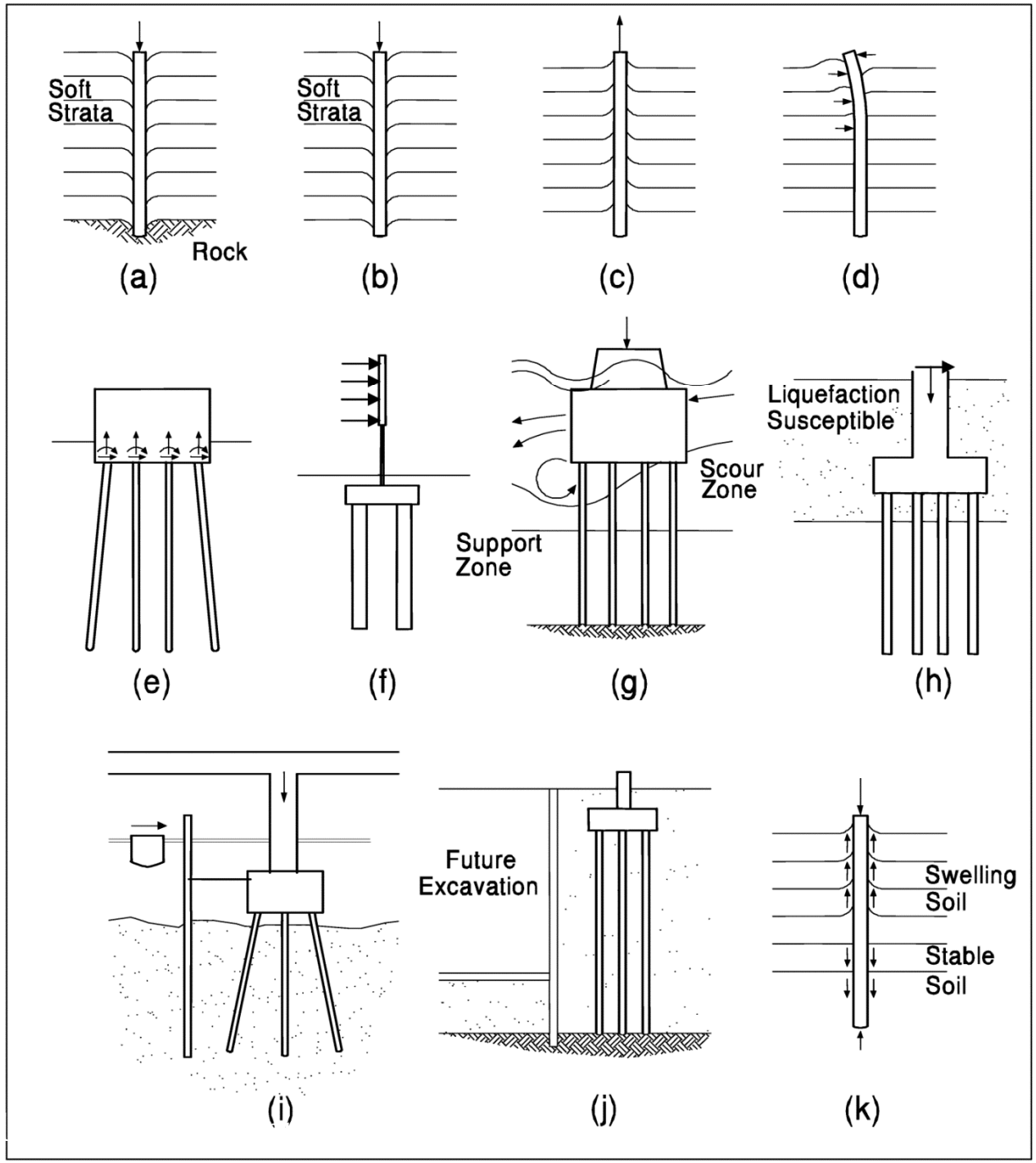
ENCE 4610
Foundation Analysis and Design

Figure 20-3 Reinforcing Cage with Steel Access Tubes for CSL Testing

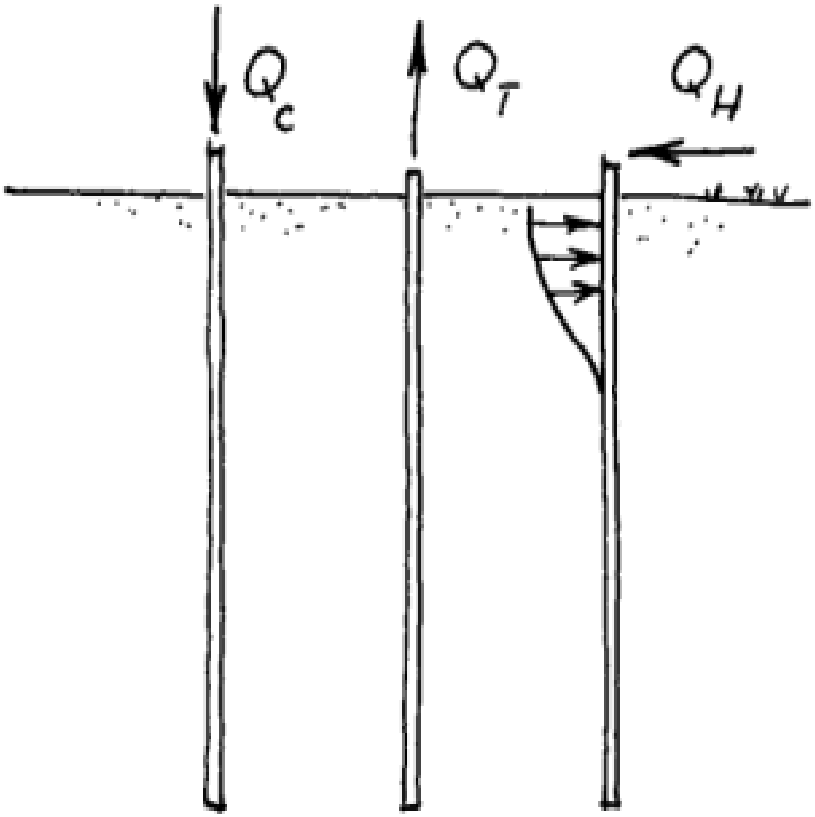
Lecture 18
Overview of Drilled Shafts and Auger Cast Piles

Reasons for Deep Foundations



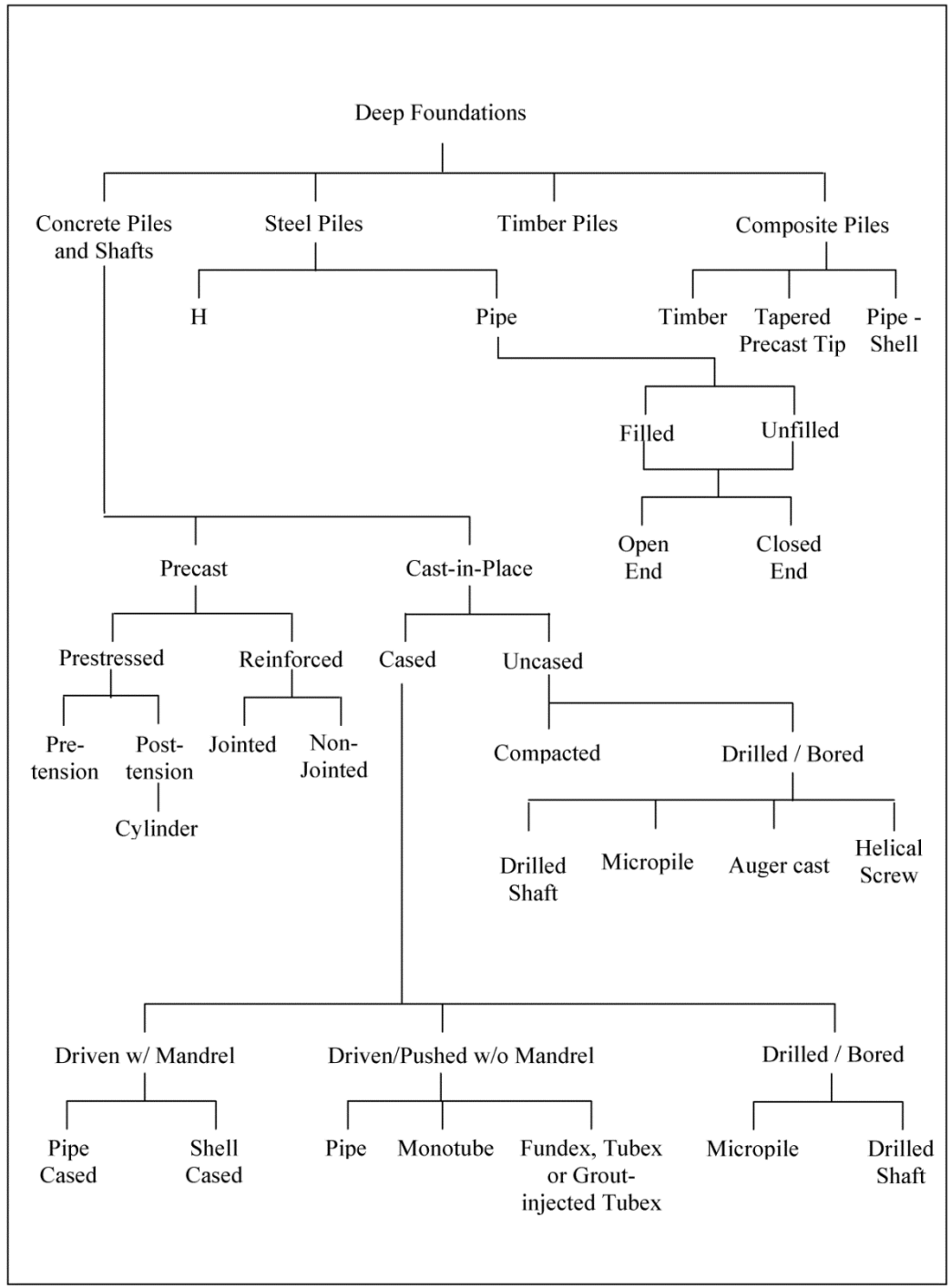
- Also: Found

Loading of Deep Foundations

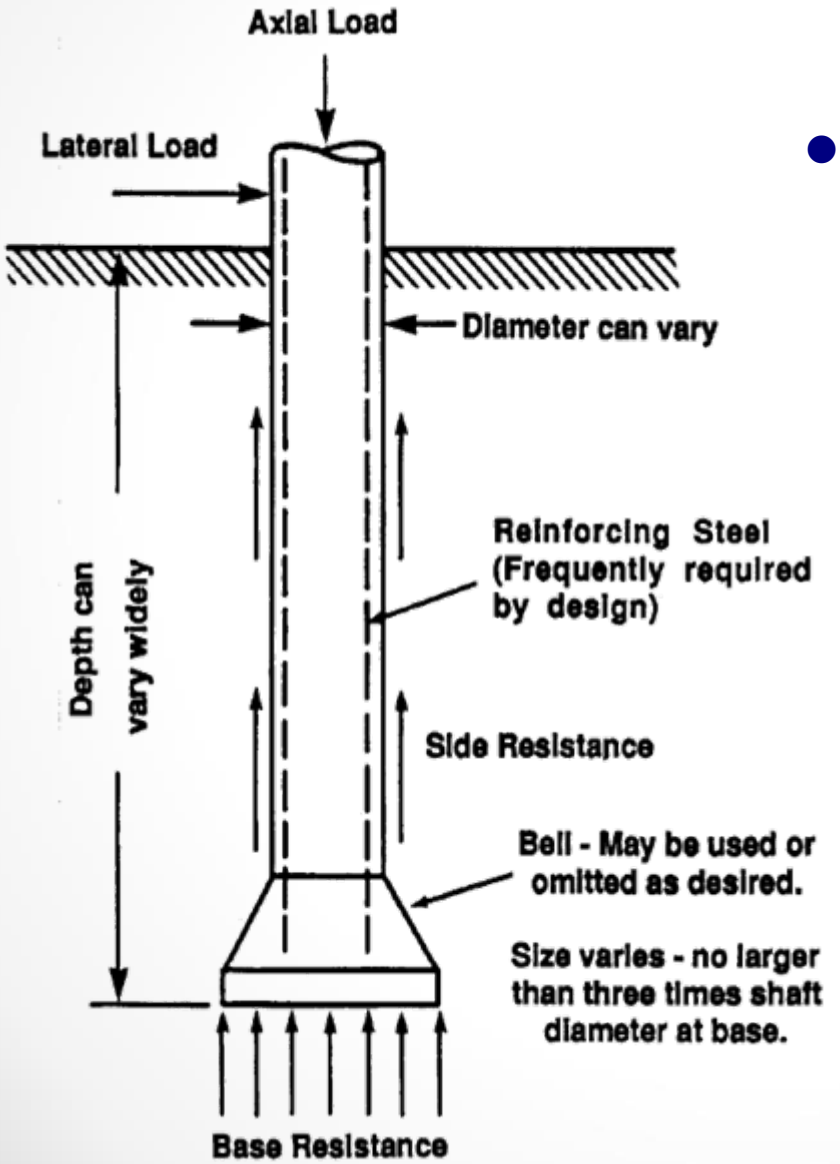


- One of the main reasons for deep foundations is the ability of deep foundations to bear loads that shallow foundations cannot
  - Lateral Loads
  - Tension Loads
  - Compression Loads in Soft Soils

Types of Deep Foundations



Drilled Shafts



- Other terms
  - Pier
  - Drilled pier
  - Bored pile
  - Cast-in-place piles
  - Caisson
  - Drilled Caission
  - Cast-in-drilled-hole (CIDH) foundation

History of Drilled Shafts

- Started as an extension of shallow foundations; until 1920's most were hand dug
  - Chicago Well Method used a wooden "barrel" form to prevent collapse of the soil
- Drilling rigs first used in states with oil drilling, whose technology was applied to shaft drilling
- Technology of cutting tools, casing and drilling mud, then advanced on its own
- Drilled shafts are widely used today in a wide variety of geographical areas

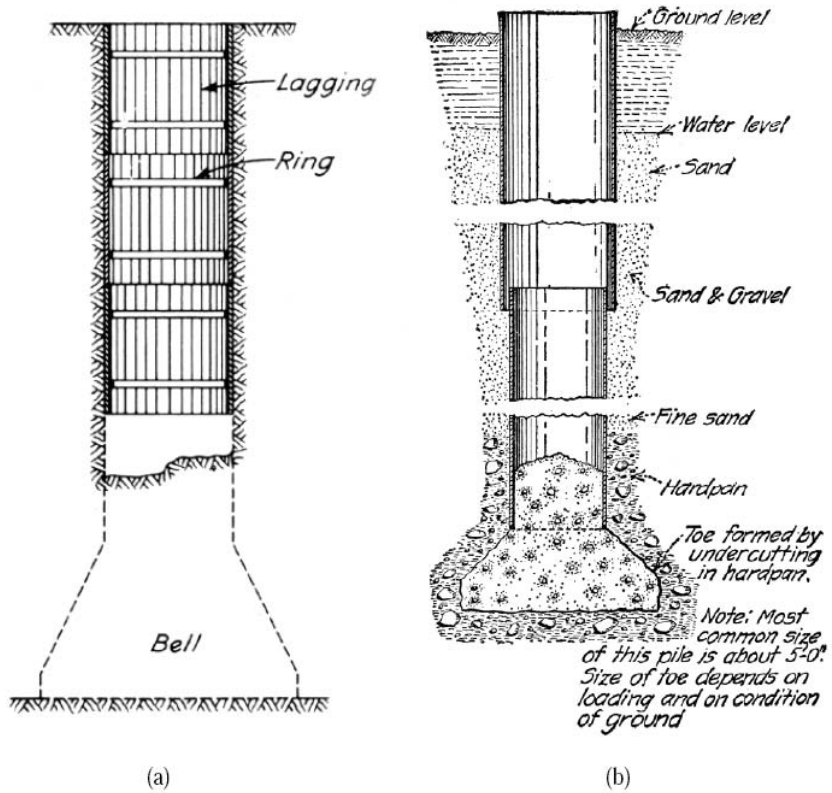


Figure 1-6 Early "Caisson" Foundations (Rogers, 2006); (a) "Chicago Method" and (b) "Gow Caisson"

Equipment for Drilled Shafts

- Most drilled shafts are 500 – 1200 mm (18"-48") in diameter and 6 – 24 m (20'-80') in length
- Most are drilled with a truck mounted rig; specialised rigs are used for longer and larger shafts
- The flight auger used is a helix-shaped drill bit with a relatively short flight
- For rock, hardened teeth can be added to the end of the auger to enhance rock drilling capabilities

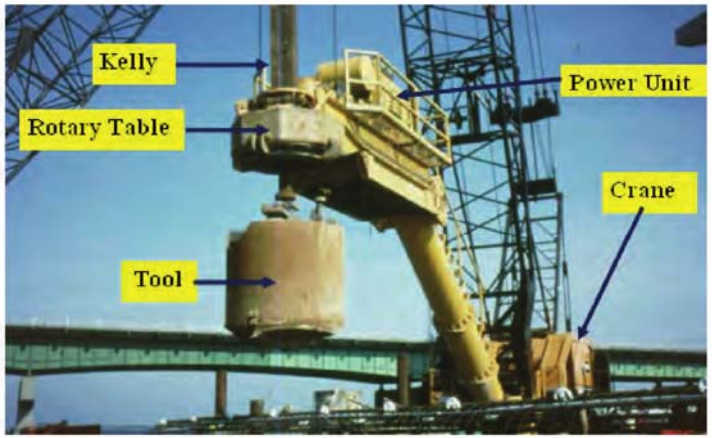


Figure 5-2 Drill Rig Terminology

Advantages and Disadvantages of Drilled Shafts

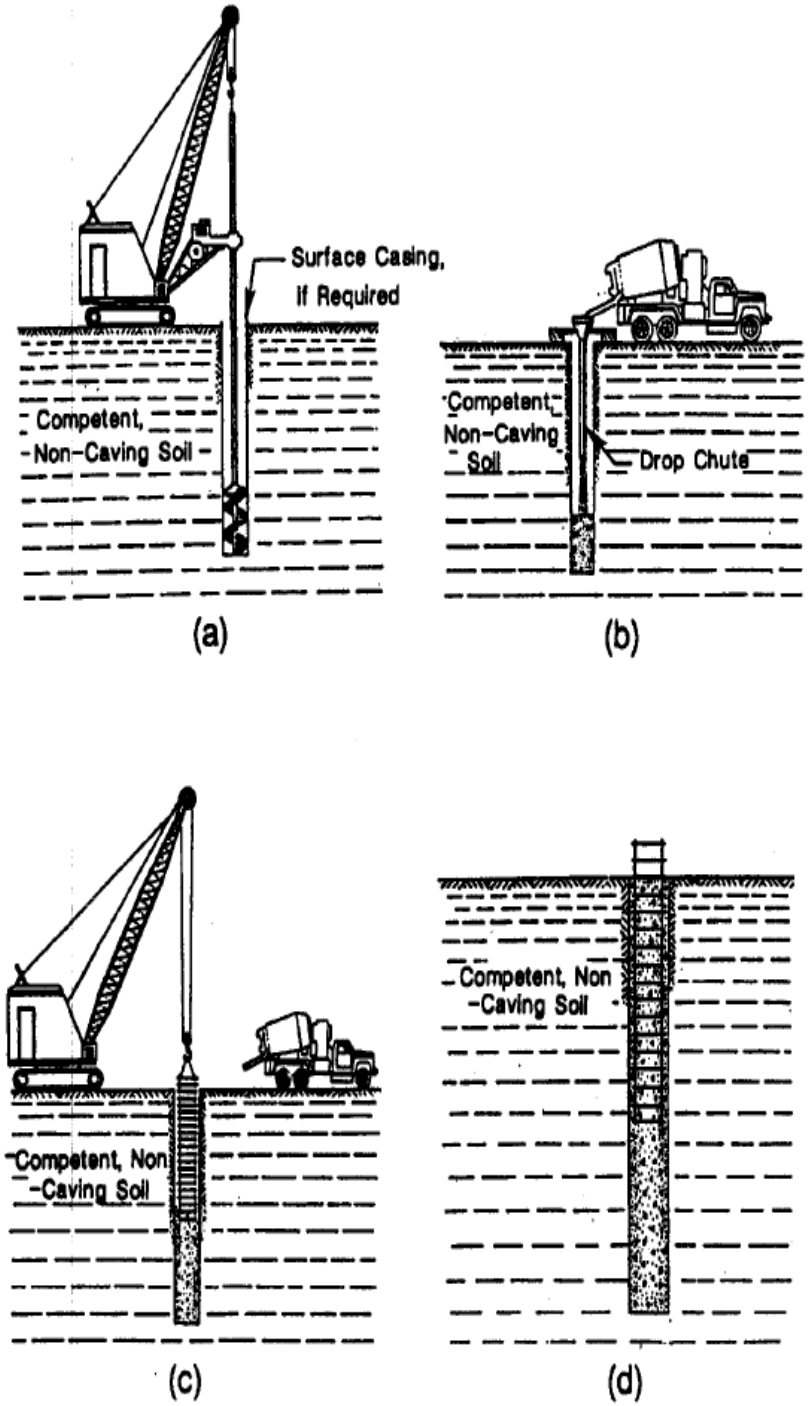
- Disadvantages
  - Successful construction depends upon the quality control and skill the contractor can exercise on the pour; defects are usually not visible and can be serious
  - Driving piles pushes soil aside, thus increasing capacity of piles of same size (both shaft and toe)
  - Full scale load testing is mandatory to determine actual load bearing capacity of drilled shafts; this is being mitigated by dynamic (CAPWAP) and semi-dynamic (Statnamic) methods

- Advantages
  - Mobilisation and demobilisation costs are in many cases lower
  - Construction process generates less noise and vibration
  - Diameter and length of the shaft can be changed during the job more easily
  - With proper cutting tools, can penetrate through cobbles and boulders and even in to rock
  - Shafts can be large and columns can be supported with one shaft as opposed to multiple driven piles

Shafts in Firm Soils

- Dry method (preferable) is preferred method to install a drilled shaft
  - Only applicable to competent, non-caving soils
- Procedure
  - Using a drill rig, excavate the shaft to the required depth
  - Fill the lower end of the shaft with concrete
  - Place a prefabricated reinforcing steel gage inside of the shaft
  - Fill the shaft with concrete

Figure 4-1 Dry Hole in Stable Soil



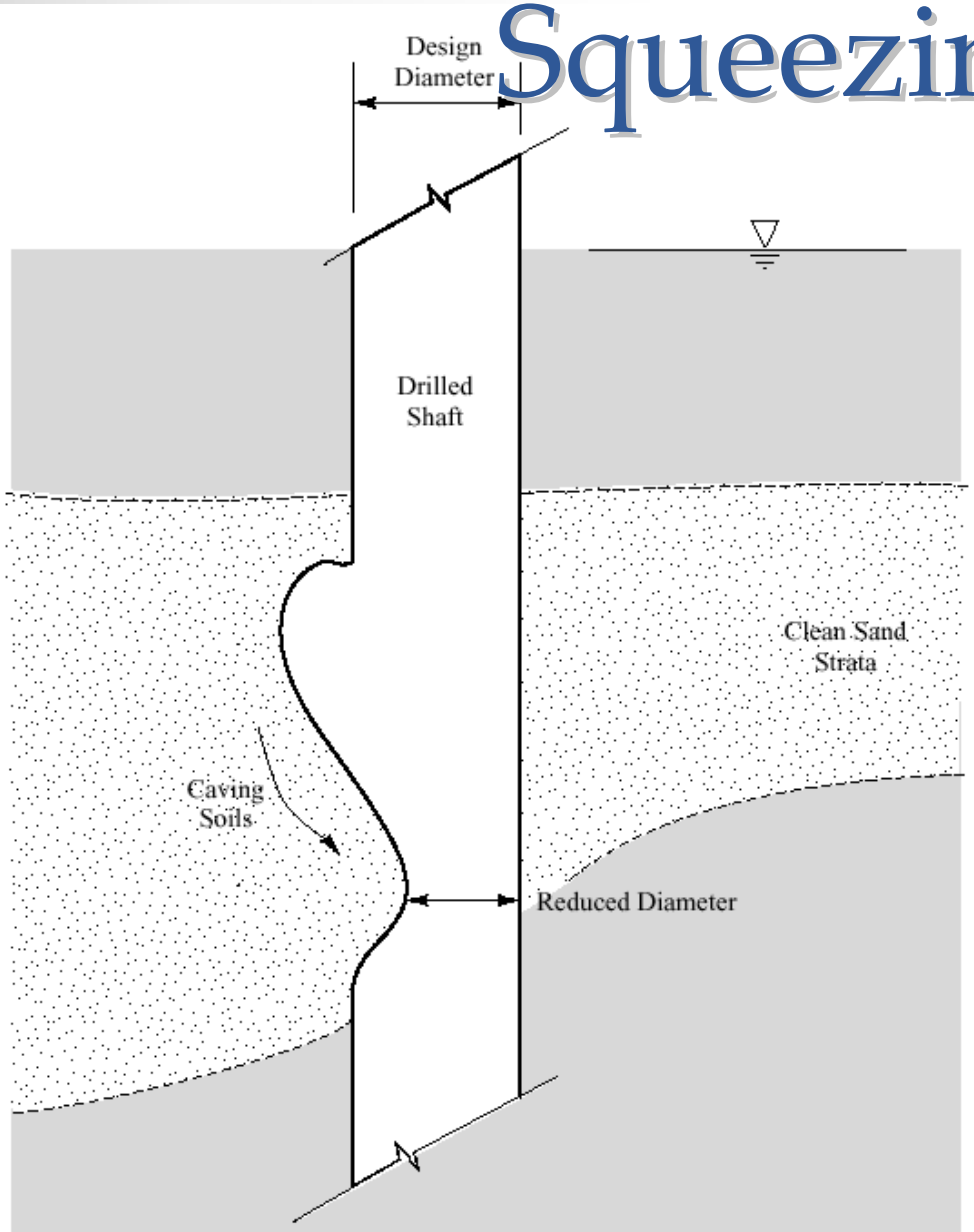
Drilled Shafts in Firm Soils

- Firm soils offer a relatively straightforward material into which to drill a shaft
- Holes are usually drilled without any special support
- After the holes are drilled, the reinforcing cage is inserted and the hole filled with concrete
- Caving is usually not a problem in firm soils
- If drilling under the groundwater table, water is pumped out as the hole advances and concrete is placed in dewatered shaft

Figure 1-10 Construction of Drilled Shaft in Dry, Cohesive Soils

Figure 1-11 Drilled Shafts for Bridge Foundations where Small Footprint is Desirable

Drilled Shafts in Caving or Squeezing Soils



- Soft or caving soils present serious problems for conventional drilled shafts
- Solutions
  - Slurry Method
  - Casing Method

Slurry and Casing Methods

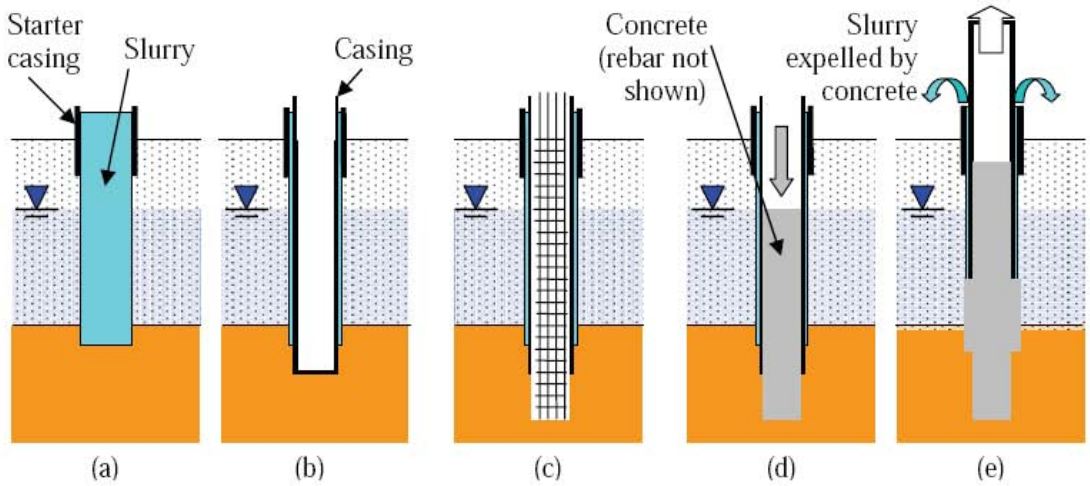


Figure 4-7 Construction Using Casing Through Slurry-Filled Starter Hole: (a) drill with slurry; (b) set casing and bail slurry; (c) complete and clean excavation, set reinforcing; (d) place concrete to head greater than external water pressure; (e) pull casing while adding concrete

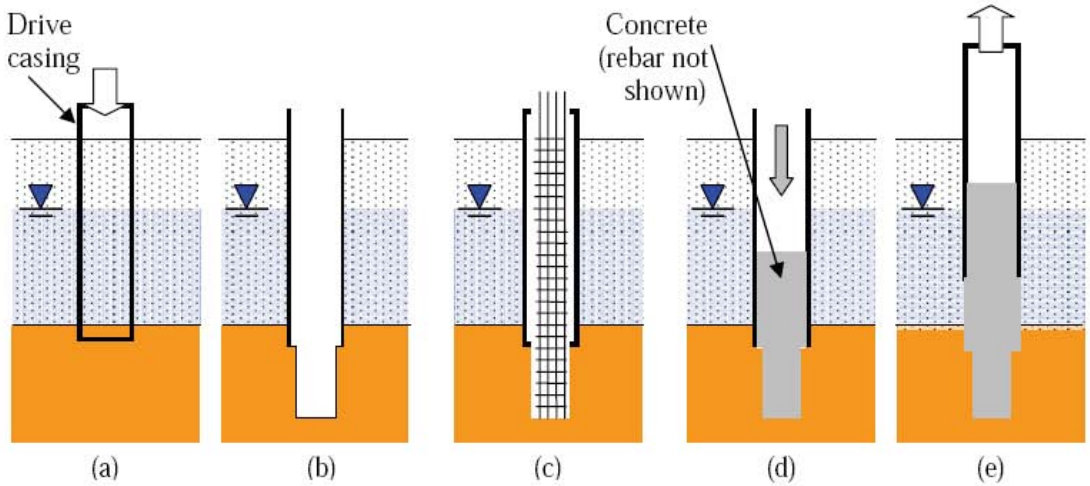


Figure 4-8 Construction Using Casing Advanced Ahead of Excavation: (a) drive casing into bearing stratum; (b) drill through casing; (c) complete and clean hole, set reinforcing; (d) place concrete to head greater than external water pressure; (e) pull casing while adding concrete

Use and Methods of Advancing Casing

Figure 4-6 Drilling into Rock through a Cased Hole

Figure 4-9 Oscillator Rig Used to Advance Segmental Casing Ahead of the Excavation

Figure 4-10 Use of a Vibro-Hammer (Left) and Twister Bar (Right) to Advance Casing

Results of Poor Excavation and Casing

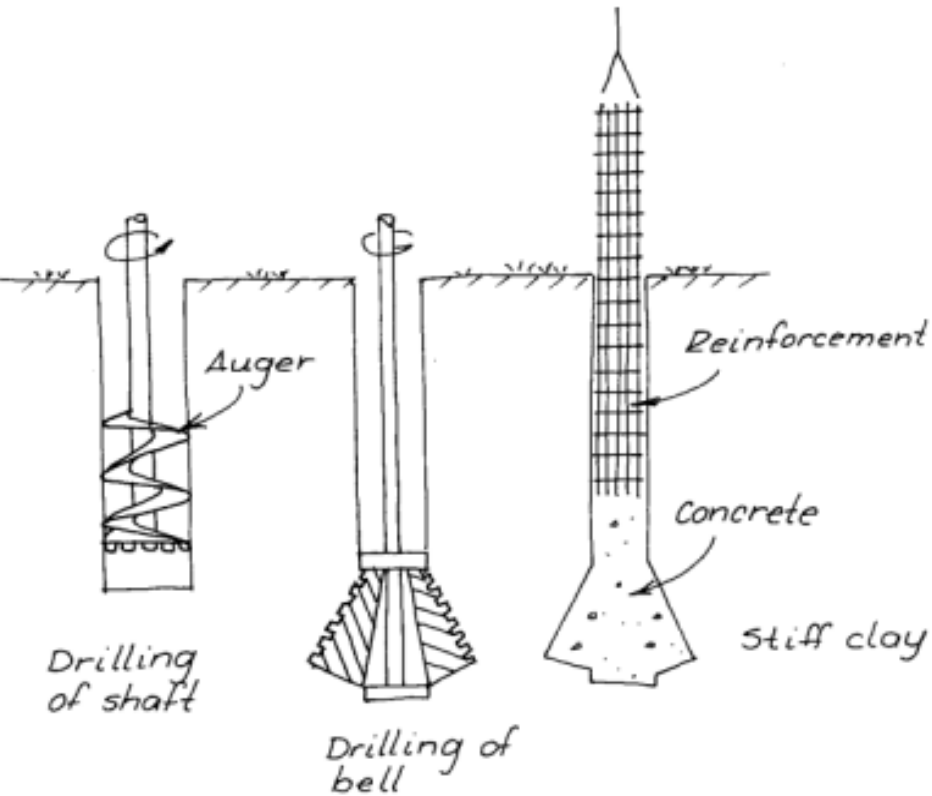
(a)

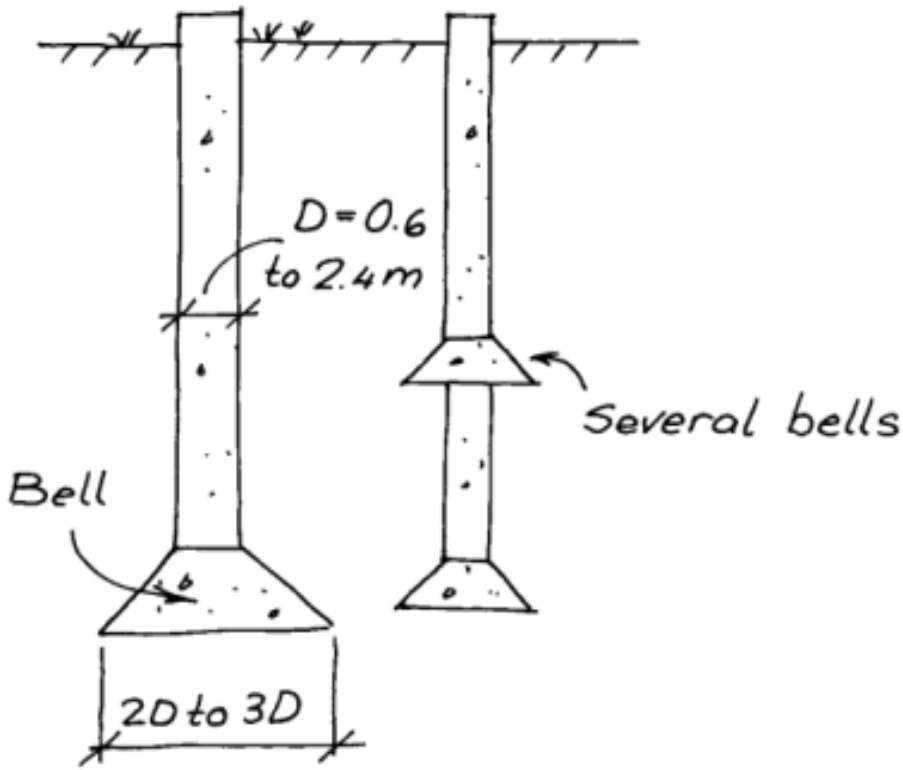
(b)

Figure 9-57. Photographs of exhumed shafts (a) shaft where excavation was not adequately cleaned, (b) shaft where excavation was properly cleaned (FHWA, 2002d).

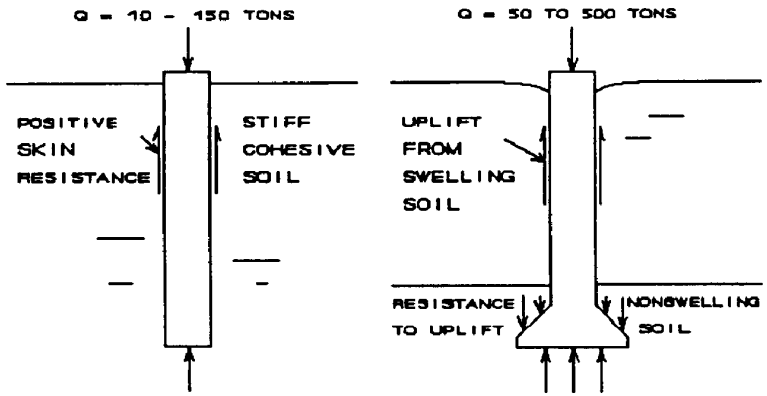
Underreamed (Belled) Shaft

Cleaning out the bell at the bottom of the shaft can be a dangerous operation

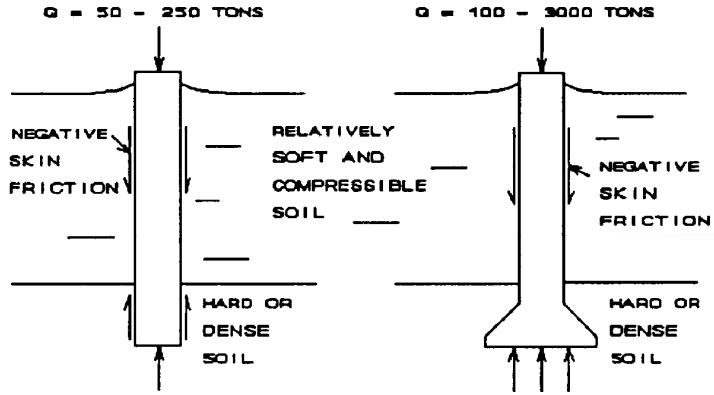




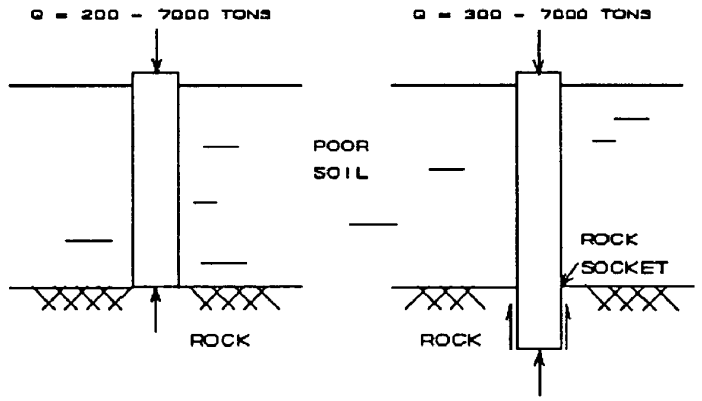
Load Transfer of Drilled Shafts



a. FLOATING SHAFTS IN HOMOGENENOUS SOIL

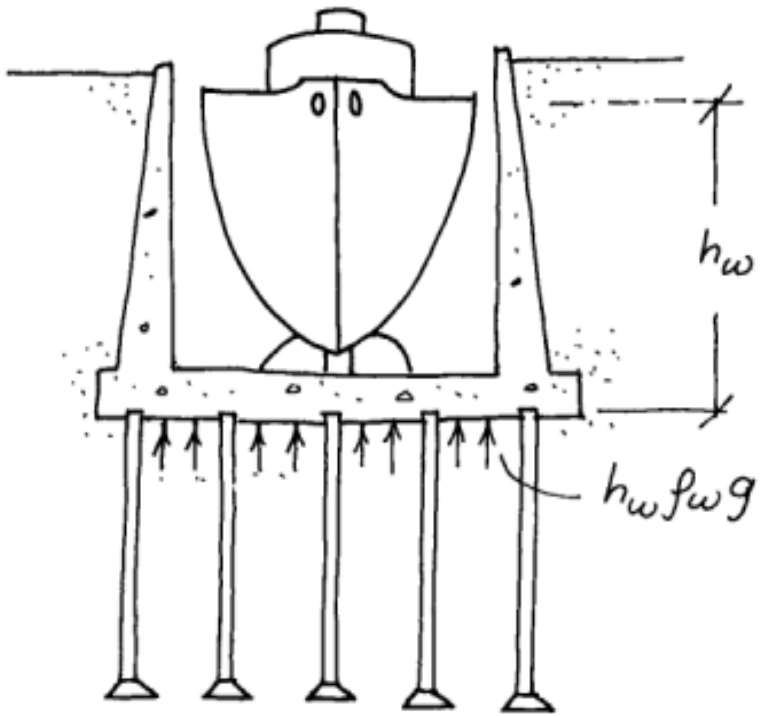


b. SHAFTS END BEARING IN HARD SOIL

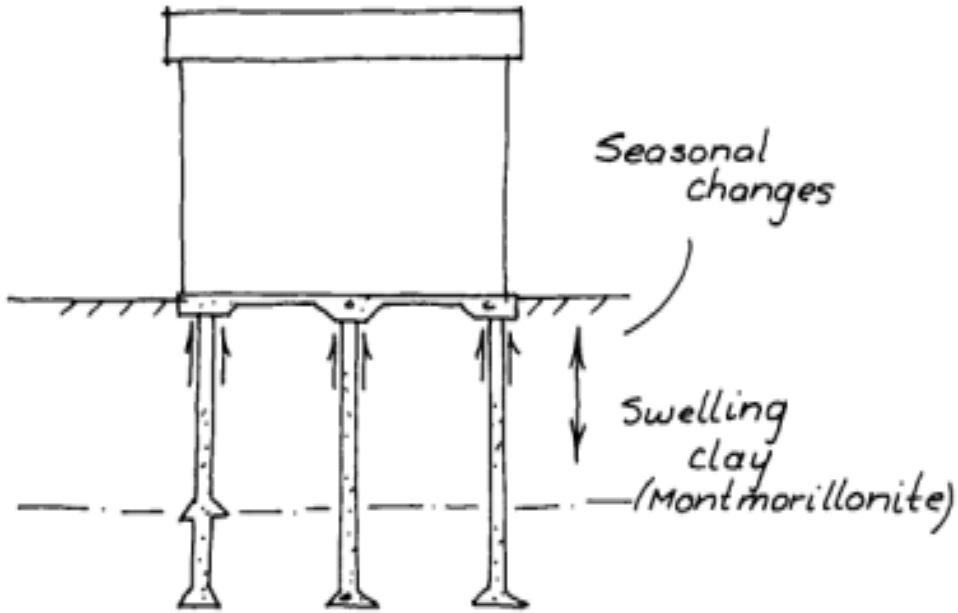


c. SHAFTS END BEARING IN ROCK

Applications of Drilled Shafts



Dry docks
Subway stations



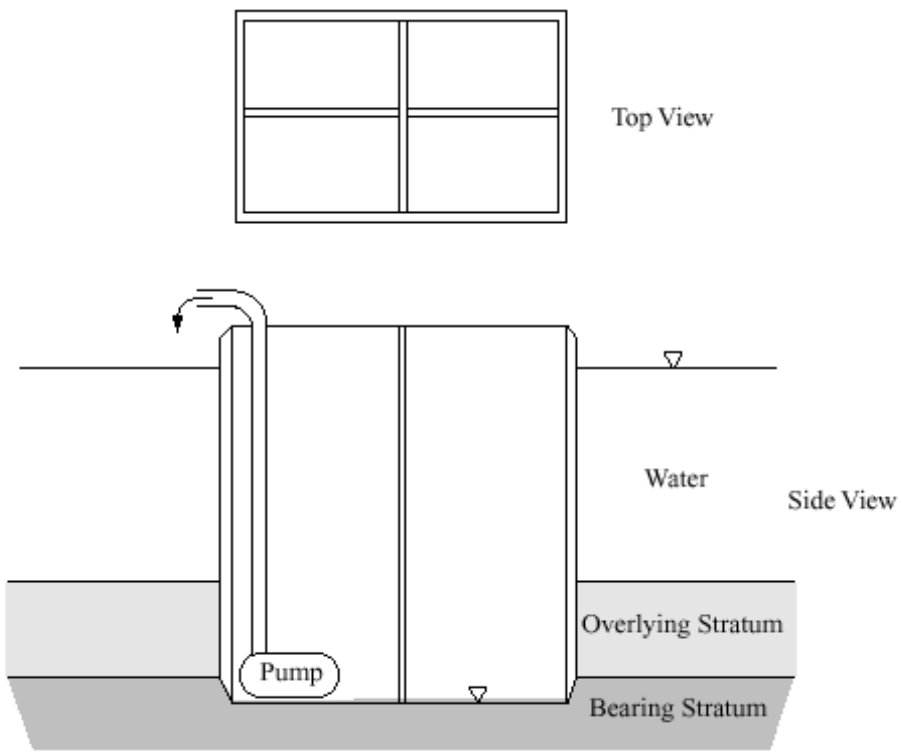
India: Black cotton soil
Texas: Beaumont clay

High w_L, I_p

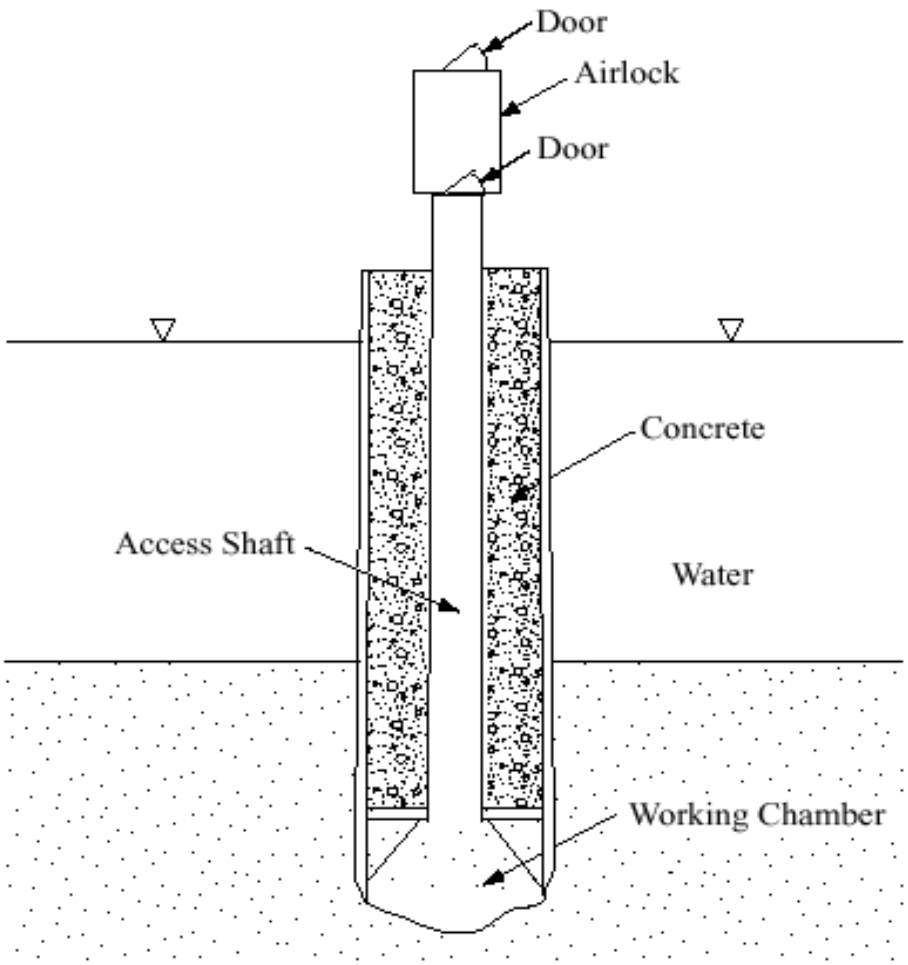
Caissons

- A prefabricated hollow box or cylinder which is sunk into the ground and then filled with concrete
- Are usually used in construction of bridge piers and other structure where the foundation is under water

Open Caisson



Pneumatic Caissons



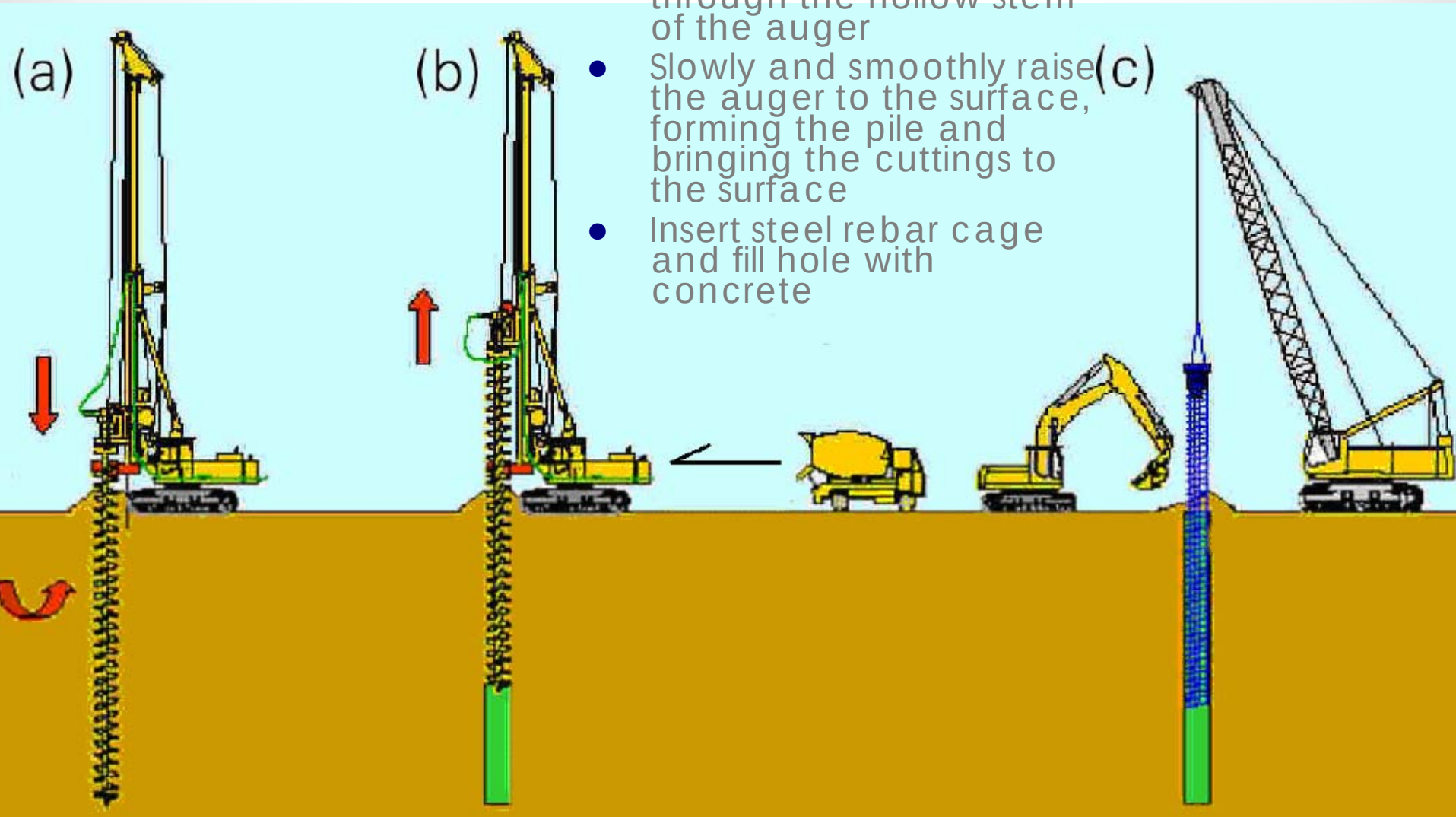
- Compressed air is used to keep water out and allow installation and construction in the dry
- High air pressures can and have created dangerous air conditions for workers, who must use and air lock

Auger-Cast Piles

- Other names
  - Augered Presure Grouted (APG) Piles
  - Augered cast-in-place pile
  - Continuous flight auger pile
  - Intruded mortar piles
  - Augerpass Pile
  - Auger Pile
  - Grouted Bored Pile

Auger-Cast Piles

- Using a continuous flight auger 300-400 mm (12-16") in diameter, drill a hole in the ground
  - Typical depths are 6 – 15 m (20'-50') but can go up to 27 m (90')
- Inject cement grout through the hollow stem of the auger
- Slowly and smoothly raise the auger to the surface, forming the pile and bringing the cuttings to the surface
- Insert steel rebar cage and fill hole with concrete



Advantages and Disadvantages of Auger-Cast Pile

- Advantages
  - Low mobilisation cost
  - Low noise and vibration
  - Auger protects the hole from caving
  - Grout is injected under pressure, so there is good soil bond and some soil compaction
  - Used in a wide variety of soils
- Disadvantages
  - Must have good contractor quality control and skills
  - Auger can draw up more soil than it should under some conditions
  - If equipment breaks down, pile is lost
  - Cannot be used with cobbles and boulders
  - No check on capacity

Questions?