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COMPARISON OF CBR VALUES OF DIFFERENT TYPES OF SOILS WITH VARYING ATTERBERG LIMITS

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ABSTRACT- CBR value is the predominant design parameter for flexible design. Generally, sub-grade strength is stated as California Bearing Ratio (CBR). Thicker layers are basically included in lower subgrade, while the powerful subgrade easily works with thinner pavement layers. In the saturation level subgrade is always depends on changes because of the water table's subsidence, abrupt rise or flood, capillary action, and precipitation. Subgrade's strength is changed due to changes in subgrade's humidity levels. As well as it is very important that subgrade strength's dependence's exact nature on humidity variation must be clearly understood by the engineer. Improved design as well as maintenance practices are contributed if local soil CBR's dependence on water content is understood clearly. Usually, a well-established and easy method, CBR test, is utilized on samples of soil for measuring the subgrade strength. Although, subgrade strength can also be assessed through various other tests. The soil strength utilized for subgrade varies greatly depending on the soil's saturation amount that means water amount which is exposed to the soil. Thus, in the current study, they attempted to vary the soaking degree as well as, therefore, the saturation level in different soil types as well as to evaluate the soil's engineering properties that includes CBR, at various levels of saturation. It has been perceived that the worst engineering properties are discovered for coarse grained soils after 3 days of soaking as well as similar scenario was discovered for fine grained soils at the end of four days.

Keywords: CBR, Saturation degree, Compaction, Moisture content, Sub-grade soil

I. INTRODUCTION

Earth is a multi-component system that typically consists of stones, clay, sand, silt, water and organic humus near the bottom. Since a long time ago, the Earth's surface has been used continuously for building across the globe, spanning various climate regions and cultures. The structural stability of the built buildings on the surface of the earth is controlled by the structural integrity of the sand and stone frames, by the silt potential of the pore filling and, importantly, by the clay binding properties that are actually dependent on the wet content of the soil. Compared to some building materials, soil or earthy soil is often thought to have some drawbacks – comparatively low compressive strength, durability and abrasion resistance. In addition, it can reduce its rigidity within the availability of moisture. However, the innovative, remarkably wide-ranging, environmentally friendly, powerfully coupled with skilled construction practices, will make a significant contribution to the aesthetics of buildings and the comfort felt by users. Smart quality and robust earth buildings are often designed with due care in mind.
Generally, the problems faced by on-site geotechnical engineers are that the properties of the raw material cannot generally meet the specified requirements. Issues are unremarkably investigated by soft soils such as organic clay. The nature of the soil is complicated and has varying compositions in terms of material and, ordinarily, the soil is incompatible with the construction needs either in whole or in part. Generally, clays have high compressibility and low strength. Several areas can be prone in terms of reducing mechanical power. As a result, the development over clay soil may result in a failure of bearing capacity due to its less shear strength. The clay soil must therefore be changed before any building works are carried out. The need for a decision emerges on the basis of consideration whether or not to make use of the desired design and the actual material present at the site in order to preserve its actual quality or; to substitute the positioning material with the superior material or; to create a replacement site material that meets the quality criteria by altering the current material properties referred to as stabilizer. The undesired replacement of soil with suitable foreign filling materials is one of the normal choices. But, of course, this technique is extremely tiresome, especially when a thick layer is encountered.

The surface of the pavement, whether fluid or rigid, lies on the base of the soil on the cutting or embankment, usually recognized as the subgrade. Furthermore, subgrade can be described as the compacted layer, usually consists of local soil that occurs naturally, having thickness of 500/300mm, below the crust of pavement that provides appropriate pavement foundation. There are 2 layers in the bank subgrade, normally to a level above in comparison to the deposit's lower part. Usually, the subgrade soil is strained to particular least stress levels because of the traffic loads as well as the quality of subgrade soil must be good as well as well compacted in order to use its maximum strength for withstanding the traffic loads generated stress. It results in savings the pavement's overall thickness. In contrast to this, characterization of subgrade soil is done by its strength for pavement's design and analysis purpose. The output of the subgrade usually based on 3 primary characteristics that are listed briefly as below:

1. Swelling and/or shrinkage: Certain soils swell or shrink based on the soil's moisture content. In addition, in northern climates, soils can be prone to frost due to extreme fine content. Frost, swelling and shrinkage has the capability to crack as well as deform any pavement type that has been constructed on them.
2. Moisture content: various properties of subgrade are affected by the moisture that includes swelling, shrinkage and load bearing capacity. There exists several factors like pavement porosity, infiltration, groundwater table elevation, or drainage that affect the moisture content (that might be aided by pavement cracks). Usually, under load deformation is noticed when subgrades are overly wet.
3. Load bearing capacity: Load transmitted from pavement structure must be carried by the subgrade. Usually, soil type, moisture content, and compaction degrees affects the load bearing capacity. A subgrade capable of sustaining a large loading amount exclusive of extreme deformation is believed as fine.

The CBR (California Bearing Ratio) is most common parameter used to determine the pavement layer strength. Soil texture, dry density and water content determines the CBR value. Usually, research samples are prepared by water content and dry density that are found in the fields and then in the laboratory, CBR test is conducted on them. However, challenges in assessing the content of stable moisture for the study can be predicted with field dry density.
This paper is aimed for studying the various soil types' different strength properties produced at various density and moisture levels as well as concludes the moisture conditions' general aspects on determining the various strength parameters in order to accomplish the economical and most viable design of pavement. The objectives of the present work are to classify and study various properties of three different soil samples. The paper is also based upon to study effect of degree of compaction on CBR and to establish graphs between moisture content and CBR for 3 different samples with a standard value of compaction effort (3 layers and 55 blows each). CBR measures the strength of foundation soil and strength is mainly dependent on the degree of compaction of soil. Furthermore, degree of compaction depends on the soil type, moisture content and compaction effort. Therefore, the my project aims to study the of these dependable factors' effects on the CBR value because CBR is the most extensively used test for assessing the sub grade soil strength as well as other pavements material and is associated with the thickness of flexible pavement needs for airfields, highways etc.

II. METHODOLOGY

For the three type natural soil plasticity index, plastic limits and liquid limits were performed according to Test IS: 2720 (Part 5) – 1985 for the stabilized soil as well as natural soils. The CBR test was performed according to IS: 2720 (Part 16) –1987(Re-affirmed 2002) for the natural and treated soils.

III. RESULTS AND DISCUSSION

3.1 PARTICLE SIZE DISTRIBUTION OF SOIL

For all the three soil types, sieve analysis was performed and the results have been given in table 4.1, 4.2 and 4.3 and figure 1 provides the percentage retained on the sieves for all the three types of soils. It was observed that soil 1 is coarser than soil 2 and 3 whereas soil 2 is less coarse than soil 3.

3.2 SPECIFIC GRAVITY OF SOIL

Soil type1's specific gravity is maximum i.e 1.95 whereas that of soil type2 is 1.91 as well as that of soil type3 is 1.85. It indicates that soil type1 is heaviest whereas soil type3 is lightest, however the difference is not so large (Table 1 and Figure 2).

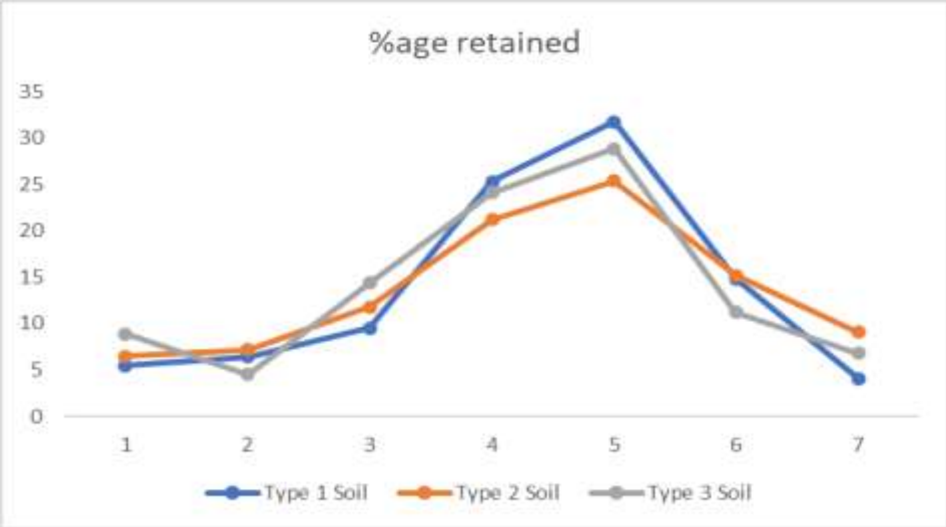

Figure 1. Natural Soil's Particle Size Distribution Curve

Table 1. Specific gravity values for soil type1, 2, and 3

Soil Type	Type 1	Type 2	Type 3
Specific gravity of soil	1.95	1.91	1.85

3.3 ATTERBERG LIMITS

LIQUID LIMIT

The soil type1, 2 and 3 liquid limit variation is shown in Figure 3. The reaction with the liquid limit concept is in agreement that is water content at which dynamic shear strength is exhibited by the soil. The soil type1 liquid limit value was found to be 69, for soil type2 is 74 as well as for soil type3 is 81. It has been discovered that from soil1 to soil3, there has been elevation in liquid limit (Table 2).

Table 2. Atterberg limit test results for soil type 1,2 and type 3

Soil Type	Liquid Limit of Soil	Plastic Limit of Soil	Plasticity Index	Maximum dry density	Optimum Moisture Content
Type 1	69	24	45	1.44	29
Type 2	74	26	48	1.57	33
Type 3	81	31	50	1.62	41

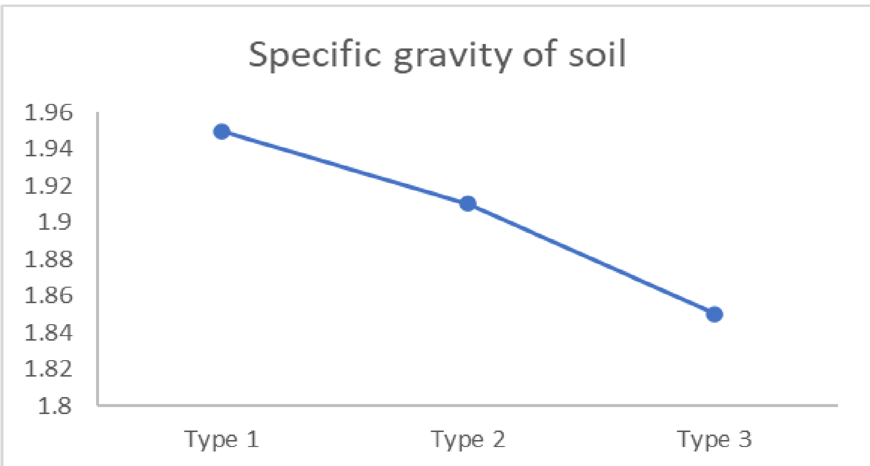

Figure 2. Specific gravity for soil type 1, 2, and 3

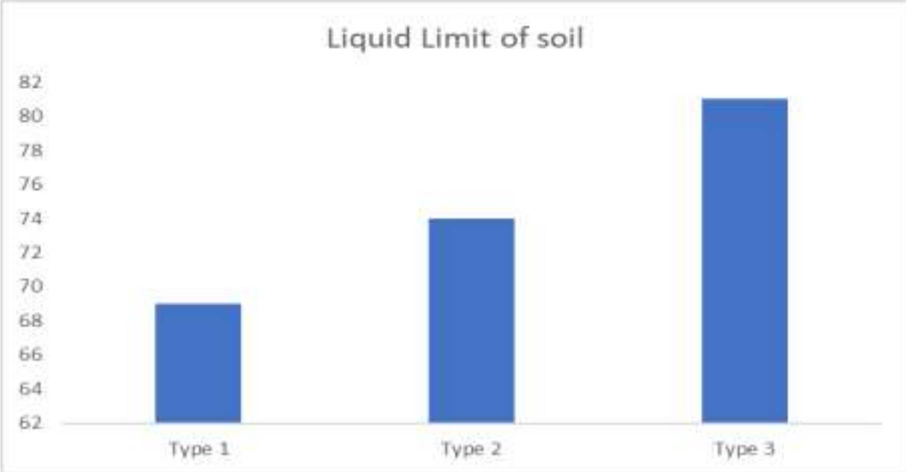

Figure.3 Liquid Limit for soil type 1, 2, and 3

PLASTIC LIMIT

The soil type1, 2 and 3 liquid limit variation is shown in Figure 4.4. Plastic limit of soil type1 is lesser than soil type2 as well as type3 which is contrast with the liquid limit as the same trend was observed in liquid limit also. The soil type1 plastic limit was observed to be 24, for soil type2, it was 26 as well as for soil type3 it was observed to be 31.

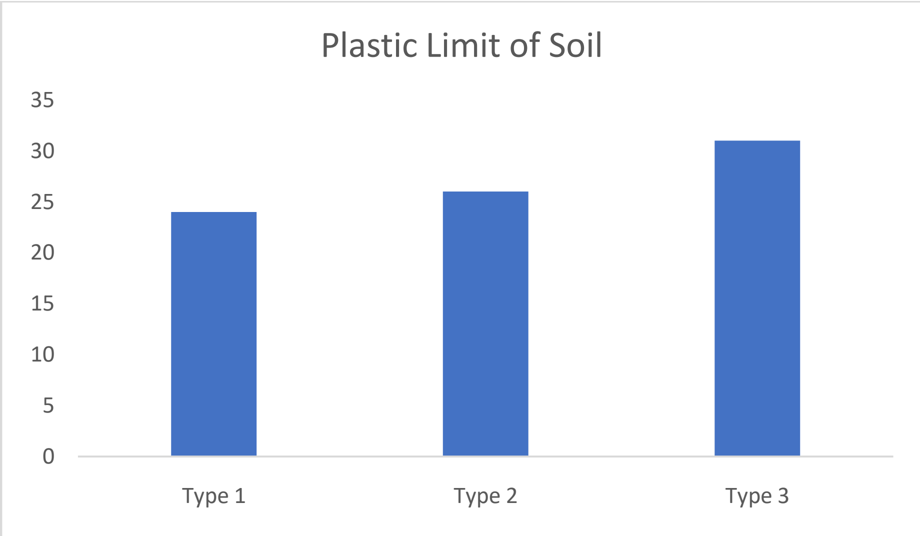

Figure 4. Plastic Limit for soil type 1, 2, and 3

PLASTICITY INDEX

The soil type1, 2 and 3 plasticity index variation were shown in Fig 5. The increase in liquid limit as well as plastic limit were associated by a common show increase in the value of plasticity index. The value of Plasticity index for soil type 1 was observed to be 45 and for soil type2 it was 48 as well as for soil type3 it was observed to be 50%. In fine seeded soil, clay and silt contents are assessed with the help of Atterberg's plasticity and limits, as with higher clay content plasticity increases. Alternatively, some significant information on soil's mechanical performance has been provided that can be utilized as material's construction or foundation. A high swelling/ shrinkage potential as well as a high compressibility is usually indicated by a high liquid limit. Usually a low shear strength is resulted due to Ip high-plasticity index. Whereas, it has been signified by low Ip that the foundation soil will considerably varies its consistency, even with water's small change.

Table 3. Plasticity Index for Silt and Clay

Soil	Plasticity I_p (%)	Plastic limit w_p (%)	Liquid limit w_L (%)
Silt, low plasticity	4–11	20–28	25–35
Silt, medium plasticity	7–20	22–23	35–50

Clay, low plasticity	7–16	15–22	25–35
Clay, medium plasticity	16–28	18–25	40–50
Clay, high plasticity	35–55	20–35	60–85

So we can conclude that for all the soils Type 1not only is the water content that depends on the clay's plasticity but the clay minerals' nature as well as content are also significant. Therefore, type as well as clay type minerals along with content can be estimated with plastic Smectites produce very sticky or rigid soils sometimes whereas in illitic as well as especially in kaolinitic soils there is reduction in plasticity.

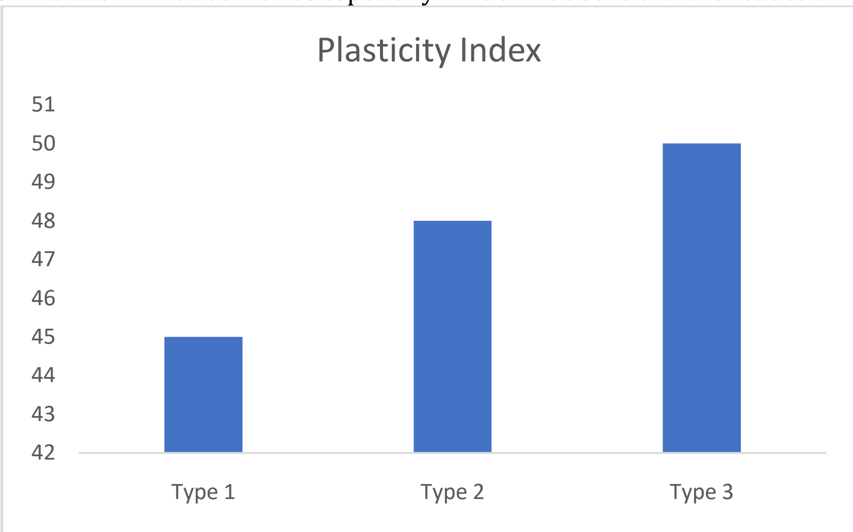

Figure 5 Plasticity Index for soil type 1, 2, and 3

3.4 MAXIMUM DRY DENSITY

The soil type1, 2 and 3 maximum dry densities (MDD) variation has been shown in figure 6. The MDD for soil type1 was discovered as 1.44 and for type 2 it was 1.57 and for soil type 3 was found to be 1.62. When the test samples' moisture content enhances due to dryer conditions, the water having a lubricating effect as well as helps in effective tension reduction, by decreasing the holes as well as requiring more compaction. In the case of coarse-grained soils with current dry density below than highest dry density, the soil grains rearrangement results in vibration. The outcomes are decrease in compressibility and void ratio, and internal friction angle increases.

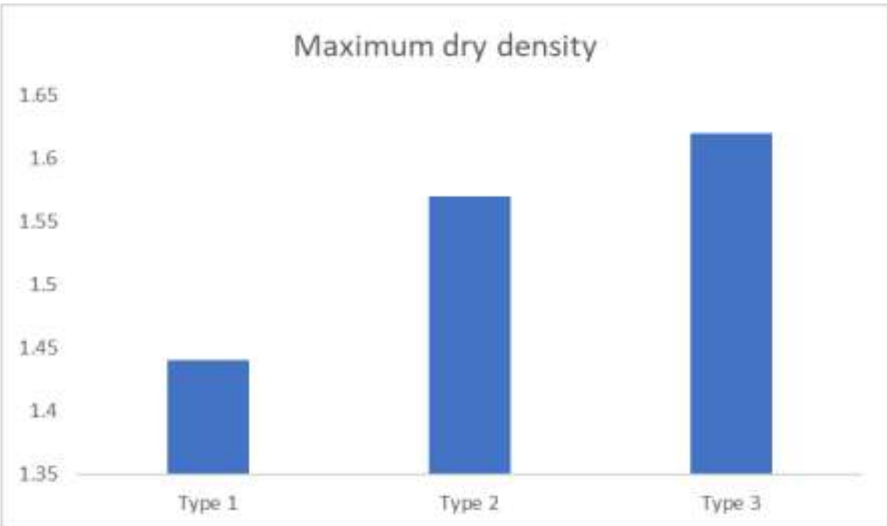

Figure 6 Maximum dry density for soil type 1, 2, and 3

3.5 OPTIMUM MOISTURE CONTENT

The soil type1 optimum moisture content variation was found to be 29, for soil type2, it was 33 as well as for soil type3, it was found be 41 (Figure 7).

The content of soil moisture is water amount contained by soil. Technical as well as scientific areas wide range utilizes the water content as well as it can be described as a ratio that ranges from 0 which means totally dry to material's porosity value at saturation. The presence of moisture can be seen on internal surfaces as adsorbed moisture as well as on small pores as capillary condensed water. Primarily, moisture comprises of adsorbed water at low relative humidity. Whereas, there is much more significance of liquid water at higher relative humidity which depends on the size of the pore. Because of the aggregational properties as well as colloidal properties of soil, they retain moisture or water. Presence of water is seen in the pores, colloids' surface and other particles. Surface attraction and surface tension that are generally known as surface moisture stress are the forces that are accountable for accumulation of water in the soil after stoppage of drains. It applies to the energy idea in relation to retention of moisture.

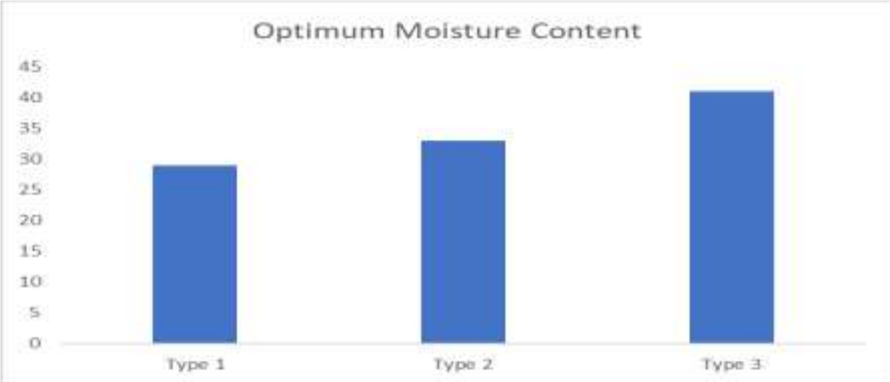

Figure 7 For soil type1, 2, and 3 Optimum Moisture Content

3.6 CALIFORNIA BEARING RATIO

The soil of type 1, type 2 and type 3, California bearing ratio (CBR) value is a significant parameter in evaluating the soil suitability for engineering purpose. It provides soil's bearing ability as well as strength. The CBR values were tested at various days i.e. at 0day, 1day, 3day, 5day as well as at 7 days. The values were observed at different level of compression i.e. at 99% density, 98 % density, 97% density, 96% density and at 95% density. The values of CBR decreases with decrease in density of soil, and also decreases with days from 0 to 7 days at 1,3,5 and 7 days. The variation of the CBR of soil type 1 at 99%, 98%, 97%, 96% and at 95 density was found to decrease as 3%, 8%, 17%, 20%, and 23% for 1day, 10%, 14%, 22%, 27% and 30% for 3 day, 16%, 20%, 31%, 32% and 34% at 5 day, and 26%, 33%, 39%, 41% and 42% for 7days w.r.t 0 day. The variation of the CBR of soil type 2 at 99%, 98%, 97%, 96% and at 95 density was found to decrease as 5%, 11%, 17%, 23%, and 27% for 1day, 12%, 20%, 27%, 32% and 33% for 3 day, 19%, 26%, 32%, 38% and 39% at 5 day, and 23%, 29%, 35%, 42% and 47% for 7days w.r.t 0 day. The variation of the CBR of soil type 3 at 99%, 98%, 97%, 96% and at 95 density was found to decrease as 3%, 10%, 18%, 23%, and 27% for 1day, 9%, 14%, 23%, 27% and 31% for 3 day, 13%, 29%, 25%, 32% and 35% at 5 day, and 30%, 26%, 31%, 39% and 41% for 7days w.r.t 0 day (Figure 8-13).

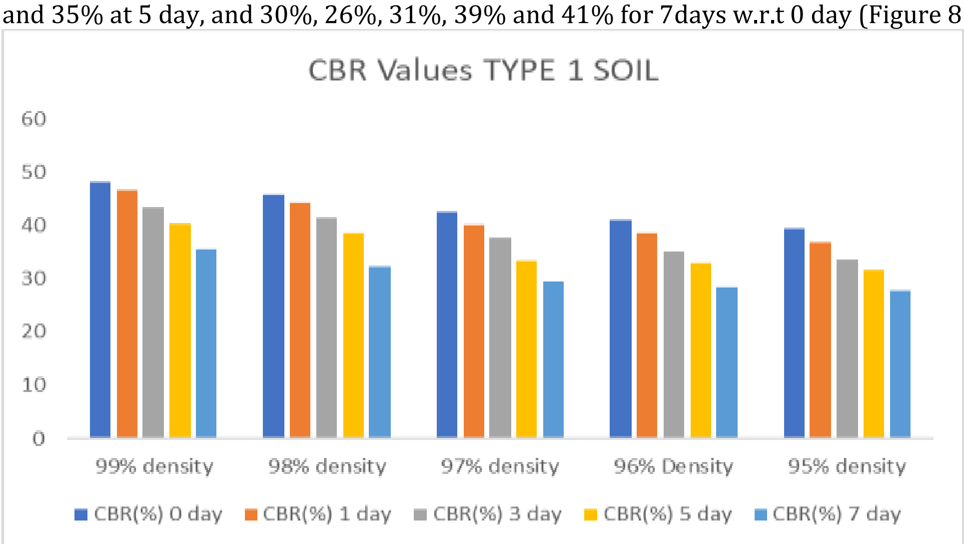

Figure 8 California Bearing Ratio Tests Results For Soil Type 1

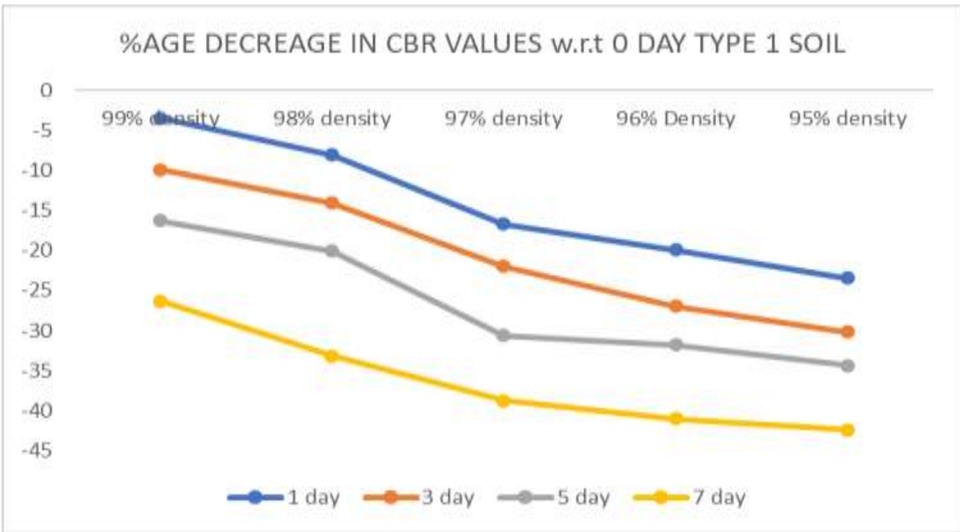

Figure 9 %age decrease in CBR at 1,3,5 and 7days w.r.t. 0 day for soil type 1

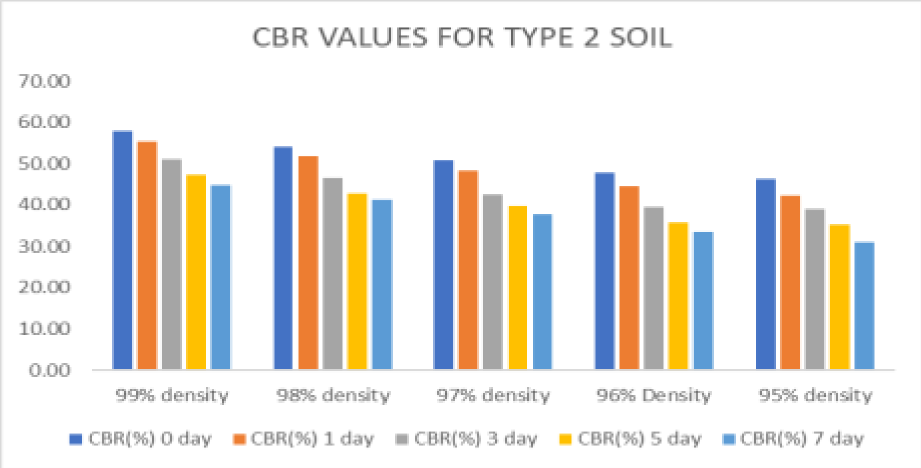

Figure 10 California Bearing Ratio Tests Results For Soil Type 2

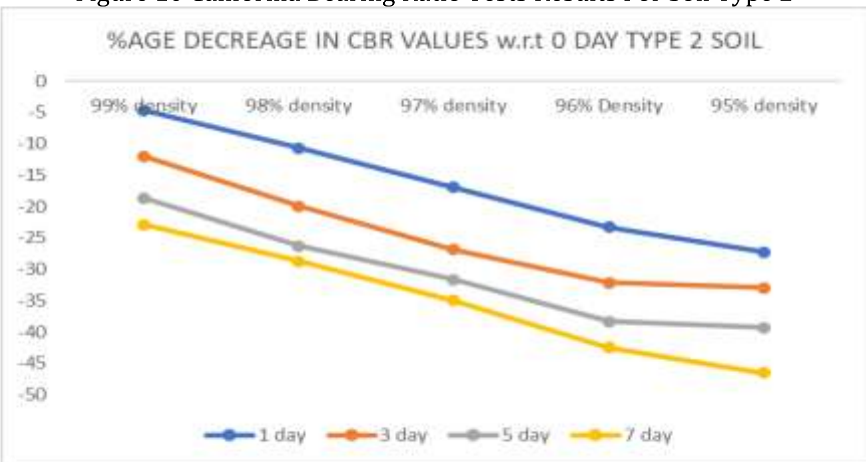

Figure 11 %age decrease in CBR at 1,3,5 and 7days w.r.t. 0 day for soil type 2

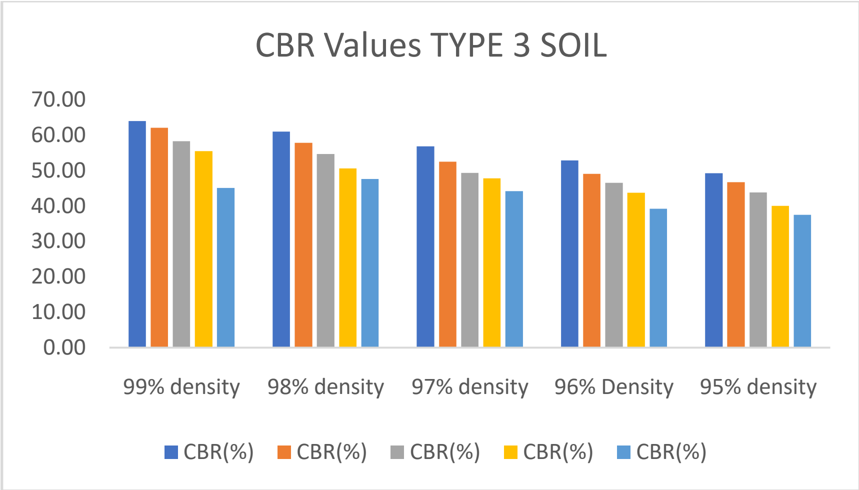

Figure 12 California Bearing Ratio Tests Results For Soil Type 3

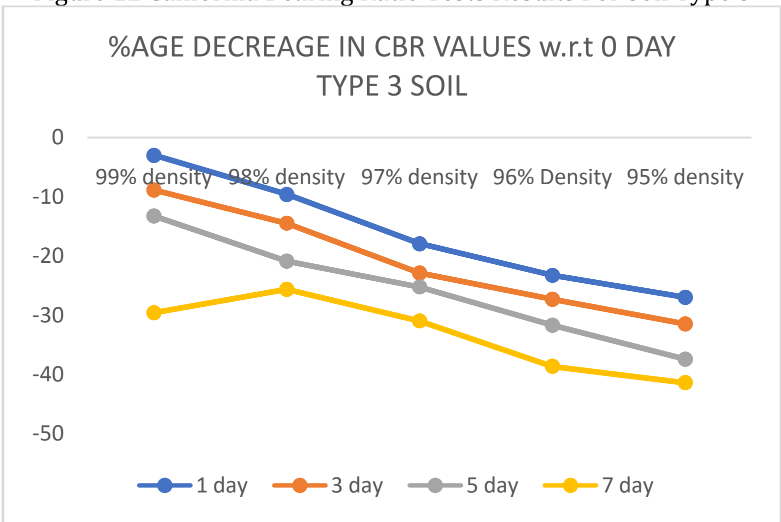

Figure 13%age decrease in CBR at 1,3,5 and 7days w.r.t. 0 day for soil type 3

IV. CONCLUSION

In this thesis, attempts have been made for exploring the saturation effect that is soaking on the subgrade soil's strength properties, known as CBR that is commonly utilized for measuring the all pavement forms' quality. The soaking effect on saturation degree on soil sample's various sections was also measured in analysis. The following conclusions are taken from the findings and discussions discussed earlier:

1. Given clay soil type1 sample's CBR value with BIS classification prepared at a specific density is observed to decrease slowly with the soaking period up to 1 day after which the rate of decrease is more in comparison to 0 day. Although the CBR value decreases by about 42 times at 7 day in comparison to 0 day at 95% density, the CBR value loss in 3days is approximately triple as compared to that in 1day.
2. With the soil type 2 measured as well as discovered as the pattern is identical to the soil type1. In soil type3 the rate of strength reduction is much lower. While there is reduction in the CBR value when soaking day increases, the decrease rate is higher in soil type1 as well as soil type2.
3. The optimum moisture content, maximum dry density, Plasticity index, Plastic Limit and liquid limit was found to enhance for soil type2 as well as soil type3 as compared to soil type 1.

Future scale of work

1. Other engineering properties, like triaxial checking, unconfined compression and direct shear, must also be measured for various saturation degrees.
2. Stabilization effect on engineering properties with thin (clayey) soil at various saturation level requires to be discovered.
3. Above referred engineering properties' considerations can be extended to soils variety, such that a database can be developed for explaining the time during which the soil is soaked in order to assess the importance of the CBR or any of the engineering properties that may be used for the design of the pavement.

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