# Shallow foundation

**Objectives :** At the end of this lesson you shall be able to,
- **define shallow foundation**
- **explain various types of shallow foundation**
- **describe setting out of building on ground.**

### Introduction

It is possible to construct foundation of a building at a reasonable shallow depth, the foundations are termed as the shallow foundations.

### Definition

The depth of foundation is equal or less than its width, is known as shallow foundation.

### Setting out of building on ground

1 Clear the Site.

2 Prepare a plan of setting out on paper.

3 Centre lines of walls to be marked on plan

4 This is to be marked on ground.

5 Mark the centre lines of walls by stretching a string between wooden pegs.

6 Cross walls set by 3, 4,5 method.

7 Corners of building are laid and sides checked by measuring diagonals.

8 Entire width of foundation marked

9 For big projects reference pillars of brick may be constructed.

### Shallow foundation

Foundation having its depth less than or equal is its width are known as shallow foundation. Since such foundation are constructed by open excavation.

Hence those foundation having its depth even greater than its width but are constructed by way of open excavation are also come under shallow foundation.

### Design of shallow foundation

Following data are required before design of a foundation

a The total load to be transmitted by the wall or pier to the foundation bed.

b The results of trial pit and the corresponding bearing capacity of each strata of soil.

### The design of foundation required the three terms,

a Width of foundation.

b Depth of foundation below ground level.

c Depth of concrete block below the masonry rooting.

### Width of foundation

The width of foundation should be sufficient enough to bear the super imposed load per unit length on the foundation bed. The width of foundation is obtained by

i) Dividing the total load per unit length on foundation bed by safe bearing capacity of the soil.

Thus, width of foundation = $\frac{w}{p}$

Where, w = total load in tone/metre

p = safe bearing capacity of soil in tonne/$m^2$

ii) Width of foundation = 2 (T+J) Where,

T= thickness of wall above the plinth level.

J= the projection of concrete block on the either side of the lowermost masonry footing. which should be atleast 10cm-15cm.

### Depth of foundation below ground level

This is generally determined by the rankine's formula. Which gives the maximum depth.

Depth of foundation below the ground level,

$$d = \frac{p}{w}\left[\frac{1-\sin\theta}{1-\sin\theta}\right]^2$$

Where p = total load on soil in kg/$m^2$

w = wt of soil in kg/$m^3$

$\theta$ = Angle of repose of the soil.

In order that all the shallow foundation should be taken to a minimum depth of 80cm below the natural ground level. Unless hard soil is available within 80cm.

### Angle of repose

Angle of repose is the angle 95 the loose soil will make with the horizontal, if allowed to remain free in loose condition. The angle of repose of the soil varies with the type of earth.

### Depth of concrete block

The depth of concrete block below the masonry footing is calculated by using the formula

$$d = \sqrt{\frac{3PJ^2}{m}}$$

Where, P = the load on soil in kg/m$^2$

J= The projection of concrete on either side of the lowermost masonry footing which should be at least 10-15cm.

m= modulus of rupture of concrete in kg/m

The depth of concrete block below the masonry footing is also determined by the formula

$$d = \frac{5}{6}T$$

Where T = thickness of wall above the plinth level.

**TYPES OF SHALLOW FOUNDATION**

**A) Spread footing**

The total load of the structure is transmitted to the base of the structure is spread out to a large area by spread footing.

**a) Strip footing**

Spread footing for a wall is known as strip footing.

**b) Pad footing**

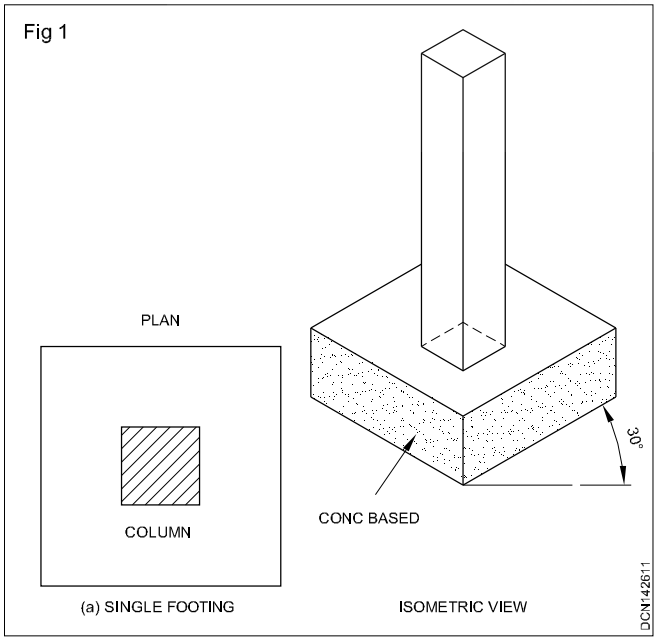
The spread footing for a single column is known as pad footing or isolated footing.

The spread footing may be of the following types

**i) Single footing**

Fig 1 shows the single footing for a column in which the loaded area (bxb) of the column has been spread to the

Fig 1

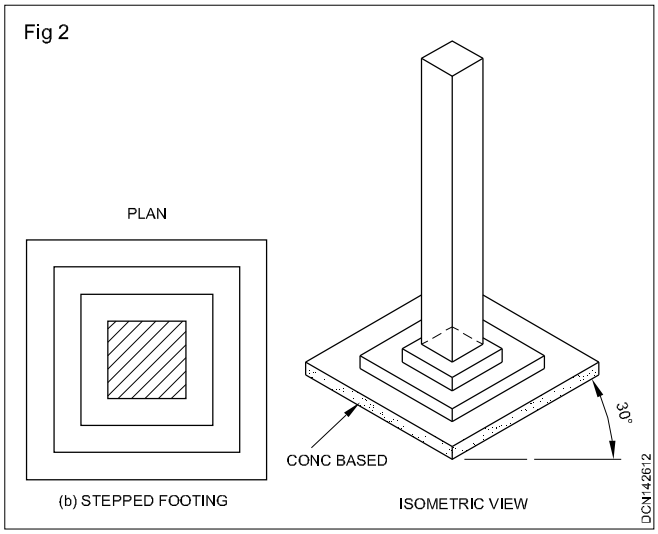



size (BxB) through a single spread.

**Stepped footing**

The Fig 2 shows the stepped footing for a heavily loaded

Fig 2

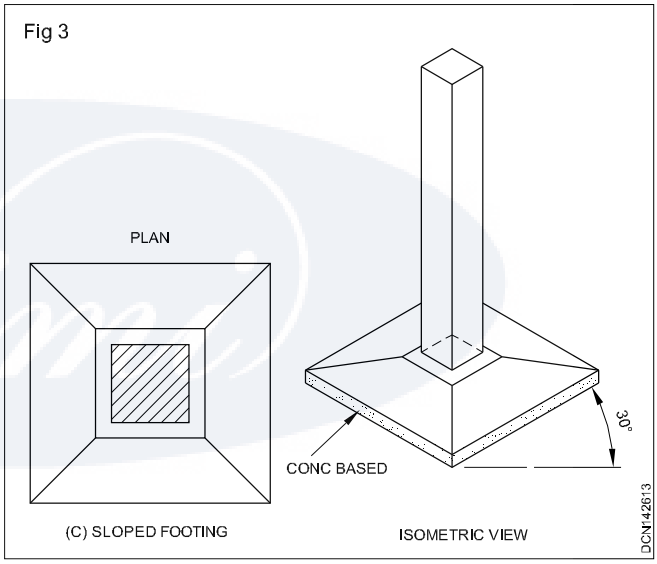



column which require greater spread. The base of the column is made of concrete.

**iii) Sloped footing**

Fig 3 shows the sloped footing made in concrete base of

Fig 3




non uniform thickness. Greater thickness at its bottom, smaller thickness at the top.

**iv) Wall footing without step**

Fig 4 shows the stepped footing for a wall consisting of concrete base without step.

**v) Stepped footing for a wall**

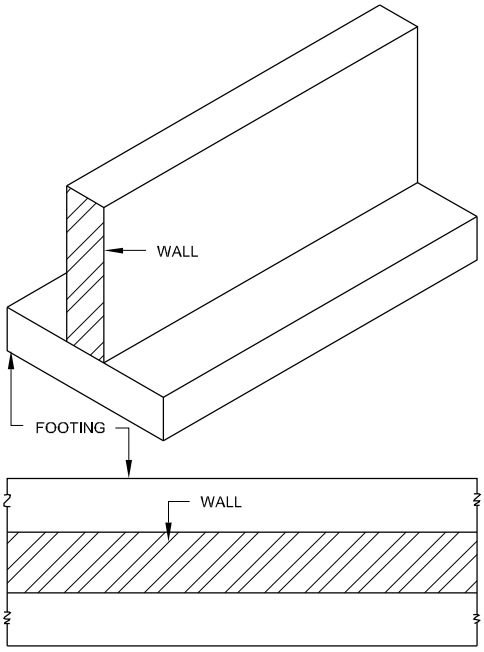
Fig 5 shows the masonry wall have stepped footing with a concrete base.

**vi) Grillage foundation**

A grillage foundation is a special type of isolated footing. Generally provided for heavily loaded steel stanchions or column, specially in those location where bearing capacity of soil is poor. The depth of foundation is limited from 1-1.5m. The load of the column or stanchion is distributed or spread to a very large area by means of layers of tiers of joist, each tier being placed at right angle to the next tier.

Grillage foundation are of two types:-

Fig 4




WALL FOOTING WITHOUT STEP

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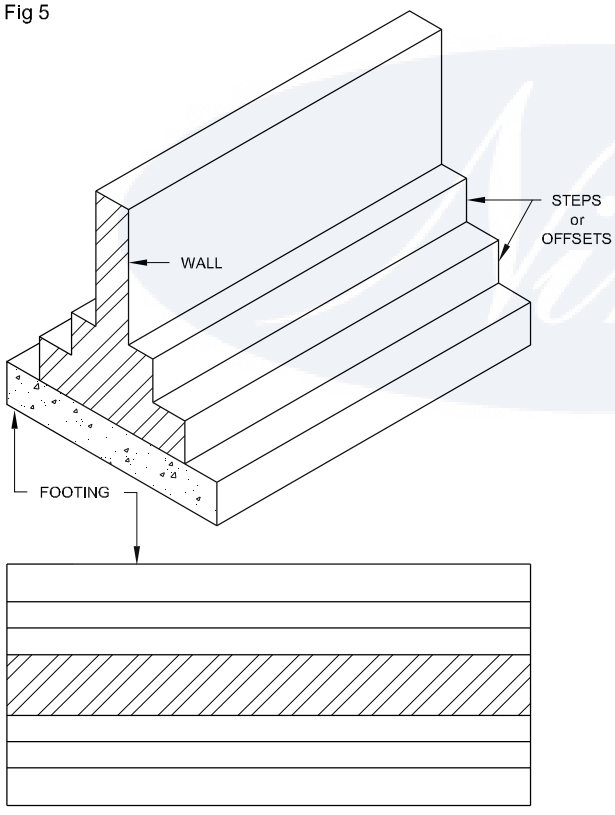
Fig 5




(b) STEPPED FOOTING

SPREAD FOOTINGS FOR WALLS

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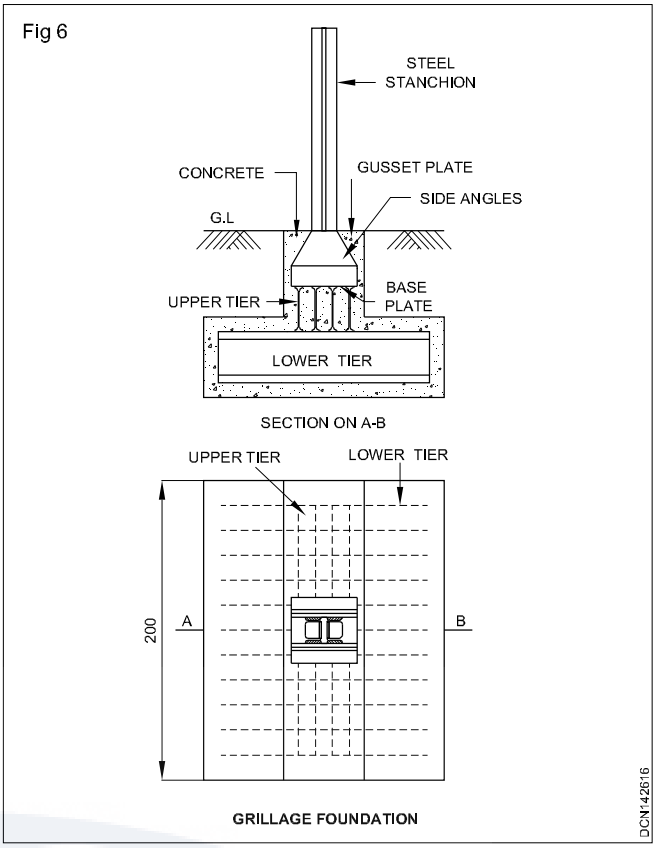
**Steel grillage foundation**

**Timber grillage foundation.**

**Steel grillage foundation**

Steel grillage foundation is constructed of steel beams, structurally known as rolled steel joist (RSJ) provided in two or more tiers. In case of double tier grillage (which is commonly provided) the top tier of grillage beams is laid at right angle to the Bottom tier. The joists or beams of

Fig 6




GRILLAGE FOUNDATION

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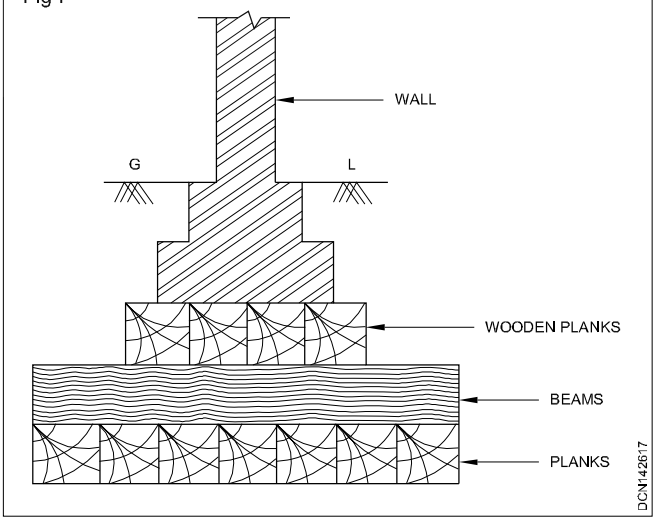
each tier are held in position by 20mm diameter pipe separators (tie rod 20mm diameter) as shown in Fig 6..

The grillage beams are embedded in concrete. Generally, the minimum clearance of 8cm is kept between the grillage beams. So that the concrete can be easily poured ,properly compacted. However the distance between the flanges should not exceed 30cm or 1 1/2 times the flange width. So that the filled concrete acts monolithically with the beams. It should prevent their corrosion. A minimum concrete cover of 10cm is kept on the outerside

Fig 7

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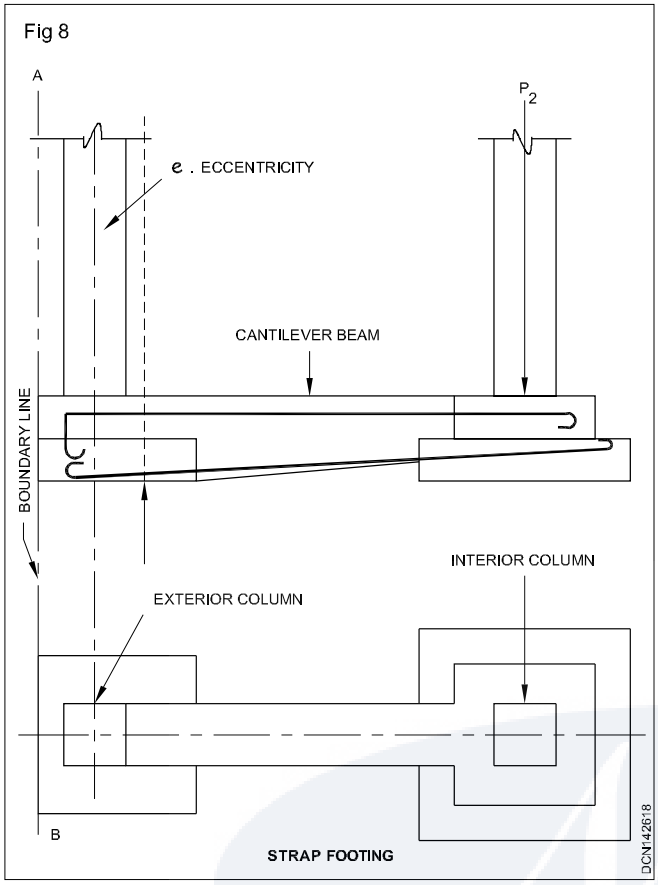
of the external beams as well as upper flanges of top tier.

**Timber grillage foundation** (Fig 7)

Temporary grillage foundation in the form of timber beams may be provided to timber columns, posts or walls etc. They can be design for supporting light building. In water

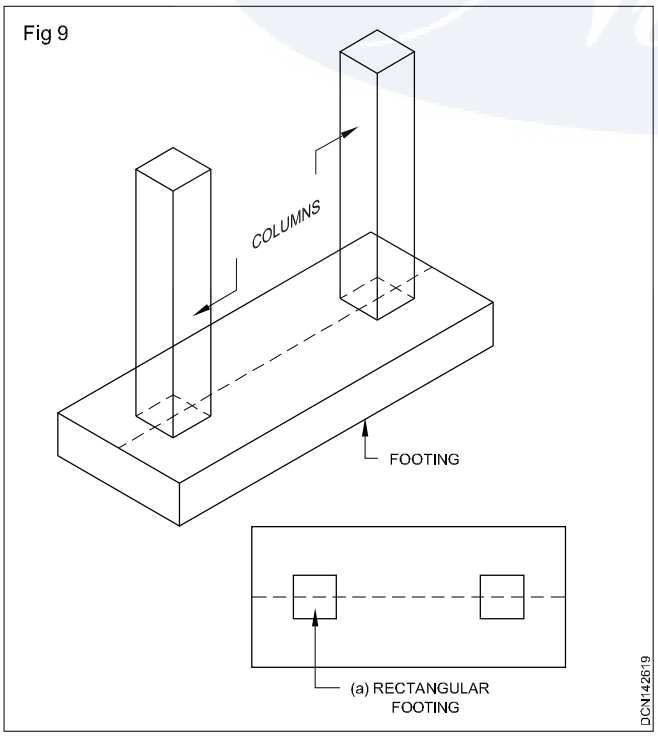
logged areas. The loading on the soil is limited is 5.5 tone/m. The grillage takes the form of a platform of wooden planks arranged in 2 layers at rectangle to each other.

Fig 8




The two layers of planks are separated by rectangular

Fig 9

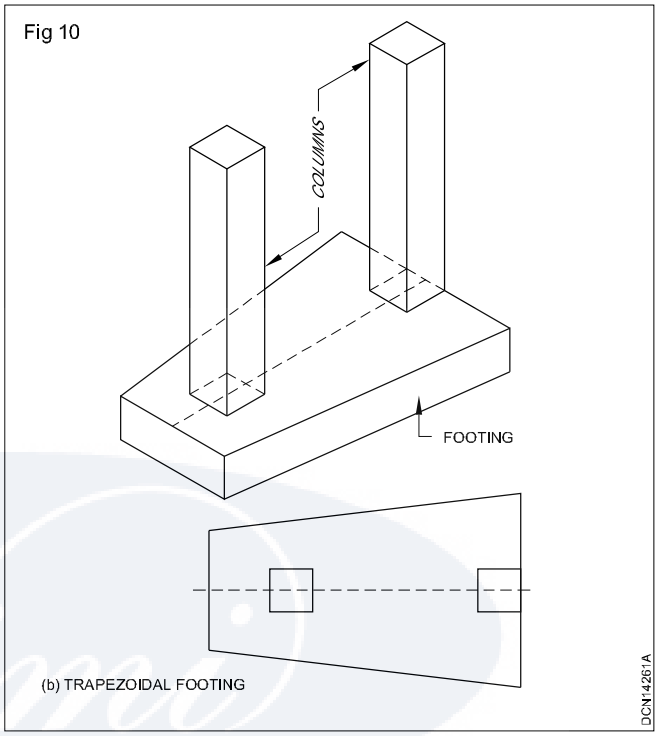



section of timber placed at centre to centre distance of about 3.5cm-40cm.

**B) Strap footing or cantilever footing** (Fig 8)

A strap footing comprises of two or more footings of individual columns, connected by a beam called a strap. When a column is near or right next to a property limit, its foundation cannot extended beyond the property line, and if the distance between this columns and the adjoining column is large, in that case strap footing may be provided. The strap beam connecting the spread footings of the two columns do not remain in contact with soil and does not transfer any pressure to the soil. The function of strap beam is to transfer the load of heavily loaded outer column to the inner column. In doing so the strap beam is subjected to bending moment and shear force and it

Fig 10




should be suitably designed to withstand these.

**iii) Combined footing**

**RECTANGULAR FOOTING (Fig 9)**

A spread footing which supports two columns is termed has combined footing. If the footing supports more than two columns it is known as continuous footing.

A combined footing is provided under the following circumstances

1) When the columns are very near to each other so that their footings overlap.
2) When the bearing capacity of soil is less requiring more area under individual footing.
3) When the end column is near a property line so that its footing spread in that direction.

A combined footing may be rectangular or trapezoidal in plan. The aim is to get uniform pressure distribution under the footing. For this the centre of gravity of the footing area should coincide with centre of gravity of the combined load of two columns. If the outer column, near the properly

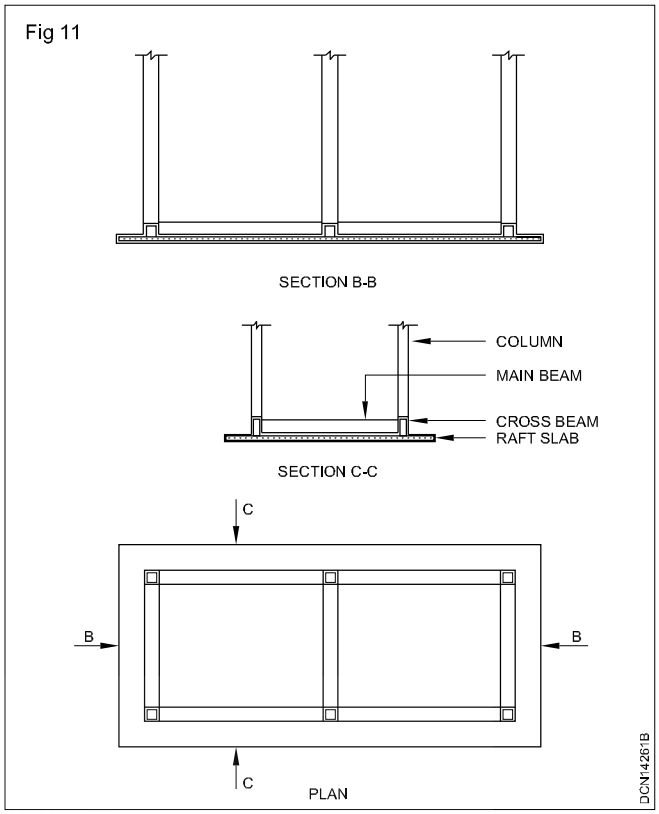
line carries heavier load, provision of trapezoidal column becomes essential to bring the c.g of the footing in line with the c.g of the two column loads. In other cases rectangular footing may be prefered.(Fig 10)

**IV) Mat or raft foundation**

Generally a raft or mat foundation is used when the bearing capacity of soil is very poor and when it is required to distribute heavy concentrated load over a large area. The raft foundation is useful where there is a possibility of unequal settlement to occur. The raft foundation consist of thick R.C.C slab covering whole area in the form of a mat. If the required area of footing exceeds half the total area of the structures, raft foundation is used. Raft foundation is also used for increasing the area of foundation to neutralise the hydrostatic uplifts.

**v) Inverted arch foundation -** The foundation which consist of inverted arches between the pier are known as inverted arch foundation. The rise of the arch is about 1/5th -1/10th of the span. The load transmitted to the soil through inverted arch. These are suitable for the construction of bridges, reservoirs, tanks etc. Now a days this type of foundation is rarely used in India.

Fig 11



# Deep foundation

**Objectives :** At the end of this lesson, you shall be able to
- **define deep foundation**
- **state classification of deep foundation**
- **explain pile foundation**
- **identifies various types of piles**
- **describe pier foundation**
- **explain well foundation (caisson).**

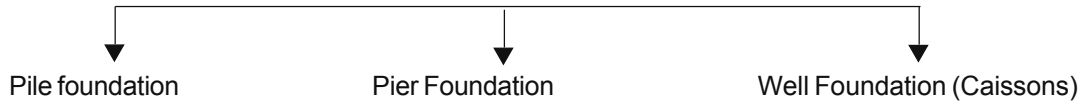
### Introduction

This construction is adopted when the loose soil extends to a great depth. The load of the structure is transmitted by the piles to hard stratum below or it is resisted by the friction developed on the sides of piles.

### Definition

The depth of foundation is greater than its width is called deep foundation.

**Classification of deep Foundation**




### A Pile Foundation

Pile is a long vertical load transferring member which may be of timber, steel or concrete.

1 The loads are taken to a low level by means of columns in the soil.

2 It may be adopted where no firm bearing strata exists at reasonable depth and the loading is uneven

3 The pumping of subsoil water is too costly for keeping the foundation trench in dry condition.

4 This foundation is to be adopted for the structures in the area where canals ,deep drainage lines, etc. are to be constructed

### Pile

Following are the situation in which a pile foundation is preferred:-

a When the load coming from the structure is very high and concentrated.

b When the other type of foundation cannot be provided due to heavy cost and site difficulties.

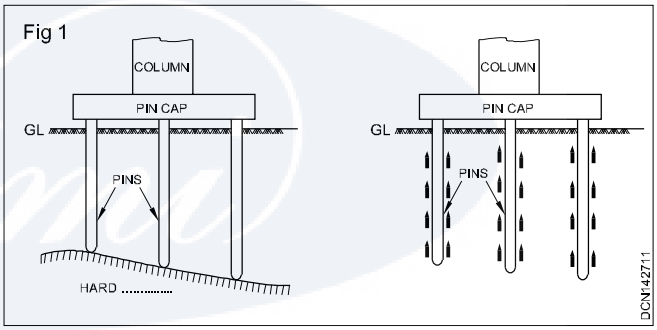
c When the water table is very near to the ground level and may defect the other type of foundation.

d When due to heavy inflow seepage, it is not possible to execute the trenches and keep them dry.

e Where there are chances of construction of irrigation canal in the near by area, which causes seepage of water in the foundation.

f When hard bearing strata is at a greater depth.

Fig 1

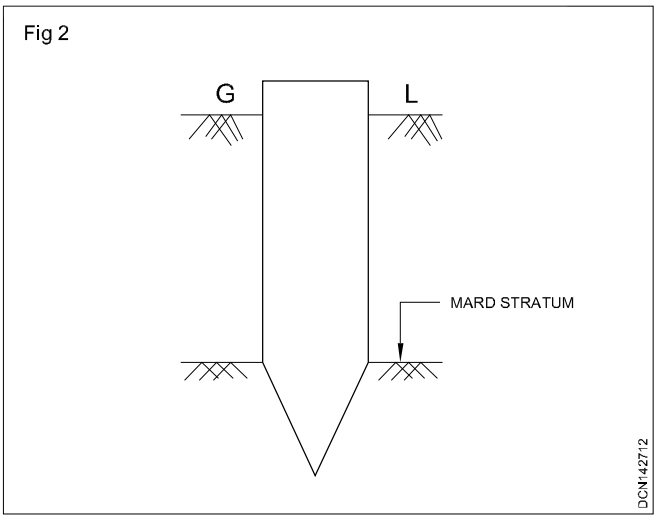



### Classification of piles

(a) Classification according to foundation:-

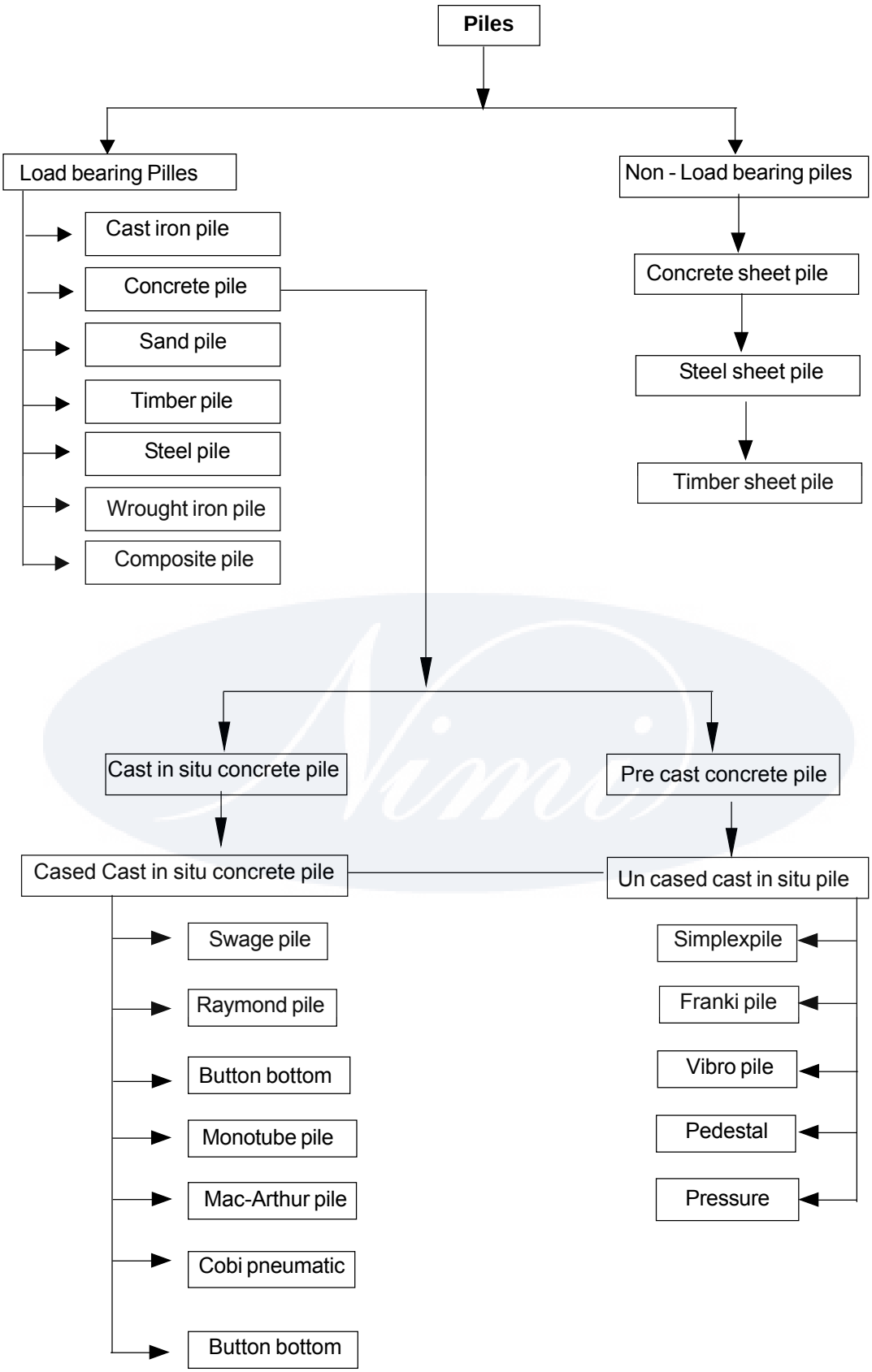
**1 End bearing piles** (Fig 2)

Fig 2




Piles whose lower end rest on hard rock (hard stratum) is known as end bearing piles. These piles are used to transfer heavy load through water or soft soil to a suitable hard stratum.

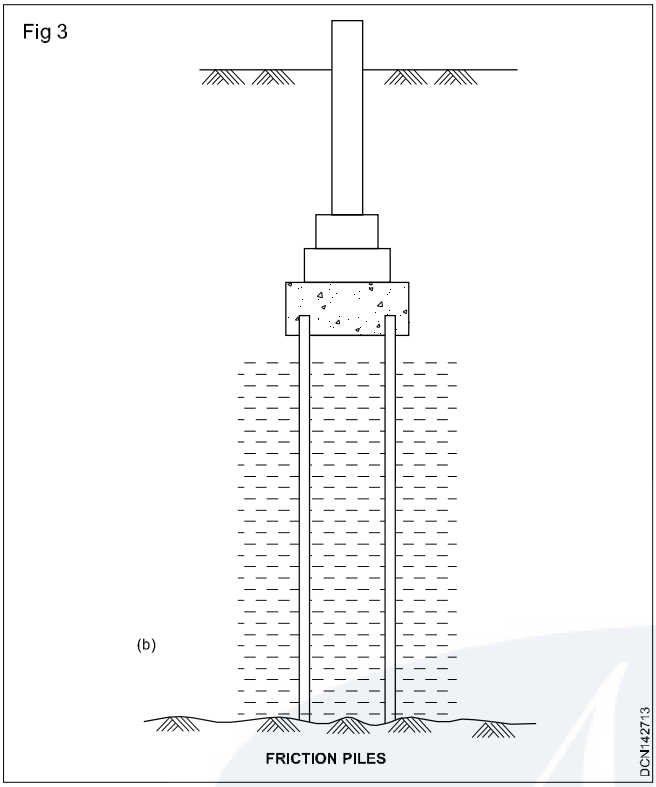
**Types of pile**



## 2 Friction piles (Fig 3)

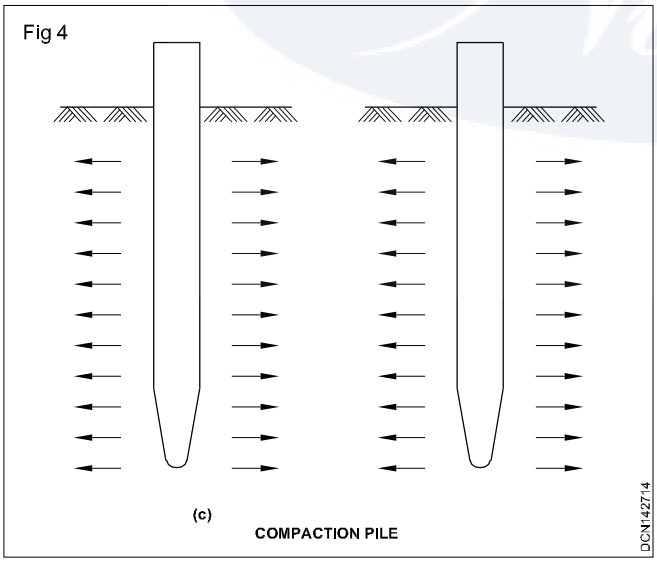
The piles which support the structure load due to friction between the piles and surrounding soil are known as friction piles. Such piles are generally use in granular soil when the depth of hard strata is very great.

Fig 3




## 3 Compaction piles (Fig 4)

Fig 4




Compaction piles are used to compact loose granular soil thus increasing their bearing capacity. The compaction piles themselves do not carry any load. Hence they may be made of weaker materials like timber, bamboo sticks etc. Sometimes they may be made of sand only. The pile tube driven to compact the soil, is gradually taken out and sand is filled in its place thus forming a sand pile.

## 4 Tension or uplift pile

The tension piles anchor down the structures subjected to uplifts due to hydrostatic pressure or due to overturning moment.

## 5 Anchor piles

These piles provide anchorage against the horizontal pull from sheet piling or other pulling force.

## 6 Sheet piles

The piles are differ from bearing pile and friction pile. In that they are rarely used to furnish vertical supports, but are used to retain the soil that is, liable to escape laterally when subjected to pressure or to enclose the area required for some foundation. And protect it from the action of running water or leakage.

## 7 Fender piles and dolphins

These piles are used to protect the concrete deck or other water front structures against impact from ship or other floating objects.

## 8 Batter piles

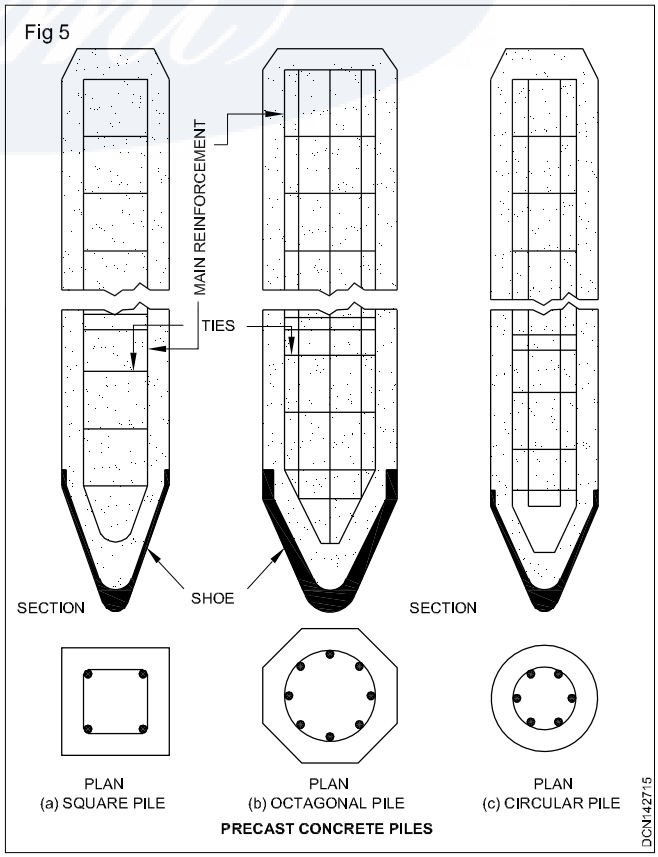
These piles are driven at an inclination to resist large horizontal or inclined forces.

b) Classification according to materials used

1) Concrete piles
2) Timber piles
3) Steel piles
4) Composite piles

## 1 Cement concrete piles (Fig 5)

Fig 5




Cement concrete possess excellent compressive strength. R.C.C piles are becoming more popular and they are fast

replacing piles of other material. R.C.C piles are divided into two groups.

**i Pre cast concrete piles (Fig 5)**

Pre-cast concrete piles are those which are manufactured in a factory or at a place away from the construction site and then driven into the ground at the place required. They may be square and octagonal piles are cast in horizontal form. The round piles are cast in vertical forms. The size of the piles may be 30cm-50cm and the length may be much as 18m or moré.

The reinforcement may consist of longitudinal steel bars of 20-40 mm in diameter 4-8 No's with lateral ties of 5-10mm wires spaced at 10cm-30cm c/c from bottom to middle respectively. A concrete cover of atleast 50mm is provided as shown in figure. At the toe of the piles a steel shoe is generally provided. The steel shoe protect the toe and helps the pile in penetrating into the ground during the driving. Pre-casting piles are useful in carrying fairly heavy loads through soft materials to tinner strata.

**Advantages of pre-cast concrete piles**

a The position of reinforcement in pile is not disturbed from its original position.

b These piles can be driven under water. Concrete in the cast-in-site piles may not be set under water.

c It is possible to have a proper control over the composition and design of these piles as they are manufactured in a workshop.

d Any defect of casting such as hollows etc can be found out and repaired before driving the pile.

e Any number of piles can be manufactured at a convenient place and this may prove to be economical.

f These piles process high resistance to biological and chemical action of the ground.

g These piles, when driven are ready to take up the load. There is no wastage of time.

**Disadvantages of pre-cast concrete piles**

a These piles are heavy in weight and it is therefore difficult to transport, to handle and to drive them.

b Extra reinforcement is provided to resist the stresses during handling and driving operation. This fact makes the pile costly.

c If sufficient care is not taken, piles may break during transport or driving.

d The size and length of pile will depend on the available transport facilities.

**ii) Cast-in-situ concrete pile**

In this type of concrete piles a bore hole is dug into the ground by inserting a casing. This bore is then filled with concrete after placing reinforcement, if any. The casing may be kept in position or it may be withdrawn. The former piles are known as cased-cast-in-situ concrete piles and the latter is known as uncased-cast-in-situ concrete piles.

**Advantages of cast-in-situ concrete piles**

a Light weight shells are used in cast-in-situ concrete piles and these shells are easy to handle and to drive in the ground.

b No extra reinforcement is necessary to resist stresses developing during handling or driving operation only.

c There is no wastage of materials as the piles of required length is constructed.

d The pile are sound in construction as they are not driven into the ground by a hammer.

**Disadvantages**

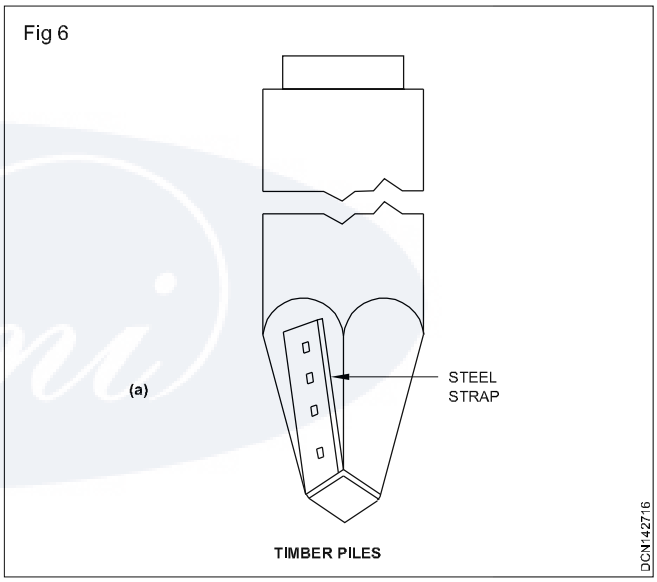
a It is difficult to maintain the reinforcement in correct position during construction of piles.

b These pile cannot be constructed under water.

c The dry ground may absorb, moisture from the wet concrete. The piles are then weakened.

**2 Timber piles (Fig 6)**

Fig 6




The timber pile may be rectangular, circular, square. The size of timber varies from 30cm-5-cm. The length of the timber pile does not exceed 20times its top width otherwise it may fail by buckling. At the bottom a cast-iron shoe is provided and at the top, a steel plate is fixed. The timber pile should be properly treated so as to make them durable.

A timber pile is made of trunk of a tree. The wood to be used for timber pile should be free from knots. flaws and shakes and other defects. The common Indian timber which are used are babool, chir, jarul, poon,. Sal, teak.

**Advantages of timber piles**

a Where timber is available easily these piles prove to be economical in cost.

b These piles can be handled easily with little risk or danger of break.

c The length of the timber pile can be adjusted either by cutting or lengthening without must extra cost.

d Skilled supervision is not required in the construction of timber lile.

e These piles can be removed easily if necessary.

f These pile donot required heavy equipment for driving them into the ground.

**Disadvantages**

a These piles cannot be take heavy loads and are unsuitable for used as end bearing piles.

b A joint in the lengthened timber pile is a source of weakness.

c It becomes very difficult to drive these piles in the hard formation.

d Timber piles are generally used for temporary work.

**3 Steel piles**

Steel piles are used as load bearing piles in the different form.

**i H-beam piles**

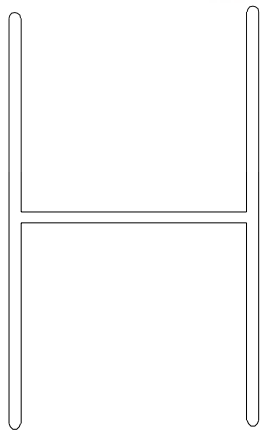
**ii Box-piles**

**iii Tube-piles**

**i H-beam piles**

Fig 6 shows the plan of an H-beam steel piles. These piles are usually of wide flange section and they are most common variety of steel piles in general use. They are found very much suitable especially for trested type structure in which the pile extent above ground level and work also as column for the structure. The driving of H-piles is very simple and energy from a piles hammer is effectively transmitted to the lower portion of the pile.

Fig 7



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**ii) Box pile**

Fig 8 shows the plan of box pile. Various type of patended box piles are available, the figure shows "Larssen-Box pile". A box is driven either with closed bottom or with open bottom. These piles are used when it is not possible to drive H-beam piles upto the hard strata.

**iii) Tube piles**

Fig 9 shows the plan of tube pile. In this type of steel piles, tubes or pipes of steel are driven into the ground. The pile may be driven either with open end or with closed end. Concrete is filled in side the tube piles. Because of circular cross section these piles are easily to handle and easy to drive.

Fig 8

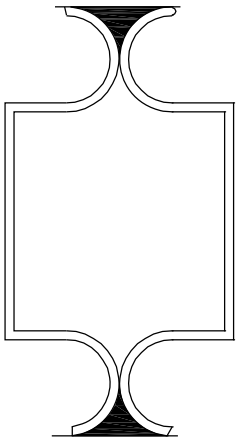

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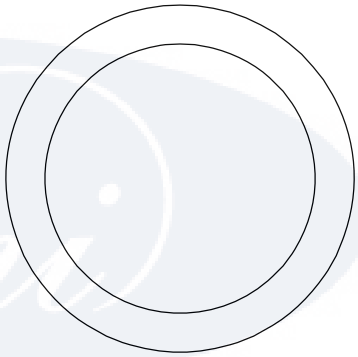
Fig 9



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**Advantages of steel piles**

a These piles withstand easily the stresses due to driving.

b These piles can be easily to lengthened by welding without any delay in driving operation.

c The extra length of these piles can be cut off easily.

d The bearing capacity of these pile is comparatively high. The allowable compressive stress on steel is taken as about 6-8 kg/mm$^2$

e These piles can be handled roughly without any serious damage.

**Disadvantages**

a Corrosion is the only drawback of steel pile.

**4 Composite piles**

Composite piles are those which are made of two portion of two different materials driven one above the other. Two common type of composite piles are :

**a Timber and concrete pile**

In the timber and concrete composite pile, timber portion

is use below the permanent or lowest water level, while concrete piles, usually cast-in-situ is formed above it. Due to this combination the advantages of both types are combined. Also the total cost of the pile is reduced.

**b Steel and concrete composite pile**

This type of composite pile is used where the required length of pile is greater than that available for the cast-in-situ type pile. The pile consist of steel pile attached to the lower end of concrete pile. This type of composite pile is used where satisfactory penetration of the pile into the rock is required for heavy loads.

**Foundation for black cotton soil**

Black cotton soil is a loose type of soil, and it considerably swells and shrinks by variation in moisture content. The variation in the volume of the soil is to the extent to the extend of 20%-30% of the original volume. During rainy season moisture penetrates into the soil the particles separate out, resulting in increase in the volume.

This increase in volume is known as swelling. During summer season, moisture moves out of the soil and consequently the soil shrinks, shrinkage cracks are formed on the ground surface. These shrinkage cracks are formed on the ground surface. These shrinkage cracks sometimes also known as tension cracks may 10-15cm wide,1/2-2m deep. Hence extreme care should be taken when foundation are to rest on this soil.

Following are the precautions to be taken in designing footings on black cotton soil:-

a For important structure the raft foundation should be adopted.

b The black cotton soil should be completely removed if possible and convenient.

c The black cotton soil should not be allowed to come in direct contact with the foundation masonry.

d The construction work should be carried out in dry season.

e The depth of foundation should extend beyond the depth of crack in black cotton soil.

**Pile cap and pile shoe**

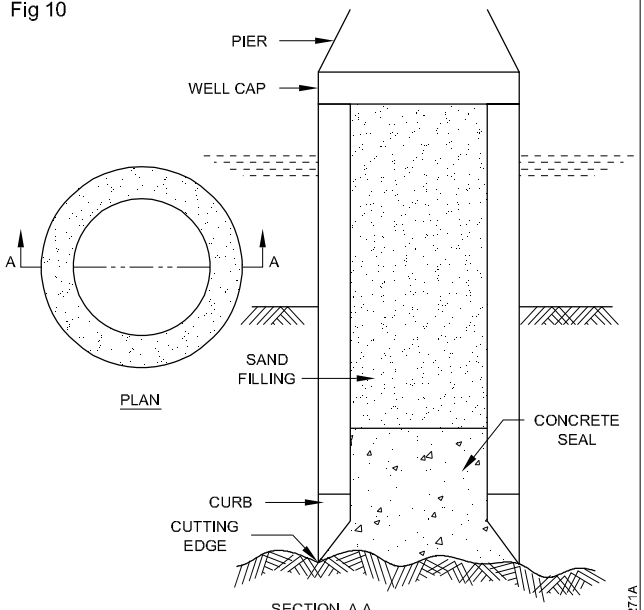
When the column or any other load carrying structural component is supported on more than one pile, the pile should be connected through a rigid pile cap, to distribute the load to individual pile, pile cap maintain the proper alignment of the pile. It is advisable to ensure that a pile projects atleast by about 10cm in the pile cap.

Pile shoes are provided at the tips to facilitate the process of driving through hard strata. Pile shoes are made from cast iron, steel or wrought iron. In case of steel piles it is necessary.

**B Well foundation(caissons)**

Well foundation is the convenient of securing a trust worthy foundation in deep sand or soft soil. It is also useful in moderate depth of water when foundation is to be taken in soft sandy soil, well are generally made of concrete or masonry. In masonry well vertical holding down bolt and iron plate or loop iron are provided to secure good bond.

Fig 10




CYLINDRICAL OPEN CAISSON (WELL FOUNDATION)

In order to prevent cracks during sinking operation. At the bottom of the well curb made of concrete, a steel or cast iron, cutting edge is attached. The position of well to be sank is first correctly marked on the ground and the curb is placed upon it. On the curb masonry ring is built to a hight of about 1.2m and allowed to drying.

**Type of foundation in black cotton soil**

Foundation in black cotton soil may be of the following types.

1 Strip or pad foundation

2 Pier foundation

3 Under-reamed pile foundation

**1 Strip or pad foundation**

For medium loads strip foundation (for walls) and pad foundation (columns) may be provided. These are two method of strip or pad foundation.

**1st method**

This method of constructing foundation on black cotton soil is adopted when the depth of black cotton soil is more and there are not chances for surface water to penetrate through the soil for more than 1m-1.5m.

The procedure is as follows

a The foundations trenches are excavated to a depth given by the equation.

d = maximum depth of crack+30cm

b The width of the trenches is kept such that the allowable bearing capacity of the soil does not exceed 15 tone/ $m^2$.

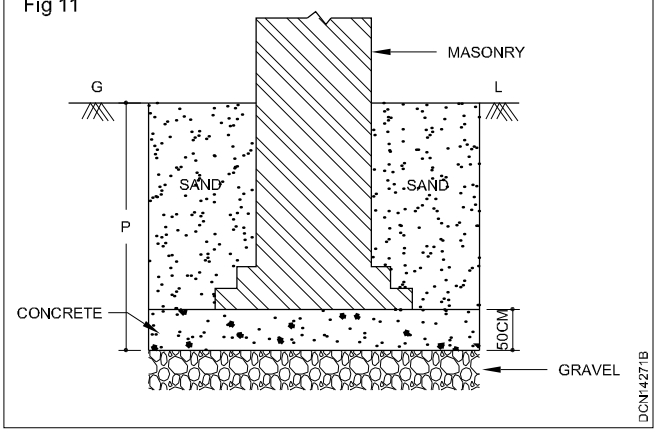
c Gravel is spread for the face width of the trench and well rammed.

d A layer of concrete of 50cm depth is laid on the gravel.

e The masonry work is started on the top of the foundation soil and it is carried out upto the plinth level.

f The side of the trenches are filled with sand as shown in fig 11.

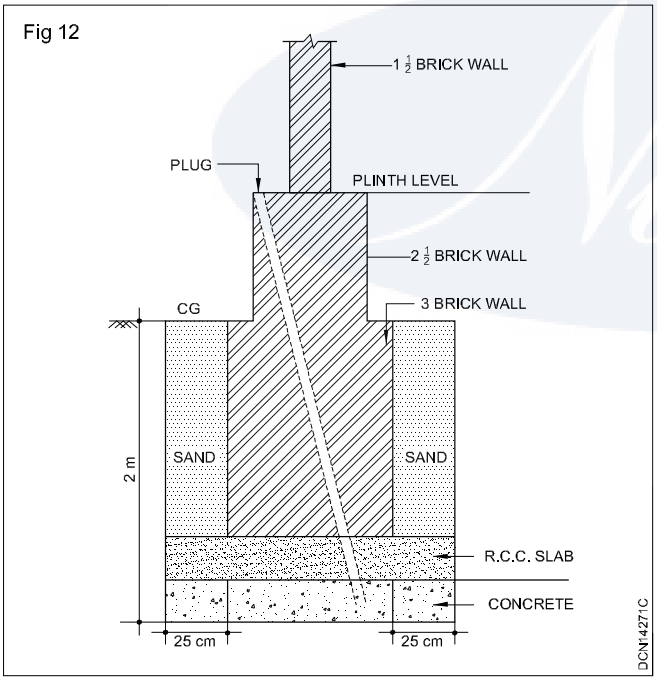
Fig 11




**II method**

This method of constructing foundation on black cotton soil is adopted at places where there is heavy rain-fall and there are chances for surface water to reach a greater depth in the soil.

Fig 12




The procedure as follows

a The foundation trenches are excavated to a depth of 2m.

b The side portion of the trenches are filled with concrete having a section of 25cmx25xm as shown in fig 11 and the hollow space equal to 1st layer of masonry is filled with sand.

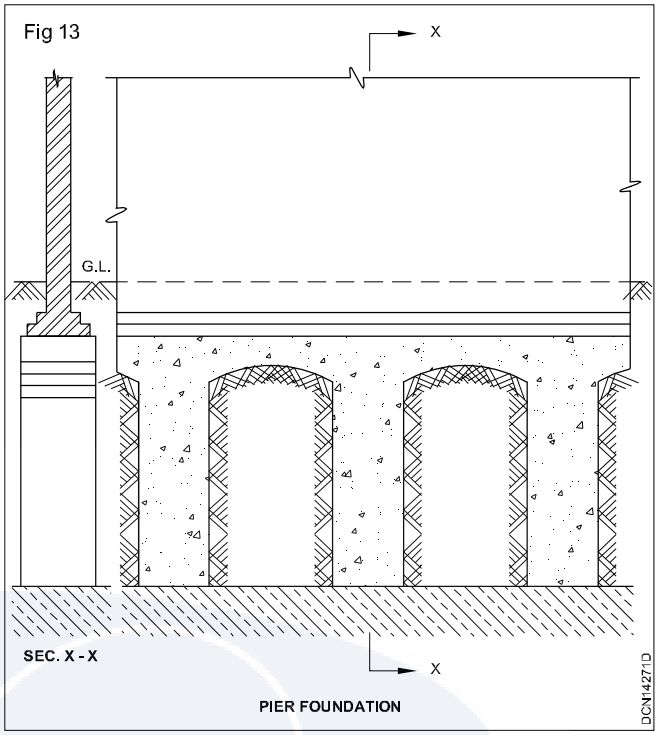
c 12cm-15cm thick R.C.C slab covering the face width of the trench is laid.

d The masonry work is started on the top of R.C.C slab and it is carried upto the plinth level.

e 80mm diameter pipes spread at 1.5cm centre to centre are placed through the masonry and R.C.C slab, as shown in figure. The pipes are brought upto plinth level and filled with sand. A plug is provided at the plinth level. These piles are inspected periodically if required.

**2 Pier foundation (Fig 13)**

Fig 13




When a heavy loaded building is situated in a sandy soil, black cotton soil or soft soil, over lying hard bed at reasonable depth pier foundation are sometimes used to transfer the load the building to the hard bed below. This method consist in sinking vertical shaft upto hard bed and filling them with concrete.

The diameter of the shaft and the centre to centre spacing depend upon the loading condition, the nature of soil and depth at which hard bed is situated. The diameter or horizontal dimension should be less than 1/12th its height. To prevent the side earth from falling in the side, the shaft is sometimes lined with timber. The timber lining is removed during the filling upthe shaft with concrete. The shaft are connected to each other by an arch or reinforced cement concrete or steel grillage cap.

**3 Under reamed pile foundation**

These piles are developed for serving as foundation for black cotton soil. An under reamed pile is a bored concrete pile having one or more bulbs in its lower portion. The bulbs or under-reams are formed by under reaming tools. The foundation will be anchored to the ground, and it would not move with the movement of the soil. The diameter of a under-reamed pile is about 3m-8m. The spacing of pile may vary from 2m-4m. The safe load for an under reamed pile varies from 20 to 40 tone (Fig 14).

The load carrying capacity of under reamed pile can be increased by adopting pile of large diameter or by extending the length of pile, or by making more bulb at the base. A single under-reamed pile has only one bulb at

the bottom. When the no.of bulbs at the base (2 or more) it is known as multi under-reamed piles. The vertical distance of bulbs varies from 1.25 to 1.50 times the diameter of the bulb. The under-reamed pile is selected by the consideration of pile length, stem diameter, bulb diameter, a no of bulbs. In black cotton soil the bulb of under-reamed piles, not only increase the load bearing capacity, but also provide anchorage against uplifts.

Fig 14

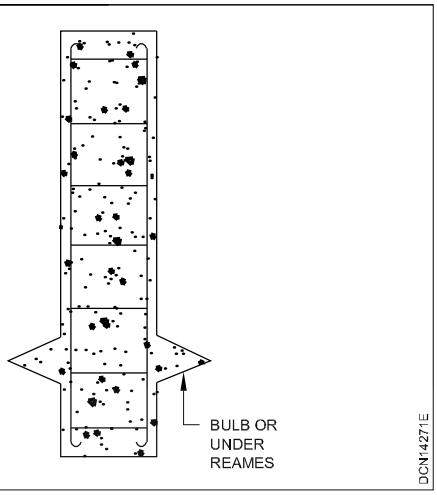
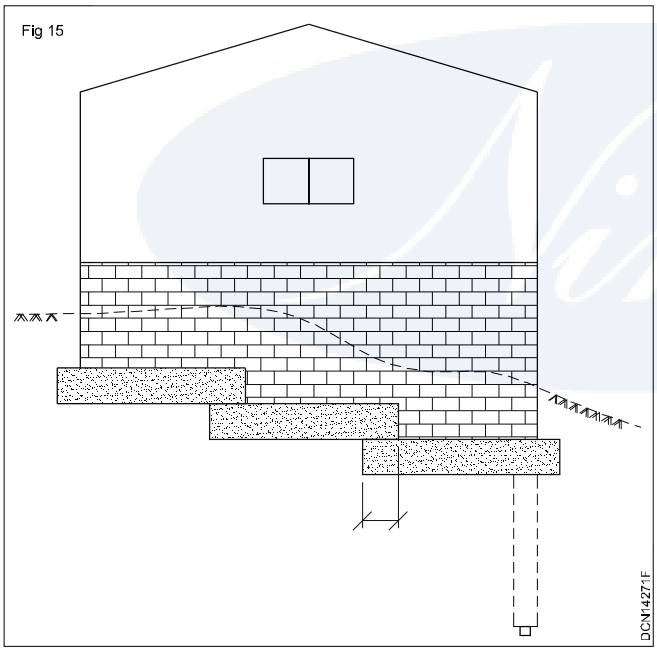



Fig 15




**Stepped foundation on slopping ground**

1 When the ground is sloping it becomes an-economical to provides foundation at same level along the length of the wall, in such cases stepped or benching foundation may be provided. The foundation trunch is excavated in the form of steps, if possible all the steps should be of equal depth and length. Overlap between two layer of foundation concrete should be atleast equal to the depth of foundation concrete. A minimum depth of 1m for soil and 60cm for rock should be provided between sloping surface and the lower edge of the footing.

**COFFER DAM AND CAISSON**

**Coffer dam**

Is defined as a temporary structure which is constructed so as to remove water and soil from an area and make it possible to carry out the construction work under reasonably dry condition.

Following are the uses of coffer dam

1 To facilitate the pile driving operation

2 To place grillage and raft foundation.

3 To construct foundation for pier and abutment of bridge, dams etc.

4 To provide working platform for the foundation of buildings when water is met with.

5 To provide space for carrying out the foundation work without disturbing or damaging the adjoining structure such as building, pipe line etc.

**Caisson**

It is defined as a structure which is sunk through ground or water to exclude the water and semifluid material during the process of excavation of foundation and which subsequently becomes an integral part of the sub-structure.

**Following are the use of the caisson**

1 To reach the hard bearing stratum for transferring the load coming on supports for bridge pier

2 To serve as an impervious core wall of earth dams. when place adjacent to it.

3 To provide on acces to a deep shaft or tunnel.

4 To provide an encloser below water level for installing machinery, pump etc.

The main difference between coffer dam and caisson is that the coffer dam is a temporary structure, while caisson forms the part of the permanent work.

**Method of settingout of foundation trench**

Setting out or ground tracing is the process of laying down the excavation lines and centre lines etc on the ground.

The process for setting out of foundation trenches as follows :-

1 From the site plan of the building one line which can be easily established on the ground is selected.

For example as per fig16 the point 'A' can be easily located on the ground and its co-ordinates are completely defined. With the help of point 'A' line 'AB' can be demarcated on the ground.

Thus line 'AB' will be the base line and from this base line the entired building can be traced out on the ground. It should be noted that the point 'A' and 'B' are on the centre line of the wall and hence it is essential to prepare the centre line plan of the building before starting this work.

2 Centre line wooden pegs are driven on the ground and they project about 25mm above the ground level. Nails are provided on the top of the pegs as shown in figure.

3 Two other pegs are driven at equal distance on either side of the centre line peg such that the distance between them becomes equal to the width of the foundation tranch as shown in figure 16.

4 With the help of these pegs the foundation plan can be completely traced on the ground. For this purpose strings are tied to respective pegs and lines are marked along these strings with the help of pick-axe or wing powder.

5 Along the centre line pegs brick pillars of size 20cm x 20cm are constructed about 2m away from centre. In some level upto plinth level height. The top surface of the piller is plastered and grooves showing centre lines are provided as shown in figure.

6 The masonry pillar should be preserved till the foundation work is completed.

7 The depth of excavation can be started.

8 The depth of excavation is check by fixing a strings along the grooves on the opposite pillars and holding boning rod. The length of the boning rod should be equal to the depth of foundation trenches.

# Simple- Machine foundation

**Objectives:** At the end of this lesson you shall be able to
- **state the functions of a foundation bolt**
- **name the type of foundation bolts**
- **explain the specific application of the bolts.**

Machines are generally subjected to the vibration of forces. Due to this cause the machines are like to shift or move or dislocate from their positions. To over come this defaults the machines are fixed to the ground with the help of specific devices which are called as foundation bolts.

These bolts do not have a specific shape of head similar to hexagonal or square bolts. The length of the shank is according to the thickness of nut and the thickness of machine base. The odd shaped part of the bolt hold the machine firmly to the ground and preventing the machine, shift or move or dislocation from its positions.

**Types (Fig 1 & 2)**

Fig 1

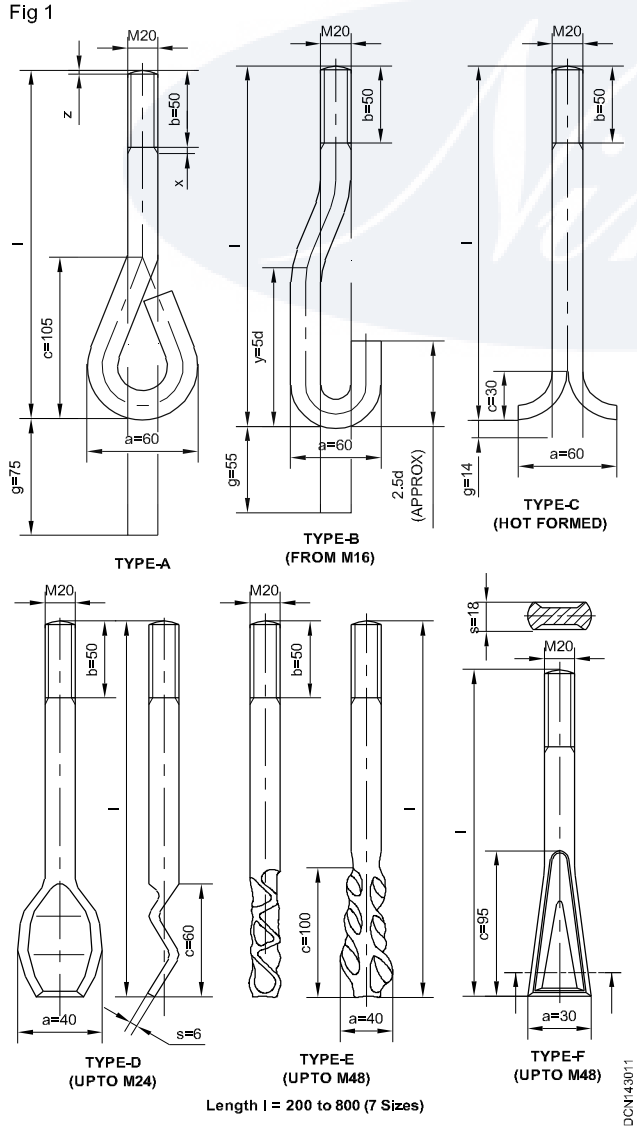
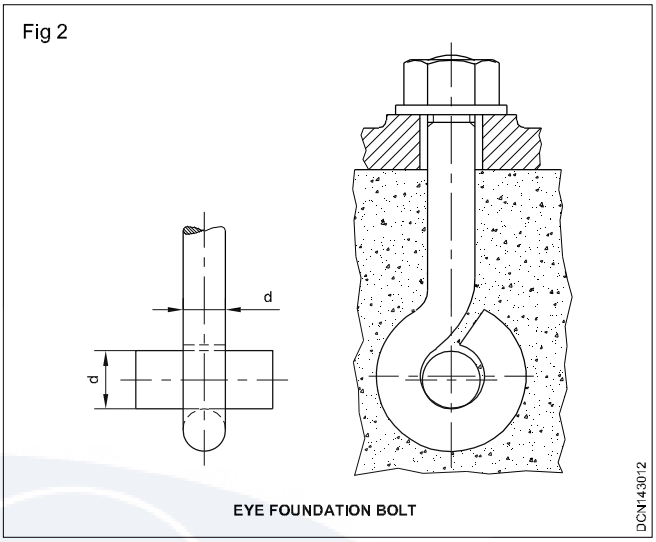



Fig 2




As per IS : 5624-1971 there core six types designated as type A, B, C, D, E & F figure 1 shows the same. These bolts are available in 13 dia sizes from M8 to M75, length 80mm to 320mm. These botls are designated by the shanks dia and length without nut . The ends tare formed by forging .

There are other non standard forms which are generally used are

- Eye foundation bolt
- Rag foundation bolt
- Lewis foundation bolt

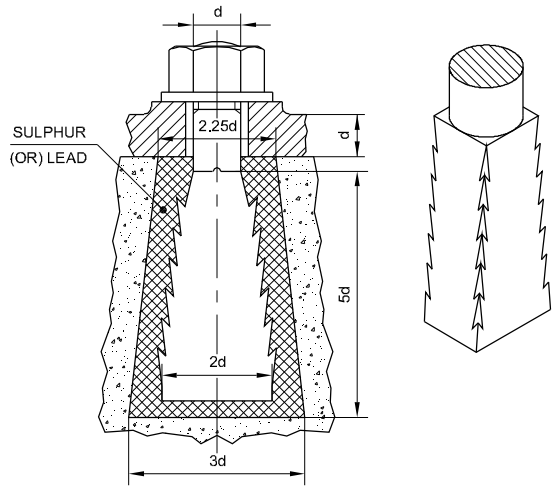
The position of the holes of machine base /feet marked on the ground. Pits are formed and foundation bolts are placed in position, with cross bars placed in bolt eyes. The position of eye bolt is checked and aligned. The thread and of the bolt protrude above the ground level. Cement eye foundation bolt (Fig 2) and rubble are mixed with water and pounced around the bolt. When it sets, the bolts are hold in aligned. After this, the machine is placed in position and nut are toughened on the bolts holding the machine firmly.

**Rag bolt (Fig 3)**

This is in the shape of a rectangular pyramid with round shanks are formed with rags or grooved, forming small projections. These are bolts are placed in the foundation cavity in position as done in previous case and then molten lead of sulphur is pound around with. When the molten lead or sulphur /lead solidified the bolts are held firmly. The machines are placed in position and nuts are fixed.

By melting the lead or during the sulphur the bolt can be removed.

Fig 3




RAG FOUNDATION BOLT

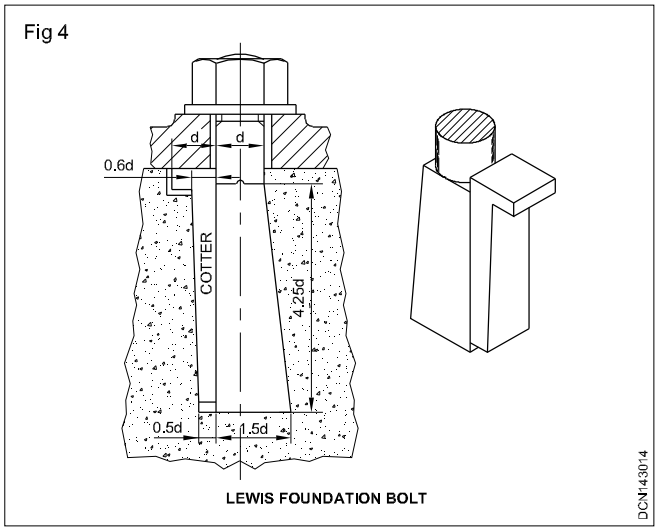
**Lewis foundation bolt (Fig 4)**

This is a rectangular shanks bolt with one side taper. AGIB headed key is placed on the other side of the taper and concrete is panned around it if is aligned. The foundation bolt can easily be with drawn by removing the gib headed key first and then the bolt.

**Cotter foundation bolt (Fig 5)**

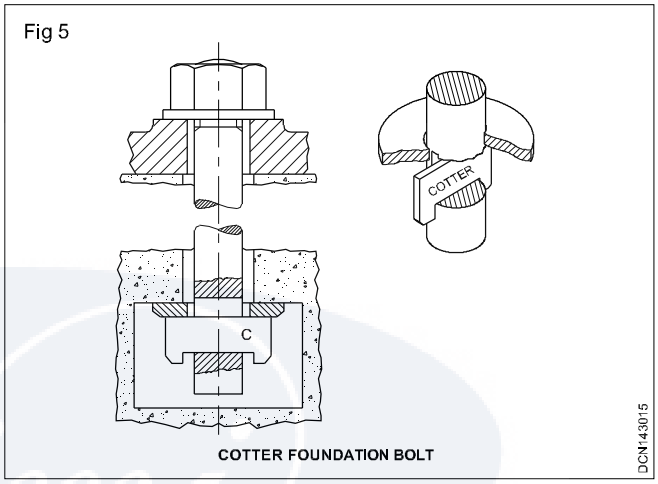
This type of bolt has a rectangular slot through which a double headed cotter is placed. A cast iron washer is rests above the cotter. Through the hand hole, connecting the cavity in the concrete and the bolt is pulled down and lifting the cotter. Now the cotter is placed in position.

Fig 4




LEWIS FOUNDATION BOLT

Fig 5




COTTER FOUNDATION BOLT