Changes with this version. (2016/01/11)

Slides 188 to 203. Use "Retail Store" instead of "Big Box Store"

Slides 202 and 203. Added Source including URL of source document.

WoodWorks™
WOOD PRODUCTS COUNCIL

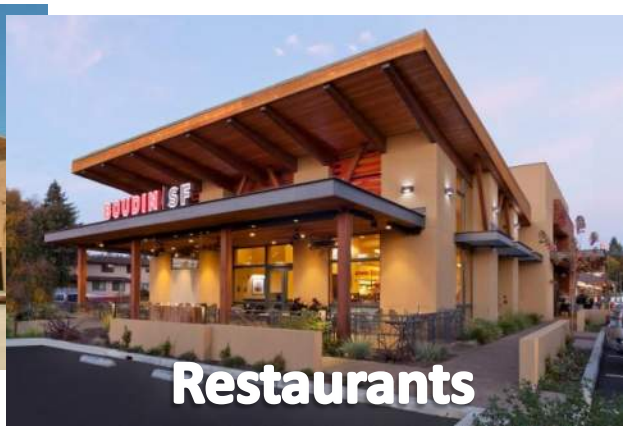
Opportunities for Wood Use in Low Rise Commercial Buildings

Outline

- Introduction
- Framing System Design and Details
  - Structural Design Compliance
  - Wall Framing
  - Wall Bracing
  - Roof Framing
- Non-Structural Requirements and Design
  - Allowable Heights and Areas
  - Multi-Tenant and Multi-Occupancy Buildings
  - Fire Resistance and Detailing
- Large Retail Project Case Study

Introduction

Low-Rise Wood Construction

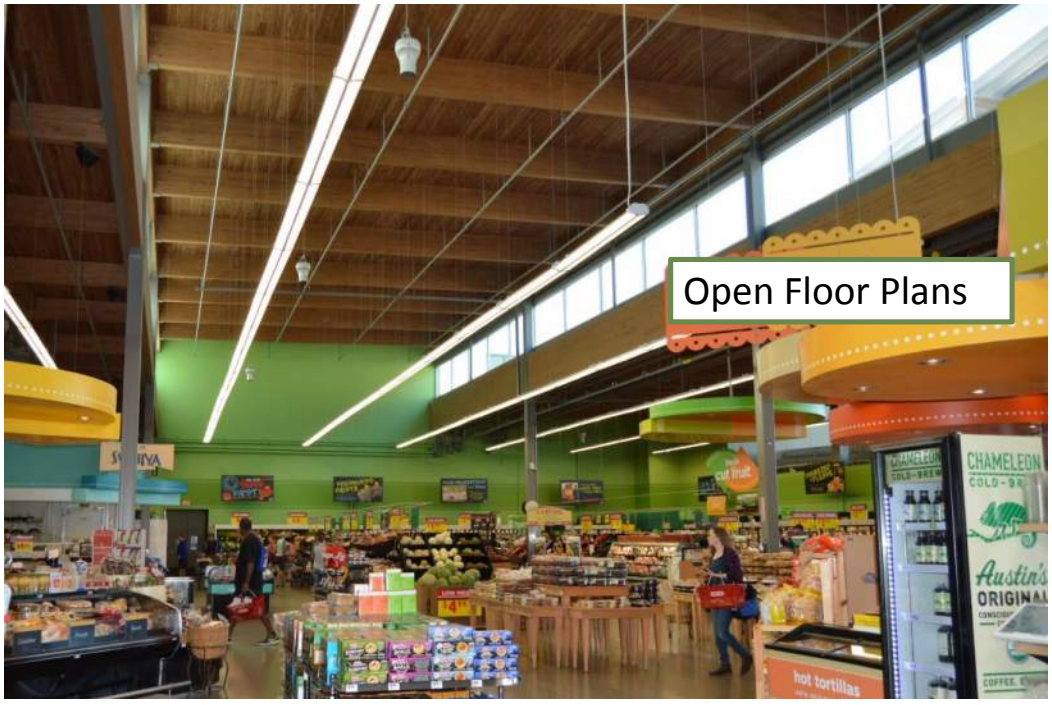


Storage Facilities
Offices
Medical Office Buildings
Schools

Wood Can Handle Common Features

Wood Can Handle Common Features

Wood Can Handle Common Features



IBC Occupancy Groups

Assembly : Groups A-1, A-2, A-3, A-4 and A-5.
Business: Group B.
Educational: Group E.
Factory and Industrial: Groups F-1 and F-2.
High Hazard: Groups H-1, H-2, H-3, H-4 and H-5.
Institutional: Groups I-1, I-2, I-3 and I-4.
Mercantile: Group M.
Residential: Groups R-1, R-2, R-3 and R-4.
Storage: Groups S-1 and S-2.
Utility and Miscellaneous: Group U.

IBC Occupancy Groups

Assembly : Groups A-2

- Nightclubs, Restaurants, Taverns and bars

Business: Group B

- Banks, barber and beauty shops, dry cleaning and laundries, professional services, etc.

Mercantile: Group M

- Department stores
- Drug stores
- Markets
- Motor fuel-dispensing facilities
- Retail or wholesale stores
- Sales rooms

ICC Building Valuation Data

	Construction Type								
Occupancy Group	IA	IB	IIA	IIB	IIIA	IIIB	IV	VA	VB
A-2 Assembly	177	172	166	160	150	147	155	136	132
B Business	182	176	170	162	148	142	155	129	124
M Mercantile	132	128	122	116	106	103	111	92	88

Published $ / Square Foot of Building Area

Structural Wood Framing Allowed

Source August 2015, ICC Published National Building Valuation Data
http://www.iccsafe.org/codes-tech-support/codes/code-development-process/building-valuation-data/

ICC Building Valuation Data

	Construction Type		
Occupancy Group	IIA	IIIA	**Diff**
A-2 Assembly	166	150	$16/sf
B Business	170	148	$22/sf
M Mercantile	122	106	$16/sf

Type IIA and IIIA construction have very similar allowable heights and areas

Is this enough to matter to you or your clients?

Source August 2015, ICC Published National Building Valuation Data

ICC Building Valuation Data

	Construction Type		
Occupancy Group	IIB	VA	**Diff**
A-2 Assembly	160	136	$24/sf
B Business	162	129	$33/sf
M Mercantile	116	92	$24/sf

Type IIB and VA construction have very similar allowable heights and areas.

An even larger difference than IIA and IIIA

Source August 2015, ICC Published National Building Valuation Data

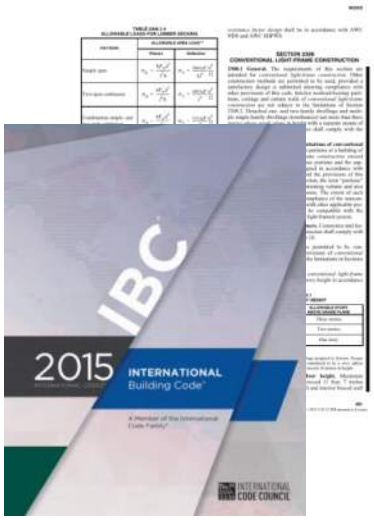
Framing Systems Design and Details

Paths to Structural Compliance

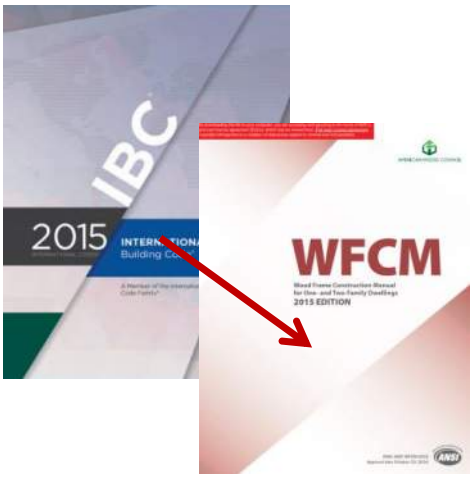
- IBC Chapter 16 as starting point for most structural requirements
- IBC Chapter 23 for wood specific requirements and paths to compliance
- ASCE 7 Minimum Design Loads for Buildings and Other Structures referenced from IBC Chapter 16 for Wind and Earthquake Loading

	Path to Compliance	Reference	Approach
1	Convention Construction	**In** IBC 2308	Prescriptive
2	AWC Wood Frame Construction Manual	IBC 2309	Prescriptive or Engineered
3	AWC National Design Specification for Wood Construction (NDS) AWC Special Design Provisions for Wind and Seismic (SPDWS)	IBC 2305 IBC 2306 (ASD) IBC 2307 (LRFD)	Engineered

Prescriptive Methods



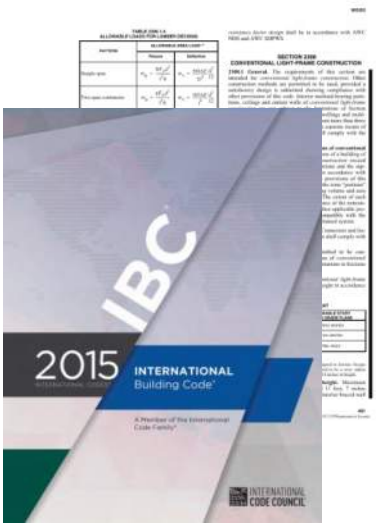
IBC Conventional Construction



AWC Wood Frame Construction Manual

Both Limited to 40 psf Live loads.
Possibly useful for 1 story Commercial Buildings

Conventional Construction in IBC 2308



IBC Conventional Construction Scope of Application

- Max stud height:
  - **10’ load bearing**
  - 20’ non-load bearing
- Max Roof Dead Load 15 psf
- Max Live Load **40 psf**
- Max Ground Snow Load 50 psf
- Max Ultimate Wind Speed 130mph
- Max roof span 40 ft

Prescriptive Design

- Similar to IRC provisions for conventional construction
- When in scope, many details defined in the code.
- Span Tables for headers, beams, joists and rafters
- Braced Wall Panels not Engineered Shear Walls

Can be useful for 1 story Commercial Buildings

AWC Wood Frame Construction Manual

AWC WFCM Scope of Application:

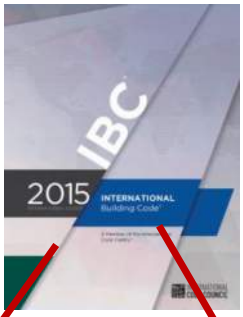
- Risk Category I or II Buildings (See IBC Table 1604.5)
- Max stud height
  - **10’ load bearing**
  - 20’ non-load bearing
- Max Roof and Ceiling Dead Load 25 psf
- Max Live Load **40 psf**
- Max Ground Snow Load 70 psf
- Max Ultimate Wind Speed 195 mph
- Max Roof Span
  - Rafter Span 26 ft
  - Truss Span 60 ft

AWC WFCM Includes:

- Engineered And Prescriptive Design Sections
- Useful tables such as allowable wall stud spans including deflection criteria (***quick tall-wall checks***)

Can be useful for 1 story Commercial Buildings.
Broader scope than IBC 2308

Engineered Design via AWC NDS and SDPWS



IBC 2015

AWC NDS 2015 for Wood Members and Connections

AWC SDPWS 2015 for Wood Shear Walls and Diaphragms

General Engineered Approach: Not limited in scope as Conventional Construction and WFCM

Wall Framing

Wall Framing Options

Solid Sawn Lumber Sizes
- 2x4 to 2x14
- 4x, 6x and greater thickness available

Different Species Groups Available
- "Southern Pine" is not a single species but a group of related species which are graded together
- Other common species groups include: Doug-Fir Larch, Hem-Fir, Spruce-Pine-Fir

Different Grades
- Visually Graded: #1, #2, etc
  - Most Common
- Machine Graded:
  - Machine Stress Rated (MSR)
  - Mechanical Evaluated Lumber (MEL)

Automatic Lumber Tester
Photo: Metriguard

Wall Framing Options

Finger-Jointed Dimensional Lumber:

- Structural end-gluing of shorter members
- Technically called “End-Jointed”
- Can be used interchangeably with solid sawn lumber of same species and grade, where approved. See IBC 2303.1.1
- Look for grading and grade stamp by

Variations of Finger Jointed Lumber

- **HRA** (Heat Resistant Adhesive)
  - Only use HRA FJ Lumber in fire rated assemblies
- **Non-HRA** (or no HRA in stamp)
- **Vertical Use Only** or **Stud Use Only**
  - Bending or tension stresses only from short term loading

Wall Framing Options

Solid Sawn Lumber

- 2x4 to 2x14
- Visually Graded: #2, #1, etc.
- Machine Stress Rated (MSR)
- Mechanical Evaluated Lumber (MEL)

Finger-Jointed Dimensional Lumber

- Vertical Stud Use Only
- Structural Finger Joint
- HRA or Non- HRA (Heat Resistant Adhesive)

Wall Framing Options

Engineered Lumber Products

- Laminated Strand Lumber (LSL)
- Laminated Veneer Lumber (LVL)
- Parallel Strand Lumber (PSL)
- Glue Laminated Lumber (Glulam)

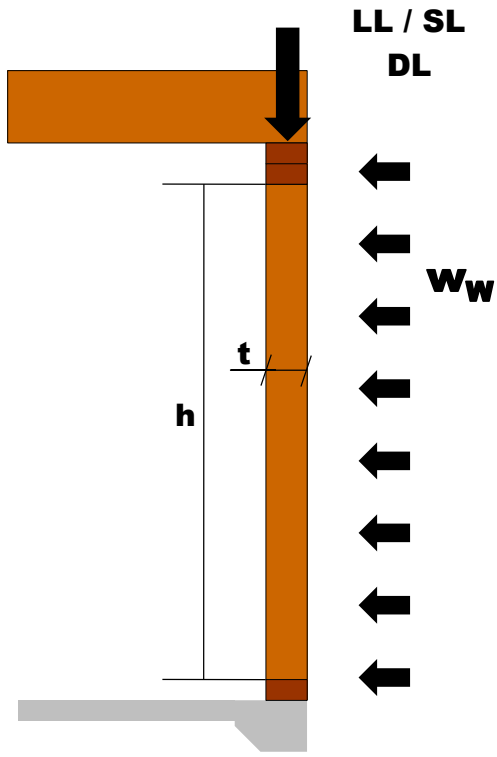
Tall Walls in Low Rise

Parameters for Engineered Stud Design

Structure Parameters
- Design height - **h**
- Stud spacing
- Wall thickness - **t**

Loading Parameters
- Dead Load - **DL**
- Live and Snow Load – **LL/SL**
- Wind Loads (C&C and MWFRS) – $\mathbf{w_w}$
- Any Eccentricity

Deflection Criteria based on Finishes



Exterior Wall Design Checks for Studs

- Strength Check 1:
  Gravity + Main Lateral Force Loads
- Strength Check 2:
  Full Components and Cladding Wind Loads
- Deflection Check:
  Reduced Components and Cladding Wind Loads

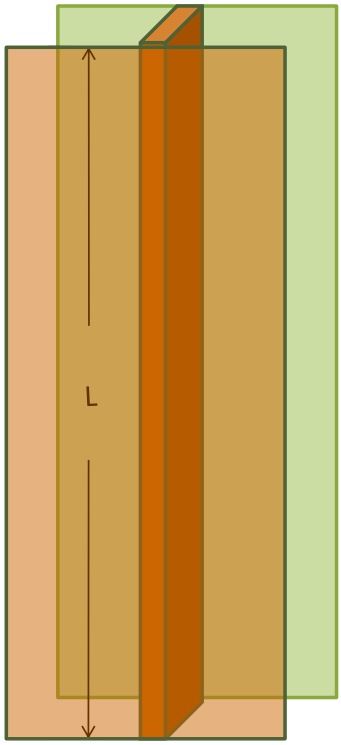
Strength Check 1 for Stud Design

Strength Check as a Vertical Load Supporting element:

- Apply Vertical Dead, Live, Roof and/or Snow Loads
- Apply out-of-plane lateral loads
  - MWFRS wind loads (ASCE 7-10 Chapter 27 or 28)
  - Seismic wall forces (ASCE 7-10 12.11.1)
- Apply vertical MWFRS wind or Seismic force (if any)
  - For example for a hold-down post.
- Combined Bending & Axial Load Check per AWC NDS
- Use standard load combinations
  - IBC Section 1605 or
  - ASCE 7 Chapter 2

Design Tip: Bottom plate crushing may govern over Stud and Post Capacities

Wall Sheathing Provides Weak Axis Bracing



NDS Commentary:
"Experience has shown that any code allowed thickness of gypsum board, hardwood plywood, or other interior finish adequately fastened directly to studs will provide adequate lateral support of the stud across its thickness irrespective of the type or thickness of exterior sheathing and/or finish used."

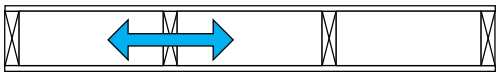
Design Considerations

Slenderness Limits (NDS 2015 3.7.1.4)

Max Effective Unbraced Length = 50d, d = depth in inches

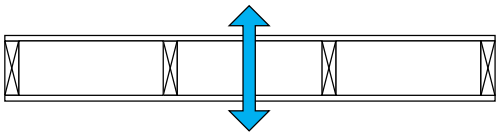
Max of 75d during construction

1½" depth
6'-3" max unbraced length.
9'-4" during construction.



Stud or column can be braced against buckling in this direction by sheathing.

3½" (2x4) Max Height: 14'-7"
5½" (2x6) Max Height: 22'-11"
7¼" (2x8) Max Height: 30'-2"



Stud or column is **not** braced against buckling in this direction by sheathing.

Intermediate Wall Stud Blocking

Strength Checks on Stud Design 2

Strength Check for Components & Cladding Winds

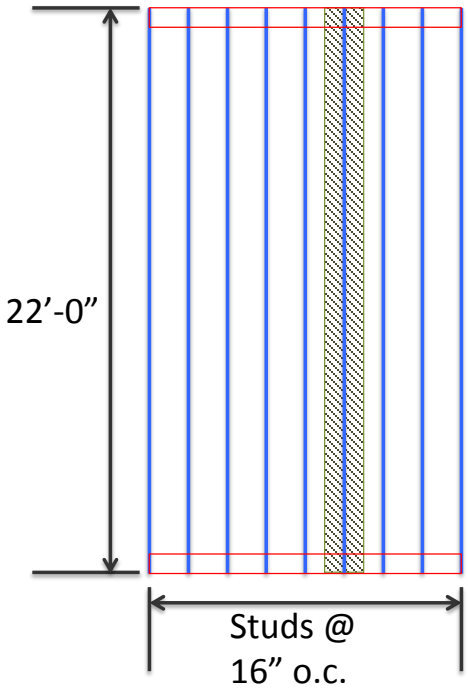
- No axial loading
- **C&C transverse Wind loads only**
- Check stud for bending and shear

Design Tip: Be aware of ASCE 7 Definition of Effective Wind Area to decrease the required C&C wind load

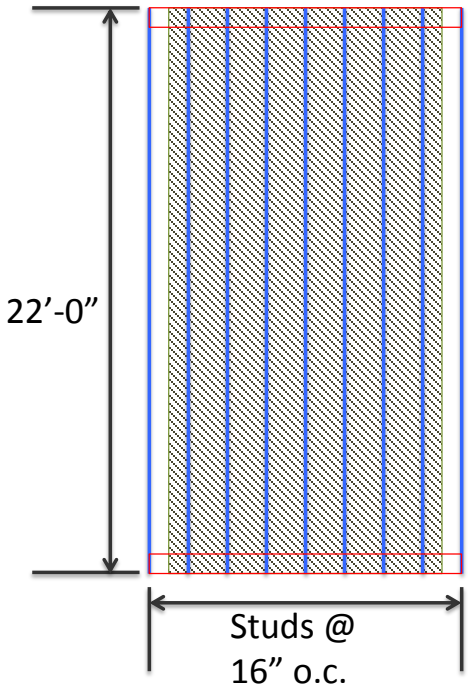
EFFECTIVE WIND AREA, *A*: The area used to determine (GC_p). For component and cladding elements, the effective wind area in Figs. 30.4-1 through 30.4-7, 30.5-1, 30.6-1, and 30.8-1 through 30.8-3 is the span length multiplied by an effective width that need not be less than one-third the span length. For cladding fasteners, the effective wind area shall not be greater than the area that is tributary to an individual fastener.

Effective Wind Area Example

Tributary Area = (22)(1.33) = 29 ft^2



Effective Wind Area = $22^2/3$ = 161 ft^2



Strength Checks on Stud Design 2

Strength Check for Components & Cladding Winds

- No axial loading
- C&C transverse Wind loads only
- **Check stud bending** and shear.

Design Tip: For bending stress check, be aware of Repetitive Use factor C_r of NDS or Wall Stud Repetitive Member Factor of SDPWS 3.1.1

Table 3.1.1.1 Wall Stud Repetitive Member Factors

Stud Size	System Factor
2x4	1.50
2x6	1.35
2x8	1.25
2x10	1.20
2x12	1.15

Strength Checks on Stud Design 2

Strength Check for Components & Cladding Winds

- No axial loading
- C&C transverse Wind loads only
- **Check stud bending** and shear.

Design Tip: Is using ASD for design, don't forget to take the allowed reduction in the wind load for the ASD load combinations for ASCE 7-10 Ultimate Wind Speed Loads

$$D + H + F + (0.6W \text{ or } 0.7E) \qquad \textbf{(Equation 16-12)}$$

Deflection Checks on Stud Design

Deflection Check for Components and Cladding Winds

- No Axial Loading
- C&C transverse Wind load only.
- Check out-of-plane deflection to IBC Table 1604.3 or other more stringent requirements.

Note: This check often governs tall walls

Design Tip: ASCE 7 Definition of Effective Wind Area to decrease the required C&C wind load applies here.

Deflection Checks on Stud Design

Deflection Check for Components and Cladding Winds

- No Axial Loading
- C&C transverse Wind load only.
- Check out-of-plane deflection to IBC Table 1604.3 or other more stringent requirements.

Design Tip: Read all the footnotes!

Multiply calculated C&C Wind Loads by
0.42 when using V_{ULT} (ASCE 7-10) OR
0.70 when using V_{ASD} (ASCE 7-05 and earlier)

Deflection Checks on Stud Design

Deflection Check for Components and Cladding Winds

- No Axial Loading
- C&C transverse Wind load only.
- Check out-of-plane deflection to IBC Table 1604.3 or other more stringent requirements.

Design Tip: Change in IBC 2012 created new L/360 limit for Stucco and Plaster (L/360 limit has been in IRC longer)

TABLE 1604.3
DEFLECTION LIMITS[a, b, c, h, i]

CONSTRUCTION	*L*	*S* or *W*[f]
Exterior walls:		
With plaster or stucco finishes	—	*l*/360
With other brittle finishes	—	*l*/240
With flexible finishes	—	*l*/120

Deflection Checks on Stud Design

Deflection Check for Components and Cladding Winds

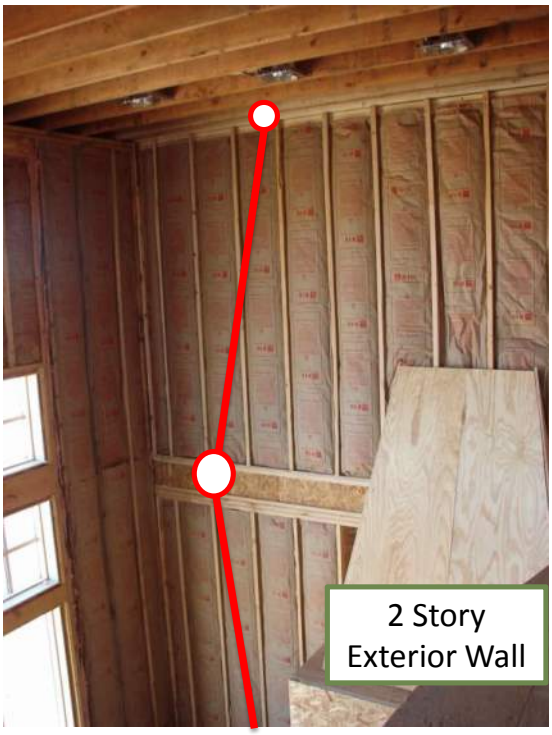
- No Axial Loading
- C&C transverse Wind load only.
- Check out-of-plane deflection to IBC Table 1604.3 or other more stringent requirements.

Design Tip: Change in SDPWS 2015 referenced from IBC 2015 allows application of Wall Stud Repetitive Factor to Stud STIFFNESS. See SDPWS 3.1.1

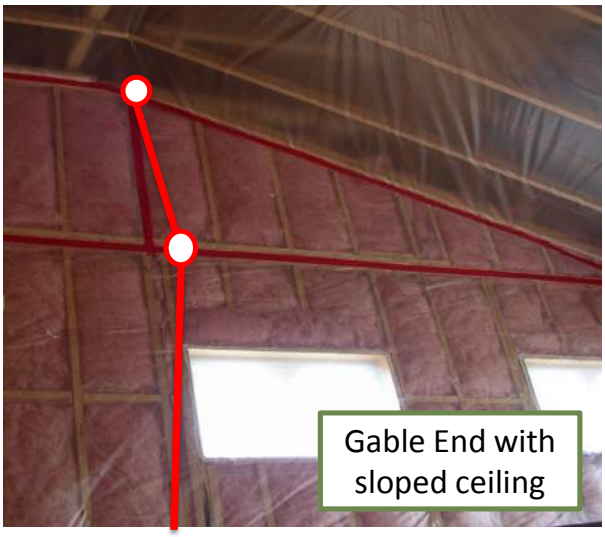
Table 3.1.1.1 Wall Stud Repetitive Member Factors

Stud Size	System Factor
2x4	1.50
2x6	1.35
2x8	1.25
2x10	1.20
2x12	1.15

Can this Exterior Wall Pass Deflection Check?



"Hinge Point" creates a structural weakness in the wall



Can this Exterior Wall Pass Deflection Check?

Solution = Continuous Studs

AWC WFCM Prescriptive Stud Tables

Table 3.20A2 Maximum Exterior Loadbearing[1] and Non-Loadbearing Stud Lengths for Common Lumber Species Resisting Interior Zone Wind Loads - Stud Deflection Limit = H/240

Exposure B H/240

(Fully Sheathed with a Minimum Sheathing Material)[a]

700-yr. Wind Speed 3-second gust (mph)			110			115			120			130			140		
Stud Spacing (in.)	Species	Grade	2x4	2x6	2x8	2x4	2x6	2x8	2x4	2x6	2x8	2x4	2x6	2x8	2x4	2x6	2x8
			Maximum Allowable Stud Length (ft-in.)[3]														
16	DFL	SS	12 - 3	19 - 8	20-0†	11 - 11	19 - 1	20-0†	11 - 6	18 - 6	20-0†	10 - 11	17 - 6	20-0†	10 - 4	16 - 8	20-0†
	DFL	No.1	11 - 10	18 - 11	20-0†	11 - 5	18 - 4	20-0†	11 - 1	17 - 10	20-0†	10 - 6	16 - 10	20-0†	10 - 0	16 - 0	20-0†
	DFL	No.2	11 - 7	18 - 6	20-0†	11 - 2	18 - 0	20-0†	10 - 10	17 - 5	20-0†	10 - 3	16 - 6	20-0†	9 -		
	DFL	No.3/Stud	11 - 0	17 - 8	20-0†	10 - 8	17 - 2	20-0†	10 - 4	16 - 8	20-0†	9 - 10	15 - 9	20-0†	9 -		
	DFL	Standard	11 - 0	-	-	10 - 6	-	-	10 - 0	-	-	9 - 3	-	-	8 -		
	HF	SS	11 - 7	18 - 6	20-0†	11 - 2	18 - 0	20-0†	10 - 10	17 - 5	20-0†	10 - 3	16 - 6	20-0†	9 -		
	HF	No.1	11 - 3	18 - 2	20-0†	10 - 11	17 - 7	20-0†	10 - 8	17 - 1	20-0†	10 - 1	16 - 2	20-0†	9 -		
	HF	No.2	10 - 9	17 - 3	20-0†	10 - 5	16 - 9	20-0†	10 - 1	16 - 3	20-0†	9 - 7	15 - 4	20-0†	9 -		
	HF	No.3/Stud	10 - 5	16 - 9	20-0†	10 - 2	16 - 3	20-0†	9 - 10	15 - 9	20-0†	9 - 4	14 - 11	19 - 11	8 -		
	HF	Standard	10 - 5	-	-	10 - 2	-	-	9 - 10	-	-	9 - 0	-	-	8 -		
	SP	SS	12 - 0	19 - 4	20-0†	11 - 8	18 - 9	20-0†	11 - 4	18 - 2	20-0†	10 - 9	17 - 2	20-0†	10 -		
	SP	No.1	11 - 7	18 - 6	20-0†	11 - 2	18 - 0	20-0†	10 - 10	17 - 5	20-0†	10 - 3	16 - 6	20-0†	9 -		
	SP	No.2	11 - 0	17 - 8	20-0†	10 - 8	17 - 2	20-0†	10 - 4	16 - 8	20-0†	9 - 10	15 - 9	20-0†	9 -		
	SP	No.3	10 - 9	17 - 3	20-0†	10 - 5	16 - 9	20-0†	10 - 1	16 - 3	20-0†	9 - 7	15 - 0	19 - 2	9 -		
	SP	Stud	10 - 9	17 - 3	20-0†	10 - 5	16 - 9	20-0†	10 - 1	16 - 3	20-0†	9 - 7	15 - 0	19 - 2	9 -		
	SP	Standard	9 - 11	-	-	9 - 6	-	-	9 - 1	-	-	8 - 4	-	-	-		
	SPF	SS	11 - 3	18 - 2	20-0†	10 - 11	17 - 7	20-0†	10 - 8	17 - 1	20-0†	10 - 1	16 - 2	20-0†	9 -		
	SPF	No.1	11 - 0	17 - 8	20-0†	10 - 8	17 - 2	20-0†	10 - 4	16 - 8	20-0†	9 - 10	15 - 9	20-0†	9 -		
	SPF	No.2	11 - 0	17 - 8	20-0†	10 - 8	17 - 2	20-0†	10 - 4	16 - 8	20-0†	9 - 10	15 - 9	20-0†	9 -		
	SPF	No.3/Stud	10 - 5	16 - 9	20-0†	10 - 2	16 - 3	20-0†	9 - 10	15 - 9	20-0†	9 - 4	14 - 11	19 - 11	8 -		
	SPF	Standard	10 - 5	-	-	10 - 2	-	-	9 - 10	-	-	9 - 0	-	-	8 -		

If building within scope of AWC WFCM, it contains useful wall height tables

Tall Walls in Office

- 2 story, 12k sf office bldg
- Atlanta, GA
- ~20ft tall 2x6 SYP #2 at high entry

Tall Walls in Restaurant

- Emeryville, CA
- 24'+ tall
- 2x8 Doug Fir

Tall Walls in Retail

Large Diamond Retailer
Murfreesboro, TN
22’ tall 2x8 Pre-Fabricated

Example Projects

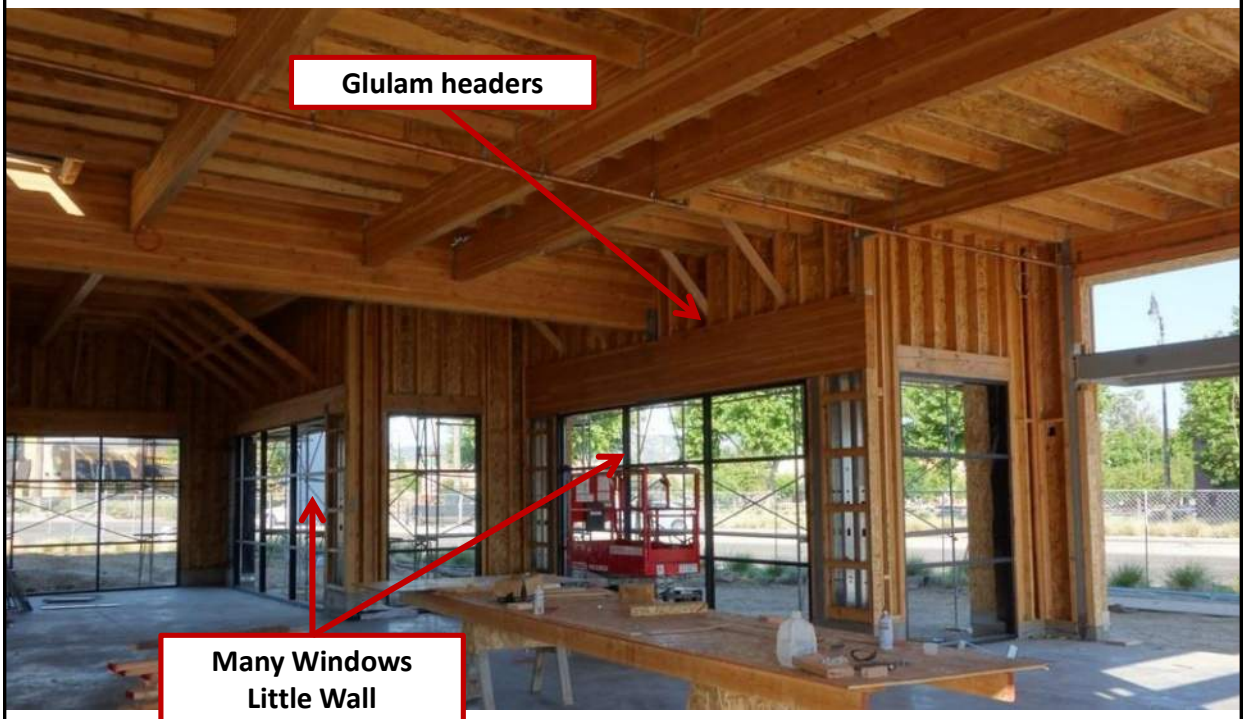
Small Retail Building – Northern CA

Small Retail Building – Northern CA

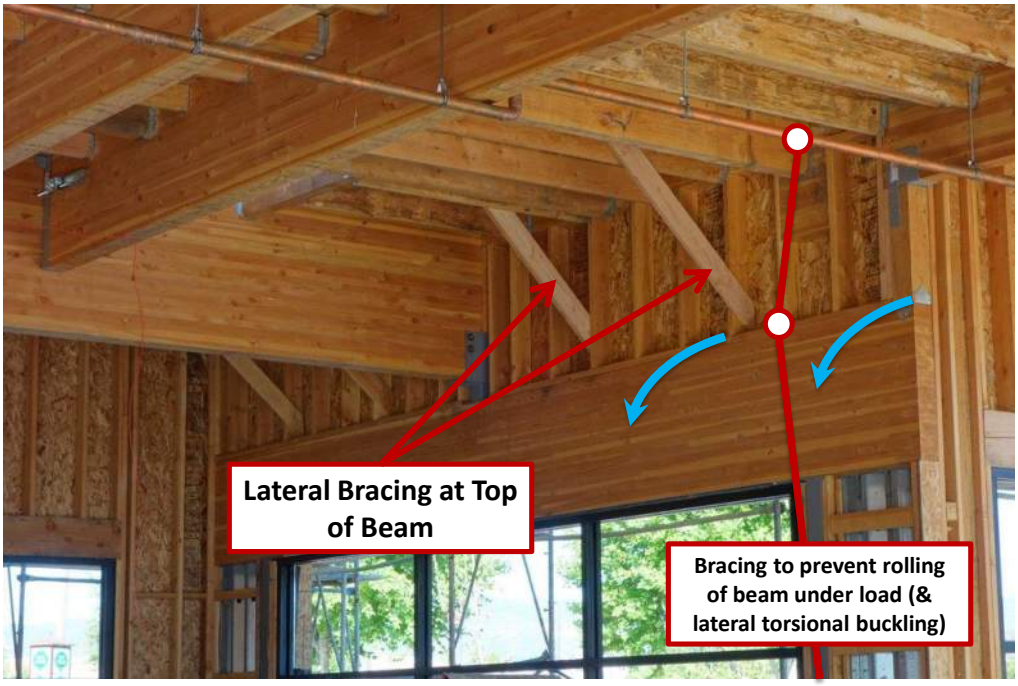
- Flat Roof with
  - WSP Sheathing
  - 2x Sub-Purlins
  - Glulam Pulins
  - Glulam Beams

- 20 ft 2x6 DF walls
  - Interior
  - Exterior

Small Retail Building – Northern CA



Small Retail Building – Northern CA



Small Retail Building – Northern CA

Retail Building – Berlin Vermont

Retail Building

- Berlin, VT
- 4,500 sf

Retail Building – Berlin Vermont

Roof Construction:

- Metal Plate Connected Monoslope Wood Roof Trusses
- 6’ Deep at Front, 4.5’ at Back, 50’ Span, 24” o.c.
- Wood Structural Panels
- 2x6 @ 16” o.c. Bearing Walls & Shear Walls– 13’ Tall
- Structural Steel Open Front Frame

Retail Building – Berlin Vermont

Retail Building – Berlin Vermont

Retail Building – Berlin Vermont

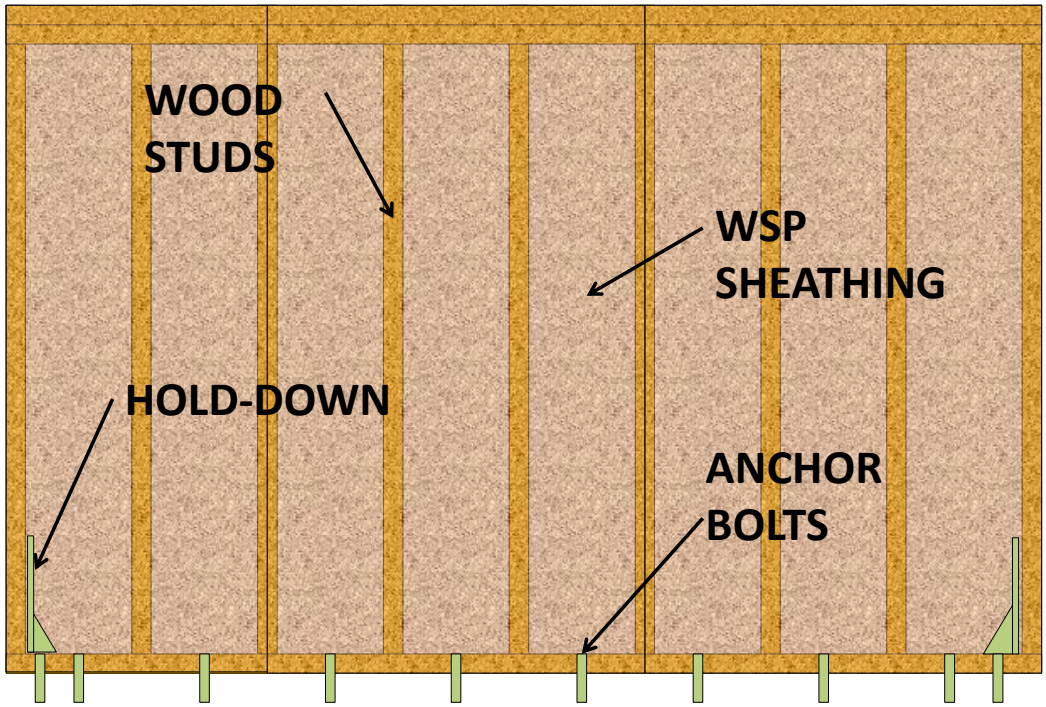
Front Canopy and Façade

Retail Building – Berlin Vermont

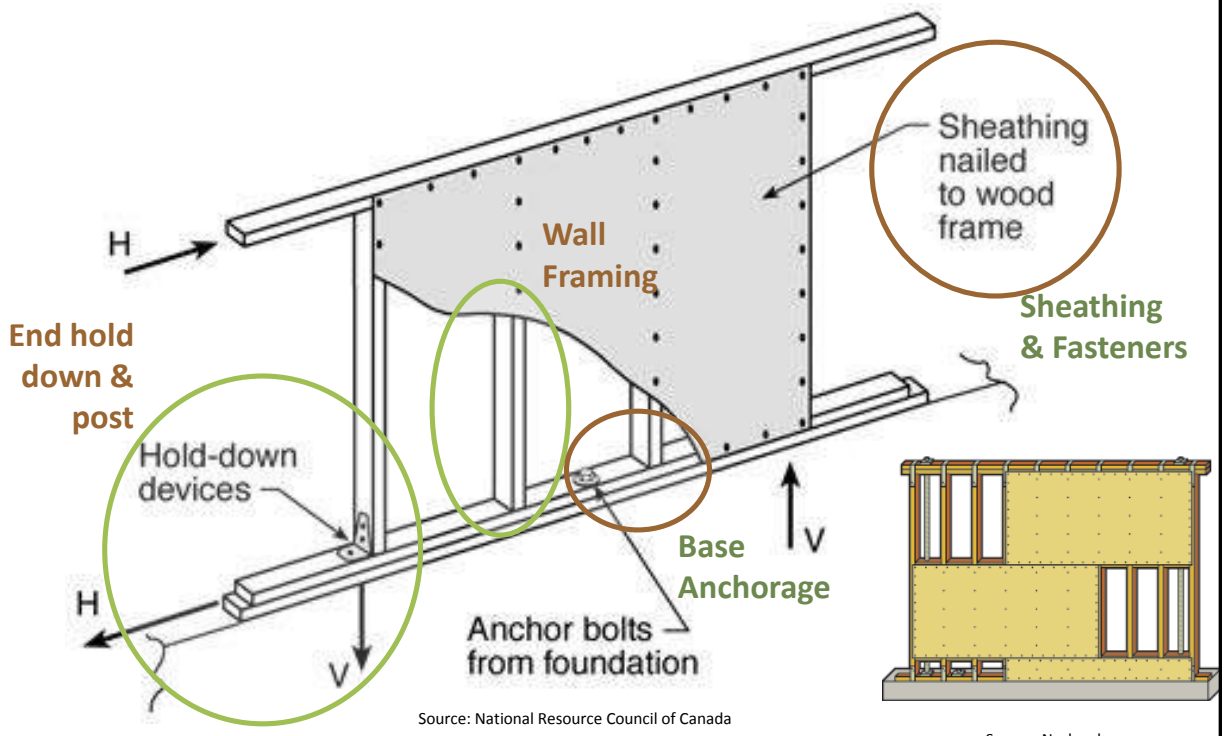
Retail Building – Berlin Vermont

Wall Bracing – Shear Walls

Anatomy of Wood Sheathed Shearwalls



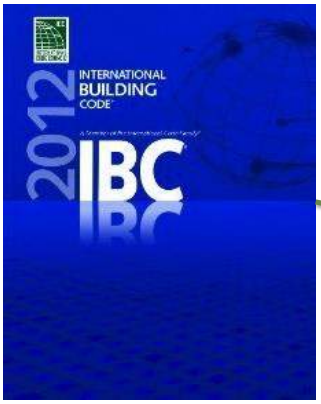
WSP Shear Wall Components



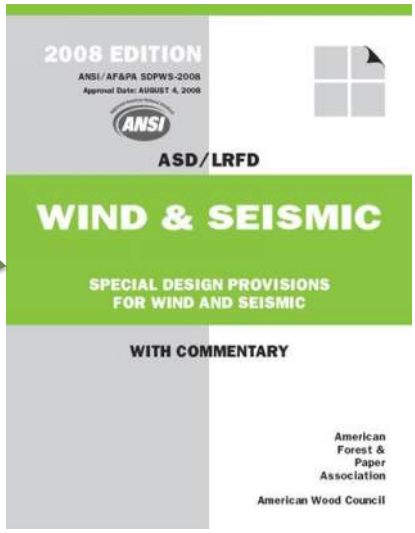
Source: National Resource Council of Canada

Source: Norbord

Lateral Load Capacity

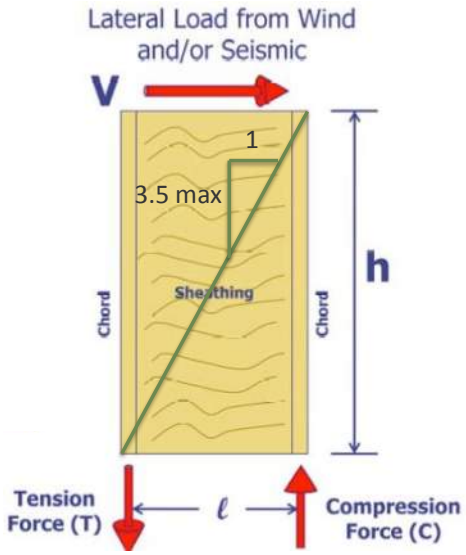


Tip: Nailed Wood Shear Wall Allowable Capacities in IBC 2009 and earlier versions. Not in IBC 2012 or 2015. Nominal capacity in SDPWS



AWC SDPWS
Provides details and capacities of these types of nailed wood shear walls

Shear Wall Requirements in AWC SDPWS



Wood Education Institute

Table 4.3.4 Maximum Shear Wall Aspect Ratios

Shear Wall Sheathing Type	Maximum h/b, Ratio
Wood structural panels, unblocked	2:1
Wood structural panels, blocked	3.5:1[1]
Particleboard, blocked	2:1
Diagonal sheathing, conventional	2:1
Gypsum wallboard	2:1[2]
Portland cement plaster	2:1[2]
Structural Fiberboard	3.5:1[3]

3:5:1 max aspect ratio for blocked Wood Structural Panel Shear Wall. Reduction in Capacity when greater than 2:1

Shear Wall Requirements in AWC SDPWS

- Capacities in SDPWS are **Nominal** values. Not ASD

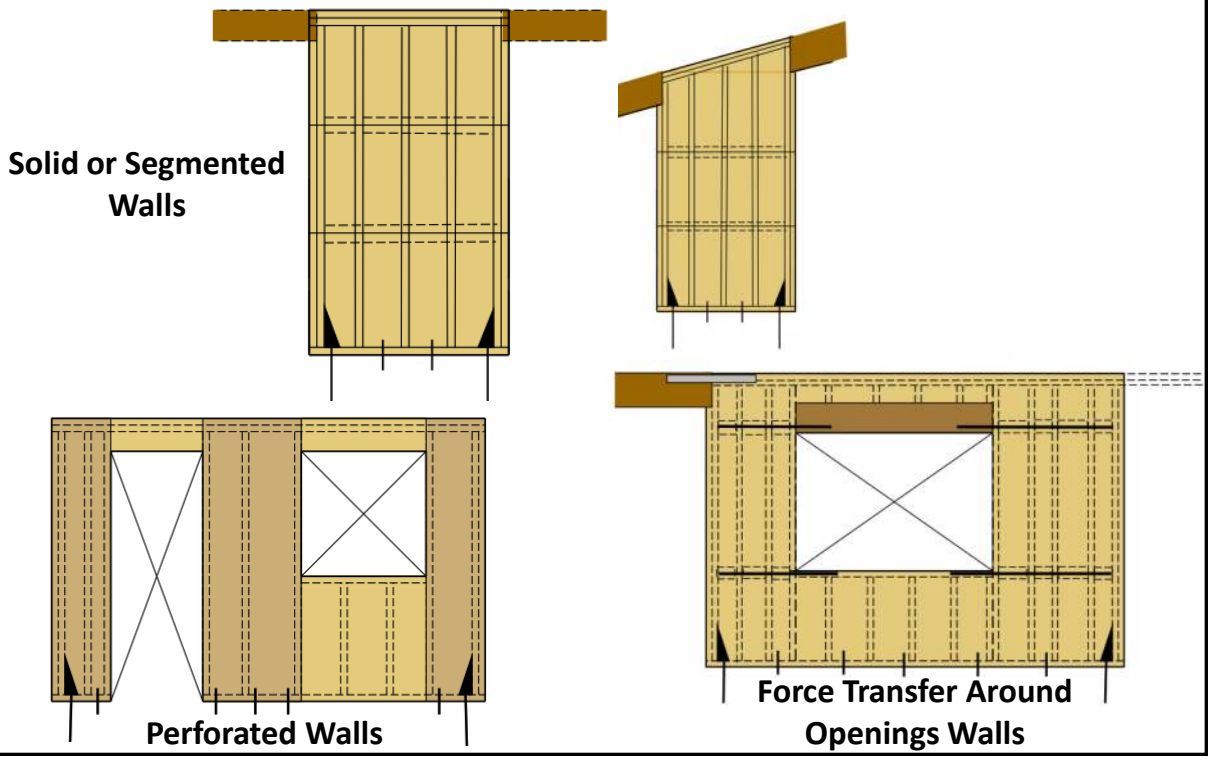
Divide Nominal Values by 2.0 for ASD Capacity
Multiply Nominal Values by 0.8 for LRFD Capacity

Table 4.3A Nominal Unit Shear Capacities for Wood-Frame Shear Walls[1,3,6,7]

Wood-based Panels[4]

Sheathing Material	Minimum Nominal Panel Thickness (in.)	Minimum Fastener Penetration in Framing Member or Blocking (in.)	Fastener Type & Size	A SEISMIC										B WIND			
				Panel Edge Fastener Spacing (in.)										Panel Edge Fastener Spacing (in.)			
				6			4			3			2				
				v_s (plf)	G_a (kips/in.)		v_s (plf)	G_a (kips/in.)		v_s (plf)	G_a (kips/in.)		v_s (plf)	G_a (kips/in.)		6 v_w (plf)	4 v_w (plf)	3 v_w (plf)	2 v_w (plf)
			Nail (common or galvanized box)		OSB	PLY		OSB	PLY		OSB	PLY		OSB	PLY				
Wood Structural Panels - Structural I[4,5]	5/16	1-1/4	6d	400	13	10	600	18	13	780	23	16	1020	35	22	560	840	1090	1430
	3/8[2]	1-3/8	8d	460	19	14	720	24	17	920	30	20	1220	43	24	645	1010	1290	1710
	7/16[2]			510	16	13	790	21	16	1010	27	19	1340	40	24	715	1105	1415	1875
	15/32			560	14	11	860	18	14	1100	24	17	1460	37	23	785	1205	1540	2045
	15/32	1-1/2	10d	680	22	16	1020	29	20	1330	36	22	1740	51	28	950	1430	1860	2435
Wood Structural Panels – Sheathing[4,5]	5/16	1-1/4	6d	360	13	9.5	540	18	12	700	24	14	900	37	18	505	755	980	1260
	3/8			400	11	8.5	600	15	11	780	20	13	1020	32	17	560	840	1090	1430
	3/8[2]	1-3/8	8d	440	17	12	640	25	15	820	31	17	1060	45	20	615	895	1150	1485
	7/16[2]			480	15	11	700	22	14	900	28	17	1170	42	21	670	980	1260	1640
	15/32			520	13	10	760	19	13	980	25	15	1280	39	20	730	1065	1370	1790
	15/32	1-1/2	10d	620	22	14	920	30	17	1200	37	19	1540	52	23	870	1290	1680	2155
	19/32			680	19	13	1020	26	16	1330	33	18	1740	48	22	950	1430	1860	2435

Engineered Shear Wall Types



Why Use Force Transfer Around Openings?

Why Use Force Transfer Around Openings?

Open Front & Narrow Walls

Prefabricated Shear Wall Options

Proprietary Products with Evaluation Reports

Different Material Options

Metal Panel
Hardy Frame

Metal Panel
Simpson Strong-Tie

Wood Panels
Simpson Strong-Tie

The primary benefit is to have lateral force resistance where a 3:5 to 1 aspect ratio shear wall does not fit.

Prefabricated Shear Wall Options

Proprietary Products with Evaluation Reports

Different Material Options

Metal Panel
Hardy Frame

Metal Panel
Simpson Strong-Tie

Wood Panels
Simpson Strong-Tie

Example shear (wind) capacities of 8 ft tall, 24” wide panel on concrete foundation:

4085-7175# (HSB) 5105# 4808# 2110#

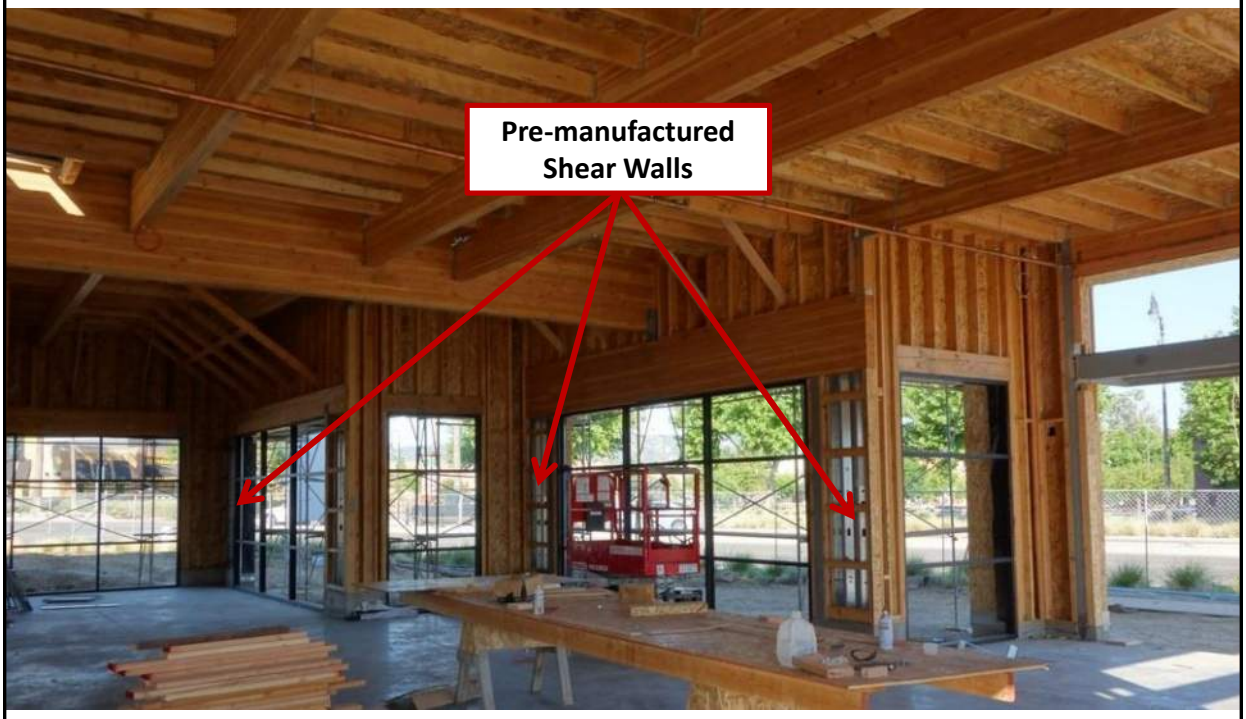
Using Prefabricated Shear Walls

Considerations:

- Drift compatibility with other walls sharing load
- Large hold-down forces
- Foundation Anchorage Coordination
- Sizes range from 12”->24” wide to 6.5’->20’ tall

Tip: Cast-in-place anchorage to concrete needed. Don’t expect post-installed concrete anchors to work.

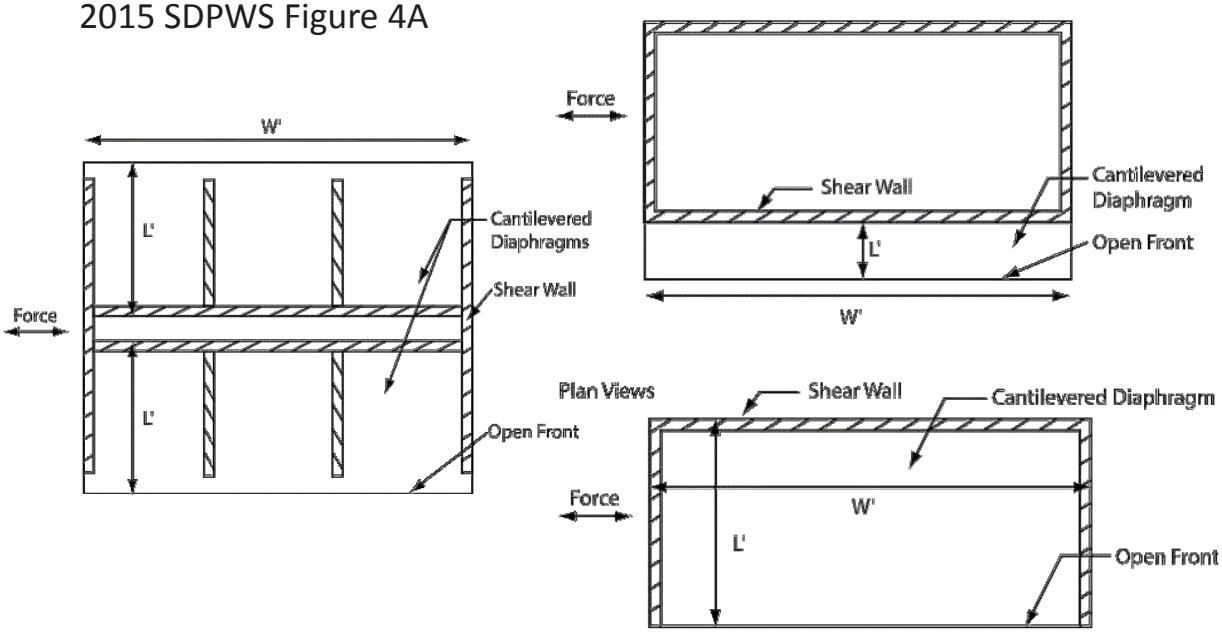
Small Retail Building – Northern CA



Open Front Structures

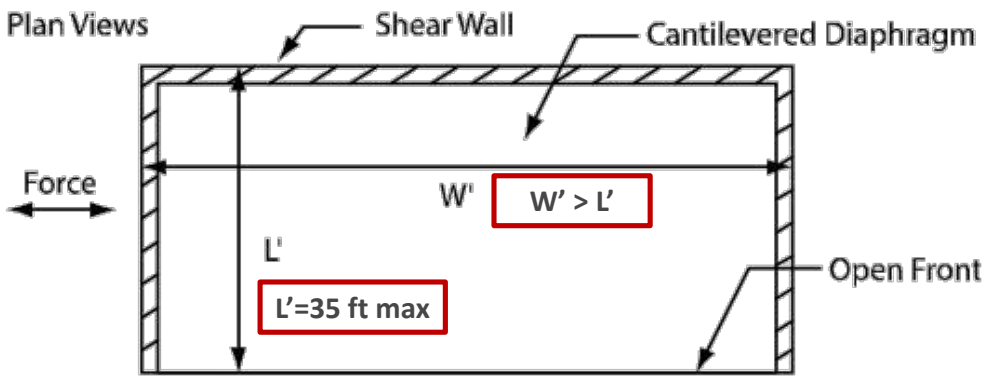
2015 SDPWS unifies Cantilever Diaphragms and Open Front Structures

2015 SDPWS Figure 4A



Open Front Structures

SDPWS 2008 and 2015 allow Open Front Structures… provide certain important requirements are met.



Possible **1-Story** Open-Front Structure in SDPWS 2015

Open Front Structures (SDPWS 4.2.5)

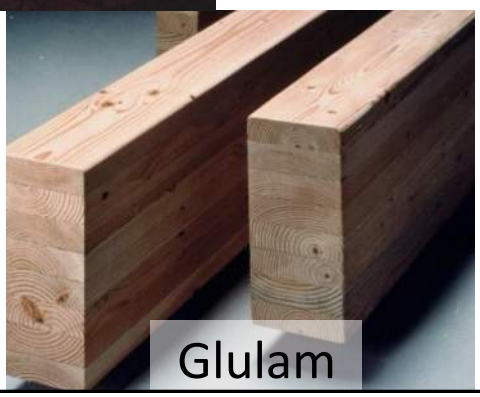
- Can idealize diaphragm as rigid if max. in-plane diaphragm deflection is ≤ 2x avg. story drift of vertical elements
- If not idealizing as flexible or rigid, may use semi-rigid analysis, distributes shear based on relative stiffness of both diaphragm and vertical resisting elements
- Common to use envelope analysis in lieu of semi-rigid analysis
- 2015 SDPWS: Diaphragm Cantilever ≤ 35 feet

Additional Considerations:

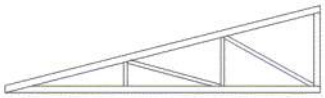
- L/W Ratio
- Irregularities & Torsional Effects
- Diaphragm deflections, especially at corners

Roof Framing

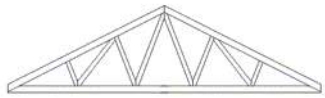
Common Roof Framing Options



Truss Configurations



MONOPITCH



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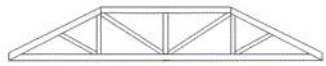
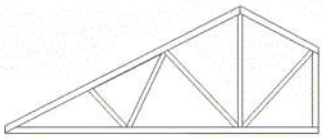
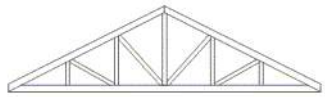


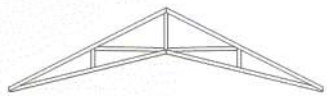
HIP



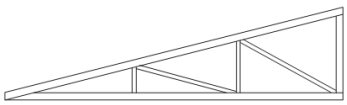
STUB



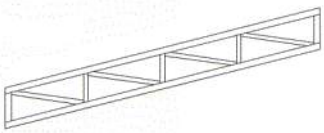
DOUBLE HOWE



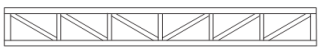
SCISSORS



MONOPITCH



SLOPING FLAT



FLAT

Metal Plated Wood Truss

Metal Plated Wood Truss

Exposed Timber Trusses

Berlin Shopping Mall, Berlin VT T&G Deck over Timber Trusses

Exposed Timber Trusses

90ft Span Concealed Connector Timber Truss

Exposed Timber Trusses

Whole Foods Market, Atlanta, GA

67’ Span Glulam Trusses

Metal Plated Trusses over Exposed Timber Trusses

Shenandoah Social Center

Photo courtesy D. Remy & Co.

I-Joist Roof Framing

- Flat or Sloped Roofs
- Vaulted Ceiling Possibilities

Strip Mall Building

Havens Elementary, Photo courtesy RedBuilt

Large Flat Roof Systems

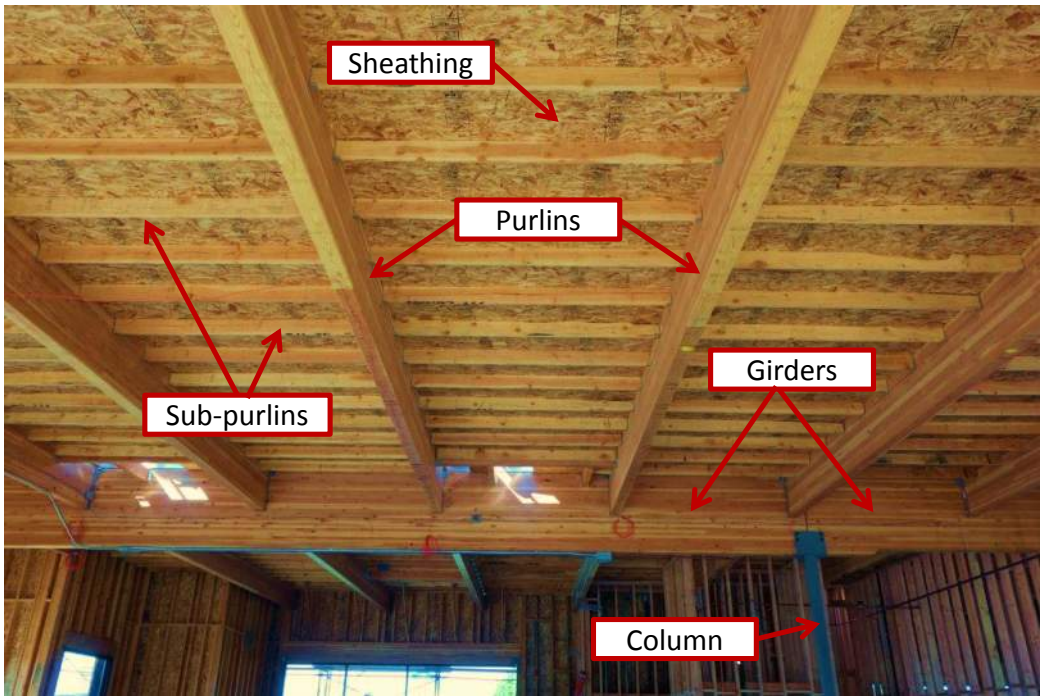
Creating Open Floor Space

Grid dimensions in low rise commercial buildings are often a deciding factor when determining structural systems. Accommodation of large, open floor plans with a minimal number of columns is required

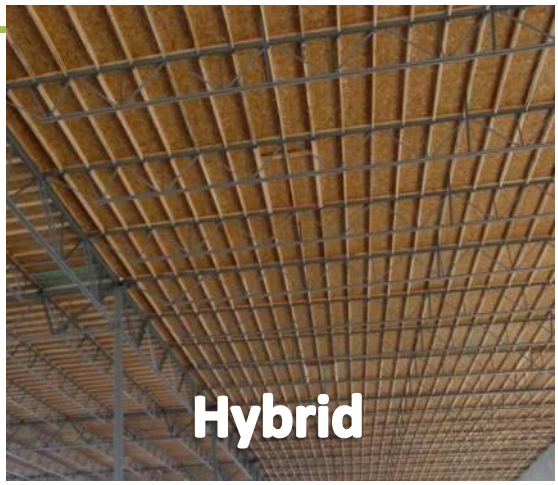
Common Grid Dimensions: 25'x30' to 45'x50' and larger

Photo: Myers-Company.com

Anatomy of a Large Flat Roof

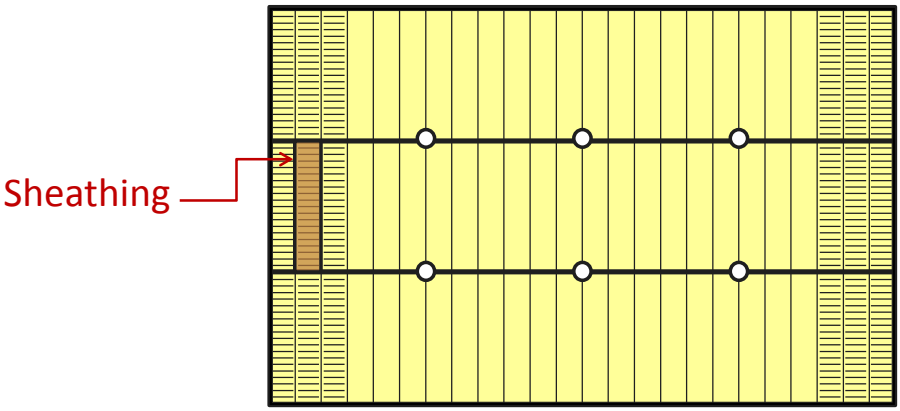


Commercial Flat Roof System



- Two common types
  - All wood
  - Hybrid

Anatomy of a Large Flat Roof

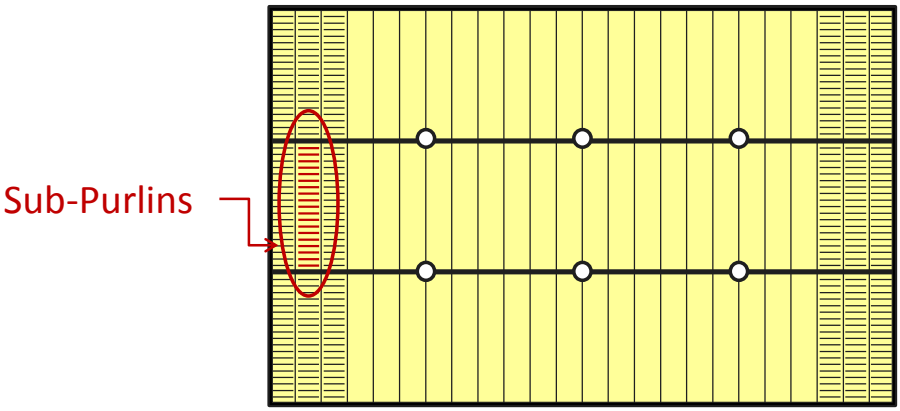


Sheathing

Wood Structural Panel Sheathing

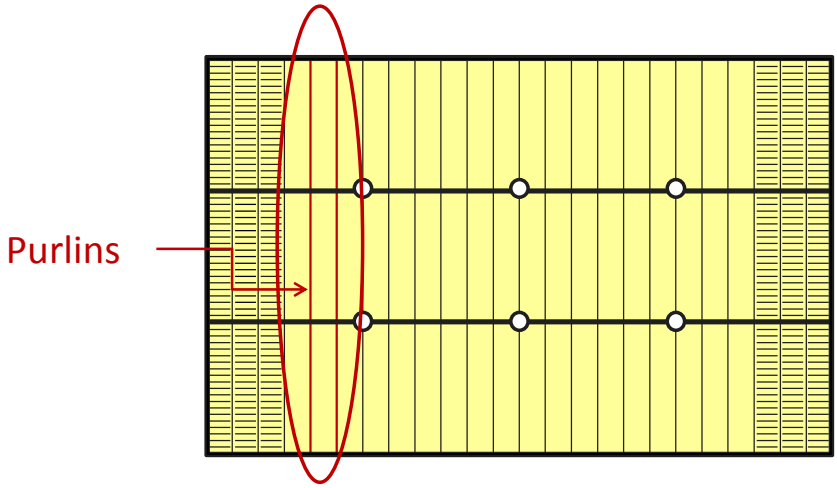
4x8, 4x10, 8x8 panels, spanning 24 or 48 inches

Anatomy of a Large Flat Roof



Solid Sawn Lumber @ 24 or 48 inches on center
Spanning 4 to 10 feet. 8ft most common

Anatomy of a Large Flat Roof

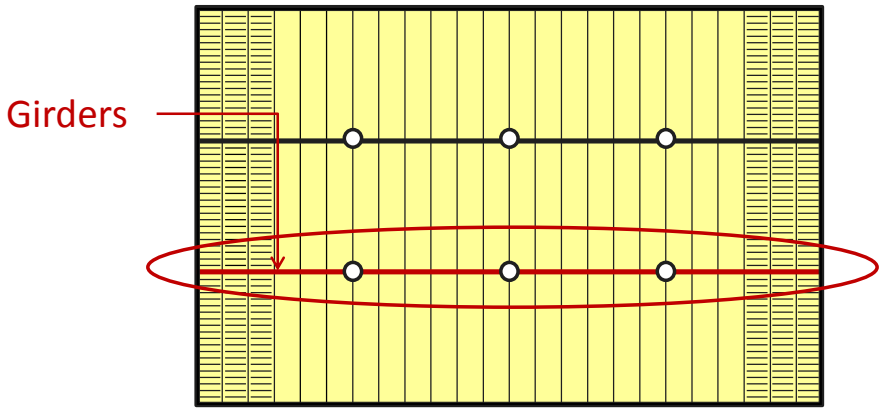


Many Options:

- Glu-lam beams
- I-Joists
- Metal Plated Wood Trusses
- Wood Flange Metal Web Trusses

Wood purlins can be viable to spans of 50 feet or more

Anatomy of a Large Flat Roof



Glulam beams most commonly used
Simply Supported or Cantilevers

Glulam Girders can be viable to spans of 40 feet or more

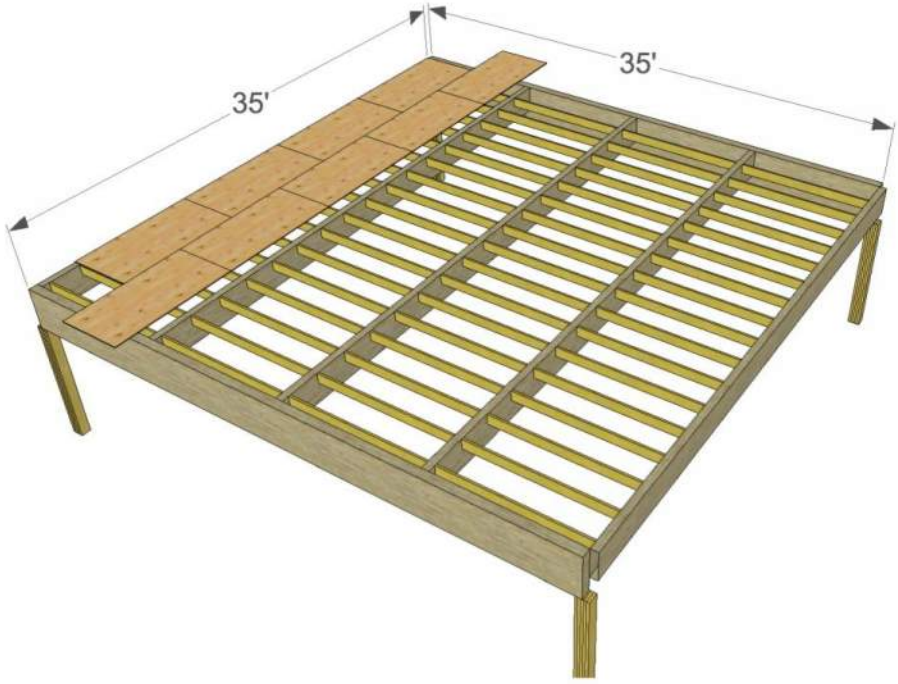
Different Flat Roof Framing Systems

Girder	Purlin	Sub-Purlin	Sheathing
Glulam	Glulam @ 8’ to 10’ o.c.	2x	WSP
Glulam	Trusses @ 4’ to 10’ o.c.	2x	WSP
Glulam	Trusses @ 16” to 48” o.c.	None	WSP
Glulam	I-Joists @ 16” to 48” o.c.	None	WSP
Glulam	Glulam @ 4’ to 10’ o.c.	None	T&G Decking
Glulam	Glulam @ 8’+ o.c.	None	Mass Timber Panels: Cross-Laminated Timber Nail-Laminated Timber Etc.

Architectural Grade Exposed Wood Options

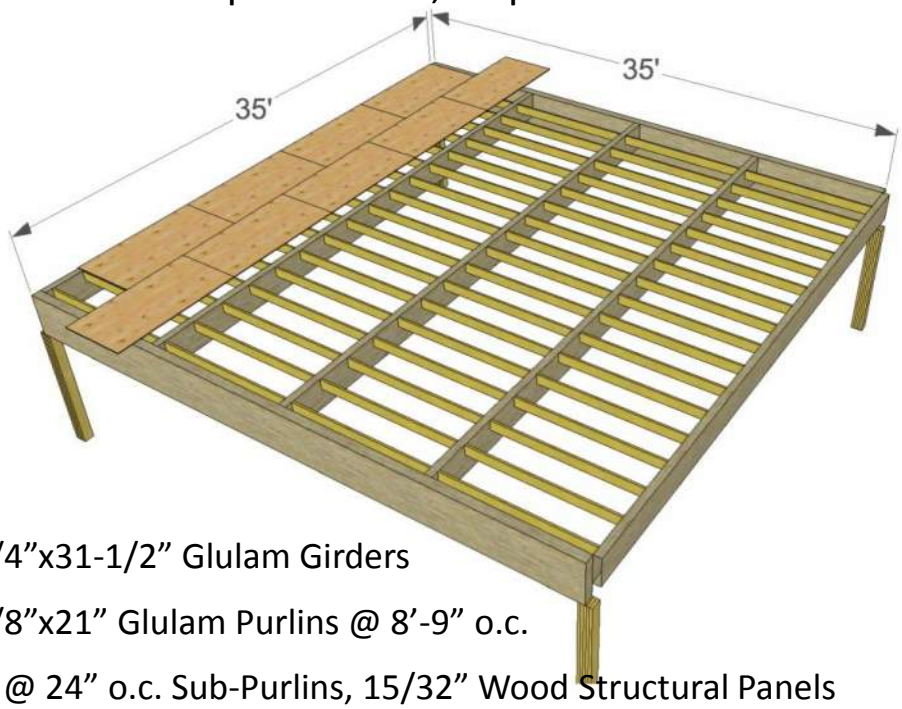
Example Roof Framing System

15 psf Roof DL, 20 psf Roof Live Load



Example Roof Framing System

15 psf Roof DL, 20 psf Roof Live Load

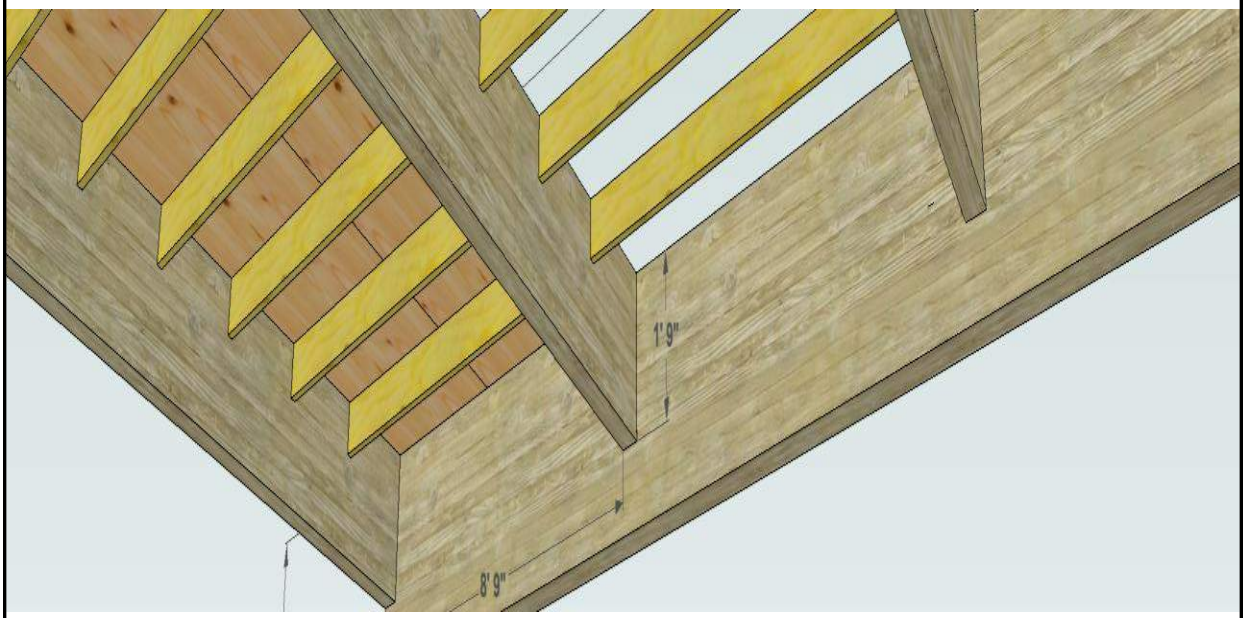


6-3/4”x31-1/2” Glulam Girders

5-1/8”x21” Glulam Purlins @ 8’-9” o.c.

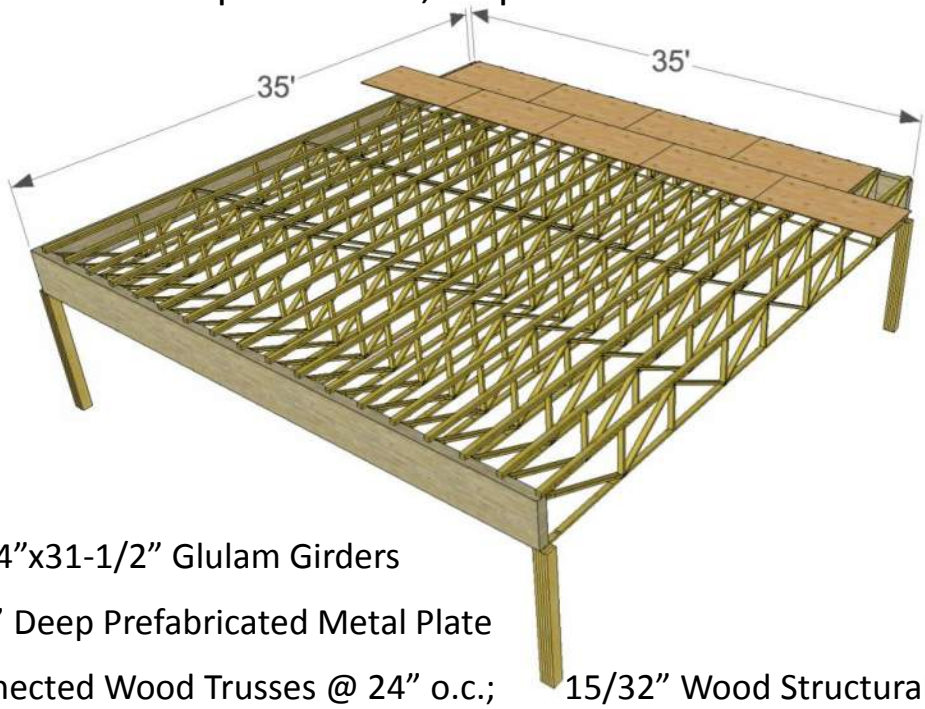
2x8 @ 24” o.c. Sub-Purlins, 15/32” Wood Structural Panels

Example Roof Framing System



Example Roof Framing System

15 psf Roof DL, 20 psf Roof Live Load



6-3/4”x31-1/2” Glulam Girders

3’-0” Deep Prefabricated Metal Plate Connected Wood Trusses @ 24” o.c.; 15/32” Wood Structural Panels

Example Roof Framing System

15 psf Roof DL, 20 psf Roof Live Load

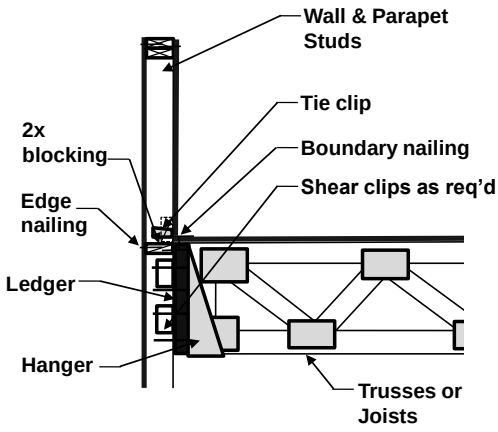
6-3/4”x31-1/2” Glulam Girders

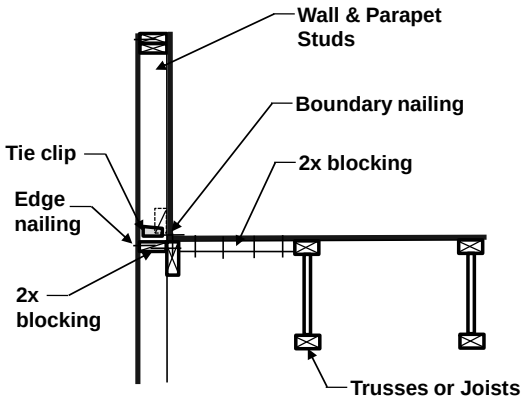
5-1/8”x21” Glulam Purlins @ 8’-9” o.c.

HT/Mass Timber Decking Options: NLT, CLT, GLT, 3x T&G

Example Roof Framing System

Parapet Framing Options





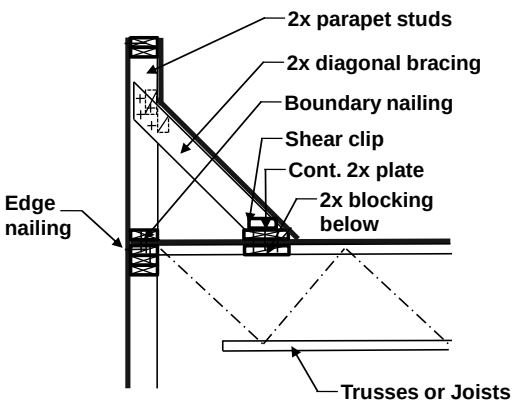
Tall Stud Parapet Style

Parapet Wall Example

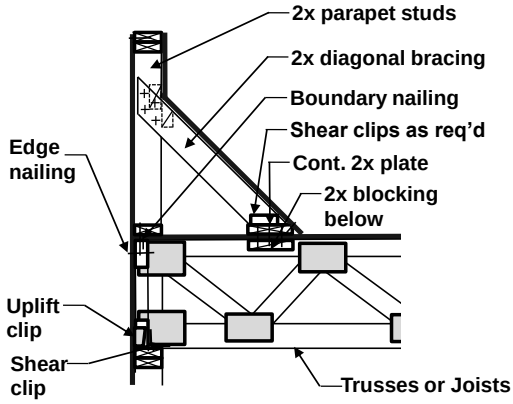
- Sporting Good Retailer
- Dinuba, CA
- 17’ to top of roof
- 22’ to top of parapet
- 2x6 DF
- Used with hybrid panelized roof

Pelton Engineering

Parapet Framing Options



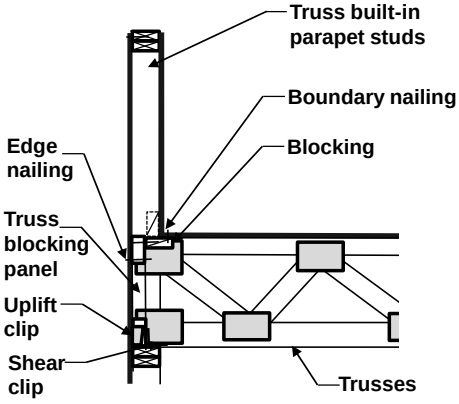
Top Flange Hanger Style



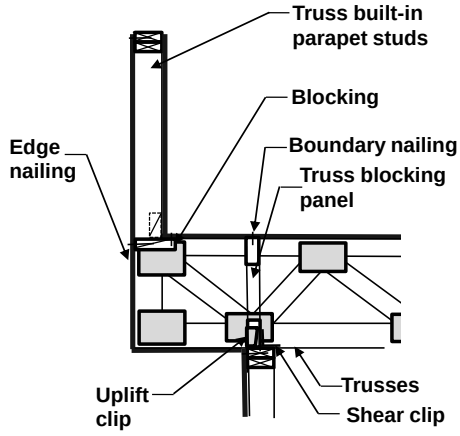
Platform Framing Style

Built-Up Parapet Style

Parapet Framing Options



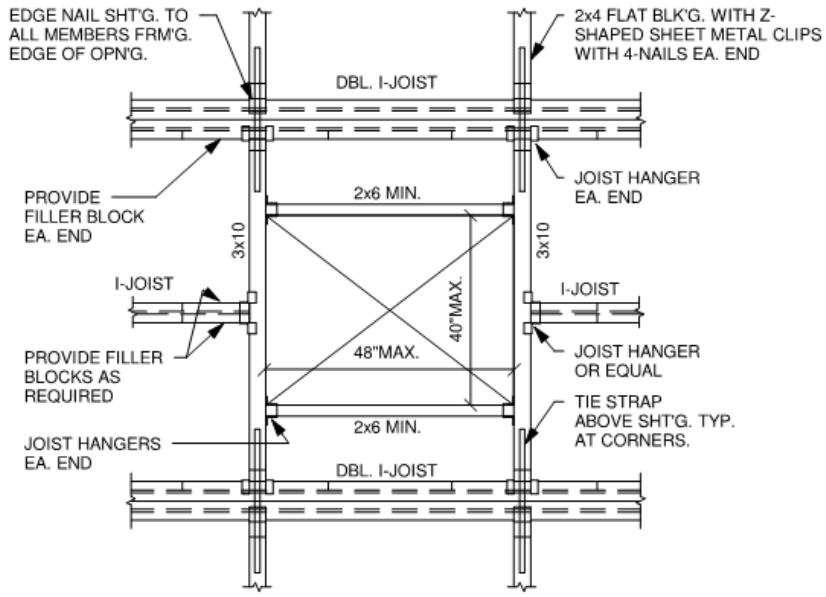
Parapet Flush with Wall



Cantilevered Truss

Parapet in Truss Style

Flexible Detailing for Roof Openings



www.woodworks.org/design-and-tools/design-tools/cad-revit-details/ for example details

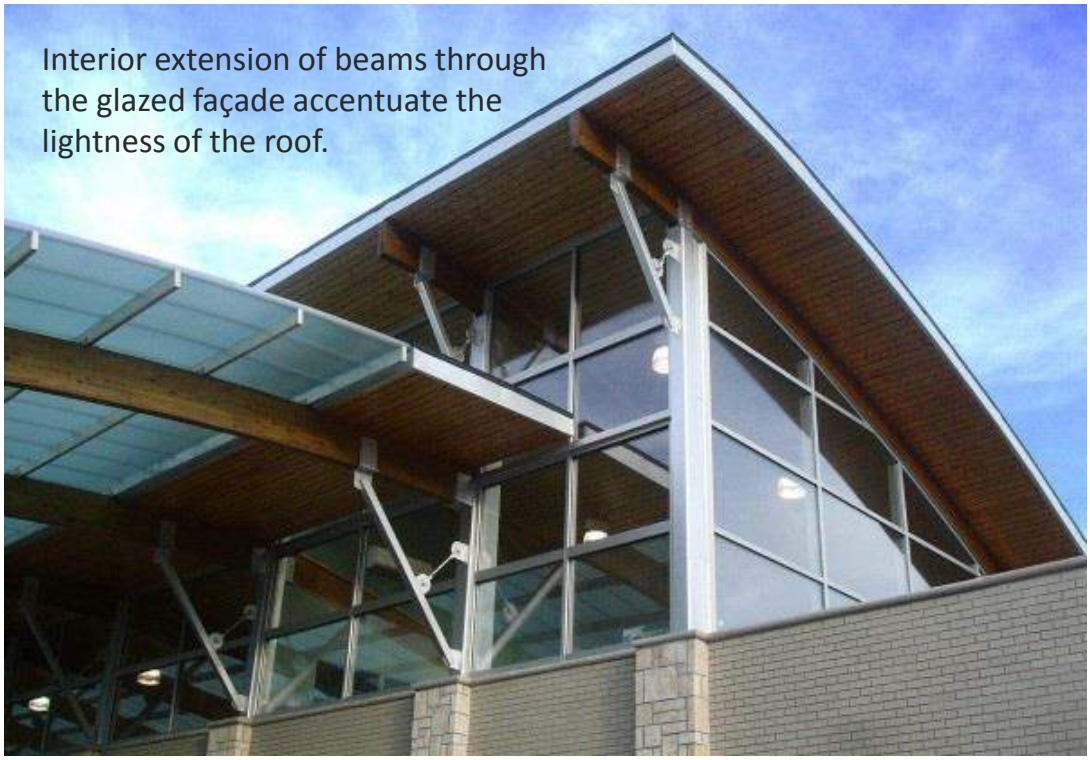
Example Projects

Layton Petro Mart --- Greenfield, WI

Commercial Wood Design Award 2009
Arquitectura, Inc. – Milwaukee, WI

Layton Petro Mart, Greenfield, Wisconsin

Photos: Arquitectura, Inc.



Layton Petro Mart, Greenfield, WI
Photos: Arquitectura, Inc.


OPEN

Fast Food Restaurant

- 2x6 wall studs
- 10’ tall walls + 3’ Parapet
- Brick and Stone Cladding

Fast Food Restaurant

Roof Construction:

- Metal Plate Connected Wood Roof Trusses
- 36” Deep, 34’ Spans, 32” o.c.

Wood in Retail Design

National Chain Jewelry Store

Retail – Jewelry Store

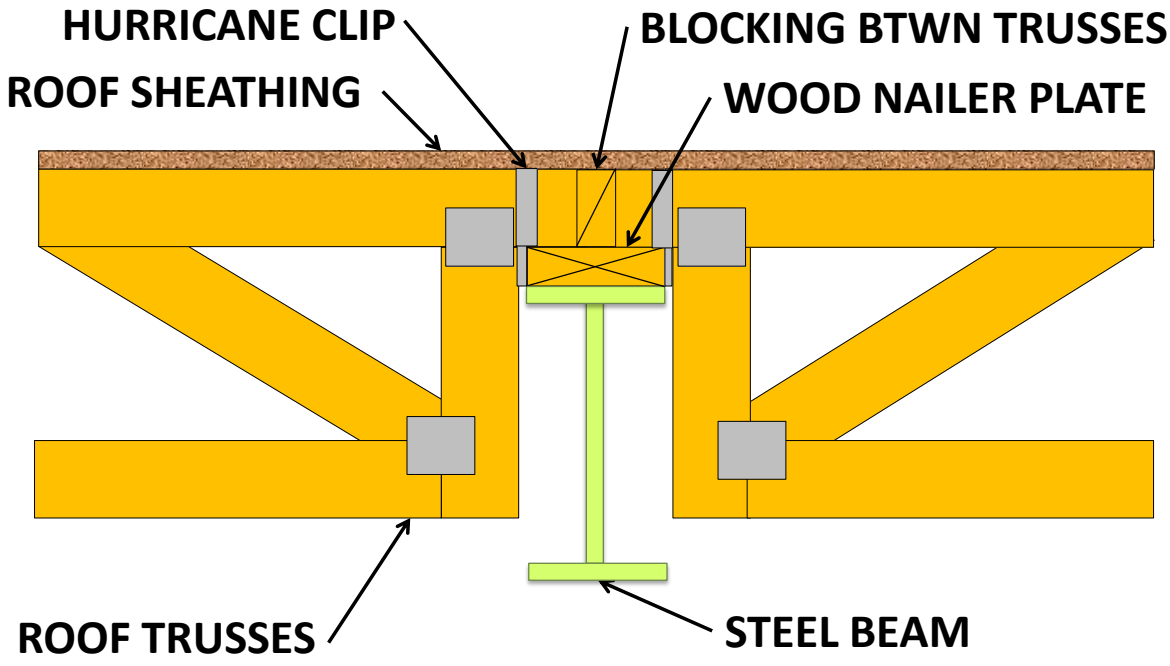
- Murfreesboro, TN
- 2x8 wall studs, 22’ tall
- Panelized walls
- Exterior Finishes Applied

Retail – Jewelry Store

Roof Construction:

- Metal Plate Connected Wood Roof Trusses, 25’ Spans
- Steel beam utilized along center of building. 32’ Spans

Roof Framing Detail



Wood in Retail Design

Restaurant

- Murfreesboro, TN
- Completed July, 2015

Restaurant – Brewery Chain

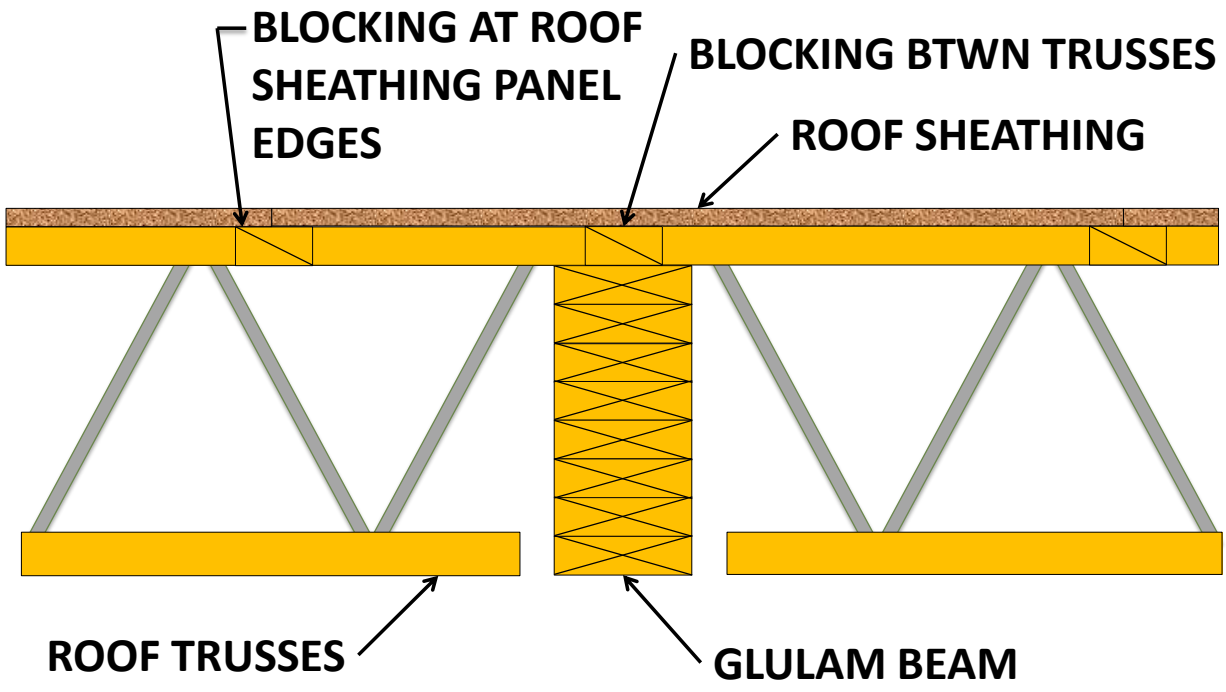
Roof Construction

- Wood Structural Panels Sheathing
- Composite Wood-Steel Open Web Trusses
- Glulam Beams
- 2x6 Bearing Walls

Restaurant – Brewery Chain

- Blocked Roof Diaphragm for Higher Capacity

Roof Framing Detail



Wood in Retail Design

Fast Food Restaurant

- Provo, UT

Fast Food Restaurant

Building Construction

- Wood Structural Panels & T&G Decking Sheathing
- Composite Wood-Steel Open Web Roof Trusses & Solid Sawn Rafters
- Glulam Beams
- PSL & Built-Up Solid Sawn Columns
- 2x6 Bearing Walls & Shear Walls

Fast Food Restaurant

Fast Food Restaurant

Building Code:
Allowable Heights and Areas

Height and Areas Code Analysis

Question:

For the building program, including occupancies and size, what Construction Types are allowed by the Building Code?

Answer:

Determined by Heights and Areas Code analysis

Heights and Areas – IBC 2009 Table 503

GROUP		TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
	HEIGHT (feet)	UL	160	65	55	65	55	65	50	40
	STORIES(S) AREA (A)									
M	S	UL	11	4	2	4	2	4	3	1
	A	UL	UL	21,500	12,500	18,500	12,500	20,500	14,000	9,000
R-1	S	UL	11	4	4	4	4	4	3	2
	A	UL	UL	24,000	16,000	24,000	16,000	20,500	12,000	7,000
R-2	S	UL	11	4	2	4	2	4	3	2
	A	UL	UL	21,500	12,500	18,500	12,500	20,500	12,000	7,000
R-3	S	UL	11	4	4	4	4	4	3	3
	A	UL	UL	24,000	16,000	24,000	16,000	20,500	UL	UL
R-4	S	UL	11	4	2	4	2	4	3	2
	A	UL	UL	24,000	16,000	24,000	16,000	20,500	12,000	7,000
S-1	S	UL	11	4	2	3	2	4	3	1
	A	UL	48,000	26,000	17,500	26,000	17,500	25,500	14,000	9,000
S-2[b, c]	S	UL	11	5	3	4	3	5	4	2
	A	UL	79,000	39,000	26,000	39,000	26,000	38,500	21,000	13,500
U[c]	S	UL	5	4	2	3	2	4	2	1
	A	UL	35,500	19,000	8,500	14,000	8,500	18,000	9,000	5,500

Normal Calculated Allowable Heights and Area one route to an answer. Don't overlook Unlimited Area Route

Allowable Story Area – IBC 2012 506

Equation 5-1

$$A_a = A_t + [A_t \times I_f] + [A_t \times I_s]$$

A_a = Allowable area per story (sq. ft.)

A_t = Tabular area per story (sq. ft.)

I_f = Area increase factor due to frontage (IBC 506.2)

I_s = Area increase factor due to sprinkler protection (IBC 506.3)

I_s=3 for 1 story

I_s=2 for > 1 story

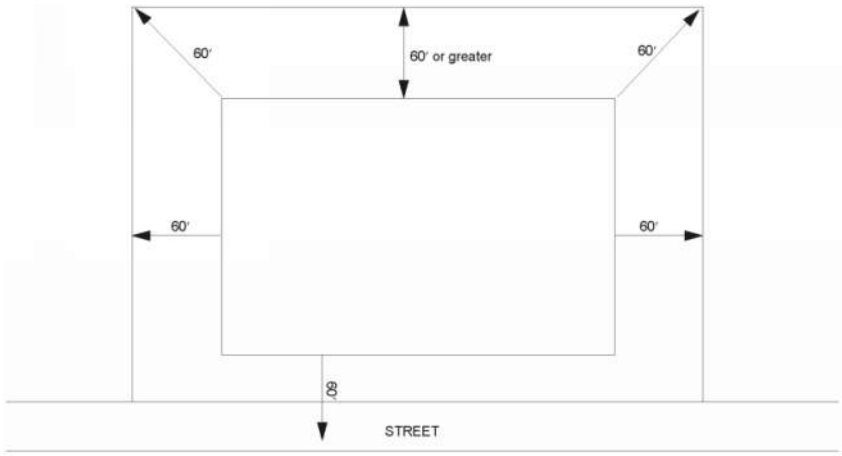
Unlimited Area Buildings

IBC Section 507 gives Unlimited Area Building routes for Type III, IV and/or V Construction for the following occupancies:

- Assembly
- Education
- Business
- Factory
- Mercantile
- Storage

Unlimited Area Buildings

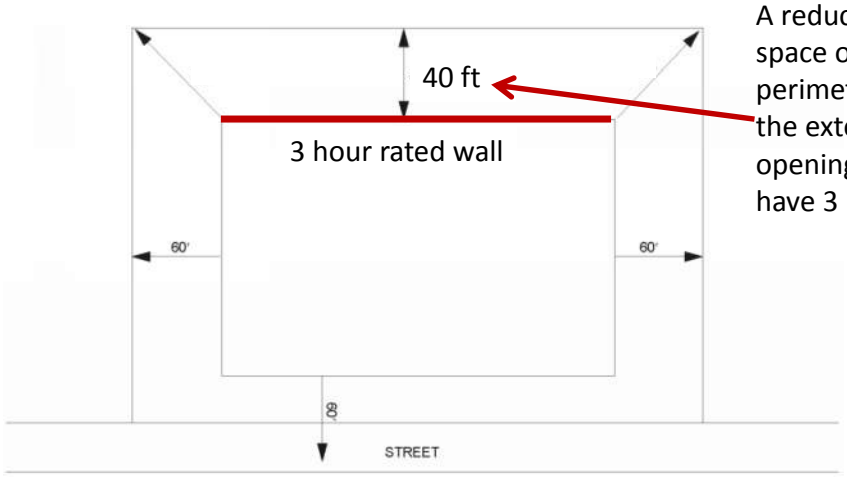
Provisions for unlimited area buildings rely on open space surrounding building (IBC 507)



REQUIRED SEPARATION FOR UNLIMITED AREA BUILDINGS

Unlimited Area Buildings

Provisions for unlimited area buildings rely on open space surrounding building (IBC 507)



REQUIRED SEPARATION FOR UNLIMITED AREA BUILDINGS

A reduction to 40 feet open space of up to 75% of perimeter is allowed provided the exterior wall and openings at reduced frontage have 3 hour ratings

Unlimited Area Building Route 1

B F M and S Occupancies can have **unlimited area** for **any construction type** provided:

- Two stories or less above grade plane
- Equipped with automatic sprinklers
- See IBC 2012 507.4 or IBC 2015 507.5

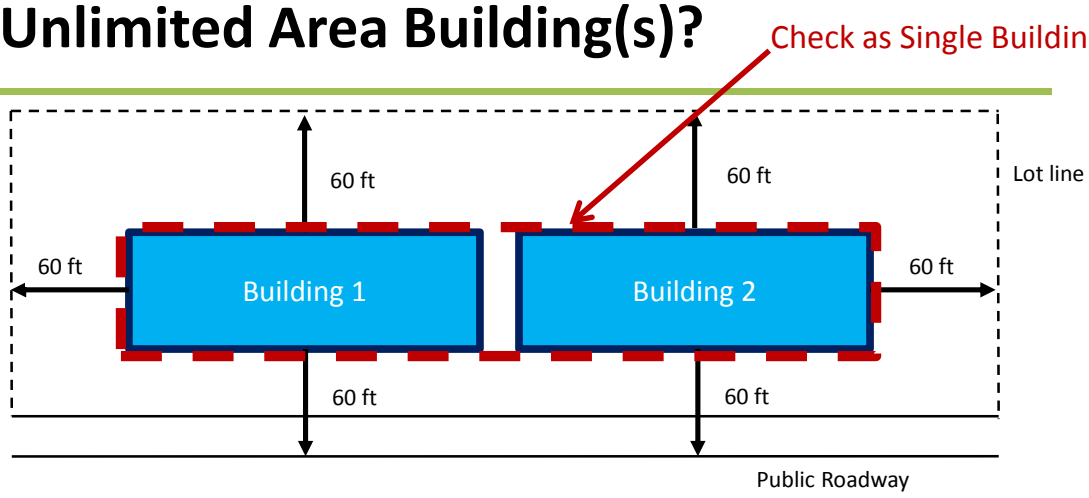
Photo Steve Fareham- Creative Commons

Unlimited Area Buildings

Can these buildings meet the open space provision to qualify for Unlimited Area?

Photo Steve Fareham- Creative Commons

Unlimited Area Building(s)?



IBC 2015 507.2 Commentary: Two unlimited area buildings ***on the same lot*** must be separated by 60 feet [or 40 feet if Section 507.2.1 is used] unless they are treated as a single building under the provisions of Section 503.1.2

Other Unlimited Area Buildings Routes

- 1 Story A-4, Sprinklered of Type III or IV
  - See IBC 2015 507.4
- 1 Story A-3 of Type III or IV.
  - See IBC 2015 507.7
- 1 Story Group E Buildings of Type IIIA or IV
  - See IBC 2015 507.11

New IBC 2015 Chapter 5 H&A Format

- Significant Reorganization from 2012
  - Simpler, but More, Equations
  - Bigger, and More, Tables
  - Generally the Same Results

TABLE 504.3[a]
ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE

OCCUPANCY CLASSIFICATION	TYPE OF CONSTRUCTION									
	SEE FOOTNOTES	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
A, B, E, F, M, S, U	NS[b]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
H-1, H-2, H-3, H-5	NS[c, d]	UL	160	65	55	65	55	65	50	40
	S									
H-4	NS[c, d]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
I-1 Condition 1, I-3	NS[d, e]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
I-1 Condition 2, I-2	NS[d, f, e]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85						
I-4	NS[d, g]	UL	160	65	55	65	55	65	50	40

Allowable Building Height

IBC 2015 Allowable Height:

No Sprinklers

TABLE 504.3[a]
ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
A, B, E, F, M, S, U	NS[b]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
H-1, H-2, H-3, H-5	NS[c, d]	UL	160	65	55	65	55	65	50	40
	S									
H-4	NS[c, d]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
I-1 Condition 1, I-3	NS[d, e]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
I-1 Condition 2, I-2	NS[d, f, e]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85						

Allowable Building Height

IBC 2015 Allowable Height:

Sprinklers

TABLE 504.3[a]
ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
A, B, E, F, M, S, U	NS[b]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
H-1, H-2, H-3, H-5	NS[c, d]	UL	160	65	55	65	55	65	50	40
	S									
H-4	NS[c, d]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
I-1 Condition 1, I-3	NS[d, e]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
I-1 Condition 2, I-2	NS[d, f, e]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85						

Allowable Building Height

IBC 2015 Allowable Height:

Type II and Type III have same height limits

TABLE 504.3[a]
ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
A, B, E, F, M, S, U	NS[b]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
H-1, H-2, H-3, H-5	NS[c, d]	UL	160	65	55	65	55	65	50	40
	S									
H-4	NS[c, d]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
I-1 Condition 1, I-3	NS[d, e]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
I-1 Condition 2, I-2	NS[d, f, e]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85						

Allowable Building Stories

IBC 2015 Allowable Stories above Grade:

No Sprinklers

TABLE 504.4[a, b]
ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
A-1	NS	UL	5	3	2	3	2	3	2	1
	S	UL	6	4	3	4	3	4	3	2
A-2	NS	UL	11	3	2	3	2	3	2	1
	S	UL	12	4	3	4	3	4	3	2
...										
B	NS	UL	11	5	3	5	3	5	3	2
	S	UL	12	6	4	6	4	6	4	3
...										
M	NS	UL	11	4	2	4	2	4	3	1
	S	UL	12	5	3	5	3	5	4	2

Allowable Building Stories

IBC 2015 Allowable Stories above Grade:

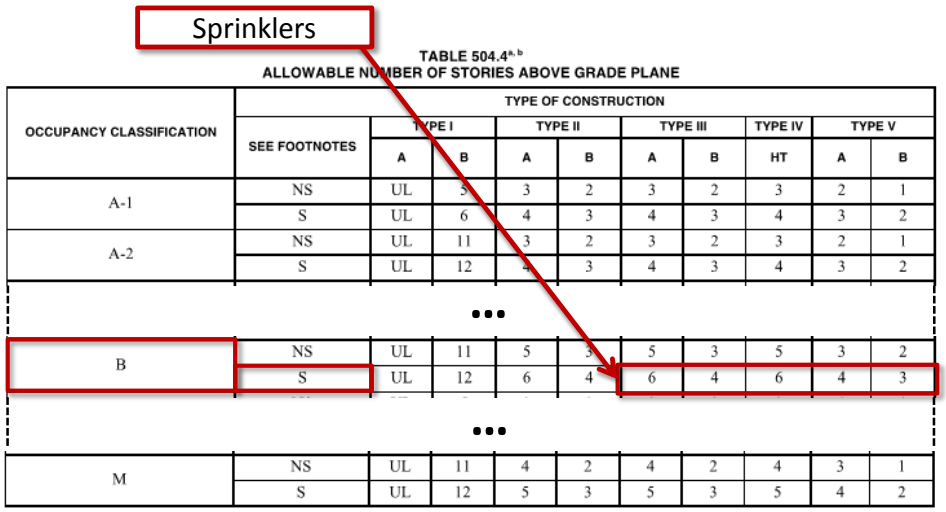


TABLE 504.4[a, b]
ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
A-1	NS	UL	5	3	2	3	2	3	2	1
	S	UL	6	4	3	4	3	4	3	2
A-2	NS	UL	11	3	2	3	2	3	2	1
	S	UL	12	4	3	4	3	4	3	2
...										
B	NS	UL	11	5	3	5	3	5	3	2
	S	UL	12	6	4	6	4	6	4	3
...										
M	NS	UL	11	4	2	4	2	4	3	1
	S	UL	12	5	3	5	3	5	4	2

Allowable Building Stories

IBC 2015 Allowable Stories above Grade:

Type II and Type III have same number allowed stories

TABLE 504.4[a, b]
ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
A-1	NS	UL	5	3	2	3	2	3	2	1
	S	UL	6	4	3	4	3	4	3	2
A-2	NS	UL	11	3	2	3	2	3	2	1
	S	UL	12	4	3	4	3	4	3	2
...										
B	NS	UL	11	5	3	5	3	5	3	2
	S	UL	12	6	4	6	4	6	4	3
...										
M	NS	UL	11	4	2	4	2	4	3	1
	S	UL	12	5	3	5	3	5	4	2

Allowable Story Area – IBC 2012 506

Equation 5-1

$$A_a = A_t + [A_t \times I_f] + [\cancel{A_t \times I_s}]$$

In Tables in IBC 2015

A_a = Allowable area per story (sq. ft.)

A_t = Tabular area per story (sq. ft.)

I_f = Area increase factor due to frontage (IBC 506.2)

I_s = Area increase factor due to sprinkler protection (IBC 506.3)

I_s=3 for 1 story

I_s=2 for > 1 story

Allowable Story Area – IBC 2015 506

Equation 5-1

$$A_a = A_t + [NS \times I_f]$$

A_a = Allowable area per story (sq. ft.)

A_t = Allowable Area Factor

Now varies by sprinklers and stories.

NS = Allowable Area Factor for Non Sprinklered Building

I_f = Area Factor Increase for frontage (IBC '15 506.3)

Allowable Story Area - Area Factor

No Sprinklers

TABLE 506.2[a, b]
ALLOWABLE AREA FACTOR (A_t = NS, S1, S13R, or SM, as applicable) IN SQUARE FEET

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
•••										
A-2	NS	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	60,000	46,000	24,000
	SM	UL	UL	46,500	28,500	42,000	28,500	45,000	34,500	18,000
•••										
B	NS	UL	UL	37,500	23,000	28,500	19,000	36,000	18,000	9,000
	S1	UL	UL	150,000	92,000	114,000	76,000	144,000	72,000	36,000
	SM	UL	UL	112,500	69,000	85,500	57,000	108,000	54,000	27,000
•••										
M	NS	UL	UL	21,500	12,500	18,500	12,500	20,500	14,000	9,000
	S1	UL	UL	86,000	50,000	74,000	50,000	82,000	56,000	36,000
	SM	UL	UL	64,500	37,500	55,500	37,500	61,500	42,000	27,000

Allowable Story Area: Area Factor

Sprinklers, 1 Story

TABLE 506.2[a, b]
ALLOWABLE AREA FACTOR (A_t = NS, S1, S13R, or SM, as applicable) IN SQUARE FEET

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
•••										
A-2	NS	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	60,000	46,000	24,000
	SM	UL	UL	46,500	28,500	42,000	28,500	45,000	34,500	18,000
•••										
B	NS	UL	UL	37,500	23,000	28,500	19,000	36,000	18,000	9,000
	S1	UL	UL	150,000	92,000	114,000	76,000	144,000	72,000	36,000
	SM	UL	UL	112,500	69,000	85,500	57,000	108,000	54,000	27,000
•••										
M	NS	UL	UL	21,500	12,500	18,500	12,500	20,500	14,000	9,000
	S1	UL	UL	86,000	50,000	74,000	50,000	82,000	56,000	36,000
	SM	UL	UL	64,500	37,500	55,500	37,500	61,500	42,000	27,000

Allowable Story Area: Area Factor

Sprinklers, Multiple Stories

TABLE 506.2[a, b]
ALLOWABLE AREA FACTOR (A_t = NS, S1, S13R, or SM, as applicable) IN SQUARE FEET

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
•••										
A-2	NS	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	60,000	46,000	24,000
	SM	UL	UL	46,500	28,500	42,000	28,500	45,000	34,500	18,000
•••										
B	NS	UL	UL	37,500	23,000	28,500	19,000	36,000	18,000	9,000
	S1	UL	UL	150,000	92,000	114,000	76,000	144,000	72,000	36,000
	SM	UL	UL	112,500	69,000	85,500	57,000	108,000	54,000	27,000
•••										
M	NS	UL	UL	21,500	12,500	18,500	12,500	20,500	14,000	9,000
	S1	UL	UL	86,000	50,000	74,000	50,000	82,000	56,000	36,000
	SM	UL	UL	64,500	37,500	55,500	37,500	61,500	42,000	27,000

Total Allowable Building Area

Total Allowable Building Area
= Allowable Building Area per Story Times
2 for 2 story building
3 for 3 story ***or taller*** building
4 for 4 story building with NFPA 13R sprinklers

See IBC 2015 506.2.3 and 506.2.4 for particulars.

Allowable Story Area – IBC 2015 506

Equation 5-1

$$A_a = A_t + [NS \times I_f]$$

A_a = Allowable area per story (sq. ft.)

A_t = Allowable Area Factor

Now varies by sprinklers and stories.

NS = Allowable Area Factor for Non Sprinklered Building

I_f = Area Factor Increase for frontage (IBC '15 506.3)

Allowable Story Area – IBC 2012 506

Equation 5-1

$$A_a = A_t + [A_t \times I_f] + [A_t \times I_s]$$

A_a = Allowable area per story (sq. ft.)

A_t = Tabular area per story (sq. ft.)

I_f = Area increase factor due to frontage (IBC 506.2)

I_s = Area increase factor due to sprinkler protection (IBC 506.3)

I_s=3 for 1 story

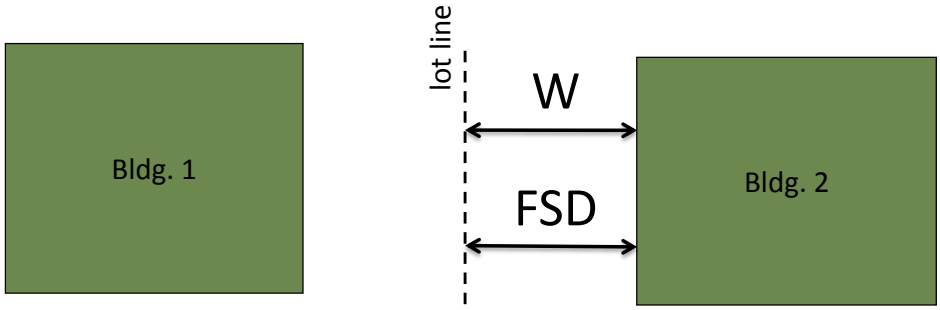
I_s=2 for > 1 story

Frontage Increase – IBC 2015 506.3.2

"W" for frontage increase to area and Fire Separation Distance for purposes of fire resistance ratings of walls and openings are not the same

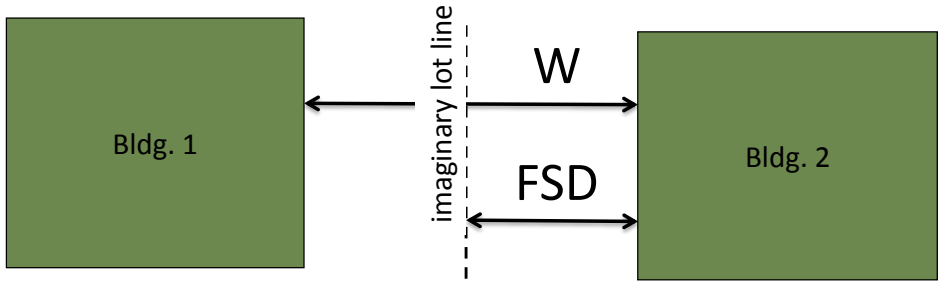
Frontage Increase – IBC 2015 506.3.2

For two buildings on DIFFERENT lots



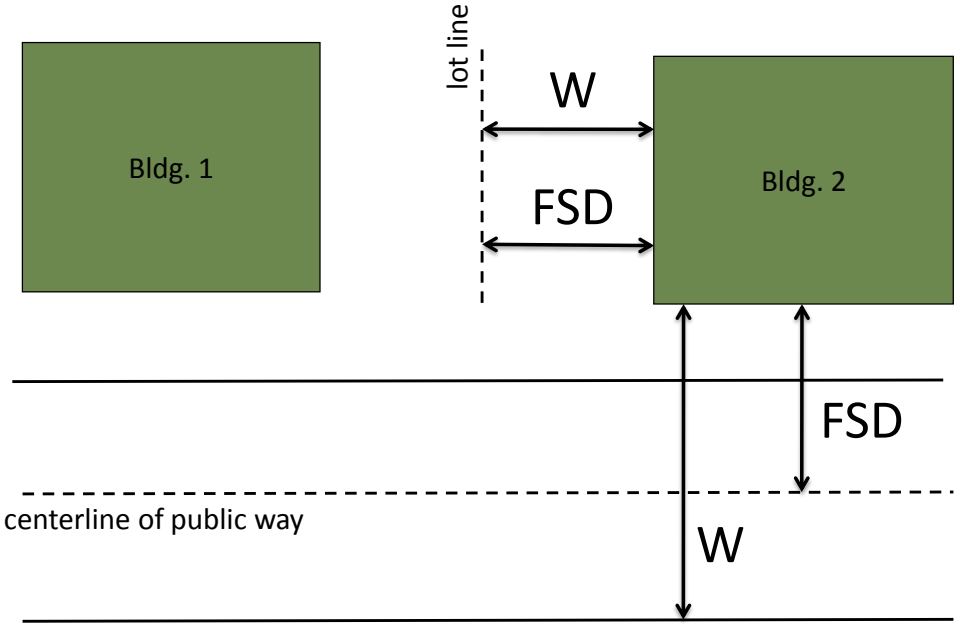
Frontage Increase – IBC 2015 506.3.2

For two buildings on the SAME lot



Frontage Increase – IBC 2015 506.3.2

Buildings near public right of ways:



AWC Code Conforming Wood Design

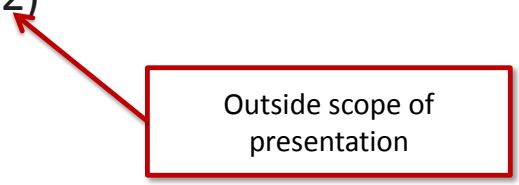
Building Code: Multi-Tenant and Multi-Occupancy Buildings

Multi-Tenant Buildings

Lead to mixed occupancy buildings

Code Sections Related to Multiple Occupancies

- Incidental Uses (509)
- Accessory Occupancies (508.2)
- Non-Separated Occupancies (508.3)
- Separated Occupancies (508.4)
- Separate Buildings (503.1)
- Covered and Open Malls (402)



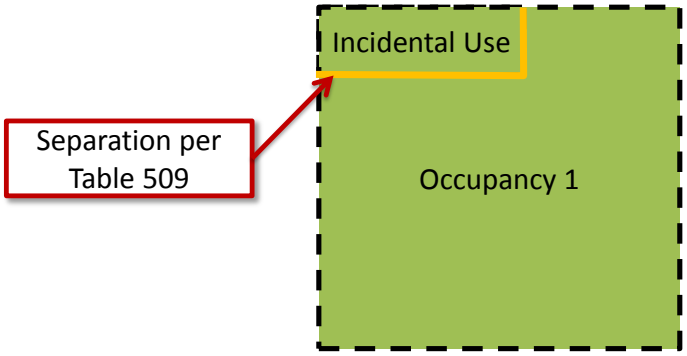
Incidental Uses (IBC 509)

- Ancillary function associated with an Occupancy
- Pose GREATER risk than the Occupancy
- Examples:
  - Laundry room over 100 square feet.
  - Refrigerant machinery room
  - Incinerator room
  - Furnace room
  - Boiler room

Incidental Uses (IBC 509)

Photo Sean Hackbarth/Flickr

- Not more than 10% of area of story
- Have fire separation, smoke separation and/or sprinkler systems per Table 509 and Section 509.4
- **NOT classified as a different occupancy.**
- **Allowable Building Area and Height per main Occupancy**

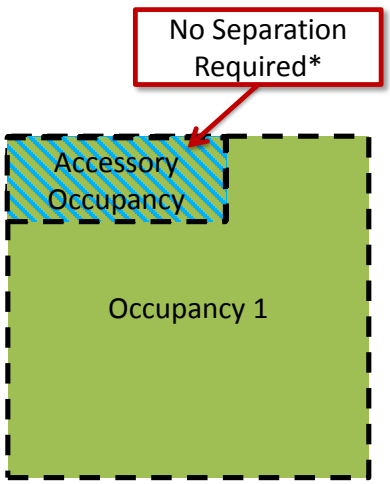


Accessory Occupancies (508.2)

- Ancillary to the main Occupancy
- Accessory Area not greater than:
  - 10% of the main Occupancy on same floor
  - IBC 506 “NS” Allowble Area limit of Accessory Occupancy
- No separation between occupancies required*
- **Allowable Building Area and Height per main Occupancy**

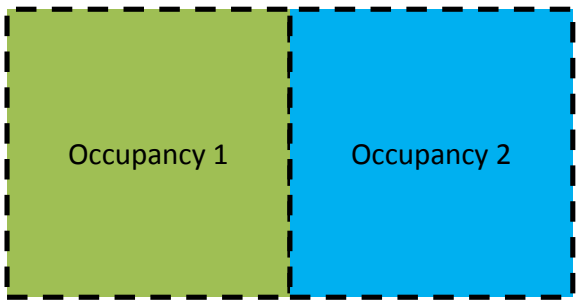
*Hazardous occupancies require separation

*Residential separations per Section 420 still apply



Non-Separated Occupancies (508.3)

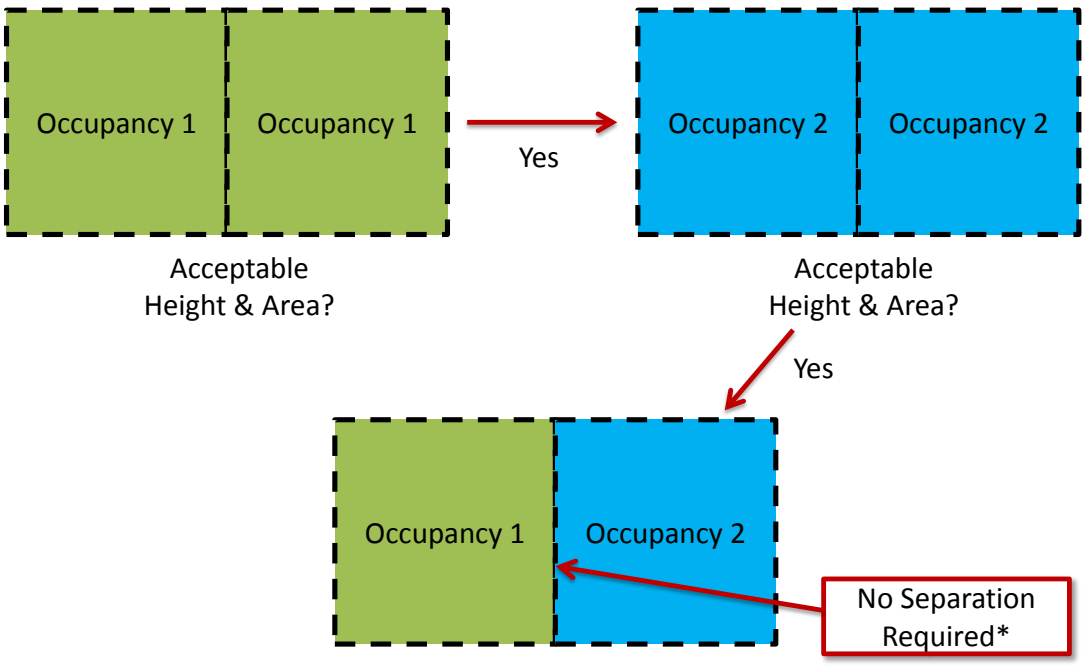
- Most restrictive requirements of all occupancies apply for:
  - Fire Protection Systems (Chapter 9)
  - Allowable Height and Area
- Other requirements for each portion based upon occupancy of that portion
- No separation between occupancies required*



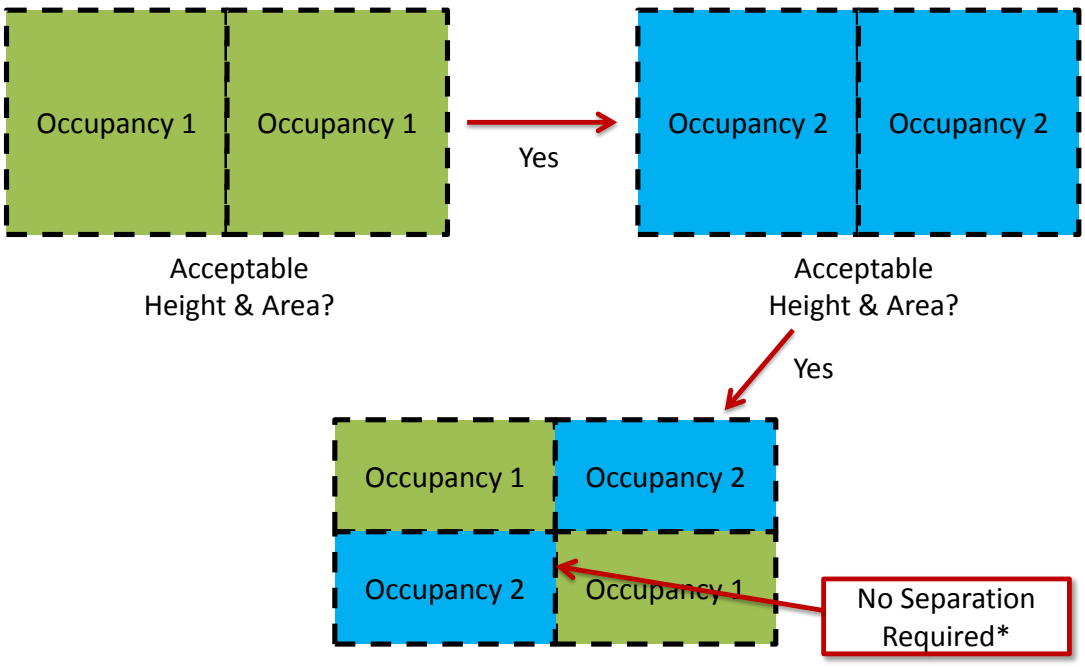
*Hazardous occupancies require separation.

*Residential separations per Section 420 still apply

Non-Separated Occupancies (508.3)



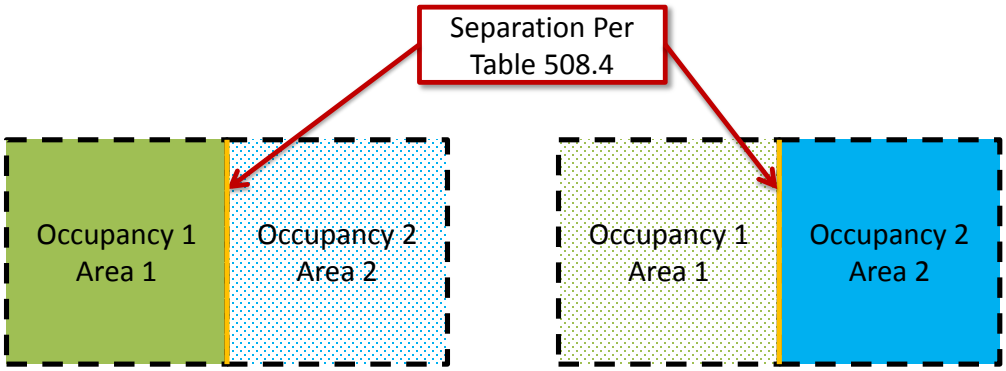
Non-Separated Occupancies (508.3)



Separated Occupancies (508.4)

- Requirements of code for each portion based upon occupancy of that portion
- Allowable Height of each occupancy based upon construction type and occupancy
- Allowable Area of each story
  - Sum of actual area over allowable area of each occupancy ≤ 1.0

Separated Occupancies (508.4)



$$\frac{A1}{\text{Allowable Area for Occupancy 1}} + \frac{A2}{\text{Allowable Area for Occupancy 2}} \leq 1.0$$

Check Performed for each Story.
Separation by Fire Barriers and Horizontal Assemblies

Separated Occupancies (508)

Separation by *Fire Barriers* and *Horizontal Assemblies* required per Table 508.4

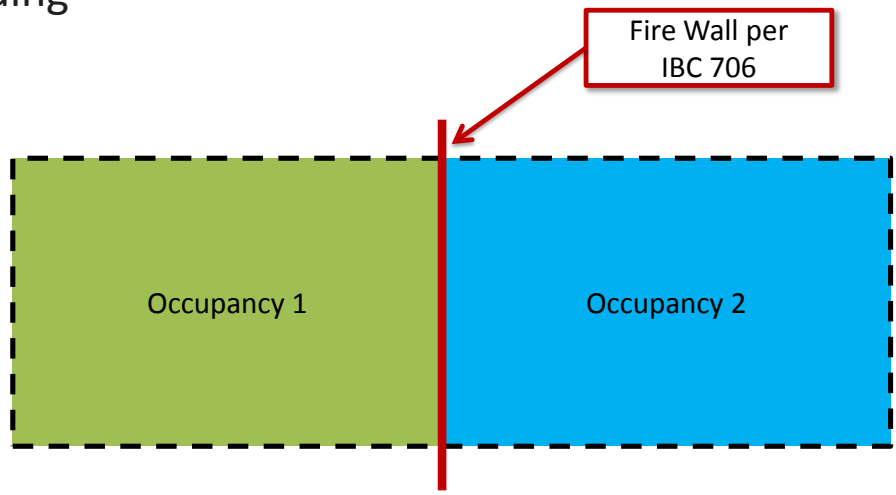
OCCUPANCY	A, E		I-1[a], I-3, I-4		I-2		R[a]		F-2, S-2[b], U		B[e], F-1, M, S-1	
	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS
A, E	N	N	1	2	2	NP	1	2	N	1	1	2
I-1[a], I-3, I-4	—	—	N	N	2	NP	1	NP	1	2	1	2
I-2	—	—	—	—	N	N	2	NP	2	NP	2	NP
R[a]	—	—	—	—	—	—	N	N	1[c]	2[c]	1	2
F-2, S-2[b], U	—	—	—	—	—	—	—	—	N	N	1	2
B[e], F-1, M, S-1	—	—	—	—	—	—	—	—	—	—	N	N
H-1	—	—	—	—	—	—	—	—	—	—	—	—
H-2	—	—	—	—	—	—	—	—	—	—	—	—
H-3, H-4	—	—	—	—	—	—	—	—	—	—	—	—
H-5	—	—	—	—	—	—	—	—	—	—	—	—

Table 508.4 (Abbreviated)

NP = Not Permitted, N = No Separation Required

Separate Buildings

Each portion of a building separated by one or more ***fire walls*** shall be considered to be a separate building



Heights and Areas Calculator

IBC H&A Calculator available from WoodWorks website

http://www.woodworks.org/design-and-tools/design-tools/online-calculators/

Handles Separated Occupancies

Non-Separated Occupancies (Check "both")

Building Code:
Fire Resistance and Detailing

Fire Resistance Ratings – IBC Table 601

Building Element	Type III		Type IV	Type V	
	A	B	HT	A	B
Primary Structural Frame	1	0	HT	1	0
Exterior Bearing Walls*	2	2	2	1	0
Interior Bearing Walls	1	0	1/HT	1	0
Exterior Nonbearing walls*	Varies per Fire Separation Distance – See IBC Table 602				
Interior Nonbearing walls	0	0	See IBC section 602.4.6	0	0
Floors	1	0	HT	1	0
Roofs	1	0	HT	1	0

* See IBC Table 602 for Exterior wall Fire Resistance Rating modifications due to Fire Separation Distance

IBC 2012 Sprinkler Substitute for 1 hour

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A[d]	B	A[d]	B	HT	A[d]	B
Primary structural frame[g] (see Section 202)	3[a]	2[a]	1	0	1	0	HT	1	0
Bearing walls									
Exterior[f, g]	3	2	1	0	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	1/HT	1	0
Nonbearing walls and partitions Exterior	See Table 602								
Nonbearing walls and partitions Interior[e]	0	0	0	0	0	0	See Section 602.4.6	0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	1 1/2[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	HT	1[b,c]	0

For SI: 1 foot = 304.8 mm.

a. Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.

b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members shall not be required, including protection of roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.

c. In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.

d. An approved automatic sprinkler system in accordance with Section 903.3.1.1 shall be allowed to be substituted for 1-hour fire-resistance-rated construction, provided such system is not otherwise required by other provisions of the code or used for an allowable area increase in accordance with Section 506.3 or an allowable height increase in accordance with Section 504.2. The 1-hour substitution for the fire resistance of exterior walls shall not be permitted.

e. Not less than the fire-resistance rating required by other sections of this code.

f. Not less than the fire-resistance rating based on fire separation distance (see Table 602).

g. Not less than the fire-resistance rating as referenced in Section 704.10

2012 INTERNATIONAL BUILDING CODE® 107

IBC 2012 Sprinkler Substitute for 1 hour

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A[d]	B	A[d]	B	HT	A[d]	B

d. An approved automatic sprinkler system in accordance with Section 903.3.1.1 shall be allowed to be substituted for 1-hour fire-resistance-rated construction, provided such system is not otherwise required by other provisions of the code or used for an allowable area increase in accordance with Section 506.3 or an allowable height increase in accordance with Section 504.2. The I -hour substitution for the fire resistance of exterior walls shall not be permitted.

used for such unprotected members.

c. In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.

d. An approved automatic sprinkler system in accordance with Section 903.3.1.1 shall be allowed to be substituted for 1-hour fire-resistance-rated construction, provided such system is not otherwise required by other provisions of the code or used for an allowable area increase in accordance with Section 506.3 or an allowable height increase in accordance with Section 504.2. The 1-hour substitution for the fire resistance of exterior walls shall not be permitted.

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f. Not less than the fire-resistance rating based on fire separation distance (see Table 602).

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IBC 2012 Sprinkler Substitute for 1 hour

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A[d]	B	A[d]	B	HT	A[d]	B

d. An approved automatic sprinkler system in accordance with Section 903.3.1.1 shall be allowed to be substituted for 1-hour fire-resistance-rated construction, provided such system is not otherwise required by other provisions of the code or used for an allowable area increase in accordance with Section 506.3 or an allowable height increase in accordance with Section 504.2. The 1-hour substitution for the fire resistance of exterior walls shall not be permitted.

Removed from IBC 2015

used for such unprotected members.
c. In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.
d. An approved automatic sprinkler system in accordance with Section 903.3.1.1 shall be allowed to be substituted for 1-hour fire-resistance-rated construction, provided such system is not otherwise required by other provisions of the code or used for an allowable area increase in accordance with Section 506.3 or an allowable height increase in accordance with Section 504.2. The 1-hour substitution for the fire resistance of exterior walls shall not be permitted.
e. Not less than the fire-resistance rating required by other sections of this code.
f. Not less than the fire-resistance rating based on fire separation distance (see Table 602).
g. Not less than the fire-resistance rating as referenced in Section 704.10

2012 INTERNATIONAL BUILDING CODE® 107

Fire Resistance Rating -IBC Table 601

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (hours)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A[d]	B	A[d]	B	HT	A[d]	B
Roof construction and secondary members (see Section 202)	1 1/2[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	HT	1[b,c]	0

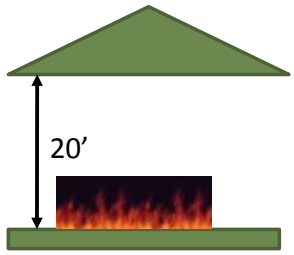
b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members shall not be required, including protection of roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.

c. In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.

Table 601 Footnotes – "b"

Fire protection of structural members shall not be required, where every part of the roof construction is 20 feet or more above any floor immediately below.

- FRT wood allowed in Roofs of Such Type I and II buildings



Except in group F-1, H, M, and S-1 occupancies

Table 601 Footnotes – "c"

Heavy Timber roof can be used where fire rating is 1hr or less

- Applies to any type of construction except Type IA

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (hours)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A[d]	B	A[d]	B	HT	A[d]	B
Roof construction and secondary members (see Section 202)	1 1/2[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	HT	1[b,c]	0

Whole Foods Market
Atlanta, GA

15,000 sf Type VA Structure
67’ Span Glulam trusses @ 14’ o.c. & 2x6 T&G SP Deck
On glulam beams and 8x8 Columns @ 20 ft o.c.

Sources of Fire Rated Assemblies and Components

In the IBC:

- Prescriptive designs of IBC Section 721 and Tables 721.1(2) [Walls] and 721.1(3) [Floors and Roofs].
- Calculated designs of IBC Section 722.

  IBC Section 722.6 can be used for assemblies requiring 1-hour ratings or less.

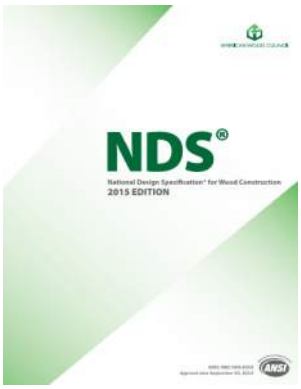
TABLE 721.1(2)—continued
RATED FIRE-RESISTANCE PERIODS FOR VARIOUS WALLS AND PARTITIONS [a, o, p]

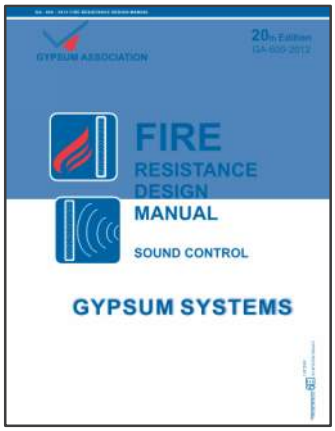
MATERIAL	ITEM NUMBER	CONSTRUCTION	MINIMUM FINISHED THICKNESS FACE-TO-FACE[b] (inches)			
			4 hours	3 hours	2 hours	1 hour
	14-1.1[h, m]	2" × 4" wood studs 16" on center with two layers of $^3/_8$" regular gypsum wallboard[c] each side, 4d cooler[n] or wallboard[n] nails at 8" on center first layer, 5d cooler[n] or wallboard[n] nails at 8" on center second layer with laminating compound between layers, joints staggered. First layer applied full length vertically, second layer applied horizontally or vertically.	—	—	—	5
	14-1.2[l, m]	2" × 4" wood studs 16" on center with two layers $^1/_2$" regular gypsum wallboard[c] applied vertically or horizontally each side[k], joints staggered. Nail base layer with 5d cooler[n] or wallboard[n] nails at 8" on center face layer with 8d cooler[n] or wallboard[n]	—	—	—	$5^1/_2$

Sources of Fire Rated Assemblies and Components

Referenced from the IBC

- NDS Chapter 16 can be used for exposed wood construction up to a 2-hour rating. Referenced from IBC 722.1
- US Gypsum GA-600. Referenced from IBC Tables 721.1





Sources of Fire Rated Assemblies and Components

Commonly Approved Sources:

- American Wood Council's DCA3: Fire-Rated Wood-Frame Wall and Floor/Ceiling Assemblies
- APA's Document W305 – Fire-Rated Systems.
- SBCA's Metal Plate Connected Wood Truss Handbook – Section 17 Fire Performance of Trusses
- Underwriters Laboratory Fire Rated Listing

An "UL Assembly" listed by the Underwriters Laboratory is only ONE of MANY routes to compliance with fire ratings.

Retail Store Case Study

Retail Store Design

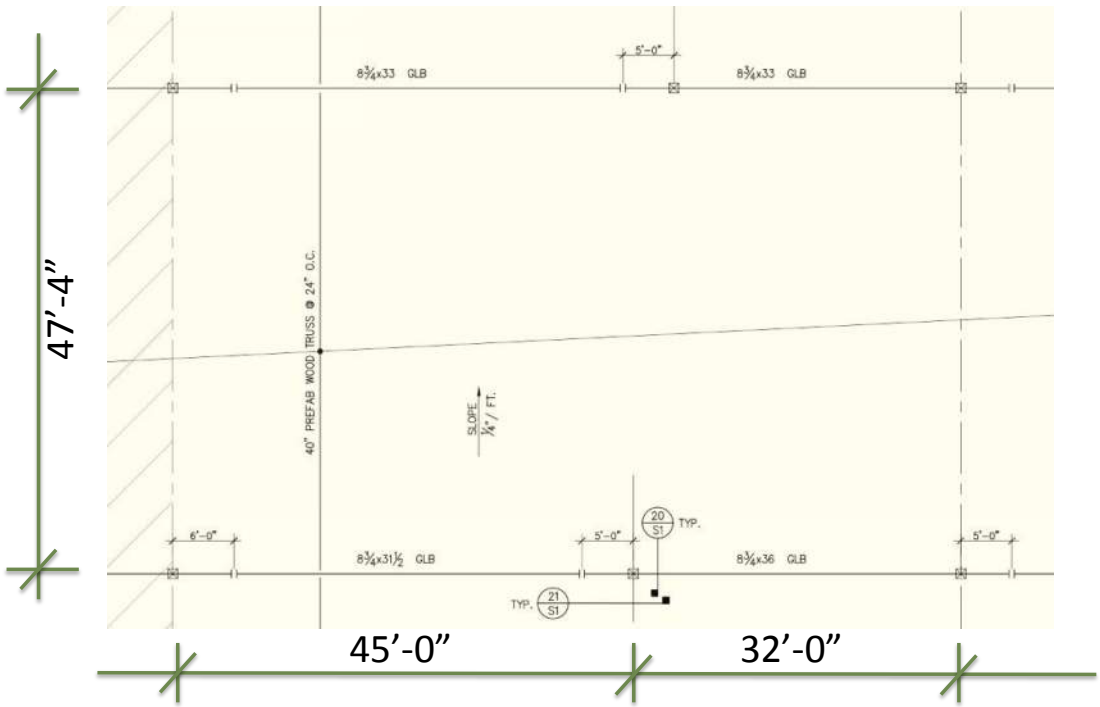
- 55,000 sf chain grocery store in northern CA
- Originally designed and built with steel and masonry
- WoodWorks commissioned structural re-design with wood framing
- Comparing original to wood re-design, WoodWorks commissioned cost estimate & LCA studies

Big Cost Savings for Retail Store

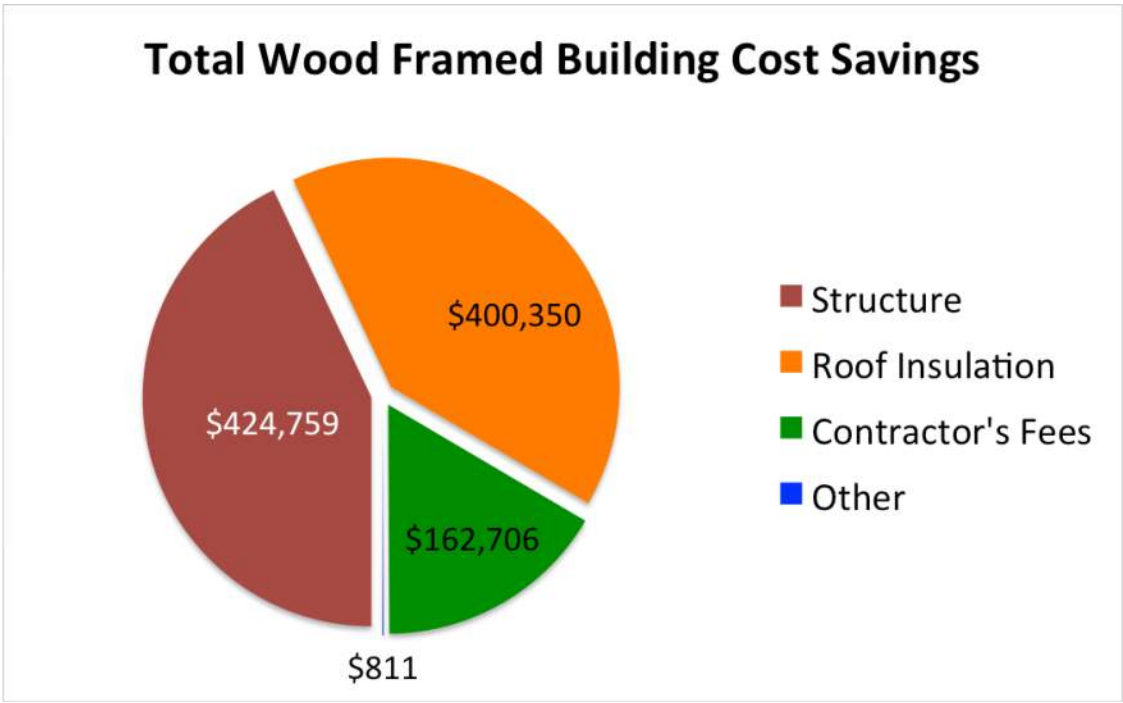
- Original Steel & Masonry Building: $4.49 M
- Wood Building: $3.5 M
- Nearly **$1 M Savings** – 22% Savings - $18/sf Savings

Retail Store: Gravity Framing System

Partial Roof Framing Plan



Cost Savings Factor: Structure



Cost Savings Factor: Roof Insulation

- Original Steel & Masonry Building: 4.5” Extruded Polystyrene (XPS) Rigid Insulation on Top of Steel Roof Deck. R-22. Cost = $783,000
- Wood Building: 5.5” Fiberglass Batts Between Roof Trusses. R-22. Cost = $383,000
- **Roof Insulation Savings of $400,000**

Source: Owens Corning

Source: Networx

Cost Savings Factor: Structure

Source: Canadian Wood Council

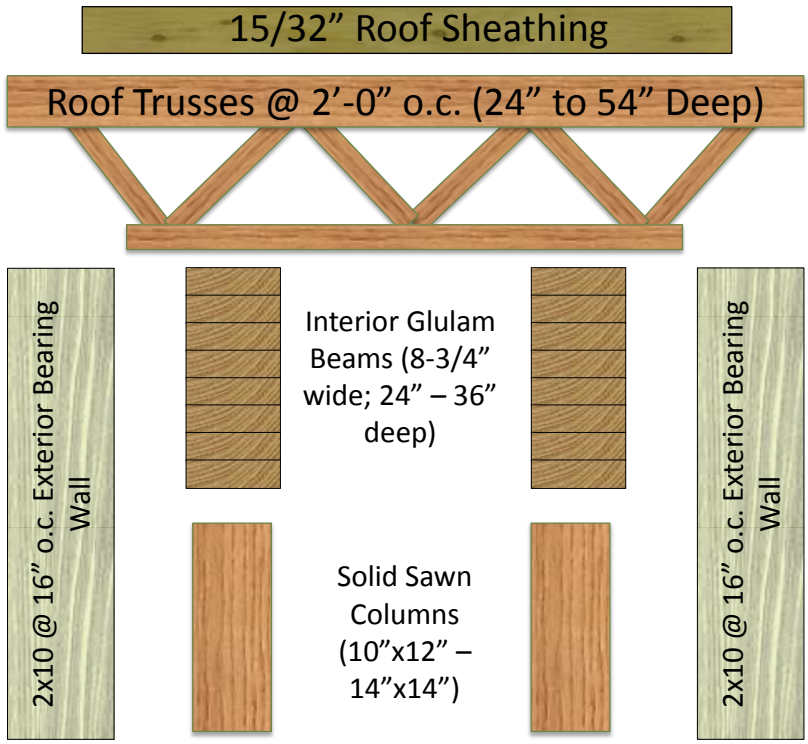
Cost Savings Factor: Structure

Source: APA

Total Structure Cost Savings for Wood Building = $425,000

Source: LP Building Products

Retail Store: Gravity Framing System

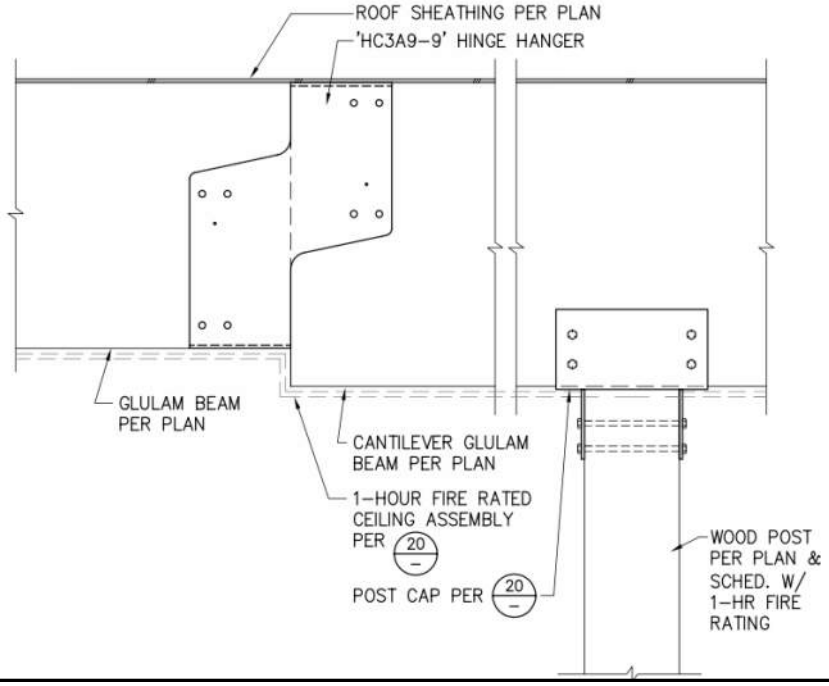


Cost Savings Factor: Structure

Category	Steel Bldg Element	Wood Bldg Element	Wood Bldg Cost Savings
Roof Beams	Open web steel joist girders	Glulam Beams	$164k
Roof Decking	1-1/2” Steel Deck	15/32” Sheathing	$114k
Columns	HSS Columns	Solid Sawn Columns	$107k
Primary Roof Framing	Open web steel joists	Prefab Trusses	$66k
Wall Framing	6” metal studs & 8” masonry	2x10 @ 16” o.c.	$54k
Ceiling	N.A.	5/8” gyp & RC	$80k Extra
Total Wood Structure Cost Savings			**$425k**

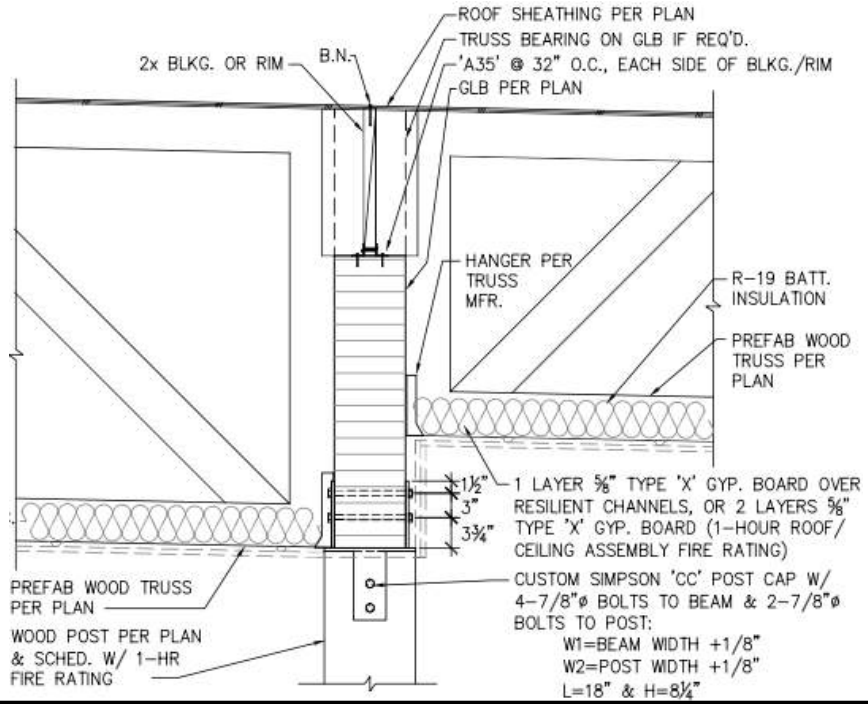
Retail Store: Gravity Framing System

Glulam Roof Beam Connection Details



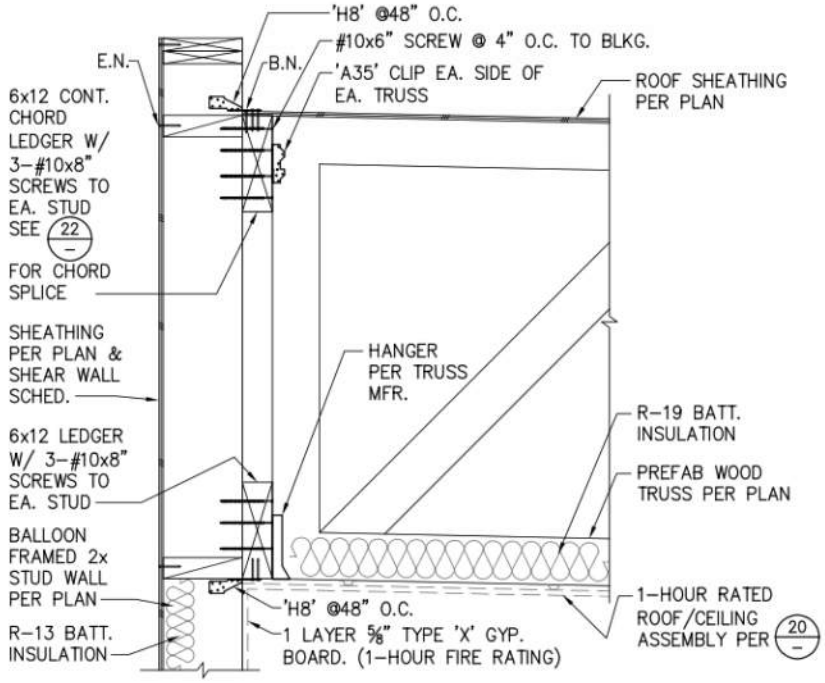
Retail Store: Gravity Framing System

Glulam Roof Beam Connection Details



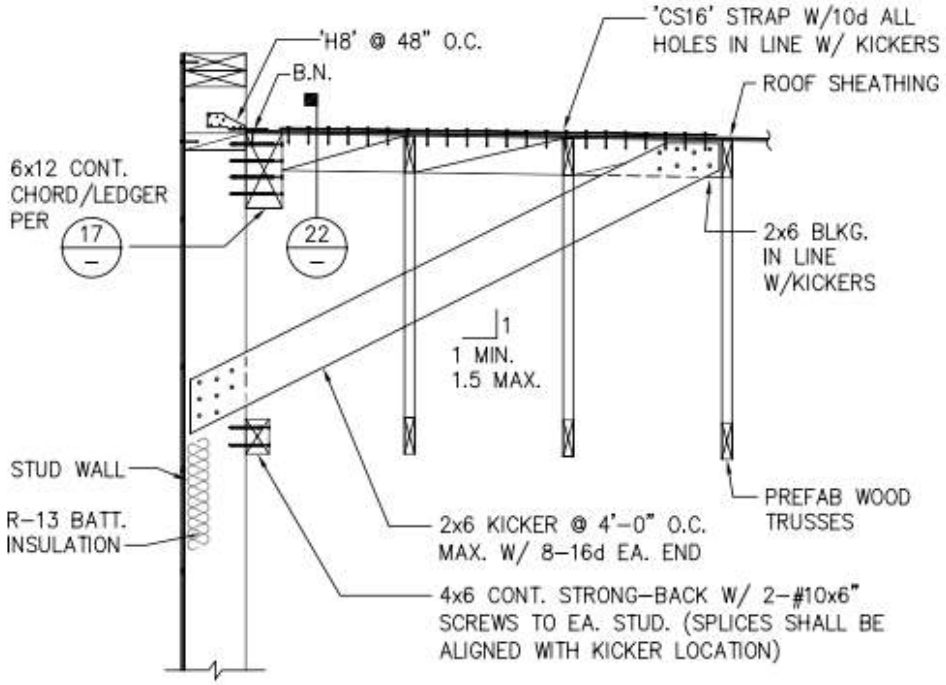
Retail Store: Gravity Framing System

Exterior Wall Details

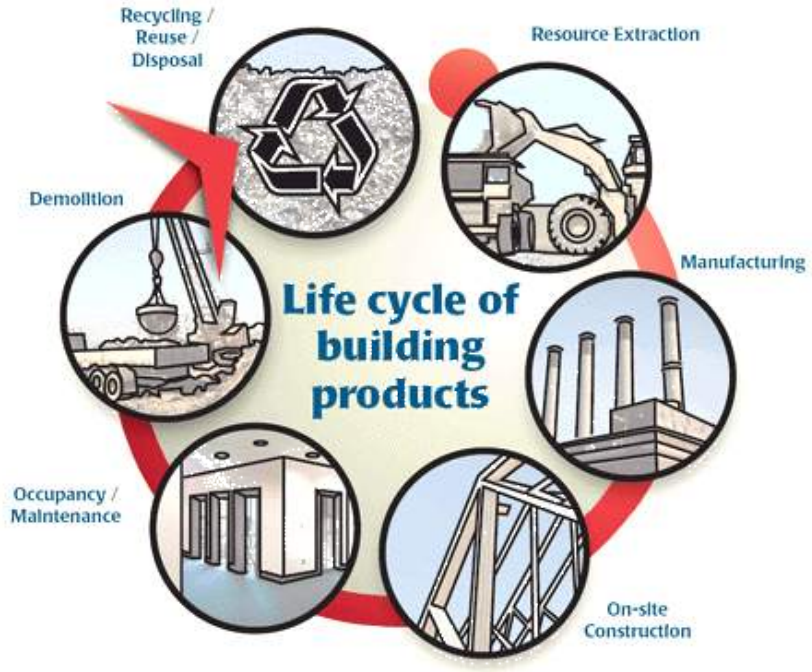


Retail Store: Gravity Framing System

Exterior Wall Details



Life Cycle Assessment

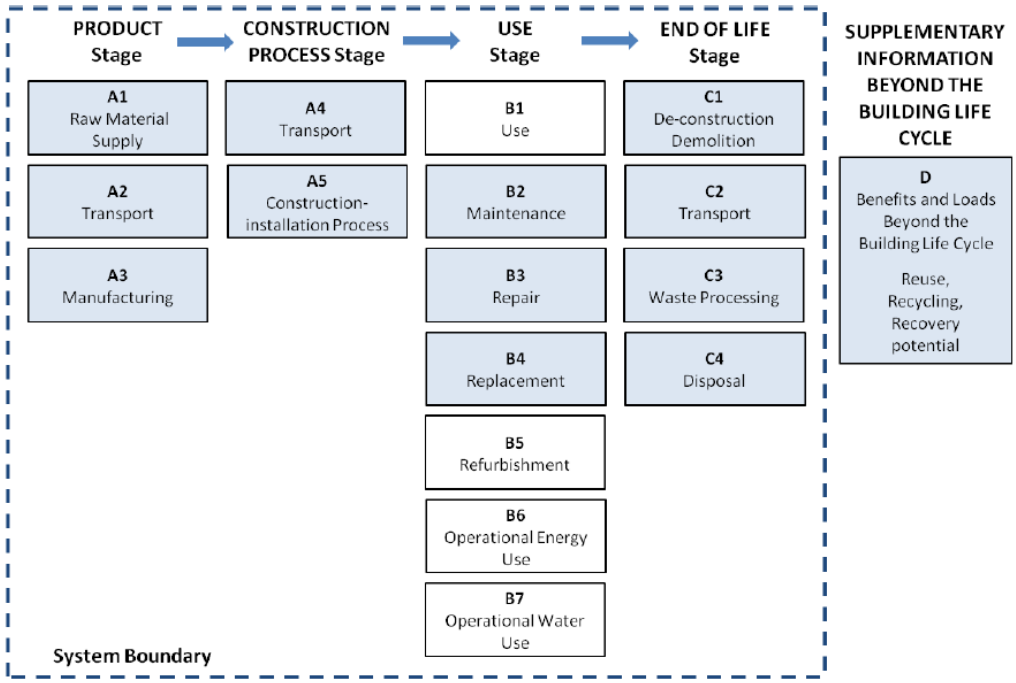


Source: Athena Sustainable Materials Institute

Life Cycle Assessment

- Measures the environmental impacts of materials, assemblies or buildings over their entire lives—from extraction or harvest of raw materials through manufacturing, transportation, installation, use, maintenance and disposal or recycling.
- Allows design professionals to compare different building designs based on their environmental impacts and make informed choices about the materials they use.

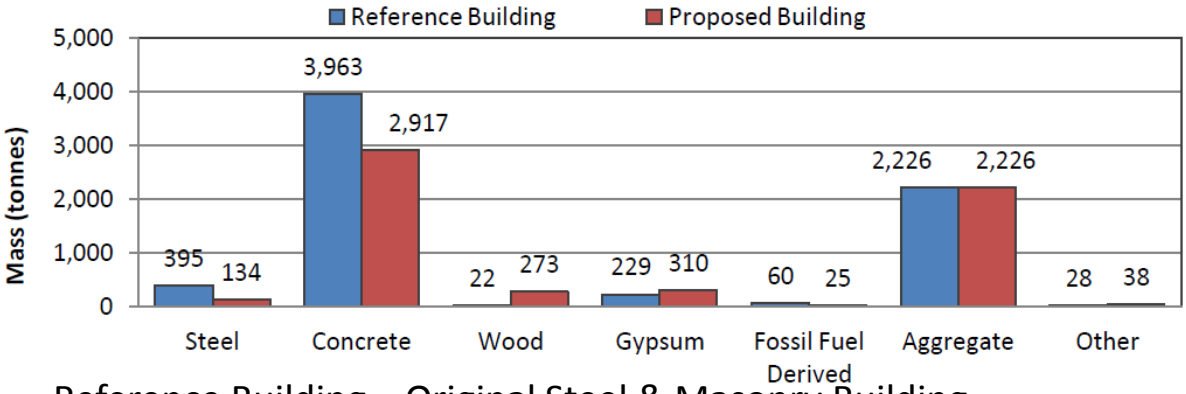
Life Cycle Assessment (LCA)



Source: Athena Sustainable Materials Institute

Retail Store: LCA Comparison

Life Cycle Product Use Mass Comparison by Building Product Type



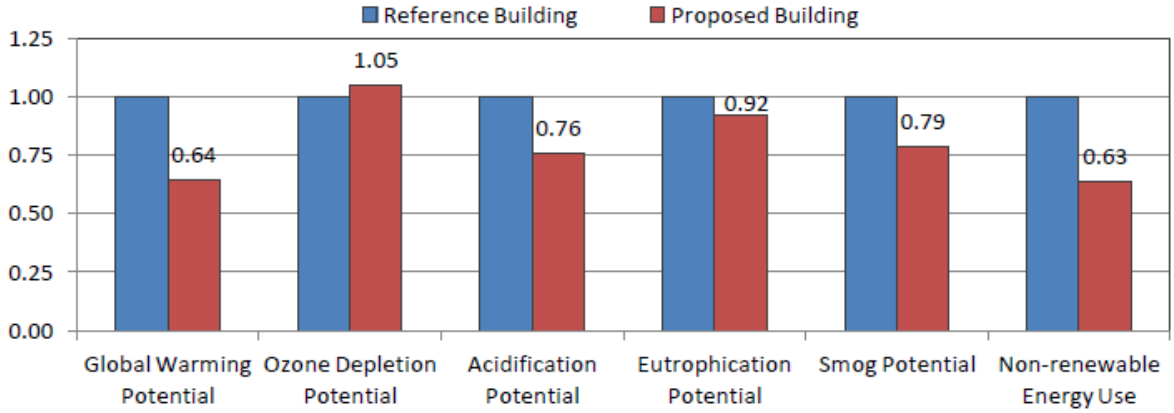
Reference Building = Original Steel & Masonry Building

Proposed Building = Wood Building

Source WoodWorks Case Study "Big Box Retail: Wood Saves Nearly $1 million" available at http://www.woodworks.org/wp-content/uploads/Big-Box-Retail-Wood-vs-Steel-Oct-2015.pdf

Retail Store: LCA Comparison

LCA Results Comparison – Raw Materials through Demolition/Disposal



Reference Building = Original Steel & Masonry Building

Proposed Building = Wood Building

Source WoodWorks Case Study "Big Box Retail: Wood Saves Nearly $1 million" available at http://www.woodworks.org/wp-content/uploads/Big-Box-Retail-Wood-vs-Steel-Oct-2015.pdf

Closure

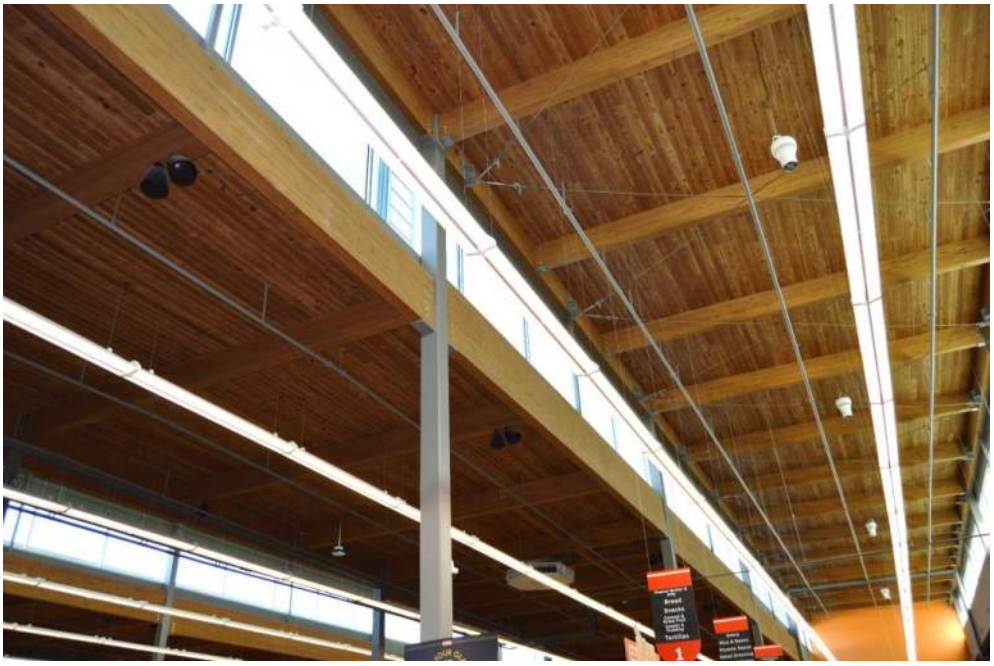
Yard House Bar & Grill

6,500 sq ft restaurant
Chino Hill, CA

Architectural Grade Glulam Beams
I-Joist Roof Framing
Doug Fir Posts
Wood Stud Exterior Walls

Mueller HEB - Austin

Mueller HEB - Austin



Mueller HEB - Austin

Boudin SF

Santa Rosa, CA

7200 sq ft
Restaurant
& Coffee Shop

Boudin SF

Alaskan Yellow Cedar GluLam Beams
Doug Fir Ceiling Planks
Engineered Wood Wall Studs

Additional Resources

American Wood Council Publications: www.awc.org

- National Design Specification (NDS) for Wood Construction
- Special Design Provisions for Wind and Seismic (SDPWS)
- Wood Frame Construction Manual (WFCM)
- Code Conforming Wood Design Series

Force Transfer Around Openings Paper by APA

- www.apawood.org/Data/Sites/1/documents/technicalresearch/seaoc-2015-ftao.pdf

Metal Plated Wood Trusses:

- Structural Building Components Association. www.SBCIndustry.com

Large Commercial Roof Design:

- www.woodworks.org/design-and-tools/building-systems/panelized-roofs-publications/

Big Box Retail Design Case Study:

- www.woodworks.org/wp-content/uploads/Big-Box-Retail-Wood-vs-Steel-Oct-2015.pdf

Questions?

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