International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN: 2350-0557, Volume-9, Issue-2, April 2022
https://doi.org/10.55524/ijirem.2022.9.2.53
Article ID IJIR-2256, Pages 353-359
www.ijirem.org

Laboratory Investigation for Variation of Subgrade Strength Related to Moisture

Shiasta Yousuf[1], and Ashish Kumar[2]

[1]Scholar, civil engineering Department RIMT University Mandi Gobindgarh, Punjab (INDIA).
[2]Assistant Professor, Civil Engineering Department University Mandi Gobindgarh, Punjab (INDIA)

Correspondence should be addressed to Shiasta Yousuf: shiastayusuf@gmail.com

ABSTRACT- The design of the pavement layers to be laid over sub grade soil starts off with the estimation of sub grade strength and the volume of traffic to be carried. Design of the various pavement layers are very much dependent on the strength of the sub grade soil over which they are going to be laid. Sub grade strength is mostly expressed in terms of CBR (California Bearing Ratio). Weaker sub grade essentially requires thicker layers whereas stronger sub grade goes well with thinner pavement layers. The sub grade is always subjected to change in saturation level due to precipitation, capillary action, flood or abrupt rise or subsidence of water table. Change in moisture level in sub grade causes change in the sub grade strength. And it becomes quite essential for an engineer to understand the exact nature of dependence of sub grade strength on moisture variation. An understanding of the dependence of the CBR strength of local soils on water content will contribute towards better design and maintenance practices. Normally CBR test is an easy and well adopted method conducted on soil samples to measure the strength of sub grade. However, many other tests are also considered for assessing the sub grade strength. The strength of soil, used for sub grade may vary largely on the amount of saturation in it, i.e. amount of water exposed to the soil. Hence, in this study an attempt has been made to vary the degree of soaking and hence the saturation level in various types of soils and study the engineering properties of soils including CBR at different saturation levels.

It is observed that for fine grained and clayey soil, worst engineering properties are observed after three days of soaking.

KEYWORDS- CBR, Compaction, Degree of saturation, Liquid limit, Moisture content, Sub grade soil.

I. INTRODUCTION

The first stage in planning the pavement layers to be laid on subgrade soil is to estimate strength of subgrade and the traffic volume to be carried.

The strength of the subgrade soil over which the pavement layers will be built influences the design of the various pavement layers [1]. When the subgrade is weak, thicker layers are required, but when the subgrade is strong, pavement layers that are thinner are appropriate. The IRC patterns the precise pavement layer design methodologies depending on subgrade strength. The CBR (California Bearing Ratio) is a commonly used measure of subgrade strength. As a result, the traffic volume must be supported by both the pavement and the subgrade [2].

The irregularity or changeable nature of the subgrade strength makes it difficult for the engineer to create an ideal pavement design. Changes in the moisture content of the subgrade are caused by rainfall, capillary forces, floods, and sudden elevations / subsidence of the water level, for example. As the moisture level changes, so does the subgrade strength. And an engineer's understanding of the precise nature of subgrade strength's dependence on moisture content becomes critical [3].

The goal of this study is to learn more about the nature of subgrade strength variations with moisture content. As a result, several soil samples are soaked in a water bath for various days to determine their strengths at varied moisture levels [4]. Test findings can be used to make the necessary inferences.

A. Subgrade

Subgrade, according to MORD specifications, is a compacted layer directly beneath the crust of pavement that serves as the pavement's base. It is often constructed of organically existing local dirt and is 300 mm thick [5]. The embankment's subgrade is compacted in two levels, with the upper layer usually being of higher quality than the lower. In cuts, the sliced formation, which acts as subgrade, is treated in the same way to produce a sufficient foundation for the pavement.

In regions where found naturally localized subgrade soils have poorly engineered characteristics and weak CBR strength, such as Black Cotton soil regions, enhanced subgrades are given via lime/cement processing, mechanical stabilisation, as well as other comparable techniques.

The subgrade should be adequately compacted, whether in cutting or embankment, in order to maximise its strength and reduce overall thickness of pavement. The subgrade must be compacted to a maximum dry density of 100 percent, as determined by the Modified Proctor Test, as per current MORD requirements (IS 2720-Part 7). The dry unit weight of the material used for subgrade construction should be at least 16.4kN/m3.

II. GENERAL REVIEW OF LITERATURE

The structure of a road is referred to as pave. In order for road traffic's massive wheel loads to travel with the least amount of rolling resistance, this structure must be sturdy and non-yielding [6]. To allow fast vehicles to drive at the design speed safely and pleasantly, the road surface should be even along the longitudinal profile. Over a broader region, the pavement takes the wheel loads and distributes the load pressures to the soil sub-grade below. One of the aims of a well-designed and constructed pavement is to keep the elastic deformation of the pavement within acceptable limits so that it can bear a large number of repeated load applications during its design life[7].

ERES Division (2001): The link between CBR values and soil index characteristics was examined by the ERES Division (2001). The objective of this study was to establish broad correlations that defined the link between the two variables.

Unbound materials in pavement systems, including the foundation, subbase, and subgrade layers, have the California Bearing Ratio (CBR) and Resilient Modulus (M

The link between CBR values and soil physical characteristics was examined by Rahman (2010). The study presented a correlation based on the obtained soil data and findings from laboratory 7 works to estimate the CBR values at the top face of the soil sample for Malaysia's kind of soil. These connections were made using the maximum dry density (MDD), the optimum moisture content (OMC), and the number of blows (of CBR test)[8]

Jaleel examined the effect of soaking on the top and bottom CBR values of a sub-base material (2011). He generated fourteen CBR samples at 95 percent relative modified AASHTO compaction. Soaking resulted in a significant loss of CBR on both the top and bottom, according to the data. The majority of the reduction in soaking CBR value happened in the early days for both top and bottom CBR. Based on the findings of the experiments done in this study on the impact of soaking time on top and bottom subbase for highway purposes, he concluded that the load applied to the subbase layer decreases as the soaking period rises.Singh et al. (2011) developed regression-based methods for estimating soaking and unsoaking California Bearing Ratio (CBR) values in fine-grained subgrade soils.[10]

In West Bengal's different zones, five locally accessible soils were gathered. On the dry and wet sides of a soil's optimal moisture content (OMC), the samples were compacted at four different degrees of compaction (50, 56, 65, and 75 blows) and at five different moisture content levels (i.e., 2 percent OMC, 1 percent OMC, and OMC). To build regression models, several independent factors were utilised, such as soil index quality, degree of compaction, and moisture content.

Both soaking and unsoaking, changes in moisture content and compaction effort were demonstrated to have a significant influence on the CBR value.

Ningsih et al. examined the relationship between index features and CBR tests of Pekanbaru (Indonesia) soils with and without soaking (2012). The purpose of this study is to compare CBR soaking test results to CBR un-soaking test results in a range of clay content, as well as to create simple comparisons between CBR soaking and CBR un-soaking by considering soil characteristics. The findings indicated a linear relationship between CBR soaking and CBR un soaking, which was also impacted by the type of the index (the properties of the soil).[9]

III. MATERIALS AND METHODS

A. Bearing Ratio of California (the real laboratory procedure)

It's the ratio of the force per unit area necessary to enter a soil mass with a standard circular needle at a rate of 1.25 mm/min to the force required to pierce a standard material at the same rate. The California Bearing Ratio Test (CBR Test) is a penetration test designed by the California State Highway Department (USA) to determine the bearing capability of subgrade soil for flexible pavement design.

Tests are conducted on natural or compacted soils in wet or dry circumstances, with the findings compared to established test curves to determine the subgrade soil's strength.

- The CBR test is one of the most widely used procedures for determining the strength in subgrade soil, sub base, as well as base course materials for highway and airport pavement thickness design .The California bearing ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement.
- The laboratory procedure for determining C.B.R. of undisturbed and remoulded /compacted soil specimens, both wet and unsoaked, is covered in this instruction sheet.

B. CBR Test Procedure

- Compaction is used in the laboratory to make remoulded samples. The remoulded samples material must pass I.S. sieve of 19mm. Allowance for big material is made by substituting an equivalent quantity of material that passes the 19mm I.S Sieve but is held on the 4.75 mm sieve.
- The value of the maximum dry density calculated by the compaction test (Heavy Compaction Test according to IS 2720 (Part-8) - 1983, for Railway Construction) should be used to determine the dry density for such a remoulding. The optimal water content must be employed for compaction.
- Compaction in Motion: A random sample of soil, weighing 4.5 kg or more for fine-grained soil and 5.5 kg or more for coarse grained soil, must be taken and well mixed with water.
- If the soil would be compacted to such maximum dry density at optimal moisture content, the accurate mass of the clay required must be collected, and the appropriate amount of water must be supplied until the moisture content of the soil sample is equivalent to a calculated optimum water content.

Attach the base plate with extension collar to mould. Place the spacer disc on top of the base. Put the filter paper upon the spacer disc's top.

- Lubricate the inside side of the mould with lubricating oil. Heavy compaction is used to compact the mix dirt in the mould. i.e. compress the dirt in 5 layers with 55 blows from the 4.89 kg rammer on each layer.
- Carefully cut the compacted soil somewhere at level of the top of the specimen with a straight edge after removing the extension collar. Any holes created on the surface of the compacted soil as a result of the coarse material being removed must be fixed with smaller size material. Measure the mass of the mould and compacted soil samples after removing the perforated base plate, Spacer disc, and filter paper. Invert the mould and compacted soil, place a disc of coarse filter paper on the perforated base plate, and clamp the perforated base plate to the mould with the compacted soil in contact with the filter paper.
- Cover the specimen with filter paper and lay a perforated plate on top of the compacted soil specimen in the mould. To the closest 2.5 kg, place annular weights to generate a surcharge equal to the weight of the base material and pavement.
- Soak the mould assembly and weights for 96 hours in a tank of water. Place the expansion measuring device on the mold's edge and record the initial dial gauge reading. Every day, keep track of your readings versus the time you read them. Throughout the duration, the tank's water level must remain steady.
- At the end of the soaking period, record the dial gauge's final reading and remove the mould from the water tank.
- Remove the top filter paper and the perforated plate. Weigh and record the weight of the wet soil sample.

Values of CBR are generally calculated for penetrations of two point five in mm and five in mm. Because values of CBR at 2.5mm penetration are often higher than those at 5mm penetration, the former is used in design. The test should be repeated if the value of CBR for a penetration of 5mm surpasses that of 2.5mm. If the findings are equivalent, the bearing ratio equivalent to a 5mm penetration is used in the design.

Table 1 shows the Result of OMC & MDD.Table 2 shows the penetration values of sample without soaking. Table 3 shows the penetration value for samples soaked for One Day. Table 4 shows the penetration value for samples soaked for two Days.Table 5 shows the penetration value for samples soaked for three Days.

Figure 1, Figure 2, Figure 3 & Figure 4 shows the graph between penetration value and loading for Soaked & Unsoaked conditions.

For 2nd sample the penetration values of soil samples for without soaking and soaking conditions for one, two and three days are shown below in Table 6, Table 7, Table 8 & Table 9

Figure 5, Figure6, Figure 7 & Figure 8 shows the graph between Graph of penetration v/s load dial reading.

IV. RESULTS AND DISCUSSIONS

A. *Determination of Proctor Density and Optimum*

Table 1: Result of OMC & MDD

Description	OMC (%)	MDD(g/mm^3)
1	12	1.96
2	14	1.81
3	13.5	1.85
4	15.2	1.89
5	15.8	1.80

B. *Calculation of CBR*

1) First Sample Taken at Budgam

Table 2: Penetration Value without soaking

Penetration (mm)	Load dial readings in (Kg)
0	0
2.5	280
5	410

$CBR_{2.5}$= (280/1370) *100=20.43%
CBR_5 = (410/2055) *100=19.9%

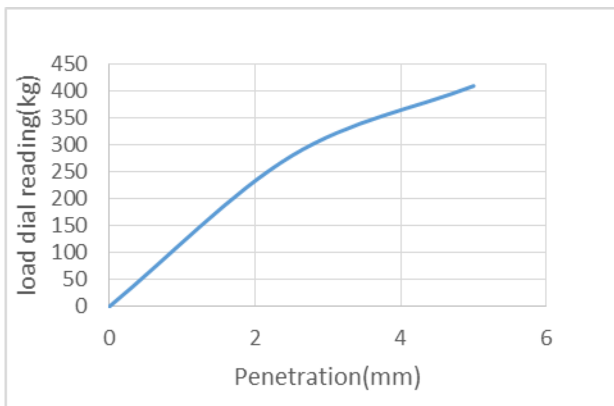

Figure 1: Graph of penetration v/s load dial reading

Table 3: Penetration Value of Soil Sample soaked for One day

Penetration in (mm)	Load dial readings in (Kg)
0	0
2.5	105.56
5	152

$CBR_{2.5}$= (105.56/1370) *100=7.7%
CBR_5 = (152/2055) *100=7.39%

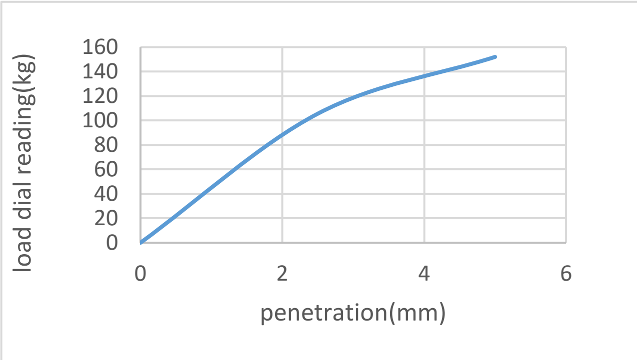

Figure 2: Graph of penetration v/s load dial reading

Table 4: Penetration Value of Soil Sample Soaking for two days

Penetration in (mm)	**Loading in (Kg)**
0	0
2.5	94
5	125

$CBR_{2.5}$= (94/1370) *100=6.86%
CBR_5 = (125/2055) *100=6.08%

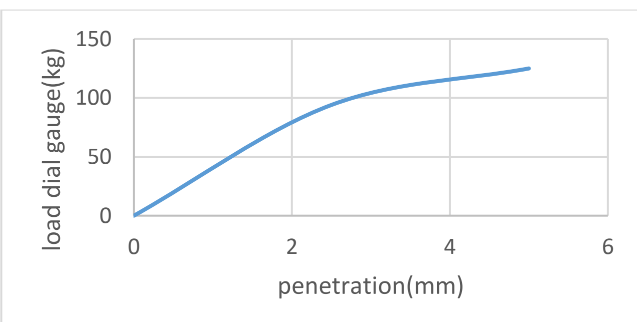

Figure 3: Graph of penetration v/s load dial reading

Table 5: Penetration Value of Soil Sample Soaking for three days

Penetration in (mm)	**Load dial reading in (Kg)**
0	0
2.5	48.65
5	102.36

$CBR_{2.5}$= (48.65/1370) *100=3.55%
CBR_5= (102.36/2055) *100=4.98%

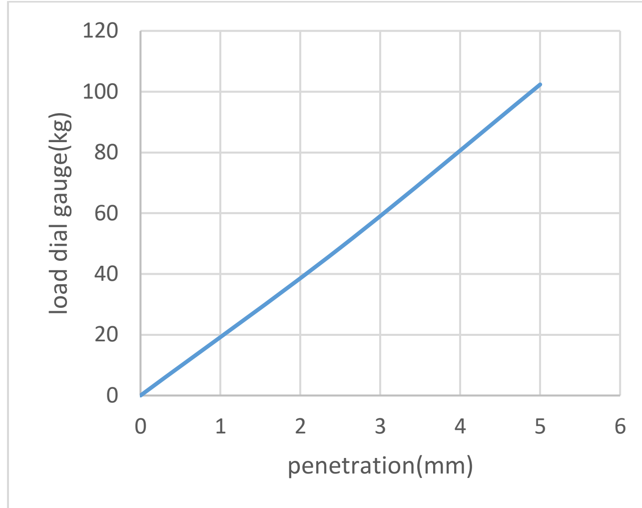

Figure 4: Graph of penetration v/s load dial reading

2) 2nd Sample Taken at a Distance of About 2km From Budgam

Table 6: Penetration Value of Soil Sample Without soaking

Penetration in (mm)	**Load dial reading in (Kg)**
0	0
2.5	156.5
5	224.6

$CBR_{2.5}$= (156.5/1370) *100=11.42%
CBR_5= (224.6/2055) *100=10.92%

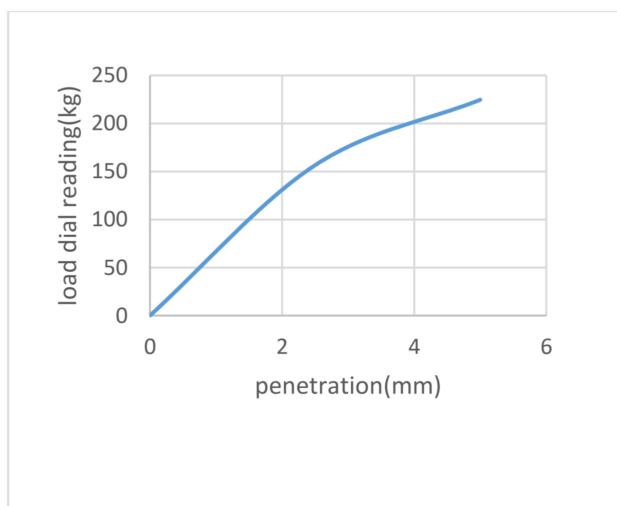

Figure 5: Graph of penetration v/s load dial reading

Table 7: Penetration Value of Soil Sample Soaking for one day

Penetration in (mm)	Load dial reading in (Kg)
0	0
2.5	25.36
5	28.25

$CBR_{2.5}$=(25.36/1370)*100=1.85%
CBR_5= (28.25/2055)*100=1.37%

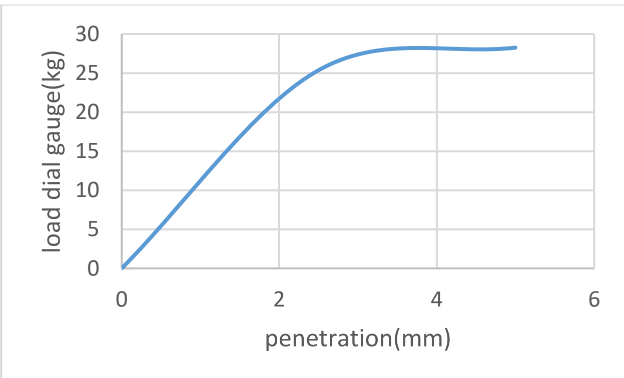

Figure 6: Graph of penetration v/s load dial reading

Table 8: Penetration Value of Soil Sample Soaking for two days

Penetration in (mm)	Load dial reading in (Kg)
0	0
2.5	18.24
5	25.21

$CBR_{2.5}$= (18.24/1370) * 100=1.33%
CBR_5= (25.21/2055) * 100=1.22%

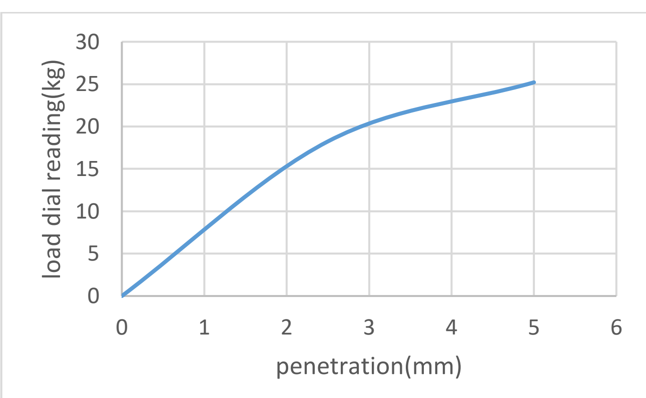

Figure 7: Graph of penetration v/s load dial reading

Table 9: Soaking for three days

Penetration in (mm)	Load dial reading in (Kg)
0	0
2.5	9.31
5	14.6

$CBR_{2.5}$=(9.31/1370)*100=0.68%
CBR_5 = (14.6/2055)*100=0.71%

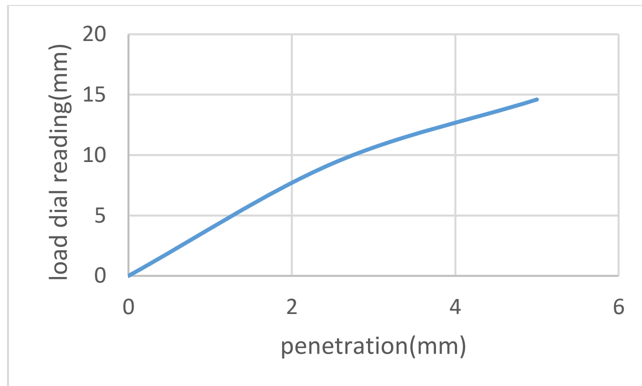

Figure 8: Graph of penetration v/s load dial reading

C. CBR Variation Based on Soaking Days

Table 10: FIRST SAMPLE

Soaking Period in (days)	CBR
0	20.43
1	7.7
2	6.80
3	4.98

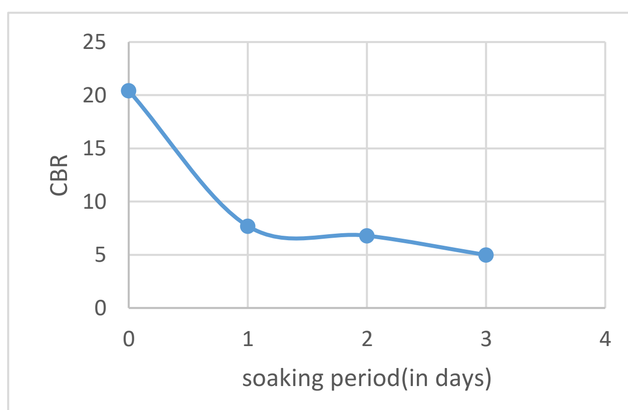

Figure 9: Graph of soaking period v/s CBR

Table 11: 2ND SAMPLE

Soaking Period in (days)	CBR
0	11.42
1	1.85
2	1.33
3	0.71

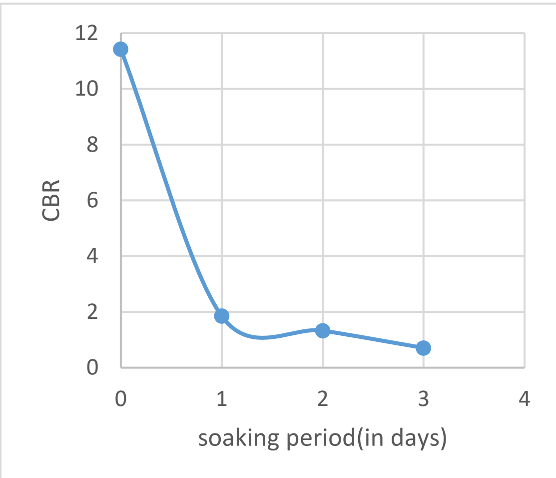

Figure 10: Graph of soaking period v/s CBR

D. Moisture Content and CBR Variation (After Every Day of Soaking, Upto 3 Days)

Table 12: FIRST SAMPLE

SOAKING PERIOD IN (DAYS)	MOISTURE (%)	CBR (%)
0	12	20.43
1	19.5	7.7
2	21	6.80
3	22.2	4.98

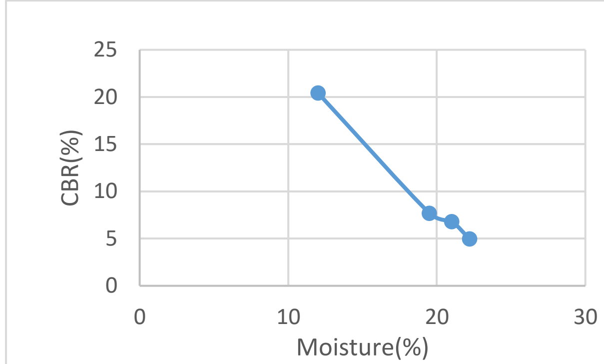

Figure 11: Graph of moisture content v/s CBR

Table 13: 2ND SAMPLE

SOAKING PERIOD IN (DAYS)	MOISTURE (%)	CBR (%)
0	14	11.42
1	19.9	1.85
2	20.8	1.33
3	21.26	0.71

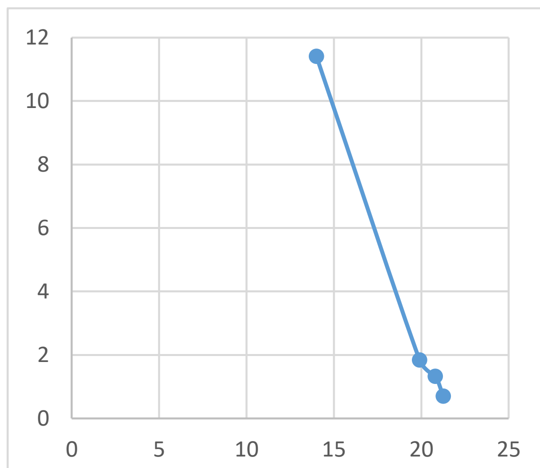

Figure 12: Graph of moisture content v/s CBR

V. CONCLUSIONS

Due to increased water infiltration, CBR decreases as the number of days of soaking rises. When unsoaked soil is soaked in water for one day and then tested for CBR strength, it loses a lot of its strength. A gradual and not spectacular decrease of strength is observed when the number of days of soaking is increased. As a result, the curve (CBR vs. soaking period) starts over with a significant dip before progressively decreasing. After a few days of soaking, the rate of water penetration reduces as it gets closer to saturation The most water is soaked on the first day, resulting in the lowest CBR strength in the soil sample.

REFERENCES

[1] Singh, A., Singla, S. and Garg, R., 2020, November. Performance analysis of Papercrete in presence of Rice husk ash and Fly ash. In IOP Conference Series: Materials Science and Engineering (Vol. 961, No. 1, p. 012010). IOP Publishing.
[2] Ashraf, S., Kaur, S. and Singla, S., 2022. Water Quality Assessment of Anchar Lake, Srinagar, India. Civil and Environmental Engineering Reports, 32(1), pp.88-115.
[3] Ahmad, Uzair. (2018). A Study on Effect of Polymers on the Properties of Vg-10 Grade Bitumen. International Journal for Research in Applied Science and Engineering Technology. 6. 2572-2576. 10.22214/ijraset.2018.4433.
[4] Singh, J., Singh, B. and Singla, S., Enhancement of Expensive Soil by Addition of Stone Dust and LDPE Fibre.
[5] Singh, P. and Singla, S., 2023. Estimation of Land Surface Temperature of Srinagar City, India Using Landsat 8 Data. Sustainability, Agri, Food and Environmental Research, 12(1).
[6] Irshad, U and Singla, S.,2019 "Impact of Road Conditions on Traffic Management-A Case Study of Chenab Valley." International Journal of Scientific & Technology Research 8 1179-1186.
[7] Arora K.R. (2008),Soil Mechanics and Foundation Engineering Standard Publishers Distribution, New Delhi, Seventh Edition
[8] Fiber and Optimum Moisture Content value of Strengthen Peat International Journal of
[9] Physical Sciences Vol. 7(8), pp 1276-1285
[10] IS: 1498-1970,Classification and Identification of Soils for General Engineering purposes…IS 2720: Part 3: 1980 Methods of Tests for soils (Khanna S.K and Justo C.E 2001, Highways Engineering Third Edition Volume 2