ARCH 1230
BUILDING TECHNOLOGY II

Professor Friedman

FALL 2012

SUBJECT

Building Technology II

Foundations Part II

DATE FALL 2012

PROFESSOR Friedman

FOUNDATIONS

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spread the load into the earth

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this week

objective:

overview of the function of foundations and the process of designing foundations

- foundation requirements
- deep foundations
- caissons
- piles
- pile caps
- grade beams
- underpinning
- designing foundations

Foundation Requirements

FOUNDATIONS MUST MEET FOLLOWING THREE GENERAL REQUIREMENTS:

1. MUST BE SAFE AGAINST STRUCTURAL FAILURE THAT COULD RESULT IN COLLAPSE

2. MUST NOT SETTLE DURING LIFE OF BUILDING IN SUCH A WAY THAT WOULD DAMAGE STRUCTURE OR IMPAIR FUNCTION

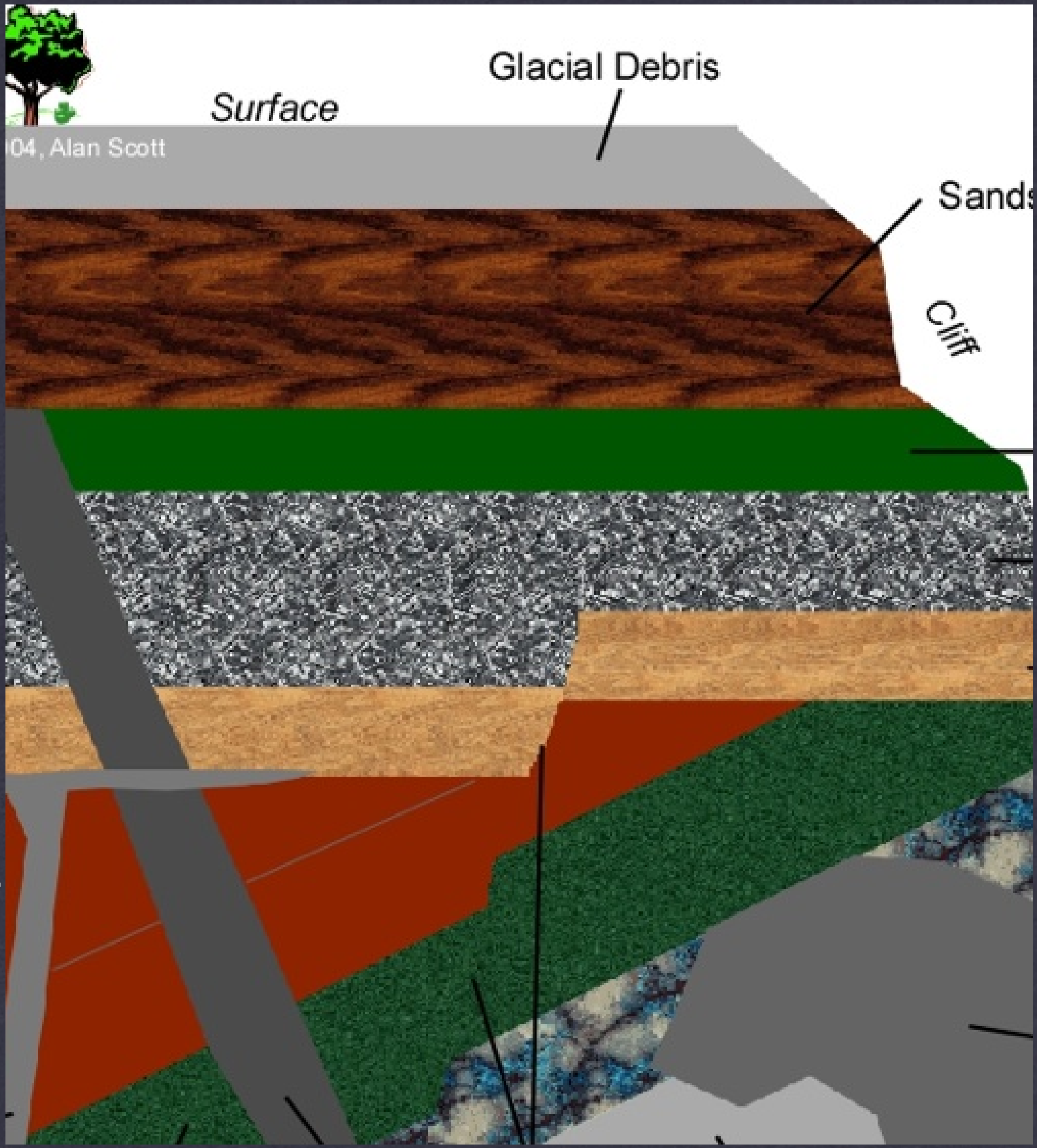
3. MUST BE FEASIBLE, ECONOMICAL, & PRACTICAL (WITH NO IMPACT ON NEIGHBORS)

DEEP FOUNDATIONS ARE REQUIRED WHERE:

• THE DEPTH OF ADEQUATE BEARING MATERIALS IS TOO GREAT FOR SHALLOW FOUNDATIONS (IMPRACTICAL, TOO $$$$)

AND/OR

• THE PRIMARY AVAILABLE BEARING MATERIAL REQUIRES FRICTION RESISTANCE WITH THE FOUNDATION SYSTEM

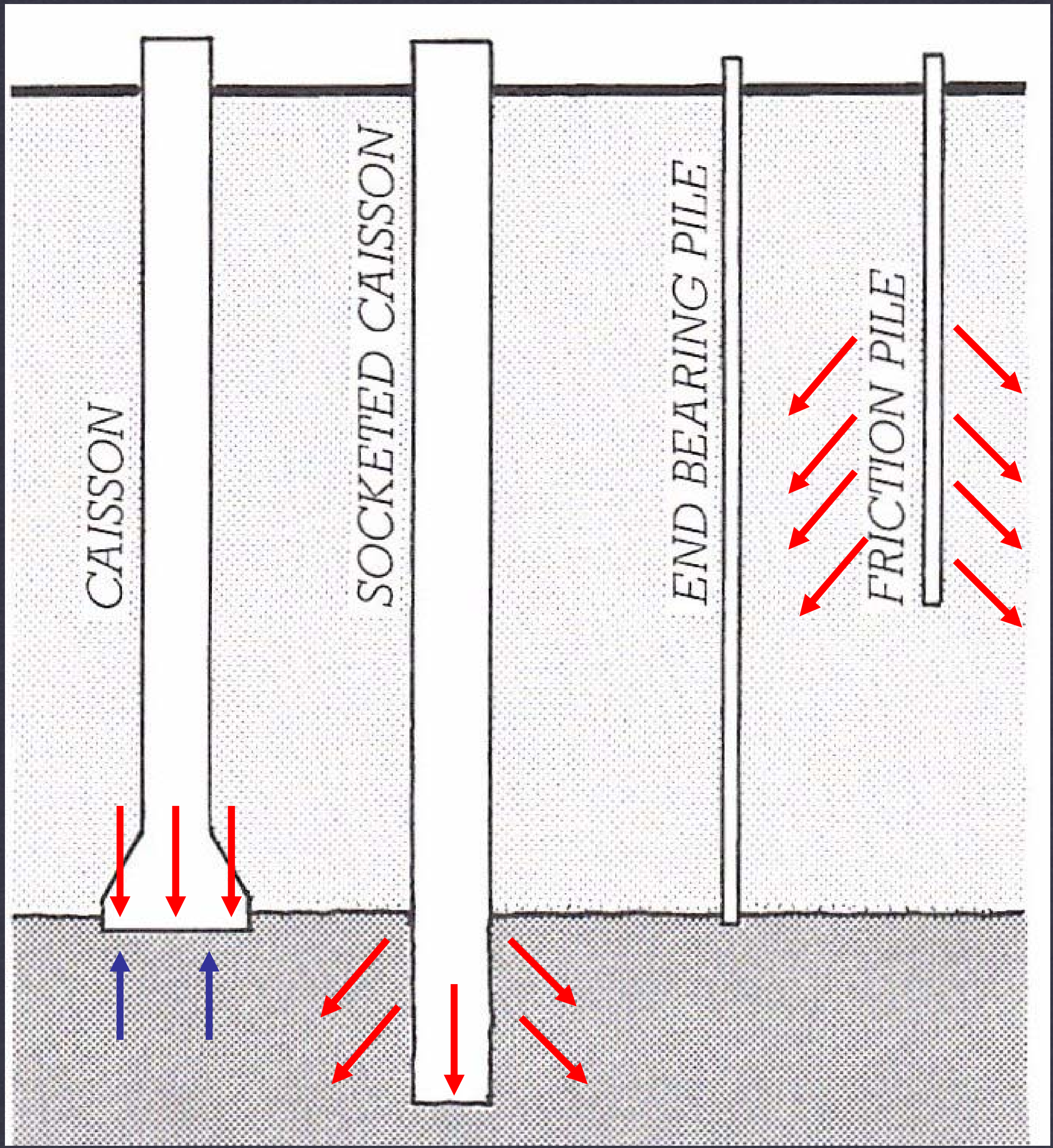


DEEP FOUNDATIONS:

TRANSMIT BUILDING LOADS TO DEEPER, MORE COMPETENT SOILS
THE TWO TYPES OF DEEP FOUNDATIONS ARE:

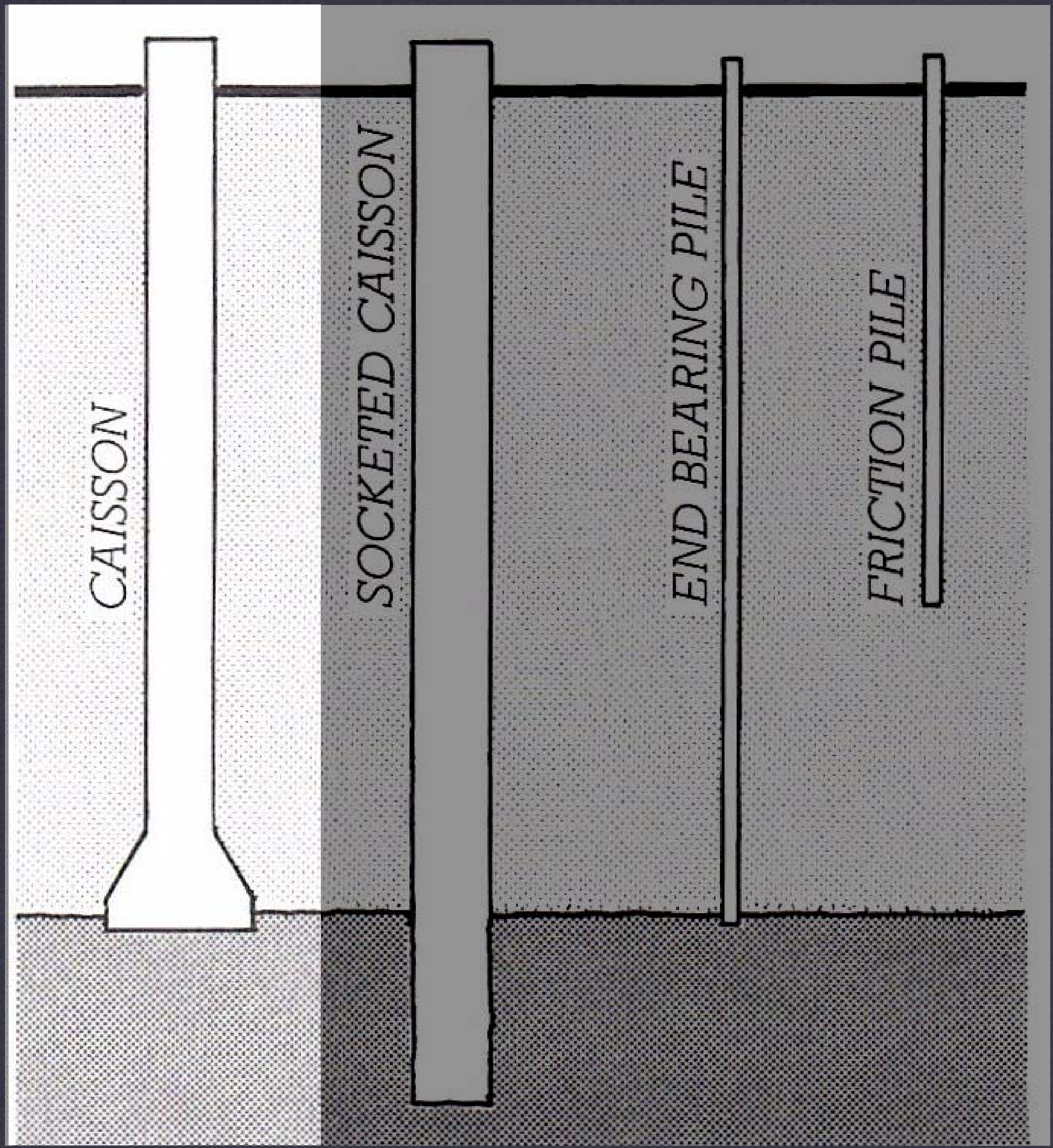
- END BEARING
- BEARING THROUGH FRICTION

NOTE: SOME DEEP FOUNDATIONS FUNCTION IN BOTH MODES.



CAISSON:

Is similar to a column footing in that it spreads the load from a column over a large enough area of soil that the allowable stress in the soil is not exceeded.



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Caissons

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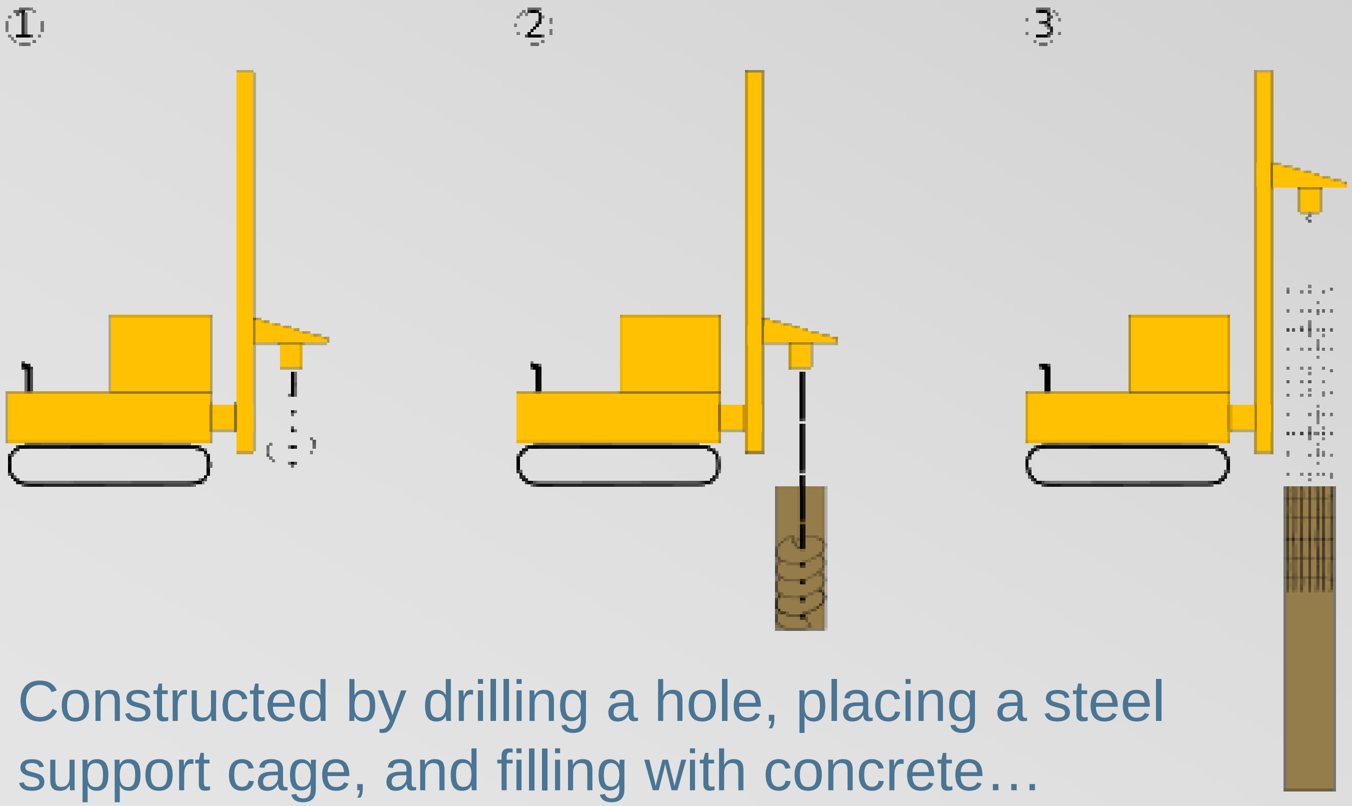


Constructed by drilling a hole, placing a steel support cage, and filling with concrete…

CAISSONS:

A CONCRETE CYLINDER POURED INTO A DRILLED HOLE.

Caissons

Steel Casings may be used to temporarily support the side walls of the hole.
[Can be removed after concrete placed.]

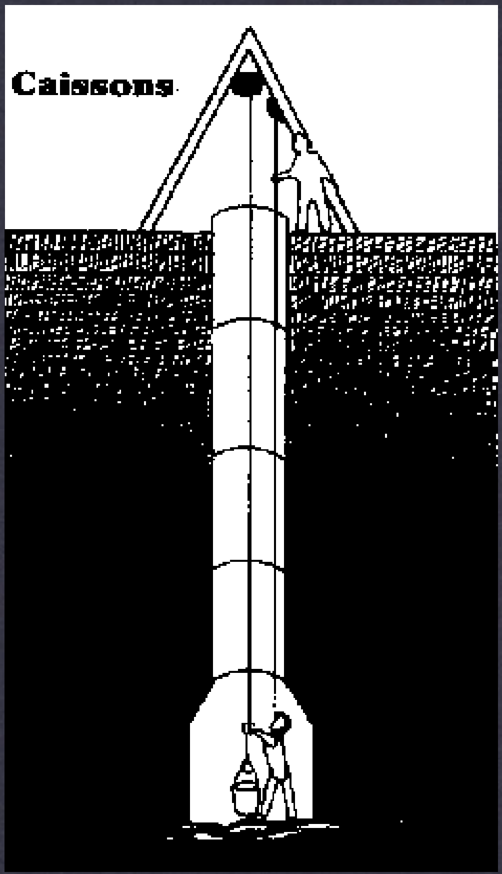
Caissons

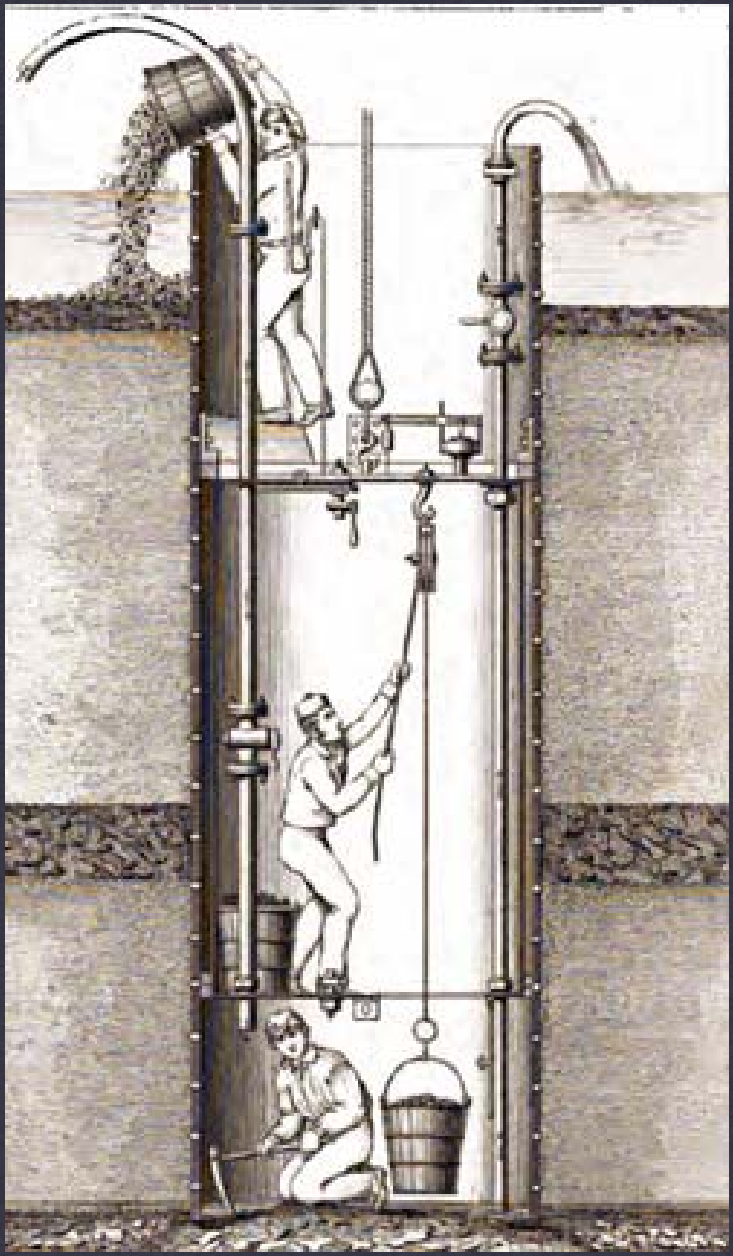
Reinforcement is usually only required at the top to tie the caisson to the structure it supports

Caissons

Caissons (sometimes called piers) can sometimes be as small as 12 to 18 inches in diameter.

Most of the time, are much larger, up to 8 ft in diameter and carry 3,500 tons or more.



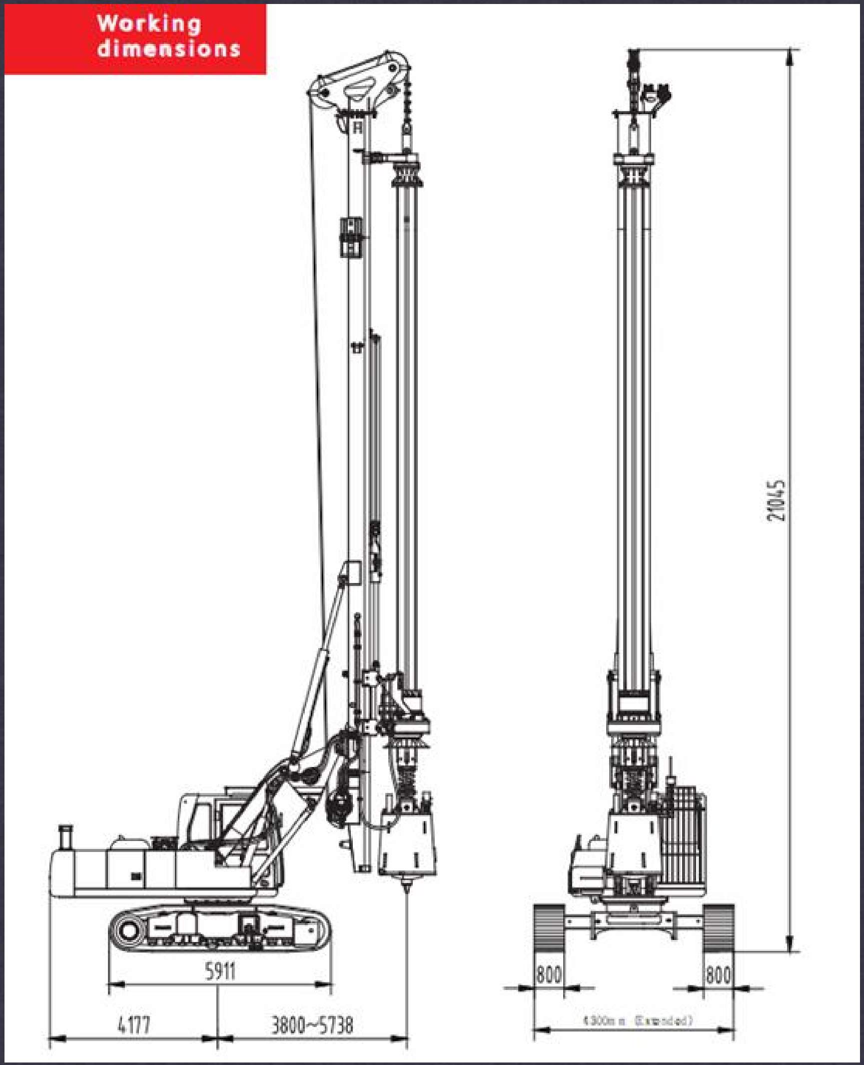


Caissons

Auger drills generally used to bore deep into the earth and remove the soil.

Small portable drills

Larger telescoping drills

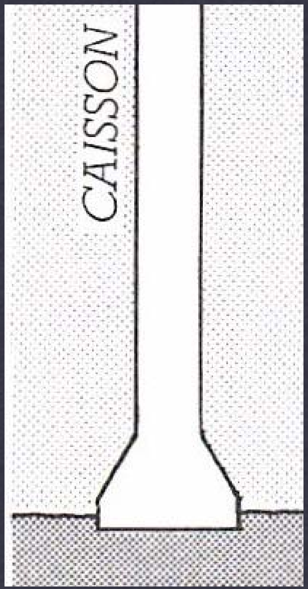


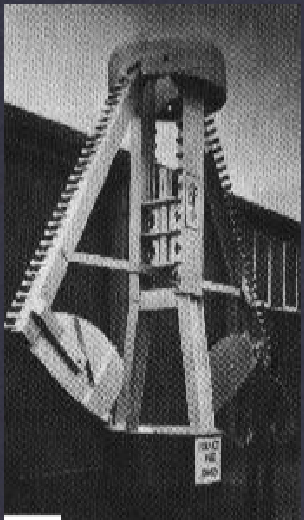
Caissons

Belling Bucket
Used to significantly increase the bearing capacity of bored piles/ caissons by enlarging the base area.

Cutting arms are opened mechanically.

-Practical in stable conditions (a cohesive soil such as clay) that can retain its shape until concrete is poured.



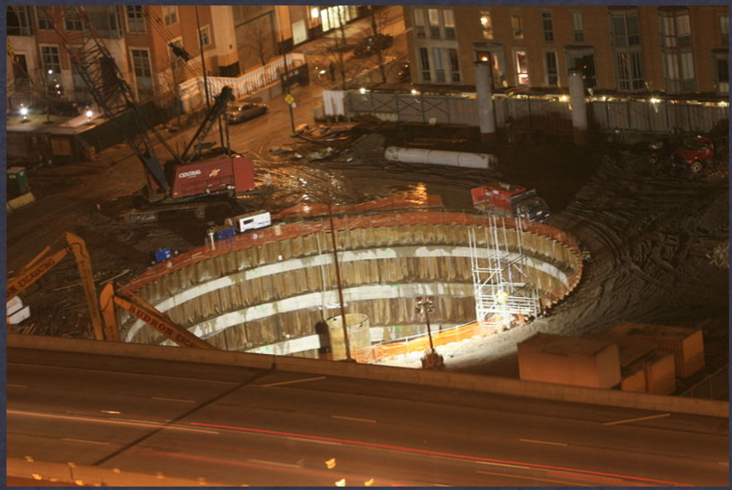


c)

Steel Casings

Lowered around the drill as it progresses to support the soil around the hole.
Later removed after concrete is poured.

<u>Chicago Spire by Santiago Calatrava</u>
(under construction)
2,000 feet tall, 150 stories (proposed)
34 caisson holes dug 120’ underground



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Tower columns supported by Caissons

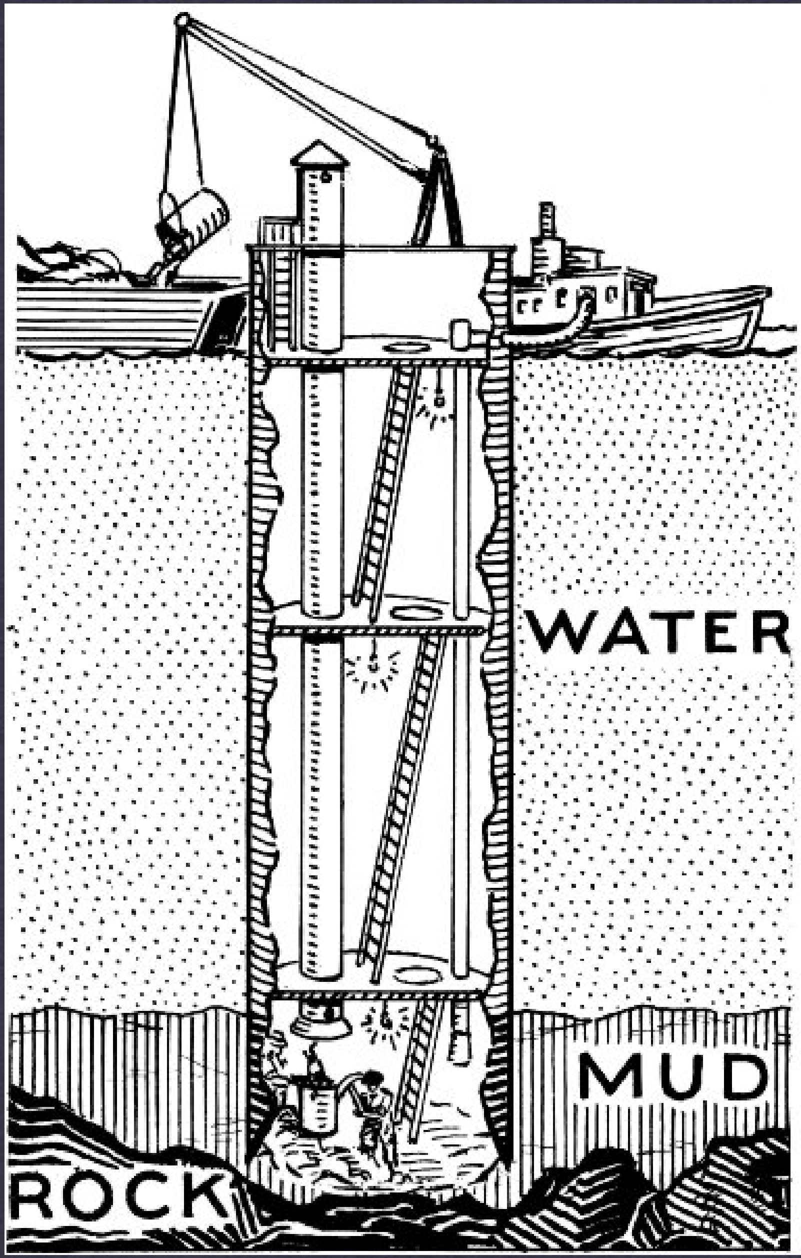




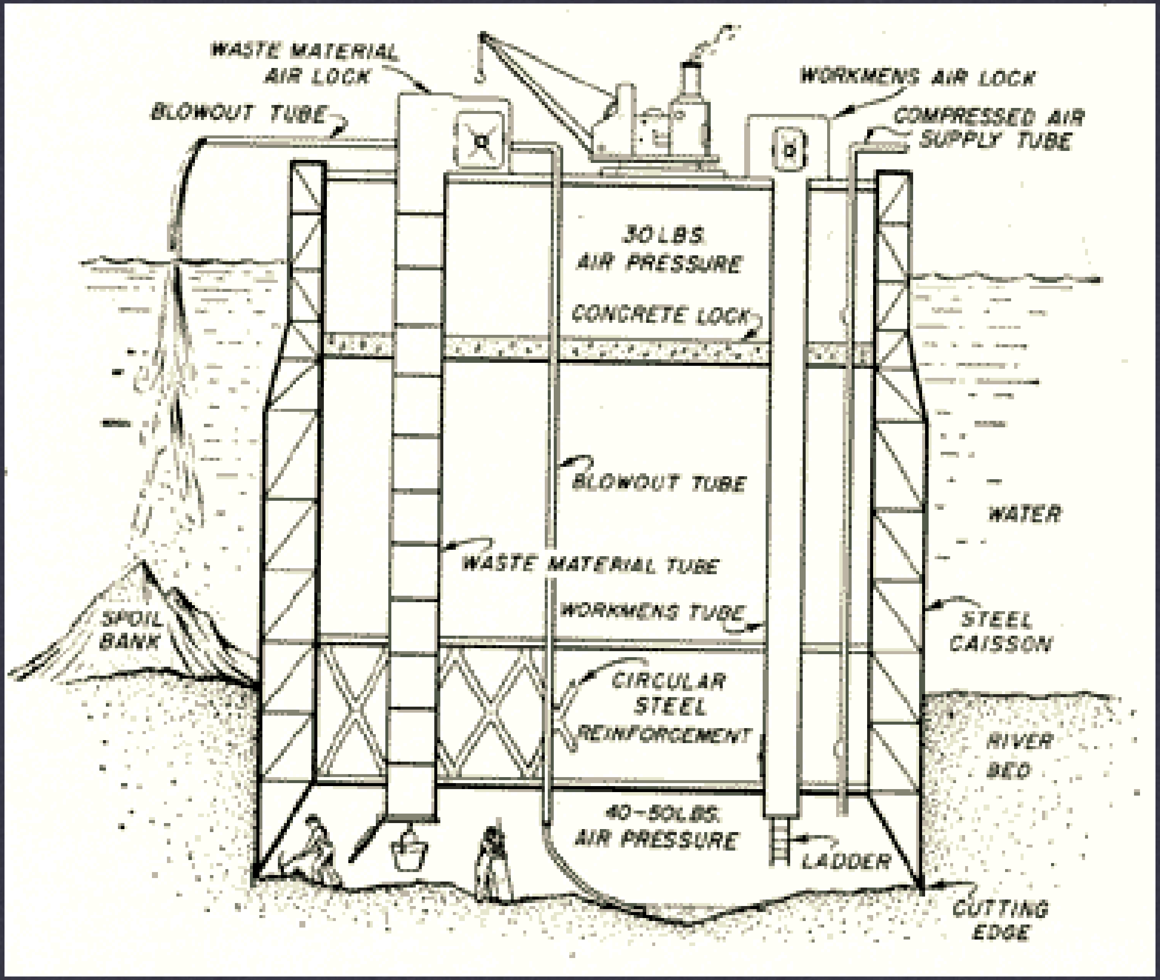


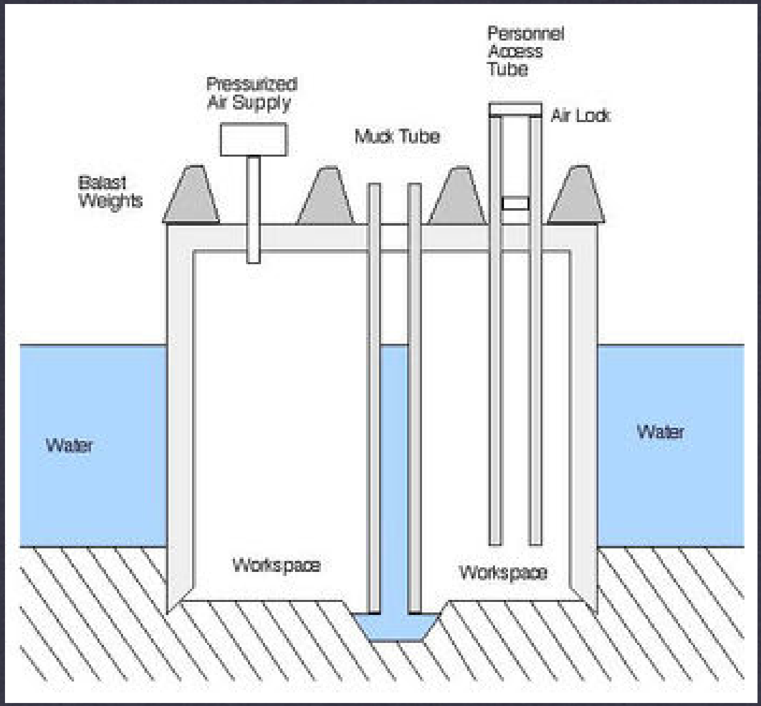
Caissons in water:

Over the years, builders have used caissons to provide support for bridges, deep water drilling, docks, etc…

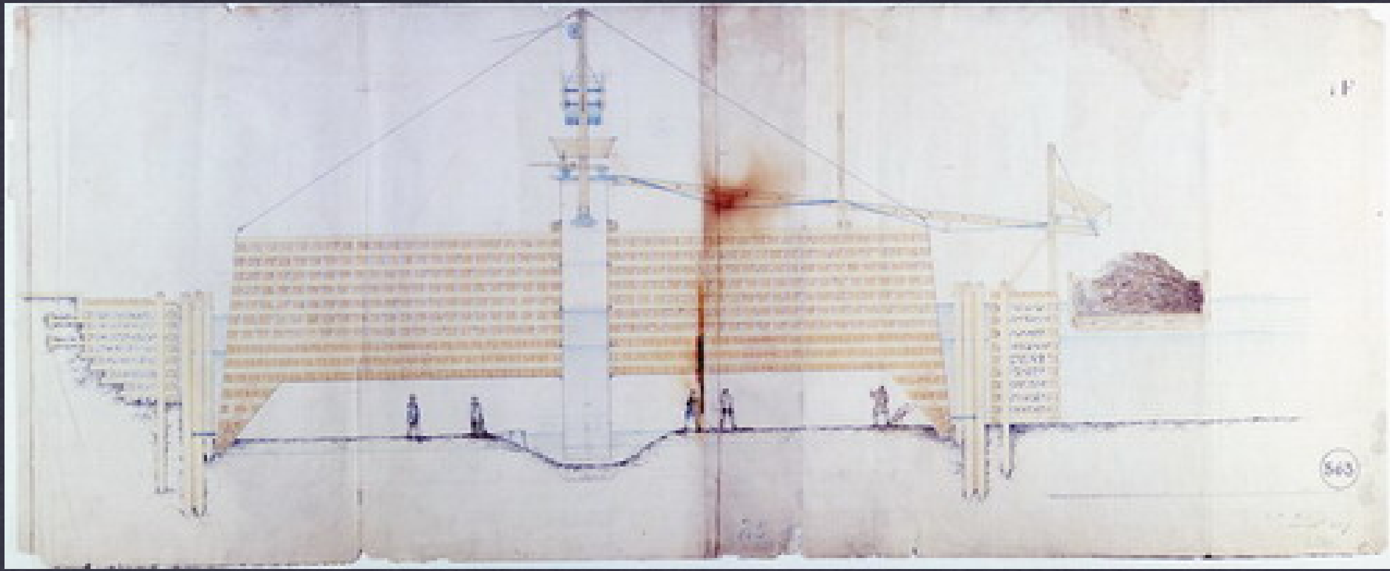


Caissons


WASTE MATERIAL AIR LOCK
BLOWOUT TUBE
WORKMENS AIR LOCK
COMPRESSED AIR SUPPLY TUBE
30 LBS. AIR PRESSURE
CONCRETE LOCK
BLOWOUT TUBE
WATER
WASTE MATERIAL TUBE
WORKMENS TUBE
STEEL CAISSON
SPOIL BANK
CIRCULAR STEEL REINFORCEMENT
RIVER BED
40-50 LBS. AIR PRESSURE
LADDER
CUTTING EDGE


Personnel Access Tube
Pressurized Air Supply
Air Lock
Muck Tube
Balast Weights
Water
Water
Workspace
Workspace

Brooklyn Bridge:
Towers built upon caissons up to 78’ underwater.
A large wooden box was built offsite, shipped, and dropped into the water. Water was pumped out and the ground/mud was removed by hand.



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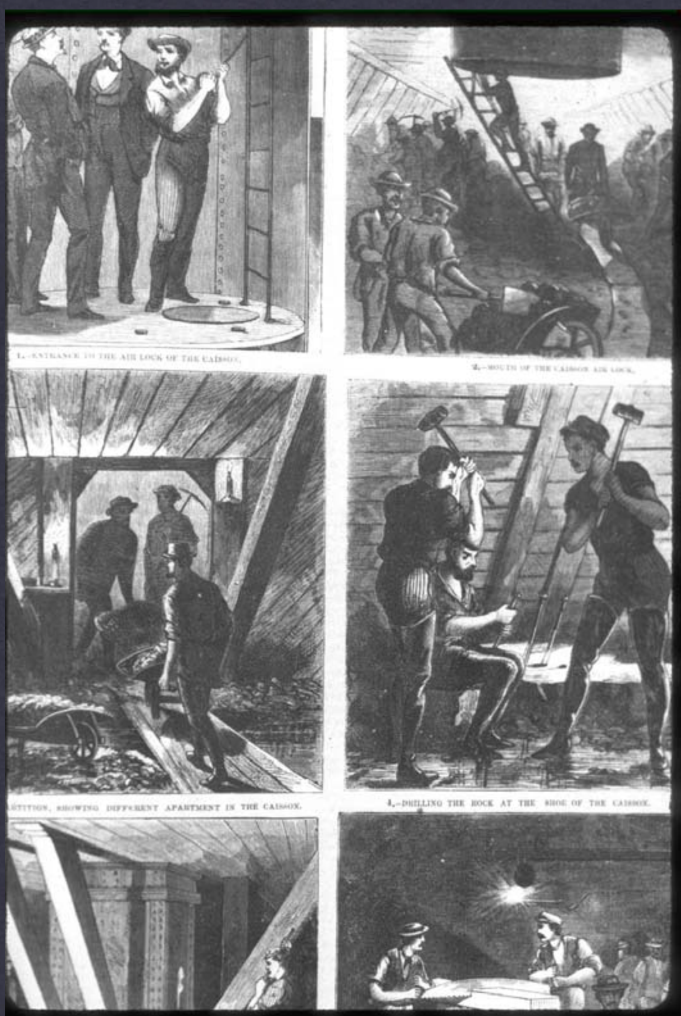
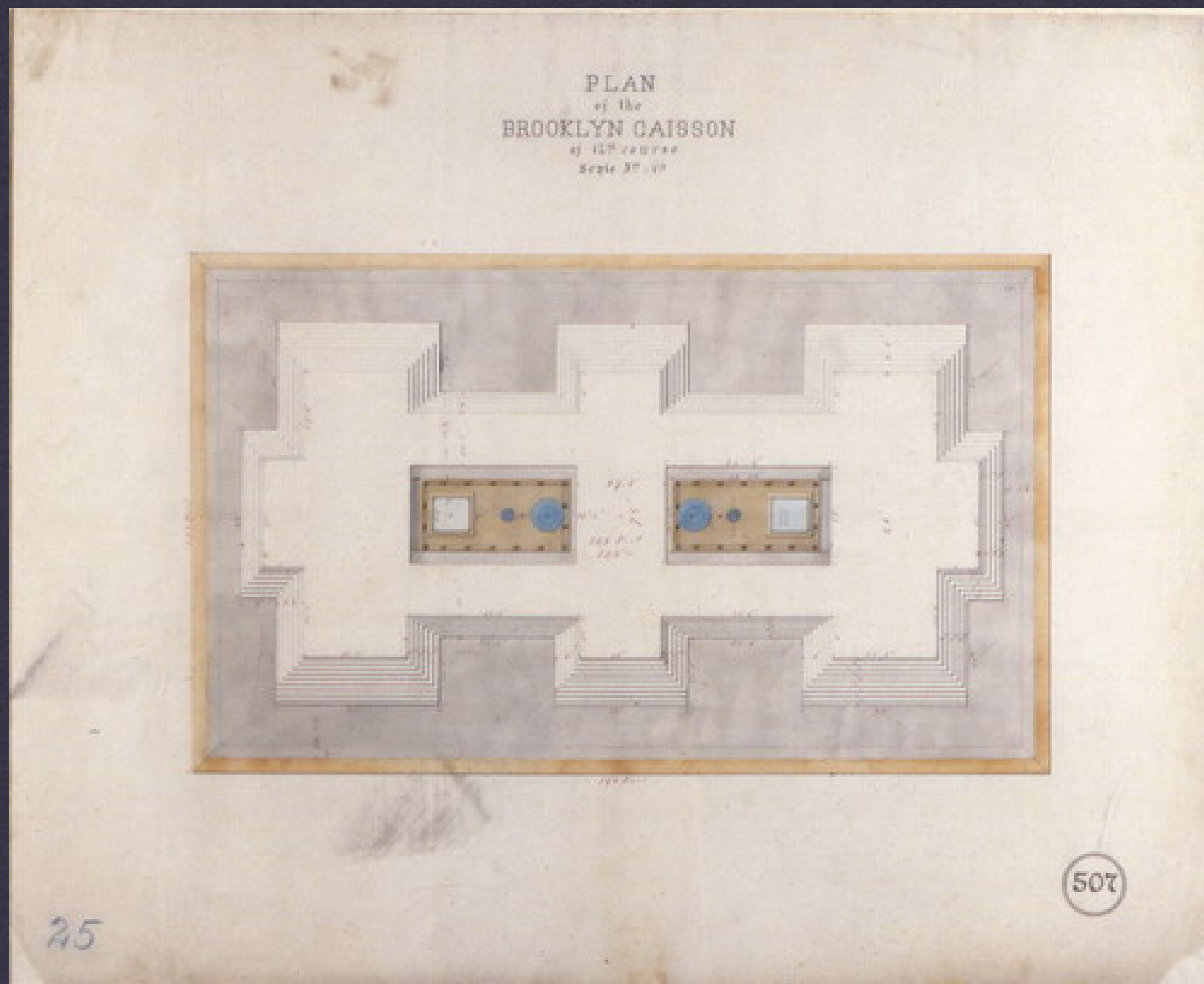
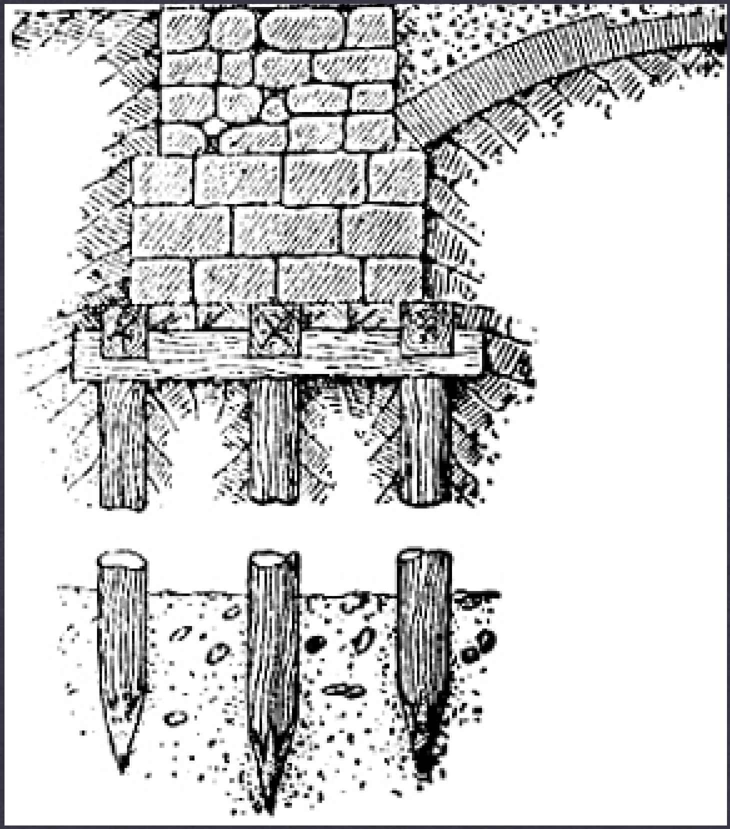
Conditions were rough, air was pressurized and if workers came up to the surface too quickly, they would get the bends (called Caisson disease).





PILES:
a structural element that is forcibly driven into the earth (as a nail is driven into wood).



PILES:

Generally used in conditions where caissons are impractical.

-Non-cohesive Soil

-Subsurface water conditions

-Excessive depth of bearing strata

Materials Used:

•WOOD

•STEEL

•PRE CAST CONCRETE (PICTURED)

Material must be suitable to subsurface conditions

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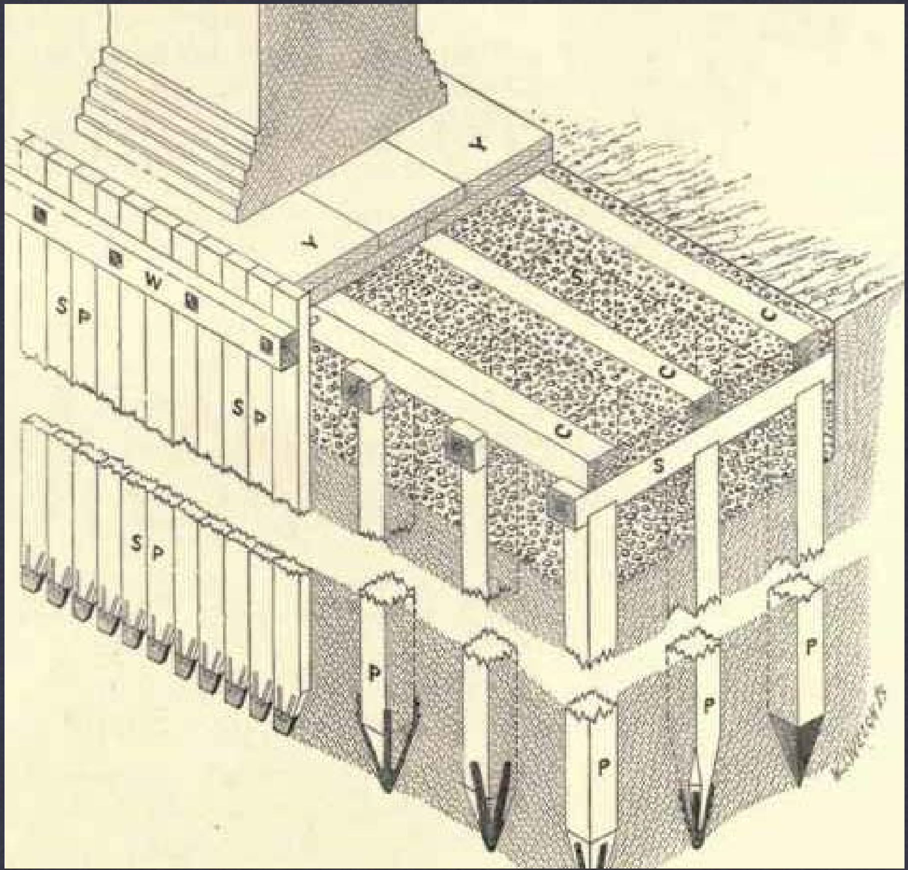
PILES ARE DRIVEN INTO THE EARTH OFTEN CLOSELY SPACED TO DEVELOP ENOUGH BEARING CAPACITY FOR THE WALL OR PIER IT WILL SUPPORT.



Wood/ Timber Piles

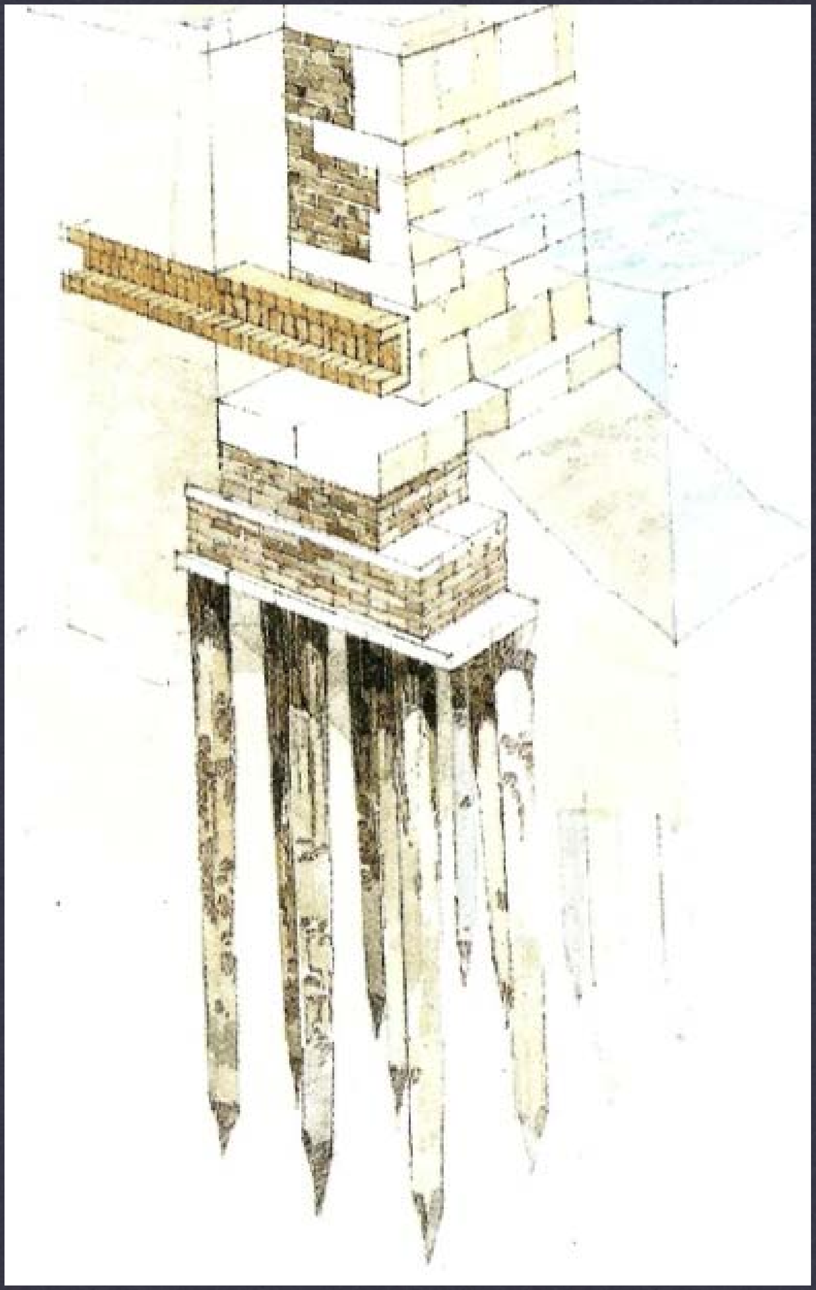
-Have been used for over 2000 years.
-Some Timber piles beneath bridges in Europe are known to have remained in continuous service for more than 1,000 years.

Negatives

-Suitable only for relatively light loads (40 tons each).
-Must be preservative-treated when they will extend above the water table.
-Limited in length to the effective height of the tree from which they are cut (45' – 65') since they cannot be spliced together.

Piles

WOOD PILES WORK WELL WHEN CONSISTENTLY KEPT UNDER WATER



<u>Steel Piles</u>

-May be "H" shaped sections or pipes.

-H shaped piles are heavy, wide-flange sections varying in size from 8-14" wide.

-Can carry loads of 50- 200 tons each.

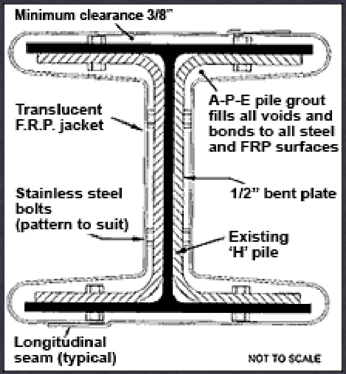
-May be up to 150' long.

-To produce super lengths, sections can be welded together as they are being driven.

H-Steel Piles

-H-piles have a maximum length of 250'

--Can hold up to 200 tons each



Steel Pipe Piles

-Are later filled with concrete.
-May be smooth walled or corrugated, round or fluted.
-Can carry up to 250 tons.
-Pipes with open ends can be driven up to about 80’.
--Pipes with closed ends can be driven up to 120’.

Precast Piles

-Are either solid concrete or open cylinders that are later filled solid.
-May be square, round, or octagonal in cross section.
-All are reinforced and most are pre-stressed.
-Sizes can vary from 10- 54 inches wide.
-Solid rectangular piles w/ simple reinforcement can be up to 80' long and hold 100 tons.
-Pre-stressed Cylinder piles can be extended up to 200' long and hold 500 tons.

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Piles are driven with heavy hammers in large machines called Pile Drivers. Drop hammers are simply raised and dropped on a pile by force of gravity. Today, they also use steam pressure, compressed air, vibratory hammers, and diesel driven hammers.

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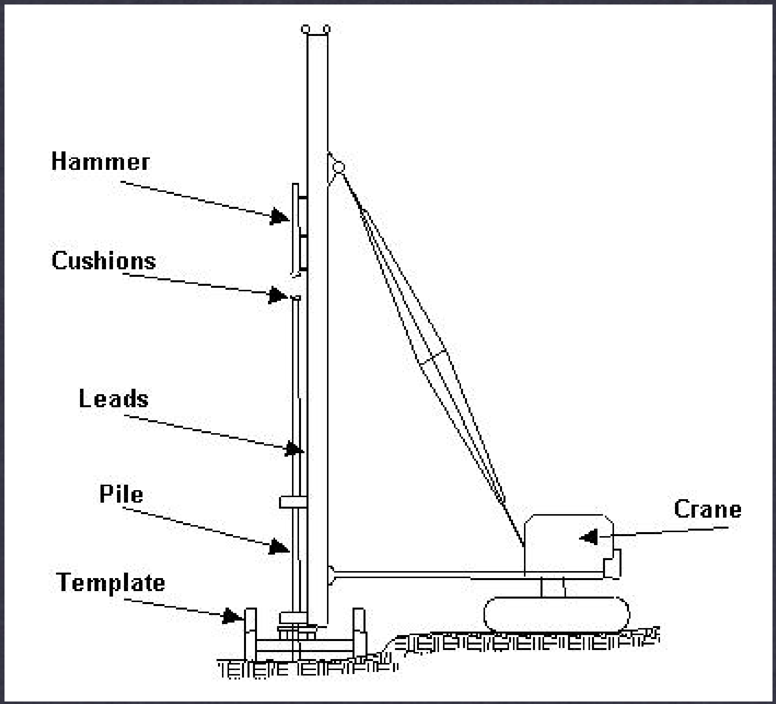

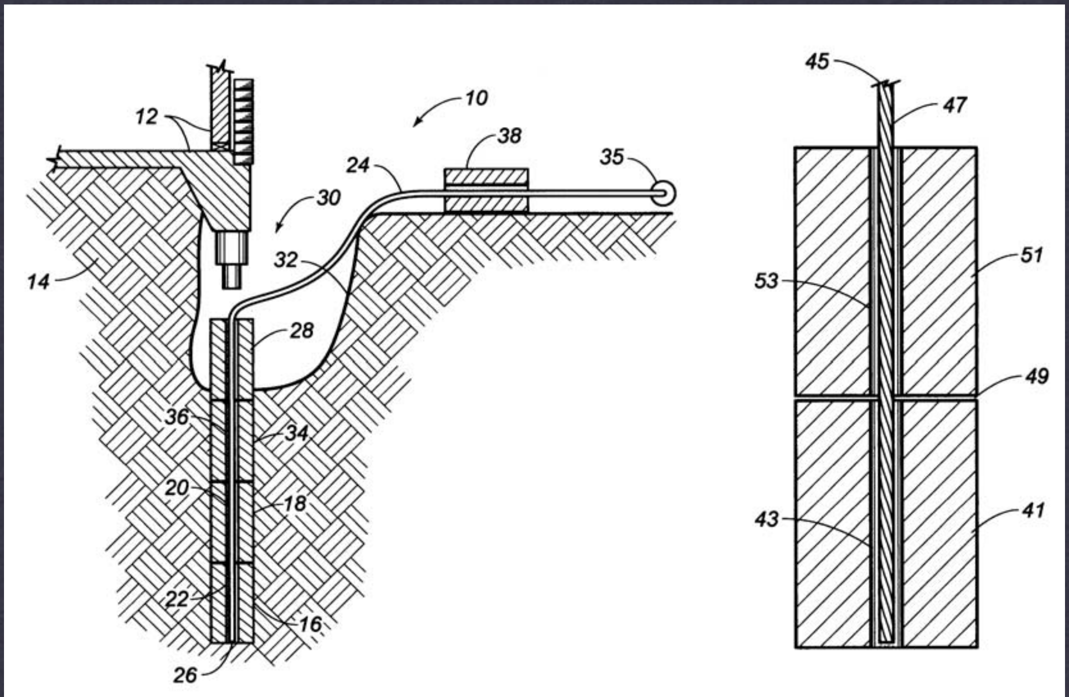

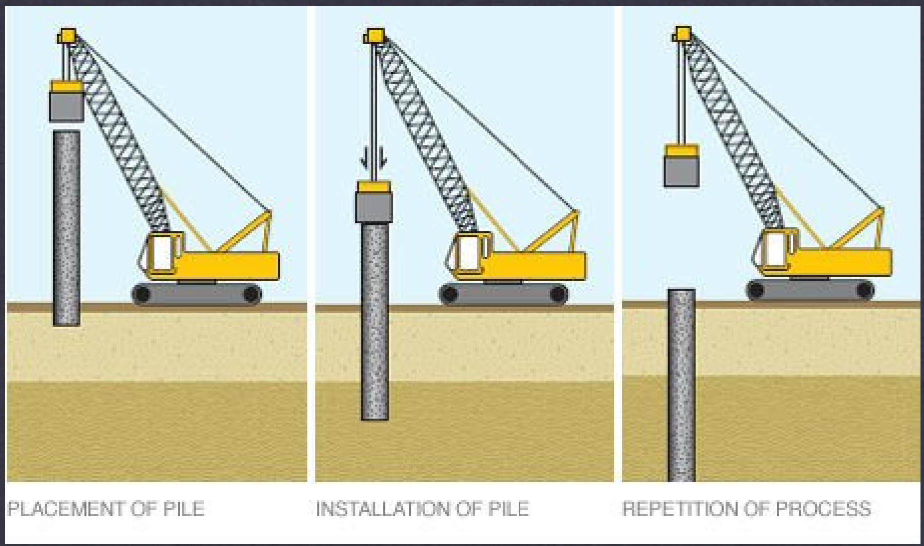

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DENSE PILES CAPPED BY A MASSIVE MATT SLAB SUPPORT THE BURJ KHALIFA

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Pile Caps

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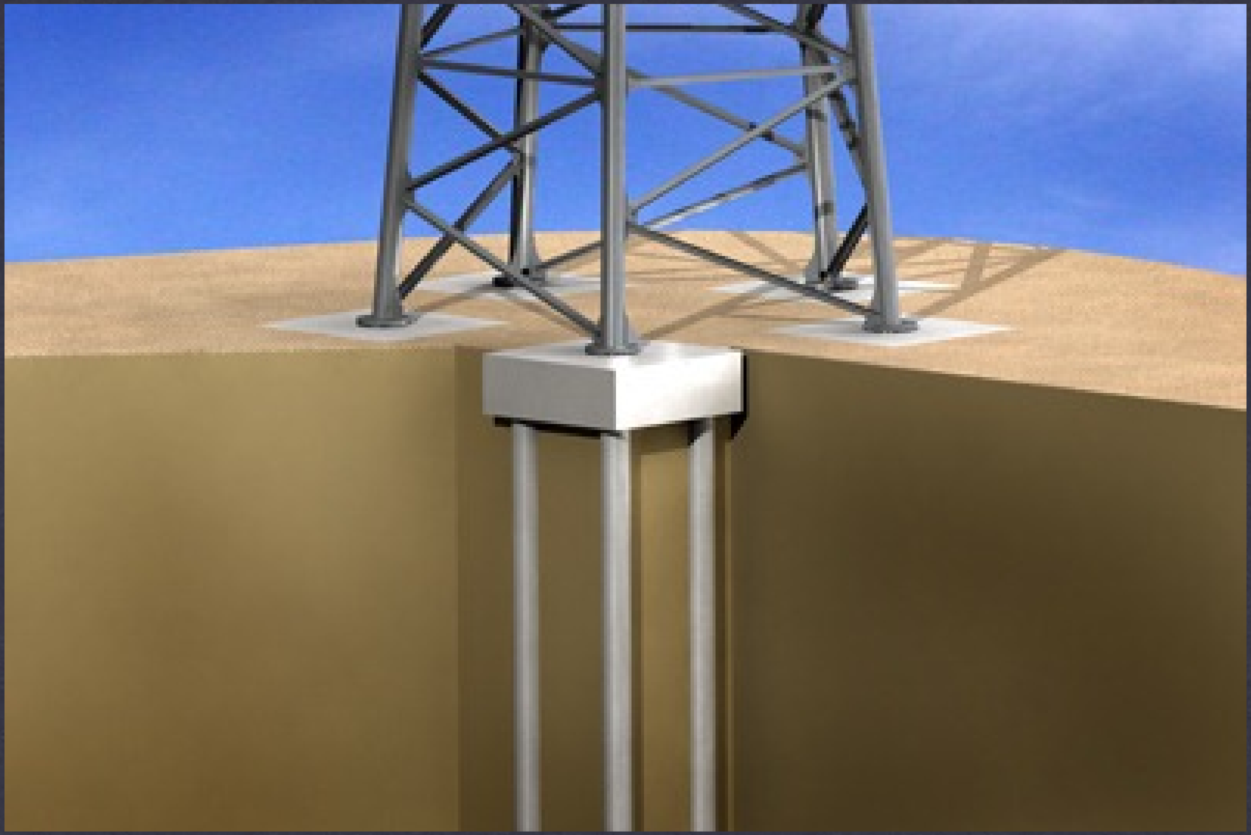

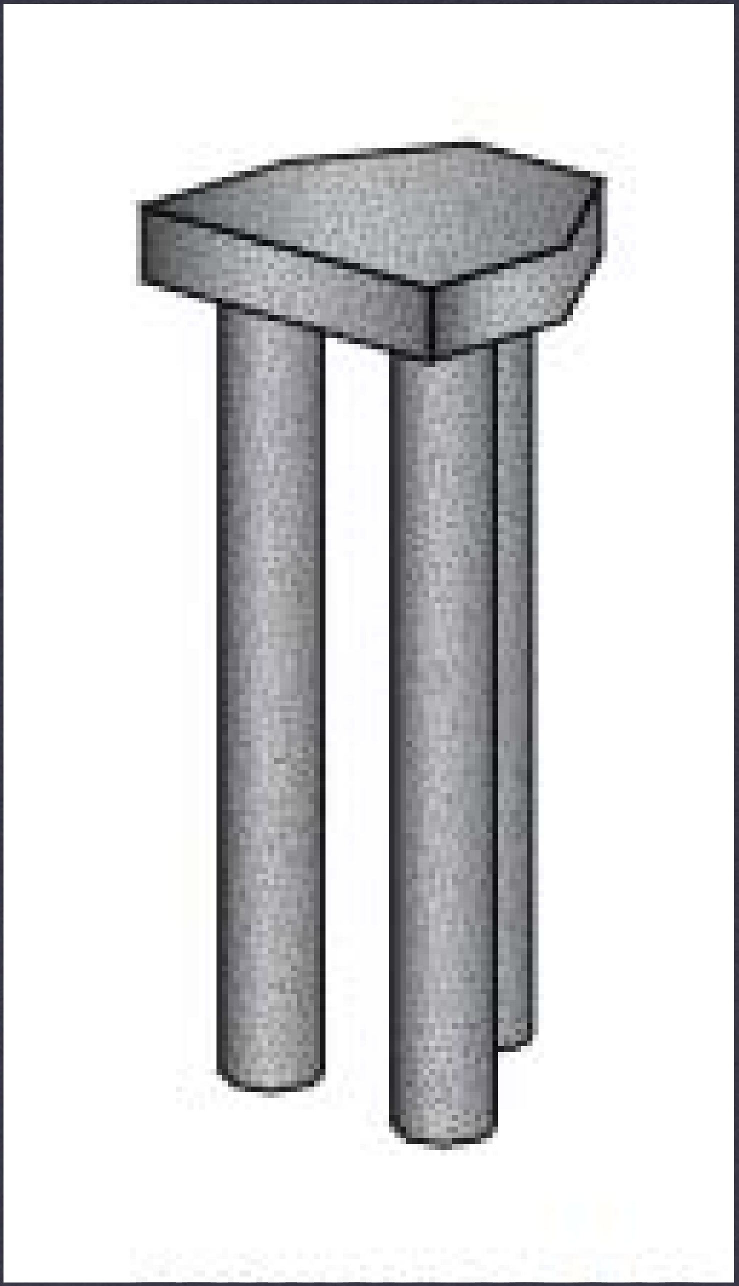

PILE CAPS:

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

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Pile Caps

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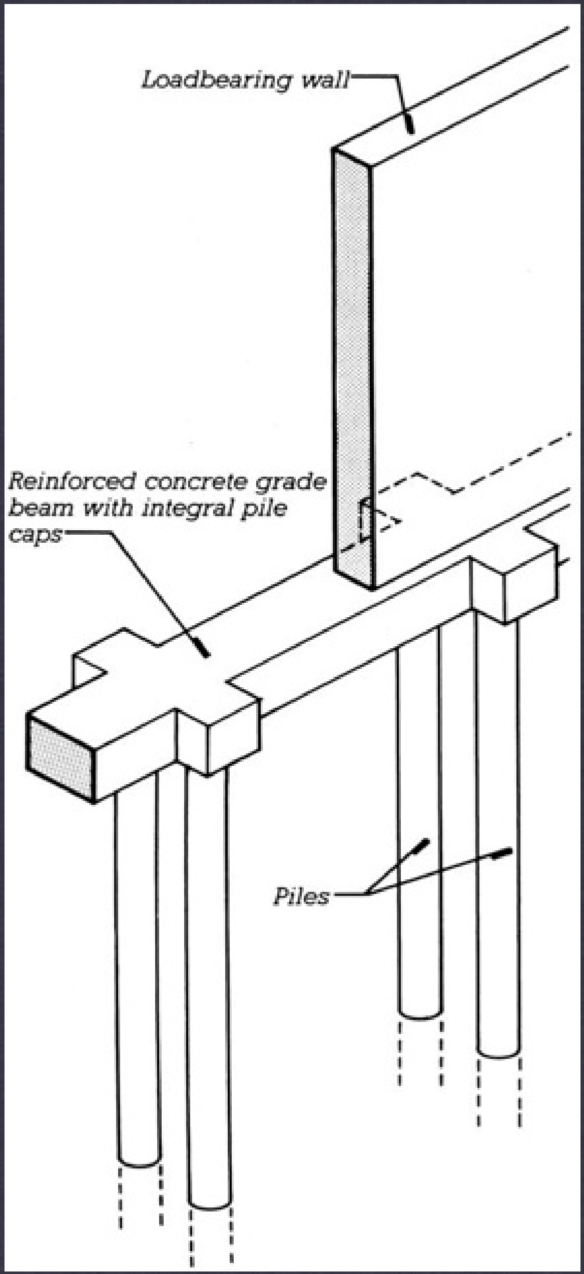
Pile Cap Casting

GRADE BEAMS:

GRADE BEAMS ARE SUPPORTED BY CAISSONS OR PILES EVEN THOUGH THEY SIT ON THE EARTH AT GRADE.

Grade Beams



GRADE BEAMS:

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

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Grade Beams

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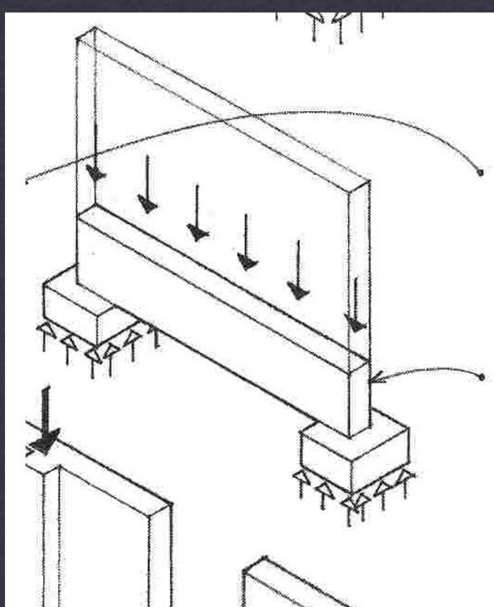
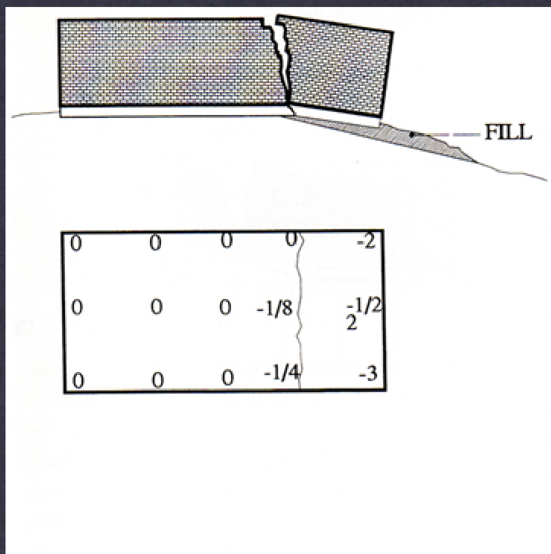


spread footings supporting freestanding columns and piers.

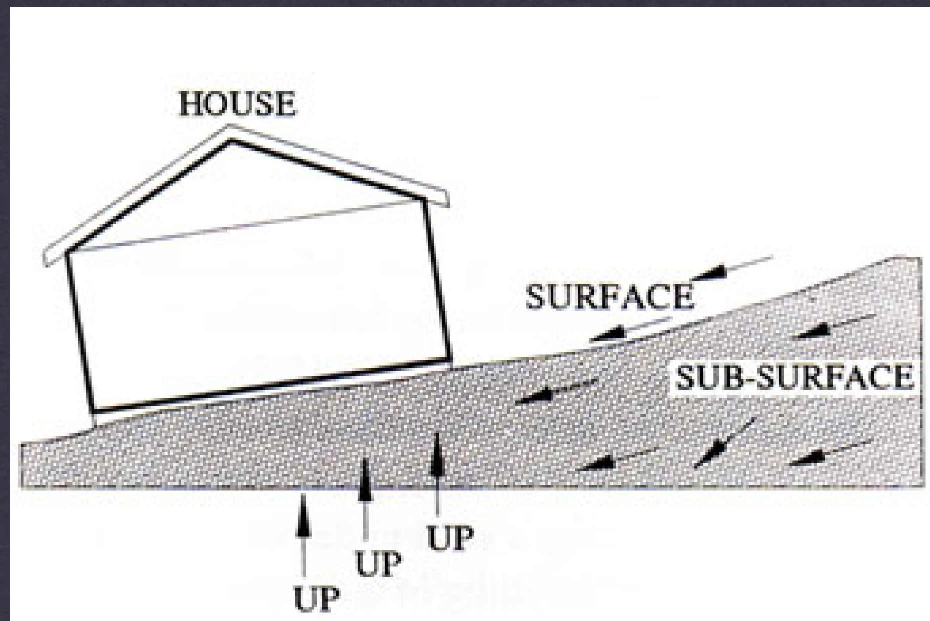
A continuous footing is a reinforced concrete footing extended to support a row of columns.

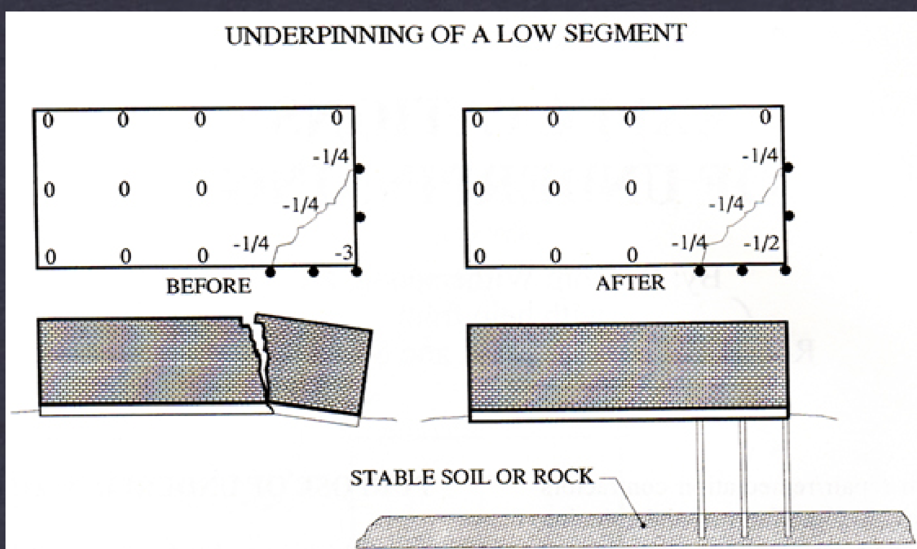
A grade beam is a reinforced concrete beam supporting a bearing wall at or near ground level and transferring the load to isolated footings, piers, or piles.

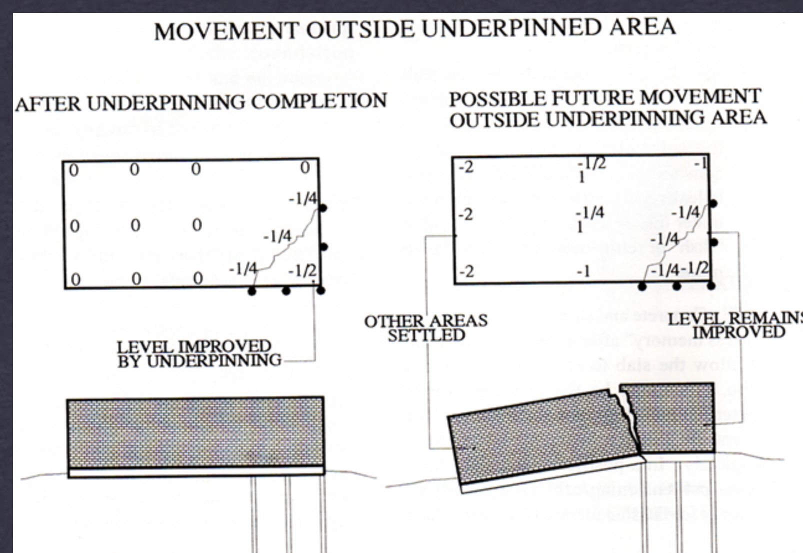
UNDERPINNING:



Settlement As A Result Of Poor Pre-Construction Compaction







UNDERPINNING:
REQUIRED WHEN:

1. EXISTING FOUNDATION IS SETTLING IN DANGEROUS MANNER.

2. NEIGHBORING PROJECT REQUIRES DEEPER FOUNDATIONS DIRECTLY ADJACENT TO EXISTING FOUNDATIONS

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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

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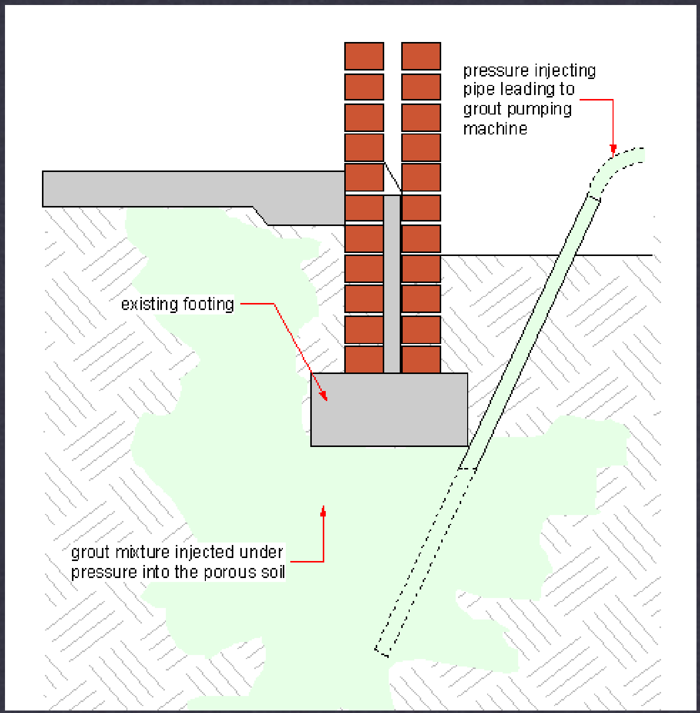

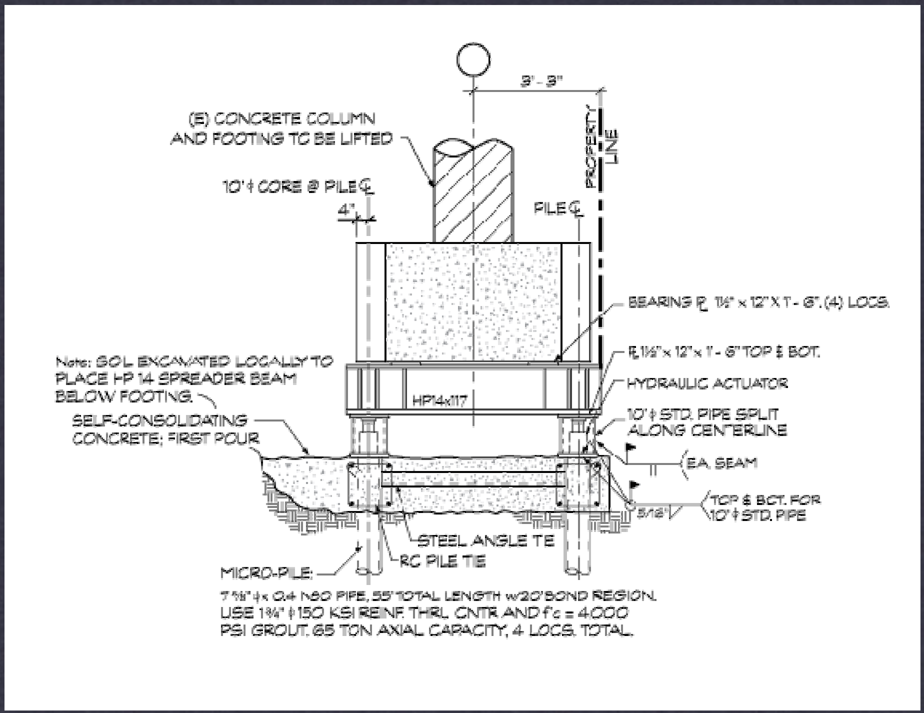

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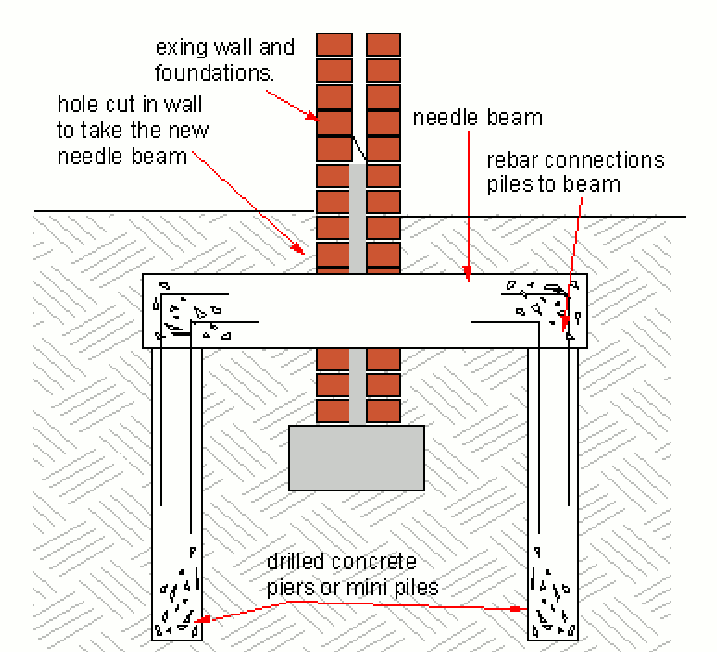
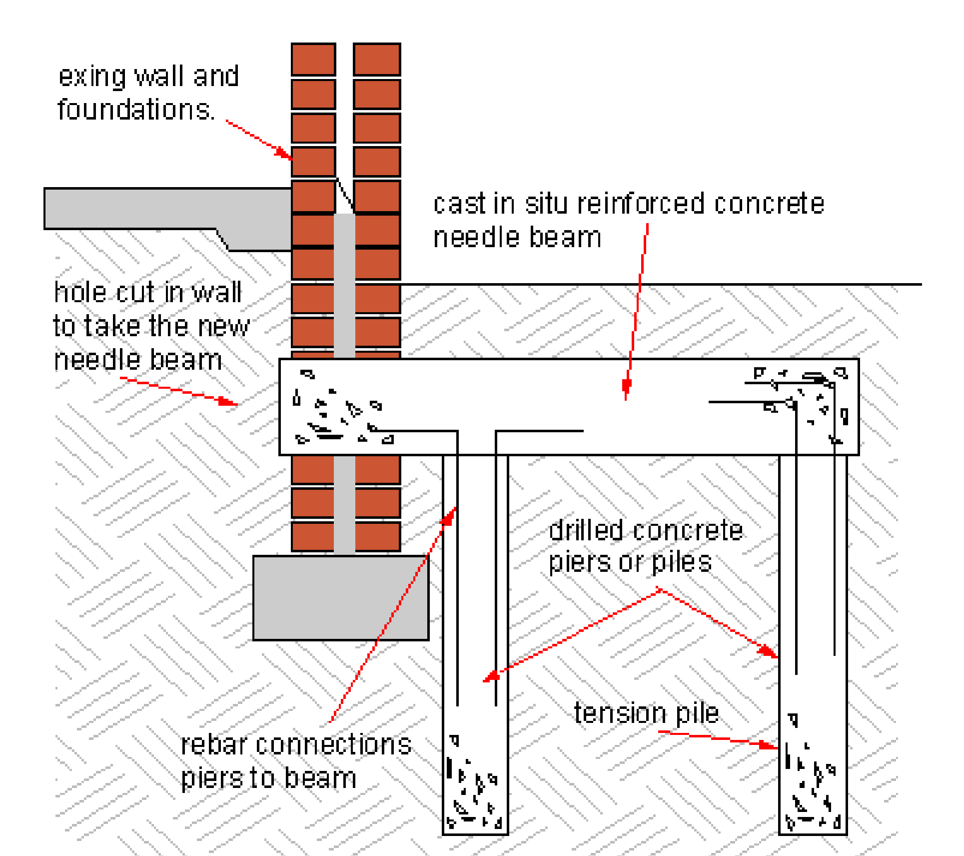
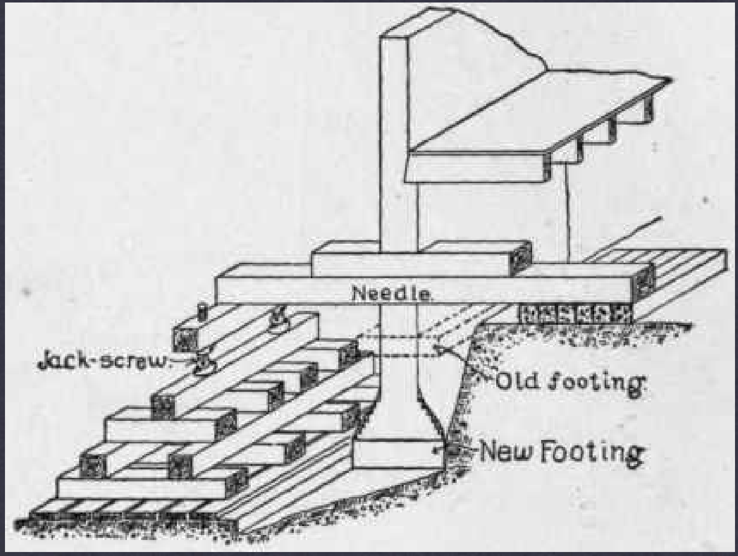


Cast In Situ Needle Beam



Cantilever Needle Beam



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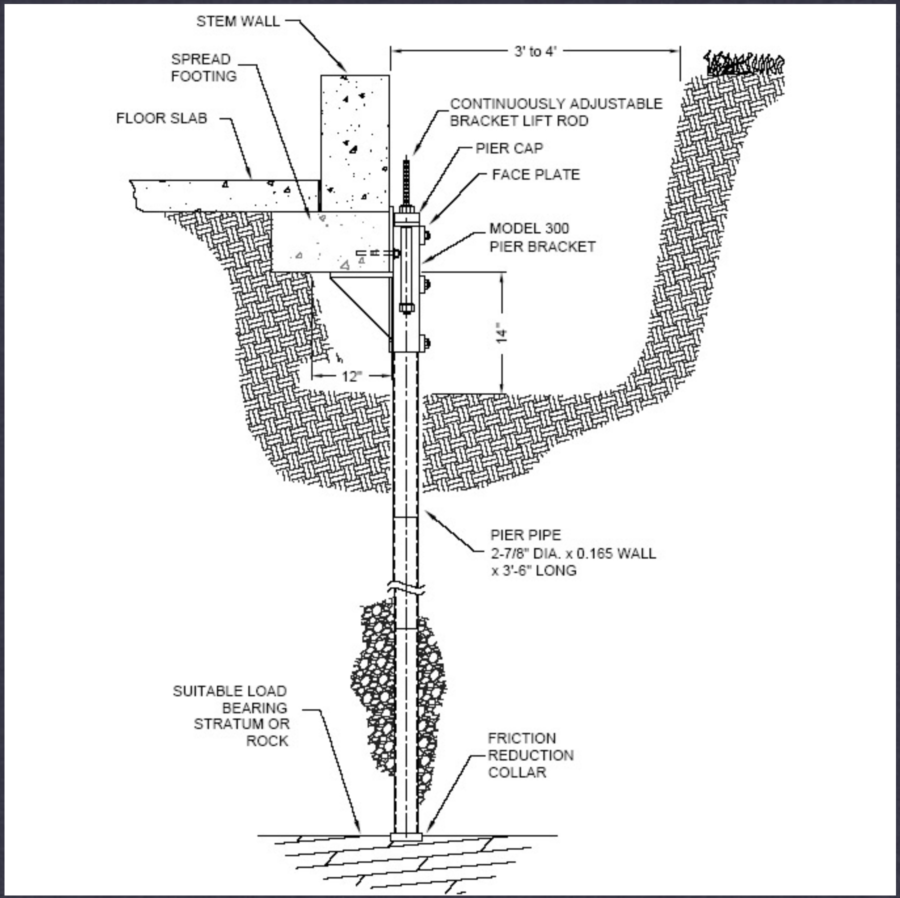

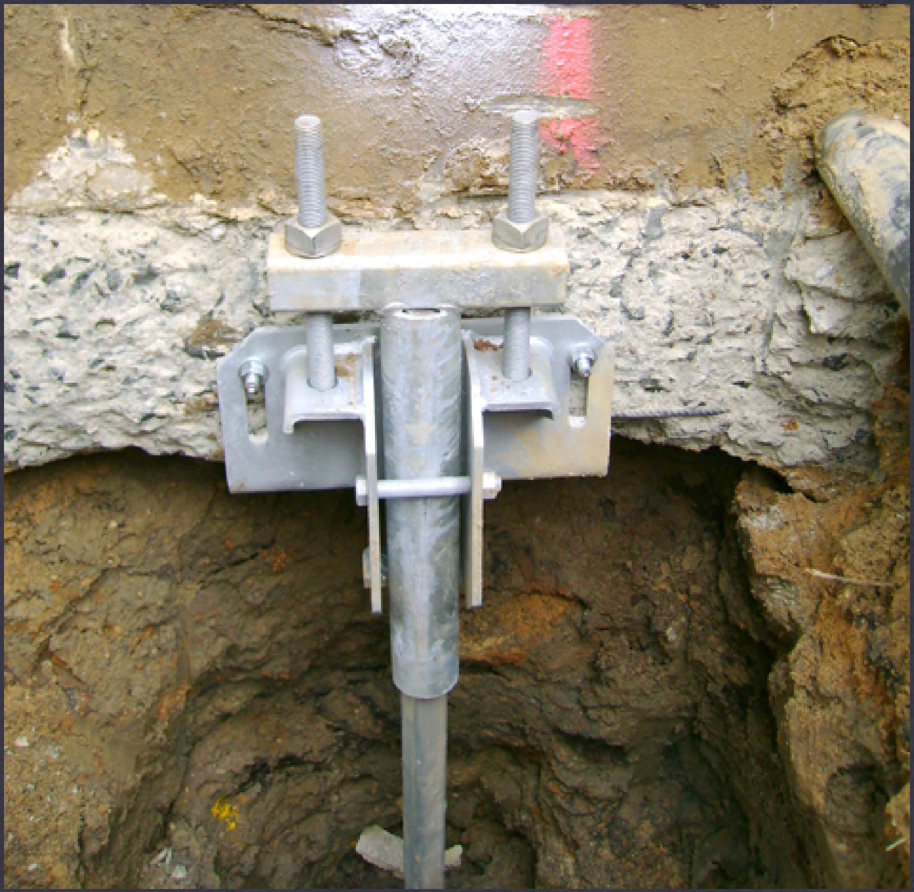

Designing Foundations

DESIGN THRESHOLDS TO CONSIDER:

•WATER TABLE DEPTH

•SITE BOUNDARIES AND NEIGHBORING STRUCTURES

•INCREASED BUILDING LOADS ON FOUNDATIONS (DUE TO HEIGHT)

•LOCATION AND QUALITY OF BEARING MATERIALS UNDER THE SITE

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.