ARCH 2231
BUILDING TECHNOLOGY II

HSB Turning Torso

ARTstor ; Santiago Calatrava , Turning Torso; close view of the base with entrance bridge, pond and sculpture

Class Overview:

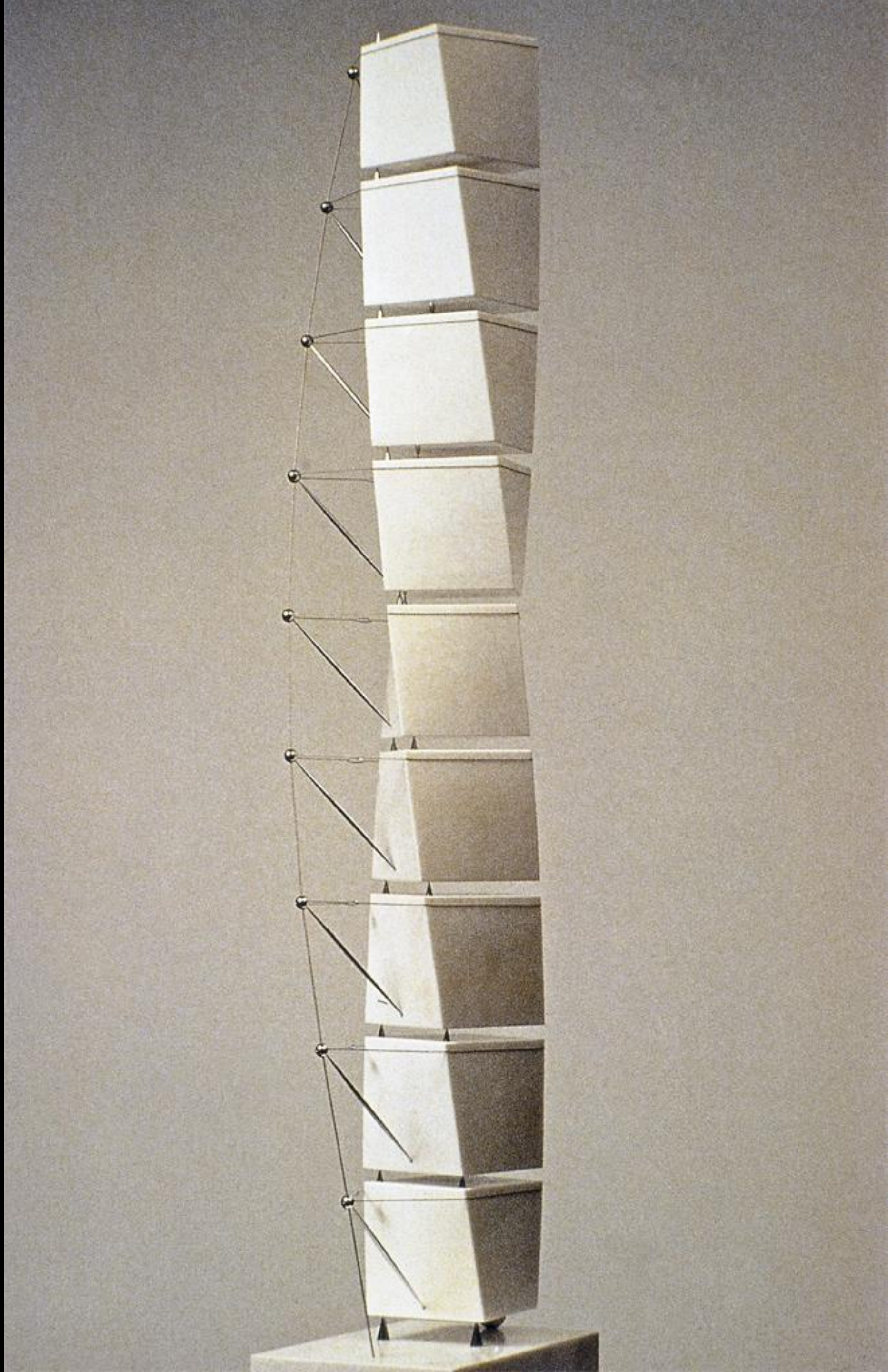
- Discussion/Lecture on Geotech + Excavations + Foundations: Procedures and Consultants, Geotechnical Investigation, Soil Bearing Pressure. Foundation materials: concrete, wood, and steel. Foundation types: deep foundations. Underpinning existing foundations

Upcoming:

- Quiz Thursday

Santiago Calatrava

HSB
Turning Torso



ARTstor ; www.artonfile.com

Santiago Calatrava

HSB Turning Torso

ARTstor ; www.artonfile.com

http://www.bizzbook.com/map/turningtorsonews.html

Foundations

Foundations

Shallow Foundations

Deep Foundations

Underpinning

Retaining Walls

Waterproofing and Drainage

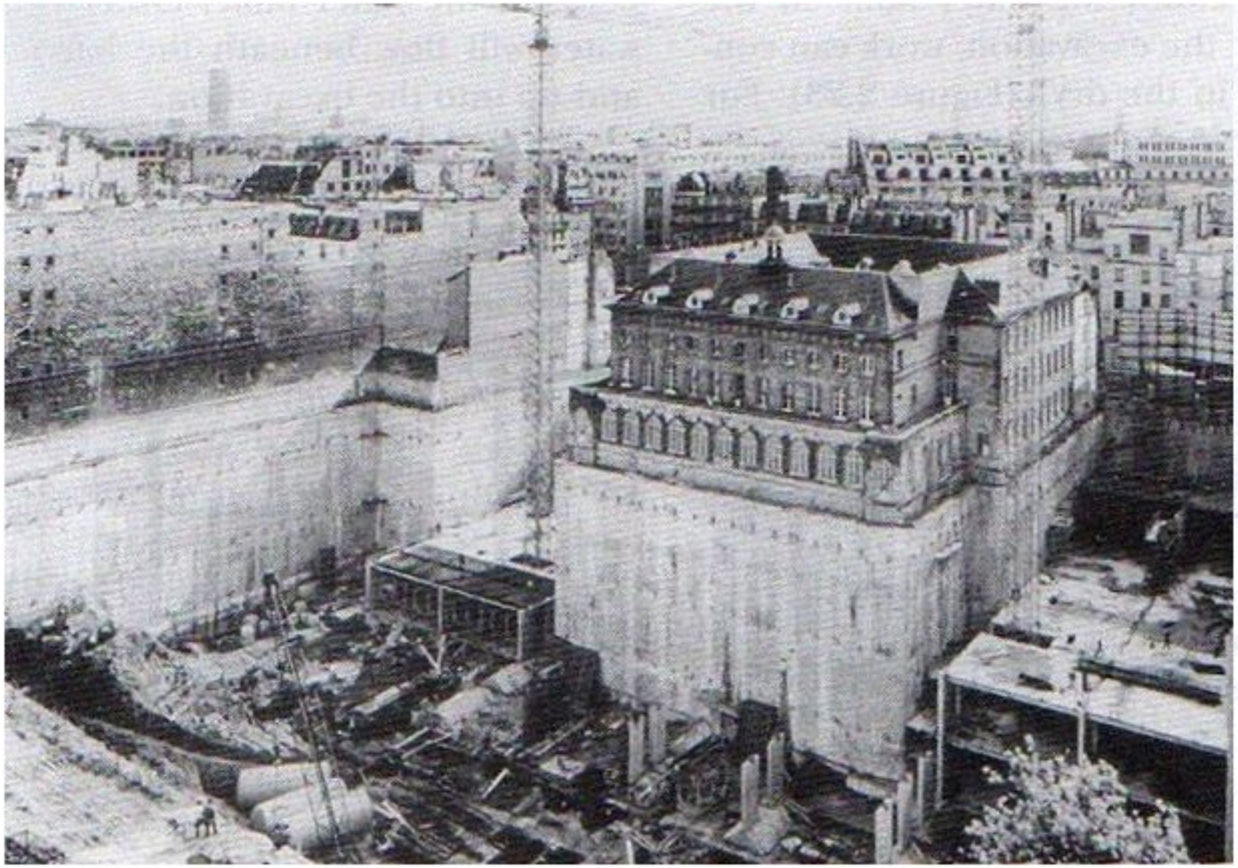
courtesy of PROF. Jason Montgomery

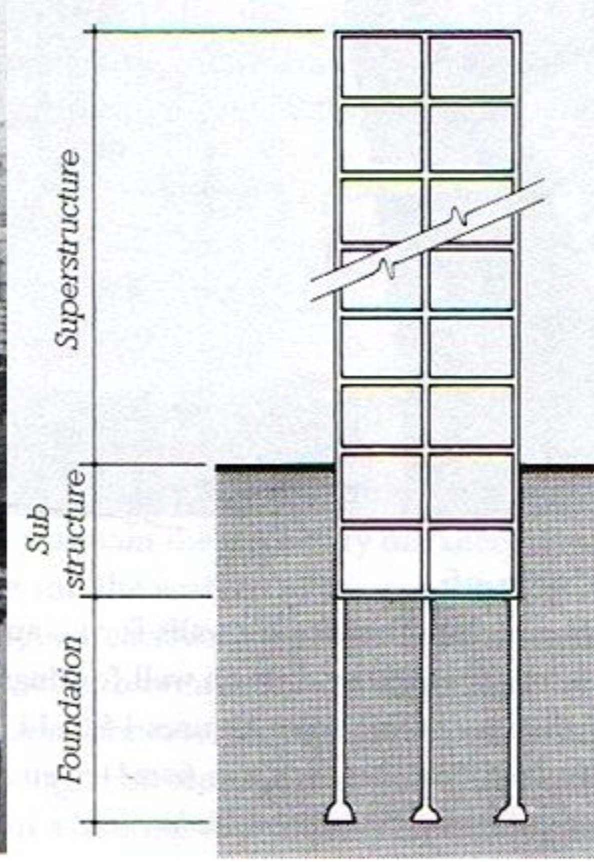
Foundation Loading

Must meet Three Requirements:

1. The foundations, underlying soil, and rock composition must be strong enough to support the structure .
2. During the life the building, the foundation must not settle(move) in such a way as to damage the structure or impair its function.
3. The foundation must be feasible both technically and economically and practical to build without adverse effects to surrounding property.

Foundations

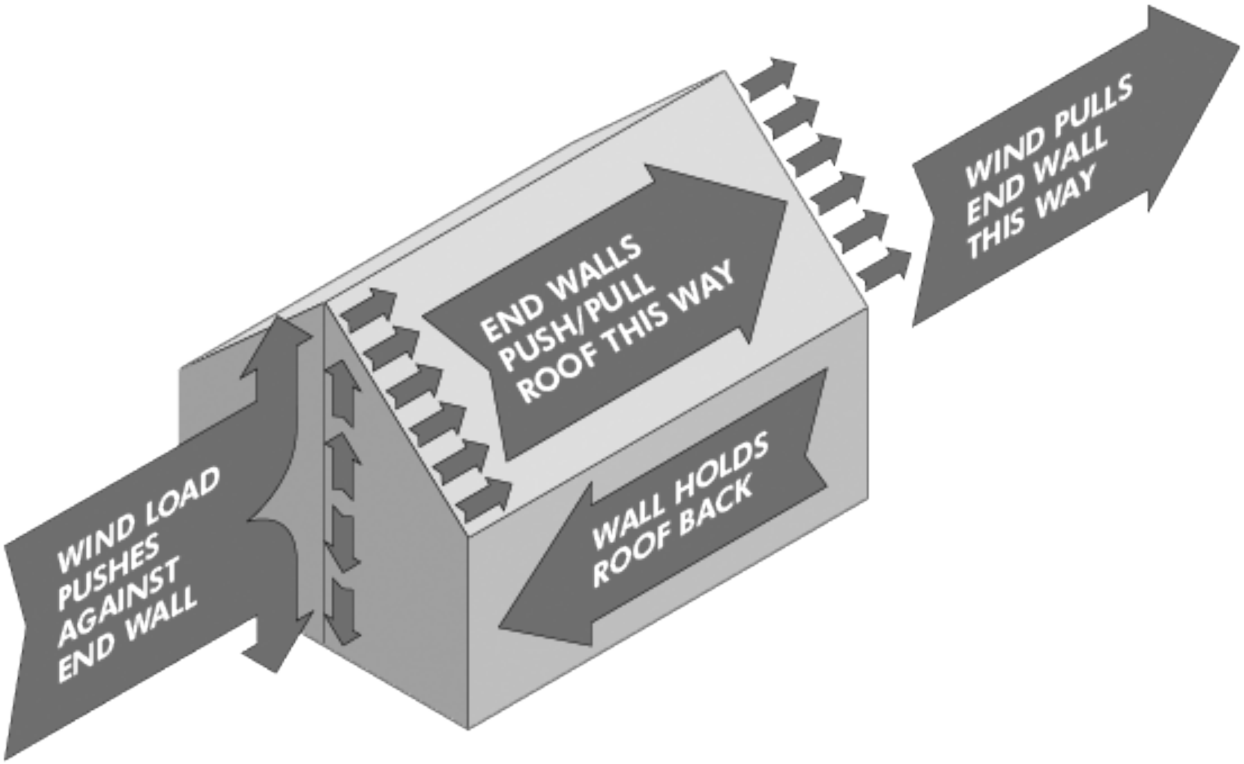




courtesy of PROF. Jason Montgomery

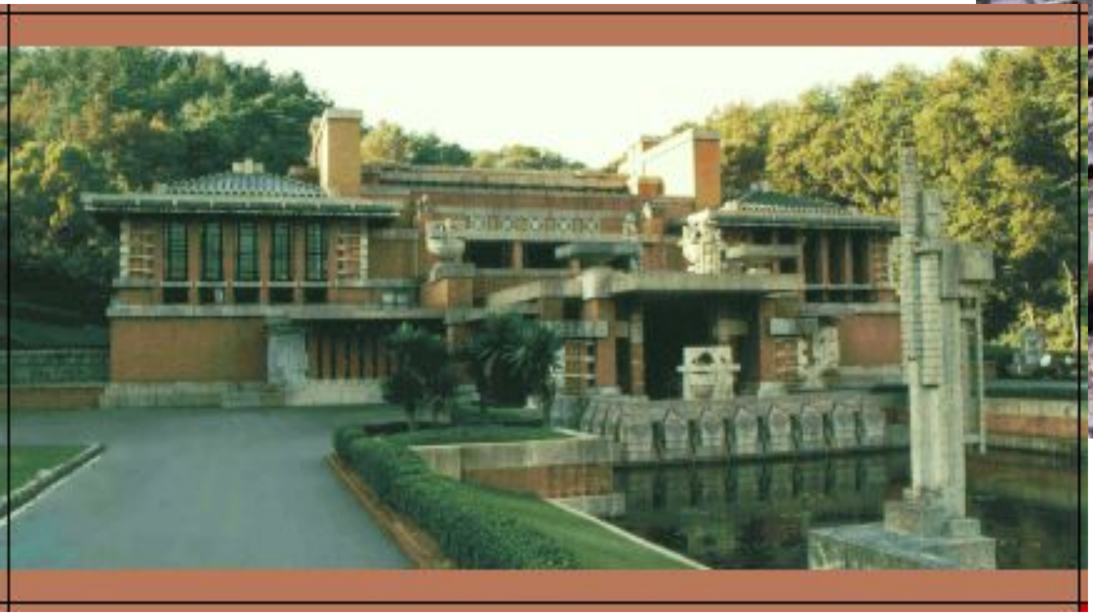
Other Loads on a structure:

1. *Wind load – lateral, up, down*



Other Loads on a structure:

2. ***Earth & water pushing horizontally***
3. ***Underground water pushing upward***
4. ***Earthquakes: horizontal & vertical forces***



What makes for a good foundation?

- *It (and underlying soil) must be strong enough to support structure above.*

- *It must not settle enough to damage structure.*

- *It must be feasible, economical to build, & not endanger its neighbors.*

1. *__Uniform__: Equal across foundation*

= little or no damage

2. *__Differential__: Columns & Bearing Walls settle*

different amounts

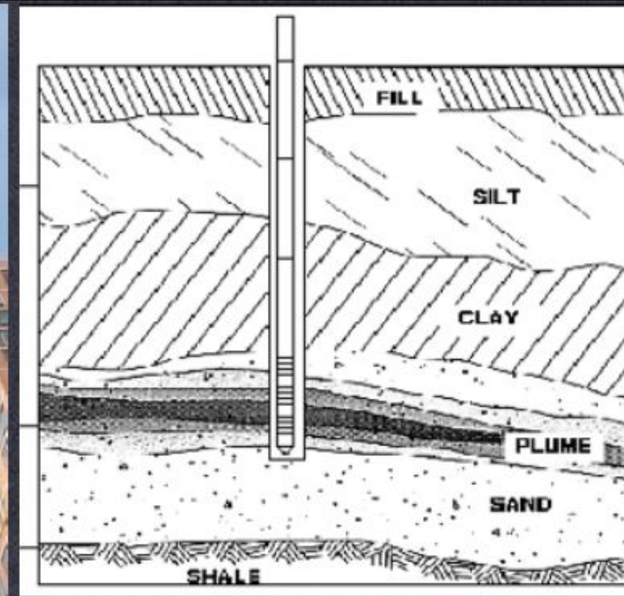
= damage or failure.

Most common cause of differential settlement: multiple soil types under building

Classifying Earth Materials

- *Rock:* continuous mass of solid mineral material
  - Generally, the strongest, most stable of earth materials
  - Strength varies with mineral content and physical structure
- *Soil:* particulate

  Small enough to be lifted by hand
  - Characteristics and suitability for foundation support vary with particle size and shape, mineral content, and sensitivity to moisture content


FILL
SILT
CLAY
PLUME
SAND
SHALE

Types of soil by size:

1. *Rock (limestone, granite)*
   Strongest, most stable

2. *Gravel (half of particles less than 1 / 4 inch*

3. *Sand (1 / 4" .002 inch)*

4. *Silt (.002 – .008 inch)*

5. *Clay (less than .008 inch & plate-shaped*

Classifying Earth Materials

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

COARSE-GRAINED SOILS
(more than 50% of material is larger than No. 200 sieve size.)

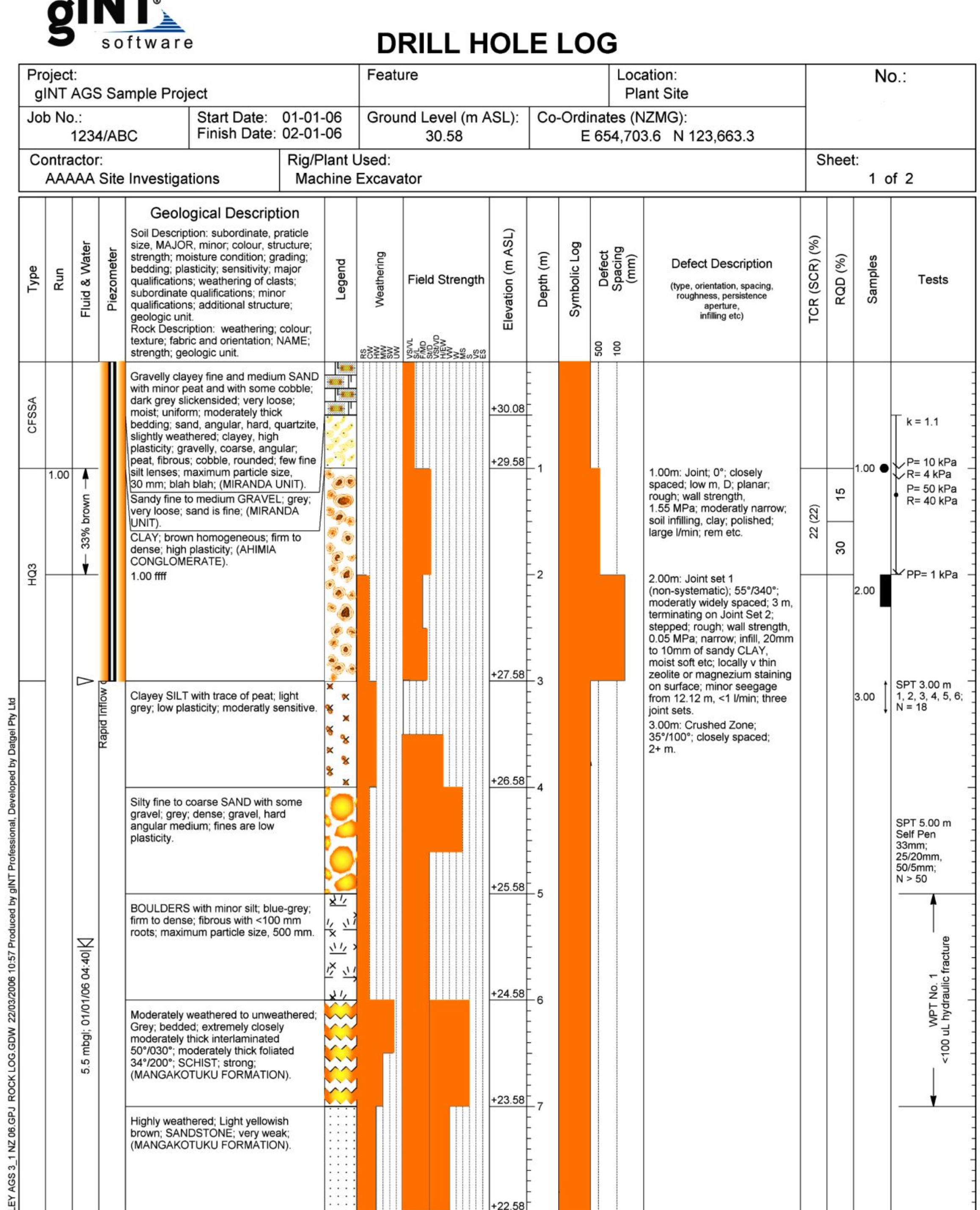
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	Clean Gravels (Less than 5% fines)	
	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
	GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
	Gravels with fines (More than 12% fines)	
	GM	Silty gravels, gravel-sand-silt mixtures
	GC	Clayey gravels, gravel-sand-clay mixtures
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	Clean Sands (Less than 5% fines)	
	SW	Well-graded sands, gravelly sands, little or no fines
	SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with fines (More than 12% fines)	
	SM	Silty sands, sand-silt mixtures
	SC	Clayey sands, sand-clay mixtures

FINE-GRAINED SOILS
(50% or more of material is smaller than No. 200 sieve size.)

SILTS AND CLAYS Liquid limit less than 50%	ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	CH	Inorganic clays of high plasticity, fat clays
	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS	PT	Peat and other highly organic soils

http://matrix.vtrc.virginia.edu/DATA/GINT/vdotusc.PDF

- Boring Report
  - -- soil type
  - -- particle size
  - -- bearing capacity
  - -- water content
  - -- expected settlement



http://www.gintsoftware.com/reports_boringlogs.html

TABLE 1804.2
ALLOWABLE FOUNDATION AND LATERAL PRESSURE

CLASS OF MATERIALS	ALLOWABLE FOUNDATION PRESSURE (psf)[d]	LATERAL BEARING (psf/f below natural grade)[d]	LATERAL SLIDING	
			Coefficient of friction[a]	Resistance (psf)[b]
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[c]	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.

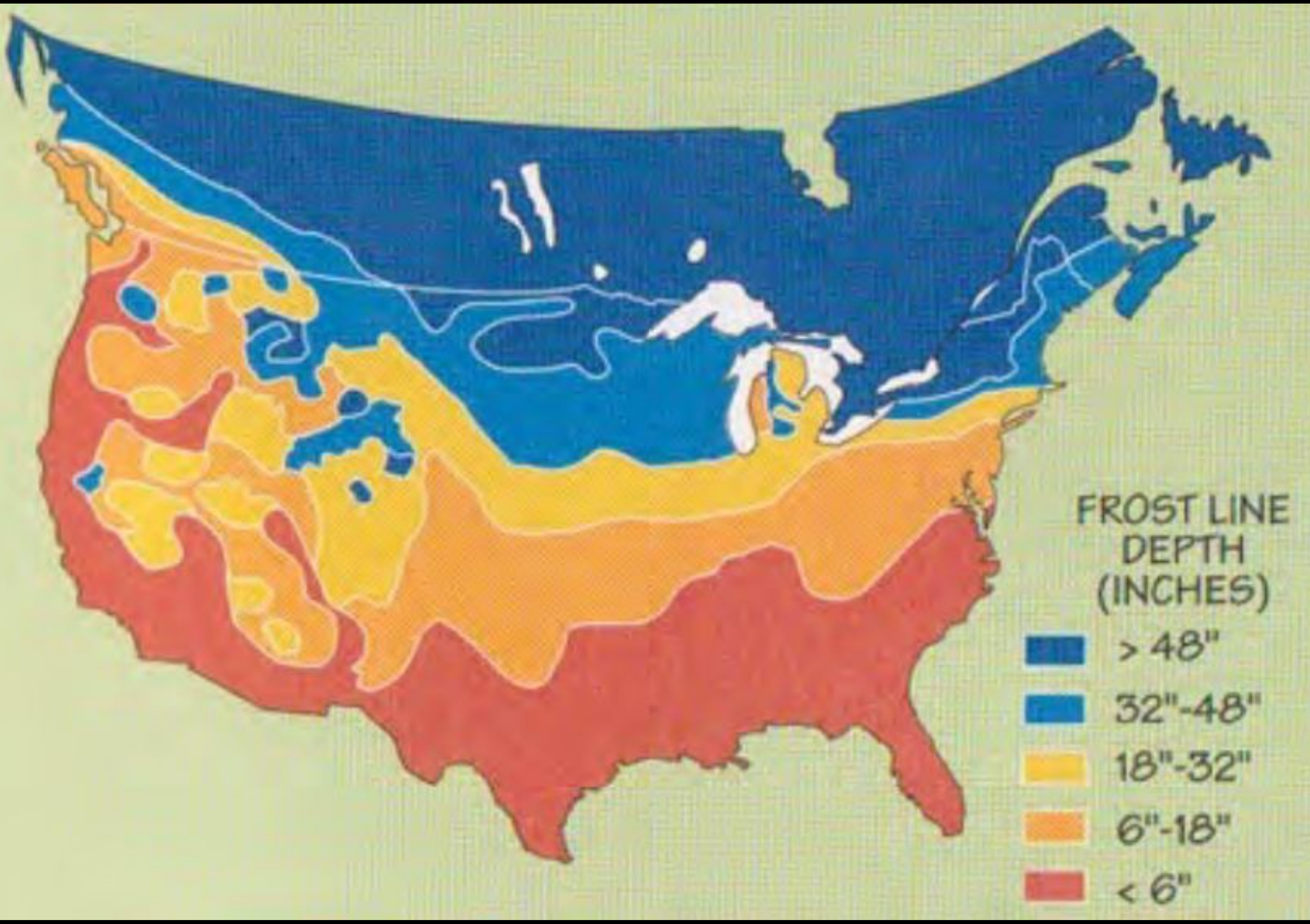
b. Lateral sliding resistance value to be multiplied by the contact area, as limited by Section 1804.3.

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.

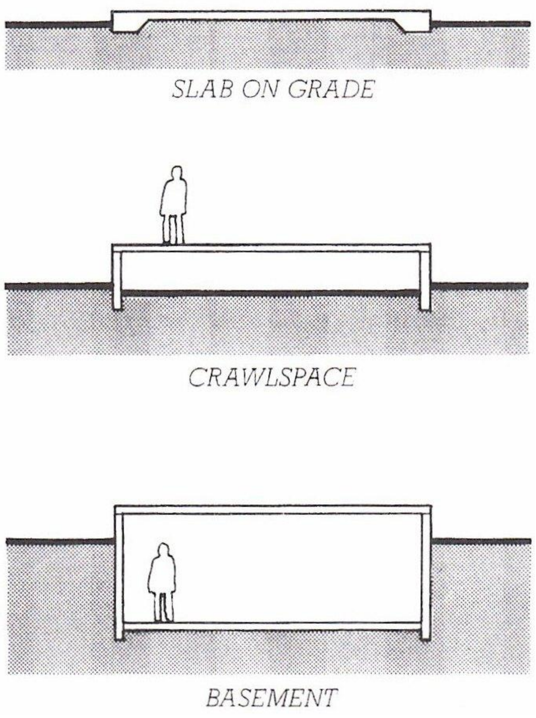
d. An increase of one-third is permitted when considering load combinations, including wind or earthquake loads, as permitted by Section 1605.3.2.

ON SITE AND LABORATORY INVESTIGATION CAN DETERMINE:

- THE ALLOWABLE FOUNDATION PRESSURE FOR THE GIVEN EARTH MATERIALS BENEATH THE SITE

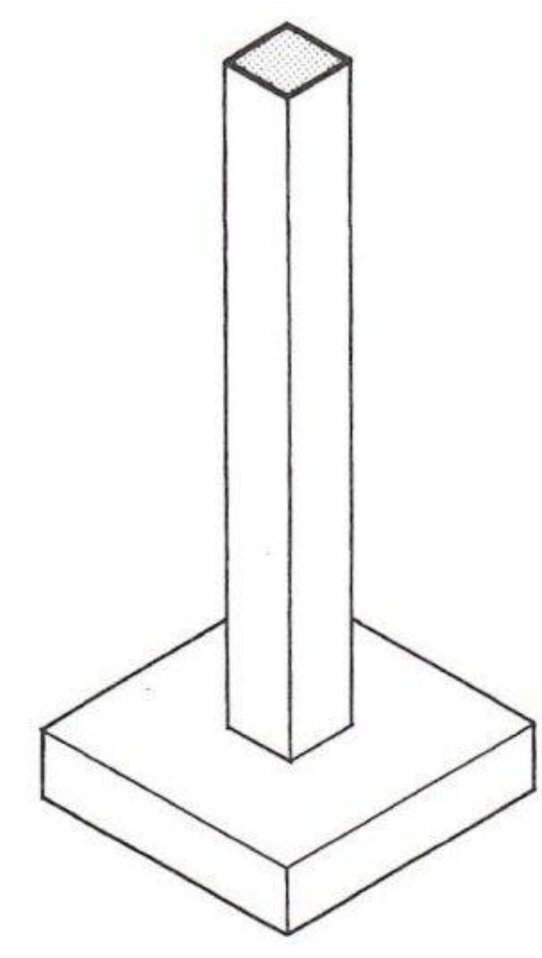

FROST LINE
DEPTH
(INCHES)
> 48"
32"-48"
18"-32"
6"-18"
< 6"

Shallow Foundations



courtesy of PROF. Jason Montgomery

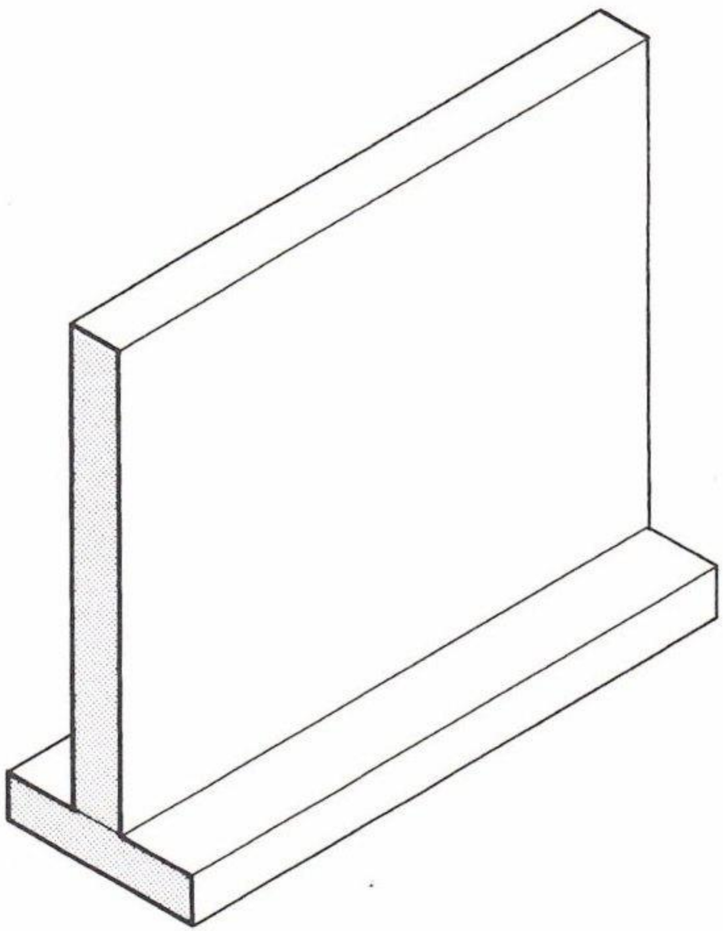
COLUMN FOOTING



COLUMN FOOTING

courtesy of PROF. Jason Montgomery

WALL FOOTING
(STRIP FOOTING)



WALL FOOTING

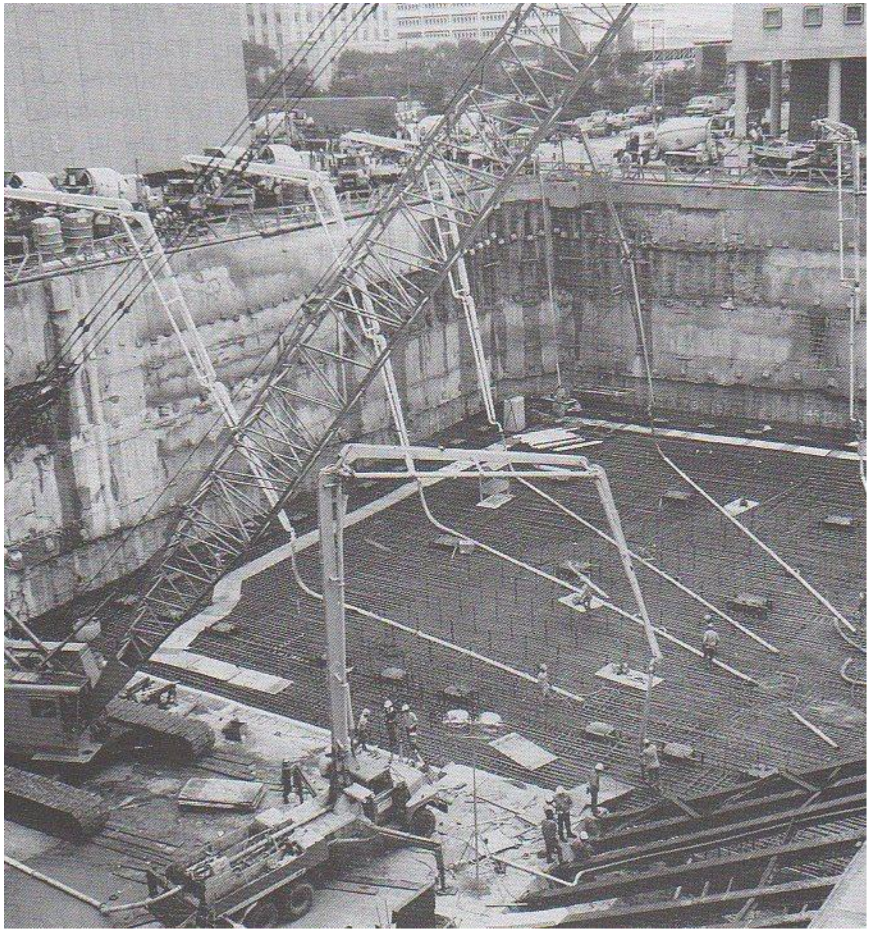
courtesy of PROF. Jason Montgomery

Special Foundations

Shallow Foundations on Soil w/ Low Bearing Capacity

Mat or Raft Foundation

Floating Foundation



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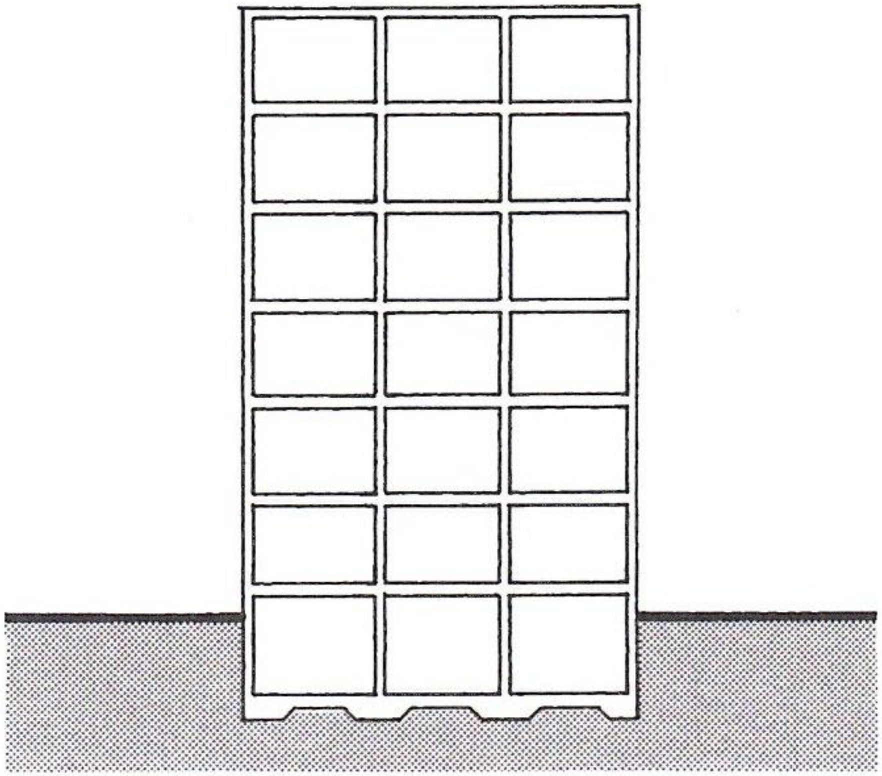
Floating Foundations

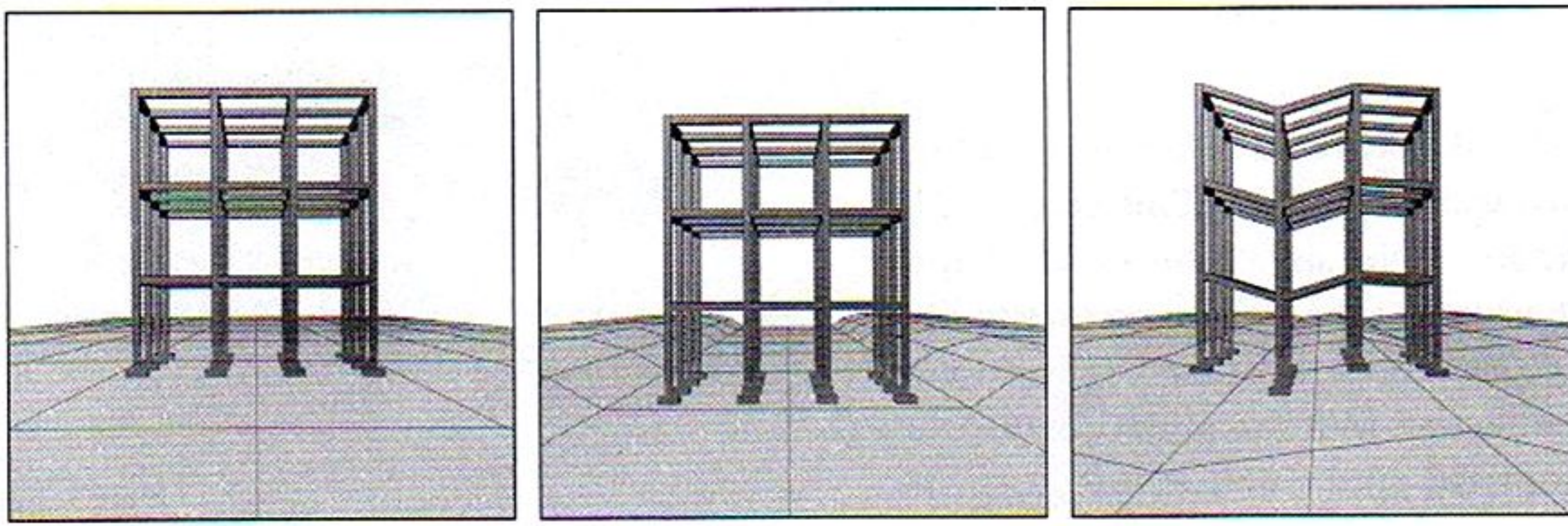
Balances the weight of soil removed with the weight of building to be constructed

The load on the remaining soil is little changed.



courtesy of PROF. Jason Montgomery

Foundation Settlement



(a) **Building before settlement occurs**　*(b)* **Uniform settlement**　*(c)* **Differential settlement**

"Fundamentals of Building Construction / Materials and Methods" Allen & Wiley

DEEP FOUNDATIONS
ARE REQUIRED
WHERE:

1. THE DEPTH OF
ADEQUATE
BEARING MATERIALS IS
TOO GREAT FOR SHALLOW
FOUNDATIONS
(IMPRACTICAL, TOO $$$$)
AND/OR

2. THE PRIMARY AVAILABLE
BEARING MATERIAL
REQUIRES
FRICTION RESISTANCE
WITH THE FOUNDATION
SYSTEM

Deep Foundations

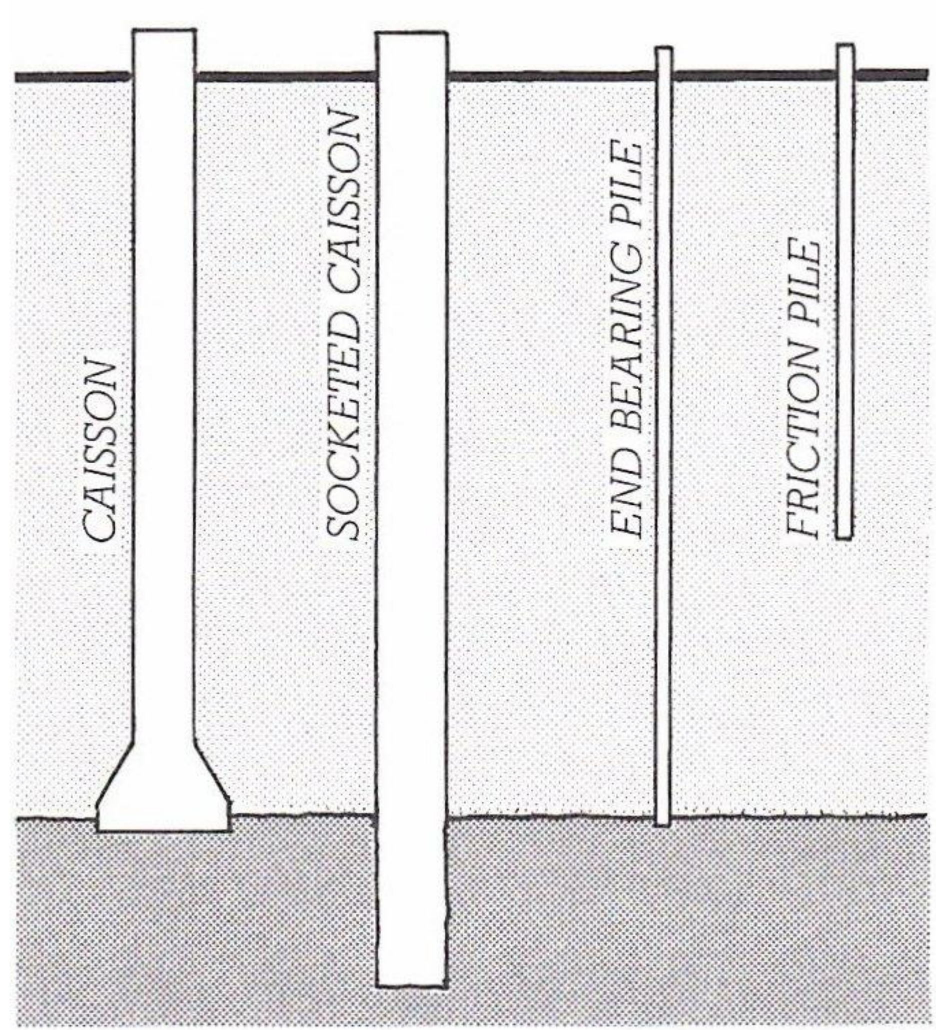
DEEP FOUNDATIONS:

TRANSMIT BUILDING LOADS TO DEEPER, MORE COMPETENT SOILS

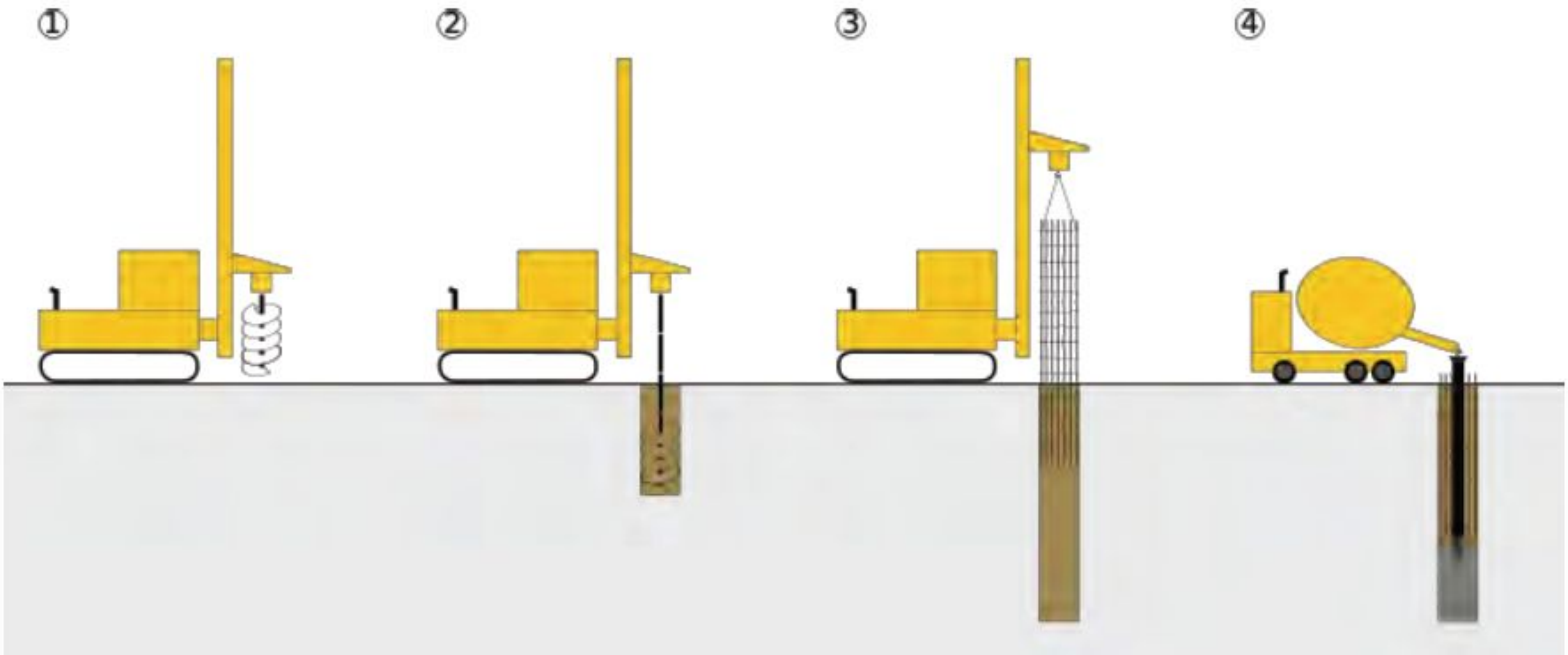
THE TWO TYPES OF DEEP FOUNDATIONS ARE:

1. END BEARING
2. BEARING THROUGH FRICTION

NOTE: SOME DEEP FOUNDATIONS FUNCTION IN BOTH MODES.



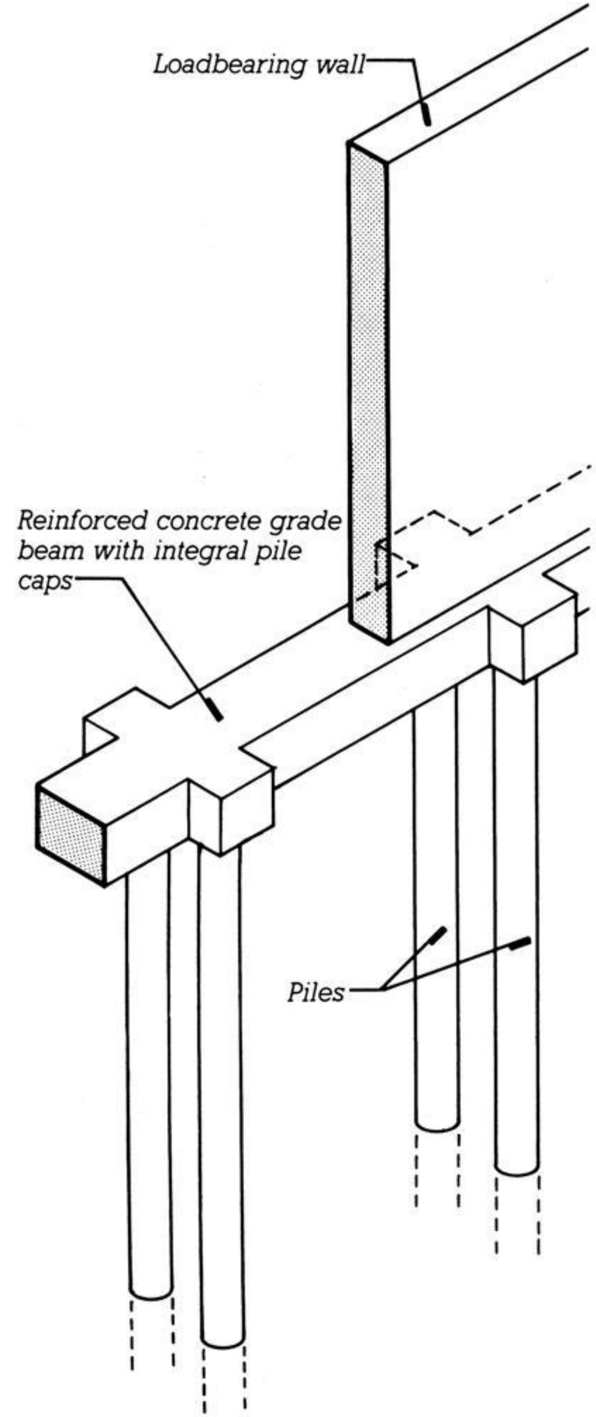
"Fundamentals of Building Construction / Materials and Methods" Allen & Wiley


①
②
③
④

Piles and Grade Beams

Pile caps share loads among clustered piles.

A *grade beam* spans between the piles to provide continuous support for the wall above.

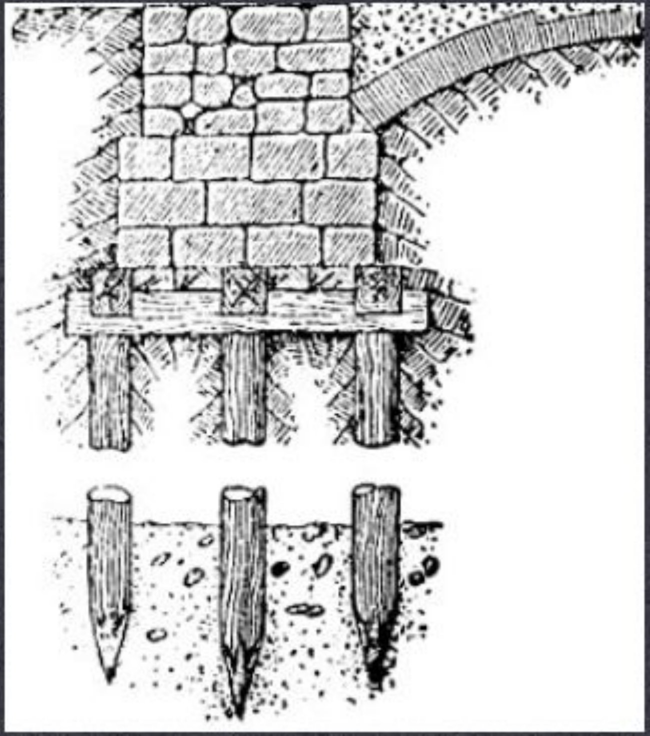


STEEL CASINGS MAY BE USED TO TEMPORARILY SUPPORT THE SIDE WALLS OF THE HOLE.

REINFORCEMENT IS USUALLY ONLY REQUIRED AT THE TOP TO TIE THE CAISSON TO THE STRUCTURE IT SUPPORTS

PILES:

A STRUCTURAL ELEMENT THAT IS FORCIBLY DRIVEN INTO THE EARTH (AS A NAIL IS DRIVEN INTO WOOD)



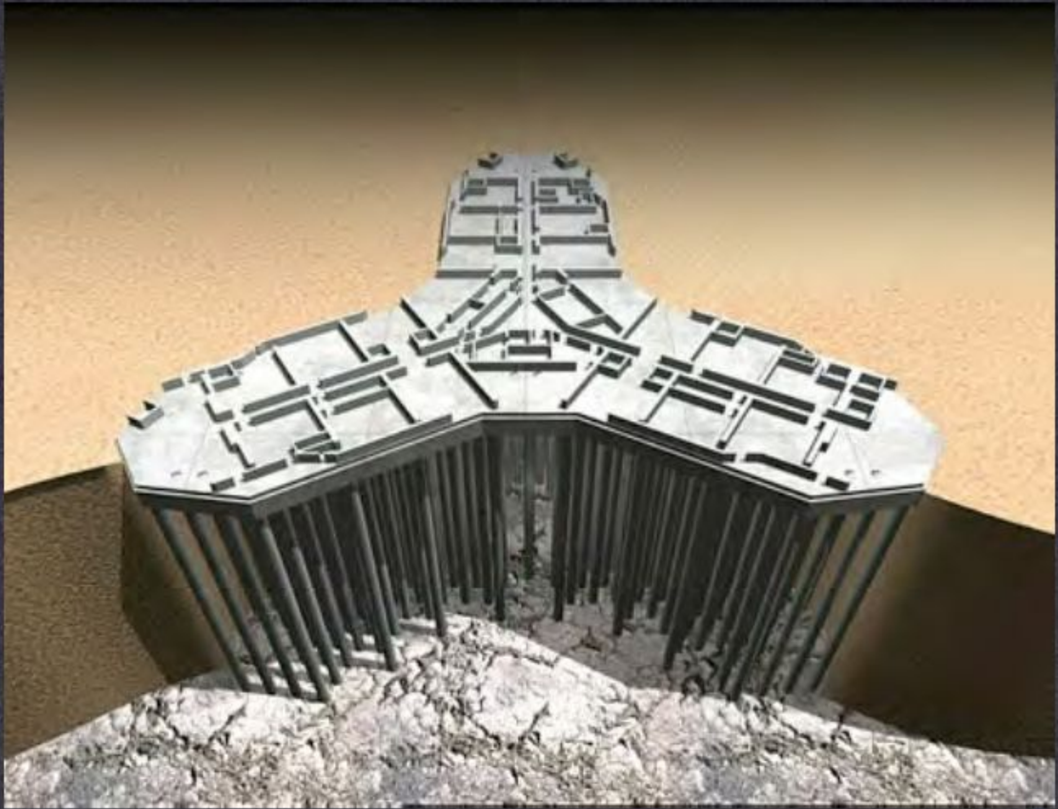
PILES:

MATERIALS USED:

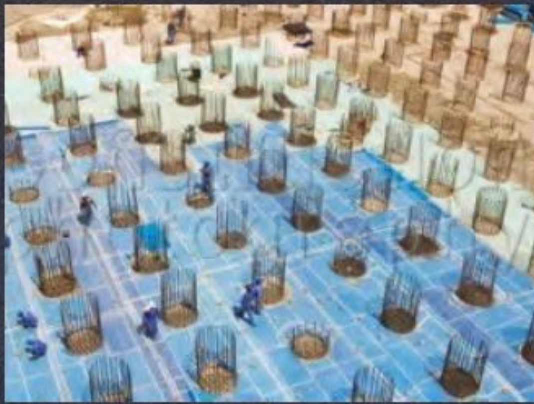
1. WOOD
2. STEEL
3. PRE CAST CONCRETE (PICTURED)

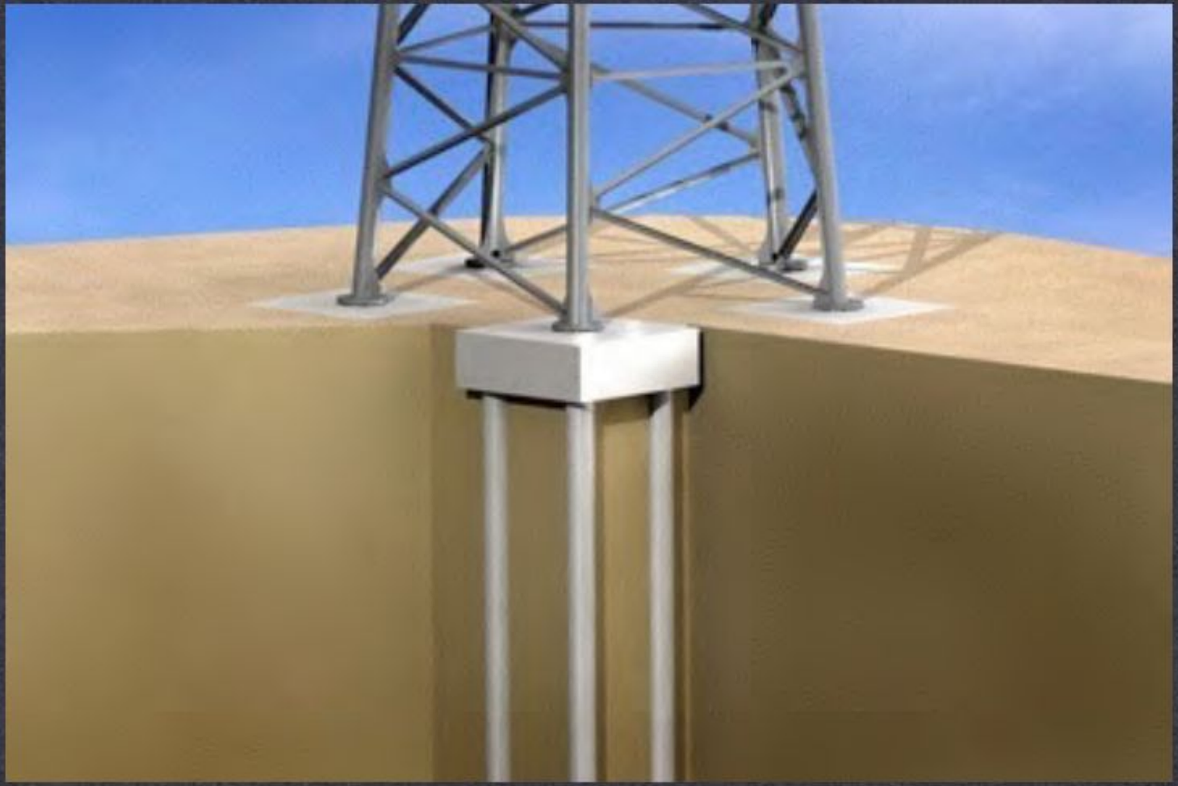
MATERIAL MUST BE SUITABLE TO SUBSURFACE CONDITIONS

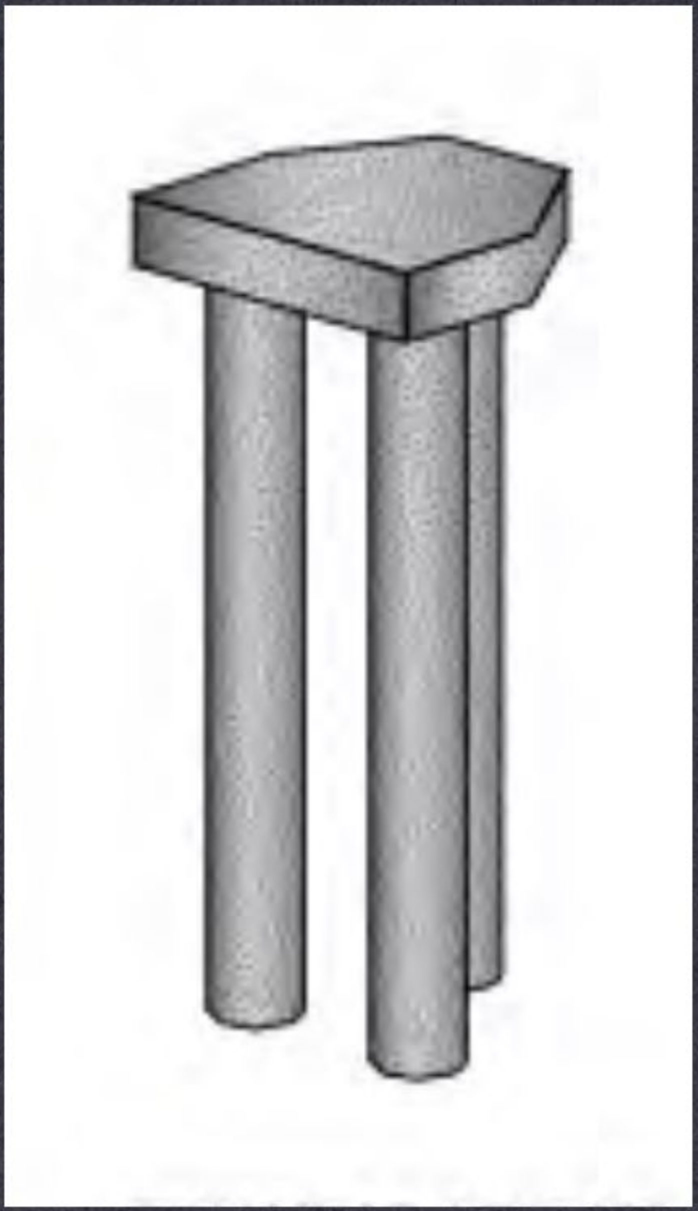
PILES ARE A COMMON APPROACH TO RAISING HOMES IN FLOOD PRONE AREAS



DENSE PILES
CAPPED BY A
MASSIVE MATT
SLAB SUPPORT THE
BURJ KHALIFA





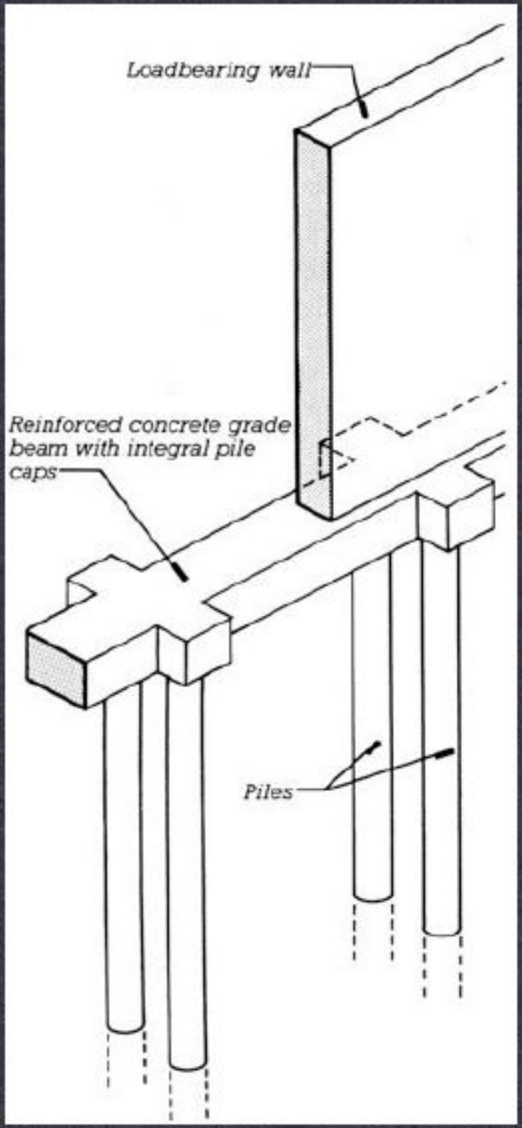


PILE CAPS:

CAPS JOIN SEPARATE PILES AT THE TOP TO TRANSFER AND DISTRIBUTE THE LOAD OF THE STRUCTURE ABOVE DOWN THROUGH THE INDIVIDUAL PILES.

GRADE BEAMS:

GRADE BEAMS ARE SUPPORTED BY CAISSONS OR PILES. EVEN THOUGH THEY ARE FORMED ON THE SOIL, THEY ARE <u>NOT</u> SUPPORTED BY THE SOIL. THE SOIL IS ONLY PART OF THE FORMWORK FOR THE GRADE BEAM



GRADE BEAMS:

REINFORCEMENT OF GRADE BEAMS IS SIMILAR TO ORDINARY CONCRETE BEAMS IN A FRAMED STRUCTURE.

professor Montgomery

UNDERPINNING REQUIRED WHEN:

1. EXISTING FOUNDATION IS SETTLING IN DANGEROUS MANNER.
2. A NEW PROJECT REQUIRES FOUNDATIONS DEEPER THAN EXISTING FOUNDATIONS IMMEDIATELY ADJACENT TO THE NEW FOUNDATION

UNDERPINNING PROCESS:

1. DIG NARROW TRENCHES WIDELY SPACED APART UNDER EXISTING FOUNDATIONS
2. POUR NEW CONCRETE WALL/ FOOTING INTO TRENCH
3. REPEAT FOR SOIL AREA BETWEEN FIRST TRENCHES

DESIGN THRESHOLDS TO CONSIDER:

1. WATER TABLE DEPTH
2. FLOODING HAZARDS
3. SITE BOUNDARIES AND NEIGHBORING STRUCTURES
4. INCREASED BUILDING LOADS ON FOUNDATIONS (DUE TO HEIGHT)
5. LOCATION AND QUALITY OF BEARING MATERIALS UNDER THE SITE

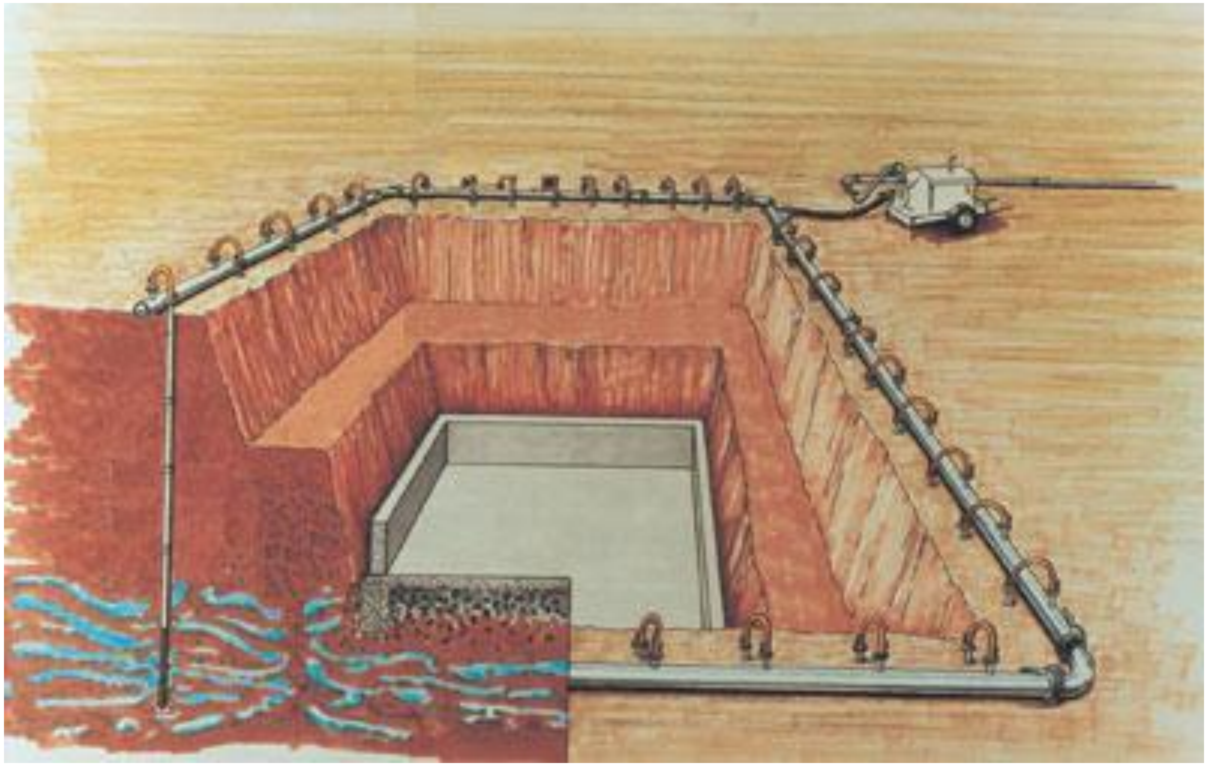
WATERPROOFING AND DRAINAGE

courtesy of PROF. Jason Montgomery

DEWATERING:

Done when excavating below water table.

Methods: 1. Well Points drain off water



2. Build water-tight barrier…

Drainage

Drainage mat and free-draining backfill material allow ground water to flow away from the substructure.

The machine in the foreground is used to compact the fill material as it is placed in *lifts* roughly 6 inches deep at a time.

courtesy of PROF. Jason Montgomery

Dampproofing & Waterproofing

Dampproofing materials are water-resistant.

Waterproofing materials are resistant to hydrostatic pressure.

courtesy of PROF. Jason Montgomery

Drainage

Perforated piping conducts water away from the substructure.

Filter fabric “socks” cover the piping to prevent soil particles from accumulating in and eventually clogging the pipes.

courtesy of PROF. Jason Montgomery

Foundations Summary:

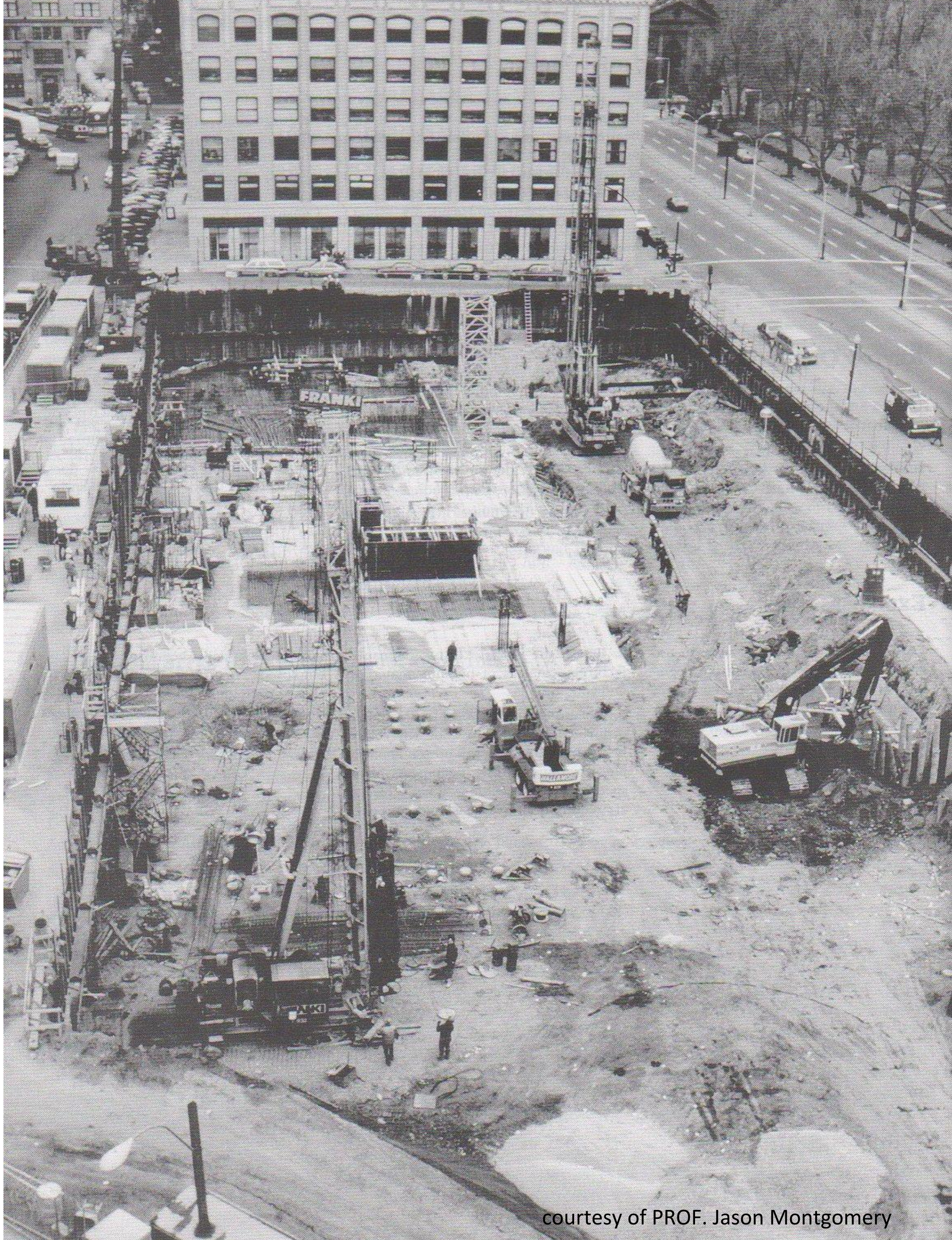
Starts with Subsurface Exploration

Shallow or Deep

Bearing or Friction

Drainage is Critical

Economics



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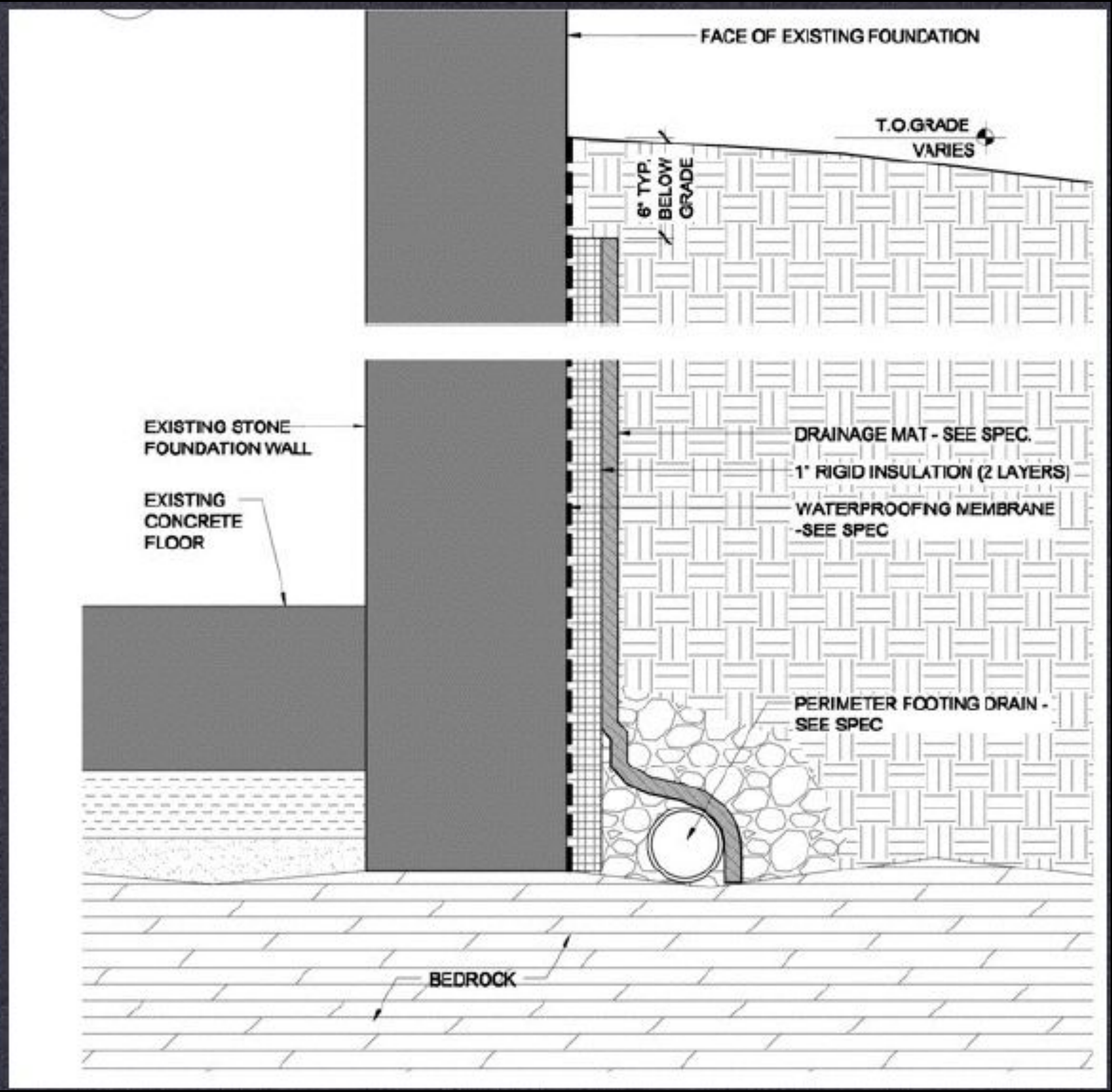
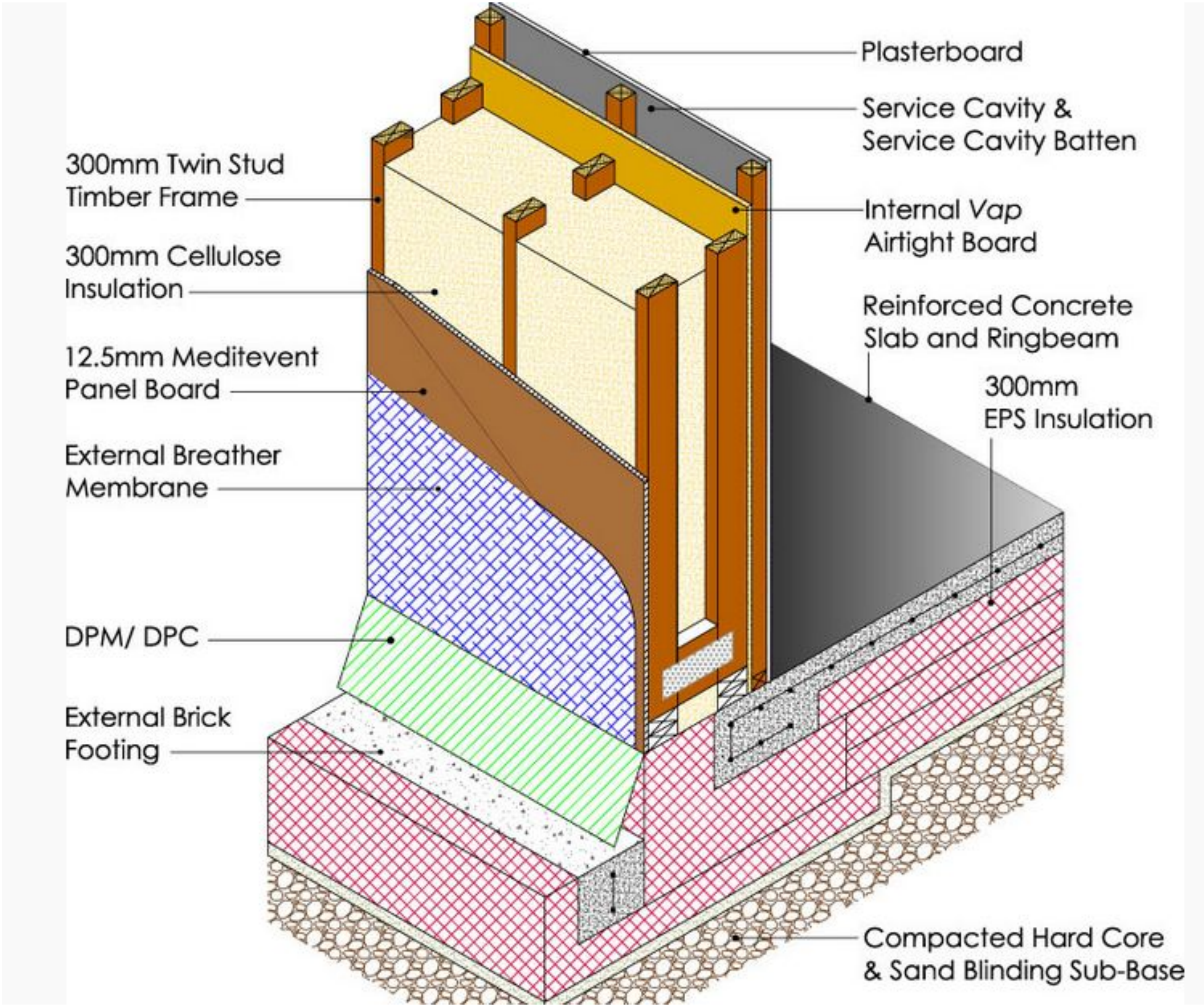

FACE OF EXISTING FOUNDATION
T.O.GRADE
VARIES
6" TYP.
BELOW
GRADE
EXISTING STONE
FOUNDATION WALL
EXISTING
CONCRETE
FLOOR
DRAINAGE MAT - SEE SPEC.
1" RIGID INSULATION (2 LAYERS)
WATERPROOFNG MEMBRANE
-SEE SPEC
PERIMETER FOOTING DRAIN -
SEE SPEC
BEDROCK



https://mbctimberframe.co.uk/passive-wall/

wrap up

FOUNDATION DESIGN AND SELECTION IS A CRITICAL ACTIVITY IN PROJECTS THAT MUST OCCUR AT THE EARLY STRATEGIC LEVELS TO TEST THE VIABILITY OF THE PROJECT

- deep foundations can solve many challenging site conditions, even for super large/tall buildings and structures
- shallow foundations are preferred as there is less risk and expense
- underpinning is a common exercise in urban environments where adjacencies are unavoidable.