UNIT-III
FOUNDATIONS

CONTENTS OF UNIT-3

- Functions of foundations
- Types of shallow foundation
- Sub-surface investigations
- Geophysical methods
- General features of shallow foundation
- Foundations in water logged areas
- Design of masonry wall foundation
- Introduction to deep foundations i.e. pile and pier foundations

FOUNDATION- DEFINITION

- It is the lowest part of a structure which provides a base for the super-structure.
- This term includes the portion of the structure below the ground level.
- Foundation transmits the load of the super-structure to the soil below.

FOUNDATION- PURPOSE

1. To distribute the weight of the structure over large area so as to avoid overloading of the soil beneath.
2. To load the sub-stratum evenly and thus prevent unequal settlement.
3. To provide a level surface for building operations.
4. To take the structure deep into the ground and thus increase its stability, preventing overturning.

SUB-SURFACE INVESTIGATIONS

- Sub-surface investigations are done to gather adequate information regarding the type and nature of soil available at different depths for safe design, sound and economical foundation for a structure.

SUB-SURFACE INVESTIGATIONS-PURPOSE

- To collect complete details of the site to enable designer to take following decisions:-

1. To fix the value of safe bearing capacity of soil.
2. To select an economical & safe type of foundation
3. To fix the depth up to which the foundation must be taken inside the ground.
4. To predict the likely settlement of the selected foundation and to make allowance for the same in the design.
5. To know the underground water level and if needed, to decide upon the method to be adopted to solve the ground water problem.
6. To forecast the difficulties which are likely to be encountered due to nature of the sub-soil during construction and to take advance actions in this regard.

METHODS OF SUB-SURFACE INVESTIGATIONS

1. **Test pits-**

- These are used only for structures having shallow foundations (<3m)
- These are normally square in plan and are dug by hand or excavating equipment.

2. **Probing-**

- A steel bar 25 to 40mm in dia. With a pointed end is driven into the ground until a hard sub-stratum is reached.
- The bar is driven by vertical fall under its own weight or by drop hammer.
- At intervals the bar is taken out and the type of soil at regular depth interval is observed by examining the nature of soil sticking to it.
- A rough idea of the strength of the soil is obtained by the number of blows required to drive the rod inside the ground.

METHODS OF SUB-SURFACE INVESTIGATIONS

3. **Sub-surface soundings-**

- It consists of measuring the resistance offered by the soil with the depth by means of a tool known as penetrometer
- The penetrometer consists of a 50 mm dia. Mild steel cone fitted loosely to a steel rod or it may be a tool known as standard split spoon
- The sampler can be split into two parts longitudinally for removal of the soil sample which get filled up in its tube when it is driven in the ground.
- The penetrometer is driven in the ground with the help of blows from a 650N weight falling from a height of 750mm.
- The number of blows required to drive penetrometer into the ground through a distance of 300mm is termed as standard penetration resistance of the soil(n) [SPT].
- The n value is co-related with the engg properties of soil like density, consistency, permeability and bearing capacity.

4. **Boring**-

(a) Augur Boring- Used up to 15m max. depth for examination of the sub-soil conditions for ordinary buildings to be constructed in clayey and sandy soil. This method is not adopted where the ground consists of gravels or compact material.

(b) Shell and Augur Boring- used up to 25m depth with hand rig and 50m with mechanical rig. Different types of tools are adopted for different types of sub-soil. For soft to stiff clay, cylindrical augur with hollow tube with a cutting edge at bottom is used. For stiff to hard clay, shells with cutting edge at lower end is used. In sandy

METHODS OF SUB-SURFACE INVESTIGATIONS

(C) Wash Boring- Adopted for soft to stiff cohesive soil and fine sand. A hollow steel casing pipe is driven into the ground. Then a wash pipe which is shorter in dia. is lowered into casing pipe. The upper end of wash pipe is connected to water supply system and lower end is contracted so as to produce jet action. The hydraulic pressure displaces the soil immediately below the pipe and slurry is forced up through the annular space between the two pipes. The change of stratification is guessed by the rate of progress of driving the casing pipe as well as the colour of slurry flowing out.

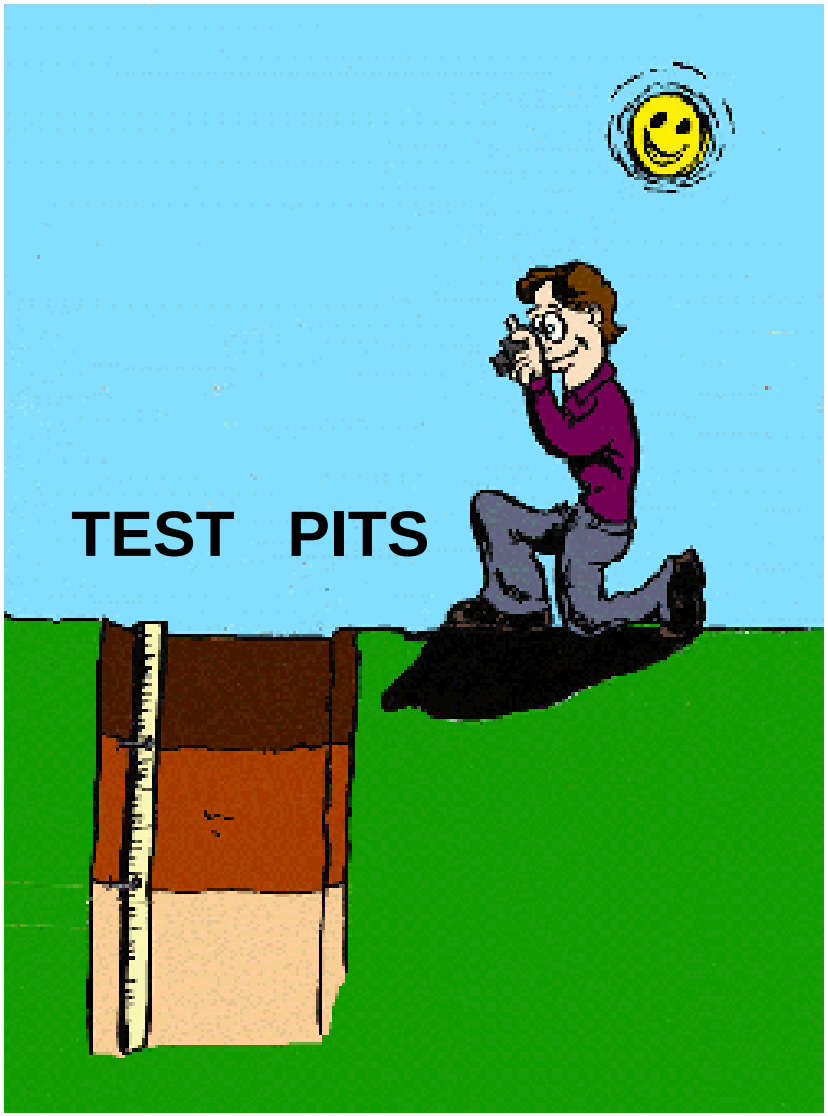
METHODS OF SUB-SURFACE INVESTIGATIONS

(D) **Percussion Boring-** Adopted in rocks and soils having boulders. This method consists of breaking of sub-strata by repeated blows from a bit or chisel. The material is converted into slurry by pouring water in the bore. At intervals the slurry is taken out and dried for examination.

(E) **Rotary Drilling-** Used when rocks or hard strata are to be penetrated. Core drilling is done. The cutting bit (of diamond) at the base of hollow steel tube cuts a cylindrical core of the material in the hollow tube as the tube is rotated.

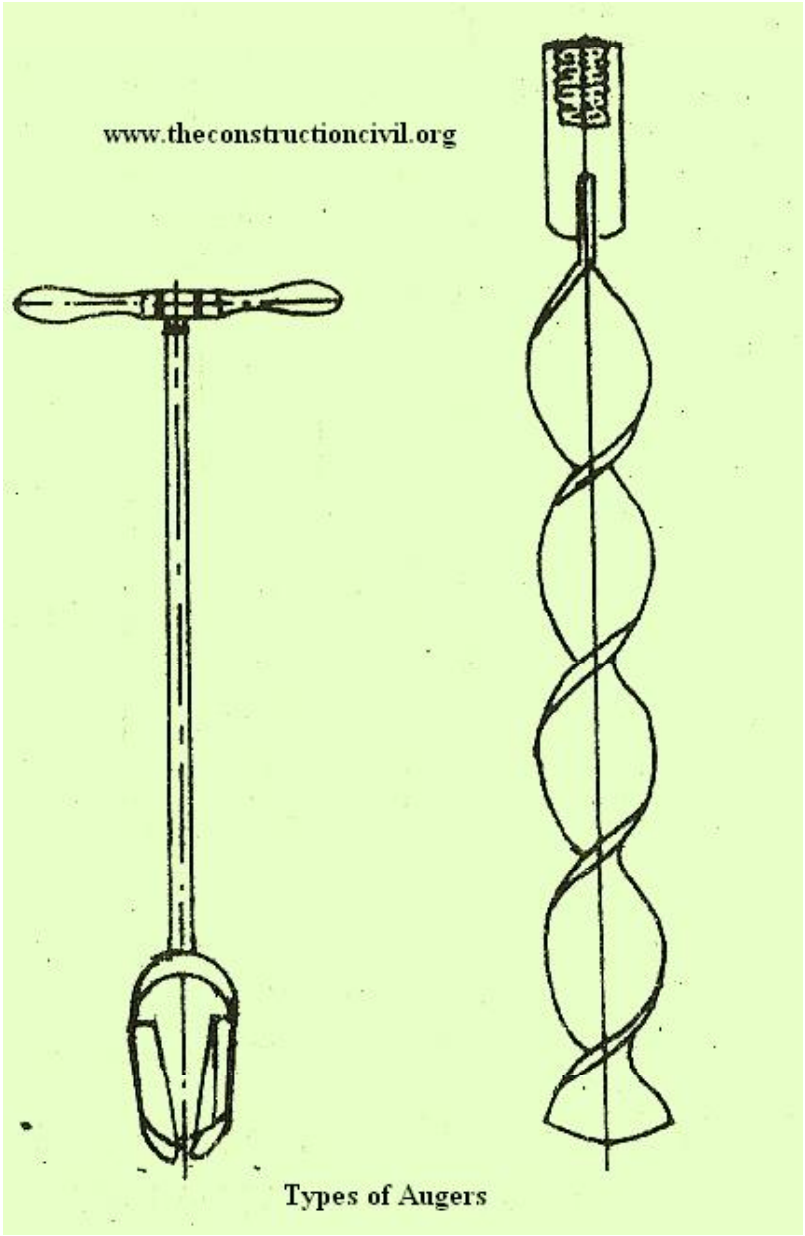
METHODS OF SUB-SURFACE INVESTIGATIONS

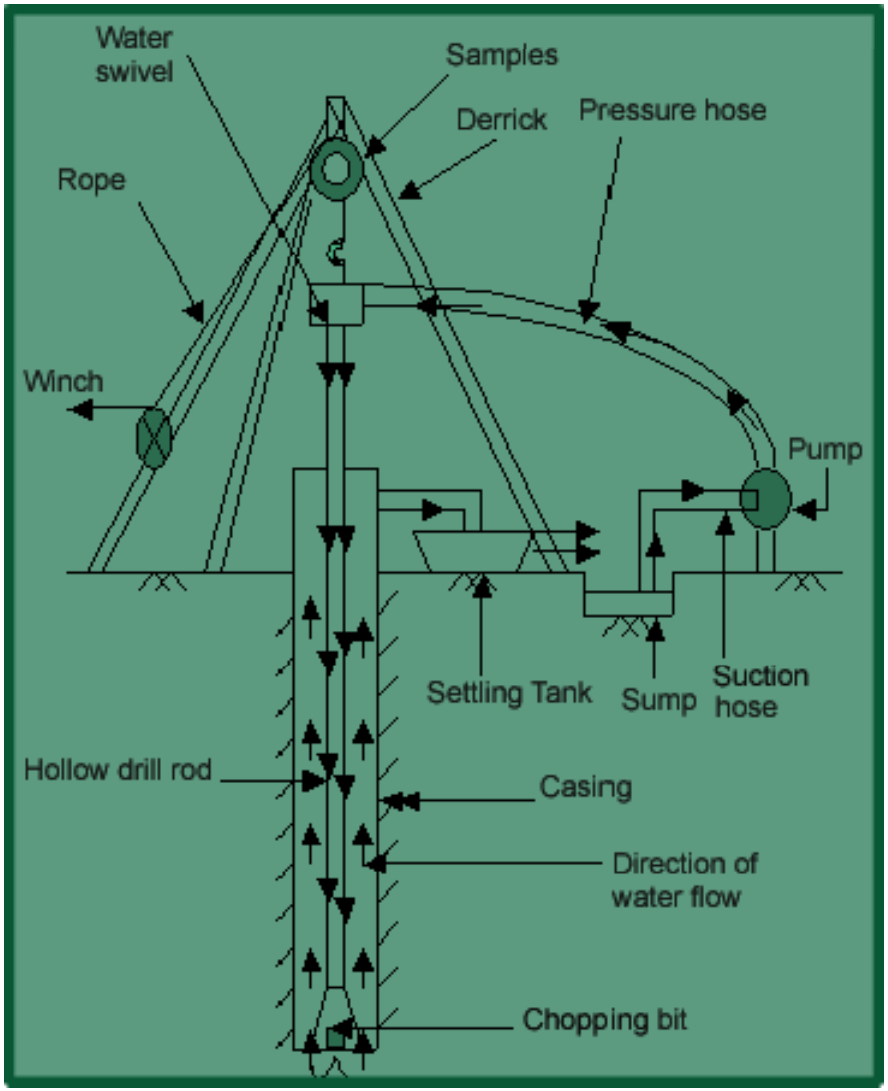
5. **Geo-physical methods**- this method is used when soil exploration is to be carried out in large area with great speed. These methods are based on principle that physical properties like electrical conductivity, elasticity or seismicity, magnetic susceptibility, density etc. Vary for different types of soils. Of all geo-physical methods, seismic refraction and electrical resistivity methods are widely used.



PROBING ROD

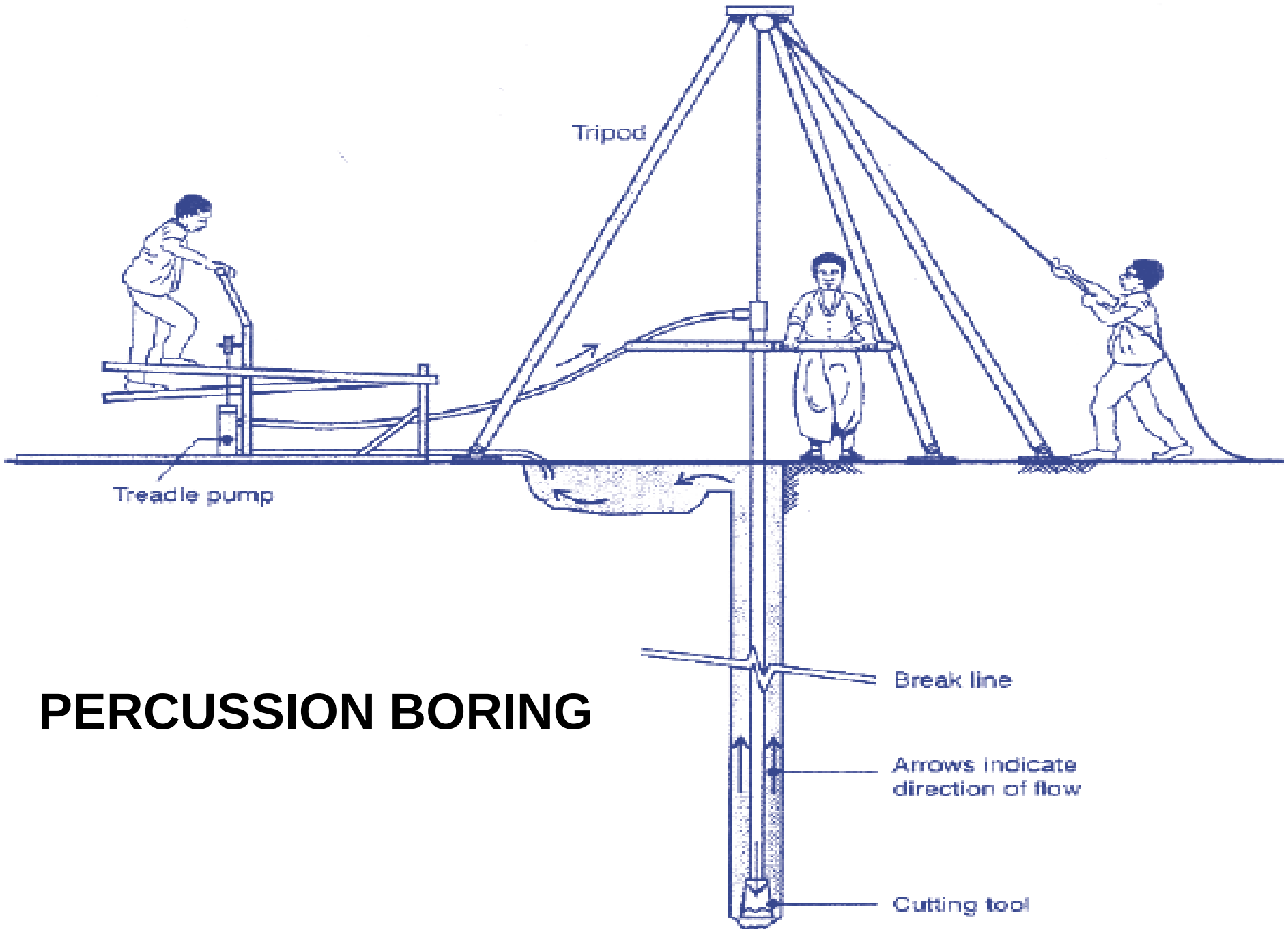
BORING





Wash boring

PERCUSSION BORING



METHODS OF SUB-SURFACE INVESTIGATIONS

(I) SEISMIC METHOD-

- This method is based on the principal that sound waves travel faster in rock than in soil.
- Shock waves are created into the soil at ground level either by striking a plate on the soil with the hammer.
- The shock waves so produced travel down in the sub-soil strata and get refracted after striking a hard rock surface below.
- The refracted shock waves are sensed by vibration detector (geophone) where the time of travel of shock wave gets recorded.
- Time and distance graphs are drawn and depth of various strata in the sub-soil is evaluated.

METHODS OF SUB-SURFACE INVESTIGATIONS

(II) ELECTRICAL RESISTIVITY METHOD-

- EACH SOIL HAS DIFFERENT ELECTRICAL RESISTIVITY DEPENDING UPON THE TYPE, WATER CONTENT, COMPACTION AND COMPOSITION OF SOIL.
- SATURATED SOIL HAS LOWER ELECTRICAL RESISTIVITY AS COMPARED TO DRY GRAVEL OR SOILD ROCK.
- 4 ELECTRODES ARE DRIVEN IN THE GROUND AT EQUAL DISTANCE APART AND IN A STRAIGHT LINE
- A CURRENT IS PASSED BETWEEN THE TWO OUTER ELECTRODES AND THE POTENTIAL DROP BETWEEN THE INNER ELECTRODES IS MEASURED BY POTENTIOMETER
- THE MEAN RESISTIVITY IS CALCULATED BY THE FOLLOWING FORMULA:

$$P = \frac{2\pi DE}{I}$$

WHERE P= MEAN RESISTIVITY (ohm-cm)

D= DISTANCE BETWEEN ELECTRODES (cm)

E= POTENTIAL DROP BETWEEN INNER ELECTRODES (volts)

I= CURRENT FLOWING BETWEEN OUTER ELECTRODES (amperes)

- ON KNOWING THE CHANGE IN THE VALUE OF RESISTIVITY, THE NATURE AND DISTRIBUTION OF DIFFERENT TYPES OF SOILS IN THE FORMATION CAN BE ESTABLISHED.

TYPES OF FOUNDATIONS

(a) **SHALLOW FOUNDATION-** foundation is placed immediately beneath the lowest part of the super-structure. The object is to distribute the structural loads over a wide horizontal area at shallow depth below the ground level. The various types of shallow foundations are:

(i) Spread footings

(ii) Grillage foundation

(iii) Eccentrically- loaded footings

(iv) Combined footings

(v) Mat or raft foundation

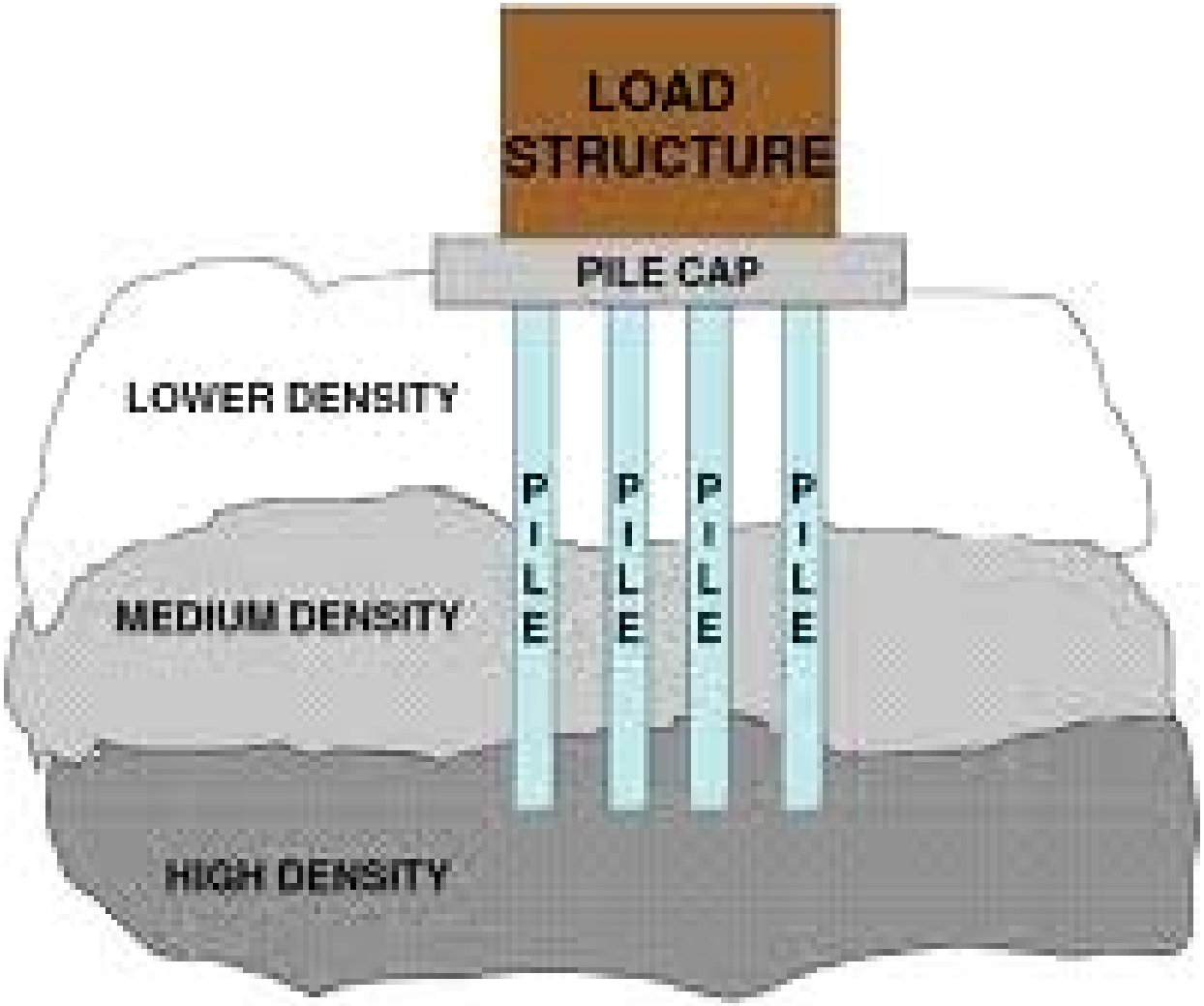
B) **DEEP FOUNDATION-** in case the strata of good bearing capacity is not available near the ground, the foundation of the structure has to be made deep with the purpose of attaining a bearing stratum which is suitable in all respects. The common types of constructions pertaining to deep foundations are:

(i) Piles

(ii) Cofferdams

(iii) Caissons

BASIC PRINCIPAL OF PILE FOUNDATION




COFFERDAM

DESIGN OF MASONRY WALL FOUNDATION

The design consists of calculation of

(a) The depth of the foundation below the ground level.

(b) The depth of concrete bed block.

(c) The width of the footing.

CALCULATION OF DEPTH OF THE FOUNDATION

DEPTH OF FOUNDATION (RANKINE'S FORMULA:

$$D_f = \frac{p_0}{\gamma}\left(\frac{1-sin\emptyset}{1+sin\emptyset}\right)^2$$

WHERE

D_f= MINIMUM DEPTH OF FOUNDATION IN METRES

p_0= BEARING CAPACITY OF SOIL IN KN/m^2

γ= UNIT WEIGHT OF SOIL IN KN/m^2

$\emptyset$= ANGLE OF REPOSE OF THE SOIL

CALCULATION OF THE DEPTH OF CONCRETE BLOCK

THE DEPTH OF CONCRETE BLOCK:

$$d = \sqrt{\frac{3px^2}{m_r}}$$

WHERE

d= DEPTH OF CONCRETE BLOCK IN cm

x= THE POSITION OF CONCRETE BLOCK ON EITHER SIDE OF THE LOWERMOST COURSE OF WALL FOOTING IN mm

m_r= SAFE MODULUS OF RUPTURE OF CONCRETE MIX USED IN N/mm^2

p= NET UPWARD SOIL PRESSURE IN KN/m^2 (MAY BE TAKEN AS SAFE BEARING CAPAVITY OF THE SOIL)

MODULUS OF RUPTURE OF VARIOUS GRADES OF CONCRETE MIX

S.NO	TYPE OF CONCRETE	m_r in N/mm^2
1.	PURE LIME AND SURKHI CONCRETE (1 MORTAR : 3 STONE BALLAST)	0.155
2.	MODERATELY HYDRAULIC LIME AND SAND CONCRETE (1 MORTAR : 3 STONE BALLAST)	0.155
3.	1: 4: 8 PLAIN CEMENT CONCRETE	0.246
4.	1: 3: 6 PLAIN CEMENT CONCRETE (M 10)	0.352
5.	1: 2: 4 PLAIN CEMENT CONCRETE (M 15)	0.527

CALCULATION OF WIDTH OF FOOTING

THE WIDTH OF FOOTING IS THE GREATER OF TWO RESULTS OBTAINED BY:

(i) THE WIDTH OF THE FOOTING = $\frac{W}{p_0}$ IN m

WHERE

W = TOTAL WEIGHT INCLUDING SELF WEIGHT OF FOOTING IN KN/m (IS CALCULATED AS SELF WT. OF WALL + LOAD DUE TO ROOF + LOAD DUE TO FLOORS + SELF WT OF FOUNDATION)

p_0 = SAFE BEARING CAPACITY OF SOIL IN KN/m^2

(ii) THE WIDTH OF FOOTING = $2b + 2x$ WHERE

b = WIDTH OF THE WALL

x = THE POSITION OF CONCRETE BLOCK ON EITHER SIDE OF THE LOWERMOST COURSE OF WALL FOOTING IN m