross sectional area) noted in a critical section of one or more members.
- Local failures of structural components have occurred in primary members.
- Severe weakening of primary elements is evident.
- Partial or total closure of the structure may be required.

1 "Imminent" Failure Condition - Structure is Closed.

- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Structure is Closed.

- Structure is beyond repair or rehabilitation.

9.1.6. TIMBER

The following guidelines have been developed for the condition rating of Timber Bridges. They are intended to supplement the FHWA Recording and Coding Guide to make it easier to determine the most appropriate condition rating to be assigned to the timber elements and should be used in conjunction with the FHWA Recording and Coding Guide used for data entry into forms BRI-18 and BRI-39.

These ratings shall apply to all solid sawn and glued laminated timber bridge superstructures and decks. The condition of bearings, joints, paint system, etc., shall not influence the rating of the bridge elements. Deficiencies or decay noted in previous inspection reports, that have since been retrofitted, shall only consider the condition of the retrofit when establishing the condition code.

Definitions:

Deficiency - Lack or shortage of a structural component (i.e., missing fasteners, under sizing, etc.) from the quantity specified in design that affects the ability of the structural component to function in its design capacity.

Deterioration - Areas exhibiting fungus growth, decay, parasite infestation, fire damage, collision or impact damage, section loss, weathering or warping, splitting, cracking, checking, chemical damage, or signs of overstress that detracts from the "As-Built" condition of the member.

Code **Description**

9 Excellent Condition - No maintenance or rehabilitation concerns.

- No noticeable deficiencies or deterioration.

8 Very Good Condition - No maintenance or rehabilitation concerns.

- No decay, cracking, or splitting of beams, stringer or axially loaded members.
- Deck flooring has no crushing, rotting or splitting and is tightly secured to the superstructure members.

7 Good Condition - Potential exists for minor maintenance.

- Minor decay, cracking or splitting of beams, stringers or axially loaded members in non-critical locations.
- Timber deck has minor splitting, checking or a few loose planks.

6 Satisfactory Condition - Potential exists for major maintenance.

- Minor decay, cracking or splitting of beams, stringers or axially loaded members.
- Less than 30% of the deck planks have checks and splits, but are sound. Some loose planks.
- Fire damage is limited to surface scorching with no measurable section loss.
- Some wet areas noted, with no measurable loss of effective section.

5 Fair Condition - Potential exists for minor repair or rehabilitation.

- Moderate decay or deterioration, cracking, splitting, or minor crushing of beams, stringers or axially loaded members.
- Fire damage limited to surface charring with minor measurable section loss.
- Numerous (30% to 40%) deck planks are checked, split, rotted, or crushed. Many planks are loose. Less than 10% of the deck planks need replacement.

4 Poor Condition - Potential exists for major repair or rehabilitation.

- Advanced decay or deterioration, cracking and splitting with moderate crushing of beams, stringers or axially loaded members.
- Fire damage is significant with moderate section loss.
- Over 40% of the deck planks are rotted, crushed, cracked or split with over 10% in need of replacement.

3 Serious Condition - Repair or rehabilitation required.

- Severe decay or deterioration, cracking and splitting with advanced crushing of beams, stringers, or axially loaded members.
- Major fire damage with advanced section loss.
- Local failures may be evident.
- Severe signs of distress in deck planks.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Extensive decay or deterioration is causing severe weakening and significant local failures of primary bridge elements.
- Partial or total closure of the structure may be warranted.

1 "Imminent" Failure Condition - Structure is closed.

- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Structure is closed.

- Structure is beyond repair or rehabilitation.

9.1.7. STONE MASONRY ARCHES

The following guidelines have been developed for the condition rating of stone masonry. They are intended to supplement the FHWA Recording and Coding Guide to make it easier to determine the most appropriate condition rating to be assigned to the stone masonry and should be used in conjunction with the FHWA Recording and Coding Guide used for data entry into forms BRI-18 and BRI-39.

These rating guidelines were developed based on Ashlar type masonry and shall be applied to stone masonry arches. In general, these guidelines shall apply to other types and shapes of stone masonry. However, these guidelines will have to be adjusted based on engineering judgment if the stone masonry was designed for dry laid conditions. These condition codes evaluate the structural integrity of the stone and joint material and include items such as alignment, settlement and deterioration. In all cases where these guidelines are applied, sound engineering judgment shall be incorporated to ensure an accurate rating is assigned.

For the stones that comprise the arch ring, integrity of the structure depends on these stones remaining aligned and in bearing with adjacent stones in the compression ring. If any rotation, sliding, crushing or loss of joint mortar occurs, the bearing area between stones will be reduced, increasing the stress in the remaining area. If displacement occurs and stone on stone contact is made, the uneven surface characteristic of stone masonry will produce locations of concentrated stress that could lead to cracking of the stone. In addition, the characteristics of stone behavior are such that minor displacements can suddenly and without warning experience major displacements due to increased stress. Therefore, although minor rotation, sliding, crushing, heaving, settlement or other deterioration noted may not indicate the arch is at that moment unstable, their presence does indicate that the load path is being altered or that the load path has been altered and is now stabilized. (Note that it is impossible to discern from visual observation whether stabilization has occurred.) The presence of rotation, sliding, crushing, etc., also indicates that stress concentrations are developing and that close monitoring is warranted. For stones in the spandrel walls, deterioration such as cracking, crushing, heaving, and settlement are generally less serious than those in the arch ring unless the conditions are severe or widespread. However, similar to the arch ring stones, spandrel stones can experience sudden, major displacements due to increased stress. If failure of one spandrel stone occurs, the bearing capacity of the soil fill within the spandrel walls may be seriously affected. Therefore, deformations and displacements of spandrel stones still warrant close monitoring to determine the rate of deterioration and any adverse effects, both immediate and future, on the integrity of the spandrel wall.

Concrete components of the arch superstructure (i.e. concrete spandrels on a stone masonry arch ring) shall be coded in accordance with Section 9.1.3, Reinforced Concrete.

Definitions:

Deficiency - Lack or shortage of a structural component from the quantity specified by design that affects the ability of the structure to function in its design capacity.

Deterioration - Areas exhibiting cracking, spalling, crushing, loss of joint mortar, efflorescence, displaced, loose cracked or missing stones, weathering or other defects.

Displacement - Sliding, tilting, heaving, rotating or settling of the masonry stones. Displacements may be caused by, but are not limited to, such things as collision, deterioration, water infiltration and freeze/thaw action, and settlement of the substructure.

Code	Description
9	Excellent Condition - No maintenance or rehabilitation concerns. • No noticeable deficiencies or deterioration.
8	Very Good Condition - No maintenance or rehabilitation concerns. • Very minor construction defects that do not affect the capacity or function of the structure. • Isolated locations of lost joint pointing and widespread cracking of joint pointing observed.
7	Good Condition - Potential exists for minor maintenance. • Widespread loss of joint pointing with interior joint mortar in good condition. • Light efflorescence bleeding from joints. • Evidence of minor water leakage noted at isolated locations through the spandrel or arch ring stones.
6	Satisfactory Condition - Potential exists for major maintenance. • Widespread loss of joint pointing material. Cracking and/or minor loss of interior joint mortar observed. • Moderate efflorescence bleeding from the joints. • Minor deterioration of spandrel stones noted. • Evidence of moderate water leakage noted throughout the spandrel or arch ring stones.
5	Fair Condition - Potential exists for minor repair or rehabilitation. • Widespread loss of joint pointing material. Widespread cracking with moderate loss of interior joint mortar noted. • Minor displacements or deteriorations of spandrel stones noted with no adverse effect on the structural integrity or capacity of the spandrel wall. • Isolated spandrel stones cracked. Pieces of stone on both sides of the crack are tight. • Heavy efflorescence bleeding from the joints. • Moderate deterioration of the spandrel stones noted. • Heavy leakage of water through the arch ring and spandrel walls with minor deteriorations present.

4 Poor Condition - Potential exists for major repair or rehabilitation.

- Severe loss and cracking of joint pointing and interior mortar materials.
- Minor displacements or deformations of spandrel stones noted with potential to have adverse effects on the structural integrity or capacity of the spandrel walls.
- Cracks extend through two or more horizontal stone courses in the spandrel area. Pieces adjacent to crack may be loose.
- Signs of minor crushing or other deterioration on the surface of the arch ring stones.
- Signs of minor sliding or rotating of the arch ring stones.
- Advanced deterioration of the spandrel stones noted.
- Advanced deterioration due to water penetration, with minor displacements, noted.

3 Serious Condition - Repair or rehabilitation required.

- Severe loss and cracking of joint pointing and interior mortar materials.
- Moderate displacements or deformations of spandrel stones with moderate adverse effects on the structural integrity or capacity of the spandrel walls.
- Crushing is noted on one or more arch ring stones.
- Cracks extend full height of the spandrel wall at one or more locations. Pieces adjacent to the crack may be loose or tight.
- Moderate sliding or rotating of the arch ring stones observed.
- Serious deterioration of the spandrel stones noted.
- Serious deterioration due to water penetration, with moderate displacements, noted.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Severe loss and cracking of joint pointing and interior mortar materials.
- Major displacements or deformations of spandrel stones with severe adverse effects on the structural integrity or capacity of the spandrel walls.
- Crushing is noted on one or more arch ring stones. Localized total failure of stones may have occurred.
- Advanced signs of sliding or rotating of the arch ring stones. Localized failures may have occurred.
- Severe deterioration of spandrel stones noted.
- Severe deterioration due to water penetration with major displacements of stones noted.

1 "Imminent" Failure Condition - Structure is closed.

- Multiple locations of stone failure due to deterioration or displacement of the stone.
- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Structure is closed.

- The arch superstructure has failed by sliding, rotation, or crushing.
- Structure is beyond repair or rehabilitation.

9.2. WATERWAYS

9.2.1. Channel and Channel Protection

The following guidelines have been developed for the condition rating of the channel and channel protection devices. They are intended to supplement the FHWA Recording and Coding Guide to make it easier to determine the most appropriate condition rating to be assigned to the channel and channel protection and should be used in conjunction with the FHWA Recording and Coding Guide, Item 61 used for data entry into forms BRI-18 and BRI-39.

The guidelines presented in this section describe the physical conditions associated with the water flow such as stream stability, condition of scour protection devices such as riprap, spur dikes, gabions, and slope protection. The inspector should be particularly concerned with excessive water velocity or turbulence, which may cause degradation of the channel, scour and undermining of the channel protection devices or substructure elements, erosion of the banks, lateral movement of the channel or aggradation of the channel bed.

Accumulation of debris deposited on the superstructure or substructure elements shall not influence the condition code assigned to the channel and channel protection. However, accumulation of debris in the channel, as described in Section 6.5, Appendix A6.10 and this section, shall have direct influence on the condition code assigned, as applicable.

Code **Description**

9 Excellent Condition - No maintenance or rehabilitation concerns.

- No notable deficiencies on protective devices.
- No bank erosion, scour or undermining of substructure elements.
- No channel debris observed.

8 Very Good Condition - No maintenance or rehabilitation concerns.

- No debris accumulation in the channel or along the banks that disrupts water flow through the hydraulic opening.
- No water turbulence noted around substructure elements or protective devices. No signs of channel scour noted.
- Channel protection devices are properly functioning with very minor deterioration or impact damage noted.
- Channel banks are stable, well vegetated and show no signs of erosion.
- Channel is stable with no signs of aggradation, degradation or lateral movement.

7 Good Condition - Potential exists for minor maintenance.

- There may be minor misalignment between the channel and the substructure elements (up to 25 degrees).
- Debris buildup in the channel or along the banks is causing minor increases in water flow velocity and turbulence through the hydraulic opening.
- Water turbulence and/or increased water flow velocity caused by channel contractions and/or high flow rates are producing minor contraction scour and general scour. No adverse effects on the bridge structure.
- Channel protection devices are properly functioning, with minor deterioration or impact damage. No undermining or exposure of footings noted.
- Channel banks are well vegetated but experiencing minor erosion.
- Channel bed is experiencing minor aggradation or degradation, with no lateral movement observed.

6 Satisfactory Condition - Potential exists for major maintenance.

- Debris buildup in the channel or along the banks is causing moderate increases in water flow velocity and turbulence through the hydraulic opening.
- Water turbulence and/or increased water flow velocity caused by channel contractions and/or high flow rates are producing moderate contraction scour and general scour. Potential exists for bridge structure to be affected by local scour.
- Moderate deterioration or impact damage to channel protection devices. Footings are partially exposed with no signs of undermining. Serviceability is slightly diminished.
- Channel banks are experiencing moderate erosion. Sloughing of bank material and vegetation present.
- Moderate aggradation or degradation of the channel noted.
- Minor upstream lateral movement of the channel noted since the last inspection.

5 Fair Condition - Potential exists for minor repair or rehabilitation.

- Heavy debris buildup in the channel or along the banks is causing significant increase in water flow velocity and turbulence through the hydraulic opening.
- Water turbulence and/or increased water flow velocity caused by channel contractions and/or high flow rates are producing extensive contraction scour and general scour. Bridge structure is being affected by local scour but is stable.
- Heavy deterioration or impact damage to channel protection devices. Footings are exposed and have experienced minor undermining with no signs of displacement, tilting, settlement or other movement.
- Channel banks are experiencing extensive erosion. Moderate sloughing of bank material and vegetation present.
- Extensive aggradation or degradation of the channel noted.
- Moderate upstream lateral movement of the channel noted since the last inspection.

4 Poor Condition - Potential exists for major repair or rehabilitation.

- Heavy debris buildup in the channel or along the banks is causing a severe increase in water flow velocity and turbulence through the hydraulic opening.
- Water turbulence and/or increased water flow velocity caused by channel contractions and/or high flow rates are producing severe contraction scour and general scour. Potential exists for the stability of the bridge structure to be affected by local scour.
- Severe deterioration or impact damage to channel protection devices. Footings are fully exposed and are experiencing undermining with signs of displacement, tilting, settlement or other movement. Only partial effectiveness remains.
- Channel banks are experiencing severe erosion. Heavy sloughing of bank material and vegetation present.
- Severe aggradation or degradation of the channel noted.
- Extensive upstream lateral movements of the channel noted since the last inspection. Potential exists for lateral movement to adversely affect the approach roadway.

3 Serious Condition - Repair or rehabilitation required.

- Severe general scour, contraction scour or local scour is adversely affecting the stability of the substructure elements.
- Severe deterioration and undermining, displacement, tilting, settlement or other movement have caused the channel protection devices to fail or become ineffective.
- Channel aggradation, degradation or lateral movement threatens the stability of the structure or approach roadway.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- The structure or approach is severely weakened by channel misalignment.
- Structure or approach is in danger of collapse.
- Debris accumulation blocks hydraulic opening.

1 "Imminent" Failure Condition - Structure is closed.

- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Structure is closed.

- Structure or approach roadway have failed and are beyond repair or rehabilitation.

9.2.2. <u>Waterway Adequacy</u>

The condition rating guidelines to be used in the appraisal of waterway adequacy are those developed in the FHWA Recording and Coding Guide for Item 71.

9.3. CULVERTS

The following guidelines have been developed for the condition rating of culverts. They are intended to supplement the FHWA Recording and Coding Guide to make it easier to determine the most appropriate condition rating to be assigned to the culvert and should be used in conjunction with the FHWA Recording and Coding Guide used for data entry into forms BRI-18 and BRI-39.

These rating guidelines shall apply to concrete, steel, aluminum, and stone masonry culverts. This condition code evaluates the alignment, settlement, joints, structural condition, scour and other items associated with culverts. The rating code is intended to be an overall condition evaluation of the culvert. Hydraulic Adequacy, Channel and Channel Protection shall be evaluated using the separate condition rating guidelines provided in section 9.2, Waterways. Integral wingwalls, to the first construction or expansion joint, shall be included in the evaluation. Wingwall construction beyond the first construction or expansion joint shall be inspected in accordance with Section 6.4 Culverts, but shall not influence the overall condition rating of the culvert unless severe deterioration is observed that is having an adverse effect on the stability of the backfill or other primary components of the culvert.

Definitions:

Deficiency - External factors (debris buildup, aggregation or degradation of stream bed, change in flow mass, etc.) and/or lack or shortage of a structural component from the quantity specified by design that affects the ability of the structure to function in its hydraulic design capacity.

Deterioration - General: Excessive abrasion, joint or seam defects, water exfiltration, backfill infiltration, scour, undermining, piping, construction or impact damage, fire damage or other defect described below that detracts from the "As-Built" condition of the culvert.

Steel or Aluminum: Areas exhibiting corrosion, pitting, impacted rust, section loss, cracks, dings, gouges, racking, peaking, flattening, sagging, bulging, or bent, loose or missing fasteners.

Concrete: Areas exhibiting cracking, spalling, crushing, scaling, delamination, exposed reinforcing bars, efflorescence, water or rust staining or map cracking.

Masonry: Areas exhibiting cracking, spalling, crushing, loss of joint mortar, displaced, loose or missing stones or weathering.

9.3.1. Round Or Vertical Elongated Corrugated Metal Pipe Barrels

Code	Description
9	Excellent Condition - No maintenance or rehabilitation concerns. • No noticeable deficiencies or deterioration.
8	Very Good Condition - No maintenance or rehabilitation concerns. • Barrel shape has good, smooth curvature. Horizontal span within 10% of design. • Seams and joints are tight with no openings. • Superficial corrosion, with slight pitting on aluminum components. • Light rust, with no pitting on steel components.
7	Good Condition - Potential exists for minor maintenance. • Barrel shape has good curvature. Top half has smooth curvature but minor flattening of bottom half has occurred. Horizontal span is within 10% of design. • Seams and joints have minor cracking at a few bolt holes and minor joint or seam openings with potential for backfill infiltration. • Moderate corrosion of aluminum components. No attack of core alloy. • Medium rust, with light pitting on steel components.
6	Satisfactory Condition - Potential exists for major maintenance. • Barrel shape is fair. Top half has smooth curvature. Significant flattening of bottom half has occurred. Horizontal span is within 10% of design. • Minor cracking at bolts is prevalent in one seam in lower half of pipe. Evidence of backfill infiltration through joints and seams. • Significant corrosion, with minor attack of core alloy on aluminum components. • Heavy rust, with medium pitting on steel components.
5	Fair Condition - Potential exists for minor repair or rehabilitation. • Barrel shape is fair. Significant distortion at isolated locations in top half and extreme flattening at invert. Horizontal span is 10% to 15% greater than design. • Moderate cracking at bolt holes along one seam near the bottom of the pipe. Evidence that backfill infiltration through joints and seams has caused deflection of the pipe. • Significant corrosion, with moderate attack of core alloy on aluminum components. • Advanced section loss, with heavy pitting on steel components.
4	Poor Condition - Potential exists for major repair or rehabilitation. • Barrel shape has significant distortion throughout the length of the pipe and lower third may be kinked. Horizontal span is 10% to 15% greater than design. • Moderate cracking at bolt holes along one seam near the top of the pipe. Evidence that backfill infiltration through joints and seams has caused deflection of the pipe. • Extensive corrosion, with significant attack of core alloy on aluminum components. • Advanced section loss, with heavy pitting and isolated perforations on steel components.

3 Serious Condition - Repair or rehabilitation required.

- Barrel shape is poor, with extreme deflection at isolated locations and flattening of the crown with a radius 20 to 30 feet. Horizontal span is 15% to 20% greater than design.
- Barrel seams have 3” long cracks at bolt holes on one seam.
- Extensive corrosion and attack of core alloy, with scattered perforations on aluminum components.
- Advanced section loss, with heavy pitting and scattered perforations on steel components.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Barrel shape critical, with extreme deflection, distortion and flattening of the crown with radius over 30 ft. throughout the pipe. Horizontal span in excess of 20% greater than design.
- Barrel seams have cracks, spanning from bolt to bolt, on one seam.
- Extensive perforations, due to corrosion on aluminum components.
- Advanced section loss and extensive perforations on steel components.

1 "Imminent" Failure Condition - Structure is closed.

- Barrel shape is partially collapsed, with crown in reverse curvature.
- Barrel seams have failed.
- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Structure is closed.

- Barrel shape has totally failed.
- Structure is beyond repair or rehabilitation.

9.3.2. Corrugated Metal Pipe Arch Barrels

Code	Description
9	Excellent Condition - No maintenance or rehabilitation concerns. • No noticeable deficiencies or deterioration.
8	Very Good Condition - No maintenance or rehabilitation concerns. • Barrel shape has good, smooth curvature. Horizontal span is less than 3% greater than design. • Seams and joints are tight with no openings. • Minor construction defects with the protective coating intact. • Superficial corrosion, with slight pitting on aluminum components. • Light rust, with no pitting on steel components.
7	Good Condition - Potential exists for minor maintenance. • Barrel shape has good curvature. Top half has smooth curvature and bottom half has flattened but is still curved. Horizontal span is 3% to 5% greater than design. • Seams and joints have minor cracking at a few bolt holes and minor openings with potential for backfill infiltration. • Moderate corrosion of aluminum components. No attack of core alloy. • Medium rust, with light pitting on steel components.
6	Satisfactory Condition - Potential exists for major maintenance. • Barrel shape is fair. Top half has smooth curvature and the bottom half is flat. Horizontal span is no more than 5% greater than design. • Minor cracking at bolts along one seam. Minor joint and seam openings with evidence of backfill infiltration. • Significant corrosion, with minor attack of core alloy on aluminum components. • Heavy rust, with medium pitting on steel components.
5	Fair Condition - Potential exists for minor repair or rehabilitation. • Barrel shape is fair. Significant distortion in the top in one location with slight reverse curvature in one location in the bottom. Horizontal span is 5% to 7% greater than design. • Moderate cracking at bolt holes along a seam in one section. Backfill is being lost through the seam or joint causing slight deflections in the pipe barrel. • Significant corrosion, with moderate attack of core alloy on aluminum components. • Advanced section loss, with heavy pitting on steel components.

4 Poor Condition - Potential exists for major repair or rehabilitation.

- Barrel shape has significant distortion all along the top of the arch. The bottom has reverse curvature. Horizontal span is more than 7% greater than design.
- Moderate cracking at bolt holes along one seam with backfill infiltration causing major deflections.
- Extensive corrosion, with significant attack of core alloy on aluminum components.
- Advanced section loss, with heavy pitting and isolated perforations on steel components.

3 Serious Condition - Repair or rehabilitation required.

- Barrel shape poor. Extreme deflection in top arch in one location. Arch bottom has reverse curvature throughout. Horizontal span more than 7% greater than design.
- Barrel seams have 3" long cracks at bolt holes on one seam.
- Extensive corrosion and attack of core alloy, with scattered perforations on aluminum components.
- Advanced section loss, with heavy pitting and scattered perforations on steel components.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Barrel shape critical. Extreme deflection and distortion along top of the pipe. Horizontal span more than 7% greater than design.
- Barrel seams have cracks spanning from bolt to bolt on one seam.
- Extensive perforations, due to corrosion on aluminum components.
- Advanced section loss and extensive perforations on steel components.

1 "Imminent" Failure Condition - Structure is closed.

- Barrel shape is partially collapsed.
- Barrel seams have failed.
- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Structure is closed.

- Barrel shape has totally failed.
- Structure is beyond repair or rehabilitation.

9.3.3. Structural Plate Arch Barrels

Code	Description
9	Excellent Condition - No maintenance or rehabilitation concerns. • No noticeable deficiencies or deterioration.
8	Very Good Condition - No maintenance or rehabilitation concerns. • Barrel shape has good, smooth symmetrical curvature. Rise is within 3% of design. • Seams and joints are tight with no openings. • Minor construction defects, with the protective coating intact. • Superficial corrosion, with slight pitting on aluminum components. • Light rust, with no pitting on steel components. • Footings are in good condition with no erosion.
7	Good Condition - Potential exists for minor maintenance. • Barrel shape is good, with smooth, symmetrical curvature. Slight flattening of the top or sides in one section. Rise is within 3% to 4% of design. • Seams and joints have minor cracking at a few bolt holes and minor openings, with potential for backfill infiltration. • Moderate corrosion of aluminum components. No attack of core alloys. • Medium rust, with light pitting on steel components. • Moderate erosion causing differential settlement and minor cracking in footing.
6	Satisfactory Condition - Potential exists for major maintenance. • Barrel shape is fair, with smooth but non-symmetrical curvature. Slight flattening of the top or sides throughout. Rise is within 4% to 5% of design. • Minor cracking at bolts along one or more seams. Minor joint and seam openings with evidence of backfill infiltration. • Aluminum has significant corrosion and minor attack of core alloy. • Heavy rust, with medium pitting on steel components. • Footings show moderate cracking and differential settlement, due to extensive scour.
5	Fair Condition - Potential exists for minor repair or rehabilitation. • Barrel shape is fair, with significant distortion and deflection in one section, sides beginning to flatten or non-symmetrical shape. Rise is within 5% to 7% of design. • Moderate cracking at bolt holes along a seam in one section. Backfill is being lost through the seam or joint causing slight deflections in the pipe barrel. • Significant corrosion of aluminum components. No attack of core alloy. • Advanced section loss, with heavy pitting on steel components. • Footings show significant undercutting, extreme differential settlement, and major cracking

4 Poor Condition - Potential exists for major repair or rehabilitation.

- Barrel shape has significant distortion all along the top of the arch. Sides flattened with radius 100% greater than design. Rise is within 7% to 8% of design.
- Major cracking of seam near crown exists; infiltration of soil is causing major deflection.
- Extensive corrosion, with significant attack of core alloy on aluminum components.
- Advanced section loss, with heavy pitting and isolated perforations on steel components.
- Footings have rotated due to erosion and undercutting. Settlement has caused damage to metal arch.

3 Serious Condition - Repair or rehabilitation required.

- Barrel shape is poor, with extreme deflection in one section. Sides are virtually flattened. Extremely non-symmetrical. Rise is within 8% to 10% of design.
- Barrel seams are cracked 3” to either side of bolts.
- Extensive corrosion and attack of core alloy, with scattered perforations on aluminum components.
- Advanced section loss, with heavy pitting and scattered perforations on steel components.
- Footings are rotated, severely undercut with major cracking and spalling.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Barrel shape is critical, with extreme deflection throughout. Sides are flattened. Extremely non-symmetrical. Rise is greater than 10% of design.
- Barrel seams have cracks spanning from bolt to bolt, with significant amounts of backfill infiltration.
- Extensive perforations, due to corrosion on aluminum components.
- Advances section loss and extensive perforations on steel components.
- Severe differential settlement in footings has caused distortion and kinking of metal arch.

1 "Imminent" Failure Condition - Structure is closed.

- Barrel shape is partially collapsed, with local reverse curve of crown and sides.
- Barrel seams have failed, with backfill infiltration causing major deflection.
- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Structure is closed.

- Barrel shape has totally failed.
- Structure is beyond repair or rehabilitation.

9.3.4. Corrugated Metal Box Culvert Barrel

Code	Description
9	Excellent Condition - No maintenance or rehabilitation concerns. • No noticeable deficiencies or deterioration.
8	Very Good Condition - No maintenance or rehabilitation concerns. • Barrel shape has good, smooth symmetrical curvature. • Top arc mid-ordinate is within 11% of design. • Horizontal span is within 5% of design. • Side leg slightly deflected inward or outward and curvature smooth. • Seams and joints are tight with no openings. • Minor construction defects, with the protective coating intact. • Superficial corrosion, with slight pitting on aluminum components. • Light rust, with no pitting on steel components. • Footings are good, with no erosion.
7	Good Condition - Potential exists for minor maintenance. • Barrel shape has generally good smooth, symmetrical curvature. • Top arc mid-ordinate is within 11% to 15% of design. • Horizontal span is within 5% of design. • Side leg slightly deflected inward or moderately deflected outward, curvature smooth. • Seams and joints have minor cracking at a few bolt holes and minor openings, with potential for backfill infiltration. • Moderate corrosion, with no attack of core alloy on aluminum components. • Medium rust, with light pitting on steel components. • Footings show minor differential settlement due to erosion and minor hairline cracking.
6	Satisfactory Condition - Potential exists for major maintenance. • Barrel shape is fair, with smooth but non-symmetrical curvature. • Top arc mid-ordinate is within 15% of design. • Horizontal span within 5% to 6% of design. • Side leg moderately deflected inward or extremely deflected outward, curvature smooth. • Minor cracking at bolts along one or more seams. Minor joint and seam openings, with evidence of backfill infiltration. • Aluminum has significant corrosion, minor attack of core alloy. • Heavy rust, with medium pitting on steel components. • Footing shows differential settlement, due to extensive erosion and moderate cracking.

5 Fair Condition - Potential exists for minor repair or rehabilitation.

- Barrel shape is fair, with significant distortion and deflection in one section. Half top arcs are beginning to flatten and mid-ordinate of half top arc is 30% less than design.
- Top arc mid-ordinate is within 15% to 20% percent of design.
- Horizontal span is within 5% to 6% of design.
- Side leg bowed significantly inward or outward for less than 25% of the span length.
- Moderate cracking at bolt holes along a seam in one section. Backfill is being lost through the seam or joint causing slight deflections in the pipe barrel.
- Significant corrosion, with moderate attack of core alloy on aluminum components.
- Advanced section loss, with heavy pitting on steel components.
- Footing shows significant undercutting and extreme differential settlement with major cracking.

4 Poor Condition - Potential exists for major repair or rehabilitation.

- Barrel shape has significant distortion throughout. Mid-ordinate of the half top arc is less than 50% of design.
- Top arc mid-ordinate is within 20% to 30% of design.
- Horizontal span is within 5% to 6% of design.
- Side leg bowed significantly inward or outward over 25% to 50% of the span length, curvature irregular.
- Major cracking of seam near crown exists, infiltration of soil is causing major deflection.
- Extensive corrosion, with significant attack of core alloy on aluminum components.
- Advanced section loss, with heavy pitting and isolated perforations on steel components.
- Footings are rotated due to erosion and undercutting. Settlement has caused damage to metal arch.

3 Serious Condition - Repair or rehabilitation required.

- Barrel shape is poor, with extreme distortion and deflection in one section. Ordinate of half top arc is 50% to 70% less than design.
- Top arc mid-ordinate is 30% to 40% less than design.
- Horizontal span is within 6% to 8% design.
- Side leg extremely bowed inward over 50% to 100% of the span length or leg bowed outward causing severe bulges in metal.
- Barrel seams cracked 3” or more to either side of bolts.
- Extensive corrosion and attack of core alloy, with scattered perforations on aluminum components.
- Advanced section loss, with heavy pitting and scattered perforations on steel components.
- Footing is rotated and severely undercut. Major cracking and spalling has occurred, with significant damage to structure.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Barrel shape is critical, with extreme distortion and deflection throughout. Mid-ordinate of top half arc is more than 70% less than design.
- Top arc mid-ordinate is more than 40% less than design.
- Horizontal span is more than 8% of design.
- Side leg extremely bowed inward over 50% to 100% of the span length or leg bowed outward severely causing bulges or kinking in metal.
- Barrel seams have cracks spanning from bolt to bolt, with significant amounts of backfill infiltration.
- Extensive perforations due to corrosion on aluminum components.
- Advanced section loss and extensive perforations on steel components.
- Severe differential settlement of footing has caused distortion and kinking of metal arch.

1 "Imminent" Failure Condition - Structure is closed.

- Barrel shape is partially collapsed, with top arc curvature flat or reverse curved.
- Barrel seams have failed, with backfill infiltration causing major deflections.
- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Structure is closed.

- Barrel shape has totally failed.
- Structure is beyond repair or rehabilitation.

9.3.5. Precast Concrete Culvert Barrels

Code	Description
9	Excellent Condition - No maintenance or rehabilitation concerns. • No noticeable deficiencies or deterioration.
8	Very Good Condition - No maintenance or rehabilitation concerns. • Alignment between sections is good, with no settlement or misalignment. • Joints are tight, with no defects apparent. • Concrete has no cracking, spalling or scaling present and surface is in good condition.
7	Good Condition - Potential exists for minor maintenance. • Alignment between sections is good, with minor misalignment at joints and no settlement. • Joints have minor openings, with possible infiltration/exfiltration. • Concrete has minor hairline cracking at isolated locations. Slight spalling or scaling present on invert.
6	Satisfactory Condition - Potential exists for major maintenance. • Alignment between sections is fair, with minor misalignment and settlement at isolated locations. • Slight openings at joints causing minor backfill infiltration. Minor cracking or spalling at joints allowing exfiltration. • Concrete has extensive hairline cracks, some with minor delaminations or spalling and invert scaling less than 1/4” deep.
5	Fair Condition - Potential exists for minor repair or rehabilitation. • Alignment between sections is fair, with minor misalignment or settlement throughout. Evidence of piping exists. • Joints are open and allowing backfill to infiltrate with significant cracking or joint spalling. • Concrete cracks up to 1/8” wide, with moderate delamination and moderate spalling, exposing reinforcing steel at isolated locations. Areas on invert with surface scaling or spalls greater than ¼” deep.
4	Poor Condition - Potential exists for major repair or rehabilitation. • Alignment between sections is poor, with significant settlement. Evidence of piping exists. End sections are dislocated and are about to dislodge. • Joints show differential movement and separation. Significant infiltration or exfiltration exists at joints. • Concrete cracks open more than 1/8”, with efflorescence and spalling at numerous locations. Spalls have exposed rebars that are heavily corroded. Extensive surface scaling on inverts is greater than 1/2” deep.

3 Serious Condition - Repair or rehabilitation required.

- Alignment between sections is poor, with significant ponding. End section drop off has occurred.
- Joints show significant openings. Dislocated joints, in several locations, are exposing fill material. Infiltration or exfiltration is causing misalignment and settlement or depressions in roadway.
- Concrete shows extensive cracking and spalling. Invert scaling has exposed reinforcing steel.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Alignment between sections is critical. Culvert is not functioning due to alignment problems.
- Concrete displays severe spalling of the culvert wall. Invert concrete is completely deteriorated in isolated locations.

1 "Imminent" Failure Condition - Structure is closed.

- Culvert is partially collapsed.
- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Structure is closed.

- Culvert and fill have totally failed.
- Structure is beyond repair or rehabilitation.

9.3.6. Cast-In-Place Concrete Culvert Barrels

Code	Description
9	Excellent Condition - No maintenance or rehabilitation concerns.

9 Excellent Condition - No maintenance or rehabilitation concerns.

- No noticeable deficiencies or deterioration.

8 Very Good Condition - No maintenance or rehabilitation concerns.

- Alignment between sections is good, with no settlement or misalignment.
- Joints are tight, with no apparent defects.
- Concrete has no cracking, spalling or scaling.
- Footings are in good condition, with no invert scour.

7 Good Condition - Potential exists for minor maintenance.

- Alignment between sections is good, with minor misalignment at joints and no settlement.
- Joint material is deteriorated at isolated locations.
- Concrete has minor hairline cracking at isolated locations, with slight spalling or scaling present on invert or the bottom of top slab.
- Footings are in good condition, with only minor invert scour.

6 Satisfactory Condition - Potential exists for major maintenance.

- Alignment between sections is fair, with minor misalignment and settlement at isolated locations.
- Joint material is deteriorated, with minor separation possible. Minor cracking or spalling at joints is allowing infiltration or exfiltration.
- Concrete has extensive hairline cracks, some with minor delaminations or spalling. Invert scaling less than 1/4” deep or small spalls are present on invert or bottom of top slab.
- Minor scour near footings.

5 Fair Condition - Potential exists for minor repair or rehabilitation.

- Alignment between sections is fair, with minor settlement throughout the pipe. There is a possibility that piping may be occurring.
- Joints are open and allowing backfill to infiltrate, with significant cracking or joint spalling.
- Concrete cracks up to 1/8” wide are present, with moderate delamination and spalling that may expose reinforcing steel. Large areas of surface scaling (greater than 1/4” deep) exists.

4 Poor Condition - Potential exists for major repair or rehabilitation.

- Alignment between sections is poor, with significant settlement. Evidence of piping.
- Joints show differential movement and separation, with significant infiltration or exfiltration.
- Concrete cracks are greater than 1/8” wide with efflorescence. Spalls have exposed rebar that is heavily corroded. Extensive surface scaling on invert is greater than 1/2”
- Scour along footing, with slight undermining.

3 Serious Condition - Repair or rehabilitation required.

- Alignment between sections is poor, with significant ponding. End section drop off has occurred.
- Joints show significant openings and differential movement. Infiltration or exfiltration is causing misalignment and settlement or depressions in roadway.
- Extensive cracking is evident, with delaminations, spalling and slight differential movement. Scaling has exposed rebar in the bottom of the top slab or invert.
- Footing shows severe undermining, with slight differential settlement causing minor cracking or spalling in footing and walls.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Alignment between sections is critical. Culvert is not functioning due to severe misalignment.
- Concrete displays severe cracks, with significant differential movement. The concrete is completely deteriorated in isolated locations in the top slab or invert.
- Footings show severe undermining, with significant differential settlement causing severe cracks.

1 "Imminent" Failure Condition - Structure is closed.

- Culvert is partially collapsed.
- Footings show severe undermining resulting in partial collapse of structure.
- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Structure is closed.

- Culvert and fill have totally failed.
- Structure is beyond repair or rehabilitation.

9.3.7. Masonry Culvert Barrels

Code	Description
9	Excellent Condition - No maintenance or rehabilitation concerns.
	• No noticeable deficiencies or deterioration.
8	Very Good Condition - No maintenance or rehabilitation concerns.
	• Alignment of the stones is good, with no settlement or misalignment. • Mortar is tight, with no defects apparent. • Masonry shows no cracking or settlement. No missing or dislocated masonry is present. • Footings are in good condition, with no invert scour.
7	Good Condition - Potential exists for minor maintenance.
	• Alignment of the stones is good, with minor misalignment at joints and no settlement. • Mortar shows shallow deterioration at isolated locations. • Masonry displays surface deterioration at isolated locations. • Footings are good with only minor invert scour.
6	Satisfactory Condition - Potential exists for major maintenance.
	• Alignment of the stones is fair, with minor misalignment and settlement. • Mortar shows extensive areas of shallow deterioration. There is missing mortar at isolated locations. There is possible infiltration or exfiltration and minor cracking. • Masonry shows minor cracking. • Minor scour near footings.
5	Fair Condition - Potential exists for minor repair or rehabilitation.
	• Alignment of the stones is fair, with minor misalignment or settlement. • Mortar is generally deteriorated. There is loose or missing mortar at isolated locations and infiltration is apparent. • Masonry exhibits minor cracking with slight dislocation. There are large areas of surface scaling. • Moderate scour is present along footing.
4	Poor Condition - Potential exists for major repair or rehabilitation.
	• Alignment of the stones is poor, with significant settlement. • Mortar is severely deteriorated with significant loss. Significant infiltration or exfiltration noted. • Masonry displays significant displacement. • Scour along footing, with slight undermining.

3 Serious Condition - Repair or rehabilitation required.

- Alignment of the stones is poor, with significant ponding. Stone "drop-off" from the ends of the barrel may have occurred.
- There are extensive areas of missing mortar. Infiltration and exfiltration existing, causing misalignment of the culvert and settlement or depressions in the roadway.
- Masonry, in the lower part of the structure, is missing or crushed.
- Footing shows severe undermining, with slight differential settlement causing minor cracking or spalling in footing and minor distress in walls.

2 Critical Condition - Need for immediate repairs or rehabilitation is urgent.

- Alignment of the stones is critical. Culvert is not functioning due to severe misalignment.
- Masonry, in the top of the culvert, is missing or crushed.
- Footings displays severe undermining, with significant differential settlement causing severe cracks in footing and distress in walls.

1 "Imminent" Failure Condition - Structure is closed.

- Culvert is partially collapsed.
- Footings show severe undermining, resulting in partial collapse of structure.
- Study should determine feasibility of repair or rehabilitation.

0 Failed Condition - Structure is closed.

- Culvert and fill have totally failed.
- Structure is beyond repair or rehabilitation.

9.4. MOVABLE BRIDGE CONDITION EVALUATION CODING

For the purpose of achieving uniform evaluation of existing movable bridge structural, mechanical, hydraulic and electrical components by inspectors having different technical backgrounds, inspectors should refer to the AASHTO Movable Bridge Inspection Evaluation and Maintenance Manual 1st Edition. Coding systems used by FHWA in the NBIS program are based on assessing the physical condition of the element and describing it with a numerical value, and presumably refer to structural bridge components. Therefore, established FHWA guidelines should be used to assign condition evaluation codes to all structural and structural support systems and components.

Evaluation of electrical, hydraulic and mechanical elements is somewhat more subjective due to the sealed nature of some mechanical, hydraulic and electrical components. Table 9.4a provides an equivalent to the NBIS code and is recommended for general use.

To assist in the uniform application of the coding systems, the following broad definitions apply to the verbal descriptions given in Table 9.4a:

Condition	NBIS
Excellent	9
Very Good	8
Good	7
Satisfactory	6
Fair	5
Poor	4
Serious	3
Critical	2 (or 1 or 0)

Table 9.4a - Numeric Condition Evaluation Equivalents

EXCELLENT	No defects noted, component appears to be in new condition and functions as designed.
GOOD	Minor deterioration or wear noted, component appears to be functional.
FAIR	Obvious deterioration or wear noted. Component appears to be functional, but no longer operating like new. Component has useful remaining life.
POOR	Significant deterioration or wear noted. Component appears to be generally functional, but exhibits signs that failure will result from continued wear or deterioration. Component is nearing the end of its useful life.
CRITICAL	Significant deterioration or wear noted. Component appears to be marginally functional and exhibits signs that failure will result from continued wear or deterioration in the immediate future. Corrective action is required, as soon as possible, to avoid failure. If failure has occurred, the condition should be rated critical and the element flagged for corrective action. Explanatory notes should be added concerning whether the particular component can be bypassed or "jury-rigged" to allow continued safe operation until repairs are completed.

Special Note:

FHWA coding does not make a strong objective distinction between codes 7 and 8 nor 5 and 6. They may be interpreted as different degrees of the same condition.

Evaluation Methods For Electrical and Hydraulic Components

For electrical and hydraulic components, it is at times difficult to make objective condition evaluations based upon visual inspection. Electrical and hydraulic components are frequently sealed units that require substantial engineering expertise and time consuming functional testing to evaluate their condition. For these types of components, there are two methods that may be used to inspect and make decisions for numeric condition evaluation coding:

Engineering Study - The responsible owner agency may design an appropriate inspection and testing program for the electrical or hydraulic system internal components of each individual movable bridge. This program should be carried out by experienced electrical engineers, fluid power engineers, licensed electricians or hydraulic system mechanics.

Predicted Life - Agencies may opt to use a Predicted Life System of numeric condition evaluation, where each electrical and/or hydraulic component is assigned a predicted useful life. The condition evaluation code of each component starts at EXCELLENT (when the component is new) and lowers progressively as the component ages.
The major requirements of this system are as follows:

Component Life may be obtained by one of two methods: first, values may be selected from Table 9.4b and Table 9.4c that lists a conservative predicted life for various classes of electrical and hydraulic components on movable bridges; second, is to perform a component life evaluation for individual components and substitute the values determined by this study for the Table 9.4b and 9.4c values.

Component Labels are required on all electrical and/or hydraulic equipment subjected to the predicted life method. Component labels should be permanently attached weatherproof heat resistant metal or plastic engraved, stamped or indelibly printed on laminated tags or plaques that provide the following minimum information: tag number, bridge number, component name, date of manufacture, date of installation and date of last engineering study type inspection. The team that installs the tags should keep a log of all tag data. This data will then become a part of the bridge inventory file which can be used, at a later date, to replace damaged tags.

Numeric Condition Evaluation Coding can be based upon simple component age computation from the tag data and date of inspection. Components should be deemed to have the following condition ratings based upon age:

EXCELLENT - less than 15% of predicted life expended
GOOD - 15 to 35% of predicted life expended
FAIR - 35 to 65% of predicted life expended
POOR - 65 to 85% of predicted life expended
CRITICAL - more than 85% of predicted life expended

Electrical and/or hydraulic components that are rated critical by either of the above two methods are, by definition, subject to imminent failure. Owner agencies should take one of the following corrective actions:

Replace or rebuild the critical rated component(s).

Order the replacement part and make necessary preparations to replace before the next scheduled or anticipated necessary bridge opening.

Perform an engineering study that includes sufficient performance testing of the component(s) to allow revising the predicted component life. The improvement of the predicted life of a component by this method should not exceed a 50% extension of predicted life (i.e. if life was predicted to be 50 years, the maximum extension of predicted life would be the results of the study or 75 years, whichever is less).

For some existing bridges, there may be some difficulty in determining the age of in-service components. The age of electrical components containing or connected to wires insulated with asbestos or other fiber type insulation should not be assumed to be less than 30 years, unless conclusive documented proof is available of their age. Components should be assumed to be of bridge original installation, unless other documents are available showing the component to be a replacement part. Owners may, at their option, utilize a written professional opinion or written information obtained by request from a component manufacturer concerning the age of components, in lieu of contract documentation. Documents used for determining component age should become part of the bridge file and should be included in subsequent inspection reports. Components for which no age data can be obtained should be assumed to be not less than 30 years of age.

COMPONENT TYPE	PREDICTED LIFE FOR STATED CONDITIONS (IN YEARS)					
	AVERAGE USAGE 400 to 4000 openings per year		LOW USAGE Less than 400 openings per year		HIGH USAGE More than 4000 openings per year	
	Open to environment	Closed room or sealed unit	Open to environment	Closed room or sealed unit	Open to environment	Closed room or sealed unit
Motors and Generators (Overall)	36	70	34	66	30	50
Brushes in DC Brush-Type Motors/ Generators	10	16	10	20	8	12
Limit Switches	10	14	10	18	6	10
Motor Switches	30	60	24	50	20	40
Open Wiring	20	50	18	46	16	40
Wiring in Conduit	40	60	36	54	32	50
Wiring Terminals	20	40	16	32	14	30
Contactors	36	50	34	46	30	40

Table 9.4b - Predicted Electrical Component Life

Additional Codes

There are occasions when an item cannot be coded for condition. In these situations, the item should be coded NOT APPLICABLE, INACCESSIBLE, or UNKNOWN.

NOT APPLICABLE **(NA)** is used for an item that does not and should not exist on the bridge being inspected. For example, the item "programmable logic controllers" would be coded NA for a manually operated swing bridge.

INACCESSIBLE **(IA)** is used for an item that cannot be reached by reasonable non-destructive means during inspection. For example, steel members covered by concrete encasement would be coded IA. When an item is coded IA, a note should be added explaining why the item could not be accessed and whether it might be accessed in the future.

UNKNOWN **(UN)** is to be used for items that are not feasible to investigate within the scope of the particular inspection, but which could be determined by a more in-depth procedure. For example, a structural inspector might code foundation details "UN" if plans were unavailable and a test pit was not included in the scope of his inspection.

COMPONENT TYPE	PREDICTED LIFE FOR STATED CONDITIONS (IN YEARS)					
	AVERAGE USAGE 400 to 4000 openings per year		LOW USAGE Less than 400 openings per year		HIGH USAGE More than 4000 openings per year	
	W/O Fluid Testing	With Fluid Testing	W/O Fluid Testing	With Fluid Testing	W/O Fluid Testing	With Fluid Testing
Accumulator, Reservoirs, Pumps and Motors or Rotary Actuators*	36	50	34	44	24	34
Cylinders*	20	40	18	36	16	30
Operating Valves and Hydraulic Systems Sensors other than electromechanical limit switches*	16	30	14	28	10	20
Welded Pipe or Flanged Pipe with O-Rings	36	50	34	44	24	34
Tubing	18	25	16	22	12	18
Flexible Hoses	10	14	10	18	6	10

*Note: If systems have a history of contamination or overheating, a 50% reduction in the tabulated values shall be assumed for components subject to accelerated wear of seals, o-rings and other soft parts that can be easily damaged by grit or varnish accumulation.

Table 9.4c - Predicted Hydraulic Component Life

Guidelines for Condition Coding

The procedure for condition coding of bridge components and systems requires a careful examination of many complex and often conflicting factors that the inspector may encounter during a typical inspection. In order to ensure that the coding process is performed in a consistent manner, general guidelines are presented to assist the inspector in selecting the most appropriate code for a particular item. During the condition evaluation process the inspector should use a three-step approach when gathering information for a movable bridge system or component. These steps represent different levels of condition information, which when evaluated and documented with each step, refines the inspectors decision on selecting the appropriate coding.

Routine Condition Examination: Condition information is gathered and documented by the inspector based on external signs of deterioration or defects, (e.g. corrosion, wear, abrasion, cracking, misalignment, allowable clearances, fluid levels, proper lubrication, exposed wiring, etc.)

Functional Examination: The component or system is inspected during operation of the bridge. The inspector observes the component, noting overall performance, unusual sounds, vibrations, temperature increase, unusual odors, and/or looseness in shafts, bearings, etc.

Special Examination: The component or system is disassembled or investigated by various nondestructive techniques (magnetic particle, ultrasonic, radiography, etc.).

Special Note:

Trial openings should be made, as necessary, to verify that all components and systems are functioning properly. Trial openings, for the purpose of functional examinations, should be made separately from the opening for passage of navigational traffic so as not to divert the bridge operator's attention between the two interests. Additionally, it may not be possible to perform functional examinations if it is not safe to open the bridge. In this case, or other unusual circumstances, the inspector should make note of why functional examination could not be performed

Critical Deficiency Procedures

When a component or functional system has been rated as critical, it is imperative to report this information to the bridge owner as soon as possible. If emergency repairs are required to maintain safe operation, they should begin as soon as possible. A critical deficiency report should be prepared in the field the same day and distributed in accordance with Section 3.2.6. If critical conditions, that affect safe bridge operation, cannot be corrected before the next bridge opening, the appropriate authorities within the owner agency and affected navigation regulatory agencies should be notified as soon as possible.

9.5. SUBSTRUCTURE

The following guidelines have been developed for the condition rating of bridge substructure units. They are intended to supplement the FHWA Recording and Coding Guide to make it easier to determine the most appropriate condition rating to be assigned to the substructure and should be used in conjunction with the FHWA Recording and Coding Guide, Item 60 used for data entry into forms BRI-18 and BRI-39.

These rating guidelines shall apply to steel, concrete, masonry and timber substructures. They shall be used to rate the substructure unit's overall stability and the condition of the substructure material(s). The condition of bearings, joints, paint system, etc., generally will not influence the rating of the substructure. Deficiencies in the substructure, noted in previous inspection reports that have since been retrofitted, shall only consider the condition of the retrofit when establishing the condition code.

In the event the condition of the substructure unit's overall stability (i.e. ability to support the superstructure) and the condition of the substructure unit's materials are different, the lower rated condition shall be used.

Definitions:

Deficiency - Lack or shortage of structural component (missing fasteners, undersized members, etc.) from the quantity specified by the design that affects the ability of the structural component to function in its design capacity.

Deterioration - Areas exhibiting conditions which decrease their capacity. concrete: cracks, delamination, efflorescence, scale, spalls, etc.; steel: cracks, rust, section loss, etc.; timber: checks, cracks, fire damage, insect damage, rot, etc.; masonry: cracks, joint deterioration, missing stones, etc.; movement (vertical, lateral, or rotational) due to settlement; vehicle or vessel impact damage, etc.; loss of bearing area (scour, undermining, etc.); or any other defect that detracts from the "As-Built" condition of the unit.

Code **Description**

9 Excellent Condition – No maintenance or rehabilitation concerns.

- No noticeable deficiencies or deterioration.

8 Very Good Condition – No maintenance or rehabilitation concerns.

- Very minor construction or fabrication defects (minor honeycombing of concrete members, minor fabrication or installation dents in steel members, etc.) that do not affect the capacity or function of the member.
- Isolated locations of lost joint pointing or cracking of joint pointing observed in masonry units. (Masonry joint pointing is defined as surface applied mortar in dry laid masonry or the outer 1 1/2" - 2" of the mortar bed in cement rubble mason*ry.)*

7 Good Condition – Potential exists for minor maintenance.

- Isolated locations of embankment erosion.
- Noncritical, hairline cracks (up to 1/32”) noted in concrete units that do not affect the serviceability of the member.
- Isolated locations of delamination, scaling, or small spalls up to 1” deep in concrete units, with no exposed reinforcing bars.
- Isolated locations of loose or missing fasteners.
- Light to medium rust on less than 25% of the steel surface area, with no section loss.
- Minor cracking or splitting of timber members, with no section loss.
- Widespread (up to 70%) loss of joint pointing with interior joint mortar of masonry units in good condition (maximum depth of loss = 2” for mortar laid construction).
- Minor efflorescence bleeding or water leakage from joint mortar of masonry units.

6 Satisfactory Condition – Potential exists for major maintenance.

- Numerous or large areas of embankment erosion. No evidence of undermining and/or scour is evident.
- Minor opening of vertical expansion joints, with no evidence of substructure tipping.
- Noncritical hairline or fine cracks (up to 1/16” wide), with minor efflorescence noted in concrete units.
- Isolated spalls or scale of concrete units deep enough to expose the mat of reinforcing bars closest to the surface. Light surface corrosion on the exposed reinforcing bars, with no section loss.
- Concrete may be delaminated (concrete surface sounds hollow when struck with a hammer) on less than 10% of any individual substructure unit.
- Minor crushing, denting, section loss, etc. due to impact damage, (i.e. damage that is not structurally significant).
- Light to medium rust on greater than 25% of the steel surface area.
- Severe rust (< 1/16” section loss) on less than 25% of the steel surface area of a critical section.
- Minor decay, cracking, splitting, fire damage, or wet areas of main timber members (Negligible section loss).
- Widespread (up to 70%) loss of joint pointing material, cracking and/or minor loss of interior joint mortar observed in masonry units (maximum depth of loss = 4" for mortar laid construction). Stones are firmly set in their original positions (no settlement).
- Moderate efflorescence bleeding or water leakage from joints of masonry units.

5 Fair Condition – Potential exists for minor repair or rehabilitation.

- Advanced erosion or minor scour exists, with no undermining.
- Vertical joints in the substructure unit may show differential opening.
- Noncritical cracks, spalls, scale, or impact damage in concrete units which expose the top mat of steel reinforcement, with minor deterioration or section loss of the reinforcing bars.
- Delaminations (concrete surface sounds hollow when struck with a hammer) may be more wide spread, up to 25% of the surface area on any individual substructure element.
- Widespread discoloration, efflorescence or wetness on concrete surfaces indicating porous or saturated concrete (not joint leakage), with moderate efflorescence bleeding from cracks in concrete units.
- Severe rust on greater than 25% of the steel surface area with section loss.
- Moderate decay, cracking, splitting, fire damage, or wet areas of main timber members, with measurable section loss.
- Extensive loss of joint pointing material, cracking and/or minor loss of interior joint mortar (6" maximum depth) observed in masonry units. Few stones may be loose but still in original position.
- Widespread efflorescence bleeding or water leakage from joints of masonry units.

4 Poor Condition – Potential exists for major repair or rehabilitation.

- Advanced scour, isolated areas of minor undermining may exist.
- Vertical joints in the abutment are opened wide enough to allow exfiltration of the backfill material.
- Tipping of the substructure unit measured at less than 1% (from original position, accounting for original batter, if any).
- Noncritical cracks, spalls, scale, or impact damage in concrete units which expose the top mat of steel reinforcement, with moderate deterioration or section loss of the reinforcing bars.
- Critical cracks (up to 1/32”) noted on one or more concrete units.
- Extensive efflorescence and/or active water leakage from cracks/spalls in concrete units.
- Extensive concrete delaminations in backwalls, bridge seats and cap beams (not under bearings), footings (except at connection to columns of piles), wingwalls, secondary members, and other areas not in the direct load path of the structure.
- Severe rust on greater than 25% of the steel surface area and/or section loss (up to 5% of the total flange cross sectional area or up to 25% of the total web cross sectional area) noted in a critical section on one or more members.
- Advanced decay, cracking, splitting, fire damage, or wet areas of main timber members, with advanced section loss.
- Severe loss and cracking of joint pointing and interior mortar materials of masonry units, with minor displacements or deformations of stones (mortar loss up to 12" deep).
- Cracks extend through two or more horizontal stone courses of masonry units. Pieces adjacent to crack may be loose.

3 Serious Condition – Repair or rehabilitation required.

- Advanced undermining/scour, causing a loss of contact between the foundation and support material. No evidence of deterioration or settlement of the substructure units caused by the undermining.
- Tipping of the substructure unit is less than 2% (from original position, accounting for original batter, if any).
- Noncritical cracks, spalls, scale, or impact damage which exposes top mat of steel reinforcement, with advanced deterioration or section loss of the reinforcing bars.
- Critical cracks up to 1/16" wide noted creating significant effects on the structural integrity of the member.
- Severe leakage of water through cracks and/or spalls noted on concrete units.
- Extensive concrete delaminations in bearing seats, columns, footings (at connection to columns or piles), piles, or other areas in the direct load path of the structure. Delaminated concrete is loose and poses a potential hazard to pedestrian, vehicular or marine traffic.
- Severe rust throughout steel members, with severe section loss.
- Severe decay, cracking, splitting, fire damage, or wet areas of main timber members, with severe section loss.
- Severe loss and cracking of joint pointing and interior mortar materials of masonry units, with moderate displacements or deformations of stones.
- Cracks extend full height of masonry units. Pieces adjacent to cracks may be loose.

2 Critical Condition – Need for immediate repairs or rehabilitation is urgent.

- Advanced undermining/scour, causing a loss of contact between the foundation and support material in bearing. Item #113 is coded a "2".
- The substructure has moved from its design location and is not providing adequate support for the superstructure. The substructure's ability to remain in service without corrective action should be investigated.
- Tipping of the substructure unit is severe enough for possible displacement of the superstructure.
- Severe deterioration of the concrete, reinforcing bars or anchor bolts in the vicinity of cracks, spalls, scale or impact damage.
- Critical cracks greater than 1/16" wide in concrete members creating a severe effect on the structural integrity of the member.
- Extensive concrete delamination leading to spalling in critical areas and/or loose concrete is dropping to areas where it may cause damage or injury to people or property below.
- Severe loss and cracking of joint pointing and interior mortar materials of masonry units, with major displacements or deformations of stones.
- Severe deterioration of primary structural elements.
- Local failures of structural components have occurred in primary members.

1 “Imminent” Failure Condition – Structure is closed.

- Item #113 is coded a "1".
- Multiple locations of local member failure.
- The substructure has moved from its design location and is not providing adequate support for the superstructure. The substructure is unable to remain in service without corrective action.

0 Failed Condition – Structure is closed.

- Item #113 is coded a "0".
- The substructure is not supporting the superstructure, as a result of excessive movement or deterioration, and is beyond repair or rehabilitation. Replacement is required.

Scour Critical Bridges

Item 113 - "Scour Critical Bridges", indicates a bridge's susceptibility to failure due to scour. This item is coded by the office staff based on a scour evaluation of the structure. Bridges that have a rating for Item 113 of "3" or less are considered to be "scour critical". Whenever a rating of "3" or below is assigned to Item 113, the rating for Item 60 - Substructure, should also be reviewed to reflect the severity of actual scour conditions, and resultant damage to the bridge. The rating factor given to Item 60 should be consistent with the one given to Item 113 whenever a rating factor of 2 or below is determined for Item 113 - Scour Critical Bridges.

Coding Guidance for Item 60 - Substructure, when Item 113 is "3" or less:

Code 3 **Serious Condition:** for scour having partially removed foundation support, removal of stream bed material below the top of footing for spread footings or exposing the tops of piles. Bridge foundation is potentially unstable. Item 113 is rated "3".

Code 2 **Critical Condition:** extensive scour has occurred at bridge foundations and they have been determined to be unstable. Item 113 is rated "2".

Code 1 **"Imminent" Failure Condition:** scour has removed foundation material resulting in major deterioration of critical structural components with obvious vertical or horizontal movement. Bridge is closed to traffic, but corrective action may put it back in light service. Item 113 is rated "1".

Code 0 **Failed Condition:** Bridge has failed and is closed to traffic. Item 113 is rated "0".

Note: If there is no evidence of scour present, the condition rating should be based solely on the structural condition of the substructure element. Likewise, the above numbers should be considered "maximum" ratings for substructure elements that exhibit the amount of scour indicated. The rating of elements in poor structural condition may be controlled by the structural condition and be less than the "scour ratings" given above.

9.6. RATING GUIDELINES FOR FORM BRI-18 "SUB-ITEMS"

ITEM 58 - DECK

1. OVERLAY

Rating Guidelines

The item *Overlay* shall be rated “N”.

SPECIAL NOTE
Railroad Bridges do not use an overlay.

2. DECK STRUCTURAL CONDITION

What to Rate
Elements to be rated include the deck, and any stay-in-place formwork used to construct cast-in-place concrete decks.

Conditions to Consider

The condition rating shall consider the physical condition of the deck (e.g.: concrete decks: cracks, delaminations, scale, spalls/potholes, leakage/efflorescence, etc.; steel decks: broken welds, failed/missing fasteners, rusting and section loss, etc.; timber decks: timber decay, failed/missing fasteners, splitting, etc.), as well as the quality of the riding surface (e.g. ruts, rippling, evenness at joint locations, etc.).

Rating Guidelines

The deck structural condition shall be rated in accordance with the following criteria:

Concrete Decks	-	See Section 9.1.2 Reinforced Concrete Decks
Steel Decks	-	See Section 9.1.5 Steel
Timber Decks	-	See Section 9.1.6 Timber

If the approach roadway pavement is carried on fill over the structure (filled arches, frames or culverts), there is no "deck" and the *Deck Structural Condition* is coded "N". In this case, the deck overall rating shall be coded as "P" (Partial) on Form BRI-18 so that the condition ratings and descriptions of the deck sub-items will still be printed.

3. CURBS

Rating Guidelines

The item *Curbs* shall be rated “N”.

SPECIAL NOTE
Railroad Bridges do not have curbs.

4. MEDIAN

Rating Guidelines

The item *Median* shall be rated “N”.

SPECIAL NOTE
Railroad Bridges do not have medians.

5. SIDEWALKS

What to Rate
Elements to be rated include the sidewalk deck located above the floor system (including all visible faces: top, bottom, and fascia), and any stay-in-place formwork used to construct cast-in-place concrete sidewalk decks.

Conditions to Consider

The condition rating shall consider the physical condition of the sidewalk deck (e.g. concrete decks: cracks, delamination, leaching, scale, and spalls/potholes; steel decks: broken welds, failed/missing fasteners, and section loss; timber decks: crushing, failed/missing fasteners, and section loss, etc.), as well as, the quality of the riding surface (e.g. ruts, rippling, evenness at joint locations, etc.).

Rating Guidelines

The sidewalk shall be rated in accordance with the following criteria:

Concrete Sidewalk	-	See Section 9.1.2 Reinforced Concrete Decks
Steel Sidewalk	-	See Section 9.1.5 Steel
Timber Sidewalk	-	See Section 9.1.6 Timber

6. PARAPET

Rating Guidelines

The item *Parapet* shall be rated “N”.

SPECIAL NOTE
Railroad Bridges do not use a parapet.

7. RAILING

What to Rate

Elements to be rated include the railing along both fascias of the bridge (open concrete balustrades, steel, timber, etc.), as well as, any anchor bolts or fasteners to the parapet or deck.

Conditions to Consider

The condition rating shall consider the physical condition of the railing (e.g. cracks, spalls, section loss, broken fasteners, impact damage, etc.). Pedestrian railings should be evaluated for conformance with the AREMA Specifications (Top of handrail shall be not less than 3'-6" above surface of walkways. An intermediate rail, or rails, shall be provided, with clear space between rails, or between rail and top of walkways, not to exceed 1'-9").

Rating Guidelines

9	Excellent	No defects.
8-7	Very Good /Good	Some minor defects (hairline cracks or light-moderate scale in concrete; light rust, small dents in steel; checks in timber; etc.) which do not yet require routine maintenance.
6-5	Satisfactory /Fair	Areas of deterioration with minor section loss (wide cracks, heavy scale, small spalls in concrete; moderate rust, large dents, loose or missing fasteners in steel; large dents; minor decay/rot, loose or missing fasteners in timber; etc.). Pedestrian rail openings are in excess of AREMA Specifications at few random locations due to damage or deterioration. Maintenance repairs required.
4-3	Poor /Serious	Areas of deterioration with significant section loss (large spalls, severe scale, exposed reinforcing bar in concrete; heavy rust, section loss, broken or missing sections in steel; severe decay/rot, section loss, broken or missing sections in timber; etc.). Pedestrian rail openings are in excess of AREMA Specifications at numerous locations - rail system does not comply with current Specifications. Major rehabilitation required.
2-1	Critical /"Imminent" Failure	Railing has deteriorated, such that, it is no longer functioning as intended. Replacement required.

8. PAINT

Rating Guidelines

The item *Paint* shall be rated "N".

SPECIAL NOTE
Railroad Bridges do not use paint on the decks.

9. DRAINS

What to Rate

Elements to be rated include all components of the bridge drainage system (scuppers, gratings, downspouts, troughs under deck joints, weep pipes, etc.). All supports for bridge drainage system elements shall also be rated under this item.

Conditions to Consider

The condition rating shall consider the physical condition of the bridge drainage system and its supports (e.g. cracks, spalls, section loss, broken fasteners, impact damage, etc.), as well as, the system's ability to remove runoff from the bridge.

The system’s ability to remove runoff from the bridge shall be rated in accordance with the Rating Guidelines below. In the event the bridge drainage system’s physical condition and its ability to remove runoff are not equal, the lower of the rated conditions shall be recorded.

Rating Guidelines

9	Excellent	No defects.
8-7	Very Good /Good	Light debris accumulation in gutters, troughs, gratings, etc. which is correctable through routine maintenance. Debris accumulation has little or no impact on drainage system’s ability to remove runoff.
6-5	Satisfactory / Fair	Areas of minor standing water on deck (due to moderate debris accumulation in gutters, troughs, gratings, etc.; system inadequacy to remove required runoff volume; etc.) or on bridge superstructure or substructure surfaces below deck level (due to drainage onto these areas). Maintenance repairs required.
4-3	Poor /Serious	Areas of significant standing water on deck (due to heavy debris accumulation in gutters, troughs, gratings, etc.; system inadequacy to remove required runoff volume; etc.) or on bridge superstructure or substructure surfaces below deck level (due to drainage onto these areas). Major rehabilitation required.
2-1	Critical /”Imminent” Failure	Drainage system has deteriorated such that it is no longer functioning as intended. Replacement required.

10. LIGHTING STANDARD

What to Rate

Elements to be rated include lighting standards and supports (concrete, steel, aluminum, timber, masonry, etc.), as well as, any anchor bolts or fasteners to the parapet or deck. Different types of lighting to be rated include: underbridge lights, advance warning lighting (common on movable spans, bridges on poor alignments, bridge approaches with poor sight distance, etc.), aerial obstruction lights, etc.

Conditions to Consider

The condition rating shall consider the physical condition of the lighting standards and supports (e.g. cracks, spalls, section loss, broken fasteners, impact damage, etc.). Any condition, which may create a safety hazard (e.g. exposed electrical wires, broken support or conduit hanging above traffic, etc.), shall be noted and described.

Rating Guidelines

9	Excellent	No defects.
8-7	Very Good /Good	Minor defects (loose conduit supports, globe cracked, etc.) which do not yet require maintenance repairs.
6-5	Satisfactory /Fair	Visibility is partially impaired (bulb or globe replacement required, loose supports, etc.). Maintenance repairs required.
4-3	Poor /Serious	Light is not operating (supports broken, wiring exposed, etc.). Major rehabilitation required.
2-1	Critical /"Imminent" Failure	Navigation light has defects that prohibits it from functioning as intended. Replacement required.

11. UTILITIES TYPE/SIZE

What to Rate

Elements to be rated include the grounding and bonding , utilities, utility conduits, and supports (concrete, steel, aluminum, timber, masonry, PVC pipe etc.), as well as, any anchor bolts or fasteners to the parapet, deck or cross frames and.

Conditions to Consider

The condition rating shall consider the physical condition of the utilities, utility conduits, and utility supports. Any condition, which may create a safety hazard (e.g. exposed electrical wires, broken support or conduit hanging above traffic, etc.), shall be noted and described.

Rating Guidelines

The utilities, utility conduits and supports shall be rated using engineering judgment in accordance with the 0 to 9 scale.

12. CONSTRUCTION JOINTS

Rating Guidelines

The item *Construction Joints* shall be rated “N”.

SPECIAL NOTE
Deck joints are not visible on Railroad Bridges.

13. EXPANSION JOINT

Rating Guidelines

The item *Expansion Joint* shall be rated “N”.

SPECIAL NOTE
Deck joints are not visible on Railroad Bridges.

ITEM 59 - SUPERSTRUCTURE

1. BEARING DEVICES

What to Rate

Elements to be rated include fixed and expansion bearings and anchor bolts. Additionally, the condition of the substructure may be included, if deterioration of the substructure elements (bearing seat, pier or bent cap, etc.) is so severe, it is judged to be affecting the capacity of the bearing.

Conditions to Consider

The condition rating shall consider the physical condition of the bearing (rust, cracks, loose or broken fasteners, section loss, alignment, etc.), "Pumping" the movement of the bearing under live load, anchor bolts (rust, loose or broken fasteners, etc.), and substructure (undermining of bearing), when applicable.

Rating Guidelines

The bearing devices shall be rated in accordance with Section 9.1.1 *Bearings*.

2. STRINGERS, 3. GIRDERS & 4. FLOORBEAMS

What to Rate - Stringers

Elements to be rated include the stringers, stringer connections, and stringer diaphragms that are part of a stringer/floorbeam floor system. Beams on multi-beam bridges (bridges with longitudinal beams and no transverse beams) shall not be rated under this item; they shall be rated under the Item *Girders*.

What to Rate - Girders

Elements to be rated include the girders, girder connections, and girder diaphragms. Beams on multi-beam bridges (bridges with longitudinal beams and no transverse beams) shall be rated under this item, as well as, the girder portions of girder-floorbeam-stringer bridges.

What to Rate - Floorbeams

Elements to be rated include the floorbeams and floorbeam connections.

Conditions to Consider

The condition rating shall consider the physical condition of the member, member connections, and diaphragms (cracks, spalls, rust, section loss, broken fasteners, impact damage, etc.). The condition rating of the primary structural element should be the same as the overall condition rating for Item 59 - *Superstructure*.

Rating Guidelines

Stringers, floorbeams and girders shall be rated in accordance with Sections 9.1.3 -9.1.6 of this manual, as applicable.

5. TRUSSES

What to Rate

Trusses-General:	Elements to be rated include the primary truss members (top chord, bottom chord, diagonals, and verticals) and their connections.
Trusses-Portals:	Rate the secondary support members connecting two or more trusses above the deck level and their connections, including portals, upper lateral bracing and sway bracing.
Trusses-Bracing:	Rate the secondary support members connecting two or more trusses below the deck level and their connections, including lower lateral bracing, wind bracing and sway frames on deck trusses.

Conditions to Consider

The condition rating shall consider the physical condition and alignment of the truss members, portals, bracing, and connections (rust, section loss, broken fasteners, impact damage, cracks, splits/checks, bowing, tipping, tilting, etc.).

Rating Guidelines

Truss components shall be rated in accordance with Section 9.1.5 *Steel* or Section 9.1.6 *Timber*, as applicable.

6. PAINT

What to Rate

Elements to be rated include the paint, or protective coating, on all superstructure members (bearing devices, stringers, floorbeams, girders, trusses, etc.).

Conditions to Consider

The condition rating shall consider the physical condition of the paint or protective system, and its ability to protect the surfaces where it has been applied. This rating is not based on the severity of corrosion, if any, on the protected surfaces.

Rating Guidelines

9	Excellent	No defects.
8-7	Very Good /Good	Paint system is generally smooth and uniform. The system may exhibit isolated areas (less than 10%) of peeling or delaminations in the top or inner layers; however, the primer is still intact and able to protect against the environment. Isolated areas of cracking or excessive chalking may be present (less than 10%). Less than 5% of painted surfaces may exhibit rusting.
6-5	Satisfactory /Fair	Paint system is showing signs of deterioration. Peeling or delamination in top or inner layers of the system is more prevalent. Less than 50% of painted surfaces are rusting. Most of the rusting is located at the beam ends and diaphragms where members have been subjected to leakage.
4-3	Poor / Serious	Paint system shows significant deteriorations. Greater than 50% of painted surfaces are rusted. Peeling is noted throughout the painted surfaces.
2-1	Critical /"Imminent" Failure	Paint system has fully deteriorated. Greater than 90% of painted surfaces are rusted and/or peeling.

7. RUST

What to Rate

All steel superstructure elements should be considered in this item.

Conditions to Consider

The rating shall consider the extent and severity of rusting and section loss on the overall functionality and capacity of the steel members.

Rating Guidelines

This item shall be coded in accordance with Section 9.1.5 *Steel*.

8. MACHINERY MOVABLE SPAN

What to Rate

Elements to be rated include all machinery and components of the operating systems of movable bridges (motors, gears, shafts, cables, chains, sprockets, racks, pinions, etc.), as well as, their supports and connections.

Conditions to Consider

The rating shall consider the physical condition of the operating machinery, supports, and connections (cracks, spalls, rust, section loss, broken fasteners, impact damage, etc.), as well as, the functional capacity of the machinery and components.

Rating Guidelines

The machinery components shall be rated in accordance with Section 9.4 *Movable Bridge Condition Evaluation Coding*.

9. RIVETS & BOLTS

What to Rate

All of the fasteners in the superstructure should be considered in this item.

Conditions to Consider

The rating shall consider the extent and severity of rusting and section loss on the overall functionality and capacity of the fasteners.

Rating Guidelines

This item shall be coded in accordance with Section 9.1.5 *Steel*.

10. WELDS-CRACKS

What to Rate

All welded connections in the superstructure should be considered in this item.

Conditions to Consider

The rating shall consider the condition of the welded connections, paying attention to broken or cracked weld.

Rating Guidelines

This item shall be coded in accordance with Section 9.1.5 *Steel*.

11. TIMBER DECAY

What to Rate

All timber superstructure elements should be considered in this item,

Conditions to Consider

The rating shall consider the extent of deterioration and the severity of any damage to the members (cracks, splits, rot, crushing, freeze-thaw damage, insect damage, etc.) and the member's capacity to carry the design load.

Rating Guidelines

This item shall be coded in accordance with Section 9.1.6 *Timber*.

12. CONCRETE CRACKING

What to Rate

All concrete superstructure elements should be considered in this item,

Conditions to Consider

The rating shall consider the extent and severity of cracking, hollow spots, spalls, section loss and the overall functionality and capacity of the concrete members.

Rating Guidelines

This item shall be coded in accordance with Section 9.1.3 *Reinforced Concrete*.

13. COLLISION DAMAGE

What to Rate

Evaluate the extent to which superstructure elements have been damaged by vehicle, shipping or flood debris impacts.

Conditions to Consider

The rating shall consider the extent of the collision damage on the member (bends, crushed members, dents, exposed steel reinforcement, etc.) and the member's capacity to carry the design load.

Collision damage typically occurs at the point of minimum vertical clearance (for bridges over roadways), minimum horizontal clearance, or the first location where the bridge restricts the roadway opening [fascia girders, ends of deck girders (for thru-girders) truss portals, truss endposts (for through trusses), etc.].

Rating Guidelines

These rating guidelines are to be used for the described defects when found on primary members. Defects located on secondary members should not be rated as severely as similar defects located on primary members.

9	Excellent	No evidence of collision damage.
8-7	Very Good /Good	Some evidence of minor collision(s) (minor scrapes or nicks in steel, concrete, or timber members, etc.) which do not require maintenance repairs.
6-5	Satisfactory /Fair	Areas of collision damage with minor losses (moderate bends, dents or tears in steel, concrete, or timber members; minor crushing of timber members; crushing with exposed steel reinforcing bars in concrete members, etc.). Maintenance repairs required.
4-3	Poor /Serious	Areas of collision damage with significant losses (severe bends, dents or tears in steel, concrete, or timber members; severe crushing of timber members; crushing with significant damage to reinforcing steel and distortion of concrete members, etc.). Major rehabilitation required.
2-1	Critical /"Imminent" Failure	Member has been damaged, such that, it is no longer functioning as intended. Replacement required.

14. ALIGNMENT OF MEMBERS

What to Rate

Evaluate the overall alignment of members with respect to each other and their original/design location.

Conditions to Consider

The rating shall consider the vertical and horizontal alignment of members and potential reasons for any misalignment (construction defect, overstress, thermal movement, etc.).

Rating Guidelines

These rating guidelines are to be used for the described defects when found on primary members. Defects located on secondary members should not be rated as severely as similar defects located on primary members.

9	Excellent	No defects.
8-7	Very Good /Good	Minor misalignment that appears to be the result of a construction defect, such as minor negative camber. No repairs required.
6-5	Satisfactory /Fair	Areas of misalignment that appear to be the result of a moderate construction defect, minor thermal movement, or minor overstress such as minor tipping of beam ends, measurable negative camber or rotation of bearing assemblies, etc. Maintenance repairs required.
4-3	Poor /Serious	Areas of misalignment which appear to be the result of a significant construction defect, moderate thermal movement or moderate overstress such as significant bowing or tipping of beam ends, significant movement along an entire line or bearings, significant negative camber, etc. Major rehabilitation required.
2-1	Critical /”Imminent” Failure	Member is misaligned, such that, it is no longer functioning as intended. Replacement required.

15. DEFLECTION UNDER LOAD

What to Rate

Evaluate the deflection of individual members or entire spans under live load.

Conditions to Consider

The rating shall consider the vertical deflection in relation to design standards and user (vehicles and pedestrians) safety and comfort.

Rating Guidelines

"N" - Normal Deflection that does not: create a safety hazard, alarm users (vehicles or pedestrians), or affect the strength or serviceability of the structure. Live load deflection is estimated by the inspector to be within design parameters (typically L/640 for steel bridges, where L= Span Length in feet and L/250 for timber bridges, where L= Span Length in inches.

"E" - Excessive Deflection that does: create a safety hazard, alarm users (vehicles or pedestrians), or affect the strength or serviceability of the structure. The live load deflection is estimated to be in excess of design parameters.

16. VIBRATION UNDER LOAD

What to Rate

Evaluate the vibration of individual members or entire spans under live load.

Conditions to Consider

The rating shall consider the vibration direction (vertical and transverse), as well as, the length of time vibration continues after the load has passed. Settled approaches or raised deck joints may result in impact loads on the bridge that cause excessive vibrations.

Rating Guidelines

"N" - Normal Vibration that does not: create a safety hazard, cause discomfort to users (vehicles or pedestrians), or affect the strength or serviceability of the structure.

"E" - Excessive Vibration that does: create a safety hazard, cause discomfort to users (vehicles or pedestrians), or affects the strength or serviceability of the structure.

ITEM 60-SUBSTRUCTURE

1. ABUTMENTS-STEM

What to Rate

Elements to be rated include the abutment stem, bridge seat, and pedestals of the abutments.

Conditions to Consider

The condition rating shall consider the physical condition of the stem (cracks, delamination, leaching, scale, spalls, missing stones, loose or missing mortar joints, etc.).

Rating Guidelines

The stem shall be rated in accordance with Section 9.5 Substructure.

BACKWALL (ABUTMENTS)

What to Rate

Elements to be rated include the abutment backwall.

Conditions to Consider

The condition rating shall consider the physical condition of the backwall (cracks, delamination, leaching, scale, spalls, missing stones, loose or missing mortar joints, etc.).

Rating Guidelines

The backwall shall be rated in accordance with Section 9.5 Substructure.

FOOTINGS (ABUTMENTS)

What to Rate

Elements to be rated include the abutment footing.

Conditions to Consider

The condition rating shall consider the physical condition of the footing (cracks, delamination, leaching, scale, spalls, etc.), as well as, the alignment (scour, thermal movement, etc.). Settlement of the footing shall not be included under this item; it shall be rated under the Item *Abutments-Settlement*.

Rating Guidelines

The footing shall be rated in accordance with Section 9.5 Substructure. If the footings are covered and not visible, code this item "N" and indicate "Not Visible" in the description field.

SETTLEMENT (ABUTMENTS)

What to Rate

Elements to be rated include settlement of the abutment.

Conditions to Consider

The condition rating shall consider settlement of the abutment from its original constructed position.

Rating Guidelines

Abutment settlement shall be rated in accordance with Section 9.5 Substructure.

WINGWALLS (ABUTMENTS)

What to Rate

Elements to be rated include the abutment wingwalls and cheekwalls.

Conditions to Consider

The condition rating shall consider the physical condition of the wingwalls (cracks, delamination, leaching, scale, spalls, missing stones, loose or missing mortar joints, etc.).

Rating Guidelines

The wingwalls shall be rated in accordance with Section 9.5 Substructure.

PIERS OR BENTS-CAPS

What to Rate

Elements to be rated include pier or bent caps, including bearing seats and pedestals.

Conditions to Consider

The condition rating shall consider the physical condition of the caps (cracks, delamination, leaching, scale, spalls, rust, section loss, missing stones, loose or missing mortar joints, etc.).

Rating Guidelines

The caps shall be rated in accordance with Section 9.5 Substructure.

PILE BENT (PIERS/BENTS)

What to Rate

Elements to be rated include the pile bent.

Conditions to Consider

The condition rating shall consider the physical condition of the pile bent (cracks, delamination, leaching, scale, spalls, rust, section loss, checks, decay, splits, etc.).

Rating Guidelines

The columns shall be rated in accordance with Section 9.5 Substructure.

COLUMNS (PIERS/BENTS)

What to Rate

Elements to be rated include pier or bent columns.

Conditions to Consider

The condition rating shall consider the physical condition of the columns (cracks, delamination, leaching, scale, spalls, rust, section loss, checks, decay, splits, etc.).

Rating Guidelines

The columns shall be rated in accordance with Section 9.5 Substructure.

FOOTINGS (PIERS/BENTS)

What to Rate

Elements to be rated include pier or bent footings.

Conditions to Consider

The condition rating shall consider the physical condition of the footing (cracks, delamination, leaching, scale, spalls, etc.). Settlement of the footing shall not be included under this item; it shall be included under the Item *Piers/Bents-Settlement*.

Rating Guidelines

The footings shall be rated in accordance with Section 9.5 Substructure. If the footings are covered and not visible, code this item "N" and indicate "Not Visible" in the description field.

SETTLEMENT (PIERS/BENTS)

What to Rate

Elements to be rated include settlement of piers or bents.

Conditions to Consider

The condition rating shall consider settlement of piers or bents from their original constructed position.

Rating Guidelines

Pier or bent settlement shall be rated in accordance with Section 9.5 Substructure.

2. EROSION - SCOUR

What to Rate

Elements to be rated include the erosion or scour of embankment or foundation materials.

Conditions to Consider

The condition rating shall consider the exposed portions of the substructure (abutments, wingwalls, piers, bents, footings, piles, etc.), particularly areas where the elevation of embankment or foundation material is lower than the original design elevation, or the elevation documented in past inspection reports.

Rating Guidelines

Erosion and scour shall be rated in accordance with Section 9.5 Substructure.

3. CONCRETE CRACK – SPALL

What to Rate

Elements to be rated include concrete and prestressed concrete abutments, piers, wingwalls, piles, etc., that are part of the bridge substructure. Fender system elements shall not be rated under this item; they shall be rated under the Channel Protection Item - *Fender System*.

Conditions to Consider

The rating shall consider the extent and severity of cracking and spalling on the overall functionality and capacity of the concrete members.

Rating Guidelines

This item shall be coded in accordance with Section 9.1.3 Reinforced Concrete or Section 9.1.4 Prestressed Concrete.

4. STEEL CORROSION

What to Rate

Elements to be rated include steel bents, pier caps, columns, piles, etc., which are part of the bridge substructure. Fender system elements shall not be rated under this item; they shall be rated under the Channel Protection Item - *Fender System*.

Conditions to Consider

The rating shall consider the extent and severity of rusting and section loss on the overall functionality and capacity of the steel members.

Rating Guidelines

This item shall be coded in accordance with Section 9.1.5 Steel.

5. PAINT

What to Rate

Elements to be rated include the paint, or protective coating, on all substructure members (abutments, bearing seats, columns, piers or bents, pier or bent caps, etc.).

Conditions to Consider

The condition rating shall consider the physical condition of the paint or protective system and its ability to protect the surfaces where it has been applied. This rating is not based on the severity of corrosion of the protected surfaces.

Rating Guidelines

See *Paint* under Item 59 - *Superstructure.*

6. TIMBER DECAY

What to Rate

Elements to be rated include timber piles, columns and pier caps that are part of the bridge substructure. Fender system elements shall not be rated under this item; they shall be rated under the Channel Protection Item - *Fender System*.

Conditions to Consider

The rating shall consider the extent of deterioration and the severity of any damage to the members (cracks, splits, rot, crushing, freeze-thaw damage, insect damage, etc.) and the member's capacity to carry the design load.

Rating Guidelines

Timber conditions shall be rated in accordance with Section 9.1.6 Timber.

7. COLLISION DAMAGE

What to Rate

Evaluate the extent to which substructure elements have been damaged by vehicle, shipping or flood debris impacts. Fender system elements shall not be rated under this item; they shall be rated under the Channel Protection Item - *Fender System*.

Conditions to Consider

The rating shall consider the extent of the collision damage on the member (bends, crushed members, dents, exposed steel reinforcement, etc.) and the member's capacity to carry the design load.

Rating Guidelines

9	Excellent	No evidence of collision damage.
8-7	Very Good /Good	Some minor collision scrapes which do not require corrective maintenance.
6-5	Satisfactory /Fair	Areas of collision damage with minor losses (moderate bends or dents in steel, concrete, or timber members; minor crushing of timber members; crushing with exposed reinforcing steel in concrete members, etc.). Maintenance repairs required.
4-3	Poor /Serious	Areas of collision damage with significant losses (severe bends or dents in steel, concrete, or timber members; severe crushing of timber members; crushing of concrete members with significant damage to reinforcing steel and/or significant distortion of member; etc.). Major rehabilitation required.
2-1	Critical /"Imminent" Failure	Member has been damaged, such that, it is no longer functioning as intended. Replacement required.

8. DEBRIS

What to Rate

Elements to be rated include areas of debris and/or water accumulation. Typical areas include abutment seats (around bearings and/or between beam ends and the abutment backwall), pier or bent caps, horizontal surfaces on individual members, etc.

Conditions to Consider

The rating shall consider the amount of debris and/or water accumulation and its affect on the physical condition of the members with which it is in contact. The rating shall also consider any interference with structure expansion/contraction caused by debris accumulation (debris covering expansion bearings, debris filling expansion area between beam ends and abutment backwall, etc.).

If a portion of the structure is not visible because it is covered or shielded by debris, a Bridge Maintenance Memorandum should be written requesting removal of the debris.

Rating Guidelines

9	Excellent	No defects.
8-7	Very Good /Good	Some minor debris accumulation on the bridge seats, with no noticeable effect on the structure. No cleaning required.
6-5	Satisfactory /Fair	Accumulation of debris, with minor effect on the structure (minor deterioration of structure). Cleaning required.
4-3	Poor /Serious	Major accumulation of debris, with significant effect on the structure (debris interferes with the proper movement of the bearings or is contributing to serious deterioration of the structure). Major cleaning and some rehabilitation required.
2-1	Critical /"Imminent" Failure	Debris accumulation has caused failure of structural member. Replacement required.

ITEM 61 – CHANNEL & PROTECTION

1. CHANNEL SCOUR

What to Rate

Elements to be rated include the erosion or scour of the channel banks and bottom. The channel shall be rated as far upstream and downstream from the structure as is necessary to observe changes that may affect the integrity of the bridge or approaches.

Conditions to Consider

The condition rating shall consider the loss of material from the channel bottom or banks. Areas of high water velocity (i.e. narrow sections, shallow sections, channel constrictions, items protruding into the channel from the bottom or banks, etc.) are particularly vulnerable to scour.

Rating Guidelines

Channel scour shall be rated in accordance with Section 9.2 Waterways.

2. EMBANKMENT EROSION

What to Rate

Elements to be rated include the embankment on both sides of the channel. The bridge embankment shall not be rated under this item; it shall be rated under the Substructure Item "Erosion/Scour". Riprap or other embankment protection shall not be rated under this item; it shall be rated under "Riprap".

Conditions to Consider

The condition rating shall consider the loss of material from the channel embankments. Areas of minimal vegetation, along the ends of embankment protection (i.e. riprap, slope paving, gabions, etc.), or in the path of roadway runoff are particularly vulnerable to erosion.

Rating Guidelines

Embankment erosion shall be rated in accordance with Section 9.2 Waterways.

3. DEBRIS

What to Rate

Elements to be rated include debris that affects the normal flow of the channel.

Conditions to Consider

The rating shall consider debris which has accumulated in the channel (i.e. on the bottom, along the banks, against piers or other channel obstructions, etc.).

Rating Guidelines

Debris shall be rated in accordance with Section 9.2 Waterways.

4. VEGETATION

What to Rate

Elements to be rated include the vegetation cover along the channel banks and embankments.

Conditions to Consider

The rating shall consider the condition of the vegetation along the channel banks and embankments, and its ability to protect these areas from erosion or its tendency to obstruct the waterway.

Rating Guidelines

Vegetation shall be rated in accordance with Section 9.2 Waterways.

5. CHANNEL CHANGE

What to Rate

Elements to be rated include changes (natural or man-made) in the channel width, bottom profile, or alignment, and the affect of these changes on the integrity of the bridge and approaches.

Conditions to Consider

The rating shall consider the extent of change in the channel width, bottom profile or alignment, and the severity, or potential severity, of these changes on the integrity of the bridge and approaches. Long term aggradation/degradation of the streambed and migration of the stream channel shall be evaluated under this item.

Rating Guidelines

Channel change shall be rated in accordance with Section 9.2 Waterways.

6. FENDER SYSTEM

What to Rate

Elements to be rated include all components of pier or abutment protection systems (dolphins, fenders, etc.).

Conditions to Consider

The rating shall consider the physical condition of the protection system (cracks, delamination, leaching, scale, spalls, rust, section loss, loose or broken fasteners, checks, decay, splits, impact damage, etc.) and its ability to protect the bridge.

Rating Guidelines

9	Excellent	No defects.
8-7	Very Good /Good	Some minor defects (reinforced concrete: hairline noncritical cracks, light-moderate scale, small spalls, minor efflorescence, etc.; prestressed concrete: hairline noncritical cracks, light-moderate scale, minor efflorescence, etc.; steel: light rust on less than 25% of surface area, few isolated loose fasteners in primary members or missing fasteners in secondary members, etc.; timber: minor decay, cracks, checks, or splits, etc.). Maintenance repairs not yet required.
6-5	Satisfactory /Fair	Areas of deterioration with minor section loss (reinforced concrete: wide cracks, heavy scale, small spalls or impact damage resulting in section loss on exposed steel reinforcing bars, moderate efflorescence, etc.; prestressed concrete: wide cracks, heavy scale, small spalls, moderate efflorescence, or impact damage resulting in section loss on exposed steel reinforcing bars or exposure of up to two (2) prestressing tendons, etc.; steel: severe rust with section loss on greater than 25% of surface area, isolated missing fasteners in primary members, etc.; timber: moderate decay, cracks, checks, splits with minor section loss, etc.). Maintenance repairs required.
4-3	Poor /Serious	Areas of deterioration with significant section loss (reinforced concrete: large spalls, severe scale, severe section loss on exposed steel reinforcing bars, etc.; prestressed concrete: large spalls, severe scale, severe section loss on exposed steel reinforcing bars, up to two (2) broken wires in one (1) tendon or one (1) broken wire in each of two (2) tendons, etc.; steel: severe rust with section loss throughout member, multiple broken or missing fasteners in primary members, fatigue cracks, out of plane distortion, etc.; timber: severe decay, cracks, checks, splits with advanced section loss, etc.). Major rehabilitation required.
2-1	Critical /”imminent” Failure	Member has deteriorated such that it is no longer functioning as intended. Replacement required.

7. SPUR DIKES & JETTIES

What to Rate

Elements to be rated include all portions of spur dikes and jetties, above and below the water line.

Conditions to Consider

The rating shall consider the physical condition of the spur dikes and jetties (erosion, scour, missing stones, impact damage, etc.) and their ability to protect the bridge (from high flow velocities, which may cause scour, vessel impact, etc.).

Rating Guidelines

9	Excellent	No defects.
8-7	Very Good /Good	Minor defects [isolated minor erosion, widespread loss of joint pointing (less than 2" deep) with interior joint mortar of masonry members in good condition, etc.] which do not yet require routine maintenance.
6-5	Satisfactory / Fair	Minor areas of deterioration (advanced erosion with minor scour, heavy loss of joint pointing material, cracking and/or minor loss of interior joint mortar observed in masonry members, etc.). Maintenance repairs required.
4-3	Poor /Serious	Areas of severe deterioration (advanced undermining/scour, severe loss and cracking of joint pointing and interior mortar materials of masonry members, moderate displacements or deformations of stones, etc.). Major rehabilitation required.
2-1	Critical /"Imminent" Failure	Element has deteriorated such that it is no longer functioning as intended. Replacement required.

8. RIPRAP

What to Rate

Elements to be rated include riprap or other erosion protection (slope paving, gabions, etc.) lining the channel and/or located along the channel embankments or banks. Vegetation that serves as erosion protection shall not be included under this item; it shall be rated under the Item *Vegetation*.

Conditions to Consider

The rating shall consider the physical condition of the riprap or other erosion protection (loose or missing mortar, missing stones, etc.), and its ability to protect the surface where it has been installed. The actual condition of the surface to be protected (severity of erosion, if any) shall not be rated under this item; it shall be rated under the Substructure Item *Embankment Erosion*.

Rating Guidelines

Riprap or other erosion protection shall be rated in accordance with the guidelines under *Spur Dikes & Jetties*.

ITEM 62-CULVERTS & RETAINING WALLS

1. BARREL

What to Rate

Elements to be rated include the barrel of the culvert.

Conditions to Consider

The condition rating shall consider the physical condition of the barrel (cracks, spalls, rust, section loss, broken fasteners, impact damage, etc.), as well as, the barrel alignment (deformation, lateral movement, settlement, tipping, etc.).

Rating Guidelines

The barrel shall be rated in accordance with Section 9.3 *Culverts*.

CONCRETE

What to Rate

Elements to be rated include concrete elements of the culvert.

Conditions to Consider

The condition rating shall consider the physical condition of the concrete (cracks, spalls, section loss, impact damage, etc.).

Rating Guidelines

This item shall be coded in accordance with Section 9.1.3 Reinforced Concrete.

STEEL

What to Rate

Elements to be rated include steel elements of the culvert.

Conditions to Consider

The condition rating shall consider the physical condition of the steel (rust, cracks, section loss, impact damage, etc.).

Rating Guidelines

This item shall be coded in accordance with Section 9.1.5 Steel.

TIMBER

What to Rate

Elements to be rated include timber elements of the culvert.

Conditions to Consider

The condition rating shall consider the physical condition of the timber (rot, decay, insect damage, section loss, impact damage, etc.).

Rating Guidelines

This item shall be coded in accordance with Section 9.1.6 *Timber*.

2. HEADWALL

What to Rate - Headwall

Elements to be rated include the headwall that retains the embankment material above the barrel at each end of the culvert.

Conditions to Consider

The condition rating shall consider the physical condition of the element (cracks, spalls, broken or missing masonry stones, etc.), their alignment (lateral movement, settlement, tipping, etc.), their ability to retain the embankment material, and their ability to prevent flow from passing under or around the outside of the culvert barrel.

Rating Guidelines

9	Excellent	No defects.
8-7	Very Good /Good	Some minor defects (concrete: hairline non-critical cracks, light-moderate scale, small spalls, minor efflorescence, etc.; steel: light rust on less than 25% of surface area, isolated loose fasteners, etc.; timber: minor decay, cracks, checks, or splits, etc.; masonry: widespread loss of joint pointing with interior joint mortar in good condition, light efflorescence bleeding or water leakage from joint mortar, etc.; isolated embankment erosion, etc.) which do not yet require repair.
6-5	Satisfactory /Fair	Areas of deterioration with minor section loss (concrete: wide cracks, heavy scale, small spalls or impact damage resulting in section loss on exposed steel reinforcing bars, moderate efflorescence, etc.; steel: severe rust with section loss on greater than 25% of surface area, isolated missing fasteners, etc.; timber: moderate decay, cracks, checks, splits with minor section loss, etc.; masonry: heavy loss of joint pointing material, cracking and/or minor loss of interior joint mortar, widespread efflorescence bleeding or water leakage from joints, etc.; advanced erosion with minor scour; etc.). Maintenance repairs required.
4-3	Poor /Serious	Areas of deterioration with significant section loss (concrete: large spalls, severe scale, heavy active water leakage through cracks/spalls, severe section loss on exposed steel reinforcing bars, etc.; steel: severe rust with section loss throughout member, multiple broken or missing fasteners, out of plane distortion, etc.; timber: severe decay, cracks, checks, splits with advanced section loss, etc.; masonry: severe loss and cracking of joint pointing and interior mortar, moderate displacements or deformations of stones, etc.; advanced undermining/scour, etc.). Major rehabilitation required.
2-1	Critical /"Imminent" Failure	Member has deteriorated, such that, it is no longer functioning as intended. Replacement required.

3. CUTOFF WALL

What to Rate – Cutoff Wall

Elements to be rated include the cutoff wall that inhibits scour under the floor at each end of the culvert.

Conditions to Consider

The condition rating shall consider the physical condition of the element (cracks, spalls, broken or missing masonry stones, etc.), their alignment (lateral movement, settlement, tipping, etc.), their ability to retain the embankment material, and their ability to prevent flow from passing under or around the outside of the culvert barrel.

Rating Guidelines

9	Excellent	No defects.
8-7	Very Good /Good	Some minor defects (concrete: hairline non-critical cracks, light-moderate scale, small spalls, minor efflorescence, etc.; steel: light rust on less than 25% of surface area, isolated loose fasteners, etc.; timber: minor decay, cracks, checks, or splits, etc.; masonry: widespread loss of joint pointing with interior joint mortar in good condition, light efflorescence bleeding or water leakage from joint mortar, etc.; isolated embankment erosion, etc.) which do not yet require repair.
6-5	Satisfactory /Fair	Areas of deterioration with minor section loss (concrete: wide cracks, heavy scale, small spalls or impact damage resulting in section loss on exposed steel reinforcing bars, moderate efflorescence, etc.; steel: severe rust with section loss on greater than 25% of surface area, isolated missing fasteners, etc.; timber: moderate decay, cracks, checks, splits with minor section loss, etc.; masonry: heavy loss of joint pointing material, cracking and/or minor loss of interior joint mortar, widespread efflorescence bleeding or water leakage from joints, etc.; advanced erosion with minor scour; etc.). Maintenance repairs required.
4-3	Poor /Serious	Areas of deterioration with significant section loss (concrete: large spalls, severe scale, heavy active water leakage through cracks/spalls, severe section loss on exposed steel reinforcing bars, etc.; steel: severe rust with section loss throughout member, multiple broken or missing fasteners, out of plane distortion, etc.; timber: severe decay, cracks, checks, splits with advanced section loss, etc.; masonry: severe loss and cracking of joint pointing and interior mortar, moderate displacements or deformations of stones, etc.; advanced undermining/scour, etc.). Major rehabilitation required.
2-1	Critical /”Imminent” Failure	Member has deteriorated, such that, it is no longer functioning as intended. Replacement required.

4. DEBRIS

What to Rate

Evaluate the degree to which any debris affects the normal flow through the culvert.

Conditions to Consider

The rating shall consider debris which has accumulated inside the culvert (on the bottom, against the sides, etc.), as well as, outside the culvert (against headwalls, cutoff walls, retaining wall stems, on the bottom, etc.) on both the upstream and downstream sides. Debris located in the channel shall not be included in this item; it shall be rated under Item 61-3 Debris.

Rating Guidelines

9	Excellent	No defects.
8-7	Very Good /Good	Minor debris accumulation in the culvert is not affecting water flow velocity or turbulence through the hydraulic opening. No repairs required.
6-5	Satisfactory /Fair	Debris accumulation in the culvert is causing an increase in water flow velocity and turbulence through the hydraulic opening or increasing the upstream backwater elevations. Maintenance cleaning is required.
4-3	Poor /Serious	Debris accumulation in the culvert is causing severe increase in water flow velocity and turbulence through the hydraulic opening which is affecting the stability of culvert elements (scour, erosion, undermining, etc.) or barrel blockage is increasing the upstream backwater elevations and threatening to by-pass the culvert. Major rehabilitation required.
2-1	Critical /"Imminent" Failure	Debris accumulation in the culvert has caused severe increase in water flow velocity and turbulence through the hydraulic opening, which has caused failure of culvert elements (scour, erosion, undermining, etc.). Complete blockage of the culvert barrel has caused the waterway to by-pass or overtop the culvert. Replacement required.

5. RETAINING WALL STEM

What to Rate – Retaining Wall Stem

Elements to be rated include the retaining wall stems (wingwalls) at each end of the culvert.

Conditions to Consider

The condition rating shall consider the physical condition of the element (cracks, spalls, broken or missing masonry stones, etc.), their alignment (lateral movement, settlement, tipping, etc.), their ability to retain the embankment material, and their ability to prevent flow from passing under or around the outside of the culvert barrel.

Rating Guidelines

9	Excellent	No defects.
8-7	Very Good /Good	Some minor defects (concrete: hairline non-critical cracks, light-moderate scale, small spalls, minor efflorescence, etc.; steel: light rust on less than 25% of surface area, isolated loose fasteners, etc.; timber: minor decay, cracks, checks, or splits, etc.; masonry: widespread loss of joint pointing with interior joint mortar in good condition, light efflorescence bleeding or water leakage from joint mortar, etc.; isolated embankment erosion, etc.) which do not yet require repair.
6-5	Satisfactory /Fair	Areas of deterioration with minor section loss (concrete: wide cracks, heavy scale, small spalls or impact damage resulting in section loss on exposed steel reinforcing bars, moderate efflorescence, etc.; steel: severe rust with section loss on greater than 25% of surface area, isolated missing fasteners, etc.; timber: moderate decay, cracks, checks, splits with minor section loss, etc.; masonry: heavy loss of joint pointing material, cracking and/or minor loss of interior joint mortar, widespread efflorescence bleeding or water leakage from joints, etc.; advanced erosion with minor scour; etc.). Maintenance repairs required.
4-3	Poor /Serious	Areas of deterioration with significant section loss (concrete: large spalls, severe scale, heavy active water leakage through cracks/spalls, severe section loss on exposed steel reinforcing bars, etc.; steel: severe rust with section loss throughout member, multiple broken or missing fasteners, out of plane distortion, etc.; timber: severe decay, cracks, checks, splits with advanced section loss, etc.; masonry: severe loss and cracking of joint pointing and interior mortar, moderate displacements or deformations of stones, etc.; advanced undermining/scour, etc.). Major rehabilitation required.
2-1	Critical /"Imminent" Failure	Member has deteriorated, such that, it is no longer functioning as intended. Replacement required.

6. FOOTINGS

What to Rate

Elements to be rated include all footings (culvert barrel, headwall, retaining wall stems, etc.)

Conditions to Consider

The rating shall consider the physical condition of the footings (cracks, spalls, section loss, impact damage, etc.) as well as the alignment (deformation, lateral movement, settlement, tipping, etc.).

Rating Guidelines

The footings shall be rated in accordance with Section 9.5 Substructure Coding.

ITEM 63-ESTIMATED REMAINING LIFE

What to enter

Enter an "N" into the data field. This item is not to be calculated for railroad bridges.

ITEM 64 - PERMIT CAPACITY (OFFICE ITEM)

What to enter

This item is not applicable to railroad bridges.

ITEM 65 - APPROACH CONDITION

What to enter

This item is not applicable to railroad bridges.

1. APPROACH SLAB

What to enter

This item is not applicable to railroad bridges.

2. RELIEF JOINT

What to enter

This item is not applicable to railroad bridges.

3. APPROACH GUIDE RAIL

What to enter

This item is not applicable to railroad bridges.

4. PAVEMENT

What to enter

This item is not applicable to railroad bridges.

5. EMBANKMENT

What to enter

This item is not applicable to railroad bridges.

6. TRAFFIC SAFETY FEATURE

What to enter

This item is not applicable to railroad bridges.

ITEM 66 – RATED LOADING

1. POSTED LOADING

What to enter

This item is not applicable to railroad bridges.

2. ADVANCED WARNING Y/N

What to enter

This item is not applicable to railroad bridges.

3. LEGIBILITY

What to enter

This item is not applicable to railroad bridges.

4. VISIBLITY/LOCATION

What to enter

This item is not applicable to railroad bridges.

INSPECTOR'S APPRAISAL OF OVERALL STRUCTURAL CONDITION

What to enter

The overall condition of the structure should be rated using engineering judgment in accordance with the 0 to 9 scale.

MIN. VERT. UNDERCLEARANCE

What to enter

Enter the minimum vertical clearance of the structure.

POSTED CLEARANCE

What to enter

Enter the posted vertical clearance.

ADVANCED WARNING

What to enter

Enter whether advanced warning signs are present.

SPEED LIMIT (IF ANY)

What to enter

Enter the speed limit of the road under if available. In the additional note section, enter the speed limits from the time tables for the passenger and freight traffic.

CHARACTER OF TRAFFIC

What to enter

Enter the character of the traffic under the structure if applicable.

ADDITIONAL NOTES

What to enter

Enter any additional information about the clearance of the traffic.

INVERNTORY OF SHEETS IN COMPLETE REPORT

INV

What to enter

Enter the number of Connecticut Railroad Bridge Forms (BRI) in the report.

PHOTOS

What to enter

Enter the number of photos included in the report.

FLD NOTES

What to enter

Enter the number of pages of field notes included in the report.

JNT MSMNTS

What to enter

Enter the number of joint measurement forms in the report.

CLEAR DIAG

What to enter

Enter the number of clearance diagrams included in the report.

ATTACH

What to enter

Enter the number of sheets attached to the report.

ADDITIONAL COMMENTS

Information to be included in this section includes:

- A statement indicating if the structure identification number is labeled on the bridge and whether the condition/readability of the label is adequate.

- Comment on the presence of any construction being done to the structure (or recently completed) and include state project numbers, whenever possible.

- Identify any significant condition changes since the last inspection and, if possible, identify the cause of the problem and recommendations to correct the problem.

- If any special access is required for the inspection, such as access on private property or keys needed for locks, identify the property contact person or the location/number of the required key to the lock.

- If various forms of access equipment are required to complete the inspection, comment on the types of equipment used in each area and the duration of time they are required. This information may be omitted if provided elsewhere in the report.

CHAPTER 10
CODING GUIDELINES FOR CONNDOT INVENTORY ITEMS

Table of Contents

CHAPTER 10: CODING GUIDELINES FOR CONNDOT INVENTORY ITEMS

10.1. RAILROAD BRIDGE CODING ITEMS for Form BRI-39

The instructions contained in this section are intended to supplement the FHWA Coding Guide and provide guidance in completing the BRI-39 Form. Exceptions to the instructions in the FHWA Coding Guide are also noted. The instructions are organized to follow the items as they appear on the BRI-39 Access Input Form.

10.1.1. BRI-39 GENERAL INFORMATION

The inspection block is the portion of the BRI-39 where information is found on the latest inspection dates and types of inspections required on a particular structure. Information shown, in the shaded areas of the inspection block, is data currently stored in the structure's database. This information needs to be updated at every inspection interval.

Bridge Number .... (6 digits)

This field should contain the official number of the bridge. There is a 6 digit limit to the number or type of characters in this field, followed by the letter R to represent "Railroad Bridge".

Inspection Date .... (8 digits)

Code the month, day and year of the end date of routine or in-depth inspections as follows:

MM DD YYYY

The inspection date shown on the BRI-18 should be the same as the date entered on the BRI-39. If the inspection requires visits on more than one day, the last date of the inspection should be entered.

Place Code (Item 4) (Town) ....(5 digits)

Code this item with the State of Connecticut designated place codes for each town (this item can only be changed under the Maintain Structures item on the Main Menu of the program).

Operator(Item 301) .... (2 digits)

Use the codes listed below to indicate the rail line operator.

Code	Description
01	Amtrak
02	Boston & Maine (B&M)
03	Branford Steam Railroad
04	Abandoned Railroad
05	Valley Railroad
06	CONN Central Railroad
07	Housatonic Railroad
08	Inactive Railroad
09	Metro-North Railroad
10	Providence & Worcester (P&W)
11	Conrail
12	New England Railroad
13	Danbury Terminal
14	Other
15	Housatonic RR
16	Naugatuck RR
17	New England Central RR
18	Connecticut Southern RR
19	Central New England RR
20	CSX Corp.

Line Name (Item 302) .... (20 digits)

The information to be recorded for this item shall be the actual Rail line name (i.e. Waterbury Branch). There are 20 digits allowed for coding of this item. Abbreviations may be used, but effort shall be made to keep them meaningful. Line names are listed in the master railroad bridge inventory.

Feature Intersected (Item 6) .... (50 digits)

The information to be recorded for this item shall be the name of the feature crossed by the bridge. There are 50 digits allowed for coding of this item. Abbreviations may be used, but effort shall be made to keep them meaningful.

Previous Inspection Date .... (8 digits)

Code the month, day and year of the date of previous routine or in-depth inspections as follows:

MM DD YYYY

Inspection Team .... (2 digits)

The field personnel performing the inspection are to enter the number corresponding to the inspection team to which they are assigned. Consultant inspection teams will be assigned numbers by the Office of Rail.

Project Number .... (6 digits)

The information to be recorded for this item shall be the state project number of the bridge inspection program.

Frequency (Item 91) .... (2 digits)

This field contains a 2-digit code to indicate the desired number of months between inspections. The maximum interval between bridge inspections in Connecticut shall be in accordance with Section 3.2.2 of this manual.

Special cases may warrant other inspection frequencies. The inspection frequency will be reviewed, and revised if necessary, following each inspection by the person reviewing the report.

Example:

	Code
Railroad Bridge on Active Line	12
Railroad Pedestrian overpass	24
Railroad Bridge on inactive or Abandoned Line	24

Flagman .... (2 digits)

This item shall be completed for each structure that requires the services of a railroad flagman to properly complete the inspection of a structure. The field personnel will fill in the appropriate Railroad Flagman code to indicate the track operator. This can be determined from the "2007 Connecticut Rail Transportation Ownership and Service" map. If no flagman is required, use code "00". Codes from the following table shall be used in the coding of this item.

FLAGMAN CODES

CODE	DESCRIPTION
00	No railroad flagman required
01	Metro-North
02	Amtrak
03	Conrail
04	Boston & Maine
05	Providence & Worcester
06	Central Vermont
07	Valley Railroad Company
08	Connecticut Central Railroad
09	Central New England Railroad
10	Connecticut Southern Railroad
11	Housatonic Railroad
12	Naugatuck Railroad
13	New England Central Railroad
14	Branford Steam Railroad
99	Other

Access .... (2 digits)

The field personnel will enter the appropriate code for any specialized inspection equipment required during the inspection of a structure. **NOTE:** Code the minimum equipment required to complete the inspection, not the equipment actually used (i.e.: if a 60' snooper was used, but a 40' snooper would normally reach, code "11". Likewise, if a 30' bucket truck was used, but the maximum bridge height is less than 25' code "00".). See the following table for the appropriate codes to be used:

ACCESS CODES

CODE	EQUIPMENT USED
00	None required
Underbridge inspection vehicle, (U.B.I.) i.e., Snooper, MOOG, Bridge Master, etc.	
11	Less than 40 ft. reach
12	Less than 40 ft. reach, buckets required
15	Over 40 ft. reach
Bucket truck, or manlift required	
21	Skyvan or similar, 30 ft. reach (Bridge Ht. $\geq$ 25’)
22	30 – 40 ft. reach required
23	40 – 50 ft. reach required
24	over 50 ft. reach required
Underbridge Insp. Vehicle and Bucket Truck - Combination	
31	40 ft. U.B.I. and 30 ft. lift required
32	40 ft. U.B.I. and 40 ft. lift required
33	40 ft. U.B.I. and 50 ft. lift required
34	40 ft. U.B.I. and >50 ft. lift required
35	>40 ft. U.B.I. and 30 ft. lift required
36	>40 ft. U.B.I. and 40 ft. lift required
37	>40 ft. U.B.I. and 50 ft. lift required
38	>40 ft. U.B.I. and >50 ft. lift required
40	Boat or raft (other than inflatable boats issued to inspection teams)
50	Rigging or scaffolding
51	>40 ft. U.B.I. and Rigging to access areas not reachable with snooper
99	Other

If portions of a structure cannot be accessed during an inspection, these areas shall be indicated on a plan view sketch of the structure and noted in the report.

In-depth Inspection Date .... (8 digits)

The last date of an in-depth inspection is to be entered and is to be recorded in the same format as the Inspection Date. Both the Inspection Date and In-depth Inspection fields should be completed whenever an in-depth inspection is performed.

10.1.2. CRITICAL FEATURE INSPECTIONS

The Critical Feature Inspection fields shall be coded for those structures which:

A) have fracture critical members,
B) require underwater inspections,
C) require other special inspections or any combination thereof.

The following items indicate the type of critical feature inspection required, the desired frequency and the latest date of inspection for the critical feature. If there are no critical features, these items are to be left blank.

"Fracture Critical" - Fracture Critical Member Inspection

If the structure has any fracture critical members (FCM's), fill in the following

Type.. (1 digits)
Fill in the item with the appropriate code for the fracture critical member from the following table.

Fracture Critical Member Codes:

I. Two Girder System (1. Single Span, 2. End Span of Continuous Span Units)
Code A - With fixed hanger suspended spans
B - With suspended spans
C - Welded plate girders
D - Riveted or bolted plate girders

II. Truss Systems (1. Simple Spans, 2. Continuous Spans)
Code E - Eyebar trusses
F - Welded trusses
G - Riveted trusses
H - Trusses with suspended spans

III. Steel Pier Caps
Code J - Welded box or plate girders
K - Riveted box or plate girders

IV. Longitudinal Box Beams
Code L - Single welded box
M - Single riveted or bolted box

Frequency .... (2 digits)

The person reviewing the inspection report shall determine the desired inspection "Frequency", in months.

Date.. (8 digits)

Code the month, day and year of the date of the inspections as follows: MM DD YYYY

"Underwater" - Underwater Inspection

Frequency .... (2 digits)

The person reviewing the inspection report shall determine the desired inspection "Frequency", in months. In general, the frequency will be 24 months for most underwater inspections.

Date .... (8 digits)

Code the month, day and year of the date of the inspections as follows: MM DD YYYY

"Special" – Special Inspections

If the structure has various components that require periodic inspections, i.e. monitoring, record the following data.

Type .... (1 digits)
Fill in the item with the appropriate code for the type of inspection from the following table

CODE	TYPE OF SPECIAL INSPECTION
A	Pin & hanger or hinge measurements
B	Shiplap measurements
C	Tipping/settlement of substructure
D	Lateral movement of beams/bearings
E	Temporary bents/supports
F	Crack growth
G	Check of scour or undermining
X	Any combination of the above (specify in comments section of BRI 39)
Z	Other (specify in comments section of BRI-19)

Frequency .... (2 digits)

The person reviewing the inspection report shall determine the desired inspection "Frequency", in months.

Date .... (8 digits)

Code the month, day and year of the date of the inspections as follows: MM DD YYYY

10.1.3. IDENTIFICATION

Owner (Item 300) .... (2 digits)

Use the codes listed below to indicate the rail line owner.

Code	Description
01	Amtrak
02	Boston & Maine (B & M)
03	Branford Steam Railroad
04	CONNDEEP
05	CONNDOT
06	Conrail
07	New England Railroad
08	D'Addario Industries
09	Maybrook Properties
10	Providence & Worcester (P & W)
11	PENNCTRL
12	Private
13	Tilcon
14	Housatonic RR
15	Naugatuck RR
16	New England Central RR
17	Connecticut Southern RR
18	Central New England RR
19	CSX Corp.
20	Other

Milepost (Item 303) .... (5 digits)

Code a 5-digit number to represent the mile post location of the structure. The 5-digit code will be to the hundredth of a mile. The mile post shall reference the beginning of the structure in the direction of the track line inventory.

Location (Item 9) .... (text)

This item is a description of the structure location. It is recommended that the location be referenced to a nearby intersection or some other landmark discernable on a roadway map.

Examples: 1 ½ miles from intersection of Elm Street and Main Street
¾ mile north of the Railroad station

Other Trackage Rights (Item 304) .... (2 digits)

This item provides information concerning the use of the inventory rail line by other rail facilities. The 2-digit coding will be from the *Operator* list in the BRI-39 General Information Data. Four 2-digit codings are available, if more than one rail facility uses the same rail line.

Latitude (Item 407) .... (8 digits)

For all structures, code the latitude in degrees, minutes and seconds (use the coordinate at the centerline of the bridge).

Longitude (Item 408) .... (8 digits)

For all structures, code the longitude in degrees, minutes and seconds (use the coordinate at the centerline of the bridge).

Co-Owner Bridge (Item 305) .... (2 digits)

This item provides information concerning structures that share ownership of a structure. The 2-digit coding will be from the *Operator* list in the BRI-39 General Information Data.

10.1.4. GEOMETRIC DATA

Length of Maximum Span (Item 48) ....(5 Digits)

This item is a description of the length of the longest span. For this item, enter the length of the longest span from centerline to centerline of bearing (recorded in feet).

Structure Length (Item 49)..(6 Digits)

This item is a description of the total length of the structure. For this item, enter the total length of the structure from back to back of the abutments (recorded in feet).

Deck Width, Out to Out (Item 52) ....(4 Digits)

This item is a description of the out to out width of the structure. For this item, enter the total out to out width of the structure (recorded in feet).

Catwalk Widths (Item 306) .... (3 digits)

The information to be recorded for this item is a 3-digit measurement for the most restrictive width of a catwalk, measured to the nearest tenth of a foot. “Left” and “Right” should be determined on the basis of direction of inventory.

Deck Area...(6 Digits)

The deck area for the structure is the total deck area calculated between out-to-out of deck and end-to-end of the structure. Where deck widths vary, the actual area of the deck is calculated, accounting for the actual widths present.

<u>Skew Angle (Item 34)</u> .... (2 Digits)

The skew angle is the angle between the centerline of a pier and a line normal to the railroad centerline. When plans are available, the skew angle can be taken directly from the plans. If no plans are available, the angle is to be field measured, if possible. Record the skew angle to the nearest degree. If the skew angle is 0, it should be so coded. When the structure is on a curve or if the skew varies for some other reason, the average skew should be recorded, if reasonable. Otherwise, record 99 to indicate a major variation in skews of substructure units. A 2-digit number should be coded.

EXAMPLES:	Skew angle	Code
	0°	00
	10°	10
	8°	08
	29°	29

<u>Min Vertical Clearance Over (Item 53)</u> .... (4 Digits)

The information to be recorded for this item is the actual minimum vertical clearance over the track to any superstructure restriction. This item is to be recorded in feet and inches. When a superstructure restriction does not exist, enter the code 99'-99".

<u>Min Vertical Underclearance (Item 54)</u> .... (5 Digits)

The information to be recorded for this item is the actual minimum vertical clearance under the superstructure. This item has two parts; a 1 digit code for the description of the feature beneath the superstructure and the actual minimum vertical clearance recorded in feet and inches.

Code	Description
H	Roadway beneath structure
R	Railroad beneath structure
N	Feature not a highway or railroad

<u>Min Lateral Underclearance on right (Item 55)</u> .... (4 Digits)

The information to be recorded for this item is the actual minimum lateral clearance from the centerline of the feature below, right to the nearest substructure unit. This item has two parts, a 1 digit code for the description of the feature beneath the superstructure, from the list above, and the actual minimum lateral clearance (recorded in feet).

<u>Min Lateral Underclearance on Left (Item 56)</u> .... (3 Digits)

The information to be recorded for this item is the actual minimum lateral clearance from the centerline of the feature below, left to the nearest substructure unit. This item is to record the actual minimum lateral clearance (recorded in feet).

10.1.5. RESTRICTIONS & UTILITIES

Passenger Track Speed (Item 318) .... (3 digits)

The number recorded for the track speed of a passenger train over the structure is an established railroad safe speed based on approach alignment and local conditions. This track speed is implied, not posted.

Freight Track Speed (Item 319) .... (3 digits)

The number recorded for track speed of a freight train over the structure is an established railroad safe speed based on approach alignment, impact on structure and local conditions. This track speed is implied, not posted.

Utilities...(1 digit)

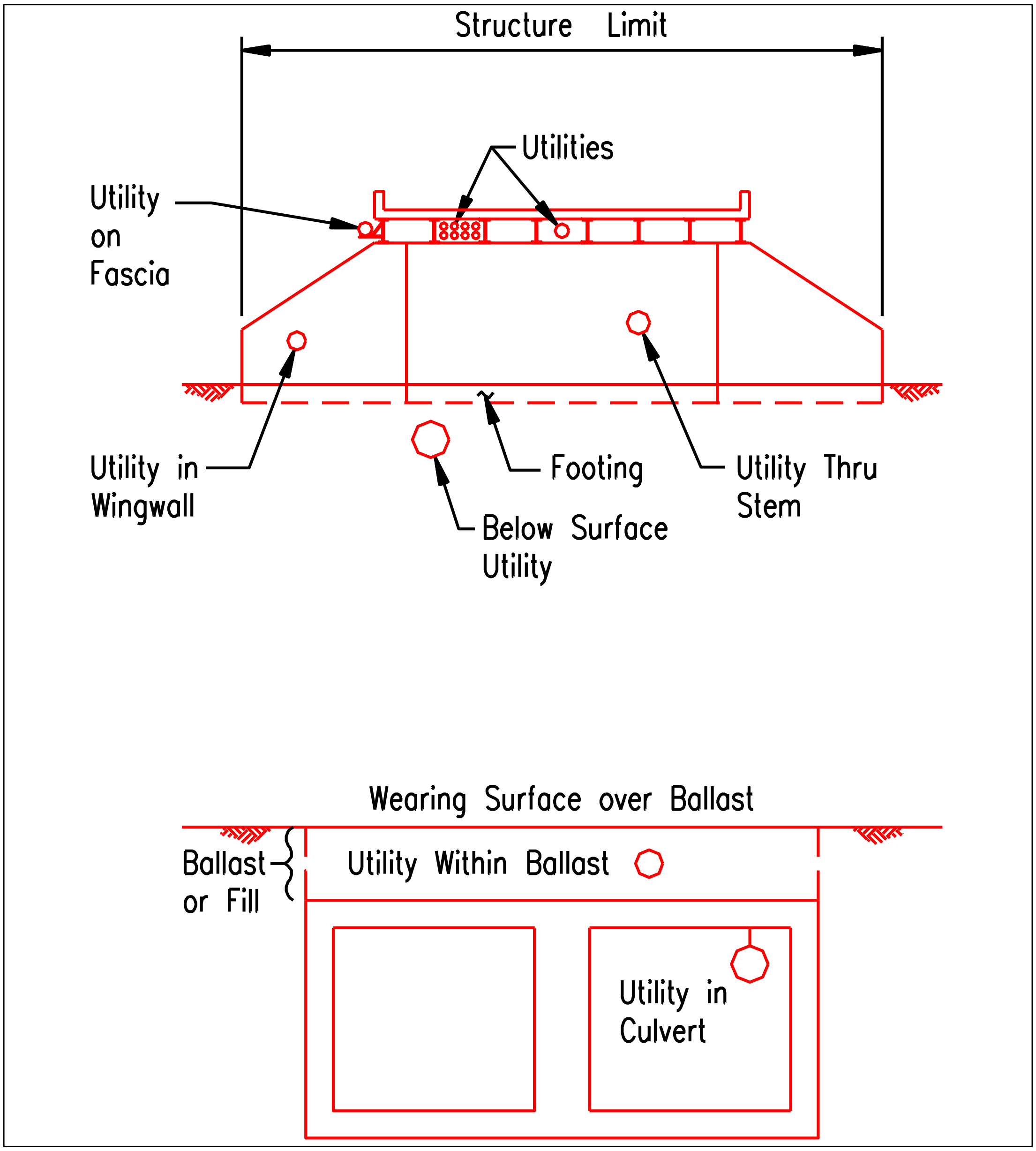
Record the utilities that are located within the structure's limit, as shown below. There is no limit to the number of utilities that can be entered for a bridge. If there are not enough blank boxes on the form, write the numbers for the desired utilities under the boxes.

If there are no utilities within the structure's limit, leave the item blank.

UTILITIES CODING:

0	Other
1	Gas
2	Water
3	Electric
4	Telephone
5	Steam line
6	Cable TV
7	Sewer
8	Chemical line
9	Fuel line
F	Fiber Optics
U	Unknown duct

* Do not include wires supported on poles that are not attached to the structure.


Structure Limit
Utilities
Utility on Fascia
Utility in Wingwall
Footing
Utility Thru Stem
Below Surface Utility
Wearing Surface over Ballast
Ballast or Fill
Utility Within Ballast
Utility in Culvert

10.1.6. APPRAISALS

Structure Evaluation (Item 67).. (1 digits)

For structures other than culverts, record the lowest of the codes obtained from Item 59 - Superstructure, Item 60 – Substructure from the BRI-18 and Chapter 9.
For culverts, record the lowest of the codes obtained from Item 62 – Culverts from the BRI-18 and Chapter 9.

Under Clearance, Vert & Horiz (Item 69).. (1 digits)

Vertical and horizontal underclearances are measured from the through roadway to the superstructure or substructure units, respectively. Code "N" is used for bridges that are not over a highway or roadway.
The vertical underclearance is evaluated using Table A.
The horizontal underclearance is evaluated using Table B.
The lower of the codes obtained from Table A and Table B is to be used.

Table A

Underclearance Rating Code	Minimum Vertical Underclearance			
	Functional Class			Railroad
	Interstate and Other Freeway	Other Principal and Minor Arterial	Major and Minor Collectors and Locals	
9	> 17’-0”	> 16’-6”	> 16’-6”	> 23’-0”
8	17’-0”	16’-6”	16’-6”	23’-0”
7	16’-9”	15’-6”	15’-6”	22’-6”
6	16’-6”	14’-6”	14’-6”	22’-0”
5	15’-9”	14’-3”	14’-3”	21’-0”
4	15’-0”	14’-0”	14’-0”	20’-0”
3	Underclearance less than value in rating code of 4 and requiring corrective action.			
2	Underclearance less than value in rating code of 4 and requiring replacement.			
0	Bridge closed.			

Notes
1. Use the lower rating code for values between those listed in the tables.
2. The functional classification of the underpassing route shall be used in the evaluation. If an "under" record is not coded, the underpassing route shall be considered a major or minor collector or a local road.

Table B

Underclearance Rating Code	Minimum Lateral Underclearance						
	Functional Class						Railroad
	1-Way Traffic				2-Way Traffic		
	Interstate and Other Freeway				Other Principal and Minor Arterial	Major and Minor Collectors and Locals	
	Main line		Ramp				
	Left	Right	Left	Right			
9	> 30’	> 30’	> 4’	> 10’	> 30’	> 12’	> 20’
8	30’	30’	4’	10’	30’	12’	20’
7	18’	21’	3’	9’	21’	11’	17’
6	6’	12’	2’	8’	12’	10’	14’
5	5’	11’	2’	6’	10’	8’	11’
4	4’	10’	2’	4’	8’	6’	8’
3	Underclearance less than value in rating code of 4 and requiring corrective action.						
2	Underclearance less than value in rating code of 4 and requiring replacement.						
0	Bridge closed.						

Notes:

1. Use the lower rating code for values between those listed in the tables.
2. Dimensions are in feet.
3. When acceleration or deceleration lanes or ramps are provided under 2-way traffic, use the value from the right ramp column to determine code.
4. The functional classification of the underpassing route shall be used in the evaluation. If an "under" record is not coded, the underpassing route shall be considered a major or minor collector or a local road.

Waterway Adequacy (Item 71) .... (1 digits)

This item appraises the waterway opening with respect to passage of flow through the bridge. The following codes shall be used in evaluating waterway adequacy (interpolate where appropriate). Site conditions may warrant somewhat higher or lower ratings than indicated by the table (e.g., flooding of an urban area due to a restricted bridge opening).

Where overtopping frequency information is available, the descriptions given in the table for chance of overtopping mean the following:

Remote - greater than 100 years
Slight - 11 to 100 years
Occasional - 3 to 10 years
Frequent - less than 3 years

Adjectives describing traffic delays mean the following:

Insignificant - Minor inconvenience. Highway passable in a matter of hours.
Significant - Traffic delays of up to several days.
Severe - Long term delays to traffic, with resulting hardship.

Functional Classification			
Principal Arterials - Interstates, Freeways, or Expressways	Other Principal and Minor Arterials and Major Collectors	Minor Collectors, Locals	Description Code
N	N	N	Bridge not over a waterway.
9	9	9	Bridge deck and roadway approaches above flood water elevations (highwater). Chance of overtopping is remote.
8	8	8	Bridge deck above roadway approaches. Slight chance of overtopping roadway approaches.
6	6	7	Slight chance of overtopping bridge deck and roadway approaches.
4	5	6	Bridge deck above roadway approaches. Occasional overtopping of roadway approaches, with insignificant traffic delays.
3	4	5	Bridge deck above roadway approaches. Occasional overtopping of roadway approaches, with significant traffic delays.
2	3	4	Occasional overtopping of bridge deck and roadway approaches, with significant traffic delays.
2	2	3	Frequent overtopping of bridge deck and roadway approaches, with significant traffic delays.
2	2	2	Occasional or frequent overtopping of bridge deck and roadway approaches, with severe traffic delays.
0	0	0	Bridge closed.

10.1.7. AGE & SERVICE

Year Built (Item 27) .... (4 digits)

Record and code the year of construction of the structure. Code all 4 digits of the year in which construction of the structure was completed. If the year built is unknown, provide a best estimate.

Year Reconstructed (Item 106) .... (4 digits)

Record and code the year of most recent reconstruction of the structure. Code all 4 digits of the latest year in which reconstruction of the structure was completed. If there has been no reconstruction, code 0000.

<u>Type of Service (Item 42)</u> .... (2 digits)

The type of service on the bridge and under the bridge is indicated by a 2-digit code composed of 2 segments.

Segment	Description	Length
42A	Type of service on bridge	1 digit
42B	Type of service under bridge	1 digit

The first digit indicates the type of service "on" the bridge and shall be coded using one of the following codes:

Code	Description
1	Highway
2	Railroad
3	Pedestrian-bicycle
4	Highway-railroad
5	Highway-pedestrian
6	Overpass structure at an interchange or second level of a multilevel interchange
7	Third level (Interchange)
8	Fourth level (Interchange)
9	Building or plaza
0	Other

The second digit indicates the type of service "under" the bridge and shall be coded using one of the following codes:

Code	Description
1	Highway, with or without pedestrian
2	Railroad
3	Pedestrian-bicycle
4	Highway-railroad
5	Waterway
6	Highway-waterway
7	Railroad-waterway
8	Highway-waterway-railroad
9	Relief for waterway
0	Other

<u>Electrification (307)</u> ....(1 digit)

The type of service on the bridge is indicated by a 1-digit code; if electrified, code “Y” (YES), if not electrified, code “N” (NO).

<u>Number Of Tracks Structure Designed For (308)</u> .... (2 digits)

The information to be recorded for this item is the actual number of tracks the substructure was designed to carry.

Number Of Tracks Presently On Structure (309)... (2 digits)

The information to be recorded for this item is the actual number of tracks presently on the structure. This number includes all tracks whether in use or not in use.

Number Of Tracks In Service (310) .... (2 digits)

The information to be recorded for this item is the actual number of tracks actively in use. Active use will include tracks used infrequently (an example might include a "once a week" freight delivery).

Number Of Trains/Day (311) .... (4 digits)

The information to be recorded for this item is the actual number of trains that cross the structure in both directions, utilizing all tracks. The count will be for (A) passenger trains per day and (B) freight trains per month.

Year Of Census (312) .... (2 digits)

The year of census will be the most recent year of record, relative to the time of the inspection.

Average Passengers/Train (313) .... (4 digits)

The number recorded for this item is the total number of passengers using the train or trains in both directions divided by the number of trains in a given day. This average is calculated over a one year period of time.

Freight Carloads/Year (314) .... (5 digits)

The number recorded for this item reflects the total freight cars that cross the structure in both directions, as documented in the most recent year of record.

10.1.8. WATERWAY

Drainage Basin Code (W9) .... (4 digits)

This is a four digit code maintained by the Office of Rail that indicates the Drainage Basin Code for the bridge, based on the location of the bridge.

Navigation Control (Item 38) ....(1 digit)

For this item, indicate whether navigation control (a bridge permit for navigation) is required. Use one of the following codes:

Code	Description
N	Not applicable, no waterway.
0	No navigation control on waterway (bridge permit not required).
1	Navigation control on waterway (bridge permit required).

Navigation Vertical Clearance (Item 39).. (3 digits)

If Item 38 - Navigation Control has been coded 1, record the minimum vertical clearance imposed at the site as measured above a datum that is specified on a navigation permit issued by a control agency. The measurement shall be coded as a 3-digit number, rounded down to the nearest foot. This measurement will show the clearance that is allowable for navigational purposes. In the case of a swing or bascule bridge, the vertical clearance shall be measured with the bridge in the closed position (i.e., open to vehicular traffic). The vertical clearance of a vertical lift bridge shall be measured with the bridge in the raised or open position. Also, Item 116 – Minimum Navigation Vertical Clearance Vertical Lift Bridge shall be coded to provide clearance in a closed position. If Item 38 - Navigation Control has been coded 0 or N, use code 000 to indicate not applicable.

Navigation Horizontal Clearance (Item 40) .... (4 digits)

If Item 38 - Navigation Control has been coded 1, record the horizontal clearance measurement imposed at the site that is shown on the navigation permit. This may be less than the structure geometry allows. If a navigation permit is required, but not available, use the minimum horizontal clearance between fenders, if any, or the clear distance between piers or bents. Code the clearance as a 4-digit number. If Item 38 - Navigation Control has been coded 0 or N, use code 0000 to indicate not applicable.

Vertical Lift Bridge Navigation Minute (Item 116)... (3 digits)

Record to the nearest foot (rounding down), the minimum vertical clearance imposed at the site as measured above a datum that is specified on a navigation permit issued by a control agency. Code this item only for vertical lift bridges in the dropped or closed position, otherwise leave blank.

Pier Navigation Protection (Item 111)..(1 digit)

If Item 38 - Navigation Control has been coded 1, use the codes below to indicate the presence and adequacy of pier or abutment protection features such as fenders, dolphins, etc. The condition of the protection devices may be a factor in the overall evaluation of Item 60 - Substructure. If Item 38 - Navigation Control has been coded 0 or N, leave blank to indicate not applicable.

Code	Description
1	Navigation protection not required
2	In place and functioning
3	In place but in a deteriorated condition
4	In place but reevaluation of design suggested
5	None present but reevaluation suggested

Scour Critical Bridge (Item 113) ....(1 digit)

Item 113 - "Scour Critical Bridges", indicates a bridge's susceptibility to failure due to scour. This item is coded by the office staff based on a scour evaluation of the structure.

10.1.9. CONDITION

Deck (Item 58) ....(1 digit)

Code item according to Section 9.1 and the FHWA Coding Guide.

Superstructure (Item 59)..(1 digit)

Code item according to Chapter 9.1 and the FHWA Coding Guide.

Substructure (Item 60) ....(1 digit)

Code item according to Section 9.5 and the FHWA Coding Guide.

Channel/Protection (Item 61)...(1 digit)

Code item according to Section 9.2.1 and the FHWA Coding Guide.

Culverts (Item 62)...(1 digit)

Code item according to Section 9.3 and the FHWA Coding Guide.

10.1.10. STRUCTURE TYPE & MATERIAL

Structure Type, Main (Item 43)... (3 digits)

Record the description on the inspection form and indicate the type of structure for the main span(s) with a 3-digit code composed of 2 segments.

Segment	Description	Length
43A	Kind of material and/or design	1 digit
43B	Type of design and/or construction	2 digits

The first digit indicates the kind of material and/or design and shall be coded using one of the following codes:

Code	Description
1	Concrete
2	Concrete continuous
3	Steel
4	Steel continuous
5	Prestressed concrete *
6	Prestressed concrete continuous *
7	Wood or Timber
8	Masonry
9	Aluminum, Wrought Iron, or Cast Iron
0	Other

* Post-tensioned concrete should be coded as prestressed concrete.

The second and third digits indicate the predominant type of design and/or type of construction and shall be coded using one of the following codes:

Code	Description
01	Slab
02	Stringer/Multi-beam or Girder
03	Girder and Floorbeam System
04	Tee Beam
05	Box Beam or Girders - Multiple
06	Box Beam or Girders - Single or Spread
07	Frame (except frame culverts)
08	Orthotropic
09	Truss - Deck
10	Truss - Thru
11	Arch - Deck
12	Arch - Thru
13	Suspension
14	Stayed Girder
15	Movable - Lift
16	Movable - Bascule
17	Movable - Swing
18	Tunnel
19	Culvert (includes frame culverts)
20 *	Mixed types
21	Segmental Box Girder
22	Channel Beam
00	Other

* Applicable only to approach spans - Item 44

Deck Type (315)..(1 digit)

Code	Description
1	Open deck
2	Concrete slab
3	Concrete/Ballast
4	Steel plate/Ballast
5	Other

Depth of Ballast (316) .... (3 digits)

Code a 3-digit number to the tenth of a foot (XX.X) to indicate the depth of ballast on the bridge. Code zeros if the item does not apply.

Structure Type, Approach Spans (Item 44) .... (3 digits)

Indicate with a 3-digit code composed of 2 segments; the type of structure for the approach spans to a major bridge or for the spans where the structural material is different. The codes are the same as for Structure Type, Main (Item 43). However, code 000 if this item is not applicable. Use code 20 (Item 44B) when no one type of design and/or construction is predominate for the approach units. If the kind of material (Item 44A) is varied, code the most predominant.

Number of Spans, Main Unit (Item 45) .... (3 digits)

Record and indicate with a 3-digit code, the number of spans in the main or major unit. This item will include all spans of most bridges, the major unit only of a sizable structure, or a unit of material or design, different from that of the approach spans.

Number of Approach Spans (Item 46) .... (4 digits)

Record and indicate with a 4-digit code, the number of spans in the approach spans to the major bridge, or the number of spans of material, different from that of the major bridge.

SUBSTRUCTURE TYPE (317)..(1 digit)

This item is to be coded in two parts: "A", the material that makes up the primary portion of the substructure and "B", the foundation type. Use the codes listed below which best define "A", the material and "B", the foundation type.

"A" Code	Description
1	Stone
2	Concrete
3	Timber
4	Steel
5	Other

"B" Code	Description
1	Full height stem
2	Stub abutment
3	Pile bent
4	Crib
5	Other

10.1.11. CLASSIFICATION & R-O-W INFORMATION

Parallel Structure (Item 101)...(1 digit)

Code this item to indicate situations where separate structures carry the inventory route in opposite directions of travel over the same feature.
One of the following codes shall be used:

Code	Description
R	The right structure of parallel bridges carrying the roadway in the direction of the inventory. (For a defense highway, this is west to east and south to north.)
L	The left structure of parallel bridges. This structure carries traffic in the opposite direction.
N	No parallel structure exists.

Temporary Structure (Item 103) ....(1 digit)

Code this item to indicate situations where temporary structures or conditions exist. This item should be blank if not applicable.

Code	Description
T	Temporary structure(s) or conditions exist.

Maintainer (Item 21) .... (2 digits)

The actual name(s) of the agency(s) responsible for the maintenance of the structure shall be recorded on the inspection form. The codes below shall be used to represent the type of agency that has primary responsibility for maintaining the structure. If more than one agency has equal maintenance responsibility, code one agency in the hierarchy of state, federal, county, city, railroad, and other private.

Code	Description
01	State Highway Agency
02	County Highway Agency
03	Town or Township Highway Agency
04	City or Municipal Highway Agency
11	State Park, Forest, or Reservation Agency
12	Local Park, Forest, or Reservation Agency
21	Other State Agencies
25	Other Local Agencies
26	Private (other than railroad)
27	Railroad
31	State Toll Authority
32	Local Toll Authority
60	Other Federal Agencies (not listed below)
61	Indian Tribal Government
62	Bureau of Indian Affairs
63	Bureau of Fish and Wildlife
64	U.S. Forest Service
66	National Park Service
67	Tennessee Valley Authority
68	Bureau of Land Management
69	Bureau of Reclamation
70	Corps of Engineers (Civil)
71	Corps of Engineers (Military)
72	Air Force
73	Navy/Marines
74	Army
75	NASA
76	Metropolitan Washington Airports Service
80	Unknown

R-O-W Info. File Location Of Maps, Plans, Etc. (322) .... (text)

The information to be recorded for this item is the descriptive location of maps, plans, etc. for future reference. Abbreviations may be used, but they must be meaningful.

10.1.12. LOAD RATING

Design Load (Item 31) .... (1 Digit)

Use the codes below to indicate the live load for which the structure was designed. The numerical value of the railroad loading should be recorded on the form. Classify any other loading, when feasible, using the nearest equivalent of the loadings given below.

Code	Description
1	H 10
2	H 15
3	HS 15
4	H 20
5	HS 20
6	HS 20+Mod
7	Pedestrian
8	Railroad
9	HS 25
0	Other or Unknown (describe on inspection reporting form)

Structure Operational Status (Item 41) .... (1 Digit)

This item provides information about the actual operational status of a structure. The field review could show that a structure is posted, but Item 70 - Bridge Posting may indicate that posting is not required. This is possible and acceptable coding since Item 70 is based on the operating stress level and the governing agency's posting procedures may specify posting at some stress level less than the operating rating. One of the following codes shall be used:

Code	Description
A	Open, no restriction
B	Open, posting recommended but not legally implemented (all signs not in place or not correctly implemented)
D	Open, would be posted or closed except for temporary shoring, etc. to allow for unrestricted traffic
E	Open, temporary structure in place to carry legal loads while original structure is closed and awaiting replacement or rehabilitation
G	New structure not yet open to traffic
K	Bridge closed to all traffic
P	Posted for load (may include other restrictions such as temporary bridges which are load posted)
R	Posted for other load-capacity restriction (speed, number of vehicles on bridge, etc.)

E-Cooper Rating By Track Number (323) .... (3 digits)

Code two 3-digit codings for each track carried by the structure. The two codings are:

1. Normal Rating
2. Maximum Rating

Note: Track is typically numbered in the following manner.
1. An east-west, four-track line is designated 3,1,2,4, left to right while facing east. Additional tracks to the left would be 5,7,9, etc. Additional tracks to the right would be 6,8,10, etc.
2. A north-south, four-track line is numbered in the same manner while facing north.

10.2. RAILROAD BRIDGE CODING ITEMS for Form BRI-25

The instructions contained in this section are intended to supplement the FHWA Coding Guide and provide guidance in completing the BRI-25 Form. Exceptions to the instructions in the FHWA Coding Guide are also noted. The instructions are organized to follow the items as they appear on the BRI-25 Access Input Form.

10.2.1. BRI-25 GENERAL INFORMATION

The inspection block is that portion of the BRI-25 provides inventory data on any state numbered routes that pass under the structure.

Bridge Number .... (6 digits)

This field should contain the official number of the bridge. There is 6 digit limit to the number or type of characters in this field.

Inspection Date .... (8 digits)

Code the month, day and year of the starting date of routine or in-depth inspections as follows:

MM DD YYYY

The inspection date shown on the BRI-18 should be the same as the date entered on the BRI-39. If the inspection requires visits on more than one day, the last date of the inspection should be entered.

Town ....(5 digits)

Code this item with the State of Connecticut designated place codes for each town. (This item can only be changed under the Maintain Structures item on the Main Menu of the program.)

NBIS Bridge Length .... (6 Digits)

This item is a description of the total length of the structure. For this item enter the total length of the structure from back to back of the abutments (recorded in feet).

Facility Carried .... (2 digits)

Use the codes listed below to indicate the rail line owner.

Code	Description
01	Amtrak
02	Boston & Maine (B & M)
03	Branford Steam Railroad
04	Abandoned Railroad
05	Valley Railroad
06	Connecticut Central Railroad
07	Housatonic Railroad
08	Inactive Railroad
09	Metro-North Railroad
10	Providence & Worcester (P & W)
11	Conrail
12	New England Railroad
13	Danbury Terminal
14	Other
15	Housatonic Railroad
16	Naugatuck Railroad
17	New England Central Railroad
18	Connecticut Southern Railroad
19	Central New England Railroad
20	CSX Corp.
21	Rails to Trails

Feature Intersected .... (50 digits)

The information to be recorded for this item shall be the name of the feature crossed by the bridge. There are 50 digits allowed for coding of this item. Abbreviations may be used, but effort shall be made to keep them meaningful.

10.2.2. IDENTIFICATION

Inventory Route (Item 5).. (8 digits)

The inventory route is a 8-digit code composed of 4 segments.

Segment	Description	Length
5A	Record Type	1 digit
5B	Route Signing Prefix	1 digit
5C	Designated Level of Service	1 digit
5D	Route Number	5 digits

Record Type (Item 5A) ....(1 digit)

There are two types of National Bridge Inventory records: "on" and "under". Code the first digit (leftmost) using one of the following codes:

Code	Description
1	Route carried "on" the structure
2	Single route goes "under" the structure
A through Z	Multiple routes go "under" the structure

A signifies the first of multiple routes under the structure.
B signifies the second of multiple routes under the structure.
Z signifies 26 routes under the structure.

"On" signifies that the inventory route is carried "on" the structure. Each bridge structure carrying highway traffic must have a record identified with a type code = 1 (numeric). All of the NBI data items must be coded, unless specifically excepted, with respect to the structure and the inventory route "on" it.

"Under" signifies that the inventory route goes "under" the structure. If an inventory route beneath the structure is a Federal-aid highway, a STRAHNET route or connector or otherwise important, a record must be coded to identify it. The type code must be 2 or an alphabetic letter A through Z. Code 2 for a single route under the structure. If 2 or more routes go under a structure on separate roadways, the code of 2 shall not be used. Code A, B, C, D, etc. consecutively for multiple routes on separate roadways under the same structure. STRAHNET routes shall be listed first. When this item is coded 2 or A through Z, only the following items must be coded: Items 1, 3-13, 16, 17, 19, 20, 26-30, 42, 43, 47-49, 100-104, 109 and 110. All other items may remain blank.

It cannot be overemphasized that all route-oriented data must agree with the coding as to whether the inventory route is "on" or "under" the structure.

Tunnels shall be coded only as an "under" record; that is, they shall not be coded as a structure carrying railroad traffic.

There are situations of a route "under" a structure, where the structure does not carry a highway, but may carry a railroad, pedestrian traffic, or even a building. These are coded the same as any other "under" record and no "on" record shall be coded.

Route Signing Prefix (Item 5B) ....(1 digit)

In the second position, identify the route signing prefix for the inventory route using one of the following codes:

Code	Description
1	Interstate highway
2	U.S. numbered highway
3	State highway
4	County highway
5	City street
6	Federal lands road
7	State lands road
8	Other(include toll roads not otherwise indicated or identified above)

When 2 or more routes are concurrent, the highest class of route will be used. The hierarchy is in the order listed above.

Designated Level of Service (Item 5C) ....(1 digit)

In the third position, identify the designated level of service for the inventory route using one of the following codes:

Code	Description
0	None of the below
1	Mainline
2	Alternate
3	Bypass
4	Spur
6	Business
7	Ramp, Wye, Connector, etc.
8	Service and/or unclassified frontage road

Route Number (Item 5D) .... (5 digits)

Code the route number of the inventory route in the next 5 positions. This value shall be right justified in the field with leading zeros filled in. (See examples below.)

If concurrent routes are of the same hierarchy level, denoted by the route signing prefix, the lowest numbered route shall be coded. Code 00000 for bridges over roads without route numbers.

In some cases, letters may be used with route numbers and as part of the route numbers and not to indicate direction. In such cases, the letter should be included in the 5-position route number field.

EXAMPLES	Record	Code
Interstate 95, on	1 1 1 00095	11100095
Interstate 70S, under	2 1 1 00070	21100070
State Highway 104, Spur, under	2 3 4 00104	23400104
U.S. 30E Bypass, on	1 2 3 00030	12300030
City street, on	1 5 0 00000	15000000
Ramp from I-81, under	2 1 7 00081	21700081
County Highway 173 on	1 4 1 00173	14100173
Interstate 84 under	2 1 1 00084	21100084
Interstate 495 on	1 1 1 00495	11100495
State Hwy 120 (STRAHNET Rte) under	A 3 1 00120	A3100120

Milepoint (Item 11) .... (5 digits)

Code a 5-digit number to represent the mile point location of the structure. The 5-digit code will be to the hundredth of a mile. The mile point shall reference the beginning of the structure in the direction of the track line inventory.

10.2.3. AGE & SERVICE

Number of Inventory Route Lanes (Item 28B) .... (2 digits)

Record and code the number of lanes being crossed over by the structure as a 2-digit number.

ADT (Inventory Route) (Item 29) .... (6 digits)

Code a 6-digit number that shows the average daily traffic volume for the inventory route identified in Item 5. Make certain the unit's position is coded even if estimates of ADT are determined to tens or hundreds of vehicles; that is, appropriate trailing zeros shall be coded. The ADT coded should be the most recent ADT counts available. Included in this item are the trucks referred to in Item 109 – Average Daily Truck Traffic. If the bridge is closed, code the actual ADT from before the closure occurred.

Truck ADT% (Inventory Route) (Item 109) .... (6 digits)

Code a 2-digit percentage that shows the percentage of Item 29 – Average Daily Traffic that is truck traffic. Do not include vans, pickup trucks and other light delivery trucks in this percentage.

If this information is not available, an estimate, which represents the average percentage for the category of road carried by the bridge, may be used. May be left blank if Item 29 - Average Daily Traffic is not greater than 100.

EXAMPLES:

		Code
Average Daily Traffic	7% trucks	07
	12% trucks	12

Year of ADT (Inventory Route) (Item 30) .... (2 digits)

The year of census will be the most recent year of record, relative to the time of the inspection.

<u>Inventory Route Operational Status (Item 41)</u>... (1 Digit)

This item provides information about the actual operational status of a structure. The field review could show that a structure is posted, but Item 70 - Bridge Posting may indicate that posting is not required. This is possible and acceptable coding since Item 70 is based on the operating stress level and the governing agency's posting procedures may specify posting at some stress level less than the operating rating. One of the following codes shall be used:

Code	Description
A	Open, no restriction
B	Open, posting recommended but not legally implemented (all signs not in place or not correctly implemented)
D	Open, would be posted or closed except for temporary shoring, etc. to allow for unrestricted traffic
E	Open, temporary structure in place to carry legal loads while original structure is closed and awaiting replacement or rehabilitation
G	New structure not yet open to traffic
K	Bridge closed to all traffic
P	Posted for load (may include other restrictions such as temporary bridges which are load posted)
R	Posted for other load-capacity restriction (speed, number of vehicles on bridge, etc.)

<u>Bypass Detour Length (Item 19)</u> ....(2 Digits)

Indicate the actual length of the detour, to the nearest mile. The detour length should represent the total additional travel for a vehicle which would result from closing of the bridge. The factor to consider, when determining if a bypass is available at the site, is the potential for moving vehicles, including military vehicles, around the structure. This is particularly true when the structure is in an interchange. For instance, a bypass likely would be available in the case of diamond interchanges, interchanges where there are service roads available, or other interchanges where the positioning and layout of the ramps is such that they could be used, without difficulty, to get around the structure. If a ground level bypass is available at the structure site for the inventory route, record and code the detour length as 00.

If the bridge is one of twin bridges and is not at an interchange, code 01 where the other twin bridge can be used as a temporary bypass with a reasonable amount of crossover grading. The detour route will be established following allowable criteria determined by the governing authority. (Some authorities will not allow a designated detour over a road or bridge of lesser "quality.") Code 99 for 99 miles or more.

10.2.4. GEOMETRIC DATA

Inventory Route Minimum Vertical Clearance (Item 10B) ....(4 Digits)

Code the minimum vertical clearance over the inventory route identified in Item 5. The minimum clearance for a 10-foot width of the pavement or traveled part of the roadway, where the clearance is the greatest, shall be recorded and coded in feet and inches. For structures having multiple openings, clearances for each opening shall be recorded, but only the greatest of the minimum clearances for the two or more openings shall be coded, regardless of the direction of travel. This would be the practical maximum clearance.

Inventory Route Total Horizontal Clearance (Item 47)..(3 Digits)

The total horizontal clearance for the inventory route identified in Item 5 should be measured and recorded to supply information that meets reporting requirements of FHPM 6-10-2. The clearance should be the available clearance measured between the restrictive features - - curbs, rails, walls, or other structural features limiting the roadway (surface and shoulders). The measurement should be recorded and coded to the nearest tenth of a foot (with an assumed decimal point).
The purpose of this item is to give the largest available clearance for the movement of wide loads. This clearance has been identified in 3 ways; use the most applicable:

1. Roadway surface and shoulders.
2. Distance from face of pier (or rail around pier) to face of rail or toe of slope.
3. Include flush or mountable medians (Item 33 - Bridge Median coded 2) but not raised medians (Item 33 coded 3). For a raised or nonmountable median, record the greater of the restricted widths in either direction, not both directions.

Min Vertical Clearance Over Bridge Roadway (Item 53) ....(4 Digits)

The information to be recorded for this item is the actual minimum vertical clearance over the track to any superstructure restriction. This item is to be recorded in feet and inches. When a superstructure restriction does not exist, enter the code 99’-99”.

Min Lateral Underclearance on Right (Item 55)...(4 Digits)

The information to be recorded for this item is the actual minimum lateral clearance from the centerline of the feature below, right to the nearest substructure unit. This item has two parts: a 1 digit code for the description of the feature beneath the superstructure, from the list above, and the actual minimum lateral clearance (recorded in feet).

Min Lateral Underclearance on Left (Item 56) ....(3 Digits)

The information to be recorded for this item is the actual minimum lateral clearance from the centerline of the feature below, left to the nearest substructure unit. This item is to record the actual minimum lateral clearance recorded in feet.

10.2.5. CLASSIFICATION

Inventory Route Functional Classification (Item 26)..(2 Digits)

For the inventory route, code the functional classification using one of the following codes:

Code		Description
	Rural	
01		Principal Arterial - Interstate
02		Principal Arterial - Other
06		Minor Arterial
07		Major Collector
08		Minor Collector
09		Local
	Urban	
11		Principal Arterial - Interstate
12		Principal Arterial - Other Freeways or Expressways
14		Other Principal Arterial
16		Minor Arterial
17		Collector
19		Local

The bridge shall be coded rural, if not inside a designated urban area. The urban or rural designation shall be determined by the bridge location and not the character of the roadway.

Defense Highway Designation (Item 100)... (1 Digit)

This item shall be coded for all records in the inventory . For the inventory route identified in Item 5, indicate defense highway conditions using one of the following codes :

Code	Description
0	The inventory route is not a defense highway.
1	The inventory route is a defense highway.
2	The inventory route is a defense highway that goes over or under a defense highway.

Direction of Traffic (Item 102) .... (1 Digit)

Code the direction of traffic of the inventory route identified in Item 5 as a 1-digit number using one of the codes below. This item must be compatible with other traffic-related items such as Item 28B Lanes under the Structure, Item 29 - Average Daily Traffic, Item 47 – Total Horizontal Clearance and Item 51 - Bridge Roadway Width, Curb-to-Curb.

Code	Description
0	Highway traffic not carried
1	1-way traffic
2	2-way traffic
3	One lane bridge for 2-way traffic

Highway System of the Inventory Route (Item 104).. (1 Digit)

This item is to be coded for all records in the inventory. For the inventory route identified in Item 5, indicate whether the inventory route is on the National Highway System (NHS). The coding is to reflect the approved NHS. Use one of the following codes:

Code	Description
0	Inventory Route is not on the NHS
1	Inventory Route is on the NHS

Designated National Network (Item 110) .... (1 Digit)

The national network for trucks includes most of the Interstate System and those portions of Federal-Aid highways identified in the Code of Federal Regulations (23 CFR 658). The national network for trucks is available for use by commercial motor vehicles of the dimensions and configurations described in these regulations. For the inventory route identified in Item 5, indicate conditions using one of the following codes:

Code	Description
0	The inventory route is not part of the national network for trucks.
1	The inventory route is part of the national network for trucks.

10.2.6. POSTED SIGNS

Posted Vertical Clearance Under Bridge ....(4 Digits)

If there is a sign displaying the vertical clearance under the Railroad bridge, enter the posted height in feet and inches.

10.2.7. COMMENTS

Information to be included in this section includes:

- Comment on the presence of any construction being done to the Route (or recently completed) and include state project numbers, whenever possible.

- Identify any significant condition changes since the last inspection and, if possible, identify the cause of the problem and recommendations to correct the problem.

- Any additional information at may be pertinent.

APPENDIX A
OFFICE OF RAIL INSPECTION FORMS

APPENDIX A
OFFICE OF RAIL INSPECTION FORMS

BRI- 9	Construction Punch List
BRI-10	Concrete Deterioration Worksheet
BRI-11	Seismic Data Sheet
BRI-12	Fracture Critical Data Sheet
BRI-13	Photo Log
BRI-14	Sliding Bearing Measurement Sheet
BRI-15	Rocker Bearing Measurement Sheet
BRI-16	Pot Bearing Measurement Sheet
BRI-17	Joint Measurement Sheet
BRI-18	Bridge Inspection Report Form
BRI-24	Incident Report Form
BRI-25	Under Entry Structure Inventory & Appraisal Form
BRI-27	Inspection Report Transmittal Form
BRI-29	Pin & Hanger Data/Analysis Form
BRI-30	Hinge Data/Analysis Form
BRI-39	Structure Inventory & Appraisal Form
BRI-58	Underwater Inspection Report Form
BRI-59	Underwater Inspection Structure Data Form

BUREAU OF PUBLIC TRANSPORTATION
OFFICE OF RAIL

DATE: _________

CONSTRUCTION PUNCH LIST

FormBRI-9, Rev. 01/12

Construction Project Number: ____

Bridge No. ______________ Town: _____________________ Route: ________________

Feature Intersected: ____

Bridge Type: ____

Mile Point: ______________________________ Construction District: ________________

Construction Company Name: ____

D.O.T. Construction Inspectors Name: ______________________________________

List of Items to be Corrected or Completed:

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____
9. ____
10. ____

BUREAU OF PUBLIC TRANSPORTATION
OFFICE OF RAIL

DATE: _________

CONSTRUCTION PUNCH LIST

FormBRI-9, Rev. 01/12

Bridge No. _______________

Photo Log:

1. ____
2. ____
3. ____
4. ____
5. ____

Additional Comments (If any):

____

____

____

____

____

____

Date copy sent to Construction: ____

Submitted By: ____ Date:____________

Checked By: ____ Date:____________

CONCRETE DECK DETERIORATION WORKSHEET

Purpose: This form is used to tally the deteriorated areas on both the topside (of bare concrete decks) and underside of the deck. The areas tallied are then used to calculate what percentage of the deck is deteriorated. The maximum % deterioration in any one span and the total % deterioration for the structure are then reviewed to determine the concrete deck condition rating in accordance with Section 10.1.

Instructions for completing Form BRI-10:

1. Estimate the area (in square feet) of each type of deterioration in each span. This can be done by totaling all the individual areas drawn on a deck sketch or by some rational method of estimating the area.

   Example: 25% of each 6' x 20' bay has map cracking with efflorescence. Assume there are 8 bays. The number to be recorded under "Map Cracking: w/Efflorescence" = 25% x 6' x 20' x 8 bays = 240 sq. ft.

   For multi-span structures, total the deteriorations for the whole bridge across each row to the column on the right side of the form.

2. Calculate the deck area of each span using the plans. This should be the out-to-out of deck dimension multiplied by the center to center of deck joints dimension. For multi-span structures, total the deck area for the whole bridge across to the column on the right side of the form.

3. Calculate the % spalled and delaminated on the topside of bare decks in each span by dividing the spalled and delaminated area by the total span area. Do the same in the total column (total % deterioration is calculated by summing the areas of deterioration and dividing by the total deck area, not by summing the individual span %'s).

4. Calculate the % deterioration on the bottom by adding the spalled, delaminated, scaled, cracked and honeycomb areas, and dividing by the total span area in each span. Do the same in the total column (total % deterioration is calculated by summing the areas of deterioration and dividing by the total deck area, not by summing the individual span %'s).

Bridge No.: _______ Date: _________ Prepared By: ________________ Checked By: ________________

CONCRETE DETERIORATION WORKSHEET

Form BRI-10, Rev. 9/01

	Deterioration By Span - In Square Feet										
	Span Number										
Deterioration Type	1	2	3	4	5	6	7	8	9	10	Total
Spalled and Delaminated Areas	Top:	Top:	Top:	Top:	Top:	Top:	Top:	Top:	Top:	Top:	Top:
	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:
Scale (Moderate to Severe Only)	Top:	Top:	Top:	Top:	Top:	Top:	Top:	Top:	Top:	Top:	Top:
	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:
Cracks: w/Efflorescence (use 6 in. width x length)	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:
w/o Efflo. (use 3 in. width x length)	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:
Map Cracking: w/Efflorescence (use full area)	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:
w/o Efflo. (use 50% of area)	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:
Honeycombed Areas (only areas more than 1 1/2 in. deep)	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:	Bot:
Total Span Area (Square Feet)											
% Spalled and Delaminated on Top											
% Deterioration on Bottom											

SEISMIC DATA SHEET FOR RAILROAD BRIDGES

Prepared By:____Date:____________________

Entered By:________Date:________________

Bridge # ____________ **Mile Point:**______________
Town:______________________
Feature Crossed:_______________
Line Name: ______________________
Operator: ________________________

Feature Crossed Information:
ADT______________ year of ADT_____________________
Community Lifeline_____________ (y/n)
Major River Crossing________(y/n)

Feature Carried Information:
Utilization
Freight Service only_______ Less than 10 passenger trains/day___________ More than 10 passenger trains/day____

Detour available______________Yes______Inconvenient______None
Alternate Service (Bus) available______(y/n)

Structure Information:
Bridge Construction
Continuous W/Integral abuts___________ Single span or continuous multiple spans___ Multiple simple spans_______

Number of Spans_________ Number of longitudinal girders __________
Ballasted Deck______(y/n) Moveable Bridge_______(y/n)
Total Bridge length ____ft Max single span____________ft
Bridge width_________________ ft Skew______________________degrees
Abutment height______ftIs abut masonry or unreinforced conc. ________(y/n)

Bearing and Bridge Seat Construction
Expansion Bearing Type __________________ If rocker, Height_________Inches
Are Bearings on Pedestals (pad > 6"' high)_________(y/n)
Expansion Bearings Transversely Restrained__________(y/n)

Vulnerable Bearing Information
Expansion Bearing Longitudinal Support Length_____________Inches
Expansion Bearing Transverse Support Length_____________Inches

Effective Length _________ft, Effective Height______________ft

Pier Construction ___ No pier (single span bridge)
Steel or ductile conc. Multi-column bent ___________ Steel or ductile conc. single column ______________ Wall type Pier__________

Is pier founded on battered pile______(y/n)
Is material masonry or unreinforced concrete___________(y/n)
Is transverse movement between pier and beams accommodated____________(y/n)

CONNECTICUT DEPARTMENT OF TRANSPORTATION
FRACTURE CRITICAL MEMBERS/FATIGUE PRONE DETAILS
INSPECTION DATA SHEET

Form BRI12, Rev 9/97

Fracture Critical Inspection Date: ☐

FC Insp Freq: ☐ Months **FC Type Code:** ☐

Bridge No: ☐

Year Built: ☐

Town: ☐ ADT: ☐ Year of ADT: ☐

Facility Carried: ☐ Structure Type: ☐ % Truck: ☐

Feature Intersected: ☐

Access Equipment Needed: ☐

Traffic Control Required: ☐

Reference to Plans: ☐

MEMBER/DETAIL TYPE # ☐

Member/Detail Type: ☐ ☐ Fracture Critical

Fatigue Category: ☐ Steel Type: ☐ ☐ Fatigue Prone

Description: ☐

Inspection Procedure: ☐

MEMBER/DETAIL TYPE # ☐

Member/Detail Type: ☐ ☐ Fracture Critical

Fatigue Category: ☐ Steel Type: ☐ ☐ Fatigue Prone

Description: ☐

Inspection Procedure: ☐

CONNECTICUT DEPARTMENT OF TRANSPORTATION
FRACTURE CRITICAL MEMBERS/FATIGUE PRONE DETAILS
INSPECTION DATA SHEET

Form BRI12, Rev 9/97

MEMBER/DETAIL TYPE # ☐

Member/Detail Type: ☐ Fracture Critical

Fatigue Category: Steel Type: ☐ Fatigue Prone

Description:

Inspection Procedure:

MEMBER/DETAIL TYPE # ☐

Member/Detail Type: ☐ Fracture Critical

Fatigue Category: Steel Type: ☐ Fatigue Prone

Description:

Inspection Procedure:

MEMBER/DETAIL TYPE # ☐

Member/Detail Type: ☐ Fracture Critical

Fatigue Category: Steel Type: ☐ Fatigue Prone

Description:

Inspection Procedure:

MEMBER/DETAIL TYPE # ☐

Member/Detail Type: ☐ Fracture Critical

Fatigue Category: Steel Type: ☐ Fatigue Prone

Description:

Inspection Procedure:

PHOTO LOG

Form BRI-13, Rev. 9/97

Bridge Information System

Image Inventory

Bridge No. ____________ Date ____________

Town: ____________ Photographer: ____________

Carried / Crossed: ____________

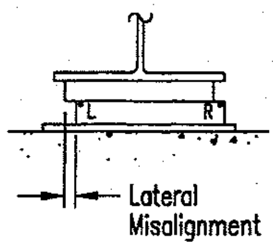
Film Frame #	Image Description

FIELD NOTES

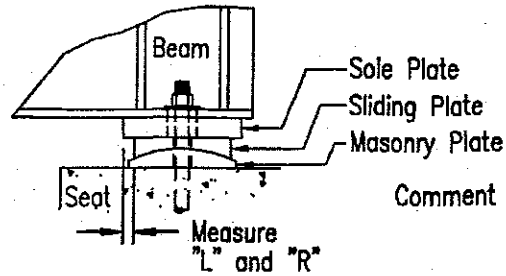
BRIDGE NO.	DATE:
CREW:	SHEET

SLIDING BEARING MEASUREMENTS

Form BRI-14, Rev. 9/01



FRONT VIEW



SIDE VIEW

Span No. = ______

Substructure Unit = ______

Temperature = ____°F

Comment On:
- Presence of keepers or work done on bearings.
- Undermining of bearing. Attach sketch with dimensions.
- Cracking of plates or welds.
- Condition of anchor bolts.

Beam	Movement				Condition			Comments
	"L"	"R"	Mode Exp. or Contr.	Lateral Misalign.	Bearing Frozen?	Normal Mov't?	Rust ? H/M/L	

FIELD NOTES

BRIDGE NO.	DATE:
CREW:	SHEET

ROCKER BEARING MEASUREMENTS

Form BRI-15, Rev. 9/97

Span No. = ______

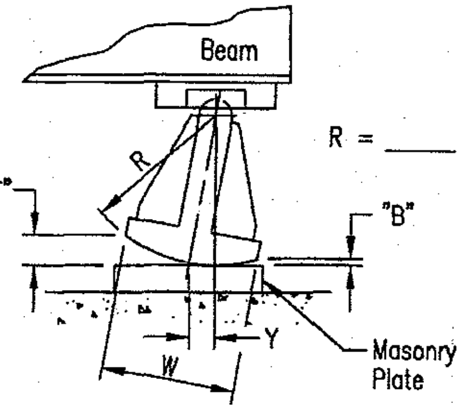
Substructure Unit = ______________________

Temperature = ____°F

$\theta = \sin^{-1} (F-B)/W$

$Y = R \tan \theta$

The "Front" of the bearing is the side facing the fixed bearing.



R = ______

W = ______

NOTE:

"F" & "B" should be measured at the left side corners of the rocker or on the side closest to to the front face of the substructure on skewed bridges.

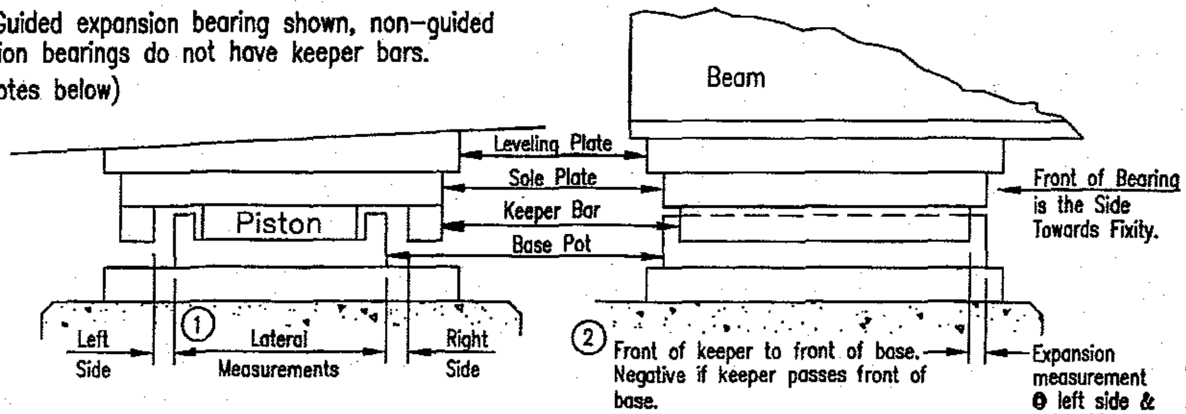
Beam	"F"	"B"	Y	Cont. or Exp.	Comments

FIELD NOTES	BRIDGE NO.	DATE:
	CREW:	SHEET

POT BEARING MEASUREMENTS

Form BRI-16, Rev. 9/97

Note: Guided expansion bearing shown, non-guided expansion bearings do not have keeper bars.
(see notes below)



FRONT VIEW　　　　SIDE VIEW

① –Left & Right are determined when facing the Front of the Bearing.
–For non-guided bearings, measure from side of sole plate to side of piston ℄ center line of piston.

② –For non-guided bearings, measure expansion from front of sole plate to front of piston ℄ center line of bearing.

Span No. & Substructure Unit = ____________________　　Temperature = ____°F

Beam	Expansion			Lateral		Comments
	Exp. Measurement		Side of Brg.	Left	Right	
	L	R	(N,S,E,W)			

JOINT MEASUREMENTS

Form BRI-17, Rev. 9/97

Bridge No.: ____________________ Town: ____________

Measurements Taken By: ____________

Measurements Reviewed By: ____________

Deck Joint Location	Deck Joint Type[1]	Effect Span[2] (ft.)	Winter Measurements			Summer Measurements			Differential Movements			Comments	Difference Between Actual & Calc'd Mov't	
			Temp °F	Date: Left (in.)	Right (in.)	Temp °F	Date: Left (in.)	Right (in.)	Actual Left (in.)	Actual Right (in.)	by Formula		Left (in.)	Right (in.)

1. The "Deck Joint Type" should be "plug" for Asphaltic Plug joints, "strip" for Strip Seals, "seg." for Segmental Joints, etc.
2. The "Effective Span" is the length contributing to expansion at the joint. This should be 0 at fixed joints of single span bridges.

File: JTBLANK.XLS(English), Printed: 9/5/97

Connecticut Department of Transportation
Bridge Inspection Report BRI-18

BRIDGE #: [ ] **INSPECTION DATE:** [ ]

INSPECTION TYPE: [ ] **PREVIOUS INSPECTION DATE:** [ ] **SNOOPER REQUIRED:** [ ]
INSPECTION PERFORMED BY: [ ] **SNOOPER USED:** [ ]

TOWN: [ ] **FEATURE CARRIED:** [ ] **YEAR BUILT:** [ ]
LOCATION: [ ] **FEATURE INTERSECTED** [ ] **YEAR REBUILT:** [ ]
MAIN MATERIAL: [ ] **MAIN DESIGN:** [ ]

INSPECTION VISITS: **INSPECTORS:**

58. DECK [ ] **OVERALL RATING** [ ]

	RATING	
OVERLAY		
DECK STR. CONDITION		
CURBS		
MEDIAN		
SIDEWALKS		
PARAPET		
RAILING		
PAINT		
FENCE		
DRAINS		
LIGHTING STANDARD		
UTILITIES TYPE/SIZE		
CONSTRUCTION JOINTS		
EXPANSION JOINTS		

59. SUPERSTRUCTURE [ ] **OVERALL RATING** [ ]

	RATING	
BEARING DEVICES		
STRINGERS		
GIRDERS		
FLOOR BEAMS		
TRUSSES-GENERAL		
TRUSSES-PORTALS		
TRUSSES-BRACING		
PAINT		
RUST		
MACHINERY MOV SPAN		

Connecticut Department of Transportation
Bridge Inspection Report BRI-18

BRIDGE #: INSPECTION DATE:

RIVETS & BOLTS
WELDS & CRACKS
TIMBER DECAY
CONCRETE CRACKING
COLLISION DAMAGE
MEMBER ALIGNMENT
DEFLECT. UNDER LOAD
VIBR. UNDER LOAD
STAND PIPES
BARREL LADDERS

ARE BARREL LADDERS OSHA COMPLIANT?

60. SUBSTRUCTURE OVERALL RATING

RATING

ABUTMENTS-STEM
ABUTMENTS-BACKWALL
ABUTMENTS-FOOTINGS
ABUT.-SETTLEMENT
ABUTMENTS-WINGWALLS
PIERS/BENTS-CAPS
PIERS/BENTS-PILE BENT
PIERS/BENTS-COLUMN
PIERS/BENTS-FOOTINGS
PIERS/BENTS-SETTLEMent
EROSION-SCOUR
CONCRETE CRACK-SPALL
STEEL CORROSION
PAINT
TIMBER DECAY
COLLISION DAMAGE
DEBRIS

61. CHANNEL PROTECTION OVERALL RATING

RATING

CHANNEL SCOUR
EMBANKMENT EROSION
DEBRIS
VEGETATION

Connecticut Department of Transportation

Bridge Inspection Report BRI-18

BRIDGE #: ____ **INSPECTION DATE:** ____

CHANNEL CHANGE

FENDER SYSTEM

SPUR DIKES & JETTIES

RIP RAP

62. CULVERTS & RETAINING WALL **OVERALL RATING**

RATING

BARREL

CONCRETE

STEEL

TIMBER

HEADWALL

CUTOFF WALL

DEBRIS

RETAINING WALL STEM

FOOTING

APPROACH CONDITION **OVERALL RATING**

RATING

APPROACH SLAB

RELIEF JOINTS

APPROACH GUIDE RAIL

APPROACH PAVEMENT

APPROACH EMBANKMENT

TRAFFIC SAFETY FEATURES:

BRIDGE RAILINGS

TRANSITIONS

APPROACH GUARDRAILS

APPR. GUARDRAIL ENDS

LOAD POSTING

SINGLE UNIT (TONS)

HS (TONS)

4 AXLE (TONS)

2S3 (TONS)

ADVANCE WARNING Y/N

LEGIBILITY

VISIBILITY/LOCATION

Connecticut Department of Transportation
Bridge Inspection Report BRI-18

BRIDGE #: ______ INSPECTION DATE: ______

MISC.

MIN VERT. UNDERCLR. ___' ___"

POSTED CLR. UNDER BRIDGE ___' ___"

POSTED CLR. ON BRIDGE ___' ___"

ADVANCE WARNING (Y/N)

SPEED LIMIT (IF ANY) ___ MPH

CHARACTER OF TRAFFIC

ADDITIONAL NOTES

ADDITIONAL COMMENTS:

Inspectors' Signatures: 1) ______________________ Date: __/__/__

2) ______________________ Date: __/__/__

3) ______________________ Date: __/__/__

4) ______________________ Date: __/__/__

P.E. Signature: ______________________ Date: __/__/__

P.E.#: ______________________

Reviewed by: ______________________ CDOT Date: __/__/__

State of Connecticut
Department of Transportation
Bureau of Public Transportation
Office of Rail

Sheet _____Of_____
Form BRI-24, Rev. 01/12

INCIDENT REPORT

Town: ________________________________ Bridge No. ____________________

Route/Street: ____

Over: _________________________________ Type: _________________________

Inspected by: ____________________________ Date: ____/____/____

Date of Incident:____/____/____ Time of Incident: ____________ "D" no.: __________

Details of Incident: ____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

Immediate Actions Taken: ____

____

____

____

Additional Remarks: ____

____

____

BRIDGE NUMBER	TOWN NAME	NBIS BRG LGTH

FACILITY CARRIED	FEATURE CROSSED

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
DIVISION OF BRIDGE SAFETY EVALUATION

INVENTORY ROUTE UNDER STRUCTURE EVALUATION

FORM BRI-25 REV 10/00

INSPECTED BY: ____________________

____

REVIEWED BY: ____________________ DATE: ____________________

SHEET_____ OF_____ (INSP. REPORT)

IDENTIFICATION

DESCRIPTION:

5) INVENTORY ROUTE:

A) RECORD TYPE

B) ROUTE SIGNING PREFIX

C) DESIGNATED LEVEL OF SERVICE

D) ROUTE NO.

11) MILE POINT (INV.RTE)

AGE & SERVICE

\+ 28B) NUMBER OF INV.ROUTE LANES

* 29) ADT (INV. RTE)

* 109) TRUCK ADT % (INV.RTE)

* 30) YEAR OF ADT (INV. RTE)

* 41) INV ROUTE OPERATIONAL STATUS

19) BYPASS DETOUR LENGTH Miles

GEOMETRIC DATA

\+ 10) INV. RTE. MIN. VERT. CLEARANCE ft in ft in

\+ 47) LOG INV. RTE. TOTAL HORIZ CLR. ft . ft

\+ 47) RLOG INV. RTE. TOTAL HORIZ CLR. ft . ft

\+ 53) LOG MIN VERT CLR OVER BRG RDWAY ft in ft in

\+ 53) RLOG MIN VERT CLR OVER BRG RDWAY ft in ft in

\+ 55) MIN LAT UNDERCLR ON RIGHT ft . ft

\+ 56) MIN LAT UNDERCLR ON LEFT ft . ft

CLASSIFICATION

26) INV. RTE. FUNCT CLASSIFICATION

100) DEFENSE HIGHWAY DESIGNATION

** 102) DIRECTION OF TRAFFIC

104) HIGHWAY SYSTEM OF INV. ROUTE

110) DESIGNATED NATIONAL NETWORK

POSTED SIGNS

\+ POSTED VERT. CLR UNDER BRIDGE ft in ft in

COMMENTS:

* FILL OUT ON EVERY INSPECTION 29, 109, 30, 41

\+ VERIFY EVERY INSPECTION 28B, 10, 47, 53, 55, 56 & POSTED VERT CLEARANCE UNDER THE BRIDGE

** MUST BE FILLED OUT OR VERIFIED ON THE FIRST INSPECTION MADE BASED ON THE NEW FHWA GUIDE 102

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
BUREAU OF PUBLIC TRANSPORTATION
OFFICE OF RAIL

INSPECTION REPORT TRANSMITTAL FORM
FORM BRI-27, REV. 01/12

Structure No ____________ Town : ____________________

Inspectors:____ Date:____________

TABLE OF CONTENTS

FORMS (bound in report)	No. of Sheets Enclosed
Railroad Maintenance Memorandum (RMM)	-
Title Cover Sheet	-
BRI-27, Inspection Report Transmittal Form (Table of Contents)	-
Bridge Location Map	-
Executive Summary	-
Time at Site Including Flagging	-
BRI-9, Construction Punch List	-
BRI-11, Seismic Screening Data Sheet	-
BRI-12, Fracture Critical Inspection Data Sheet	-
BRI-18, Bridge Inspection Form	-
BRI-24, Incident Report Form	-
BRI-25, Under Entry SI&A Form	-
BRI-39, RR Bridge SI&A Form	-
Field Notes (Include Forms BRI-10, BRI-13, BRI-14, BRI-15, BRI-16, BRI-17, BRI-29, BRI-30)	-
Calculations: Load Rating Evaluation	-
Photo Sheets	-
Back-up Material	-
BRI-58,Underwater Inspection Report Form	-
BRI-59, Underwater Inspection Structure Data Form	-

PIN & HANGER DATA SHEET

Form BRI-29, Rev. 6/99

Measurements Taken By: ____________ Date: ________

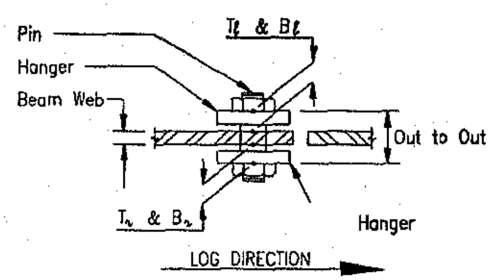
Bridge No.: 0   0   Town: 0

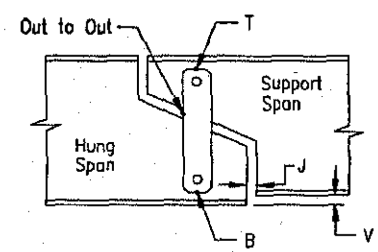
Hanger Location: 0   Effective span for Movement: 0   Page: ______ of ______

Beam No.	V (in)	J (in)	Tr (in)	Br (in)	Tl (in)	Bl (in)	Out to Out (in)	Secondary System Type	Gap[1] (Y/N)	Nut Restraint System	Temp	**Comments**
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

Notes:

1) For Pin & Hanger assemblies with a redundant support system, indicate if there is a gap between the redundant system (bearing) and the bottom flange of the suspended girder.
2) All measurements are taken in reference to log direction.
   - **V** : Vertical misalignment of girders @ left edge of girder's bottom flange.
   - **J** : Joint opening between webs, measured just above the bottom flange fillet, on the left face of the girder's web.
   - **Out to Out** : The out-to-out of hangers taken at the leading edge, based on log direction.
3) Use a permanent marker to indicate locations of field measurements.





File: P&h_form.xls(Data2), Printed: 9/24/01

HINGE DATA SHEET

Form BRI-30, Rev. 9/97

Measurements Taken By: ________ Date: ________

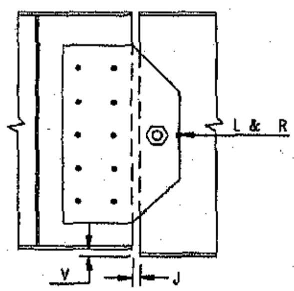
Bridge No.: ________ ____________________ Town: ________ Date: ________

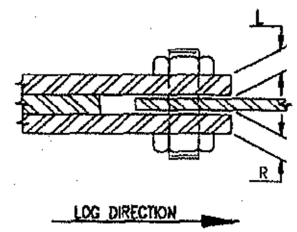
Hinge Located: ____________________ Effective span for Movement: ________ (ft) Page: ____ of ____

Beam No.	V (in)	J (in)	R (in)	L (in)	Secondary System Type	Gap[1] (Y/N)	Nut Restraint System	Comments
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Notes:

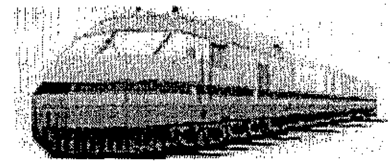
1) For Hinge assemblies with a redundant support system, indicate if there is a gap between the redundant system (bearing) and the bottom flange of the suspended girder.
2) All measurements are taken in reference to log direction.
   - **V** : Vertical misalignment of girders @ left edge of girder's bottom flange.
   - **J** : Joint opening between webs, measured just above the bottom flange fillet, on the left face of the girder's web.
3) Use a permanent marker to indicate locations of field measurements.





BRIDGE #: [redacted] TOWN: [redacted]
OPERATOR: [redacted]
LINE NAME: [redacted]
FEATURE INTERSECTED: [redacted]
PREVIOUSLY INSPECTED ON: [redacted]

STATE OF CO[illegible]TICUT
DEPARTMENT OF T[illegible]SPORTATION
BRIDGE SAFETY & EVALUATION
RAILROAD STRUCTURE INVENTORY
SHEET 1 OF 1 FORM BRI-39 10/99



REI[illegible]

TEAM: [redacted] INSPECTED BY: ____________ & ____________ INSPECTION DATE: [redacted] ______
PROJECT NUMBER: [redacted] ______ 91) FREQUENCY: [redacted] ______ FLAG MAN: [redacted] ______ ACCESS: [redacted] ______ IN-DEPTH INSPECTION: [redacted] ______

CRITICAL FEATURES INSPECTIONS	A) FRACTURE CRITICAL B) UNDERWATER C) SPECIAL	TYPE: ______ TYPE: ______	92A) FRAC. CRITICAL FREQ: ______ 92B) UNDERWATER FREQ: ______ 93C) OTHER FREQ: ______	93A) INSPECTION DATE: ______ 93B) UNDERWATER: ______ 93C) OTHER: ______

IDENTIFICATION

300) OWNER: [redacted]
303) MILEPOST:
9) LOCATION: [redacted]
304) OTHER TRACKAGE RIGHTS:
A) B) C) D)
16) LATITUDE: ° '
17) LONGITUDE: ° '
305) CO-OWNER BRIDGE:
ADJACENT OWNER BRIDGE:

GEOMETRIC DATA

48) LENGTH OF MAX. SPAN: FT
49) STRUCTURE LENGTH: FT
52) DECK WIDTH, OUT TO OUT: FT
306) CATWALK WIDTHS: LEFT FT
RIGHT FT
DECK AREA: SQ FT
34) SKEW ANGLE: DEG
53) MIN VERT CLEAR OVER: ' "
54) MIN VERT UNDER CLR: ' "
55) MIN LAT UNDER CLR R: '
56) MIN LAT UNDER CLR L: '

RESTRICTIONS + UTILITIES

318) PASSENGER TRACK SPEED: MPH
319) FREIGHT TRACK SPEED: MPH
UTILITIES CARRIED BY THE BRIDGE:

APPRAISALS

67) STRUCTURE EVALUATION:
69) UNDER CLR VERT AND HORIZ:
71) WATERWAY ADEQUACY:

AGE AND SERVICE

27) YEAR BUILT:
106) YEAR RECONSTRUCTED:
42) TYPE OF SERVICE: A) ON
B) UNDER
307) ELECTRIFICATION:
308) # OF TRACKS STRUC. DESIGNED FOR:
309) # OF TRACKS PRESENTLY ON STRUC:
310) NUMBER OF TRACKS IN SERVICE:
311) NUMBER OF TRAINS:
A) PASSENGER TRAINS/DAY
B) FREIGHT TRAINS/MONTH
312) YEAR OF CENSUS:
313) AVERAGE PASSENGERS/DAY:
314) FREIGHT CARLOADS/YEAR:

WATERWAY

W9) DRAINAGE BASIN WATERWAY CODE:
38) NAVIGATION CONTROL:
39) NAVIGATION VERT CONTROL:
40) NAVIGATION HORIZ CLEARANCE:
116) VERT-LIFT BRG NAV MIN:
111) PIER NAV PROTECTION:
113) SCOUR CRITICAL BRIDGE:

CONDITION

	Rating	By
58) DECK:		
59) SUPERSTRUCTURE:		
60) SUBSTRUCTURE:		
61) CHANNEL/ PROTECTION:		
62) CULVERTS:		

COMMENTS:

STRUCTURE TYPE AND MATERIAL

43) STRUCTURE TYPE, MAIN:
A) MATERIAL
B) DESIGN TYPE
315) DECK TYPE:
316) DEPTH OF BALLAST:
44) STRUCTURE TYPE, APPROACH:
A) MATERIAL
B) DESIGN TYPE
45) NUMBER OF SPANS, MAIN UNIT:
46) NUMBER OF APPROACH SPANS:
317) SUBSTRUCTURE TYPE:
A) MATERIAL
B) FOUNDATION TYPE

CLASSIFICATION + R-O-W INFORMATION

101) PARALLEL STRUCTURE:
103)TEMPORARY STRUCTURE:
21) MAINTAINER:
322)R-O-W FILE LOCATION OF MAPS AND PLANS:

LOAD RATING

31) DESIGN LOAD:
41) STRUCTURE OPERATIONAL STATUS:
323)COOPER E RATING BY TRACK NUMBER:

	MAXIMUM	NORMAL		MAXIMUM	NORMAL
1)			5)		
2)			6)		
3)			7)		
4)			8)		

REVIEWED BY ____________ DATE ___/___/___

Monday, September 24, 2001 9:21:5

Connecticut Department of Transportation

UNDERWATER INSPECTION

BRI-58 Form

Bridge No: 00001
Inspection Date: 06/22/02

Town: GREENWICH
Route Carried: 00095
Feature Crossed: RAM RIVER,S WATER ST

ITEM	RATING	REMARKS
60. SUBSTRUCTURE		
ABUTMENT 1:		
STEM		
FOOTING		
EROSION		
SETTLEMENT		
SCOUR		
WINGWALLS		
General remarks:		
ABUTMENT 2:		
STEM		
OOTING		
EROSION		
SETTLEMENT		
SCOUR		
WINGWALLS		
General remarks:		
PIER NO. 1		
PILES		
STEM		
FOOTING		
SCOUR		
SETTLEMENT		
General remarks:		
61. CHANNEL& CHANNEL PROTECTION:		
CHANNEL SCOUR		
EMBANKMENT EROSION		
.BRIS		

Connecticut Department of Transportation

UNDERWATER INSPECTION

BRI-58 Form

Bridge No:	**00001**	**Town:**	GREENWICH
Inspection Date:	**06/22/02**	**Route Carried:**	00095
		Feature Crossed:	RAM RIVER,S WATER ST

ITEM	*RATING*	*REMARKS*
VEGETATION		
CHANNEL CHANGE		
FENDER SYSTEM		
SPUR DIKES & JETTIE		
RIP RAP		
General remarks:		

Inspected by: ______________________ **Date:** ______________________

Inspected by: ______________________ **Date:** ______________________

D.O.T. reviewed by: ______________________ **Date:** ______________________

Connecticut Department of Transportation

UNDERWATER INSPECTION

BRI-59 Form

Bridge No: 00001 **Date Inspected:** 06/22/02

Job Number:
Client: Connecticut D.O.T.
Route: 00095 **Mile point:** 0.00
City: GREENWICH
FeatureCrossed: BYRAM RIVER,S WATER ST
State: CT
Inspector:
Assistants:
Time Arrived:
Time Departed:
Time In Water:
Time Out of Water:
Type of Inspection:
Year built: 0 **Total Length:** 1262 **No. Spans:** 3
Bridge Type:
Total Number of Piers: 0
Piers in the Water:
Type of Piers:
Abutments:
Bottom Composition:
Previous U/W Insp:
Marine Growth:
Max. Water Depth:
Max. Depth at Pier/Abut.:
Current Strength:
U/W Visibility:
Type of Water:
Access to Bridge:
Remarks:

Inspection Equipment

Number of Boats: 0 **RR Protection:** No
Boat Size: 0 **Equipment Comments:**
Dive Station: No

Inspected by: ______________________ **Date:** ______________________

Inspected by: ______________________ **Date:** ______________________

.T. reviewed by: ______________________ **Date:** ______________________

APPENDIX B
BRIDGE INSPECTION MANUAL COMMENT FORM

RAILROAD BRIDGE INSPECTION MANUAL
COMMENT FORM

All users of this manual are encouraged to submit comments/corrections to:

Manager of Office of Rails
Connecticut Department of Transportation
2800 Berlin Turnpike
P.O. Box 317546
Newington, CT 06131-7546

Date Submitted: ___________________
Submitted by (optional):________________ Organization/Team # : ____________________

CHAPTER	PAGE	COMMENT

APPENDIX C
GLOSSARY OF TERMS

GLOSSARY OF TERMS

AASHTO American Association of State Highway and Transportation Officials.

Abrasion Weathering action, wearing or grinding away of material by water laden with sand, gravel, or stones, or by rubbing together of two adjacent bridge parts.

Abutment A substructure supporting the ends of a single span or the extreme ends of a multi-span superstructure and, in general, retaining or supporting the approach embankment.

Acceleration Coefficient - Dimensionless coefficient used to describe ground motion due to seismic forces.

ACI American Concrete Institute.

Acidity The measure of acids in a solution typically represented by a pH factor less than seven. In surface water, acidity is initiated by carbon dioxide in the air which forms carbonic acid.

Acute Angle An angle less than 90 degrees.

Admixture A material other than Portland cement, aggregates, or water, which is added to a concrete batch prior to or during mixing.

ADT Average Daily Traffic.

ADTT Average Daily Truck Traffic.

Aggradation General and progressive raising of the streambed by accumulation of sediment.

Aggregate The sand, gravel, or broken stone with which a cementing material is mixed to form a mortar or concrete.

Air Entrainment The process of adding air to concrete in order to increase durability while causing only a small decrease in strength. Used in bridge construction to minimize freeze-thaw damage.

AISC American Institute of Steel Construction.

AITC American Institute of Timber Construction.

Alignment The relative horizontal and vertical positioning between the bridge and approach roadways.

Alkalinity The measure of negative ions in water, typically represented by a pH factor greater than seven.

Alligator Cracking See "Map Cracking".

Allowable Stress Design - AISC designation for Working Stress Design

Alloy A mixture of two or more metals to form a new base metal.

Alternate Design Method - ACI designation for Working Stress Design.

Alternate Load Factor Design - Another name for the Autostress Design Method; see LOAD FACTOR DESIGN.

Approach Pavement Pavement, or wearing surface, on the roadway on either end of a bridge.

Appurtenance A feature that serves the overall functionality of the bridge site (e.g., railing, lighting, signing, etc.).

AREMA American Railway Engineering and Maintenance-of-Way Association.

As-Built Plans Plans issued after the construction of a structure reflecting any field changes made to the final design plans

ASCE American Society of Civil Engineers.

Anchorage The complete assemblage of members and parts designed to hold in correct position a portion or part of a structure.

Anchor Bolt A shaft-like piece of metal, commonly threaded and fitted with a nut and washer at one end only, used to secure in a fixed position upon the substructure, the bearings of a bridge, the base of a column, a pedestal, shoe, or other member of a structure.

Anchor Pier A pier used in cantilever bridges to resist the uplift at the end of the anchor arm.

Anchor Span The span that counterbalances, and holds in equilibrium, the fully cantilevered portion of an adjacent span.

Angle A basic member shaped like an L; usually made of steel.

Anisotropy The property of some materials, such as wood, exhibiting different strengths in different directions.

Anode The positively charged pole of a corrosion cell at which oxidation occurs.

ANSI American National Standards Institute.

Anti-Friction Bearing A ball or roller-type bearing that does not resist horizontal or frictional loads.

Appraisal Rating A judgement of a bridge component condition in comparison to current standards.

Approach Portion of roadway leading to a bridge

Approach Slab A reinforced concrete slab placed on the approach embankment adjacent to and usually resting upon the abutment back wall. The function of the approach slab is to carry wheel loads on the approaches directly to the abutment, thereby eliminating any approach roadway misalignment due to approach embankment settlement.

Apron A form of scour protection consisting of timber, concrete, riprap, paving, or other construction placed adjacent to abutments and piers to prevent undermining.

Arch A curved structure element, primarily in compression, which produces at its supports reactions having both vertical and horizontal components.

Arch Barrel A single arch member that extends the width of the structure.

Arch Bridge A curved structure which produces reactions inclined to the vertical.

Arch Culvert A culvert having an arch roof.

Arch Rib The main support element used in open spandrel arch construction; also known as an arch ring.

Armor A secondary steel member installed to protect a vulnerable part of another member, e.g., steel angles placed over the edges of a joint or at the leading edge of a river pier.

As-built Rating Rating based on original condition and configuration of the structure.

ASD Allowable Stress Design.

Asphalt Black surface material made from mineral hydrocarbons containing petroleum used as a binder with sand and crushed gravel. Also known as "Bituminous Concrete".

ASTM American Society for Testing and Materials.

Auger Drill used to retrieve soil samples; see BORING.

Autostress Design Method - An extension of Load Factor Design using enhanced limit states criteria; see LOAD FACTOR DESIGN.

AWS American Welding Society.

Axial In line with the centroid of the area.

Axle Load The load borne by one axle of a traffic vehicle, a movable bridge, or other motive equipment or device and transmitted through a wheel or wheels.

Babbitt Metal An alloy of tin with copper and antimony, used for lining bearings and making bushings.

Back See EXTRADOS.

Backfill Material, usually soil, used to fill the unoccupied portion of a substructure excavation.

Backing A material or device placed against the backside of the joint, or at both sides of a weld in electroslag and electrogas welding, to support and retain molten weld metal. The material may be partially fused or remain unfused during welding and may be either metal or nonmetal.

Backstay A cable or chain attached at the top of a tower and extending to, and secured upon, the anchorage to resist overturning stresses exerted upon the tower by a suspended span.

Backwall The topmost portion of an abutment, above the elevation of the bridge seat, functioning primarily as a retaining wall with a live load surcharge; it may serve also as a support for the extreme end of the bridge deck and the approach slab.

Backwater The water upstream from an obstruction in which the free surface is elevated above the normal water surface profile.

Ballast Deck A bridge floor under a railway track upon which ballast is placed with ties embedded therein.

Ballast Retainer A timber, concrete, or steel riser on both edges or ends of a ballast deck that keeps ballast from falling off of the bridge.

Balustrade An open railing system comprised of short columns, called balusters, which are connected together by a rail.

Bank Sloped sides of a waterway channel or approach roadway, short for embankment.

Bank Protection The prevention of erosion of a bank of a stream by the use of riprap, mattresses, or other artificial means.

Barrel The tunnel portion of a culvert.

Bascule Bridge A bridge on which one or two leaves rotate from a horizontal position to a near vertical position to open the navigation channel.

Base Casting A steel or iron casting upon which the bridge-shoe rests.

Base Course A layer of compacted material directly under the wearing surface, typically consisting of mineral aggregates and additives that are compacted to support the pavement.

Base Metal The surface of a steel element to be incorporated in a welded joint; also known as structure metal or parent metal.

Base Plate A rectangular slab of steel, whether cast, rolled or forged, connected to a column, bearing or other member to transmit and distribute its load to the substructure. Also called a masonry plate.

Base of Rail The bottom of any rail placed in final position. It generally determines the elevation from which the heights of the various parts of the structure are measured.

Batten Plate A plate used in lieu of lacing to tie together the shapes comprising a built-up member.

Batter The inclination of a surface in relation to a horizontal or a vertical plane; commonly designated on bridge detail plans as so many feet to one foot; see RAKE.

Battered Pile A pile driven in an inclined position to resist horizontal forces as well as vertical forces.

Bay The area of a bridge floor system between adjacent longitudinal multi-beams.

Beam A linear structural member designed to span from one support to another.

Bearing A support element transferring loads from superstructure to substructure while permitting limited movement capability.

Bearing Capacity The load per unit area which a structural material, rock, or soil can safely carry.

Bearing Failure A crushing of material under extreme compressive load.

Bearing Pile A pile which provides support through the tip (or lower end) of the pile.

Bearing Pin A truss pin at the end of a span connecting the truss to the shoe.

Bearing Plate A steel plate that is used to transmit loads from the superstructure to the substructure.

Bearing Pressure The bearing load divided by the area to which it is applied.

Bearing Pad A prepared horizontal surface at or near the top of a substructure unit upon which the bearings are placed.

Bearing Stiffener A vertical web stiffener at the bearing location

Bearing Stress See BEARING PRESSURE.

Bearing-Type Connection - A riveted or bolted connection in which movement is restricted primarily by the bolt shank.

Bedding The soil or backfill material used to support pipe culverts.

Bedrock The undisturbed hard rock layer below the surface of the soil.

Benchmark An established reference point used to document dimensions, elevations and movement.

Bending Moment The moment which produces or tends to produce bending in a beam or other member of a structure. It is measured by the algebraic sum of the products of all the forces by their respective lever arms.

Bent A substructure unit made up of two or more column or column-like members connected at their top-most ends by a cap, strut, or other member holding them in their correct positions.

Berm The line which defines the location where the top surface of an approach embankment or causeway is intersected by the surface of the side slope.

Beveled Washer A wedge-shaped washer used in connections involving members with sloped flange legs, e.g. channels and S-beams.

Binder Course A layer between the wearing surface and base course made of a bituminous material and aggregate.

BIRM The *Bridge Inspector's Reference Manual* issued by FHWA, dated December 2006, as revised. Replaced the previously issued BITM 90.

Bitumen A black sticky mixture of hydrocarbons obtained from natural deposits or from distilling petroleum.

Bituminous Concrete See ASPHALT.

Blanket A stream bed protection against scour placed adjacent to abutments and piers.

Blocking A set of timber blocks which is placed under bridge bearings or members to raise and support them.

BMS Bridge Management System, a system designed to optimize the use of available resources for the inspection, maintenance, rehabilitation and replacement of bridges.

Boat Spike A square, chisel-pointed spike with a rounded head, ordinarily from eight to ten inches long, used to fasten heavy planks in wooden floors, railroad crossings, etc.

Bolster A block-like member used to support a bearing on the top of a pier cap or abutment bridge seat; see PEDESTAL.

Bolt A mechanical fastener with machine threads at one end to receive a nut, and usually a hexagonal head at the other end.

Bond In reinforced concrete, the grip of the concrete on the reinforcing bars, thereby preventing slippage of the bars.

Bond Stress A term commonly applied in reinforced concrete construction to the stress developed by the force tending to produce movement or slippage at the interface between the concrete and the reinforcement bars.

Bore The internal diameter, of a hole, tube, or pipe.

Boring The act of drilling a hole into the ground to remove soil samples for laboratory testing. A soil sample removed from the ground for laboratory testing.

Bottom Chord The bottom horizontal member of a truss.

Bottom Lateral Bracing Lateral bracing in the plane of the bottom chords of truss spans or bottom flange of girder spans.

Bowstring Truss A general term applied to a truss of any type having a polygonal arrangement of its top chord members conforming to or nearly conforming to the arrangement required for a parabolic truss.

Box Beam A hollow structural beam with a square, rectangular, or trapezoidal cross-section. Also called Box Girder.

Box Culvert A culvert of rectangular or square cross-section.

Bleeding A phenomenon whose external manifestation is the appearance of water on the surface after concrete has been placed and compacted but before it has set. Also, crushed rust particles exuding from adjacent meshing parts.

Brace Generally a strut supporting or fixing in position another member.

Bracing A system of secondary members that maintain the geometric configuration of primary members.

Bracket A projecting support fixed upon two intersecting members to strengthen and provide rigidity to the connection.

Breastwall The portion of an abutment between the wings and beneath the bridge seat; the breast wall supports the superstructure loads, and retains the approach fill; see STEM.

Brick Masonry Masonry composed of brick.

Bridge A structure, including supports, erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads, over an opening of greater than or equal to 20 ft. (6.08m).

Bridge Deficiency A defect in a bridge component or member that makes the bridge less capable or less desirable for use.

Bridge Frog A contrivance built of two or more pieces of rails mounted on a common base and used for passing the car or locomotive wheels across the ends of a movable bridge.

Bridge Pad The raised, leveled area upon which the pedestal, masonry plate or other corresponding element of the superstructure takes bearing by contact; also called bridge seat or bearing area.

Bridge Roadway Width - The most restrictive minimum distance between curbs or rails.

Bridge Seat The top surface of an abutment or pier upon which the superstructure span is placed and supported; for an abutment it is the surface forming the support for the superstructure and from which the backwall rises; for a pier it is the entire top surface.

Bridge Site The selected position or location of a bridge and its surrounding area.

Bridging A carpentry term applied to the cross-bracing fastened between timber beams to increase the rigidity of the floor construction, distribute more uniformly the live load and minimize the effects of impact and vibration.

Brittle Fracture A sudden failure of a steel element prior to plastic deformation typically occurring at a sharp change of section properties.

Brush Curb A narrow curb, 9 inches or less in width, which prevents a vehicle from brushing against the railing or parapet.

Buckle To fail by an inelastic change in alignment as a result of compression.

Buckling Deflection in an axially loaded member under compression.

Built-Up Member A column or beam composed of plates and angles or other structural shapes united by bolting, riveting or welding.

Bulb T-Girder A T-girder with a bulb shape at the bottom of the girder cross-section.

Bulkhead A retaining wall-like structure commonly composed of driven piles supporting a wall of a barrier of widen timbers or reinforced concrete members.

Buoyancy Upward pressure exerted by the fluid in which an object is immersed.

Butt Joint The joint between two pieces of metal in the same plane, which have been bolted or welded together.

Buttress A bracket-like wall, of full or partial height, projecting from another wall. The buttress strengthens and stiffens the wall against overturning forces. All parts of a buttress act in compression.

Buttressed Wall A retaining wall designed with projecting buttresses to provide strength and stability.

Butt Weld A weld joining two pieces of metal that are in the same plane.

Cable A tension member comprised of numerous individual steel wires twisted and wrapped in such a fashion to form a rope of steel; see SUSPENSION BRIDGE.

Cable Band A steel casting with clamp bolts which fixes a floor system suspender cable to the main cable of a suspension bridge.

Cable-Stayed Bridge A bridge in which the superstructure is directly supported by cables, or stays, passing over or attached to towers located at the main piers.

Caddis Flies A winged insect closely related to the moth and butterfly whose aquatic larvae seek shelter by digging small shallow holes into underwater timber elements.

Caisson A rectangular or cylindrical chamber for keeping water or soft ground from flowing into an excavation.

Camber The slightly arched form or convex curvature provided in beams to compensate for dead load deflection. In general, a structure built with perfectly straight lines appears to sag slightly.

Cantilever A structural member which has a free end projecting beyond its supporting wall or column; length of span overhanging the support.

Cantilever Abutment An abutment that resists the lateral thrust of earth pressure through the opposing cantilever action of a vertical stem and horizontal footing.

Cantilever Bridge A general term applying to a bridge having a superstructure utilizing cantilever design.

Cantilever Span A superstructure span composed of two cantilever arms, or of a suspended span supported by one or two cantilever arms.

Cap The topmost piece of a pier or a pile bent serving to distribute the loads upon the columns or piles and to hold them in their proper relative positions; see PIER CAP, PILE CAP.

Cap Beam The top beam in a bent which ties together the supporting columns or piles.

Cap Plate The top plate on a steel column or post.

Capstone	The topmost stone of a masonry pillar, column or other structure requiring the use of a single capping element.
Carbon Steel	Steel owing its properties principally to its carbon content; ordinary, unalloyed steel.
Carpenter Ants	Large black ants that hollow out the interior of timber members to make nests.
Cast Iron	Relatively pure iron, smelted from iron ore, containing 1.8 to 4.5% free carbon and cast to shape.
Cast-in-Place	The act of placing and curing concrete within formwork to construct a concrete element in its final position.
Cast Steel	Steel that is cast into shape directly from the furnace instead of being cast into ingots and rolled or melted.
Catch Basin	A receptacle, commonly box shaped and fitted with a grilled inlet and a pipe outlet drain, designed to collect the rain water and floating debris from the roadway surface and retain the solid material to that it may be periodically removed.
Catchment Area	See DRAINAGE AREA.
Catenary	The curve obtained by suspending a uniform rope or cable between two points; as in the main cables of a suspension bridge. An overhead electric wire used to provide power for electric railroad traction.
Cathode	The negatively charged pole of a corrosion cell that accepts electrons and does not corrode.
Cathodic Protection	A means of preventing metal from corroding. This is done by making the metal a cathode through the use of impressed direct current and by attaching a sacrificial anode.
Catwalk	An elevated, narrow walkway providing access to some part of a structure.
Causeway	An elevated roadway used to cross long expanses of water, swamps, or wetlands.
Cellular Abutment	An abutment in which the space between wingwalls, breast wall, approach slab, and footings is hollow. Also known as a vaulted abutment.
Cement	A powder that hardens when mixed with water; an ingredient used in concrete.
Cement Mortar	A mixture of four parts sand to one part cement with enough water to make it plastic
Cement Paste	The plastic combination of cement and water that supplies the cementing action in concrete.

Center Bearing Swing Span A term applied to swing spans to indicate that the dead load support is near the axis of the pivot pier instead of near the outer edge.

Center of Gravity The point at which the entire mass of a body acts. The balancing point of an object.

Centerline Centerline of the track, used as the horizontal reference.

Centrifugal Force The outward force exerted by a train going around a curve due to its inertia, against that force which is causing it to deviate from a straight-line motion and to travel in a curved path.

Centroid The point about which the static moment of all the elements of area is equal to zero.

Chain Drag A series of short medium weight chains attached to a T-shaped handle. Used as a preliminary technique for inspecting a concrete deck for delaminations.

Chamfer A notched or angled edge or corner typically formed in concrete at a 45 degree angle.

Channel A waterway connecting two bodies of water or containing moving water.

Channel A rolled steel member having a C-shaped cross section.

Channel Profile A cross-section of a channel along its centerline.

Channel Protection Devices that redirect or absorb the energy of the water flow and prevent erosion and scour. Channel protection devices include rip-rap, gabions, spurs, and spur dikes.

Charpy V-Notch Test A test that evaluates the resistance to fracture in the presence of a notch.

Check A partial depth crack in wood occurring parallel with the grain and through the rings of annual growth.

Cheekwall A return of the abutment backwall at its ends to enclose the bridge seat on three of its sides.

Chipping Hammer A welder's tool for cleaning slag from steel after welding. A hammer with a pointed tip.

Chord (1) The primary members on the top or bottom of a truss span that run the full length of the span parallel to the track(s). The top chord is usually in compression and the bottom chord is usually in tension (except on continuous spans). (2) Timber stringers bolted together to form one larger timber beam.

Chord Bolt A bolt through individual timber stringers fastening them together to form a chord.

Chloride Component in deicing agents which can cause corrosion in concrete and steel bridge elements.

Circular Arch An arch in which the intrados surface has a constant radius.

Clearance The unobstructed vertical and horizontal space provided between two objects.

Clearance Line A line on a diagram showing the minimum clearance allowed.

Clear Headway The vertical clearance beneath a bridge structure available for navigational use.

Clear Span The unobstructed space or distance between support elements of a bridge or bridge member.

Clip Angle See CONNENCTION ANGLE.

Closed Position The position of a movable bridge when it is open to allow passage of vehicular traffic and the channel is closed to navigational traffic.

Closed Spandrel Arch A stone or reinforced concrete arch span having longitudinal walls above the fascia on each side of the arch. These walls, called spandrel walls, serve to retain the fill between the arch and the roadway and/or to support the floor system of the structure.

Coarse Aggregate Aggregate which stays on a sieve of 5mm square opening.

Coating A material that provides a continuous film over a surface. A film formed by the material.

Coefficient of Thermal Expansion - The unit strain produced in a material by a change of one degree in temperature.

Cofferdam A temporary dam-like structure constructed around an excavation to exclude water; see SHEET PILE COFFERDAM

Cold Chisel A chisel used for cold-cutting soft metals when struck with a hammer.

Cold Joint Joint between old or hardened concrete and new concrete.

Collision Strut (post) A short, diagonal strut used to provide support to a truss end post.

Column A general term applying to a vertical member resisting compressive stresses and having, in general, a considerable length in comparison with its transverse dimensions.

Column Bent A bent shaped pier, using columns integrated with a cap beam.

Component A general term reserved to define a bridge deck, superstructure or substructure; subcomponents e.g. floor beams are considered elements.

Composite Action The contribution of a concrete deck to the moment resisting capacity of the superstructure beams.

Composite Construction - A method of construction where by a concrete deck is mechanically attached to a superstructure system by shear connectors.

Composite Steel Bridge - A steel span with a concrete deck rigidly attached to the steel using shear connectors so both the steel and concrete carry the bending and, in some cases, shear forces.

Compression A type of stress involving pressing together, tends to shorten a member; opposite of tension.

Compression Failure Buckling, crushing, or collapse caused by compression stress.

Compression Flange The part of a beam which is compressed; due to a bending moment.

Compression Seal Joint - A joint assembly typically consisting of an extruded neoprene elastic seal squeezed into a joint opening.

Concentrated Load A force applied over a small contact area; also known as a point load

Concrete A mixture of aggregate, water, and a binder, usually portland cement, which hardens to a stone-like mass.

Concrete Beam A structural member of reinforced concrete.

Concrete Pile A pile constructed of reinforced concrete, either precast and driven into the ground or cast-in-place in a hole bored into the ground.

Condition Evaluation Establishes the physical and functional condition of the bridge components including the extent of deterioration and other defects.

Condition Rating A judgement of a bridge component condition in comparison to its original as-built condition, used to provide an overall characterization of the general condition of the component being rated.

Conductor A metal that is suitable for carrying electric current.

Connection Angle A piece of steel angle serving to connect two elements of a member or two members of a structure; also known as clip angle.

ConnDOT Connecticut Department of Transportation.

Connection Plate A steel plate which connects two elements.

Consolidation The time dependent change in volume of a soil mass under compressive load caused by water slowly escaping from the pores or voids of the soil.

Construction Joint A pair of adjacent surfaces in reinforced concrete where concrete was intentionally stopped and continued later.

Contaminant A salt or other element not normally present in the atmosphere which may react with steel to produce corrosion.

Continuous Beam A general term applied to a beam that spans uninterrupted over one or more intermediate supports.

Continuous Bridge A bridge designed to extend without joints over one or more intermediate supports.

Continuous Footing A footing beneath a wall.

Continuous Spans Spans designed to extend without joints over one or more intermediate supports.

Continuous Truss A truss having its chord and web members arranged to continue uninterrupted over one or more intermediate points of support.

Continuous Weld A weld extending throughout the entire length of a connection.

Contraction The action of drawing together.

Cope The cutout flange and web area at the end of a beam.

Coping A course of stone laid with a projection beyond the general surface of the masonry below it, and forming the topmost portion of a wall. A course of stone capping the curved or V shaped extremity of a pier, providing a transition to the pier head proper, when so used it is commonly termed the “starling coping,” “nose coping,” the “cutwater coping” or the “pier extension coping”.

Corbel A projection from the surface of a wall, column or other portion of a structure to serve as a support for another member.

Corbel Block Short timber blocks placed on pier caps or subcaps to provide support for additional caps or bridge bearings.

Core A cylindrical sample of concrete or stone removed for laboratory testing. To drill a hole with an open center bit that produces a plug or a "core".

Corrosion The general disintegration of surface metal through oxidation (rust).

Corrugated A material (usually metal) with alternating ridges and valleys used for elements such as stay-in-place forms.

Corrugated Steel Flooring - Steel flooring, normally filled with bituminous concrete, that is the structural deck that carries the traffic loads on the bridge. Also known as deck pan.

Cosmetic Repairs An aesthetic repair. A repair that is not required to address a structural or safety related deficiency.

Counter A truss web member which functions only when the span is partially loaded; the dead load of the truss does not stress the counter; see WEB MEMBER.

Counterweight A weight that counterbalances span weight on a movable bridge, used on lift spans, bascules, swing spans, etc.

Counterfort A bracket-like wall projecting from a retaining wall on the side of the retained material to stabilize it against overturning. A counterfort, as opposed, to a buttress, acts entirely in tension.

Counterforted Abutment - An abutment which develops resistance to bending moment in the stem by use of counterforts. This permits the breast wall to be designed as a horizontal beam or slab spanning between counterforts, rather than as a vertical cantilever slab

Counterforted Wall A retaining wall designed with projecting counterforts to provide strength and stability.

Counterweight A weight which is used to balance the weight of a movable member. In bridge applications counterweights are used to balance a leaf or span so that it rotates or lifts with minimum resistance.

Couple Two forces that are equal in magnitude, opposite in direction, and parallel with respect to one another.

Coupon A portion of steel (or other material) taken from a bridge component to be used for laboratory testing.

Course A layer of bricks or stone bedded in mortar.

Cover In reinforced concrete, the clear thickness of concrete between a reinforcing bar and the surface of the concrete; the depth of backfill over the top of a pipe.

Covered Bridge A bridge, generally of timber construction, having its roadway protected by a roof and enclosing sides.

Cover Plate A plate used in conjunction with flange angles or other structural shapes to provide additional flange section in a beam, column, or similar member.

Crack A break without complete separation of parts; a fissure.

Crack Arresting Detail A hole drilled at the tip of a crack to stop further crack propagation.

Crack Initiation The beginning of a crack usually at some submicroscopic defect.

Crack Propagation The growth of a crack due to energy supplied by repeated stress cycles.

Cracking (Reflection) Visible cracks in an overlay indicating cracks in the concrete underneath.

Crazing Hairline, discontinuous surface cracking that appears in hardened concrete.

Creep An inelastic deformation that increases with time while the stress is constant.

Creosote An oily liquid obtained by the distillation of wood tar and used as a wood preservative.

Creosoted Timber Wood which has been preserved through a pressure-treatment process using creosote, where penetration of wood with preservative provides long-term protection against decay.

Crest Used to describe a vertical curve formed by an upward tangent followed by a downward tangent.

Crib A structure consisting of a foundation grillage combined with a superimposed framework providing compartments or coffers which are filled with gravel, concrete or other material to serve as a bridge abutment or pier.

Cribbing A construction consisting of wooden, metal or reinforced concrete units so assembled as to form an open, cellular-like structure for supporting a superimposed load or for resisting horizontal or overturning forces acting against it.

Critical Deficiencies Deficiencies that, if left unattended, will create a hazard to the traveling public or severely limit the capacity of the bridge.

Critical Section The weakest section of a member.

Cross Section The shape of an object cut transversely to its length.

Cross Bracing Transverse bracing between two main longitudinal members; see DIAPHRAGM, BRACING.

Cross Frame Members placed in an “X” configuration to act as diaphragms. Also termed a "Buck Brace."

Cross Girder Girders supported by bearings which supply transverse support for longitudinal beams or girders.

Cross Level The vertical position of one rail respective to the other. On tangent track both rails should be at the same elevation.

Cross-over An arrangement of turnouts enabling movement from one track to another.

Crossing An intersection. The place where two railroads cross or a roadway crosses the tracks. The term is also used for a bridge crossing a stream, river, railroad, or highway.

Cross-Sectional Area The area of a cross-section.

Crown The highest point of a pipe, arch, cross-sloped roadway or vertical curve.

Crown of Roadway The vertical dimension describing the total amount the surface is convexed or raised from gutter to centerline; this is sometimes termed the cross fall of roadway.

Culvert A drainage structure beneath an embankment.

Curb A short barrier paralleling the side limit of the roadway to guide the movement of vehicle wheels and safeguard constructions and pedestrian traffic existing outside the roadway limit from collision with vehicles and their loads.

Curb Inlet See SCUPPER.

Curtain Wall A term commonly applied to a thin wall between main supports not designed to withstand superimposed loads either vertically of transversely.

Curvature The degree of curving of a line or surface.

Cut A term used to define a region of excavation, as in cut and fill.

Cutoff That part of a pile that has been sawed off after the pile is in place.

Cut-off Wall A short vertical projection of a concrete culvert floor, intended to prevent erosion of the culvert bedding material at the inlet and outlet.

Cutting Edge An edge of timber or steel angles placed on the bottom of the working chamber of a caisson.

Cutwater A sharp-edged structure built around a bridge pier to protect it from the flow of water and debris in the water.

Cylinder Pier A pier made of a cylindrical steel shell filled with concrete.

Damage Inspection An inspection conducted immediately following any incident that may have an effect on the structural integrity of a bridge.

Dead Load The weight of all the parts of a bridge itself and anything that may remain upon it for any length of time, such as tracks, walkways, utilities, etc.

Dead Man A large, heavy object attached to a structure and buried to act as an anchor.

Debris Any material including floating wood trash, suspended sediment, or bed load, moved by a flowing stream.

Deck That portion of a bridge, which provides direct support for vehicular and pedestrian traffic.

Deck Bridge A bridge where most or all of the structure is below track level.

Deck Plate Girder A deck bridge fabricated from steel plates and angles riveted, bolted, or welded together.

Deck Truss A truss span where the entire structure is at or below track level.

Decking A term specifically applied to bridges having wooden floors and used to designate the flooring only; it does not include the members serving to support the flooring.

Deck Joint A joint between the deck sections, or between the deck and the abutment or approach roadway that allows for some rotation and/or translation.

Deck Pans See CORRUGATED STEEL FLOORING.

Deficiency See BRIDGE DEFICIENCY.

Deflection Elastic movement of a structural member under a load.

Deformation Distortion of a loaded structural member; includes plastic, non-recoverable movement.

Deformed Bars Concrete reinforcement consisting of steel bars with projections or indentations to increase the mechanical bond between the steel and concrete.

Degradation Progressive lowering of the stream bed by erosion.

Delamination Subsurface separation of concrete into layers.

Design Load The force for which a structure is designed; the worst possible combination of loads.

Deterioration Decline in quality over a period of time due to chemical or physical action of the environment.

DHV Design Hourly Volume.

Diagonal A sloping structural member of a truss or bracing system.

Diagonal Bracing Bracing along diagonal lines.

Diagonal Stay A cable support in a suspension bridge extending diagonally from the tower to the roadway system to add stiffness to the structure and diminish the deflection of the deck under live load.

Diagonal Tension The principal tensile force due to horizontal and vertical shear in a beam.

Diaphragm A member placed within a member or superstructure system to distribute stresses and improve strength and rigidity; see BRACING.

Diaphragm Wall A transverse wall built across an arch to tie together and reinforce the spandrel walls. May also provide support for the floor system. Also known as a cross wall.

Differential Settlement - Uneven settlement of individual or independent elements of a substructure.

Dike An earthen embankment constructed to retain floodwater. When used in conjunction with a bridge, it prevents stream erosion and localized scour, and/or directs the stream current such that debris does not accumulate. Also known as dyke; see SPUR DIKE.

Discharge The volume of fluid per unit of time flowing along a pipe or channel.

Displacement Induced Stress - Stresses caused by differential deflection of adjacent members.

Distributed Load A load uniformly applied along the length of an element or component of a bridge.

Ditch A trough-like excavation made to collect water.

Diver A specially trained individual who inspects the underwater portion of a bridge substructure and the surrounding channel.

Dolphin A group of piles driven close together and placed to protect portions of a bridge exposed to marine traffic.

Double Cap Two caps set on top of one another.

Double Movable Bridge - A bridge in which the clear span for navigation is produced by joining the arms of two adjacent swing spans or the leaves of two adjacent bascule spans at or near the center of the navigable channel. See MOVABLE BRIDGE.

Dowel A short length of bar embedded in two parts of a structure to hold the parts in place and to transfer stress.

Drainage A system designed to remove water from a structure.

Drainage Area An area in which surface run-off collects and from which it is carried by a drainage system; also known as catchment area.

Drape Placement of prestressing/post-tensioning strands such that they are in the bottom flange in the high moment region, typically midspan, and rise to the upper half of the member at the ends.

Draw The movable portion of a draw-bridge.

Drawbridge A general term applied to a bridge over a navigable body of water having a movable superstructure span of any type permitting the channel to be freed of its obstruction to navigation.

Drift Bolt	A short rod or square bar to drive into holes bored in timber for attaching adjacent members to each other or to piles. The length generally varies from one foot to two feet. A drift bolt is generally provided with some sort of head. Drift bolts with a sharpened end are often referred to as drift pins. Similar to a dowel.
Drip	A small channel cut under the lower projecting edge of a coping, etc., so that when rain reaches that point, it will drip or fall off.
Drip Notch	A recess cast on the underside of a parapet that prevents water from following the concrete onto the supporting beams and causing deterioration of the members.
Drop Hammer	A large, heavy block acting as hammer in a pile driver.
Drop Inlet	A type of inlet structure that conveys the water from a higher elevation to a lower outlet elevation smoothly without a free fall at the discharge.
Drop Line	A line extended from the bridge deck to a water crossing underneath used to generate channel cross sections.
Drum	A revolving cylinder around which ropes or belts either travel or are wound, such as on a movable bridge.
Drum Girder	The circular, main support girder at the center portion of a swing span.
Dry Laid Masonry	Masonry constructed without mortar between the stones.
Duct	The void in a prestressed concrete member in which the prestressing tendon is placed.
Ductile	Capable of being molded or shaped without breaking; plastic.
Ductile Fracture	A fracture characterized by plastic deformation.
Ductility	The ability to withstand nonelastic deformation without rupture.
Dump	The backfill area immediately behind a bridge abutment.
Dumbbell Pier	A pier consisting of two cylindrical or rectangular shaped columns joined by a web constructed integral with them.
Dump Bent	The end bent on a timber bridge.
Durability	The ability of a material to resist weathering action.
E	The modulus of elasticity of a material. The stiffness of a material.

Earth Pressure	The lateral pressure exerted by a bank of earth when supported by a retaining wall or an abutment.
Eccentric Load	A load which is applied off-center to the axis of a member, producing a bending moment on the member considered.
Eddy	A whirl or backward current of water. A vortex. That portion of the water in a stream that actually swirls.
Effective Width	In composite construction, the width of a concrete slab which functions as the top flange of a composite T-shape section.
Efflorescence	A white deposit on concrete or brick caused by crystallization of soluble salts brought to the surface by moisture in the masonry or concrete.
Elastic	Capable of sustaining deformation without permanent loss of shape.
Elastic deformation	Nonpermanent deformation. When the stress is removed, the material returns to its original shape.
Elasticity	The property whereby a material changes its shape under the action of loads but recovers its original shape when the loads are removed.
Elastomer	A natural or synthetic rubber-like material.
Elastomeric Pad	A pad made of a synthetic rubber that compresses under loads and is used in bearings.
Electrode	A material which, when combined with the base metal, helps form the weld between two pieces of metal.
Electrolyte	A medium of air, soil, or liquid carrying ionic current between two metal surfaces, the anode and the cathode.
Electrolytic Cell	A device for producing electrolysis consisting of the electrolyte and electrodes.
Electrolytic Corrosion	Corrosion of a metal associated with the flow of electric current in an electrolyte.
Elevation	A vertical distance from a fixed reference (datum). Also used to denote a view along the length of a member or structure.
Elliptic Arch	An arch in which the intrados surface is a full half of the surface of an elliptical cylinder.
Elongation	The elastic or plastic extension of a member.
Embankment	A bank of earth constructed above the natural ground surface to carry a road or to prevent water from passing beyond desirable limits; also known as bank.

End Block On a prestressed concrete beam, the increase in beam web width at the end to provide adequate anchorage bearing for the post tensioning steel and to resist high cracking stresses.

End Floorbeam The floorbeam at the end of a span.

End-lift Machinery The machinery that releases the ends of a swing span for turning.

End Post The end compression member of a truss, either vertical or inclined in position and extending from top chord to bottom chord.

End Section A concrete or steel appurtenance attached to the end of a culvert for the purpose of hydraulic efficiency and anchorage.

End Span A span adjacent to an abutment.

End Stiffener Vertical angles fastened to the web of a plate girder at its ends for the purpose of stiffening it and transferring the end shear to the shoe or base plate.

Epoxy A synthetic resin which cures or hardens by chemical reaction between components which are mixed together shortly before use.

Epoxy Coating A protective coating that inhibits corrosion.

Epoxy Concrete A mixture of aggregates with an epoxy polymer as the sole binder.

Equilibrium In statics, the condition in which the forces acting upon a body are such that no external effect (or movement) is produced.

Equivalent Uniform Load - A load having a constant intensity per unit of its length producing an effect equal to that of a live load consisting of vehicle axle or wheel concentrations spaced at varying distances.

Erosion Wearing away of soil by flowing water

Expansion An increase in size or volume.

Expansion Bearing A bearing designed to permit the longitudinal movements resulting from temperature changes and superimposed loads without transmitting a horizontal force to the substructure; see BEARING.

Expansion Dam The part of an expansion joint serving as an end form for the placing of concrete at a joint; also applied to the expansion joint device itself.

Expansion Joint A joint designed to provide means for expansion and contraction movements produced by temperature changes, loadings or other forces.

Expansion Rocker A bearing device at the expansion end of a beam or truss that allows the longitudinal movements resulting from temperature changes and superimposed loads through a rocking motion.

Expansion Roller A cylinder so mounted that by revolution it facilitates expansion, contraction or other movements resulting from temperature changes, loadings or other forces.

Expansion Shoe An expansion bearing member, or assembly, designed to provide means for expansion and contraction; also known as an expansion pedestal. In general, the term "shoe" is applied to an assemblage of structural plates permitting movement by sliding, while the term "pedestal" is used to describe assemblages of castings, or built-up members, providing for movement either by sliding or by rolling.

Expansion Support A support designed to accommodate both rotation and longitudinal translation.

Exterior Girder An outermost girder supporting the bridge floor. The fascia beam.

Extrados The curve defining the exterior surface of an arch, also known as the back.

Eyebar A member consisting of a rectangular bar with enlarged forged ends having holes through them for engaging connecting pins.

Facial Referring to the surface of an element.

Factor of Safety A factor applied to the failure stress assumed to exist in a structure to provide a conservative margin in the strength of a structure compensating for irregularities existing in structural materials and workmanship, uncertainties involved in mathematical analysis and stress distribution, service deterioration and other unevaluated conditions.

Failure A condition at which a structure reaches a limit state such as cracking or deflection; usually does not involve fracture since failing structures are deemed unsafe, therefore unusable, before they collapse.

Falsework A temporary wooden or metal framework built to support the weight of a structure during the period of its construction and until it becomes self-supporting.

Fascia The longitudinal exterior face of a structure.

Fascia Girder An exposed outermost girder of a span sometimes treated architecturally or otherwise to provide an attractive appearance.

Fatigue The tendency of a member to fail at a lower stress when subjected to cyclical loading rather than when subjected to static loading.

Fatigue Crack Any crack caused by repeated cyclic loading.

Fatigue Cycle The loading and unloading of a bridge member during the passage of trains, and having a sufficient range of stress to accumulate fatigue damage.

Fatigue Damage Member damage (crack formation) due to cyclic loading.

Fatigue Life The anticipated length of service of a member prior to the development of cyclic induced cracking.

Fatigue Resistance The ability of a structural component to withstand cyclical tension stress without onset of fatigue cracking.

Fatigue Sensitive Details - Components and details susceptible to load induced fatigue. AASHTO detail categories are grouped according to their fatigue resistance, A being the best and E' the worst.

Fender A structure that acts as a buffer to protect the portions of a bridge exposed to floating debris and marine traffic; sometimes called an ice guard in regions with ice flows.

Fender Pier A pier-like structure which performs the same service as a fender but is generally more substantially built; see GUARD PIER.

Fender Pile A pile which is driven at wharfs, or in front of large masonry piers or other important works, to protect them from sudden blows by vessels.

FHWA Federal Highway Administration, U.S. Department of Transportation.

Field Coat A coat of paint applied after the structure is assembled and its joints completely connected; quite commonly a part of the field erection procedures.

Fill Materials, usually earth, used to change the surface contour of an area, or to construct an embankment.

Filler A piece used primarily to fill a space beneath a batten, splice plate, gusset, connection angle, stiffener or other element; also known as a filler plate.

Filler Metal Metal prepared in wire, rod, electrode or other adaptable form to be fused with the structure metal in the formation of a weld.

Filler Plate See FILLER.

Fillet A curved portion forming a junction of two surfaces which would otherwise intersect at an angle.

Fillet Weld A structural weld with the general shape of an isosceles right triangle. The size of the weld is given by the length of the leg. Fillet welds are generally used to join two surfaces approximately at right angles to each other.

Fine Aggregate Sand or grit for concrete which passes a sieve mesh of 5 mm square.

Finger Joints An expansion joint in which the opening is spanned by meshing steel fingers or teeth.

Fish Belly — A term applied to a girder or a truss having its bottom flange or its bottom chord constructed either haunched or bow-shaped with the convexity downward; see LENTICULAR TRUSS.

Fish Bellied Girder — A girder having the top flange horizontal and the bottom flange curved to provide a smaller depth at the end.

Fish Plates — Splice plates used to join to beams on the webs.

Fixed Beam — A beam that is restrained from expanding or contracting at both ends.

Fixed Bearing — A bearing which does not allow any longitudinal movement; see BEARING.

Fixed Bridge — A bridge in a fixed location that does not move except for expansion and contraction.

Fixed End — The end of a member or span where expansion and contraction are restrained.

Fixed-Ended Arch — See VOUSSOIR ARCH.

Fixed Span — A non-movable span.

Fixed Support — A support designed to accommodate rotation only.

Flange — The horizontal parts of a rolled I-shaped beam or of a built-up girder extending transversely across the top and bottom of the web.

Flange Angle — An angle used to form a flange element of a built-up girder, column, strut or similar member.

Flange Coupling — A coupling made up of two parts, each firmly attached to the end of its shaft, bolted together to form a permanent connection.

Flange Splice — A splice made in the flange of a beam or girder.

Flexure — Bending.

Flexural Rigidity — The ability of a beam to resist bending.

Floating Bridge — See PONTOON BRIDGE.

Floating Foundation — Used to describe a soil supported raft or mat foundation with low bearing pressure.

Flood Frequency — The average time interval in years in which a flow of a given magnitude will recur.

Flood Plain — Area adjacent to a stream or river subject to flooding.

Floor — See DECK.

Floor System The system of members in a bridge that carries the deck and its load, transferring the loads to the main girders or trusses.

Floorbeam A transverse beam or girder placed at the panel points of a span to support the stringers which carry the deck. In some instances on through plate girders, floor beams are closely spaced to support the deck without stringers.

Flow Capacity Maximum flow rate that a channel, conduit, or culvert structure is hydraulically capable of carrying.

Flux A material which protects the weld from oxidation during the fusion process.

Footbridge A bridge designed and constructed to provide for pedestrian traffic only; also known as a pedestrian bridge.

Footing The enlarged, lower portion of a substructure, which distributes the structure load either to the earth or to supporting piles; the most common footing is the concrete slab; footer is a local term for footing.

Foot Wall See TOE WALL.

Force An influence that tends to accelerate a body or to change its movement.

Forms The constructions that hold concrete in place while it is hardening; also known as form work, shuttering. See LAGGING, STAY-IN-PLACE-FORMS.

Form Work See FORMS.

Foundation That portion of a structure, usually below the surface of the ground, which distributes the pressure upon its support. Also applied to the supporting material itself.

Foundation Excavation - The excavation made to accommodate a footing for a structure; also known as foundation pit.

Foundation Failure Failure of a foundation by differential settlement or by shear failure of the soil.

Foundation Grillage A construction consisting of steel, timber, or concrete members placed in layers; each layer is normal to those above and below it and the members within a layer are generally parallel, producing a crib or grid-like effect. Usually placed under very heavy loads.

Foundation Pile See PILE.

Foundation Pit See FOUNDATION EXCAVATION.

Foundation Seal A mass of concrete placed underwater within a cofferdam to form the base portion of a structure, or to close or seal the cofferdam against incoming water; see TREMIE.

Fracture To break or split. A partial or total separation of parts of a continuous solid body under the action of force.

Fracture Critical Member - A member in tension, or with a tension element, whose failure would probably cause a portion of or the entire bridge to collapse.

Frame A structure having its parts or members so arranged and secured that the entire assemblage may not be distorted when supporting the loads, forces, and physical pressures considered in its design.

Framed Bent A bent consisting of a sill, posts, and a cap in contrast to a bent that is a cap on driven piles.

Framing The arrangement and manner of joining the component members of a bridge structure to insure a condition wherein each element and member may function in accord with the conditions governing its design.

Framing Plan A plan view of the bridge used to show the layout geometry, and properties of superstructure primary, and secondary members.

Free End The end of a member or span where expansion and contraction are not restrained.

Fretting Wear resulting from repetitive rubbing or abrasion.

Friction Pile A pile which provides support through friction resistance along the lateral surface of the pile.

Friction Roller A roller placed between members intended to facilitate change in their relative positions by reducing the frictional resistance to translation movement.

Frost Action Freeze-thaw cycles.

Frost Heave The upward movement of and force exerted by soil due to freezing of retained moisture.

Frost Line The depth to which soil may be frozen.

Frozen Bearings Movement has been prevented by corrosion, mechanical binding, intrusion of dirt or other interference to the point that the bearing does not operate properly or is held in a rigid condition.

Fungi Mold, rot or decay that feeds on wood.

G The shear modulus of a material; the ratio of shear stress to shear strain during initial elastic behavior.

Gabion Rock filled wire baskets used to retain earth or provide erosion control.

Gage The distance between the inside faces of both rail heads; 4’8½” for US Standard Gage.

Galvanic Action Electrical current between two unlike metals.

Galvanize To coat with zinc.

Ganged Forms Reusable forms that are prefabricated and assembled to make a complete unit.

Gauge The distance between parallel lines of rails, rivet holes, etc. A measure of thickness of sheet metal, or wire; also known as a gage.

Gear A wheel having teeth on its periphery or face. A piece of mechanism for transmitting motion.

Girder A flexural member which is the main or primary support for the structure, and which usually receives loads from floor beams and stringers; any large beam, especially if built up.

Girder Bridge A bridge whose superstructure consists of two or more girders supporting a separate floor system as differentiated from a multi-beam bridge or a slab bridge.

Girder Span A span in which the major longitudinal supporting members are girders.

Girt Longitudinal brace on a timber bridge.

Glued-Laminated Timber (Glulam) - An engineered, stress-rated product of a timber laminating plant comprising assemblies of specially selected and prepared wood laminations securely bonded with adhesives.

Grade The fall or rise per unit horizontal length; see GRADIENT. Also refers to the strength rating of various materials.

Grade Crossing A term applicable to an intersection of two highways, two railroads or one railroad and one highway at a common grade or elevation; now commonly accepted as meaning the last of these combinations.

Grade Intersection The location where two roadway slopes meet in profile.

Grade Separation Roadways crossing each other at different elevations; see OVERPASS, UNDERPASS.

Gradient The rate of inclination of roadway or stream bed surfaces from horizontal applying to a bridge and its approaches; it is commonly expressed as a percentage relation of horizontal to vertical dimensions.

Grating See GRID FLOORING.

Gravity Abutment A heavy abutment which resists horizontal earth pressure through its own dead weight.

Gravity Wall A retaining wall which is prevented from overturning by its weight alone.

Grid Flooring (Decks) A steel floor system comprising a lattice pattern that may or may not be filled with concrete.

Grillage A platform-like construction used to insure distribution of loads upon unconsolidated soil material; see FOUNDATION GRILLAGE.

Groin A wall built out from a riverbank to check scour.

Group Loading A combination of loads (i.e. live load, wind load, earthquake load, shrinkage, etc.).

Grout A mortar having a sufficient water content to render it a free-flowing mass, used for filling (grouting) the joints in masonry, for fixing anchor bolts and for filling cored spaces where water may accumulate.

Groove Weld A structural weld made in a groove between the edges of two parts to be joined. Groove welds generally are used to connect two plates lying in the same plane (butt joint), but they also are used for tee and corner joints.

Guard Pier A pier-like structure built to protect the swing span in its open position from collision with passing vessels or other waterborne materials; may be equipped with a rest pier upon which the swing span in its open position may be supported. See FENDER PIER.

Guardrail See GUIDE RAIL.

Guide Rail A safety feature element intended to contain and safely redirect an errant vehicle.

Guard Timber A guard-rail made of a timber, bolted to or dapped over the ties for railway bridges. Also referred to as spacer timber or tie spacer.

Gunite Portland cement mortar which is blown onto a surface using compressed air. Also known as Shotcrete.

Gusset A plate which connects the members of a structure and holds them in correct position at a joint; see SPLICE, STAY PLATE.

Gutter A paved drain commonly constructed in conjunction with the curbs of the roadway.

Gutter Grating A perforated or barred cover placed upon an inlet to a drain to prevent the entrance of debris.

Guy A cable member used to hold a structure in a desired position.

Hairline Cracks Very small cracks that form in the surface of concrete.

Half-Cell Tests An electric potential test used to determine if reinforcing steel is in a passive or active corrosion state.

Half-Through Truss A bridge with the deck placed above the bottom chord such that lateral and sway bracing cannot be placed between the top chords. Also called a Pony Truss.

Hammerhead Pier A pier with a single cylindrical or rectangular shaft and a relatively long, transverse cap; also known as a tee pier.

Hand Hole Holes provided in box sections to permit access to the interior for maintenance and construction purposes.

Hand Rail Commonly applies only to sidewalk railing presenting a latticed, barred, balustered or other open web construction.

Hands-On Access Arm's length; close enough to the member or component so that it can be touched with the hands.

Hanger A hip-vertical or suspender of a truss acting in tension. Also a tension member supporting a floor system in an arch or in a suspension bridge.

Haunched Girder A member whose cross-sectional depth varies from support to support.

H-Beam A rolled steel member having an H-shaped cross section and commonly used for piling; also known as an H-pile.

Hardpan A very compact layer or bed of material under the track.

Haunch An increase in the depth of a member, usually at points of support; the outside areas of a pipe between the spring line and the bottom of the pipe. That portion of a concrete deck that is above the top of the supporting member and below the bottom of the structural deck thickness.

HDPE High-Density Polyethylene Pipe.

Head A measure of water pressure expressed in terms of an equivalent weight or pressure exerted by a column of water; the height of the equivalent column of water is the head.

Headloss The loss of energy between two points along the path of a flowing fluid due to fluid friction reported in feet of head.

Headwall A vertical or slightly inclined wall at the ends of a culvert to protect the embankment slopes from erosion and anchor the culvert.

Headwater The source or the upstream waters of a stream.

Heartwood The oldest, central rings of any timber. Typically, preservative treatment will not penetrate into the heartwood, making it susceptible to decay.

Heat Treatment Any of a number of various operations involving heating and cooling that are used to impart specific properties to metals; examples are tempering, quenching, annealing, etc.

Heave The upward movement of soil which can be caused by moisture, excavation, pile driving, etc.

Heel The rear face of a footing. The end of a cantilever beam, such as a bascule girder, nearest to the point of support.

Helical Having the form of a spiral.

High Strength Bolt Bolt and nut made of high strength steel, usually ASTM A325 or stronger.

Hinge A point in a structure at which a member is free to rotate.

Hinged Joint A joint constructed with a pin, cylinder segment, spherical segment or other device permitting movement by rotation.

Hip Joint The juncture of the inclined end post with the end top chord member of a truss; also known as the hip truss.

Hip Vertical The vertically placed tension member engaging the hip joint of a truss and supporting the first panel floor beam in a through truss span, or instead, only the bottom chord in a deck truss span.

"H" Loading A hypothetical design truck developed by AASHTO that comes in two types, H20-44 and H15-44.

Hogjaw A diagonal bracing strut from the bottom of one bent on a timber bridge to the top of an adjacent bent to provide longitudinal stability.

Honeycomb An area in concrete with a lack of mortar to fill in the spaces between the coarse aggregate.

Horizontal Alignment The mathematical description of a roadway’s centerline or baseline alignment in the horizontal plane.

Horizontal Cracks Cracks which are parallel to the longitudinal axis of the member and thus parallel to the primary stress.

Horizontal Curve A curve in the plan location defining the alignment.

Howe Truss A truss of the parallel chord type with a web system composed of vertical (tension) rods at the panel points with an X pattern of diagonals.

HPS High Performance Steel, a weathering steel with superior weldability and toughness as compared to conventional steels of similar strength.

"HS" Loading A hypothetical design truck used as a model for the typical semitrailer truck which was developed by AASHTO that comes in two types, HS20-44 and HS15-44.

Hybrid Girder A girder with load-bearing plates of varying steel types (e.g., high-strength steel used for flanges and lower strength for webs).

Hydration The process of combining or impregnating with water, or the resulting condition.

Hydraulic Capacity The amount of water that will pass through a structure without obstruction from the superstructure usually defined by the maximum design flood (i.e. 100 year) that will pass underneath.

Hydraulics The mechanics of fluids, primarily water.

Hydrology The science of water related to its properties and distribution in the atmosphere, on the land surface, and beneath the surface of the land.

I-Beam A structural member with a cross-sectional shape similar to the capitol letter “I”.

I-Beam Bridge A small bridge consisting of a floor supported on I-beams.

Ice-breaker A structure of masonry or timber (as a pier or a cluster of piles) for the protection of bridge piers against moving ice.

Ice Guard A fender placed at the up-stream end of a bridge pier to divert the ice or else to break up the large floes into small pieces. Also see FENDER.

Impact Amplification effect on live load due to dynamic and vibratory effects of a moving load.

Impact Load (1) A dynamic increment of load created by moving loads traversing a bridge. (2) A short duration, often high magnitude load striking a portion of a structure. This can include flat train wheels, wheels moving over rail joints, vessel or vehicle strikes, etc.

Impacted Rust Rust forming between connected parts which as it expands tends to separate the connected parts.

In-Depth Inspection Bridge safety inspection conducted every ten years on all qualifying structures defined by the Bridge Safety & Evaluation Section. An in-depth inspection consists of a “hands-on” examination of all exposed parts of a bridge to assess and record the physical condition of the bridge, to ascertain that the bridge is functioning as shown on the original plans and to ensure that the bridge is adequate to safely carry the intended loads.

Incomplete Fusion A weld flaw where the weld metal has not combined metallurgically with the base metal.

Indeterminate Stress A stress induced by the use of a redundant member in a truss or an additional reaction in a beam rendering stress distributions unable to be determined by the principles of statics.

Inelastic Compression Compression beyond the yield point.

Inlet An opening in the deck of a bridge leading to a drain. The upstream entry of a culvert.

Inner Guard-rails Guard-rails placed between the running rails of a track.

Integral Deck Superstructure - A deck that is designed to share with the superstructure, the load carrying capabilities of the bridge and not merely to transfer loads to the superstructure.

Interlocking Signal appliances that are interconnected so that each of their movements follows the other in a proper sequence.

Intermediate Floorbeam - Any floor-beam between the end floor beams.

Intermediate Sill A horizontal member in the plane of a timber trestle bent between the elevations of cap and sill, to which the posts are framed.

Intermediate Stiffener Any one of the stiffeners on a plate girder between the end stiffeners.

Intermittent Weld A non-continuous weld commonly composed of a series of short welds separated by spaces of equal length.

Intrados The curve defining the interior surface of the arch; also known as the soffit.

Inventory Item Data contained in the structure file pertaining to bridge identification, structure type and material, age and service, geometric data, navigational data, classification, load rating and posting, proposed improvements, and inspections.

Inventory Rating Load which can safely utilize the structure for an indefinite period.

Invert The bottom layer or lowest point of the internal surface of the transverse cross section of a pipe or culvert.

Isotropic An object having the same material properties in all directions, e.g., steel.

Jack Arch A deck support system comprised of a brick or concrete arch springing from the bottom flanges of adjacent steel beams.

Jacket A layer of concrete placed over an existing pier or abutment surface to strengthen, stabilize, confine, or protect it.

Jacking The lifting of an element or group of elements using hydraulic or other types of jacks and, if needed, a temporary support system.

Jersey Barrier A concrete barrier named after the New Jersey Department of Transportation, which first developed it. Also known as traffic barrier, median barrier, shape barrier, and concrete barrier.

Jetty A structure of wood, stone, or other materials extending into a body of water and serving for a wharf or pier, or as a mole, rampart, or wall. Also used to restrain, charge, or direct a current, and to protect a harbor, shore, channel or the like.

Joint In stone masonry, the space between individual stones; in concrete, a division in continuity of the concrete; in a truss, point at which members of a truss frame are joined.

Journal That part of a shaft or axle which rests on the bearings.

Keeper Plate A plate which is bolted or welded to a sole plate to prohibit a beam from being disconnected from the bearing.

Key A notched or raised protrusion of concrete located on one face of a construction joint which fits into a recess on the other face.

Keystone The symmetrically shaped, wedge-like stone located in a head ring course at the crown of the arch; the final stone placed, thereby closing the arch.

Key-way A slot cut in a shaft or hub of a gear or pulley to receive the key.

King-Post The post member in a "king-post" type truss; also known as king rod.

King-Post Truss Two triangular panels with a common center vertical; the simplest of triangular system trusses.

Kip A kilopound (1000 lb.); convenient unit for structural calculations.

Knee Brace A short member engaging at its ends two other members which are jointed to form a right angle or a near-right angle to strengthen and stiffen the connecting joint.

Knee Wall A return of the abutment backwall at its ends to enclose the bridge seat on three of its sides; also called a cheekwall.

Knife Edge A condition in which corrosion of a steel member has caused a thin, sharp edge.

Knuckle An appliance forming a part of the anchorage of a suspension bridge main suspension member permitting movement of the anchorage chain.

K-Truss A truss having a web system wherein the diagonal members intersect the vertical members at or near the mid-height; the assembly in each panel forms a letter "K".

L-Abutment A cantilever abutment with the stem flush with the toe of the footing forming an L in cross section.

Laced Column A column built up from several members with lacing.

Lacing Small flat plates used to connect individual sections of built up members; see LATTICE.

Lacing Bars A system of bars not intersecting each other at the middle, used to connect two members of a strut in order to make them act as one member.

Lag Screw A large-sized wood screw with a square head larger than the shank for convenient turning with a wrench, and having a special thread to increase the holding strength.

Lagging Forms used to produce curved surfaces; see FORMS.

Laitance The residue created when concrete is subject to bleeding. Water rises in the channels within concrete, carrying with it very fine particles of cement, sand, and clay and depositing them in the form of a scum at the concrete surface.

Lamellar Tearing A cracking phenomenon that starts underneath the surface of plates as a result of excessive strain. The tear has a step like appearance consisting of a series of terraces parallel to the surface.

Laminate Two or more pieces of wood which are joined together, typically with adhesive or nails.

Laminated Timber Small timber planks glued or nailed or otherwise fastened together to form a large member

Lane Loading A hypothetical design load used to simulate a train of trucks moving across a bridge.

Lateral Bracing The bracing assemblage engaging a member perpendicular to the plane of the member; intended to resist lateral movement and deformation; also provides resistance against raking of primary parallel elements in truss bridges and girder bridges; see BRACING.

Latex Modified Concrete (LMC) - Concrete with a latex admixture that forms a continuous and coherent polymer film.

Lattice A crisscross assemblage of diagonal bars, channels or angles on a truss; also known as latticing, lacing.

Lattice Bars A system of bars crossing each other at mid-length, used to connect the two members of a strut in order to make them act as one member. Generally the crossed bars are riveted together at their intersection.

Lattice Truss In general, a truss having its web members inclined but more commonly the term is applied to a truss having two or more web systems composed entirely of diagonal members at any interval and crossing each other without reference to vertical members.

Lattice Truss Bridge A bridge having riveted trusses with multiple intersection web systems.

Lay Pitch length of a wire helix. Common term used for wire cables.

Leaching The action of removing substances from a material by passing water through it.

Lead Line A weighted chord incrementally marked, used to determine the depth of a body of water; also known as a sounding line.

Leaf The movable span of a bascule bridge.

Lenticular Truss A truss having parabolic top and bottom chords curved in opposite directions with their ends meeting at a common joint; also known as a fish belly truss.

Levee An embankment built to prevent flooding of low-lying land.

Leveling Course A layer of asphalt or binder used to smooth together two sections of pavement.

LFD See Load Factor Design.

Lift Bridge A style of movable bridge which travels in a vertical plane, sometimes called a hoist bridge.

Light-Weight Concrete No-fines concrete, aerated concrete, or concrete made of lightweight aggregate.

Limit States Design A method of design based on the ability of a structure to fulfill its function. This ability is defined by limit states defining safety and serviceability.

Line The lateral, or side to side, tolerance of a section of track to its original survey. Also called Alignment.

Link A hanger plate in a pin and hanger assembly.

Live Load A dynamic load such as vehicular traffic that is applied to a structure; also accompanied by vibration or movement affecting its intensity.

Load The weight carried by a beam, girder, truss, span, or structure of any sort, including its own weight.

Load Factor Design A form of limit states design used by AASHTO as an alternative to Working Stress Design. Commonly abbreviated as LFD.

Load Indicating Bolt A bolt whose head carries small projections on its underside which compress as the bolt is tightened, giving a direct indication of the bolt tension that has been achieved.

Load Rating An engineering exercise to determine the ability of a bridge to carry load. The member with the minimum capacity controls the rating of the structure.

Local Buckling Localized buckling of one of a beam's plate elements which can potentially lead to failure of the member.

Locked-coil Strand An arrangement of wires resembling structural strands except that the wires in some layers are shaped to lock together when in place around the core.

Longitudinal Used to describe the axis of a bridge which proceeds from abutment to abutment.

Longitudinal Bracing Bracing that runs lengthwise with a bridge and provides resistance against longitudinal movement and deformation of transverse members.

Longitudinal Shear A shear parallel to the longitudinal axis of a member.

Lower Chord See BOTTOM CHORD.

LRFD Load and Resistance Factor Design, a form of limit states design used by AISC and AASHTO as an alternative to Working Stress or Load Factor Design.

Luminaire A lighting fixture.

Main Beam A beam which supports the span and bears directly on the substructure.

Maintenance The preservation and upkeep of a structure, component or system to its as installed, or subsequently rehabilitated condition.

Maintenance and Protection of Traffic - The control of traffic through a work zone that ensures safety to both vehicles and construction personnel.

Mandrel A thin steel shell used in the placement of cast-in-place concrete piles.

Map Cracking An interlocking pattern of fine cracks that form a network resembling the lines on a map.

Marine Borers Parasites that burrow small excavations into wood and destroy it in a saltwater environment.

Masonry That portion of a structure composed of stone, brick or concrete block placed in layers and in some cases cemented with mortar.

Masonry Joint A joint between masonry stones that is filled with mortar.

Masonry Plate A steel plate attached to the substructure to support a superstructure bearing and to distribute the load to the masonry beneath.

Mattress A mat-like protective covering composed of brush and poles compacted by wire and placed upon riverbeds and banks to prevent erosion and scour by stream flow.

Meander A twisting, winding action from side to side; characterizes the serpentine curvature of a narrow, slow flowing stream in a wide flood plain.

Median The area between opposing lanes of highway traffic; also known as median strip.

Member An individual angle, beam, plate, or built-up piece intended ultimately to become an integral part of an assembled frame or structure.

Metal Corrosion An electrical process involving an electrolyte (moisture), an anode (the metallic surface where oxidation occurs), a cathode (the metallic surface that accepts electrons and does not corrode), and a conductor (the metal piece itself).

Midspan A general reference point halfway between the supports of a beam or span.

Military Loading A loading configuration used to simulate heavy military vehicles passing over a bridge. Also known as Alternate Military Loading.

Mill Scale Black iron oxide on iron or steel which has been forged or hot worked.

Minimum Vertical Clearance - Minimum vertical distance over the bridge roadway to any superstructure restriction.

Modular Joint A deck expansion joint, used to accommodate large movements, consisting of multiple strip or compression seals.

Moisture Content The amount of water in a soil mass expressed as a percent by weight.

Moment The couple effect of forces about a given point; see BENDING MOMENT.

Monolithic Forming a single mass without joints.

Mountable Curb Curbs that are designed so that vehicles can cross them readily when required.

Mortar A paste of cement, sand, and water laid between bricks, stones or blocks.

Movable Bridge A bridge having one or more spans capable of being raised, turned, lifted, slid or otherwise moved from its normal service location to provide for the passage of navigation.

Movable Span A general term applied to a superstructure span designed to be raised, turned, lifted, slid or otherwise moved from its normal service location to provide for the passage of navigation.

Moving Load Live load which is moving, for example, vehicular traffic.

Mud Line The soil/water interface in a profile of a river crossing.

Mud Sill Timber blocking resting on the earth, to support a framed bent.

MUTCD The Manual of Uniform Traffic Control Devices.

Nail Laminated A timber member created by nailing two or more pieces of lumber together.

Navigation Lights Lighting attached or adjacent to a bridge that aids in the guidance of an approaching vessel from the open channel through the bridge opening and allows for controlled passage of vessels through a bridge site.

NBIS National Bridge Inspection Standards. Federal regulations establishing requirements for inspection purposes, frequency of inspections, qualifications of personnel, inspection reports, and preparation and maintenance of bridge inventory records. The NBIS apply to all structures defined as bridges located on or over all public roads.

NCHRP National Cooperative Highway Research Program. A research agency of the federal government.

Necking The elongation and contraction in area which occurs when a ductile metal fails in tension.

Negative Bending Bending of a member characterized by the downward curvature of the member ends.

Negative Moment Bending moment in a member such that tension stresses are produced in the top portions of the member; typically occurs in continuous beams and spans over the intermediate supports.

Neoprene A popular elastomer material for seal-type expansion joints made of polychloroprene.

Neutral Axis The internal axis of a member in bending along which the strain is zero.

NICET National Institute for Certification in Engineering Technologies
.
Node See PANEL POINT.

Non-Destructive Testing (NDT) - A method of checking the structural quality of materials that does not damage them.

Nonredundant A structural condition where there is one element of support.

Nose A pointed or tapering projection on the upstream or downstream edge of a pier, may act as an ice-break.

Notch Effect Stress concentrations caused by an abrupt discontinuity or change in section.

Offset A horizontal distance measured at right angles to a survey line to locate a point off the line.

On Center A description of a typical dimension between the centers of the objects being measured. Also center-to-center.

Open Position The location of the movable spans on a movable bridge to allow passage of marine traffic. Closed to vehicles and pedestrians.

Open Spandrel Arch A bridge which has open spaces between the deck and the arch members allowing "open" visibility through the bridge.

Open Spandrel Ribbed Arch - A structure in which two or more comparatively narrow arch rings, called ribs, function in the place of an arch barrel. The ribs are rigidly secured in position by arch rib struts located at intervals along the length of the arch. The arch ribs carry a column type open spandrel construction which supports the floor system and its loads.

Operator's House The building containing the power plant and operating machinery and devices required for the operator's (bridge tender's) work in executing the complete cycle of opening and closing a movable bridge span.

Operating Rating Maximum permissible load to which a structure may be subjected.

Orthotropic A description of the physical properties of a material that had pronounced differences in two or more directions at right angles to each other.

Orthotropic Deck A steel deck which is stiffened both longitudinally and transversely using open or closed ribs and floor beams, respectively.

OSHA Occupational Safety and Health Administration, a division of the U.S. Department of Labor.

Outlet In hydraulics, the discharge end of drains, sewers, or culverts.

Out-of-plane Distortion - Distortion of a member in a plane other than that which the member was designed to resist.

Overbridge Clearances - The measurement taken to the above structure or all sign structures over the roadway, but not light standards, trees, or overhead wires.

Overhead Crossing A crossing where a bridge carries a road or tracks over the railroad.

Overlay See WEARING SURFACE.

Overload	A weight greater than the structure is designed to carry.
Overpass	The uppermost feature in a grade separated crossing.
Overturning	Tipping over or rotational movement.
Oxidation	The chemical breakdown of a substance due to reaction with oxygen.
Pack	A steel plate inserted between two others to fill a gap and fit them tightly together; also known as packing.
Pack Rust	See IMPACTED RUST.
Packing Bolt	A bolt which holds together the several parts of a member, also called chord bolts.
Packing Diagram	The arrangement of eye-bars on a truss pin.
Paddleboard	Striped, paddle-shaped signs or boards placed on the roadside in front of a narrow bridge as a warning of reduced roadway width. Also known as Object Markers.
Panel Point	The point of intersection of primary web and chord members of a truss.
Panel	The portion of a truss span between adjacent points of intersection of web and chord members. The longitudinal space between adjacent transverse members.
Panel Length	The distance between two adjacent panel points in the same chord of a truss.
Panel-point	The point at which the axis of a principal web member intersects the axis of a chord of a truss.
Parabolic Truss	A Polygonal truss having its top chord and end post vertices coincident with the arc of a parabola, its bottom chord straight and its web system either triangular or quadrangular; also known as a parabolic arched truss.
Parallel-Wire Strand	Individual wires arranged in a parallel configuration without the helical twist.
Parapet	(1) A raised wall or curb at the periphery of bridge spans or abutments to retain ballast. (2) A wall-like step placed on bridge piers to accommodate different span depths.
Parting Line	The location over a bent or pier where two stringers butt up against each other end to end on a timber bridge.
Pedestal	Concrete or built-up metal member constructed on top of a bridge seat for the purpose of providing a specific bearing seat elevation.

Pedestal Pier One or more piers built in block-like form that may be connected by an integrally built web between them. When composed of a single, wide block-like form, it is called a wall or solid pier.

Pedestrian Bridge See FOOTBRIDGE.

Penetration When applied to treated lumber, the depth to which the surface wood is permeated by the preservative treatment. When applied to pile driving, the depth a pile tip is driven into the ground.

Permeability The ease with which a fluid can flow through a solid.

Pier A substructure unit that supports the spans of a multi-span superstructure at an intermediate location between its abutments.

Pier Cap The topmost portion of a pier which distributes uniformly over the pier the concentrated loads from the bridge.

Pilaster A thin, flat projection from the face of a wall made to resemble a column, for ornamental purposes.

Pile A shaft-like linear member which carries loads through weak layers of soil to those which are capable of supporting such loads.

Pile Bent A row of driven or placed piles with a pile cap to hold them in their correct positions; see BENT.

Pile Cap The uppermost portion of a pile which acts to secure the piles in position and provides a bridge seat to receive and distribute superstructure loads.

Pile Cluster Several piles driven close together forming a group or cluster.

Pile Foundation A foundation reinforced by driving piles in sufficient number and to a depth adequate to develop the bearing resistance required to support the substructure load.

Pile Pier A pier formed by driving a cluster of piles and capping them in the form of a grillage to carry the shoes of the span.

Pile Trestle A trestle having pile bents for supporting the stringers.

Piling General term applied to groupings of piles in a construction; see PILE, SHEET PILES.

Pin A cylindrical bar used to connect.

Pin-connected Truss A general term applied to a truss of any type having its chord and web members connected at the panel points by pins.

Pinholes Small discontinuities in a weld.

Pin Joint A joint in a truss or other frame in which the members are assembled upon a cylindrical pin.

Pin Packing An arrangement of truss members on a pin at a pinned joint.

Pin Plate A plate rigidly attached upon the end of a member to develop the desired bearing upon a pin or pin-like bearing, and secure additional strength and rigidity in the member.

Pinion Any toothed gear of small size as compared with the gear which it engages.

Pintle A relatively small steel pin engaging the rocker of an expansion bearing, in a sole plate and masonry plate, thereby preventing translation of the rocker ends.

Piping A process of subsurface erosion in which surface runoff flows along the outside of a culvert and with sufficient hydraulic gradient erodes and carries away soil around the culvert.

Pitch A grade or slope given to a surface, usually to provide for adequate drainage. Also the distance between rows of shear studs or complete revolutions in a spiral shear connector.

Pitting Selective localized formation of rounded cavities in a metal surface due to corrosion.

Pivot Pier The pier supporting a swing span and upon which it turns.

Plain Concrete Concrete with no structural reinforcement except light steel to reduce shrinkage and temperature cracking.

Plan Drawing that represents the top view of a structure and structure site.

Planimetry Topographic information detailing the location and/or elevation of non-terrain related features (e.g., vegetation, fences, catch basins, etc.).

Plank A piece of lumber thicker than a board; usually measures from two to four inches in thickness and from six inches upward in width.

Plastic Deformation A permanent deformation of a member due to loads that have been placed on a member for a given period of time.

Plastic Flow Deformation of metal beyond the elastic limit.

Plate A flat sheet of metal greater that 1/8 inch thick.

Plate Girder A large I-shaped beam composed of a solid web plate with flange plates attached to the web plate by flange angles or welds.

PLC Programmable Logic Controller, a control system with instrumentation to monitor critical operating parameters and telemetry that reports monitoring results periodically to a control maintenance management office.

Plug Weld A structural weld used to transmit shear in lap joints and to prevent buckling of lapped parts. Plug welds are made by depositing weld metal in circular or slotted holes in one lapped part.

Plumb Vertical.

Plumb Bob A weight hanging on a cord used to provide a true vertical reference.

Plumb Line A true vertical reference line established using a plumb bob.

Plumb Pile A pile driven vertically, usually one of the inside piles of a bent.

Pneumatic Caisson A caisson in which the working chamber is kept full of compressed air at a pressure nearly equal to the water pressure outside it.

Pointing The compacting of the mortar in the outermost portion of a joint and the troweling of its exposed surface to secure water tightness or desired architectural effect.

Poisson's Ratio (ν)– The ratio of transverse to longitudinal strain under load.

Ponding Water backed up in a channel or ditch as the result of a culvert of inadequate capacity.

Pontoon Bridge A bridge which floats on pontoons moored to the riverbed. A portion may be removable to facilitate navigation.

Pony Truss A low truss without any overhead bracing.

Popout Conical fragment broken out of a concrete surface.

Porosity Cavity-type discontinuities in a weld formed by gas entrapment during solidification or in a thermal spray deposit.

Portal The clear unobstructed space of a through truss bridge forming the entrance to the structure.

Portal Bracing A system of sway bracing placed in the plane of the end posts of the trusses.

Positive Moment A bending moment which induces compression in the top fiber of a beam and tension in the bottom fiber.

Post A member resisting compressive stresses, located vertical to the bottom chord of a truss and common to two truss panels; sometimes used synonymously for vertical; see COLUMN.

Posted	A limiting dimension, speed, or loading indicating larger dimensions and higher speeds and loads can not be safely taken by the bridge.
Post-Stressing	See POSTTENSIONING
Post-tensioning	A method of prestressing concrete in which tendons that run through the concrete are stressed after the concrete has cured.
Pot Bearing	A bearing type that allows for multi-dimensional rotation by using a neoprene or spherical bearing element.
Pot Holes	Irregular shaped, disintegrated areas of bridge deck or approach pavement concaved by the failure of the surface material.
Power Post Beatles	Small beetles that burrow into timber and leave the timber surface pock-marked with holes.
Pratt Truss	A truss with parallel chords and a web system composed of vertical posts with diagonal ties inclined outward and upward from the bottom chord panel points toward the ends of the truss; also known as an N-truss.
Precast Concrete	Concrete members which are cast and cured before being placed into their final positions on a construction site.
Pressure	Force per unit area, usually expressed in pounds per square inch (psi) in the US system of units.
Prestressed Concrete	Concrete in which cracking and tensile forces are greatly reduced by compressing it with tensioned cables or bars.
Prestressing	Applying forces to a structure to deform it in such a way that it will withstand its working loads more effectively; see POSTTENSIONING, PRETENSIONING.
Pretensioning	A method of prestressing concrete in which tendons which run through the concrete are held in a stretched condition until the concrete has cured, then the pull on the tendons is released inducing internal compression into the concrete.
Primary Member	A load bearing member which distributes loads longitudinally and is principally designed to resist flexure.
Priming Coat	The first coat of paint applied to the metal or other material of a bridge; also known as base coat, shop coat.
Probing	Investigating the location and condition of submerged footing foundation material using a rod or shaft of appropriate length; checking the surface condition of a timber member for decay using a pointed instrument, e.g., an ice pick.
Profile	A section cut vertically through the center line of a roadway or waterway to show the original and final growth levels.

Protective System A system used to protect bridges from environmental forces that cause steel and concrete to deteriorate and timber to decay, typically a coating system.

PTFE Pads Bearings with sliding surfaces made of polytetrafluoroethylene (Teflon®).

Punching Shear Shear stress in a slab due to the application of a concentrated load.

Pylon A tower which transfers forces from the bridge to the foundation.

Quarter Pile A bent pile driven with some incline to the vertical, located between the interior plumb piles and the exterior batter piles. Also called a rail pile, it is often located below the rail.

Queen-post Truss A parallel chord type of truss having three panels with the top chord occupying only the length of the center panel; unless center panel diagonals are provided, it is a trussed beam.

Rack-circle A rack bent into the form of a circle that is engaged by drive pinions on swing or turn spans.

Radial Strut One of a series of struts radiating from a fixed point such as the radial braces of a turntable, or a swing-span drum.

Rail-lift A device used on swing spans for lifting the ends of the rails, so as to clear obstructions on adjacent spans as draw is swung open.

Rail-lock A device used on swing spans for locking the rails at the ends of the span after closing the draw.

Railing A fence-like construction built at the outermost edge of the roadway or the sidewalk portion of a bridge to protect pedestrians and vehicles; see HANDRAIL.

Rake An angle of inclination of a surface in relation to vertical plane; also known as batter.

Ramp An inclined traffic-way leading from one elevation to another.

Range of Stress The algebraic difference between the minimum and maximum stresses in a member.

Raveling Cumulative loss of aggregate from a pavement made of bituminous material, which results in a poor riding surface.

RBMP Railroad Bridge Management Program. A program designed to optimize the use of available resources for the inspection, evaluation, load rating, maintenance, rehabilitation, and replacement of bridges.

Reaction The resistance of a support against the pressure of a loaded member.

Rebar See REINFORCING BAR.

Reaction A passive force set up in opposition to an initial, active force, e. g., the upward pressure on the bottom of a beam resting on a support, equal in amount to the downward force from the loads on a beam.

Redundant Member A member in a bridge which renders it a statically indeterminate structure; the structure would be stable without the redundant member whose primary purpose is to reduce the stresses carried by the determinate structure.

Rehabilitation The restoration of bridge components (and subcomponents) to their original capacity (or that capacity determined by the owner).

Reinforced Concrete Concrete with steel reinforcing bars bonded within it to supply increased tensile strength and durability.

Reinforced Concrete Pipe - A concrete pipe designed with reinforcing steel to increase its surcharge carrying capability.

Reinforcement Rods or mesh embedded in concrete to strengthen it.

Reinforcing Bar A steel bar, plain or with a deformed surface, which bonds to the concrete and supplies tensile strength to the concrete.

Reinforcing Plate An extra plate used to reinforce or strengthen a member.

Relaxation A decrease in capacity of prestressed and post-tensioned concrete members due to creep of the concrete.

Relief Joints Joints between the rigid concrete approach pavement and the bridge approach slab that are designed to absorb the thermal expansion and contraction stresses produced by the approach pavement without imparting them on the bridge structure.

Residual Camber Camber which results from a prestressing force minus a girder’s dead load deflection.

Residual Stress Stress locked into a member after it has been formed to its final shape.

Rest Pier A pier which supports one of the ends of a draw span.

Resurfacing The overlay of wearing surface material on top of an existing approach and/or deck overlay to create a more uniform and smooth riding surface.

Retaining Wall A structure designed to restrain and hold back a mass of earth.

Retractile Draw Bridge A bridge with a superstructure designed to move horizontally either longitudinally or diagonally from “closed” to “open” position, the portion acting in cantilever being counterweighted by that supported on rollers; also known as a traverse draw bridge.

Revetment A facing of wood, mattress, stone, or concrete placed to prevent erosion.

Rib Curved structural member supporting a curved shape or panel.

Rigger An individual who erects and maintains scaffolding or other inspection access equipment.

Rigid Frame A structural frame in which the members are connected together without hinges.

Rim Bearing Draw A term applied to swing spans to indicate that the dead load is supported by a circular girder near the periphery of the pivot pier instead of near its axis.

Rip-Rap Gabions, stones, blocks of concrete or other protective covering material of like nature deposited upon river and stream beds and banks, lake, tidal or other shores to prevent erosion and scour by water flow, wave or other movement.

Rivet A metal fastener used in pre-1970 construction; made with a rounded preformed head at one end and installed hot into a predrilled or punched hole; the other end was hammered into a similar shaped head thereby clamping the adjoining parts together.

Riveted Joint A joint in which the assembled members are fastened by rivets.

Riveted Truss Any truss having its main members riveted together.

Roadway The portion of the road intended for the use of vehicular traffic.

Roadway Shoulder Area - The area immediately adjoining the roadway, used to accommodate stopped vehicles in emergencies.

Rocker A casting or built-up steel frame fastened to the end of a span or column to permit a slight rotation.

Rocker Bearing A bridge support which accommodates expansion and contraction of the superstructure through a rocking action.

Rocker Bent A bent hinged or otherwise articulated at one or both ends to provide the longitudinal movements resulting from temperature changes and superimposed loads.

Roll Rack A rack on which a pinion works.

Rolled Shape Forms of rolled steel having “I”, “H”, “Z” or other cross sectional shapes.

Rolled Steel Section Any hot-rolled steel section including wide flange shapes, channels, angles, etc.

Roller A steel cylinder intended to provide longitudinal movements by rolling contact.

Roller Bearing A single roller or a group of rollers so housed as to permit longitudinal movement of a structure.

Roller Nest A group of steel cylinders used to facilitate the longitudinal movements resulting from temperature changes and superimposed loads.

Rolling Lift Bridge A bascule type movable bridge devised to roll backward and forward upon supporting girders when operated through an "open and closed" cycle.

Rope A group of strands laid helically around a core composed of either a strand or another wire rope.

Routine Inspection Bridge safety inspections that are conducted every two years on all qualifying structures defined by the Bridge Safety & Evaluation Section. The primary purpose of routine inspections is to identify any critical problems or deficiencies.

Rubble Irregularly shaped pieces of stone in the undressed condition obtained from a quarry and varying in size.

Runoff Water, typically the result of rainfall, which collects on a bridge deck or roadway and is channeled off by catch basins, scupper drains, etc.

Saddle A member located upon the topmost portion of the tower of a suspension bridge which acts as a bearing surface for the catenary cable passing over it.

Safe Load The load which a structure can safely support.

Safety Belt A harness or belt worn in conjunction with a safety line to prevent falling a long distance when working at heights.

Safety Curb A curb between 9 inches and 24 inches wide serving as a limited use refuge or walkway for pedestrians crossing a bridge.

Safety Factor See FACTOR OF SAFETY.

Sag To sink or bend downward due to weight or pressure.

Sap Wood The outer and lighter colored portion of a timber.

Sash Brace A horizontal member secured to the posts or piles of a bent between the cap and sill.

Scab A plank bolted over the joint between two timber members to hold them in correct alignment and strengthen the joint. A short piece of I-beam or other structural shape attached to the flange or web of a metal pile to increase resistance to penetration; also known as scab piece.

Scaling The gradual deterioration of a concrete surface due to the failure of the cement paste caused by chemical attack or freeze/thaw cycles.

Schmidt Rebound Hammer - A spring controlled hammer that slides on a plunger used to check the surface hardness and uniformity of in-place hardened concrete.

Scour The general or local vertical deepening in normal stream bed elevation. Scour often occurs around obstructions in a stream such as piers or abutments.

Scour Critical Bridges A bridge with rating a of "4" of less on Item 113 of the BRI-19 form.

Scour Protection Protection of submerged material by steel sheet piling, rip rap, a gabion mattress, or combination of such methods.

Screed A long section of metal or wood which is dragged across freshly placed concrete to both smooth the surface and consolidate the concrete.

Scuba A portable breathing device for free swimming divers; acronym for **s**elf-**c**ontained **u**nderwater **b**reathing **a**pparatus.

Scupper An opening in the floor portion of a bridge to provide means for rain or other water accumulated upon the roadway surface to drain through it into the space beneath the structure.

Seal A closure material. Typically used in reference to deck joints and made out of neoprene. Used in strip seal and compression seal assemblies.

Seat A base on which an object or member is placed.

Seat Angle A piece of angle attached upon the side of a member to provide support for a connecting member either temporarily during its erection or permanently; also known as a shelf angle.

Secondary Member a member that does not carry calculated live loads; bracing members

Section Used to denote a view cut perpendicular through an element.

Section Loss Loss of a member's cross sectional area usually by corrosion or decay.

Seepage The slow movement of water through a material.

Segmental Constructed of individual pieces or segments which are collectively joined to form the whole.

Segmental Arch A circular arch in which the intrados is less than a semi-circle.

Segmental Concrete Girder - A girder composed of individual concrete units, which are generally precast and post-tensioned to form one integrated unit.

Segmental Joint An expansion joint containing elastomeric rubber dams with reinforcement and a continuous gland.

Semi-Stub Abutment Cantilever abutment founded part way up the slope, intermediate in size between a shoulder abutment and a stub abutment.

Service Life The expected duration of satisfactory operation of a structure, component, or system under routine operating and maintenance conditions.

Service Load Design AASHTO designation for Working Stress Design.

Settlement The movement of foundations or footings due to deformations and/or changes in soil properties.

Shaft A long, cylindrical bar capable of rotating and transmitting torque.

Shaft Coupling Any of the several devices for joining the ends of two shafts.

Shakes Splits or checks in timber which usually cause a separation of the wood between the annular rings.

Shale A hard, clay-like formation having a closely laminated structure.

Shear To slide one part of a body upon an adjacent part. The stress set up in opposition to a shearing action.

Shear Connector Devices used in composite construction which extended from the top flange of a girder and are embedded in the concrete slab, allowing the slab and girder to act as a unit.

Shear Spiral A type of shear connector found in older structures which consists of a coil-like assembly welded to the top flange of a girder.

Shear Stress The shear force per unit of cross-sectional area; also referred to as diagonal tensile stress.

Shear Stud A common form of shear connector which is bolt-shaped and attached to the top flange of a girder with an automatic stud welding gun.

Sheave A wheel with a grooved face for carrying a rope or cable.

Sheeting Vertical planks which are driven into the ground to act as temporary retaining walls permitting excavation.

Sheet Pile Cofferdam A wall-like barrier composed of driven piling constructed to surround the area to be occupied by a structure and permit dewatering of the enclosure for excavation.

Sheet Piles Flattened Z-shape interlocking piles driven into the ground to keep earth or water out of an excavation or to protect an embankment.

Sheet Piling A general or collective term used to describe a number of sheet piles installed to form a crib, cofferdam, bulkhead, etc; also known as sheeting.

Shim A thin plate inserted between two elements to fix their relative position and to transmit bearing stress.

Shoe A pedestal-shaped member beneath the superstructure bearing that transmits and distributes loads to the substructure bearing area.

Shock Load Any sudden, high impact force imparted to superstructure or machine component.

Shop Drawing A drawing of a structure or machine showing all parts and dimensions so that the shop can actually build what is indicated on the drawing without other information.

Shore A strut or prop placed against or beneath a structure to restrain movement.

Shoulder The portion of the roadway contiguous with the traveled way used for accommodation of stopped vehicles.

Shoulder Abutment A cantilever abutment extending from the grade line of the road below that of the road overhead. Usually set just off the shoulder.

Shoulder Area See ROADWAY SHOULDER AREA.

Shrinkage The natural (i.e., not load related) change in volume of concrete. This change in volume is typically decreasing (shrinking) and caused by moisture loss when drying.

SI&A Structure Inventory and Appraisal Sheet, a graphic representation of the data elements collected for each bridge (qualifying structure) to comprise the National Bridge Inventory (NBI) database.

Side Slope The slope on the side on an embankment.

Sidewalk Bracket Frame attached to and projecting from the outside of a bridge to serve as a support for the sidewalk stringers, floor and railing or parapet.

Sidewalk The portion of the bridge floor area serving pedestrian traffic only.

Sight Distance Length of roadway ahead visible to the driver. The distance is determined as that which is required to allow a vehicle to safely stop prior to reaching a stationary object (stopping sight distance)

Sight Triangle A triangle formed at intersecting streets used to define a region which must be free from obstructions (e.g., vegetation, signs, buildings, etc.) in order to ensure the safe operation of vehicles.

Signing Traffic or construction signs and their related support structures located at or near a work zone.

Silica A dioxide of silicon (Si02). It occurs in nature as quartz.

Sill The lower horizontal member of a framed bent.

Simple Span The span of a bridge or element which begins at one support and ends at an adjacent support with no intermediate supports.

Silt Very finely divided siliceous or other hard rock material removed from its mother rock through erosive action rather than chemical decomposition.

SIP Stay-In-Place Forms.

Site The bridge and area surrounding the structure which either affects the bridge or is affected by the bridge.

Skew Angle The angle produced when the longitudinal members of a bridge are not perpendicular to the substructure; the skew angle is the acute angle between the alignment of the bridge and a line perpendicular to the centerline of the substructure units.

Skew Bridge A bridge in which the ends of the bridge are not square or perpendicular to the centerline of the bridge.

Skew Crossing Any crossing that is not perpendicular to the tracks.

Skewback The inclined support at each end of a segmental arch.

Skewback Bridge The member transmitting the thrust of an arch to the skewback course or cushion course of an abutment or piers; also known as skewback pedestal.

Skewed Bridge A structure supported on substructure units that are not perpendicular to the longitudinal centerline of the bridge.

Skin Friction The friction between the outer surface of a pile or caisson and the surrounding materials.

Slab A flat beam, usually of reinforced concrete, which supports load by flexure.

Slab Bridge A bridge having a superstructure composed of a reinforced concrete slab that is supported directly on the substructure.

Slag A nonmetallic product which shields the weld pool in electroslag welding.

Sliding Bearings Expansion bearings with a PTFE or polished metal surface that allow thermal translation of the supported member by sliding between the bearing surfaces.

Slip-Critical Connection - A bolted structural connection that relies on the tension in the bolts to create a friction force between the clamped components that will no slip.

Slip-form Forms which are moved along a cast-in-place concrete element during its construction. The form is moved as the section it leaves reaches sufficient strength.

Slope The inclination of a surface expressed as one unit of rise or fall for so many horizontal units.

Slope Protection A thin surfacing of stone, concrete or other material deposited upon a sloped surface to prevent its disintegration by rain, wind or other erosive action; also known as slope pavement.

Slope Wall A thin wall of concrete or of flat stones laid upon the face of a sloping bank of earth to protect it from the erosive action of water.

Slot Weld See PLUG WELD.

Slough An area of soft, muddy ground.

Slump A measurement used to define the workability of concrete. Wet concrete is placed in a standard cone shaped mold. The cone is then removed, causing the wet concrete to settle, or "slump". The vertical distance from the top of the cone to the top of the settled concrete is the slump. The smaller the slump, the stiffer the concrete mix.

Soffit The underside of a bridge deck. See also INTRADOS.

Soldier Beam A steel pile driven into the earth with its projecting butt end used as a cantilever beam.

Soldier Pile Wall A series of soldier beams supporting horizontal lagging to retain an excavated surface; commonly used in limited right-of-way applications.

Sole Plate A plate attached to the bottom flange of a beam that distributes the reaction of the bearing to the beam.

Sounding A method of checking for voids in a concrete or timber member by banging with a hammer on the element and listening for hollow spots. Also a method of determining the depth of water by using an echo-sounder or sounding line.

Soundings Measurements of the elevation of a stream bottom.

Spacer Timber See guard timber

Spall Circular or oval depression in concrete caused by a separation of a portion of the surface concrete, revealing a fracture parallel with or slightly inclined to the surface.

Span The distance between the supports of a beam; the distance between the faces of the substructure elements; the complete superstructure of a single span bridge or a corresponding integral unit of a multiple span structure; see CLEAR SPAN.

Spandrel The space bounded by the arch extrados and the horizontal member above it.

Spandrel Column A column constructed on the rib of an arch and serving as a support for the deck construction of an open spandrel arch; see OPEN SPANDREL ARCH.

Spandrel Fill The fill material placed within the spandrel space of a closed spandrel arch.

Spandrel Tie A wall or beam-like member connecting the spandrel walls of an arch and securing them against bulging and other deformation. In stone masonry arches the spandrel tie walls served to some extent as counterforts.

Spandrel Wall A wall built on the extrados of an arch filing the space below the deck; see TIE WALLS.

Specifications A detailed description of requirements, materials, dimensions, and other information required for construction which cannot be shown on the design drawings. Also known as specs.

Spider-rod Steel rod that extends from the center casting of a rim bearing swing span through each individual roller to hold a constant distance or diameter from the center. Also called radial rods.

Spillway A paved channel used to carry water from the top of a slope or through a dam to an adjacent outlet.

Splice A structural joint between members to extend their effective length.

Splice Plate A plate used in splicing or joining two parts of a member.

Spread Footing A footing which is wide and usually made of reinforced concrete; ideally suited for foundation material with moderate bearing capacity.

Springing Line The horizontal line along the face of an abutment or pier at which the intrados of an arch takes its beginning or origin.

Spur Dike A projecting jetty-like construction placed adjacent to an abutment to prevent stream scour and undermining of the abutment foundation and to reduce the accumulation of stream debris against the upstream side of the abutment.

Staged Construction Construction that occurs in phases, usually to permit the uninterrupted flow of traffic through a construction site.

Staging Inspection access equipment consisting of a flat platform supported by horizontal wire-rope cables; the stage is then slid along the cables to the desired position.

Stalactite A downward pointing formation, hanging from the underside of a concrete or masonry surface, shaped like an icicle.

Stalagmite An upward pointing formation, resulting from deposited minerals leaking from the concrete or masonry surface above.

Starling A cutwater; the projecting end of a bridge-pier, usually so shaped as to allow ice, drift, etc., to strike it without damage.

Stationing A system of measuring distance along a baseline.

Stay-In-Place Forms A corrugated metal sheet used to form uncured concrete, that will remain in place after the concrete has set; see FORMS.

Stay Plate A tie plate or diagonal brace to prevent movement.

Steel An alloy of iron, carbon, and various other elements and metals.

Stem The vertical wall portion of an abutment retaining wall, or solid pier; see BREASTWALL.

Stiffener A small member attached to another member to transfer stress and to prevent buckling.

Stiffening Girder A girder incorporated in a suspension bridge to distribute the traffic loads uniformly among the suspenders and reduce local deflections.

Stiffening Truss A truss incorporated in a suspension bridge to distribute the traffic loads uniformly among the suspenders and reduce local deflections.

Stirrup U-shaped bar providing a stirrup-like support for a member in timber and metal bridges. U-shaped bar placed in concrete construction to resist diagonal tension (shear) stresses.

Stone Masonry Construction comprised primarily of stone or rock. The stones may be mortared or dry laid.

Straight Abutment An abutment whose stem and wings are in the same plane or whose stem is included within a length of retaining wall.

Strain The change in length of a body produced by the application of external forces, measured in units of length. This is the proportional relation of the amount of change in length divided by the original length.

Strain-Hardening The increase in strain accompanied by a significant increase in stress that occurs beyond the yield point and after plastic yielding.

Strand A number of wires grouped together by twisting.

Strength Design AASHTO and ACI designation for Load Factor Design.

Strengthening A method employed to enhance the capacity of a structural member.

Stress The force acting across a unit area in a solid material.

Stress Concentration Those concentrations of stress caused by a sudden change of cross section in a member.

Stress Cycle The variation in stress at a point with the passage of live load; from initial dead load value to the maximum additional live load value and back.

Stress Riser A detail which causes stress concentration.

Stress Reversal Change of stress type from tension (+) to compression (-) or vice versa.

Stress Sheet A drawing showing all computed stresses resulting from the application of a system of loads together with the design composition of the individual members resulting from the application of assumed unit stresses for the material to be used in the structure.

Stringer A longitudinal beam supporting the bridge deck.

Stringer Bracing Diagonal bracing in the plane of the upper flanges of the stringers.

Strip Seal Joint A joint assembly typically consisting of a preformed neoprene seal which is fitted to dual steel rails anchored to the faces of the joint opening.

Structure Something, such as a bridge, that is built and designed to sustain a load.

Structural Analysis An engineering evaluation of a structure to determine the distribution of loads and the capacity of the members in a structural system.

Structural Capacity The allowable load that can be supported by a structure as determined by truck type, yield point of the steel and condition of the bridge, based on lowest member rating.

Structural Member An individual piece, like a beam or strut, which is an integral part of a structure.

Structural Redundancy - The ability of a structural system to distribute force using multiple load paths through more than two main members.

Structural Shapes The various types of rolled iron and steel having flat, round, angle channel, “I”, “H”, “Z” and other cross sectional shapes adapted to the construction of the metal members incorporated in structures.

Structural Stability The ability of a structure to maintain its normal configuration, not collapse or tip in any way, under existing and expected loads.

Structural Tee A "T"-shaped rolled member formed by cutting a wide flange longitudinally along its web.

Strut A piece or member acting to resist compressive stress.

Stub Abutment An abutment perched at the top of an embankment slope having a relatively small vertical height; typically supported on piles Stubs may also be founded on gravel fill, the embankment, or natural ground itself.

Sub-diagonal A secondary member connecting the mid-point of a main diagonal with an adjacent panel point.

Subbase A base course layer within a flexible pavement structure, placed between the base course and subgrade.

Sub-Panel A truss panel divided into two parts by an intermediate web member, generally by a subdiagonal or a hanger.

Substructure The abutments, piers, or other constructions built to support the span of a bridge superstructure.

Superelevation The difference in elevation between the inside and outside edges of a roadway in a horizontal curve; required to counteract the effects of centrifugal force.

Superimposed Dead Load - Dead load that is applied to a bridge after the concrete deck has partially cured; for example, the weight of parapets or railings placed after the concrete deck has achieved its initial set, usually 7 days after the pour.

Superstructure The entire portion of a bridge structure which primarily receives and supports traffic loads and in turn transfers these loads to the bridge substructure.

Surcharge A load, in addition to soil loads, acting on a retaining wall.

Surface The vertical alignment of a section of track relative to its original survey.

Surface Fatigue The failure of surface metal stressed repeatedly beyond the endurance limit of the metal.

Suspended Span A simple span supported from the free ends of cantilevers.

Suspender A wire cable, a metal rod or bar connecting to a catenary cable of a suspension bridge at one end and the bridge floor system at the other, thus transferring loads from the road to the main suspension members.

Suspension Bridge A bridge in which the floor system is supported by catenary cables which are supported upon towers and are anchored at their extreme ends.

Suspension Cable A catenary cable which is one of the main members upon which the floor system of a suspension bridge is supported.

Swale A shallow drainage channel used to carry runoff from the bridge and/or site. A swale can be made of earth, concrete, or other material.

Sway Anchorage A guy, stay cable or chain attached to the floor system of a suspension bridge and anchored upon an abutment or pier to increase the resistance of the suspension span to lateral movement; also known as sway cable.

Sway Bracing Diagonal bracing located at the top of a through truss, perpendicular to the truss itself and usually in a vertical plane, to resist horizontal forces.

Sway Frame A complete panel or frame of sway bracing.

Swing Bridge A bridge containing a movable span which rotates on a pivot pier to permit passage of marine traffic.

T-beam A reinforced concrete beam or a rolled structural section having a cross-section resembling the letter "T."

Tack Coat A thin layer of liquid bituminous material spayed on a new or existing bituminous surface prior to placing another layer.

Tack Weld A nonstructural weld used for temporary connections.

Tangent A straight line touching a curve at only one point. (may want to leave this out altogether) The straight part of a railroad track.

Tail Water Water ponded below the outlet of a waterway, thereby reducing the amount of flow through the waterway, see HEADWATER.

Temperature Steel Reinforcement in a concrete member to prevent cracks due to stresses caused by temperature changes.

Temporary Bridge A structure built for emergency or interim use to replace a previously existing bridge rendered unserviceable.

Tendon A prestressing cable, strand, or bar.

Tensile Force A force caused by pulling at the ends of a member; see TENSION.

Tensile Strength The maximum load at which a specimen breaks in tension.

Tension Type of stress involving an action which pulls apart tending to elongate or separate.

Termites Pale colored, soft bodied parasites that eat and digest wood.

Thermal Movement Elongation or contraction of a bridge structure due to a change in temperature.

Three-Hinged Arch An arch which is hinged at each support and at the crown.

Through Arch An arch bridge in which the arches extend above the roadway level.

Through Bridge A bridge where a significant portion of the structure is above track level.

Through Girder A type of structure where the support girders project above track level outside of the tracks.

Through Plate Girder Span - A through span fabricated from steel plates and angles riveted, bolted, or welded together where the sides of the girders come up above track level.

Through Truss A truss that projects above track level and is braced across the top.

Tie A member carrying tension.

Tied-Arch Bridge An arch with a tension member between the ends of the span. The tie relieves the foundation of thrust.

Tie Bolt A round bolt with a square shank and lip for hooking ties to the flange of stringers.

Tie Plate See STAY PLATE.

Tie Rod A rod-like member in a frame functioning to transmit tensile stress; also known as a tie bar.

Tie Spacer A timber or steel strap that is connected to both ends of open deck bridge ties in order to keep the ties evenly spaced. Also called a guard timber or spacer timber.

Tie Walls One of the walls built at intervals above the arch ring to tie together and reinforce the spandrel walls; wall designed to serve as a restraining member to prevent bulging and distortion of two other walls connected thereby; see DIAPHRAGM WALL.

Timber Wood suitable for building purposes.

Tip The bottom end of a pile.

Toe The front portion of a footing from the intersection of the front face of the abutment to the front edge of the footing. The line where the side slope of an embankment meets the existing ground. The free end of a cantilevered beam, such as on a bascule span.

Toe of Slope The location defined by the intersection of the embankment slope with the surface existing at a lower elevation; also known as the toe.

Toe Wall A relatively low retaining wall placed near the “toe-of-slope” location of an embankment to protect against erosion or to prevent the accumulation of stream debris; also known as a footwall or scour wall.

Ton A unit of weight equal to 2,000 pounds.

Top Chord The top longitudinal member of a truss.

Top Lateral Bracing Lateral bracing in the plane of the top truss chords or beam/girder flanges.

Topography A representation of the bridge site composed of both relief and planimetric information.

Torque The angular force causing rotation.

Torque Wrench A hand or power tool used to turn a nut on a bolt that can be adjusted to deliver a predetermined amount of torque.

Torsion Twisting perpendicular to the longitudinal axis of a member.

Torsional Rigidity The ability of a beam to resist torsion (i.e., twisting about the longitudinal axis).

Tower A vertical structure consisting of two or more bents of framework connected by bracing."

Tower Bracing Bracing attached to the posts of a tower.

Tower Post A member of a tower which carries load directly to the pedestal. A tower column.

Track Gage The distance between the balls of the rails. (See Gage) Also the tool or device for measuring or setting that distance.

Traction Bracing Bracing in the plane of the bottom laterals which transfers the thrust of a braking or accelerating train from the stringers to the trusses.

Traffic Control Modification of normal traffic patterns by signs, cones, flagmen, etc.

Transducer A device that converts one form of energy into another form, usually electrical into mechanical or the reverse.

Transflex Joint An expansion joint containing an elastomeric rubber dam with reinforcement.

Transverse Used to describe the axis of a bridge which lies perpendicular or radial to the longitudinal centerline of the structure.

Transverse Bracing The bracing assemblage engaging the columns of bents and towers in planes transverse to the bridge alignment that resists the transverse forces tending to produce lateral movement and deformation of the columns.

Transverse Beam Any beam of a bridge that passes from one truss or girder to an adjacent truss or girder.

Transverse Girder See CROSS GIRDER.

Travel Way The roadway.

Tread Plate The bearing surface over which a wheel or roller moves.

Tremie A pipe or funnel, used for placing concrete in water whose top and bottom are open, allowing for concrete to be poured into it.

Trestle A bridge structure composed of bents or towers and supporting stringers or girders, which may include a floor system.

Truss A framed or jointed structure designed to act as a beam while each of its members is primarily subjected to tension or compression stresses only.

Truss Bridge A bridge having trusses for a superstructure.

Trussed Beam A beam stiffened to reduce its deflection by a steel tie-rod which is held at a short distance from the beam by struts.

Truss Panel See PANEL.

Truss Pin A pin used at the panel point of a truss to connect the several intersecting members.

Tubular Sections Structural steel tubes, rectangular, square or circular; also known as hollow sections

.

Tubular Truss A truss whose chords and struts are composed of pipes or cylindrical tubes.

Tunnel An excavated passageway under the ground or the water.

Turnbuckle A long, cylindrical, internally threaded nut used to connect the elements of adjustable rod and bar members.

Turntable The framework under a swing span which transmits the load to the bearings. Also, a stand alone structure used to rotate rolling stock or to line it up with approach tracks located around the perimeter of the turntable pit.

Two-Hinged Arch A rigid frame which may be arch-shaped or rectangular but is hinged at both supports.

U-bolt A bar bent in the shape of the letter “U” and fitted with threads and nuts at its ends.

Ultimate Strength The highest stress which a material can withstand before breaking.

Ultimate Strength Design - Former ACI designation for Load Factor Design.

Ultrasonic Testing Nondestructive testing of a material’s integrity using sound waves.

Undercut A reduction in the thickness of the base metal adjacent to the weld toe or weld root left unfilled by weld metal.

Underdrain A drainage conduit, usually placed in backfill material and used to transport runoff away from substructure elements.

Underpass The lowermost feature of a grade separated crossing; see OVERPASS.

Underwater Inspection - Visually or tactually inspecting the exposed underwater components of a bridge, utilizing appropriate tools and methods. This includes but is not limited to abutments, piers, footings, piles, fender systems, and channel scour problems.

Uniform Load A constant load distributed along a member.

Unit Stress The stress per unit of surface or cross-sectional area.

Unsupported Length The length of a compression member between the nearest points of lateral restraint.

Uplift A negative reaction or a force tending to lift a beam, truss, pile, or any other bridge element upwards.

Upper Chord See TOP CHORD.

Vertical Clearance The minimum height between the lower roadway surface and a bridge overpass, or other structure, which crosses the roadway.

Vertical Curve A sag or crest in the profile of a roadway.

Vertical Lift Bridge A bridge in which the span moves up and down to provide clearance for navigation while remaining parallel to the roadway.

Viaduct An extended bridge of many spans, mainly over dry ground. Usually consists of alternate towers and open spaces or bays.

Vibration The act of vibrating concrete to compact it.

Vierendeel Truss A Pratt truss without diagonal members and with rigid joints between top and bottom chords and the verticals.

V-I-P Contractor Vendor-In-Place contractor used for paving or various other maintenance functions.

Voided Slab A precast concrete deck unit containing cylindrical voids to reduce dead load.

Void An empty or unfilled space.

Voussoir One of the truncated wedge shaped stones composing a ring course in a stone arch; also known as ring stone.

Voussoir Arch An arrangement of wedge shaped blocks set to form an arched bridge.

Wale Bracing inside a sheeted pit or a cofferdam which runs along the inside walls of the structure.

Warren Truss A triangular truss consisting of sloping members between the top and bottom chords and no verticals; members from the letter "W".

Washer A small metal ring used beneath the nut or the head of a bolt to distribute the pressure.

Water/Cement Ratio The weight of water divided by the weight of cement in concrete; ratio controls the strength of the concrete.

Water Line The intersection of the free surface of a body of water with any surface or object.

Waterproofing Membrane - A protective sheet placed between a wearing surface and concrete deck or between a bridge element and retained fill material to shield the concrete from water and corrosive chemicals which could cause deterioration.

Waterway The available width for the passage of water beneath a bridge.

Wearing Surface The topmost layer of material applied upon a roadway to receive the traffic loads and to resist its abrasive action; also known as a Wearing Course.

Weathering Steel Steel that provides a resistance to atmospheric corrosion; usually at least four times that of structural carbon steel.

Web The portion of a beam located between and connected to the flanges.

Web Crippling A localized yielding in the web of a steel member which occurs when high compressive stresses occur as a result of a concentrated load.

Web Member The intermediate members of a truss, not including the end posts, usually vertical or inclined.

Web Plate The plate forming the web element of a plate girder, built-up beam or column.

Web Stiffener A small member attached to a beam web to prevent buckling of the web.

Weephole A hole in a concrete retaining wall to provide drainage of the water in the retained soil. A piped hole in a concrete bridge deck to remove water trapped between the wearing surface and the waterproof membrane.

Weld A joint between pieces of metal at faces which have been made plastic by heat or pressure.

Weldability A property of electrode and parent metal combined, estimated by the ability to make good welds by as many processes as possible.

Welded Joint A joint in which the assembled elements and members are united through fusion of metal.

Welding The process of making a welded joint.

Weld Layer A single thickness of weld metal composed of beads (runs) laid in contact to form a pad weld or a portion of a weld made up of superimposed beads.

Weld Metal The fused filler metal which is added to the fused structure metal to produce a welded joint or a weld layer.

Weld Penetration The depth beneath the original surface, to which the structure metal has been fused in the making of a fusion weld.

Weld Sequence The order of succession required for making the welds of a built-up piece or the joints of a structure, to avoid producing residual stresses.

Weld Toe Particularly in a filet weld, the thin end of the taper furthest from the center of the weld cross-section.

Wheel Load The load carried by and transmitted to the supporting structure by one wheel of a traffic vehicle, a movable bridge, or other motive equipment or device; see AXLE LOAD.

Whipple Truss A double-intersecting through Pratt truss where the diagonals extend across two panels.

Wide Flange A rolled I-shaped member having flange plates of rectangular cross section, differentiated from an S-beam (American Standard) in that the flanges are not tapered.

Wind Bracing The bracing which functions to resist the stresses induced by wind forces.

Wind Loads A load on a structure and train due to the pressure of the wind.

Wind Lock A restraining device designed to resist lateral forces resulting from wind on the structure. Typically found on steel girder and truss bridges with large pin and hanger assemblies.

Wingwall The retaining wall extension of an abutment intended to restrain and hold in place the side slope material of an approach roadway embankment.

Wire A single, continuous length of metal drawn from a cold rod.

Wire Mesh Reinforcement - A mesh made of steel wires welded together at their intersections used to reinforce concrete.

Wire Rope A rope made of small strands of twisted wire often with a cotton or hemp center.

Working Stress The unit stress in a member under service or design load.

Worm A helix or helical gear on a shaft which meshes into the worm gear.

Wrought Iron Cast iron which has been mechanically worked to removed slag and undissolved carbon.

Yield Permanent deformation which a metal piece takes when it is stressed beyond the elastic limit.

Yield Point See YIELD STRESS.

Yield Stress The stress at which noticeable, suddenly increased deformation occurs under slowly increasing load.