Soil Exploration

Disturbed soil

- A **disturbed sample** is one in which the structure of the **soil** has been changed sufficiently that tests of structural properties of the **soil** will not be representative of in-situ conditions, and only properties of the **soil** grains

Undisturbed soil

Undisturbed Soil Sample. The undisturbed soil sample is taken out for testing the properties in laboratory, without disturbing its structure, texture, density, natural water content and stress condition. It is said to be an undisturbed soil sample. This soil sample gives the original behavior of soil.

Selection of type of sample -

A sampling plan determines where and when to collect soil samples that are representative of the field to be fertilized. ... Either develop specific recommendations for each of the area types, or calculate a field average giving weight to different area samples in proportion to the amount of field area they represent.

Thin wall sampel- thin wall sampler is used for collecting undisturbed soil sample

Area ratio-

The area ratio should be preferably be less than 10 %, but it is possible that the greater area ratio can be tolerated when the sampler is provided with a stationary piston and / or the cutting edge having very small angle of taper . For good sampling process, the ratio should be within 0-2 %.

Piston sample - Like Shelby Sampler a Piston Sampler is used to sample cohesive soils. The difference being is a Piston Sampler can be used in an open borehole with Slouph.
The sampler is advanced to desired depth, then the tube is advanced with water pressure, into the undisturbed soil.

Recovery ratio- where L is the length of the sample within the tube and H is the depth of penetration of the sampling tube. For satisfactory undisturbed sampling, when excess soil is prevented from entering the tube, the recovery ratio should be between 96% and **98%**.

Resetting- Soil Resetting enriches the soil with organic matter and ultimately good soil life (bacteria and non-harmful fungi and nematodes). Soil Resetting also works as a soil improver where steaming and chemical disinfection often work unfavorably for the soil structure.

Sealing of sample- Soil sealing - the covering of the ground by an impermeable material – is one of the main causes of soil degradation in the EU. Soil sealing often affects fertile agricultural land, puts biodiversity at risk, increases the risk of flooding and water scarcity and contributes to global warming.

Bearing capacity of soil

Concept of bearing capacity- In geotechnical engineering, bearing capacity is the capacity of soil to support the loads applied to the ground. The bearing capacity of soil is the maximum average contact pressure between the foundation and the soil which should not produce shear failure in the soil.

Ultimate bearing capacity- Ultimate bearing capacity is the theoretical maximum pressure which can be supported without failure; allowable bearing capacity is the ultimate bearing capacity divided by a factor of safety.

Net safe braring capacity-Safe net bearing capacity ( ) : It is the net soil pressure which can be safety applied to the soil considering only shear failure. Allowable Bearing Pressure: It is the maximum soil pressure without any shear failure or settlement failure.

Allowable bearing pressure-Allowable Bearing Pressure: It is the maximum soil pressure without any shear failure or settlement failure. ... These values don't consider important factors affecting the bearing capacity such as the shape, width, depth of footing, location of water table, strength and compressibility of the soil.

Guide lines of BIS (is 6403) for estimation of bearing capacity-

Factors affecting bearing capacity- The bearing capacity of soil is influenced by many factors for instance soil strength, foundation width and depth, soil weight and surcharge, and spacing between foundations. These factors are related to the loads exerted on the soil and considerably affect the bearing capacity.

Vertical stress distribution of in soil due to foundation- Based on the assumption that the soil on which load is applied is reinforced by closely spaced horizontal layers which prevent horizontal displacement. The effect of the Westergaard assumption is to reduce the stresses substantially below those obtained by the Boussinesq equations.

Application compression SPT- By means of a drop hammer of 63.5kg mass falling through a height of 750mm at the rate of 30 blows per minute, the sampler is driven into the soil. This is as per IS -2131:1963. The number of blows of hammer required to drive a depth of 150mm is counted.

Unconfined compression test- Unconfined Compression Test (UCT) is a simple laboratory testing method to assess the mechanical properties of rocks and fine-grained soils. It provides a measures of the undrained strength and the stress-strain characteristics of the rock or soil.

Unconfined Compression Test Procedure:

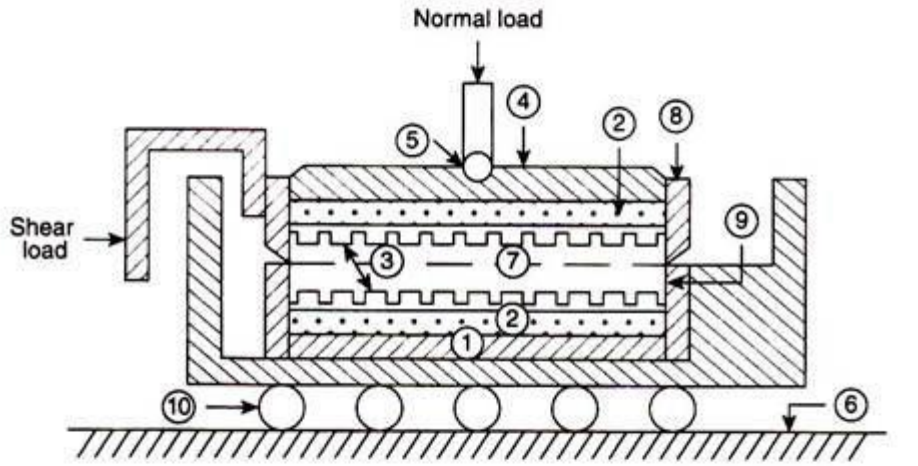
1. Extrude the soil sample from Shelby tube sampler. Cut a soil specimen so that the ratio (L/d) is approximately between 2 and 2.5.
   Where L and d are the length and diameter of soil specimen, respectively.
2. Measure the exact diameter of the top of the specimen at three locations 120° apart, and then make the same measurements on the bottom of the specimen. Average the measurements and record the average as the diameter on the data sheet.
3. Measure the exact length of the specimen at three locations 120° apart, and then average the measurements and record the average as the length on the data sheet.
4. Weigh the sample and record the mass on the data sheet.
5. Calculate the deformation (ΔL) corresponding to 15% strain (ε).
   Where L0 = Original specimen length (as measured in step 3).
6. Carefully place the specimen in the compression device and center it on the bottom plate. Adjust the device so that the upper plate just makes contact with the specimen and set the load and deformation dials to zero.
7. Apply the load so that the device produces an axial strain at a rate of 0.5% to 2.0% per minute, and then record the load and deformation dial readings on the data sheet at every 20 to 50 divisions on deformation the dial.
8. Keep applying the load until (1) the load (load dial) decreases on the specimen significantly, (2) the load holds constant for at least four deformation dial readings, or (3) the deformation is significantly past the 15% strain that was determined in step 5.
9. Draw a sketch to depict the sample failure.
10. Remove the sample from the compression device and obtain a sample for water content determination. Determine the water content.

Direct shear stress- To determine the shearing strength of the soil using the direct shear apparatus. In many engineering problems such as design of foundation, retaining walls, slab bridges, pipes, sheet piling, the value of the angle of internal friction and cohesion of the soil involved are required for the design. Direct shear test is used to predict these parameters quickly. The laboratory report cover the laboratory procedures for determining these values for cohesionless soils.

Procedure

1. The shear box is placed in a large container and is tightly held in position at the bottom in the container. The container is supported over rollers to facilitate lateral movement of lower-half of the shear box when shear force is applied to the lower shear box through a geared jack. The complete equipment of the direct shear test .

2. A normal load is applied through a loading yoke, placed over the pressure ball on the pressure pad. The required normal stress of 0.5 kgf/cm2 (or 50 kN/m2) is applied. The shear deformation dial gauge is placed in position. For drained tests, the soil specimen is allowed to consolidate under normal load.



(1) Base plate
(2) Porous disc
(3) Grid plate
(4) Pressure pad
(5) Pressure ball
(6) Platform
(7) Soil specimen
(8) Shear box (upper-half)
(9) Shear box (lower-half)
(10) Roller support

Figure 13.8 Shear box apparatus.

3. The locking pins are removed and the upper box is slightly raised using spacing screws and then the shear load is applied to the lower-half of the box through a geared jack such that the lower-half moves at a constant rate of strain. The proving ring dial gauge readings are taken at regular intervals of deformation dial gauge readings.

4. The test is continued till the shear load reaches a maximum value and then decreases.

5. The shear load is then released, and the proving ring and deformation dial gauges as well as the shear box are dismantled.

6. The test is repeated with three normal stresses of 100,200, and 400 kN/m2.

Determination of Shear Parameters:

Shear stress at failure, corresponding to each normal stress, is computed from –

$$\tau = \frac{\text{Shear load at failure}}{A_c} \qquad (13.7)$$

The area of the specimen resisting the shear force gradually decreases due to shear deformation. To calculate the shear stress at any deformation, the corrected area (Ac), computed from Eq.(13.8),is to be used.

Ac = l × lc = l × (l – δl)

where Ac is the corrected cross-sectional area in cm2 and δI the shear deformation in cm.

A graph is plotted between the normal stress on the x-axis and the shear stress on the y-axis, as shown in Fig. 13.10 that gives the Mohr-Coulomb failure envelope. The slope of the Mohr-Coulomb failure envelope is taken as the angle of shearing resistance (ϕ) and the y-intercept of the envelope is the cohesion (c). The shear stress-shear strain relation for dense sand and loose sand is shown in Fig. 13.11. The volume change during shear is shown in Fig. 13.12 as a function of shear strain.

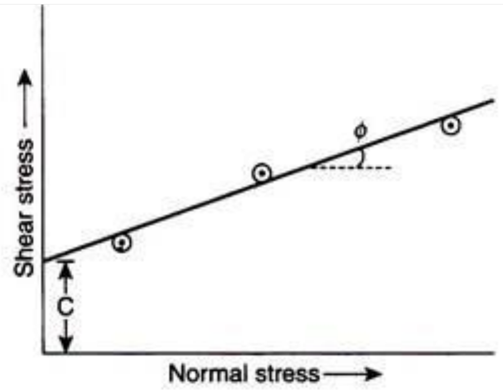


Figure 13.10 Determination of shear parameters from failure envelope.

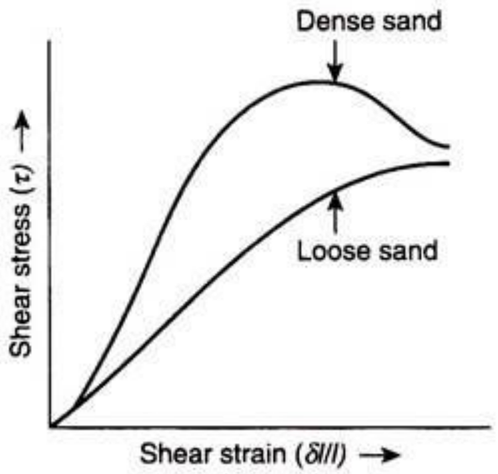


Figure 13.11 Stress–strain curve in direct shear test.

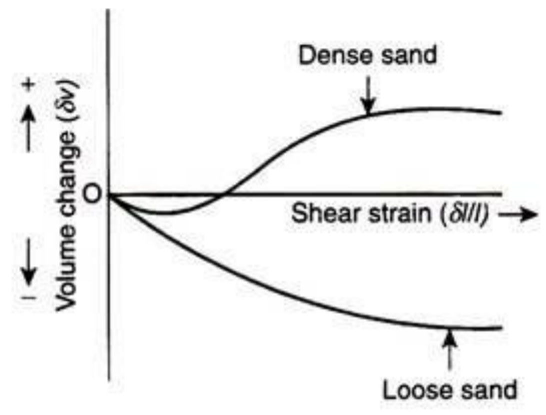


Figure 13.12 Volume change during shear in a direct shear test.

Plate load test and its limitation - Plate load test is done at site to determine the ultimate bearing capacity of soil and settlement of foundation under the loads for clayey and sandy soils. So, plate load test is helpful for the selection and design the foundation. To calculate safe bearing capacity suitable factor of safety is applied.

Limitation- (i) It has limited depth of influence. It could only give the bearing capacity of soils with depth up to two times the diameter of plate.

(ii) It may not provide information on the potential for long term consolidation of foundation soils.

(iii) There is scale effect as the size of test plate is smaller than actual foundation.

Improvement of bearing capacity by sand drain methode- With increase in percentage of water content in soil, the bearing capacity decreases. In case of sandy soil, the bearing capacity may reduce as much as 50% due to presence of water content. Cohesionless soils (i.e. sandy & gravelly soils) can be drained by laying the porous pipes to a gentle slope, over a bed of sand and filling the trenches above the pipes with loose boulders. These trenches subsequently should lead to the nearest well or any water body.

By compation- If we compact soil using appropriate method, then there will be increase in its density and shear strength. As a result the bearing capacity of soil also increases. There are many methods of compacting soils on site. Few of them are mentioned below.

- By spreading broken stones, gravel or sand and thereafter ramming well in the bed of trenches.
- Using an appropriate roller as per the soil type to move at a specified speed.

- Br driving concrete piles or wood piles and withdrawing piles and subsequently filling the holes with sand or concrete.

Foundation Engineering

Shallow Foundation

Shallow foundation are those foundations in which the depth at which the foundation is placed is less than the width of the foundation ($D < B$). Shallow foundations are generally termed as spread footing as they transmit the load of the super structure laterally into the ground.

Classification of Shallow Foundation:

On the basis of design, the shallow foundation are classified as:

- Wall Footing
- Isolated column or Column Footing
- Combined Footing
- Cantilever (Strap) Footing
- Mat (Raft) Foundation

Wall Footing

This type of foundation runs continuous along the direction of the wall and helps to transmit the load of the wall into the ground. Wall footing are suitable where loads to be transmitted are small and are economical in dense sands and gravels. In this type of foundation the width is 2-3 times the width of the wall at ground level. Wall footing may be constructed through stone, brick, plain or reinforced cement concrete.

Column Footing

Column footing are suitable and economical for the depth greater than 1.5m. In this type of foundation the base of the column is enlarged. Column footing is in the form of flat slab and may be constructed through plain or reinforced concrete.

Combined Footing

Combined footings are those foundations that are made common for two or more columns in a row. It is used when the footing for a column may extend beyond the property line. It is also suitable when the two columns are closely spaced and the soil on which the structure resist is of low bearing capacity. It may be rectangular or trapezoidal in shape.

Strap Footing

When an edge footing cannot be extended beyond the property line the edge footing is linked up with the other interior footing by means of a strap beam. Such footings are called as strap footing. It is also know as cantilever footing.

Mat Foundation

A mat foundation is a combined footing which covers the entire area beneath of a structure and supports all the walls and columns. It is also known as raft foundation. Mat foundation is applicable when:

- Allowable bearing pressure is low.
- The structure is heavy.
- The site is with highly compressible layer.

The mat foundation can be further classified into following types:

- Flat slab type.
- Flat Slab thickened under column.
- Two way beam and slab type.
- Flat slab with pedestals.
- Rigid frame mat.
- Piled mat.

Deep Foundation

Deep Foundation are those foundations in which the depth of the foundation is greater than its width (D>B). The D/B ratio is usually 4-5 for deep foundation. Unlike shallow foundation, the deep foundation transmits the load of the superstructure vertically to the rock strata lying deep. Deep foundations are used when the shallow foundation cannot support the load of the structure.

Classification of Deep Foundation

The mat foundation can be further classified into following types:

- Pile Foundation
- Pier Foundation
- Well (Caissons) Foundation

Pile Foundation

Pile is a slender member with small area of cross-section relative to its length. They can transfer load either by friction or by bearing. Pile foundation are used when:

- The load is to be transferred to stronger or less compressible stratum, preferably rock.
- The granular soils need to be compacted.
- The horizontal and the inclined forces need to be carried from the bridge abutments and the retaining walls.

Classification of Pile Foundation

The pile foundation can be further classified into following types on various basis such as function, material, method of installation which are listed below:

Based on Function:

- Bearing piles
- Friction piles
- Combined piles (Both bearing and friction)

Based on Material:

- Timber piles
- Concrete piles
- Steel piles

Based on Method of Installation:

- Large displacement piles
- Small displacement piles
- Non-displacement piles

Pier Foundation

Pier foundation are underground cylindrical structural member that support heavier load of the structure which shallow foundations cannot resist. Unlike pile foundation, pier foundation can only transfer load by bearing. Pier foundation are shallower in depth than the pile foundation. Pier foundation are used when:

- The top strata is a decomposed rock underlying as sound rock strata.
- The soil is a stiff clay that occurs large resistance for driving the bearing pile.

Well (Caissons) Foundation

The term caisson refers to box or a case. These are hollow inside and are usually constructed at the site and sunk in place into a hard bearing strata. As they are expensive in construction, they are usually restricted to major foundation works. Well foundation are suitable when the soil contains large boulders obstructing the penetration during installation of pier or pile foundations. Caissons are used for bridge piers, abutments in rivers and lakes and other shore protection works. They are used to resist heavy vertical and horizontal loads and are used in the construction of large water front structures as pump houses.

Classification of Well Foundation

- Open Caissons
- Pneumatic Caissons

- Box Caissons

Factors affecting the selection of Foundation:

On the basis of ground/soil condition

- Shallow foundations are preferred where soil close to the surface is capable of supporting structure loads.
- Where the ground close to the surface is not capable of supporting structural loads, hard strata is searched for and deep foundation is required.
- Uniform stable ground requires relatively shallow foundation whereas filled up ground has low bearing capacity thus requires deep foundation.

On the basis of Loads from Building:

- In the case of low-rise building in a larger area, the extent of loading is relatively low, so shallow foundation can resist the load from the structures.
- In the case of the high-rise building built within less area have high loads. Therefore, the deep foundation is required as shallow foundation may not be able to resist such loads of greater intensity.