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Investigation of Soil Sample Using Triaxial Test and Detailed CBR Test

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Abstract
California Bearing Ratio (CBR) value of subgrade is utilized in accordance with IRC recommendation.in order to create flexible pavements. A crucial soil parameter for the design of flexible pavements and runways at airports is the California Bearing Ratio (CBR) value. It might also utilize to calculate the soil's subgrade reaction via correlation. It is among the most significant engineering characteristics of soil for designing road subgrade. CBR value is depend upon optimal dry density (MDD), maximum moisture content (MC), and other variables liquid limit (LL), plastic limit (PL), plasticity index (PI), moisture content (OMC), and type of soil, soil permeability, etc. Additionally, the soil's condition—whether it's damp or not—affects the value. The method of determining CBR is quite drawn-out and time-consuming. This study aims to link the soaked or unsoaked CBR value with the MDD, OMC, LL, PL, PI along with triaxial of various soil samples collected from Qila Road in Aligarh, Uttar Pradesh, India.

Keywords: - CBR, soil investigations, soaked, unsoaked, triaxial analysis

1. Introduction

California bearing ratio (CBR) is a numerical measurement that is frequently used throughout the world in the construction of flexible pavement. In 1928–1929, the California Highway Department created this technique. Because of the imperialism of the process, certain sophisticated nations have recently prohibited the use of CBR test results for road design, which were first used in the USA during the Second World War and afterwards established as a standard method of design in other areas of the world. It is common practice to evaluate granular materials in the base, subbase, and subgrade layers of roads and pavements using the California bearing ratio (CBR) test. The Army Corps of Engineers adopted the CBR test for the design of flexible pavements after it was initially created by the California State Highway Department. It is now so widely used that numerous worldwide norms have adopted it.

The important nature of the CBR test was revealed by the following two information: the CBR value has been connected with several basic soil properties, such as plasticity indices, grainsize dissemination, bearing capacity, modulus of subgrade reaction, modulus of resilience, shear strength, density, and holding moisture; and the majority of pavement design charts basically describe unbound materials as a function of their CBR values when they are compacted in the various layers of pavement. The CBR test is still widely used since these correlations are still available to working engineers who have accumulated years of knowledge with them. The majority of the pavement on the Indian highway system is flexible.; Flexible pavement can be constructed by employing a variety of techniques. A way of designing flexible pavements using empirical information constitutes the California Bearing Ratio (CBR) test. It is a load test that is placed to a substrate surface and utilized in soil studies to help with pavement design. The strength of specimens created at the optimal moisture content (OMC), which coincides to the Proctor Compaction, and soaked in water for four days prior to analysis should serve as the foundation for the design of new building The soil should be molded at its ideal moisture content and soaked for four days prior tests in the event that the existing road needs to be strengthened. According to reports, four days of soaking can be extremely harsh while some circumstances result in the discarding of the item.

Triaxial shear strength testing on soil determines the soil's physical characteristics. In this test, a specimen of soil is stressed in a way that the stress that results in one direction will differ from the stress that results in the perpendicular direction. This test provides information about the soil's physical characteristics, including its shear resistance, cohesiveness, and the dilatation stress. The test is the most popular and serves the purpose for all kinds of soils.

As per the IRC, remolded soil should be subjected to a scientific CBR test. Testing in-situ is not advised for design purposes. Beginning with an assessment of subgrade strength and traffic volume to be handled, the design of the pavement layers that will be placed over subgrade soil is completed. Dependent on the subgrade strength, which is most frequently represented as a result of the California Bearing Ratio (CBR), the Indian Road Congress (IRC) incorporates the precise design methods of the pavement layers.

CBR value is always regarded as being one of the crucial metrics for pavement design. When the CBR value of the soil is known, the schematic charts suggested by IRC are used to calculate the necessary thickness of building needed above the soil for various traffic scenarios. On a soil sample collected from the work site, the value for CBR can be evaluated directly in a laboratory test in compliance with IS:2720 (Part-XVI). The CBR value for every sample of soil under wet conditions is measured in the laboratory over the course of at least 4 days. Additionally, a significant amount of soil sample must be used for the analysis, and both expertise and experience are required; otherwise, the results could be unreliable and deceptive.

2. Material Collection

Soil sample is taken from Qila road Aligarh where plenty of amount of soil sample is available.

3. Experimental Work

For investigation of soil sample following test are performed such as grain size analysis, proctor compaction, liquid limit, plastic limit, plasticity index etc.

Grain Size Analysis (IS: 2720 - Part 4)

The relative percentages of various particle sizes in the sample are calculated using a technique known as grain size analysis, which is frequently employed in the categorization of soils. A collection of sieves with various mesh sizes are used to conduct the test. In order to pass a soil sample through the stacked sieve tower, a series of sieves with progressively decreasing mesh sizes are placed on top of one another. Each sieve has squares apertures of a specific size. The mechanical properties of coarse-grained soil are controlled by these sizes. Wet method is used for finer fractions (retained on 75-micron sieve) while pipette method is used for fractions crossing 75-micron sieve. Dry method of sieving is employed for coarser fractions (retained on 4.75 mm sieve). The diagram of sieve tower shown in fig 1.

Figure 1: - Sieve Shaking Apparatus for Particle size analysis.

Procedure

1. The sample must be dried by air before being weighed and sieved. This can be accomplished by either heating to a temperature of 100° to 110°C or drying at room temperature.
2. The soil must be ground up until it is completely lump-free.
3. commencing with the largest sieve, the air-dry sample must be weighed and sieved consecutively.
4. Prior to usage, care must be taken to make sure the sieve is clean.
5. Separately, and for a total of no more than a small amount, each sieve must be shaken over a clean tray for at least two minutes.
6. The shaking must be done in a variety of directions, from left to right and backwards.
7. Material must not be hand-pressed through the sieve.
8. If lumps of fine material are present, they can be shattered with finger pressure.
9. After sieving is complete, the material that was kept on each sieve as well as any material that has been extracted from the mesh must be weighed.

Observation and Calculations: -

Method: Dry Sieving

Weight of Soil Sample Taken: 500 gm

Figure 2: - Casagrande Apparatus

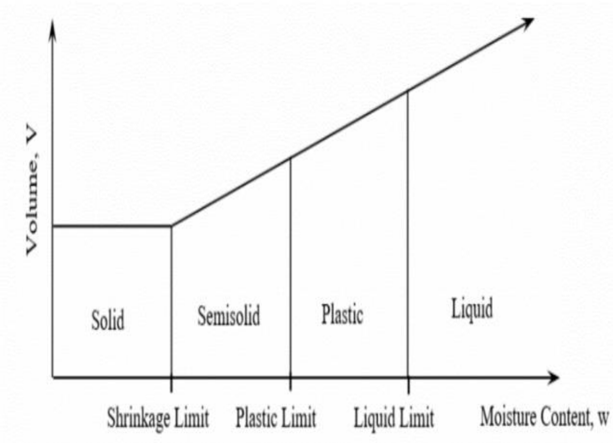


Figure 3: -Atterberg Limits

I.S Sieve Designation	Wt of sample retained in (g)	Percentage of wt. Retained (%)	Cumulative percent of wt. retained, d (%)	Percentage Finer (100-d)
600 μ	44.5	8.9	8.9	91.1
425 μ	22.0	4.4	13.3	86.7
300 μ	7.0	1.4	14.7	85.3
212 μ	18.0	3.6	18.3	81.7
150 μ	17.5	3.5	21.8	78.2
75 μ	245.5	49.1	70.9	29.1
PAN	138.5	27.7	98.6	1.4

Table 1-Sieve Analysis of Soil

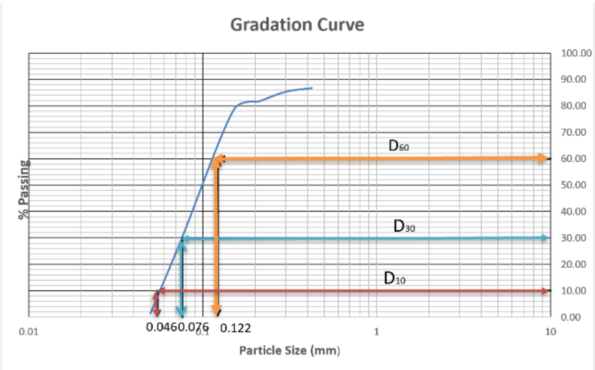


Figure 4: - Particle's size distribution curve

Results

D_{60} (mm)	0.122
D_{30} (mm)	0.076
D_{10} (mm)	0.046

$C_u = D_{60}/D_{10}$	2.667
$C_c = \frac{D30^2}{D10 \times D60}$	1.042

Liquid Limit, Plastic Limit and Plasticity Index (IS 2720- Part 5)

Purpose

The Liquid and Plastic Limits of Soil (Atterberg Limits) show the water contents at which specific alterations in Soil's physical characteristics can be seen. The engineering qualities of fine-grained soils can be inferred from Atterberg limits. A material's plasticity is what allows for deformation without obvious elastic recovery, without breaking or crumbling. One key property of soils with a significant percentage of clay granules is plasticity.

Liquid Limit (LL)

Liquid limit is evaluate using following laboratory methods.

a. Casagrande Method

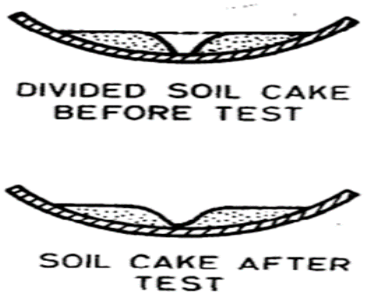
we use a device known as the Casagrande apparatus to determine the liquid limit. When sitting on the rubber bottom, the brass cup is linked such that it is in an angled position. When rotated by its handle, a brass cup rises to a height of 1 cm before falling freely onto a rubber base. Apparatus shown in fig. 3.

b. Cone penetration Method

Procedure for Casagrande Method: -

- To start, we collect a soil sample and let it air dry. Then, in order to obtain only fine-grained dirt, we put it through a 425 micron IS sieve. Since we are aware that Atterberg limitations only have an impact on fine-grained soils. The mesh holes of the 425 micron IS sieve are 425 microns, or 0.425 mm. All of the particles we obtain after sifting are smaller than 0.425 mm. Fine sand, silt, and clay are some of these constituents.
- Next, we combine around 120 grams of this sieved soil with distilled water in a dish to create a consistent soil mixture.
- A piece of this dirt mixture is placed in the Casagrande apparatus cup and smoothed and leveled.
- Using a typical grooving tool, a sharp groove is cut symmetrically through the sample.
- After cutting the soil pat, turn the handle of the equipment at a pace of 2 revolutions per second to apply blows to the grooved soil pat. As a result, the two parts of the dirt pat come into contact. When we reach a contact length of 12 mm, we stop turning the handles.
- We must ensure that the groove closes due to soil flow rather than slippage. If slippage occurs, we should discard the soil pat and restart the procedure.
- The number of blows necessary to seal the groove for a 12 mm length is recorded.

Figure 5: - section of soil in Casagrande instrument before and after test.



Flow Curve

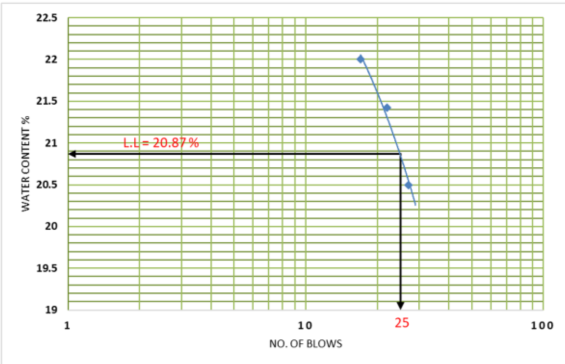
The water content on an arithmetical scale and the total amount of drops on a logarithmic scale are represented by "a flow curve" that is depicted on a semilogarithmic graph. The flow curve is a straight line that passes as nearly through all four or more plotted points as is humanly possible. Rounding up to the nearest whole amount and reporting the moisture content equal to 25 drops as measured from the curve will represent the soil's liquid limit.

Determination of Liquid Limit (LL)

Table 2: -Liquid Limit determination

S.no.	Determination	1	2	3
1	Wt of Container + wet soil (gm)	18.0	21.5	22.5
2	Wt of Container + dry soil (gm)	17.01	20.25	21.79
3	Loss of moisture (gm)	0.99	1.25	0.71
4	Wt of container	12.513	14.465	18.351
5	Wt of dry soil	4.497	5.785	3.439
6	Moisture content %	22.014	21.607	20.645
7	No. of Blows	17	22	27

Figure 6: - Liquid limit curve using test results



Results:

Moisture content at 25 blows from the graph is 20.87 (using figure 6)

Liquid limit = 20.87%

Plastic Limit (PL)

A small amount weighing of soil about 60 g shall be taken from the thoroughly mixed fraction of the material passing 425-micron IS Sieve as per with IS: 2720 (Part 1)-1983. When determining both the liquid limit and the plastic limit of a soil, a certain amount of soil suitable for both tests must be taken for preparation. A part of the soil sample in the plastic state should be collected for the plastic limit test at a stage in the process of mixing soil and water when the mass acquires plastic enough to be easily molded into a ball.

Preparation

- In an evaporating dish or on a flat glass plate, carefully mix the soil sample with distilled water until the soil mass becomes pliable enough to be conveniently molded with fingertips.
- A ball of about 8 g of this plastic soil mass should be created and squeezed between the fingers and the glass plate alongside just enough pressure to roll the mass into a thread of identical size throughout its length.

- The rolling rate should be between 80 and 90 strokes per minute, with a stroke defined as one complete motion of the hand moving forward and back to the place where it began.
- Continue rolling until the threads are 3 mm in diameter. The earth will next be kneaded into a homogenous mass and rolled once again.
- Continue the alternate rolling and kneading operation until the thread crumbles under the rolling pressure and the dirt can hardly be rolled into a thread.
- Crumbling may occur when the thread diameter exceeds 3 mm. This is deemed a suitable end point if the soil was rolled into a 3 mm diameter thread shortly before.
- No attempt shall be made at any time to cause failure at precisely 3 mm diameter by permitting the thread to reach 3 mm, subsequently reducing the rate of picking or pressure or both, and continuing rolling without further distortion until the thread falls apart.
- The broken soil thread fragments must be collected in a sealed box and the moisture content evaluated in accordance with IS: 2720 (Part 2)-1973.

S. No	Determination No.	1	2	3
1	Weight of container + wet soil (gm)	18.0	19.5	23.5
2	Weight of container + dry soil (gm)	17.453	18.830	22.70
3	Loss of Moisture (gm)	0.55	0.67	0.80
4	Wt. of container (gm)	14.422	14.826	17.295
5	Wt. of dry soil (gm)	3.031	4.004	5.405
6	Moisture content %	18.14	16.73	14.80

Table 3: -Plastic limit

Results: -

Plastic Limit (PL) = (18.14+16.73+14.80)/3

Plastic Limit (PL) =16.55%

plasticity Index (Pl) = LL - PL = 4.32%

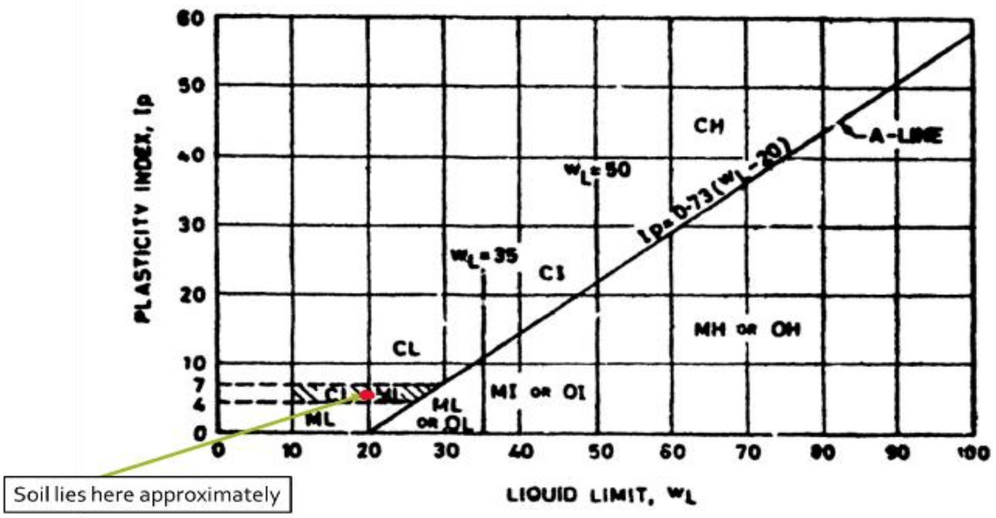


Figure 7: -Plasticity chart

Identification of Soil

- Since, 29.10 % soil is finer than 75µ. Therefore, soil is not fine-grained soil.
- Since, less than 50% soil passes through 75µ, therefore, soil is Coarse grained soil.
- As greater percentage of coarse fraction pass 4.75 mm sieve so it is Sand.
- As more than 12% of soil pass 75µ sieve so liquid limit and plastic limit tests were conducted.
- Limits plot in hatched zone on Plasticity chart. So, Soil is Identified as SM-SC

Proctor Compaction Test (IS: 2720 - Part 7)

Compaction is a manner of densifying soil mass by the reduction of air voids. The goal of a laboratory compaction test is to determine the right amount of water at which the weight of the soil grains in a unit volume of compacted soil is maximum; this amount of water is referred to as the Optimum Moisture Content (OMC). Different amounts of water and subsequent dry densities obtained after compaction are plotted in the laboratory on an arithmetic scale, the former as abscissa and the latter as ordinate. The obtained points are connected to form a curve. The curve is used to determine the maximum dry density and the corresponding OMC.

Figure 8: - Proctor compaction test apparatus

Apparatus: -

- A 944 cc Proctor mould with an interior diameter of 10.2 cm and a height of 11.6 cm. A removable collar assembly and a detachable base plate are required for the mould.
- Rammer: A 2.5 kilogram mechanically powered metal rammer with a 5.08 cm diameter face. The rammer must be outfitted with an appropriate system to control the drop height to a free fall of 30 cm.
- Mixing utensils such as a mixing pan, spoon, towel, and spatula.
- A 15 kg weight balance, Highly sensitive balance, Moisture tins, cylinder with graduation, and straight edge.

Procedure: -

- A 5.5 kg sample of air-dried soil must be taken and pass the 425 micron IS test sieve. The sample must be properly mixed with a reasonable amount of water with Optimal Moisture Content (OMC).
- Weigh the mould with the baseplate connected to the latest 1 gram. The mold must be set on a firm foundation. The moist soil should be compacted into the mould, with the extension attached, in three layers or nearly equal mass, with each layer receiving 25 blows from the 2.6 kg rammer delivered from a height of 310 mm above the soil. The blows must be dispersed evenly throughout the surface of each

layer. The operator must keep the rammer's tube clean of soil in order to ensure the rammer can always fall freely. The dirt used must be sufficient to fill the mold.

- Remove the compacted soil samples from the mould and set it on the mixing tray. The water content of an adequate test sample shall be calculated in accordance with IS: 2720 (Part -11)- 1975.
- The remaining soil specimen shall be broken up, rubbed through the 20-mm IS test sieve, and combined with the remaining original sample. A suitable increment of water should be added and mixed with the sample in stages, and the aforementioned technique from 5.1.2 to 5.1.4 ought to be performed for each increment of water added. The total number of determinations conducted must be at least five, and the range of moisture content must be such that the optimal moisture content, at which the maximum dry density occurs at this range.

Table 4: -Proctor Compaction Test Result

S.No.	Determination No.	1	2	3	4	5
1	Wt. of Mould+ Compacted soil (gm)	6712	6739	6758	6684	6681
2	Wt. Compacted soil (gm)	1993	2020	2039	1965	1962
3	Wet density γ_b(g/cc)	1.993	2.020	2.039	1.965	1.962
4	Wt. of Crucible + wet soil (gm)	36.80	39.5	43.5	45.5	58
5	Wt. of Crucible + Dry soil (gm)	34.77	36.97	40.23	41.94	52.87
6	Weight of water (gm)	2.03	2.53	3.27	3.56	5.13
7	Weight of Crucible (gm)	17.57	18.18	18.49	20.44	23.66
8	Weight of dry soil (gm)	17.20	18.79	21.74	21.5	29.21
9	Water content (%)	11.80	13.46	15.04	16.55	17.5
10	Dry Density (gm/cc)	1.69	1.78	1.77	1.68	1.67

Results: - (using figure 9)

Optimum moisture content = 14.1 %

Maximum dry density = 1.786 gm/cc

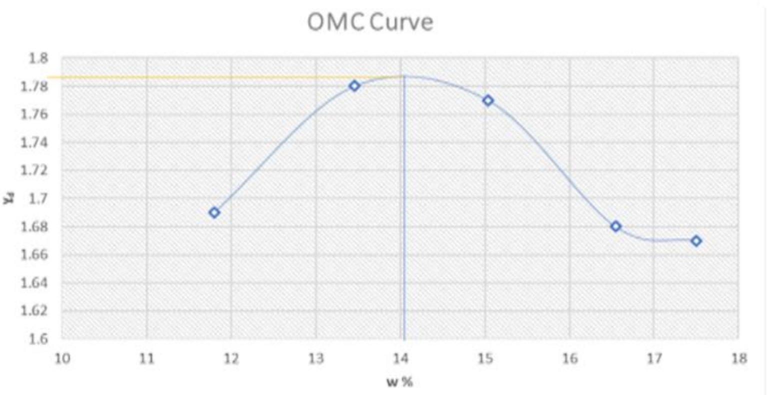
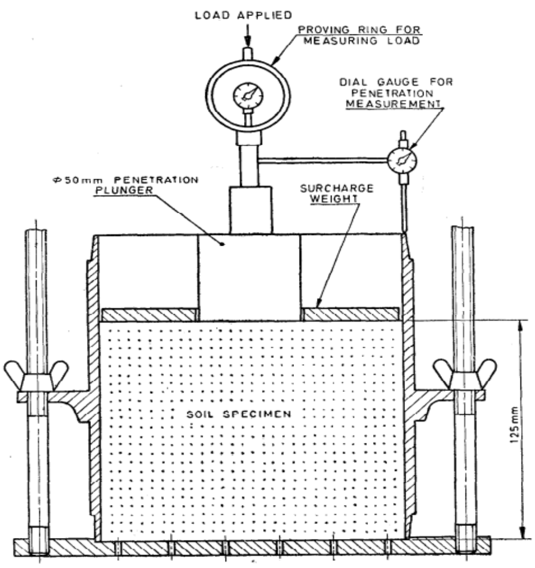


Figure 9: - OMC Curve

California Bearing Ratio Test (IS: 2720 - Part 16)

The California bearing ratio test is a penetration test used to assess the strength of roads and pavements' subgrade. The California bearing ratio is the ratio of force per unit area required to penetrate a soil mass at a rate of 1.25mm/min using a circular plunger 50mm in diameter. The results of these tests are combined with empirical curves to establish the thickness of the pavement and its constituent layers. This is the most common way for designing flexible pavement.

Figure 10: -CBR Test Apparatus



Procedure: -

Preparation of test specimen

The test can be done using

a) undisturbed specimens

b) remoulded specimens on contrast of static and dynamic compaction

a) Undisturbed Specimens: -

Undisturbed specimens shall be acquired by equipping the mold with a steel cutting edge of 150 mm internal diameter and gently driving the mold into the earth's surface. Digging away soil from the outside as the mould is pushed in may help this process. When the mould is adequately full of dirt, it is removed by under digging, and the top and bottom surfaces are trimmed flat to provide the needed length of specimen for testing. If the mould cannot be pressed in, the sample can be gathered by digging a circle larger than the perimeter of the mould and bringing out a whole undisturbed piece of soilIf the specimen is loosened in the mould, the annular depression must be filled with paraffin wax to ensure that the soil is properly supported by the mould sides through the penetration test.

According to the method described in IS: 2720 (Part 28) - 1974 or IS: 2720 (Part 29) - 1975, the density of the soil can be ascertained by weighing the soil with a mold when the mould is full of soil, by precisely measuring the dimensions of the soil sample and calculating the weight, or by determining the density in the field close to the location at which the sample is collected. Water content must always be calculated in line with IS: 2720 (Part 2).

b) Remoulded/Disturbed Specimens: -

The field density or the maximum dry density predicted by the compaction tests will serve as the dry density for a remolding. or any other density where the appropriate bearing ratio is present, see IS: 2720 (Part 7)-1980 and IS: 2720 (Part 8)-1983. The ideal water content, or the field moisture, as the situation may be, should be employed for compaction.

Soil Sample: -

The remolded specimen's substance must pass a 425 micron IS Sieve. Allowance for bigger material shall be made by replacing it with an equal amount of 425-micron material.

Statically Compacted Specimens: -

Calculate the mass of the wet soil when it fills the standard trial volume in the mold and has the requisite moisture content to provide the correct density. Water must be properly incorporated into a batch of soil to achieve the desired water content. With a filter paper placed between the disc and the soil, the proper mass of the moist soils should be added to the mold, and compaction achieved by pressing in the displacer disc.

Dynamically Compacted Specimen: -

For dynamic compaction, an adequate amount of the soil must be obtained and well mixed with water, weighing approximately 4.5 kg or more for fine-grained soils and 5.5 kg or more for granular soils. The exact mass of soil needed must be taken, and the necessary amount of water added so that the water content of the soil sample is equal to the determined optimum water content, if the soil is to be compacted to the maximum dry density at the optimal water content determined pursuant to with IS: 2720 (Part 71) - 1980 or IS: 2720 (Part 8) - 1983.

- The base plate must be secured to the mold when it has an extension collar attached. A disc of coarse filter paper should be placed on top of the spacer disc before inserting it over the base plate. The soil-water combination must be compacted into the mold using the procedures outlined in IS 2720 (Part 7) - 1980 or IS:2720 (Part 8) - 1983 for the 150 mm diameter mold. Other densities and water contents can be employed and mentioned in the report if desired.

- After removing the extension collar, the compacted dirt must be carefully trimmed with a straightedge so that it is level with the top of the mold. The perforated base plate and spacer disc must be removed, and the mass of the mould and the compacted soil specimen must be recorded. Any hole that may then form on the surface of the compacted soil due to the removal of coarse material must be patched with smaller size material. The perforated base plate should have a disc of coarse filter paper on it. The mold and compacted soil should then be turned upside down, and the perforated base plate should be fastened to the mold with the compacted soil in contact with the filter paper that is provided.

Penetration Test: -

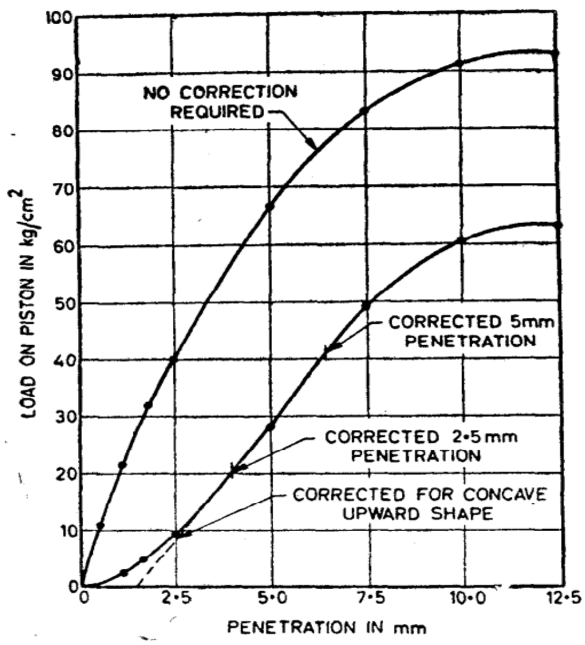


Figure 11: - load- penetration Curve

- The mold containing the specimen must be set on the lower plate of the testing apparatus with the top face exposed and the base plate in place.
- Surcharge weights must be applied to the specimen in order to provide a loading intensity equivalent to the weight of the base material and pavement. If the specimen has already been soaked, the surcharge must match the amount that was consumed during the soaking time.
- Before seating the penetration plunger and adding the remaining surcharge weights, a 2.5 kg annular weight must be placed on the soil's surface to prevent soil upheaval into the hole of the weights.
- The plunger must be seated with a weight of 4 kg so that the specimen's surface and the plunger make complete contact.
- Next, the gauges for pressure and deformation must be reset to zero, meaning that the initial force applied to the plunger must be taken into account when calculating the load penetration relation. The plunger must be loaded into the soil at a pace of 1.25 mm per minute.
- The maximum load and penetration must be recorded if it occurs for a penetration of less than 12.5 mm. Readings of the load must be collected at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 4.0, 5.0, 7.5, 10.0, and 12.5 mm.
- The mold must be removed from the loading apparatus and the plunger raised. The top 30 mm of the specimen must be removed, and 20 to 50 g of soil should be taken. The water content should then be

calculated in accordance with IS: 2720 (Part 2)-1973. A water content sample must be acquired from the complete depth of the specimen if the average water content of the entire specimen is sought.

- After the test is finished, the undisturbed specimen should be thoroughly inspected for any oversized soil particles that may have been present beneath the penetration plunger and could have impacted the results.

Load Penetration Curve: -

Plotting the load penetration curve is required (see Fig. 11). Although the beginning part of the curve may be convex downwards due to surface imperfections, this curve is typically convex upwards. After that, a correction must be made by drawing a tangent to the point of maximum slope, transposing the load's axis, and determining zero penetration as the point at which the tangent intersects the axis of penetration. The tangent from the new origin to the point of tangibility on the re-sited curve and then the actual curve would make up the corrected load-penetration curve.

California Bearing Ratio: -

Typically, penetrations of 2.5 mm and 5 mm are used to calculate the CBR values. The adjusted load value must be derived from the load penetration curve according to the penetration value at which the CBR values are wanted, and the CBR must be calculated as follows:

$$CBR = \frac{Pt}{Ps} \times 100$$

Where,

Pt is the corrected unit (or total) test load picked from the load penetration curve to correlate with the predetermined penetration, and

Ps is Unit (or Total) Standard Load at the equivalent Penetration Depth as for taken from the table

Note: 3 Specimens are taken from each sample for testing.

Calculation: -

(Case I – Unsoaked)

Sample= SM-SC

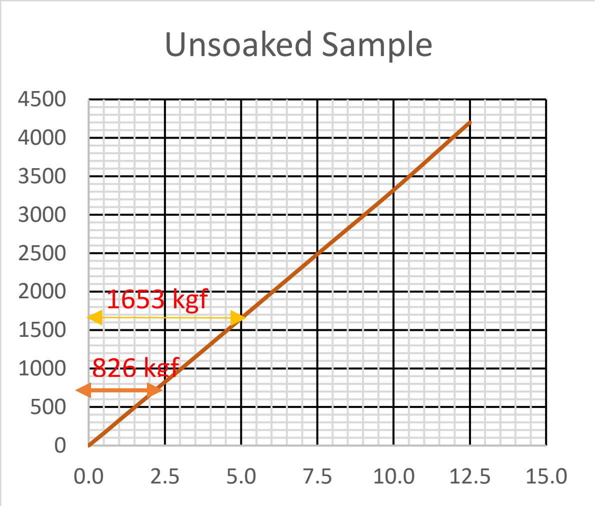
Source of material = Quarry

Value of one Division of proving ring = 2.5 Kg

Table 5: -Load vs Penetration

S. No.	Penetration of Plunger (mm)	Specimen 1	Specimen 2	Specimen3	Load (kgf)
1	0.0	0	0	0	0
2	0.5	171	165	147	161
3	1.0	313	326	345	328
4	1.5	482	496	501	493
5	2.0	643	651	677	657
6	2.5	810	819	849	826
7	3.0	973	991	997	987
8	4.0	1286	1309	1359	1318
9	5.0	1622	1680	1657	1653
10	7.5	2440	2455	2569	2488
11	10.0	3309	3350	3304	3321
12	12.5	4248	4185	4167	4200

Figure 12: - Load vs Penetration graph



Results: -

Average CBR value at 2.5 mm Penetration = 60.292 %

Average CBR value at 5.00 mm Penetration = 80.438 %

Calculation: -

(Case II – Soaked Sample)

Sample = SM-SC

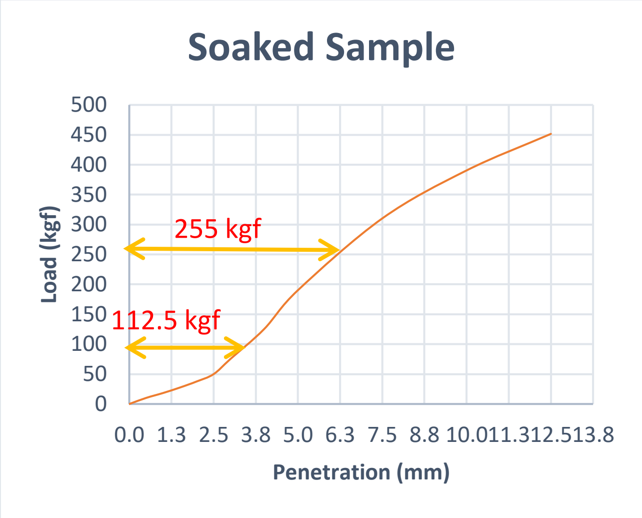
Source of material= Quarry

Value of one Division of proving Ring = 2.5 Kg

Table 6: - Load vs Penetration after 72 hrs. soaking

S. No	Penetration (mm)	Specimen 1	Specimen 2	Specimen 3	Load (kgf)
1.	0.0	0	0	0	0
2.	0.5	10.578	10.223	9.778	10.1937
3.	1.0	18.57	17.85	18.624	18.3486
4.	1.5	27.965	26.554	28.068	27.5229
5.	2.0	37.745	38.24	37.163	37.7166
6.	2.5	50.51	51.185	48.152	49.949
7.	3.0	74.547	75.24	76.236	75.341
8.	4.0	123.2	124.215	128.665	125.36
9.	5.0	190.54	185.214	195.026	190.26
10.	7.5	311.415	315.25	303.965	310.21
11.	10.0	385.365	388.45	397.535	390.45
12.	12.5	446.95	444.885	462.905	451.58

Figure 13: -Load vs Penetration graph



Results: -
Average CBR value at 2.5 mm Penetration = 8.394%
Average CBR value at 5.00 mm Penetration= 12.409%

Triaxial Shear Test

The triaxial test is used in the testing facility to evaluate the shear strength of the soil, or shears strength characteristics, which include cohesiveness and the angle of shearing resistance. In this test, the soil sample, which has a typically circular cross section, is put under compressive stress across three directions, with the added benefit of inducing shear stress.

Method: -

This test is conducted on a soil sample in a cylindrical shape that is exposed to a specific lateral pressure (also known as chamber pressure). This pressure is delivered to the sample in all directions. The symbol for this chamber pressure is 3. According to the instructions provided by Casagrande and Karl Terzaghi in 1936–1937, the sample is put into the test device. Axial pressure is added on top of the chamber pressure until the sample fails. The term "Deviator Stress" refers to this enhanced axial pressure. By loading the sample, further axial pressure is applied. With the use of a manually driven load frame to show the sample is loaded through a proving ring at a steady rate until it fails or the desired range of stress levels is reached. The proving ring dial keeps track of the deviator stress. During experiments, a different dial gauges the sample's vertical deformation. Thus, by adjusting the confining pressure and related stress at failure, several Mohr's circles can be plotted. These circles' tangential lines provide the soil's failure envelope, from which c and can be calculated. For the test on dry sand, calculating the corrected area using the equation:

$$AC = \frac{Ao}{1 - f}$$

Where,
Ac= corrected area
Ao= initial area

$$\text{Strain} = \frac{\Delta L}{Lo}$$

Where,
Lo = original length
Observation table:

S. No.	Depth (m)	σ_3 (KN/m^2)	σ_d (KN/m^2)	$\sigma_1 = \sigma_3 + \sigma_3$ (KN/m^2)	C (KN/m^2)	$N_\emptyset$	$\emptyset$
1.	1.5	100	160	260	34.51	1.7	15.03°
		150	200	350			
		200	230	430			
2.	1.5	100	144	244	42.8	1.42	10°
		150	165	315			
		200	186	386			
3.	1.5	100	148	248	15.04	2.04	20°
		150	200	350			
		200	252	452			
4.	1.5	100	130	230	14.50	1.9	18.08°
		150	174	324			
		200	220	420			
5.	1.5	100	138	238	15	1.96	18.92°
		150	186	336			
		200	234	434			

Table 6: - Triaxial Results

Formula used:

$$\sigma_1 = \sigma_3 N_\emptyset + 2C\sqrt{N_\emptyset}$$

Figure14: -Triaxial test Apparatus

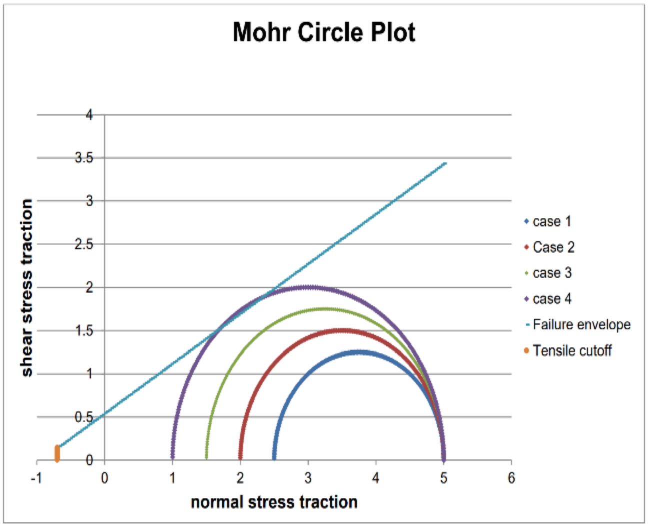


Figure 15: - Mohr Circle Plot for Triaxial Test

4. Results and Conclusion

From laboratory testing we conclude that soil is found that there are 29.1% finer and liquid limit and plastic limit are found to be 20.87% and 16.55% respectively and its plasticity index was calculated as 4.32% so after plotting plasticity chart and grain size distribution the soil specimen was found to be SM-SC (silty sand -Clayey sand),

After the classification of soil, Proctor compaction test was performed in laboratory by using Light Proctor compaction test apparatus and its optimum moisture content (OMC) and maximum dry density (MDD) were found to be 14.5% and 1.786 g/cc respectively.

The result By triaxial test shows that average ∅ is found as 16.04^0 and average value of cohesion (C) is found as 24.37 KK/m^2.

Finally, the California Bearing ratio test was performed for both soaked and unsoaked condition corresponding the optimum moisture content (OMC) and CBR values were obtained for the Unsoaked sample found to be:

Average CBR value at 2.5 mm Penetration = 60.292 %

Average CBR value at 5.00 mm Penetration = 80.438 %

And for Soaked sample were:

Average CBR value at 2.5 mm Penetration = 8.394%

Average CBR value at 5.00 mm Penetration = 12.409%

So, we can find out the required thickness of the pavement by using Cumulative Standard axles as per IRC 37 design recommendations by using above values of CBR.

5. Declaration

Ethical Statements We hereby, as authors of “Investigation of Soil Sample Using Triaxial Test and Detailed CBR Test” consciously assure following fulfillments:

a. This material is the authors own work, which has not been previously published elsewhere.
b. The paper is not considered in any publication.
c. The paper is properly crediting the meaningful contributions of co-authors and co-researchers.

d. Proper indicating reference is added in this review for all the diagrams, theories and methods etc. at the that place and at reference section. e. All the authors have been personally and actively involved in work leading to paper, will take responsibility for its content. Funding No funding has been obtained for this work in any form. We hereby declare that all the declarations are correct under my knowledge and belief.

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