- **Foundation**

  Bottom most part of the structure which carries the load of the structure including its own weight and transmits it to the underlying / surrounding soil and /or rock safely.

- **Foundation Engineering** (deals with sub-structures)

  An art that deals with (i) determining the ability of the earth to support the load (ii) designing the proper transition member to transmit the super-structure load into the ground safely.

- **Purpose of the Foundation**

  The enlarged base area of the column/wall (i.e. footing) reduces the contact pressure between the footing and soil. This prevents excessive settlement and shear failure (BC failure).

- **Basic Foundation Types**

  Shallow $D_f/B \leq 1$ (after Terzaghi)

  Generally $D_f \leq 3$ m

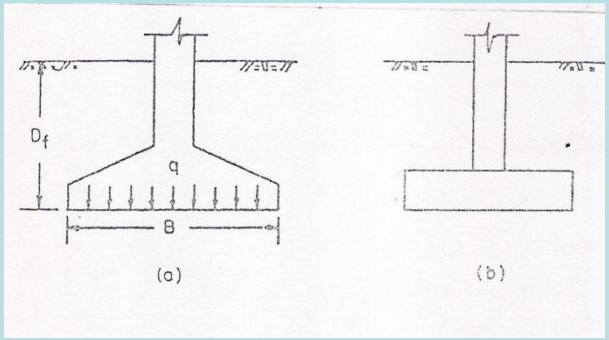
  Deep $D_f/B > 4+$ or depth > 3 m

TYPES OF FOUNDATION

1) Shallow Foundation System

a) Spread Foundation

b) Mat / Raft Foundation

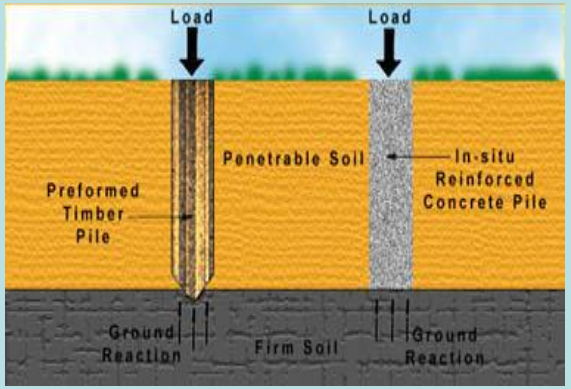


2) Deep Foundation System

a) Piles

b) Piers

c) Caissons



1.SHALLOW FOUNDATION

Advantages

a) Cost effective (affordable)
b) Construction Procedure (simple)
c) Material (mostly concrete, masonry)
d) Labor (doesn't need expertise)

It can be of two types

1a: Spread Footing Foundation

1b: Raft/Mat Foundation

1-a SPREAD FOOTING/FOUNDATION

- Also known as a footer or footing
- It's an enlargement at the bottom of a column/ bearing wall that spreads the applied structural loads over a sufficiently large soil area.
- Each column & each bearing wall has its own spread footing, so each structure may include dozens of individual footings.
- Most common type of foundation used due to their low cost & ease of construction.
- Most often used in small to medium size structure with moderate to good soil condition.

- Spread footings may be built in different shapes & sizes to accommodate individual needs such as the following:

a) Square Spread Footings

b) Rectangular Spread Footings

c) Circular Spread Footings

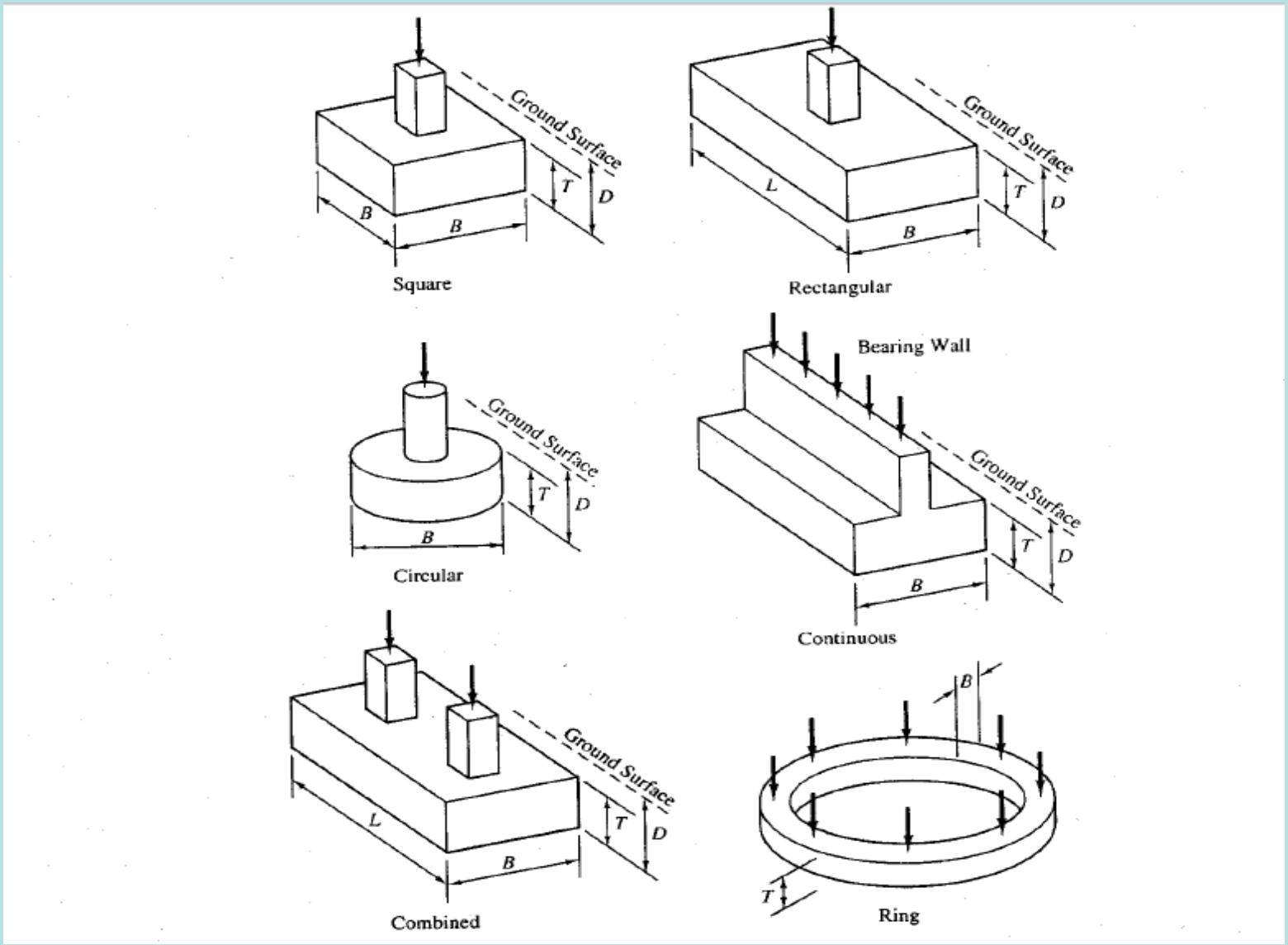
d) Continuous Spread Footings

e) Combined Footings

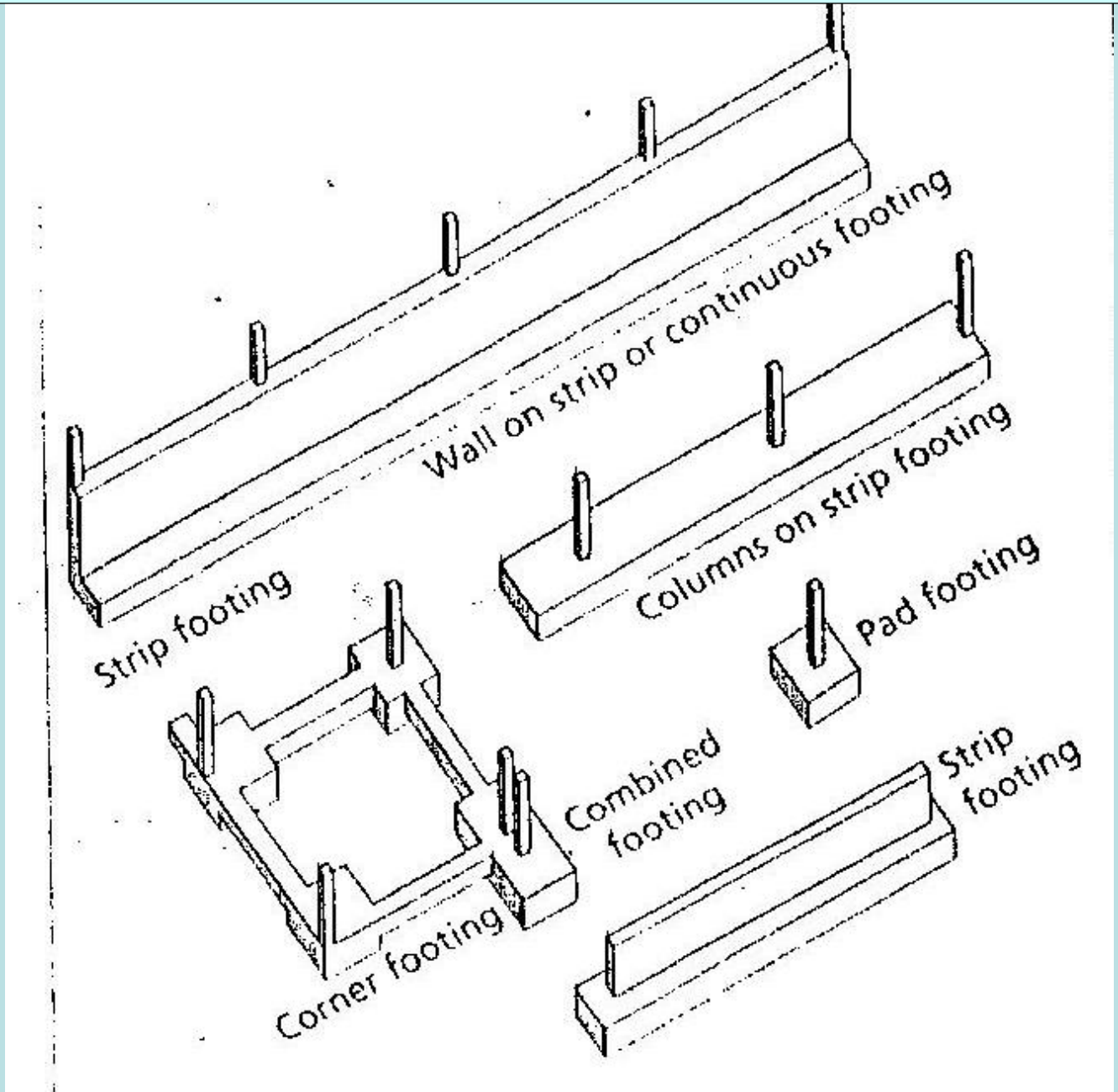
f) Ring Spread Footings

g) Strap footings

Types of Spread Footing



Types of Spread Footing



Pad Footings in a row

Strip/continuous footing

SPREAD FOOTING /FOUNDATION

a) **Square Footings / Pad Foundations**

- support a single centrally located column
- use concrete mix 1:2:4 and reinforcement
- the reinforcement in both axes are provided to resist/carry tension loads.

b) **Rectangular Footings**

- Useful when obstructions prevent construction of a square footing with a sufficiently large base area and when large moment loads are present in one direction

c) **Circular Footings**

- are round in plan view
- most frequently used as foundation for light poles, flagpoles and power transmission lines.

SPREAD FOOTING / FOUNDATION

d) Continuous / Strip Foundation

- Used to support bearing walls

e) Combined Footings

- support more than one column

- useful when columns are located too close together for each to have its own footing

f) Ring Footings

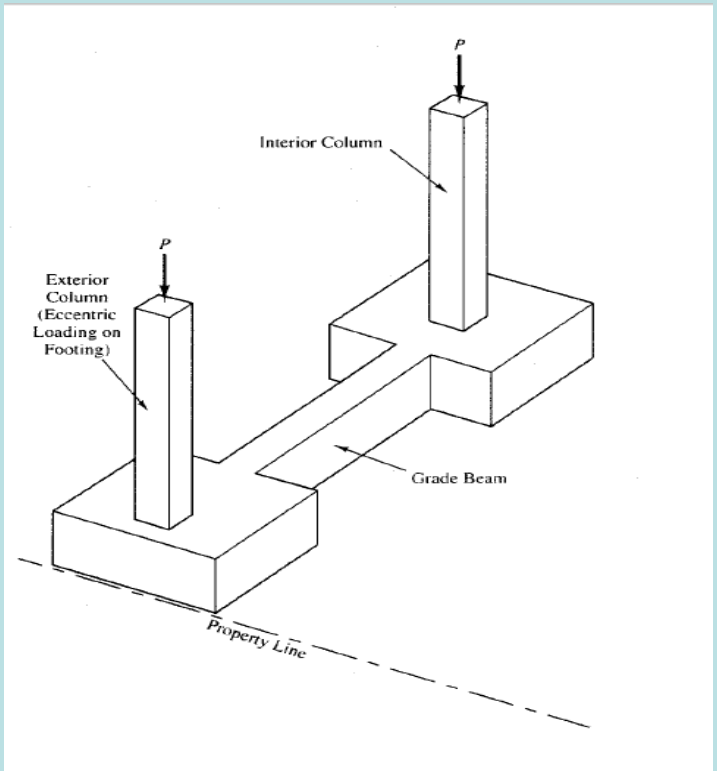
- continuous footings that have been wrapped into a circle

- commonly used to support the walls above-ground circular storage tanks.

- The contents of these tanks are spread evenly across the total base area and this weight is probably greater than that of the tank itself.

- Therefore the geotechnical analyses of tanks usually treat them as circular foundations with diameters equal to the diameter of the tank.

g). Strap Footing



-When spread footing is to construct near the property line, the footing is loaded eccentrically

- The exterior eccentrically loaded footing is connected with first interior footing using a grade beam known as Strap.

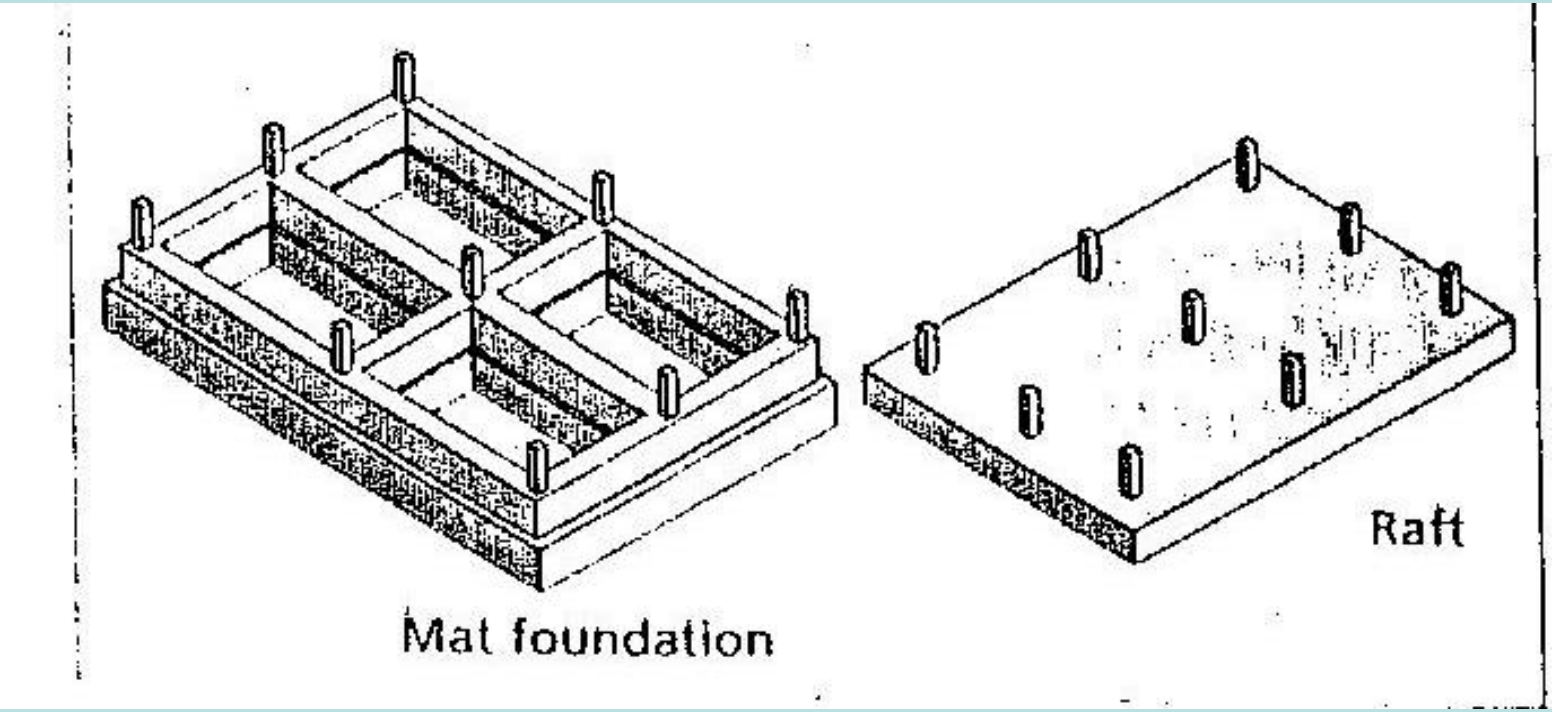
- This arrangement which is very similar to combined footing provides the necessary moment in the exterior footing to counter the eccentric load.

- Most of the times, all the spread footings are connected with grade/tie beams in a structure to provide more rigidity to the foundation system.

1b. RAFT FOUNDATION

- ✓ A foundation system in which essentially the entire building is placed on a large continuous footing covering the whole footprint building area.
- ✓ It is a flat concrete slab, heavily reinforced with steel, which carries the downward loads of the individual columns or walls.
- ✓ Raft foundations are used to spread the load from a structure over a large area, normally the entire area of the structure reducing differential settlement.
- ✓ They are often needed on soft or loose soils with low bearing capacity as they can spread the loads over a larger area.

RAFT/MAT FOUNDATION



Conditions demanding Mat Foundation

a) The structural loads are so high or the soil condition so poor that spread footings would be exceptionally large. As a general rule of thumb, if spread footings would cover more than 50% of the building footprint area, a mat or some type of deep foundation will usually be more economical.

b) The soil is very erratic & prone to excessive differential settlements. The structure continuity and flexural strength of a mat will bridge over these irregularities.

The same is true of mats on highly expansive soils prone to differential heaves.

Conditions demanding Mat Foundation

c) The structural loads are erratic and thus increase the likelihood of excessive differential settlements. Again, the structural continuity and flexural strength of the mat will absorb these irregularities.

d) The lateral loads are not uniformly distributed through the structure and thus may cause differential horizontal movements in spread footings and pile caps.

The continuity of a mat will resist such movement.

Conditions demanding Mat Foundation

e) The uplift loads larger than spread footings can be accommodated. The greater weight and continuity of a mat may provide sufficient resistance.

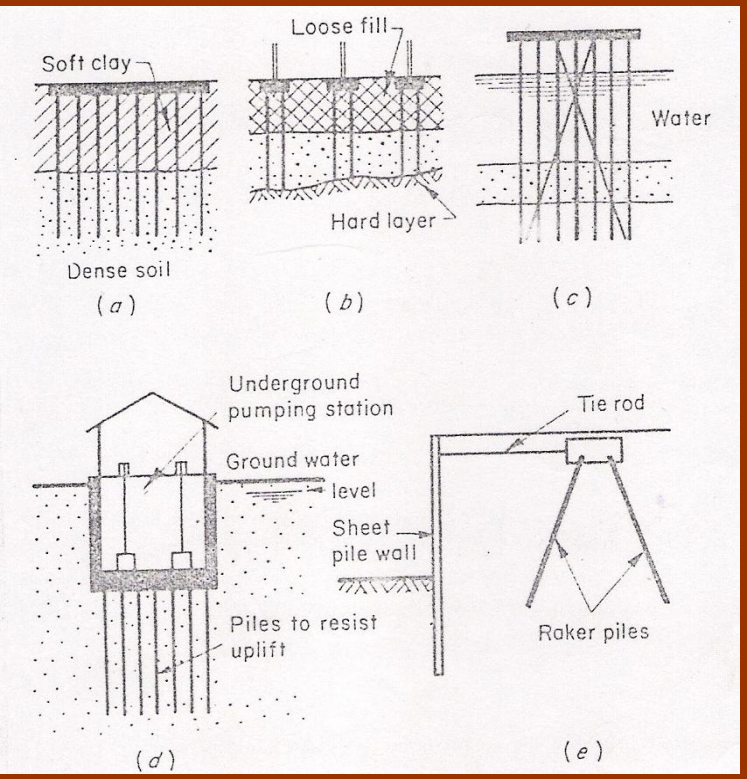
f) The bottom of the structure is located below the groundwater table, so waterproofing is an important concern. Because mats are monolithic, they are much easier to waterproof. The weight of the mat also helps in resisting the hydrostatic uplift forces from the groundwater.

DEEP FOUNDATIONS

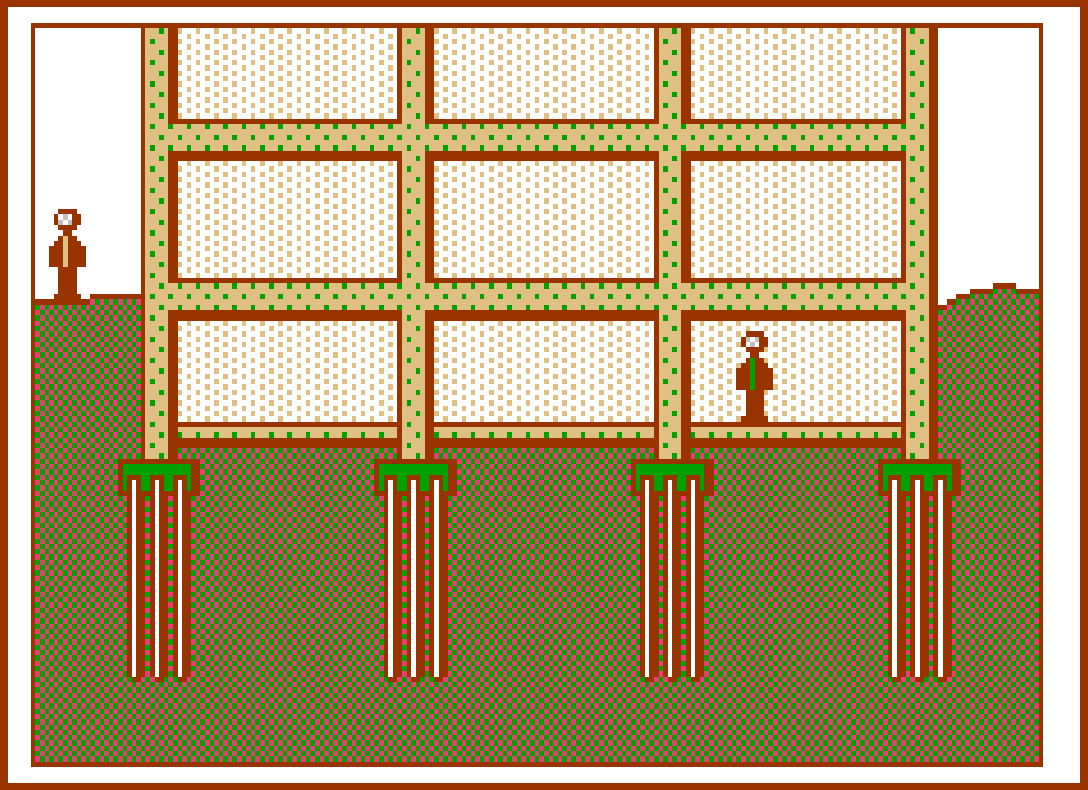
1. PILES

- A slender, structural member consisting of steel or concrete or timber.
- It is installed in the ground to transfer the structural loads to soils at some significant depth below the base of the structure.
- Piles (typical) extend to depth of 50 ft. or more.

APPLICATIONS OF PILES



Various applications of pile foundation



Frame structure supported on pile foundation

PILES FOUNDATION IS USED WHEN:

- ✓ The soil near the surface doesn't have sufficient bearing capacity to support the structural loads.
- ✓ The upper soil subjected to scour or undermining as in case of foundations of bridges.
- ✓ A large uplift capacity is required (the uplift capacity of shallow foundation is very limited due to lesser weight).
- ✓ A large lateral load capacity is required.
- ✓ There will be a future excavation adjacent to the foundation and this may undermine the shallow foundation.

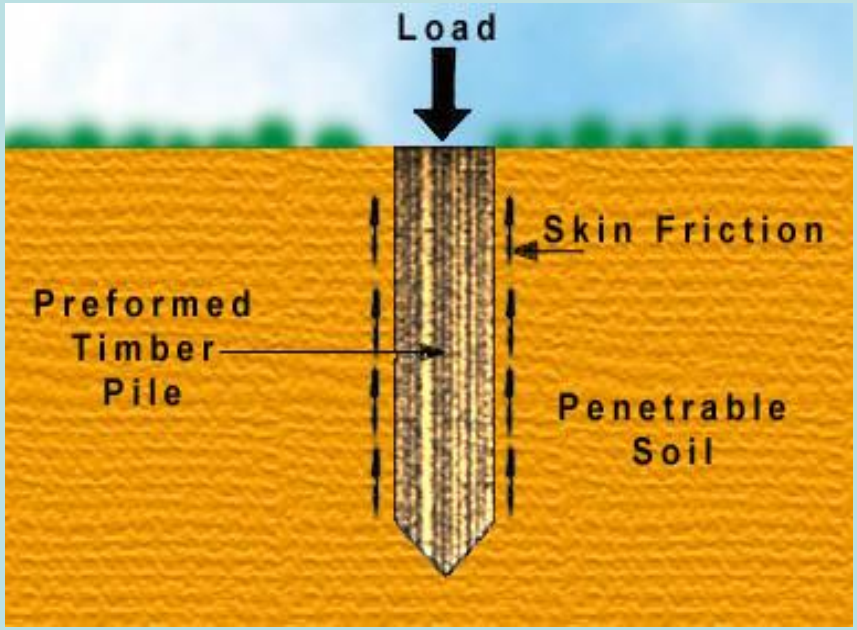
LOAD CAN BE TRANSFERRED BY PILE TO THE GROUND IN TWO WAYS:

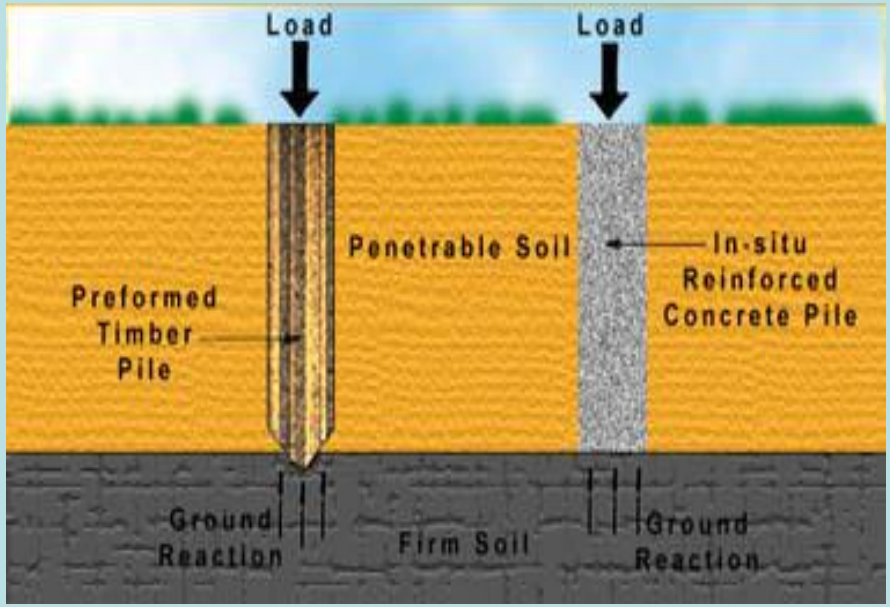
a) End Bearing Piles

- Pile will transmit load into the firm soil layer of the ground such as rock, gravel, very dense sand

b) Friction Piles

- Pile transmits the load from the structure to the penetrable soil by means of skin friction or cohesion between the soil & the embedded surface of the pile. (generally in clays)

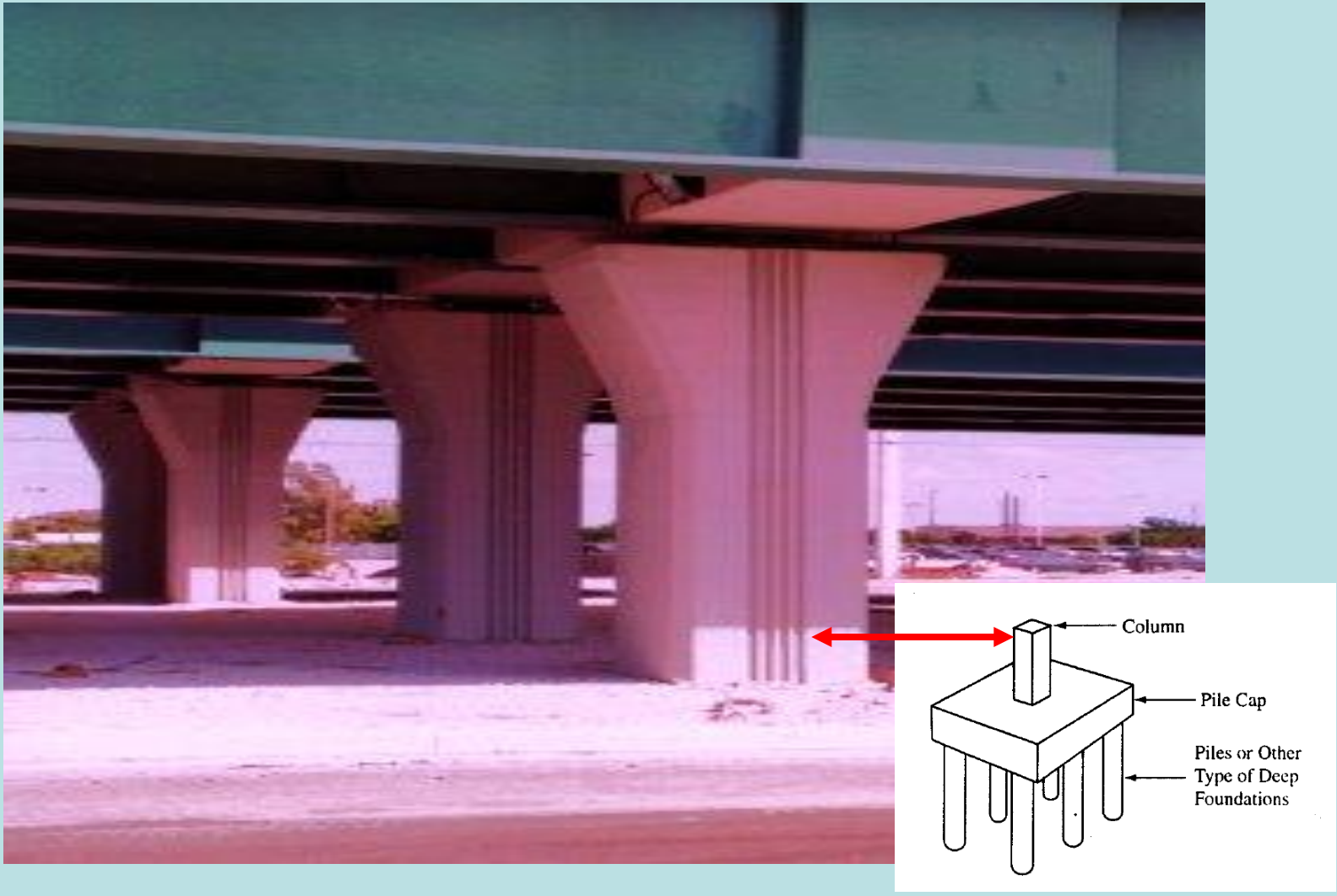




DEEP FOUNDATIONS

2. PIERS

- ✓ It’s a vertical bridge support resting on bed rock or pile supported cap slab.
- ✓ It’s a foundation for carrying a heavy structural load which is constructed in site in a deep excavation.

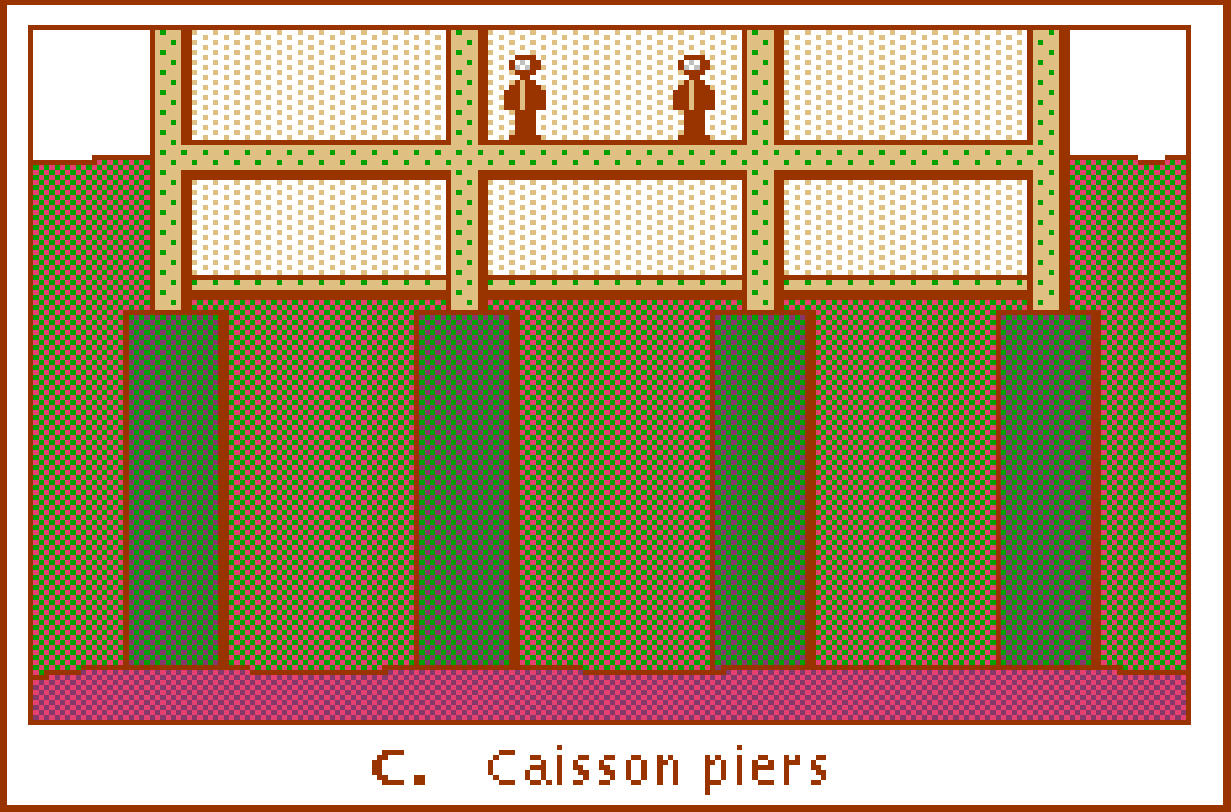


Pier

Pier

DEEP FOUNDATIONS

3. CAISSON FOUNDATION



C. Caisson piers

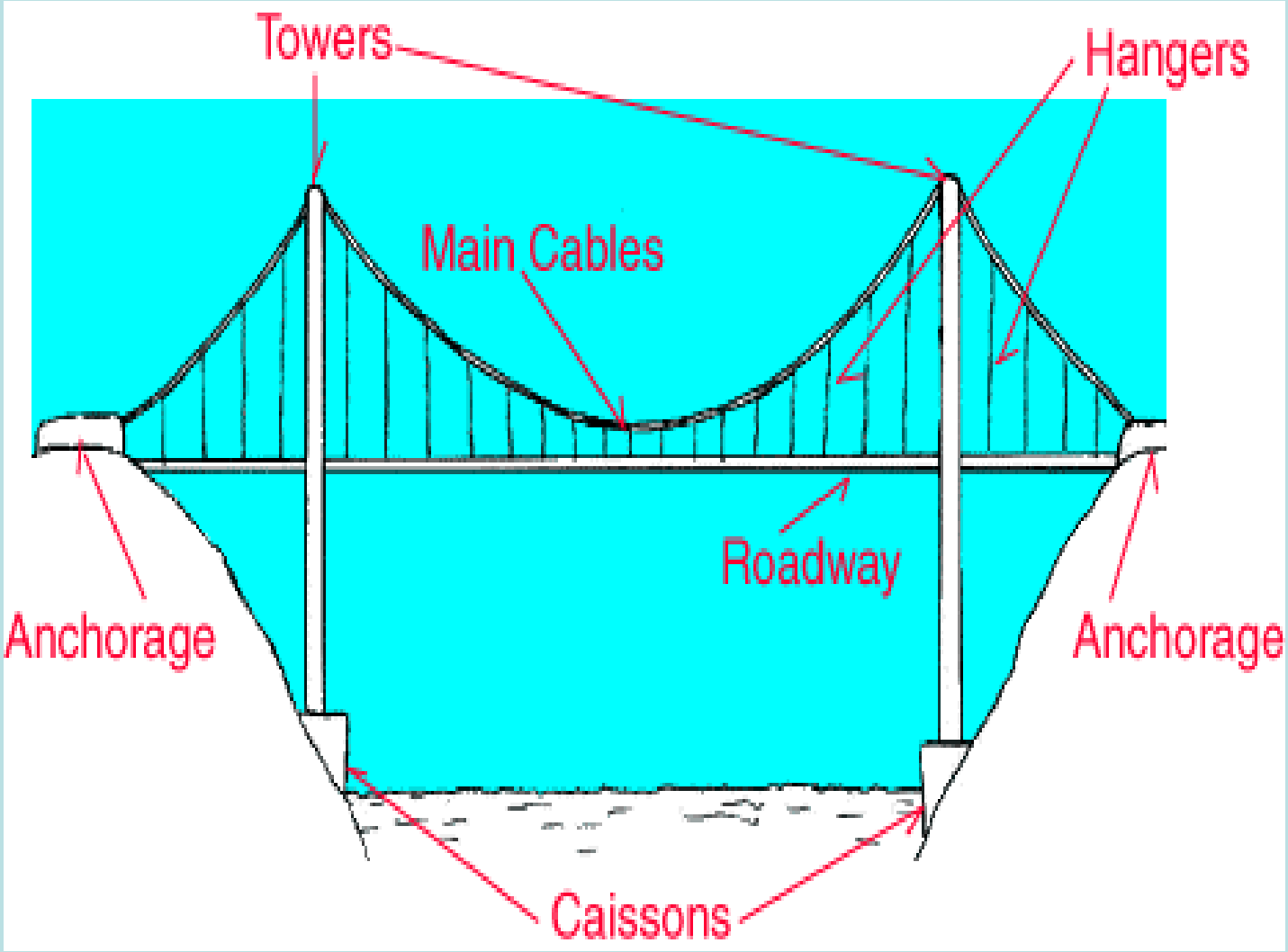
WHAT IS CAISSON?

- ✓ It’s a prefabricated hollow box or cylinder.
- ✓ It is sunk into the ground to some desired depth and then filled with concrete thus forming a foundation.
- ✓ Most often used in the construction of bridge piers & other structures that require foundation beneath rivers & other bodies of water.
- ✓ Caissons can be floated to the job site and then sunk into place.

Caissons

1000te Reinforced Concrete Caissons for RoRo Terminal-
Rosslare, Ireland

Reinforced Concrete Caissons



Caisson as one of the elements in this structure