



State of Connecticut  
Department of Administrative Services  
Division of Construction Services  
Office of Education and Data Management

## Soils and Foundations: 2012 IBC

*Presented by  
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for the*

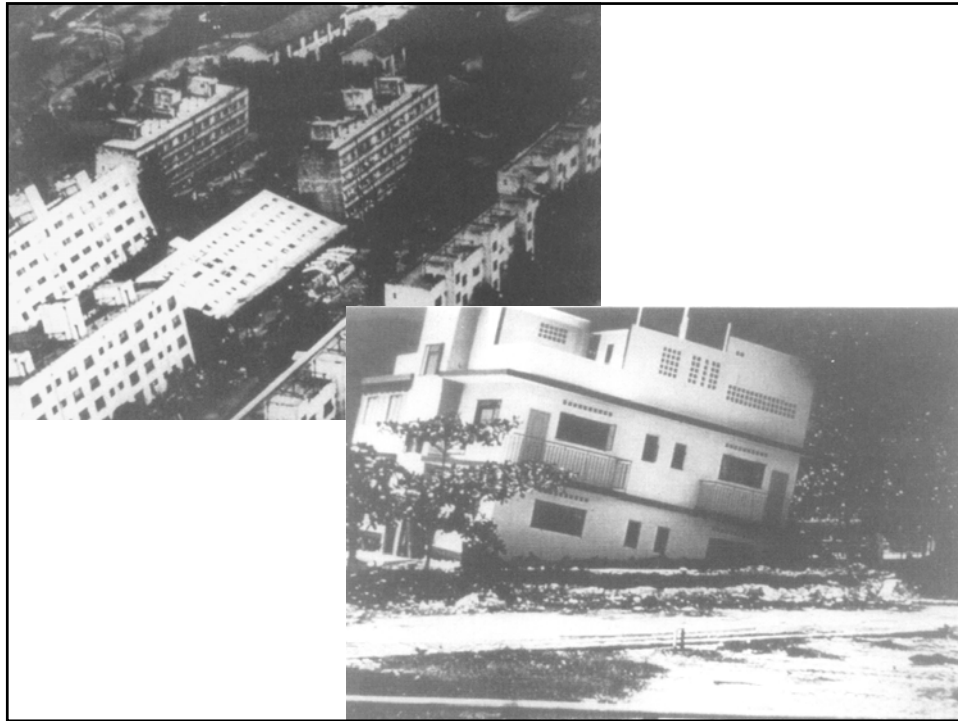
*Office of Education and Data Management  
Spring 2016 Career Development Series*

## Soils and Foundations

- Seminar will review the International Building Code requirements for soils and foundations:
  - Geotechnical investigations, foundation and soils
  - excavation, grading and fill,
  - load bearing values of soils,
  - dampproofing and waterproofing
  - design and construction of foundations
    - Shallow Foundations
    - Deep Foundations

Office of Education and Data Management - January 2016 Career Development





## Chapter 18 -Soils and Foundations International Building Code 2012

- 1801 General
- 1802 Definitions
- 1803 Geotechnical Investigations
- 1804 Excavation, Grading, and Fill
- 1805 Dampproofing & Waterproofing
- 1806 Presumptive Load-Bearing Values of Soils
- 1807 Walls, Posts, Poles
- 1808 Foundations
- 1809 Shallow Foundations
- 1810 Deep Foundations

## Section 1801 General

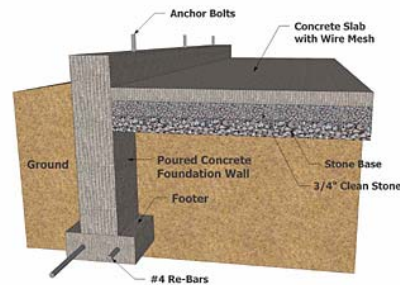
- Scope
  - The provisions of IBC Chapter 18 Soils and Foundations applies to building and foundation systems

## Section 1801 General

- Design
  - Allowable bearing pressure, allowable stresses and design formulas provided shall be used with the allowable stress design load combinations specified in Section 1605.3 - Load combinations using allowable stress design.
  - Quality and design of materials used structurally in excavations, footings and foundations shall conform to requirements specified in Chapter 16-Structural Design, 19-Concrete, 21-Masonry, 22-Steel and 23-Wood.
  - Excavations and fills shall also comply with Chapter 33 Safeguards During Construction.

## Design Basis

- 1801.2 Design basis
  - Section 1605.3 design considerations
    - All loads must be considered
      - Dead
      - Live
      - Wind
      - Flood
      - Seismic



## Section 1801 General

- Refer to Structural Design Section 1605.3 - Load combinations using allowable stress design.
  - Section 1605.3.1 Basic load Calculations
    - $D + F$
    - $D + H + F + L$
    - $D + H + F + (L_r \text{ or } S \text{ or } R)$
    - $D + H + F + 0.75(L) + 0.75 (L_r \text{ or } S \text{ or } R)$
    - $D + H + F + 0.75(0.6W) + 0.75L + 0.75 (L_r \text{ or } S \text{ or } R)$
    - $D + H + F + 0.75(0.7E) + 0.75 L + 0.75 S$
    - $0.6 D + 0.6W + H$
    - $0.6 (D+F) + 0.7 E + H$

## Section 1801 General

- Refer to Structural Design Section 1605.3 - Load combinations using allowable stress design.
  - Section 1605.3.2 Alternative basic load calculations
    - $D + L + (L_r \text{ or } S \text{ or } R)$
    - $D + L + 0.6 \omega W$
    - $D + L + 0.6 \omega W + S/2$
    - $D + L + S + 0.6 \omega W/2$
    - $D + L + S + E/1.4$
    - $0.9D + E/1.4$

## Lateral Soils Loads

TABLE 1610.1  
LATERAL SOIL LOAD

DESCRIPTION OF BACKFILL MATERIAL <sup>a</sup>	UNIFIED SOIL CLASSIFICATION	DESIGN LATERAL SOIL LOAD <sup>a</sup> (pound per square foot per foot of depth)	
		Active pressure	At-rest pressure
Well-graded, clean gravels; gravel-sand mixes	GW	30	60
Poorly graded clean gravels; gravel-sand mixes	GP	30	60
Silty gravels, poorly graded gravel-sand mixes	GM	40	60
Clayey gravels, poorly graded gravel-and-clay mixes	GC	45	60
Well-graded, clean sands; gravelly sand mixes	SW	30	60
Poorly graded clean sands; sand-gravel mixes	SP	30	60
Silty sands, poorly graded sand-silt mixes	SM	45	60
Sand-silt clay mix with plastic fines	SM-SC	45	100
Clayey sands, poorly graded sand-clay mixes	SC	60	100
Inorganic silts and clayey silts	ML	45	100
Mixture of inorganic silt and clay	ML-CL	60	100
Inorganic clays of low to medium plasticity	CL	60	100
Organic silts and silt clays, low plasticity	OL	Note b	Note b
Inorganic clayey silts, elastic silts	MH	Note b	Note b
Inorganic clays of high plasticity	CH	Note b	Note b
Organic clays and silty clays	OH	Note b	Note b

For SE: 1 pound per square foot per foot of depth = 0.157 kPa/m, 1 foot = 304.8 mm.  
 a. Design lateral soil loads are given for moist conditions for the specified soils at their optimum densities. Actual field conditions shall govern. Submerged or saturated soil pressures shall include the weight of the buoyant soil plus the hydrostatic loads.  
 b. Unsuited as backfill material.  
 c. The definition and classification of soil materials shall be in accordance with ASTM D 2487.

## Section 1803 Geotechnical Investigations

- 1803.1 General (Geotechnical Investigations)
  - 1803.2 Investigations Required
    - Exception: Building Official permitted to waived requirement where satisfactory
  - 1803.3 Basis
    - Bore samples
    - Test pits
    - Other sub-surface exploration
      - Trained gopher?



## Section 1803.3 Basis Investigations

- Soil classification shall be based on
  - observation
  - Any other necessary tests of the materials disclosed by
    - Borings
    - Test pits
    - Other subsurface explorations
- Additional Studies as necessary

## Section 1803.3 Basis Investigations

- Additional Studies as necessary to evaluate
  - Slope stability
  - Soil strength
  - Position
  - Adequacy of load bearing soils
  - Effects of moisture variation on soil bearing capacity, compressibility, liquefaction and expansiveness

## Scope of Investigation

- 1803.3.1 Scope of Investigation
  - Including
    - Number and types of boring or soundings
    - The Equipment used to drill or sample
    - The in-situ testing equipment
    - Laboratory testing program
    - Shall be determined by a registered design professional.

## Geotechnical Investigations

- 1803.4 Qualified representative
  - Directed by Design professional
- 1803.5 Investigated Conditions
  - Soil classification
  - Questionable soil bearing ability
  - Expansive soil
  - Ground Water-table
  - Deep foundations
  - Rock strata
  - Excavation near foundations
  - Fill requirements
  - Slope considerations
  - Stability during seismic event

## Section 1803 Geotechnical Investigations

### **1803.5 Investigated conditions.**

This section provides parameters for classification of soils in accordance with the code.

- **1803.5.1 Classification.**

- Soil Materials shall be classified in accordance with ASTM D 2487.



## Section 1803 Geotechnical Investigations

### **1803.5.2 Questionable soil.**

The building official shall be permitted to require that a Geotechnical Investigation be conducted

- Where the classification, strength or compressibility of the soil is in doubt, or
- Where a load-bearing value superior to that specified in this code is claimed,

## Section 1803 Geotechnical Investigations

### **1803.5.3 Expansive soils.**

- In areas likely to have expansive soil, the building official shall require soil tests to determine where such soils do exist.
- Soils Meeting all four of the following provisions
  - Plasticity index (PI) of 15 or greater, (ASTM D 4318)
  - More than 10 % of the soil particles pass a No. 200 sieve (D442)
  - More than 10 % of the soil particles are less than 5 micrometers in size (ASTM D 422)
  - Expansion index greater than 20 (ASTM D 4829)

## Section 1803 Geotechnical Investigations

### **1803.5.4 Ground-water table.**

- A subsurface soil investigation shall be performed to determine whether the existing ground-water table is above or within 5 feet (1524 mm) below the elevation of the lowest floor level where such floor is located below the finished ground level adjacent to the foundation.

**Exception:** A subsurface soil investigation shall not be required where waterproofing is provided in accordance with Section 1805.

## Section 1803 Geotechnical Investigations

### **1803.5.5 Deep foundations**

- Where used
  - Recommend deep foundation types & installed capacities
  - Center to center spacing of elements
  - Driving criteria
  - Installation procedures
  - Field inspections and Reporting procedures
  - Load Testing requirements
  - Designation of bearing stratum or strata
  - Reductions for group action where necessary

## Section 1803

### Geotechnical Investigations

#### **1803.5.6 Rock strata.**

Where subsurface explorations at the project site indicate variations or doubtful characteristics in the structure of the rock upon which foundations are to be constructed, a sufficient number of borings shall be made to a depth of not less than 10 feet (3048 mm) below the level of the foundations to provide assurance of the soundness of the foundation bed and its load-bearing capacity.

#### **1803.5.7 Excavation near Foundation**

Where excavation will remove lateral support from any foundation, an investigation shall be conducted to assess potential consequences

## Section 1803

### Geotechnical Investigations

#### **1803.5.8 Compact fill materials.**

- Where shallow foundations will bear of compacted fill more than 12 inches in depth a geotechnical investigation shall be conducted

#### **1803.5.9 Controlled low strength materials**

- Where shallow foundations will bear of controlled low-strength materials (CLSM) a geotechnical investigation shall be conducted

#### **1803.5.10 Alternate Setback and Clearance.**

- Where setbacks or clearances other than those required in Section 1808.7 are desired, The building official shall be permitted to require a geotechnical investigation by a registered design professional to demonstrate that the intent of Section 1808.7 would be satisfied.

## Section 1803

### Geotechnical Investigations

#### 1803.5.11 Seismic Design Category C through F.

- For Seismic Design Category C, D, E or F an investigation shall be conducted, and evaluate earthquake motions potential hazards resulting from: slope instability, liquefaction and surface rupture due to faulting or seismically induced lateral spreading or Lateral flow.

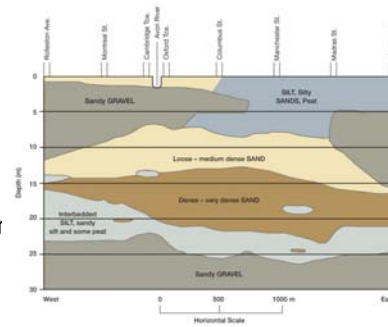
#### 1803.5.12 Seismic Design Category D through F. The Seismic Design Category D, E or F includes soils investigation requirements for Seismic Design Category C through F, **Plus**

- lateral earth pressures on basement and retaining walls
- Potential for liquefaction and soil strength loss etc.
- An assessment of potential consequences
- Mitigation measures

## Reporting

#### • 1803.6 Reporting of Geotechnical Investigations

- Submitted to the BO
- Includes:
  - 1. Plot
  - 2. Record of samples
  - 3. Soil profile
  - 4. Water table, if encountered
  - 5. Foundation recommendation
  - 6. Settlement expectation
  - 7. Deep foundation consideration
  - 8. Expansive soil foundations
  - 9. Compacted fill requirements
  - 10. Shallow foundation bearing



## Section 1804 Excavation, Grading and Fill

### 1804.1 - Excavations near foundations

Excavations for any purpose shall not remove lateral support from any foundation without first underpinning or protecting foundation against settlement or lateral translation.



## Excavation, Grading, Filling

- 1804 Excavation, Grading, Filling
  - Adjacent structures protected
    - Underpinned
    - Lateral support
  - ‘Clean’ backfill
    - No organics
    - Junk
    - Boulders
    - Installed in compacted ‘lifts’
    - No damage to moisture protection



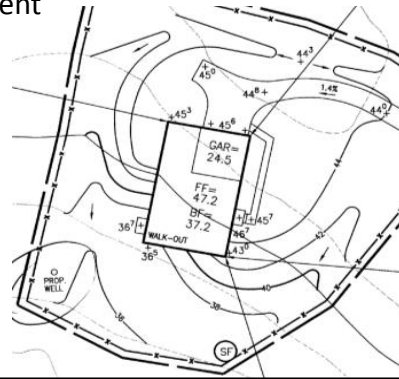
### Section 1804 - Excavation, Grading and Fill 1804.2 - Placement of backfill.

The excavation outside the foundations

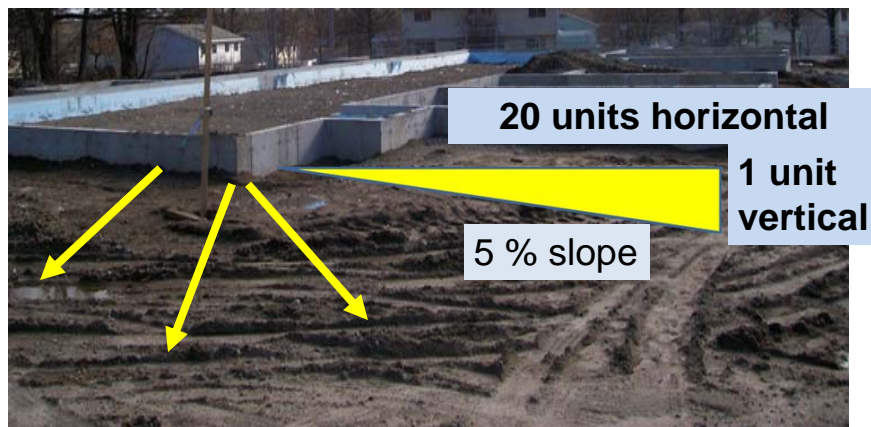
- Shall be backfilled with soil that is free of organic material, construction debris, cobbles and boulders or a controlled low strength material (CLSM)
- Backfill shall be placed in lifts and compacted in a manner that does not damage the foundation or the waterproofing or dampproofing material.

## Excavation, Grading, Filling

- 1804.3 Site Grading
  - 1:20 (5% slope) for distance of 10'
  - Drainage required if 10' not possible
  - 2% slope for swales and pavement



### 1804.3 - Site Grading.



## Excavation, Grading, Filling

- 1804 Excavation, Grading, Filling
  - 1804.4 Grading and fill in flood hazard Areas
    - Placed & sloped to minimize movement
    - Material will not exacerbate flooding
    - Will not divert waves toward structures
    - Will not become a dam to drainage



## Section 1804 - Excavation, Grading and Fill

1804.4 – (2) Grading and fill in floodways.

- Requires hydrologic and hydraulic analyses performed by a registered design professional
- In accordance with standard engineering practice
- Proposed grading or fill or both will not result in any increase in flood levels during the occurrence of the design flood.



## Section 1804 - Excavation, Grading and Fill 1804.5 – Compacted Fill Material.

Where Shallow Foundations will bear on compacted fill materials, compacted fill shall comply with the provisions of an approved geotechnical report which contains:

1. Specifications for site preparations
2. Specifications for materials to be used as compacted fill.
3. Test methods to determine max dry density and optimum moisture content
4. Maximum allowable thickness of each lift
5. Field test methods for determining in-place dry density
6. Minimum acceptable in-place dry density (accordance with 3)
7. Number and frequency of field tests

## 1804 Excavation, Grading, Filling

- 1804.5 Compacted Fill
  - Engineered design
    - Exception for shallow fill
  - Requires 1705.6 Special Inspection
- 1804.6 Controlled low-strength material (CLSM)
  - CLSM comply with provisions of approved geotechnical report



## Section 1804 - Excavation, Grading and Fill 1804.6 – Controlled Low-Strength Material.

Where shallow foundations will bear on controlled low-strength materials (CLSM), CLSM shall comply with the provisions of an approved geotechnical report (1803) which contain:

1. Specifications for site preparations
2. Specifications for the CLSM
3. Laboratory or Field Test method(s) used to determine the compressive strength or bearing capacity of the CLSM
4. Test methods for determining the acceptance of the CLSM in the field
5. Number and frequency of field test required to determine compliance with item 4.





**Examples of Compactors**

- 1. Manually Operated Walk-Behind Vibratory Plate Compactor**
- 2. Single Drum Vibratory Soil Compactor**





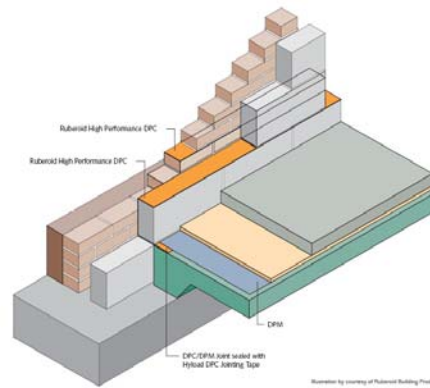
## Dampproofing and Waterproofing

- 1805.2 Dampproofing
  - Water vapor impediment
  - Compound or coating
  - Footing top to above ground
  - Sub-grade occupied areas
  - Water table is 5" below floor
- 1803.5.4 Ground-water table
  - Investigation may eliminate damp proofing as option
    - Must –waterproof



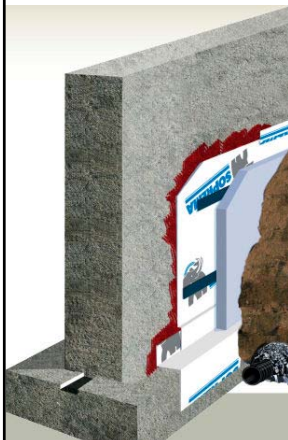
## Dampproofing and Waterproofing

- 1805.2.1 Dampproofing Floors
  - 6 mil polyethylene
  - Proper laps
  - Other approved materials
    - 4 mil plastic above floor
      - With finish floor
    - Mopped bitumen



## Dampproofing and Waterproofing

- 1805.3 Waterproofing
  - As 1803.5.4 investigation indicates
    - Hydrostatic pressure found at floor level
  - Higher degree of protection
  - Generally a membrane material
  - Hydrostatic pressure resistant
  - Bottom of wall to 12" over water table



## Dampproofing and Waterproofing

- 1805.3.1 Waterproofing Floors
  - Must be concrete
    - To counter hydraulic pressure
  - Membrane materials
    - Simple placement of 4 or 6 mil polyethylene would not meet compliance
    - 6 mil PVC lapped and sealed will work



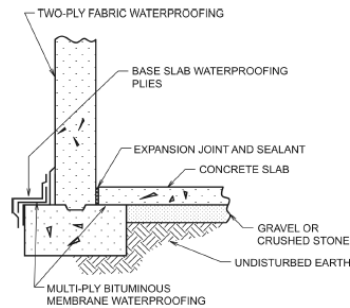
## Dampproofing and Waterproofing

- 1805.3.1 Waterproofing Walls
  - Must be concrete or masonry
    - Designed to handle the hydrostatic pressure
  - 12" above water table
    - Area above this need only be damp proofed
  - Prescriptive materials
  - Other approved methods
    - 104.11



## Dampproofing and Waterproofing

- 1805.3.3 Joint treatment
  - Waterproofing requires sealing at floor / wall joint
    - Water tight



....

## Dampproofing and Waterproofing

- 1805.3.3 Penetration Waterproofing
  - “Approved methods”

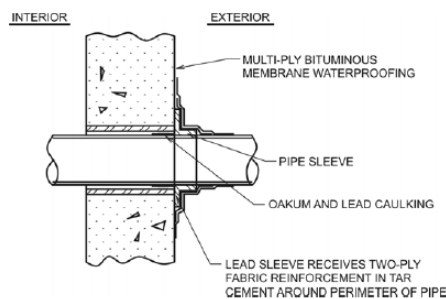
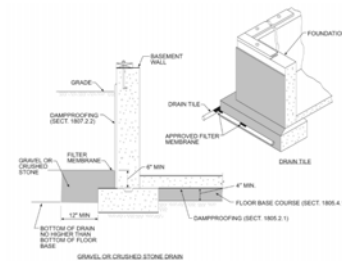


Figure 1805.3.3(2)  
PIPE DETAIL—PROPER PLACEMENT OF WATERPROOFING ELEMENTS

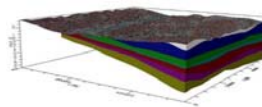
## Dampproofing and Waterproofing

- 1805.4 Subsoil Drainage System
  - Used in conjunction with dampproofing
  - Under floor - 4" thick gravel of specific size
  - Exterior perimeter drain in gravel
  - Gravity or mechanical disposal



## Dampproofing and Waterproofing

- 1805.1.3 Engineered system
- (Big scale drain application)
  - Hydraulic considerations
    - Soil type(s)
    - Hydraulic pressure
  - Water table modification
    - Drainage
    - Retention pond control dams
  - Possibly very large scale (acres)
    - Slurry wall barriers
    - Continuous pumping
    - Relief wells





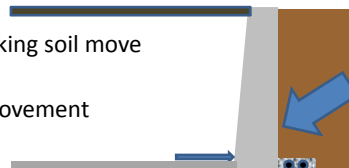
## Section 1806

### Presumptive Load Bearing Values of Soils

- Presumptive Load-Bearing Values
  - See Table 1806.2 Allowable Foundation and Lateral Pressure
  - Shall be used with the allowable stress design load combination

### Presumptive Load Bearing Values of Soils

- Table 1806.2 Presumptive Load Bearing Values
  - Lateral bearing pressure – soils close to surface
    - Resistance to pressure exerted horizontally
    - Increases with depth
      - 15X limitation per 1806.3.3
  - Lateral sliding resistance
    - Coefficient of friction
      - Difficulty factor related to making soil move
    - Cohesion
      - Ability of 'muck' to prevent movement
      - 130 psf



## Section 1806 Allowable Load Bearing Values of Soils

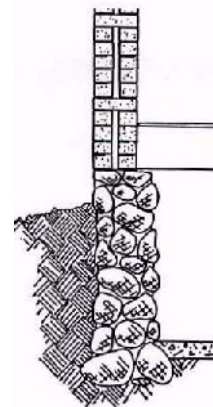
**TABLE 1806.2**  
ALLOWABLE FOUNDATION AND LATERAL PRESSURE

CLASS OF MATERIALS	ALLOWABLE FOUNDATION PRESSURE (psf) <sup>a</sup>	LATERAL BEARING (psf/ft below natural grade) <sup>d</sup>	LATERAL SLIDING	
			Coefficient of friction <sup>b</sup>	Resistance (psf) <sup>c</sup>
1. Crystalline bedrock	12,000	1,200	0.70	—
2. Sedimentary and foliated rock	4,000	400	0.35	—
3. Sandy gravel and/or gravel (GW and GP)	3,000	200	0.35	—
4. Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)	2,000	150	0.25	—
5. Clay, sandy clay, silty clay, clayey silt, silt and sandy silt (CL, ML, MH and CH)	1,500 <sup>e</sup>	100	—	130

For SI: 1 pound per square foot = 0.0479 kPa, 1 pound per square foot per foot = 0.157 kPa/m.  
 a. Coefficient to be multiplied by the dead load.  
 b. Lateral sliding resistance value to be multiplied by the contact area, as limited by Section 1804.3.  
 c. Where the building official determines that in-place soils with an allowable bearing capacity of less than 1,500 psf are likely to be present at the site, the allowable bearing capacity shall be determined by a soils investigation.  
 d. An increase of one-third is permitted when using the alternate load combinations in Section 1605.3.2 that include wind or earthquake loads.


## Foundation Walls, Retaining Walls and Embedded Post and Poles

- Section 1807.1 Foundation Walls
  - Foundation walls
  - Lateral soil loads
  - Unbalanced backfill
  - Rubble stone
  - Wood foundations
  - Concrete & Masonry Foundations
  - Prescriptive Concrete & Masonry Foundations



## Foundation Walls, Retaining Walls and Embedded Post and Poles

- Section 1807.2 Retaining Walls
  - Designed
    - Ensure stability against
      - Overturning
      - Sliding
      - Excessive Foundation Pressure
      - Water uplift
      - lateral resistance must be countered at the wall's base?
    - Lateral Soil Loads
    - Safety Factor



### Retaining Walls

- Design to ensure Stability against:
  - Overturning
  - Sliding
  - Excessive Foundation Pressure
  - Water Uplift
- Design for a Safety Factor of 1.5 against Lateral Sliding and overturning

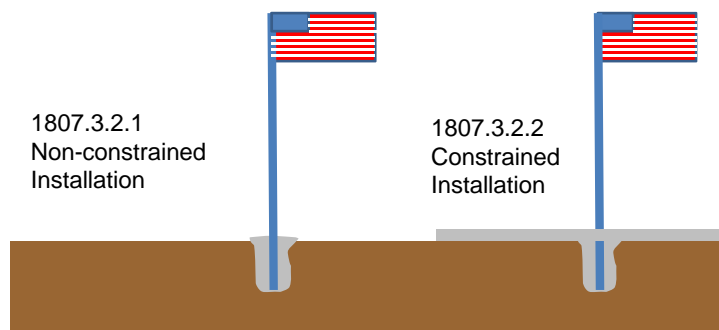
## Embedded Posts & Poles

- Section 1807.3 Embedded Posts & Poles
  - Axial & lateral loads must be considered
  - Type of soil is important to resist:
    - Lateral movement due to soil movement
    - Lateral movement due to 'slippery' soil
  - Depth of embedment is important
  - Type of embedment is important
    - Backfill is prescriptive
      - 2000 psi concrete
      - Sand
      - CLSM



## Embedded Posts & Poles

- 1807.3.2 Design Criteria



## Embedded Posts & Poles

- 1807.3.2.1 Non constrained Embedment

- Equation 18-1

- $d = 0.5A\{1 + [1 + (4.36h/A)]^{1/2}\}$
- Where:  $A = 2.34P/(S_1b)$



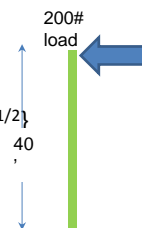
- $b$  = diameter of round post or footing / diagonal of other
- $d$  = depth of embedment to maximum of 12'
- $h$  = height to application of lateral force
- $P$  = applied lateral force in pounds
- $S_1$  = Section 1806.2 lateral pressure limit at 1/3 embed depth

## Embedded Posts & Poles

- 1807.3.2.1 Non constrained Embedment

- Equation 18-1

- $d = 0.5A\{1 + [1 + (4.36h/A)]^{1/2}\}$
- Where:  $A = 2.34P/(S_1b)$
- Step 1  $A = 2.34 \cdot 200 / (450 \cdot 1)$
- $A = 1.04$
- Step 2  $d = 0.5A\{1 + [1 + (4.36h/A)]^{1/2}\}$
- $d = 0.5 \cdot 1.04\{1 + [1 + (4.36 \cdot 40 / 1.04)]^{1/2}\}$
- $d = .52\{1 + [1 + (174.4 / 1.04)]^{1/2}\}$
- $d = 7.3'$  minimum



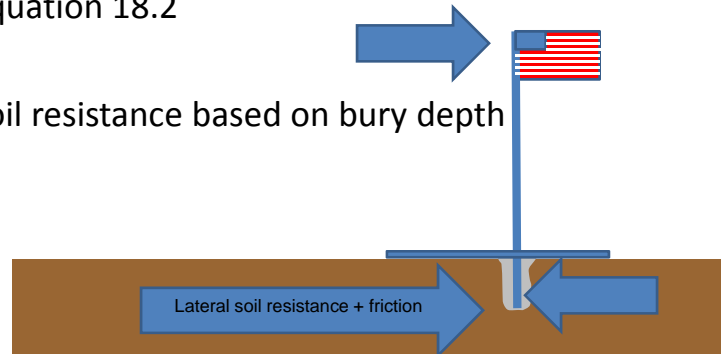
12" diameter utility pole, 9' embedment in sand

## Embedded Posts & Poles

- 1807.3.2.2 Constrained Embedment

- Equation 18.2

- Soil resistance based on bury depth

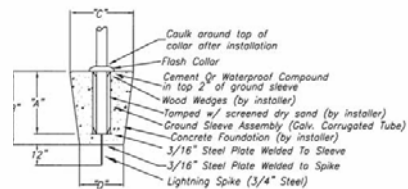


## Embedded Posts & Poles

- 1807.3.2 Design Criteria

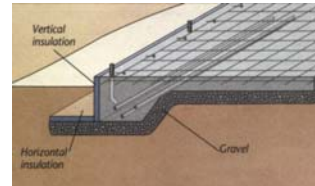
- Or by other methods “approved by BO”

Exposed Height	*A*	*B*	*C*	*D*
20'-0"	2'-0"	2'-6"	30"	24"
25'-0"	2'-6"	3'-0"	36"	24"
30'-0"	3'-0"	3'-6"	36"	24"
35'-0"	3'-6"	4'-0"	36"	30"
40'-0"	4'-0"	4'-6"	45"	36"
45'-0"	4'-6"	5'-0"	45"	36"
50'-0"	5'-0"	5'-6"	50"	42"
55'-0"	5'-6"	6'-0"	50"	42"
60'-0"	6'-0"	6'-6"	60"	48"
65'-0"	6'-6"	7'-0"	60"	48"
70'-0"	7'-0"	7'-6"	60"	48"
75'-0"	7'-6"	8'-0"	60"	48"
80'-0"	8'-0"	8'-6"	72"	48"



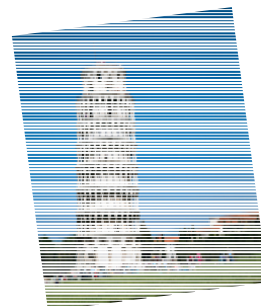
## Foundations

- 1808 Foundations
  - General foundation requirements
- 1809 Shallow Foundations (202)
  - Grade foundations
  - Mat foundations on fill
  - “slab” foundations
- 1810 Deep foundations (202)
  - 1801.2
    - Design based on Section 1803 geotechnical investigation



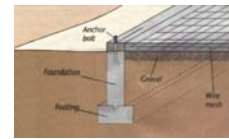
## Foundations

- 1808.2 Design for capacity & settlement
  - Based on soil conditions
- 1808.3 Design loads
  - Most severe load conditions
  - Seismic overturn resistant
- 1808.4 Vibratory loads
  - Based on machines within structure
- 1808.5 Shifting or moving soils
  - Sufficient depth to avoid movement



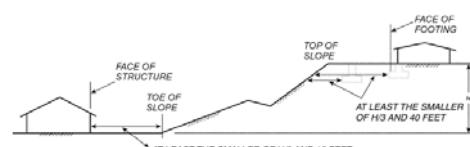
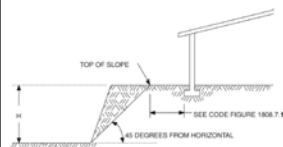
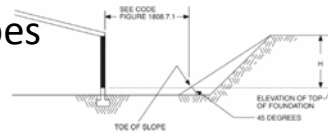
## Foundations

- 1808.6 Design Expansive Soils
  - As indentified by 1803.5.3
- 1808.6.1 Foundations
  - Designed to deal with expansive soil conditions
- 1808.6.2 Slab foundations
  - Reinforcement
- 1808.6.3 Removal of expansive soil
  - Removed to water table
- 1808.6.4 Stabilization
  - Dewatering, pre-saturation



## Foundations

- 1808.7 Foundations at slopes
  - Slope drainage concern
  - Earth movement concern
    - Landslide towards structure
    - Landslide involving the foundation
- 1008.7.5 Alternate setback & clearance
  - Approval by BO based on geotechnical report





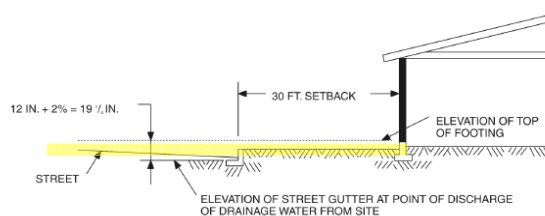
## Foundations

- 1808.7.3 Pools
  - ½ set back requirement of buildings
  - Pools < 7' from slope top
    - Greater strength required



## Foundations

- 1808.7.4 Drainage
  - Foundation wall top >12" street drain elevation
  - Exception for alternate drainage plan



## Foundations

- 1808.8 Concrete Foundations
  - Materials, design, construction details
    - Exception for ‘light frame’ structures
- 1808.8.1 Concrete strength
  - Tabular required compressive strength

**TABLE 1808.8.1  
MINIMUM SPECIFIED COMPRESSIVE STRENGTH  $f'_c$  OF CONCRETE OR GROUT**

FOUNDATION ELEMENT OR CONDITION	SPECIFIED COMPRESSIVE STRENGTH, $f'_c$
1. Foundations for structures assigned to Seismic Design Category A, B or C	2,500 psi
2a. Foundations for Group R or U occupancies of light-frame construction, two stories or less in height, assigned to Seismic Design Category D, E or F	2,500 psi
2b. Foundations for other structures assigned to Seismic Design Category D, E or F	3,000 psi
3. Precast nonprestressed driven piles	4,000 psi
4. Socketed drilled shafts	4,000 psi
5. Micropiles	4,000 psi
6. Precast prestressed driven piles	5,000 psi

## Foundations

- 1808.8.2 Concrete cover
  - Minimum thickness of cover over reinforcing steel

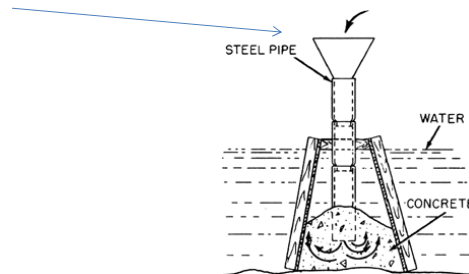
**TABLE 1808.8.2  
MINIMUM CONCRETE COVER**

FOUNDATION ELEMENT OR CONDITION	MINIMUM COVER
1. Shallow foundations	In accordance with Section 7.7 of ACI 318
2. Precast nonprestressed deep foundation elements	3 inches
Exposed to seawater	2 inches
Not manufactured under plant conditions	In accordance with Section 7.7.3 of ACI 318
Manufactured under plant control conditions	
3. Precast prestressed deep foundation elements	2.5 inches
Exposed to seawater	In accordance with Section 7.7.3 of ACI 318
Other	
4. Cast-in-place deep foundation elements not enclosed by a steel pipe, tube or permanent casing	2.5 inches
5. Cast-in-place deep foundation elements enclosed by a steel pipe, tube or permanent casing	1 inch
6. Structural steel core within a steel pipe, tube or permanent casing	2 inches
7. Cast-in-place drilled shafts enclosed by a stable rock socket	1.5 inches



## Foundations

- 1808.8.3 Concrete placement
  - Foreign matter excluded
  - Fully fill form
  - Avoid standing water
    - Tremie
    - Proper mix



## Foundations

- 1808.8.4 Concrete protection
  - Protect from:
    - Freezing – 5 days
    - Running water



## Foundations

- 1808.8.5 Concrete forms
  - Not required if BO *'approves'*
    - *Based on soil conditions*
  - If required:
    - ACI 318



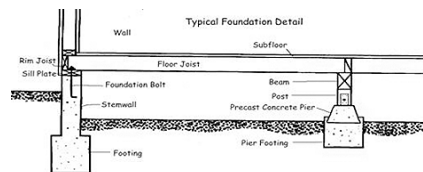
## Foundations

- 1808.8.6 Seismic requirements
  - References
    - Section 1908
    - ACI 318



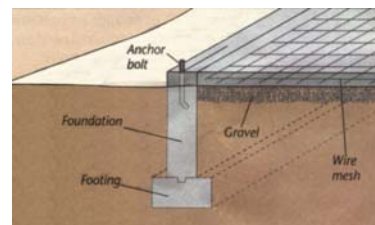
## Foundations

- 1808.9 Vertical masonry foundation elements
  - If it's not a 'pier' then it is a wall
    - Foundation pier: Isolated foundation member where the horizontal dimension to depth dimension is a maximum of 3:1 ratio and the height is no more than 4 times the thickness.
    - In other words; a short, stubby pile of concrete.



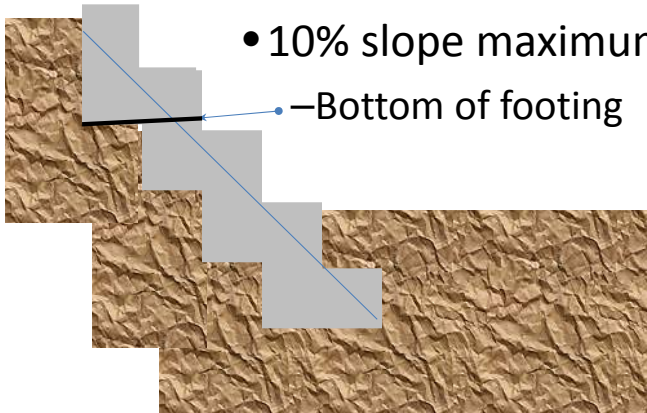
## Shallow Foundations

- 1809 Shallow Foundations
  - 1809.1 General
    - Proper design and constructed per this section
  - 1809.2 Supporting soils
    - Undisturbed earth
    - controlled fill

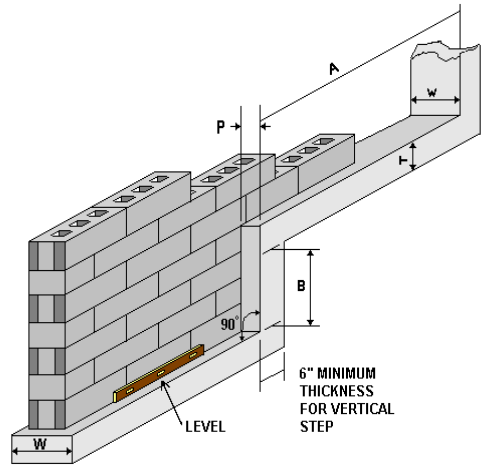


## Shallow Foundations

- 1809 Shallow Foundations
  - 1809.3 Stepped Footings
    - 10% slope maximum
    - –Bottom of footing



## Diagram of a Step Footing



**A = HORIZONTAL STEP**  
**B = VERTICAL STEP**  
**T = FOOTING THICKNESS**  
**P = PROJECTION OF FOOTING**  
**W = WIDTH OF FOOTING**

- ALL FOOTINGS AND STEPS SHOULD BE LEVEL  
 - STEP (B) SHOULD NOT EXCEED 3/4 OF STEP (A)

NOTE:  
 CONCRETE TO BE PLACED MONOLITHICALLY

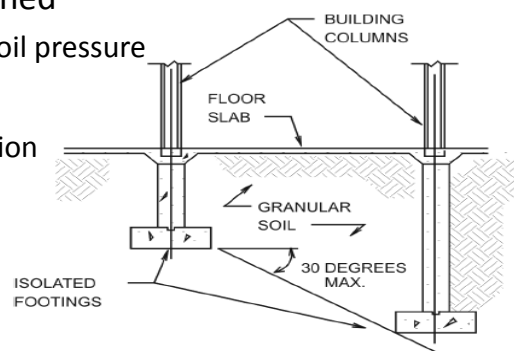
## Shallow Foundations

- 1809.4 Footing Width
  - 12" minimum width
- 1809.5 Frost Protection
  - Footings
    - 42" below grade
    - ASCE 32
      - Frost protected shallow footings
    - On solid rock
  - Several exceptions to frost protection
    - Risk category I
      - 1604.5
    - 600 ft<sup>2</sup> light frame
    - 400 ft<sup>2</sup> other frame
    - 10' height



## Shallow Foundations

- 1809.6 Location of footings
  - (Isolated Footings)
  - 30° slope maintained
    - Controls lateral soil pressure
  - Or other means
    - Engineered solution



## Shallow Foundations

- 1809 Prescriptive Footings
  - 1809.7 covers Light frame (Wood or steel stud)
    - Table 1809.7
  - 1809.8 covers other than light frame
    - 8" minimum thickness
      - Reduction for R-3

**TABLE 1809.7  
PRESCRIPTIVE FOOTINGS SUPPORTING WALLS OF  
LIGHT-FRAME CONSTRUCTION<sup>a, b, c</sup>**

NUMBER OF FLOORS SUPPORTED BY THE FOOTING <sup>d</sup>	WIDTH OF FOOTING (inches)	THICKNESS OF FOOTING (inches)
1	12	6
2	15	6
3	18	8 <sup>e</sup>

For 51: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Depth of footings shall be in accordance with Section 1809.4.

b. The ground under the floor shall be permitted to be excavated to the elevation of the top of the footing.

c. Interior stud-bearing walls shall be permitted to be supported by isolated footings. The footing width and length shall be twice the width shown in this table, and footings shall be spaced not more than 6 feet on center.

d. See Section 1905 for additional requirements for concrete footings of structures assigned to Seismic Design Category C, D, E or F.

e. For thickness of foundation walls, see Section 1807.1.6.

f. Footings shall be permitted to support a roof in addition to the stipulated number of floors. Footings supporting roof only shall be as required for supporting one floor.

g. Plain concrete footings for Group R-3 occupancies shall be permitted to be 6 inches thick.

## Shallow Foundations

- 1809.8 Plain concrete footings
  - Shear strength is a concern
    - Thickness regulated by Table 1809.7
  - Modified by 1809.8 for heavier structures
    - 8" with specific exception

**TABLE 1809.7  
PRESCRIPTIVE FOOTINGS SUPPORTING WALLS OF  
LIGHT-FRAME CONSTRUCTION<sup>a, b, c</sup>**

NUMBER OF FLOORS SUPPORTED BY THE FOOTING <sup>d</sup>	WIDTH OF FOOTING (inches)	THICKNESS OF FOOTING (inches)
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For 51: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Depth of footings shall be in accordance with Section 1809.4.

b. The ground under the floor shall be permitted to be excavated to the elevation of the top of the footing.

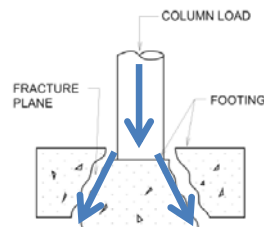
c. Interior stud-bearing walls shall be permitted to be supported by isolated footings. The footing width and length shall be twice the width shown in this table, and footings shall be spaced not more than 6 feet on center.

d. See Section 1905 for additional requirements for concrete footings of structures assigned to Seismic Design Category C, D, E or F.

e. For thickness of foundation walls, see Section 1807.1.6.

f. Footings shall be permitted to support a roof in addition to the stipulated number of floors. Footings supporting roof only shall be as required for supporting one floor.

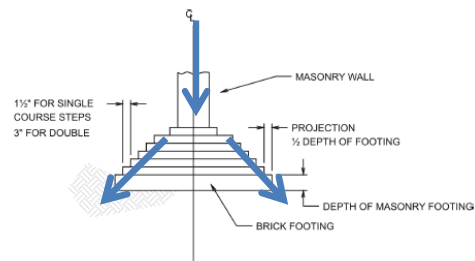
g. Plain concrete footings for Group R-3 occupancies shall be permitted to be 6 inches thick.





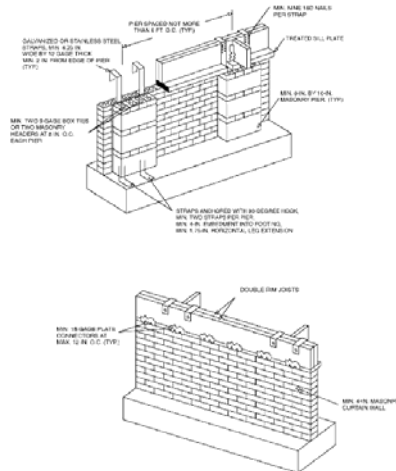
## Shallow Foundations

- 1809.9 Masonry unit footings
  - 1809.9.1 Maximum overall projection limitation
  - 1809.9.2 Maximum projection per course



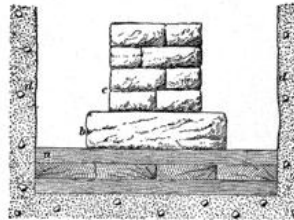
## Shallow Foundations

- 1809.10 Pier & Curtain Wall Foundations
  - Permitted for 2 story light frame
    - Continuous footing required
    - Single brick min. thickness
    - 6' maximum pier intervals
    - Pier height / area ratio of 10:1
    - Hollow piers restricted
      - Some exceptions
    - Maximum height restrictions
    - Unbalanced fill restriction



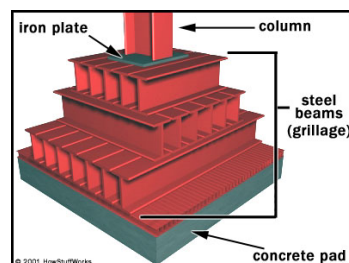
## Shallow Foundations

- 1809.10 Timber Footings
  - Type V Structures
  - PT Treated timbers
    - Exception for below water level
  - .7 compressive resistance reduction
    - Timbers on piles



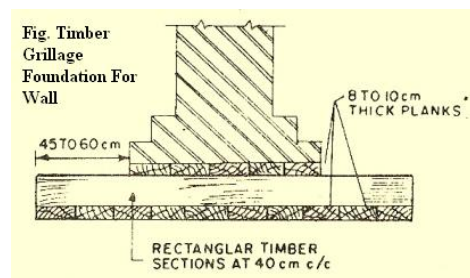
## Shallow Foundations

- 1809.11 Steel Grillage Foundations
  - Spacers required
  - Completely filled with grout or concrete



## Shallow Foundations

- 1809.12 Timber Foundations
  - OK for type V construction
  - OK if [A]104.11



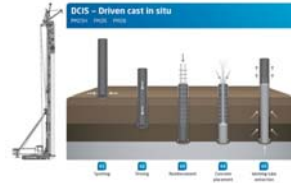
## Deep Foundations

- Section 1810 Deep Foundations
  - 1810.1.1 Geotechnical investigation
    - Required for all deep foundations
  - 1810.1.2 Use of Existing
    - Based on testing
  - 1801.3 Deep Foundation Elements classified as columns
    - Non-braced or poorly supported – treat as a column
  - 1810.1.4 Special types of Deep Foundations (other)
    - Engineered components
    - With BO approval
    - Approval based on:
      - [A] 104.11
      - [A] 104.11.1
      - [A] 104.11.2



## Deep Foundations

- 1810.2 Analysis of deep Foundations
  - 1810.2.1 Lateral support of elements
    - Are unsupported portions of piles properly sized per 1810.1.3?
  - 1810.2.2 Stability
    - Are components structurally connected?
    - Will components move as a group?
  - 1810.2.3 Settlement
    - Was settlement considered in design?
    - Will settlement damage superstructure?
  - 1810.2.4 Lateral load
    - Will design handle anticipated Seismic earth shear?
    - Was soil diversity considered in lateral load resistance?
  - 1810.2.5 Grouping effect
    - Will closely grouped elements impact lateral behavior?



## Deep Foundations

- 1810.3 Design & detailing
  - 1810.3.1.4 Driven Piles
    - Designed for driving



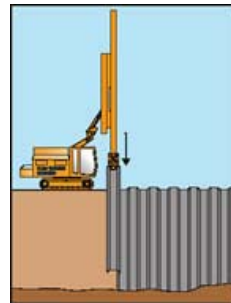
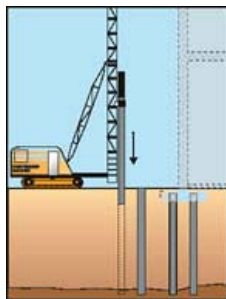
## Deep Foundations

- 1810.3 Design & detailing
  - 1810.3.1.5 Helical Piles
    - Must resist installation & service loads



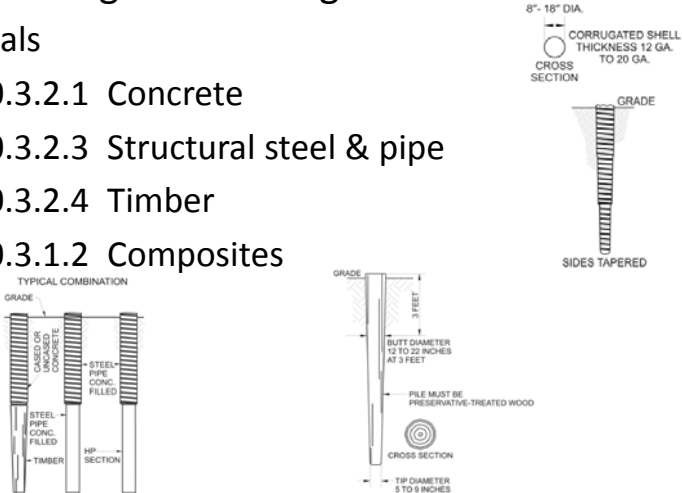
## Deep Foundations

- 1810.3 Design & detailing
  - 1810.3.1.6 Casings
    - May be temporary or permanent
    - Generally used as forms for concrete



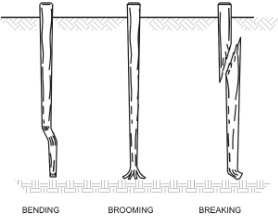
## Deep Foundations

- 1810.3 Design & detailing
  - Materials
    - 1810.3.2.1 Concrete
    - 1810.3.2.3 Structural steel & pipe
    - 1810.3.2.4 Timber
    - 1810.3.1.2 Composites




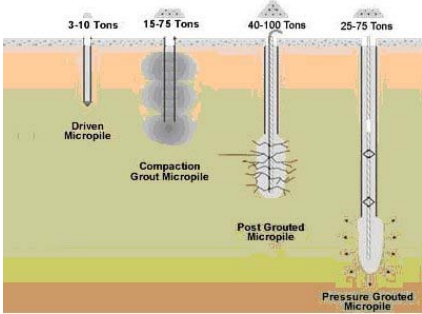
## Deep Foundations

- 1810.3 Design & detailing
  - 1810.3.1.3 Mislocation
  - Determination of Allowable Loads
    - 1810.3.3.1.1 Driving criteria
    - 1810.3.3.1.4 Frictional resistance
    - 1810.3.3.1.5 Uplift resistance
    - 1810.3.3.1.7 Load bearing capacity
    - 1810.3.3.1.8 Bent foundation element adjustment
  - 1810.3.3.2 Lateral load resistance



## Deep Foundations

- 1810.4.10 Micro piles
  - 1810.3.5.2.3 12" diameter or less

### Energy Code Related Footing and Foundation Inspection

Item Number	Footing / Foundation Inspection	Verified Value	Complies			Comments/Notes/Findings
			Y	N	N/A	
FO1 [5.8.1.7] <sup>1</sup>	Exterior insulation protected against damage, sunlight, moisture, wind, landscaping and equipment maintenance activities.		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
FO2 [5.8.1.7.3] <sup>1</sup>	When contacting ground insulation has ≤0.3% water absorption (ASTM C272).		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
FO3 [6.3.2, 6.4.4.1, 6.4.4.2] <sup>1</sup>	Piping, ducts and plenum are insulated and sealed when installed in or under a slab.	R-	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
FO4 [6.5.8.2, 7.4.3] <sup>1</sup>	Any SWH piping in or under slab is insulated.	R-	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
FO5 [5.5.3.3, 5.8.1.2] <sup>2</sup>	Below-grade wall insulation R-value. Installed per manufacturer's instructions.	R-	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
FO6 [5.5.3.5, 5.8.1.2] <sup>2</sup>	Slab edge insulation R-value, depth/length. Installed per manufacturer's instructions.	R-ft -	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
FO7 [6.4.3.8] <sup>3</sup>	Freeze protection and snow/ice melting system sensors for future connection to controls.		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

From the BUILDING ENERGY CODES UNIVERSITY

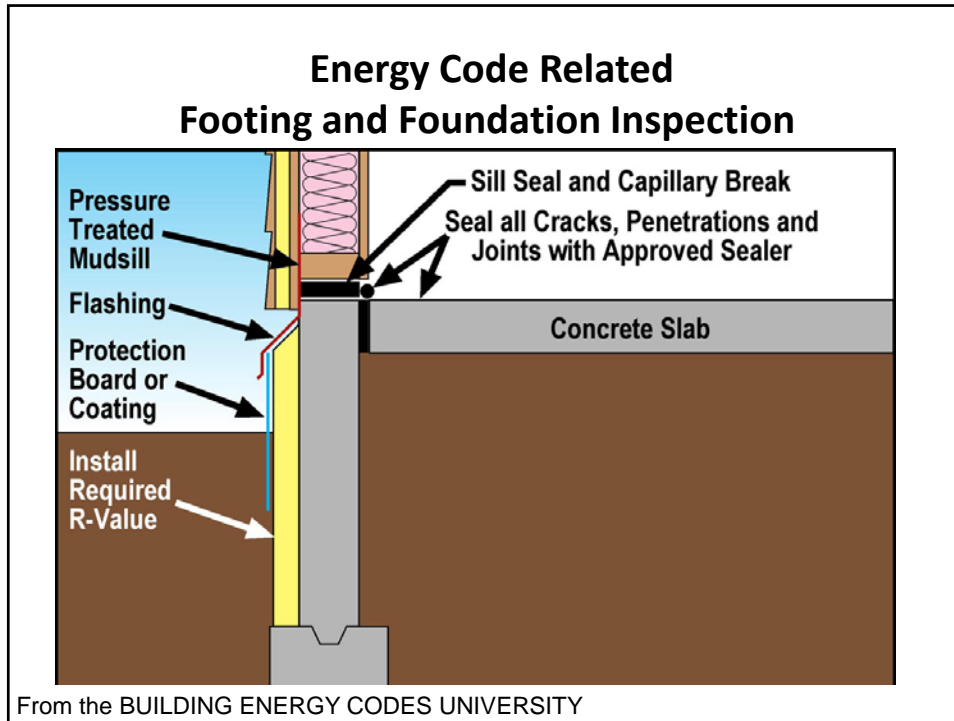


**Energy Code Related  
Footing and Foundation Inspection**



Below-grade wall insulation R-value. Installed per manufacturer's instructions.







## Conclusion and Questions

- Seminar reviewed requirements for soils and foundations under the IBC:
  - foundation and soils investigations,
  - excavation, grading and fill,
  - load bearing values of soils,
  - Damp proofing and waterproofing
  - design and construction of foundations
    - Shallow Foundations
    - Deep Foundations

Thank-You!



***State of Connecticut***

***Division of Construction Services***

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– (860) 713 - 5900
- Office of the State Fire Marshal  
– (860) 713 - 5750
- Office of Education and Data Management  
– (860) 713- 5522

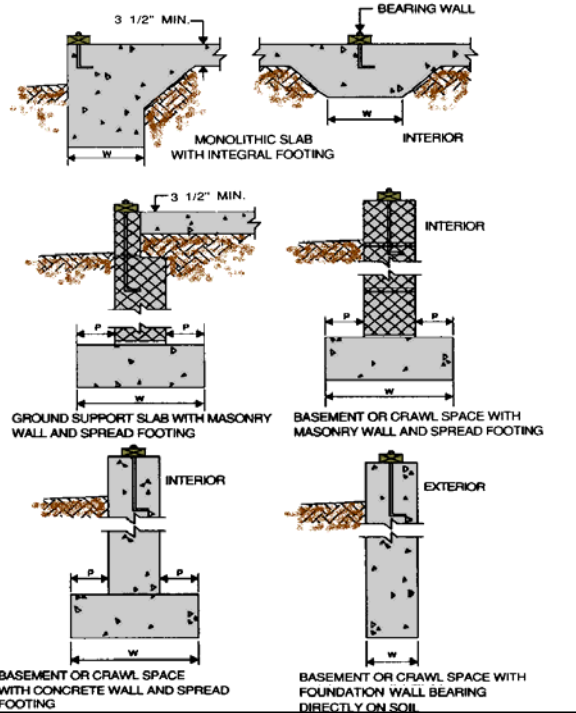
Office of Education and Data Management

101

## Photographs and Discussions

- Following slides are photographs of construction processes related to this seminar on soils and foundations

Examples of Footings



Tremie



Example of a Tremie Method of Placing Concrete Underwater

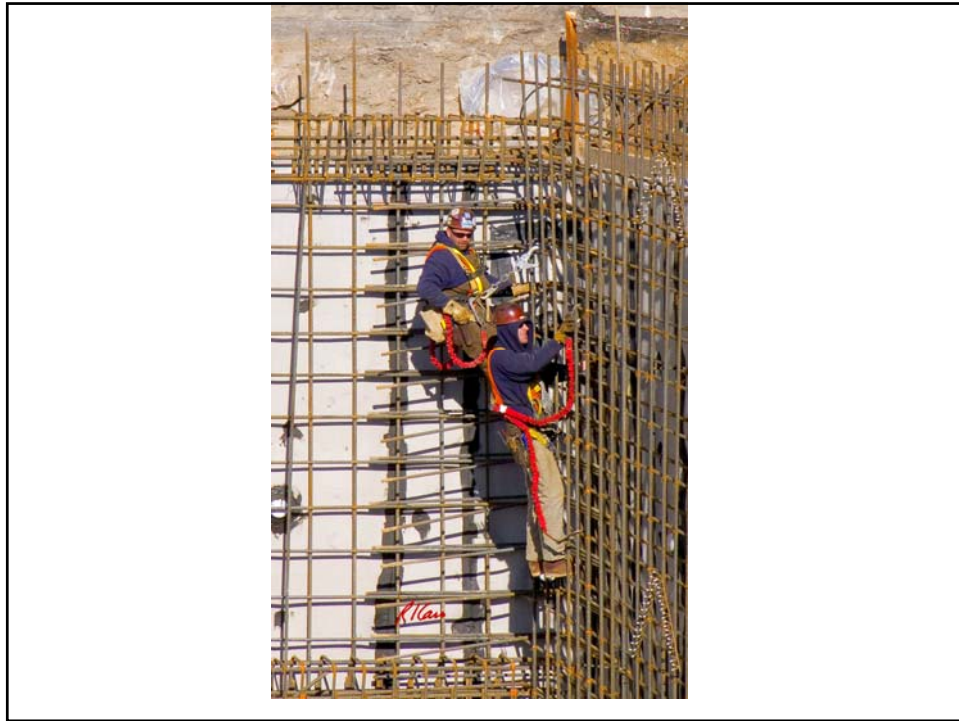


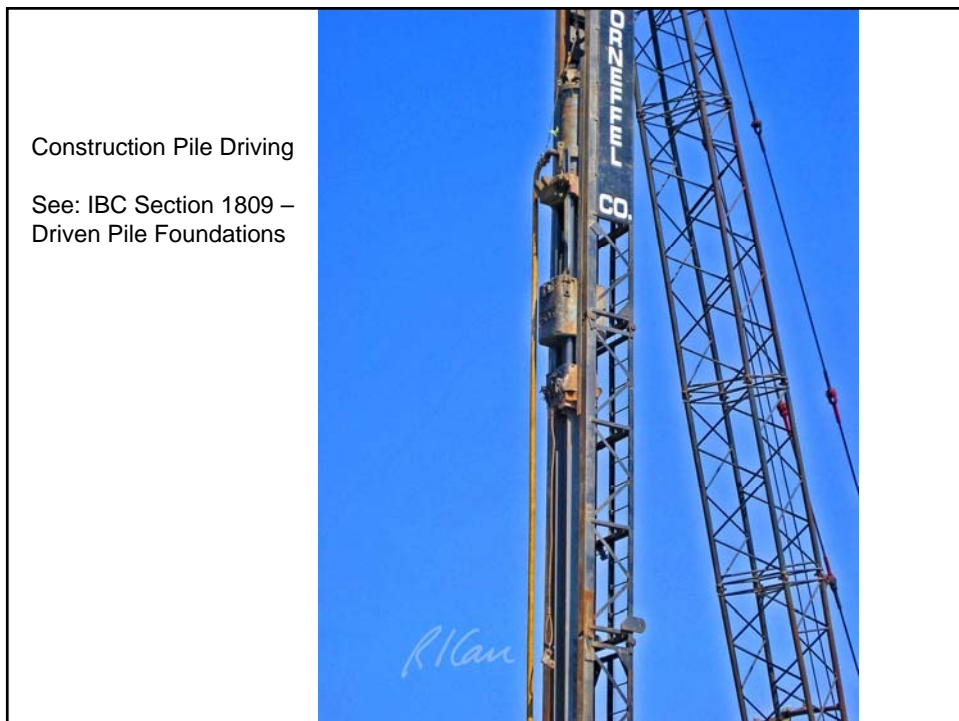
Superchute Tremie & Funnel Support (shown over a manhole)



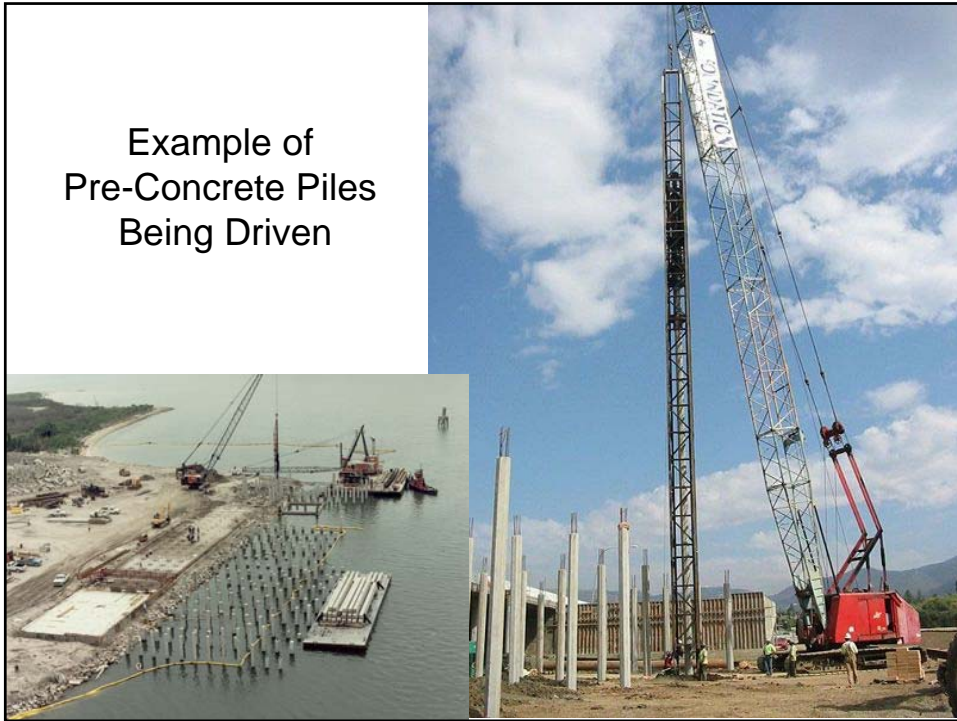
3 Foot Tremie Section







Example of  
Pre-Concrete Piles  
Being Driven



Cast-In-Place Concrete Pile Foundations





Pier Foundation  
Construction

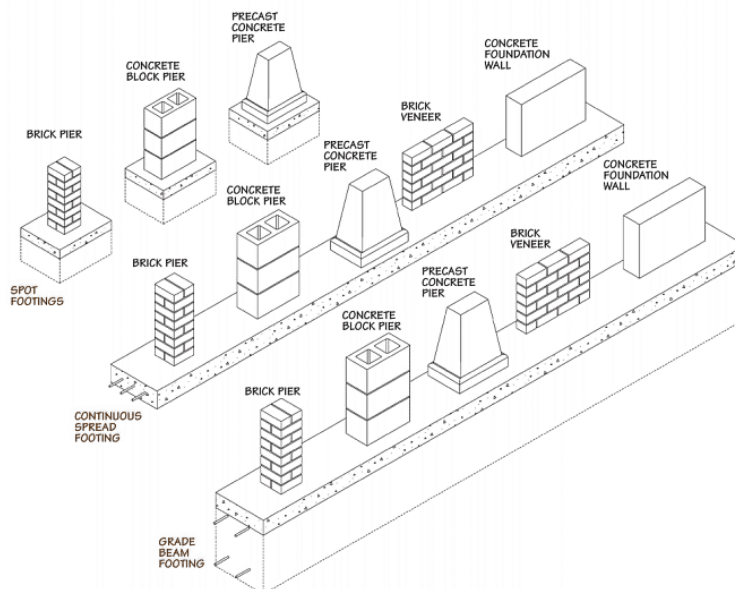






photo by Britt-Makela Group

Figure 10 Pier or Foundation Wall Options by Footing Type



Note: See additional footing detail for Permanent Wood Foundation (PWF) option, Figure 16.

