North Asian International Research Journal of Sciences, Engineering & I.T.

IRJIF. I.F. : 3.821

ISSN: 2454-7514 Vol. 8, Issue-6 June-2022

Index Copernicus Value: 52.88 Indian Citation Index Thomson Reuters ID: S-8304-2016

NAIRJC A Peer Reviewed Refereed Journal

DOI: 10.5949/NAIRJC.2022.00007.52

MOISTURE INFLUENCE ON SOIL SUBGRADE

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ABSTRACT

The most critical component determining the durability of any pavement system is the subgrade. The strength of the subgrade is an important metric to assess when constructing a pavement, and it is primarily defined by the California Bearing Ratio (CBR). The CBR value is determined by a number of parameters, including confining pressure, deviator stress, pore pressure, axle load, and moisture content, among others. The moisture level of the soil subgrade is the most important aspect that influences its CBR and, eventually, its strength. As a result, the impact of moisture content on CBR value has been thoroughly explored in this work, with samples taken at various moisture levels. Furthermore, the impact of compaction effort on CBR value has been studied. Various tests (grain size distribution and Atterberg's limits) on the soil samples included in the study are used to classify them according to the unified soil classification system USCS. Additionally, IS-heavy compaction was used to achieve Maximum Dry Density (MDD) and Optimal Moisture Content (OMC). The effect of compaction on soaked CBR is more prominent than on un-soaked CBR, according to the findings.

Keywords: Soil Sub grade, California Bearing Ratio, Maximum Dry Density, Optimum Moisture Content.

INTRODUCTION

The strength of the subgrade soil and the traffic volume to be carried both influence the design of the pavement layers laid over it. Strong sub-grades require thinner layers than weak subgrades under the same conditions, and the California Bearing Ratio (CBR) is commonly employed to indicate its strength. The type of the soil and other environmental elements influence the strength of the subgrade in unpredictable ways. Moisture content is the most important element affecting subgrade strength. It becomes vital to evaluate the behaviour of subgrade as the moisture contentof the subgrade alters owing to floods or other environmental variations. CBR is one of the most essential tests for determining the strength of a subgrade soil and comparing the various subgrade materials. Higher CBR indicates better material, resulting in less thickness, and vice versa. The purpose of this research is to investigate the impact of altering moisture content on soil subgrade strength. Other aspects such as soaking time and duration are also taken into account.

A large number of researches have been conducted to look at the numerous aspects that influence the strength of soil subgrade. The influence of compaction, moisture content, and soaking on the unsaturated shear strength characteristics of clay was investigated by Cokca et al. (2003) [1]. The angle of friction decreased significantly with increasing moisture content, but the cohesiveness component of shear strength reaches its greatest value around optimal moisture content and thereafter decreases. The fluctuation of modulus of resilience (MR) with post compaction moisture content and suction of selected subgrade soils in Oklahoma was studied experimentally by Naji NKhourietal (2004) [2]. The study looked at two soil types: sandy (S) and clayey (C). The C-soil specimen to be examined for wetness was prepared using a modified compaction process. New laboratory processes for wetting and drying specimens were also introduced and used to demonstrate relationships between MR, moisture change, and suction. Due to wetting and drying, the modulus of resilience–moisture content connections for C-Soil showed hystereticbehaviour. S-soils behaved similarly, however the C-Soil was shown to be more sensitive to moisture content than the S-Soil. Wetting S-Soil specimens compacted at OMC-4 percent to OMC+4 percent lowered their Modulus of Resilience by roughly 37%, and wetting C-Soil specimens to OMC+4 percent reduced it by 45 percent. Ampadu (2006) [3] investigated the effect of water content on the CBR of subgrade soil samples obtained at the optimal water content with various levels of compaction to obtain samples of various densities. The rate of change in CBR per percentage change in water content during drying from the OMC was 3 to 7 times higher than one during wetting from the OMC, according to CBR test findings on a subgrade material at varied water contents for three distinct dry densities. Using multiple linear regression models, Abraham Bae et al. (2008) [4] studied the effect of moisture in the subgrade on the longitudinal profile of pavement. Moisture variation accelerated the roughness deterioration at non-freezing sites, while moisture variation accelerated the roughness deterioration at freezing sites.

The influence of plasticity index (PI) on the CBR value of soft clay was investigated by Naeini etal. (2009) [5], who found that increasing PI resulted in a decrease in CBR of soaking clay. With an increase in the plasticity index of the soil, the optimum moisture content (OMC) increased and the maximum dry density (MDD) declined, resulting in a fall in soil strength and therefore CBR value. The effect of water content and compaction on CBR values of different soil samples was investigated by Dharamveer et al. (2011) [6]. The goal of the research was to create regression-based models for estimating soaked and unsoaked CBR values in fine-grained subgrade soils. The effect of varying the moisture content of samples from 90% to 120 percent of optimum moisture content was noticed, with the un-soaked CBR value at 90% OMC being 19% higher than that of CBR value at OMC, and a 38 percent reduction at 120 percent of OMC. The soaking CBR value followed a similar pattern.

Prof. R. KumerVerma et al. (2019) [7] looked into the impact of soil index characteristics and moisture content on CBR of ArbaminchChencha road Ethiopia's subgrade soil. For this study, 17representative samples were taken, and in-situ moisture content, specific gravity, grain size analysis, and the Atterberg's limit test were performed in the laboratory. When the effect of moisturecontent was investigated, it was discovered that the CBR value of

OMC and MDD of specific soil classes decreased by 4% to 28% on the dry side and by 25% to 59 percent on thewet side. The CBR was reduced by 17 to 30 percent when the saturation duration was changed from 48 to 96 hours, while it was reduced by 7 to 20 percent when the saturation period was changed from 4 to 6 days.

Ali Mirzaiia and Meghdad Negahbanb (2015) [8] wanted to see how initial dry density, moisturecontent, and saturation level affected CBR along drying and wetting routes. Along the drying andwetting routes, the CBR showed an increasing trend with initial dry density. When the CBR was plotted against the moisture content, the graph revealed that the CBR increased as the moisture content decreased along both soaking and drying paths, with the tendency being more pronounced in soils with a low beginning void ratio. Furthermore, the soil samples on the drying curve have lower water content and thus appear to have greater CBR values at a given initial void ratio.

Zheng Lu a, Chuxuan (2021) [9] investigated the influence of water content on the dynamic reaction of soil subgrade subjected to a heavy-duty truck using field methods and analytical models. Different sorts of sensors were also utilised to watch and examine the dynamic behaviour of various factors. The results showed that when axle load, temperature, depth, and vehicle speed are kept constant, the sample with higher saturation in the unsaturated subgrade causes a bigger amplitude of acceleration, and the vertical stress is unaffected by soil saturation change. The magnitude of vertical stress and acceleration decreases dramatically as depth increases.

II. MATERIALS ANDMETHODOLOGY

2.1.MATERIALS

Two soils were explored for this study: red Moorum soil from Gurgaon and black cotton soil from Karnal (India). The index characteristics, grain size distribution, moisture content, OMC, and MDD were all calculated in the first experiments (using heavy compaction test). Finally, CBR experiments were conducted to study the influence of different moisture contents, as well as CBR values for unsoaked and 5-day soaking. Variations in moisture at different strata and in different places were also investigated.

2.2.METHODS

2.2.1. Grain size distribution

Table 1: Results of index properties of soil.

Index property	Experimental value (%)
Liquid limit	37.6
Plastic limit	23.4
Plasticity index	14.2

The percentage of soil grains of various sizes present in a dry soil sample. Sieve analysis is used to determine the grain size of coarse-grained soils, whereas hydrometer or pipette methods are used for fine-grained soils.
When 50% of a soil sample passes 75 microns, it indicates that the soil is fine-grained. The soilis also clay (CI) or

silt (MI) of intermediate plasticity, as the reported liquid limit is less than 50%. The grain distribution curve was calculated using hydrometer sieve analysis.

Table 2: Results of sieve analysis.

I.S. sieve	weight retained in (gm)	percentage weight retained	Cumulative percentage retained	percentage Weight passing(%)
4.75 mm	19.9	1.99	1.99	98.01
2.36 mm	16.6	1.66	3.65	96.35
1.18 mm	37.3	3.73	7.38	92.62
0.6mm	41	4.1	11.48	88.52
0.3 mm	93.1	9.31	20.79	79.21
0.15mm	123.6	12.36	33.15	66.85
0.075mm	56.2	5.62	38.77	61.23

2.2.2. Modified proctor test

The moisture-density connection is a standard approach for observing a subgrade's compaction characteristics. This relationship is required to densify the current subgrade in order to prepare it for the application of subsequent layers. OMC and MDD, which were determined from varied densities achieved by varying moisture contents, are the required parameters from this test. MDD values ranged from 1.36 to 2.11 g/cc, whereas OMC values ranged from 9.47 to 30.31 percent.

2.2.3. Modulus of resilience(MR) test

The resilient modulus test applies a repeated axial cyclic stress of fixed amplitude, load duration,and cycle time on a cylindrical test specimen to measure elastic modulus of a soil subgrade. The MR of all the specimens was determined using the AASHTO T-307-99 test technique. The MR test comprised of a 0.1-second cyclic load followed by a 0.9-second rest period. The applied load and vertical displacement for the last five cycles of each sequence were measured and utilised to calculate the MR.

2.2.4. California bearing ratio (CBR) test

It's one of the most significant tests for determining a subgrade soil's strength. In the laboratory, this test can replicate the deformation behaviour of the Base or Sub-base under loading conditions. This test compares a material's bearing capability to that of well-graded crushed stone. The CBR test takes into account both traffic loads and surcharge loads from underlying pavements. This test is used to determine a material's strength. Around 1930, the California Division of Highways established it, and it was later adopted by other countries.

2.2.5 Moisture content

Moisture content is a critical component that influences the strength and behaviour of soil subgrades, which has a major impact on the modulus of resilience of soil subgrades; therefore, determining moisture content is critical. In this investigation, the moisture content of soil sample was calculated using the oven drying method.

Table 3: Moisture content obtained at various locations and their average value of a soil sample.

		Centre	East	West	North	South	Avg.
Unsoaked	Top	11.92	12.46	12.48	12.37	12.42	12.33
	Middle	12.43	12.30	12.06	12.16	12.54	12.30
	Bottom	12.76	12.52	12.83	12.87	13.28	12.85
Soaked Day-1		Centre	East	West	North	South	Avg.
	Top	15.16	16.05	16.41	14.80	16.75	15.83
	Middle	14.03	13.74	13.41	13.85	13.57	13.72
	Bottom	13.28	13.55	13.56	13.41	13.49	13.46

		Centre	East	West	North	South	Avg.
Soaked Day-2	Top		15.88	16.21	15.25	15.59	15.87
	Middle	14.58	14.35	14.09	14.11	14.26	14.28
	Bottom	13.66	13.31	13.78	13.70	13.04	13.50
Soaked Day-3		Centre	East	West	North	South	Avg.
	Top	15.83	16.80	17.05	16.47	16.70	16.57
	Middle	14.29	14.10	13.75	14.47	14.39	14.20
	Bottom	13.38	13.37	13.54	13.50	13.22	13.40

		Centre	East	West	North	South	Avg.
Soaked Day-4	Top	16.29	17.42	17.39	18.01	16.58	17.14
	Middle	14.18	14.23	13.65	14.01	13.76	13.97
	Bottom	13.87	13.67	13.80	13.90	13.97	13.84
Soaked Day-5		Centre	East	West	North	South	Avg.
	Top	18.77	23.18	20.11	21.58	23.41	21.41
	Middle	15.62	15.14	15.27	14.68	15.69	15.28
	Bottom	14.47	14.88	15.25	15.10	15.51	15.04

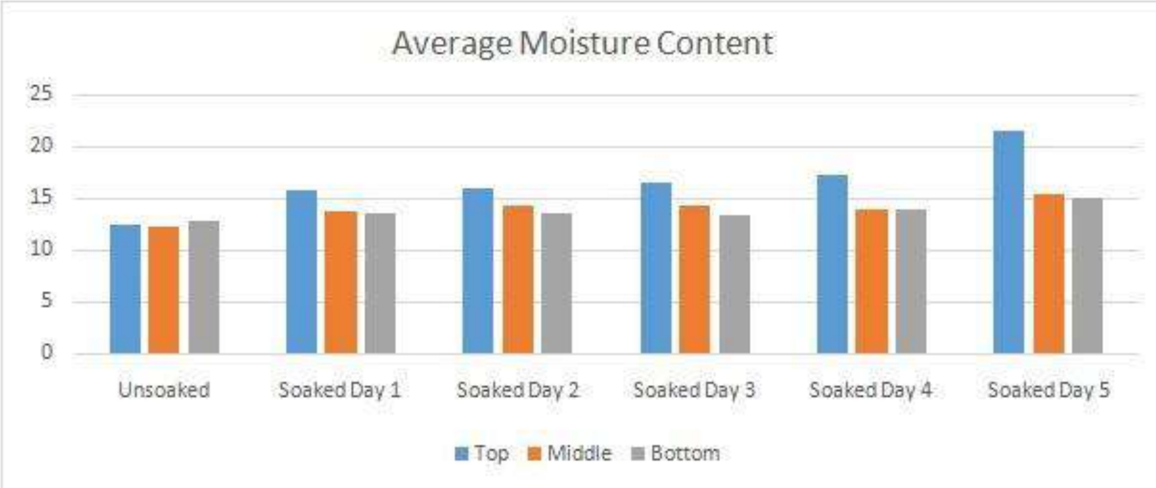

Figure 1: Plot of Average Moisture Content.

III. RESULTS

3.1. Unsoaked CBR

3.1.1. Effect of Moisture Content

It has been observed that with the increase in moisture content, the un-soaked CBR value of soils decrease. A soil with degree of compaction 90% at moisture content of 90% is seen to have 19% higher un-soaked CBR compared to sample compacted at OMC. Similarly, for a soil compacted at 120% of OMC, the un-soaked CBR value decrease approximately 38% compared to CBR value at OMC. Detailed results are tabulated in table 4.

3.1.2. Effect of Degree of Compaction

As compaction effort is increased, moisture content being constant, the unsoaked CBR value is increased, when compaction effort is increased from 80% to 90% at 90% of OMC (dry side of OMC), 6% increase in unsoaked CBR is observed. Similarly, at 110% of OMC (wet side of OMC), increase in degree of compaction from 80% to 100%, resulted in approximately 18% increase in unsoaked CBR value.

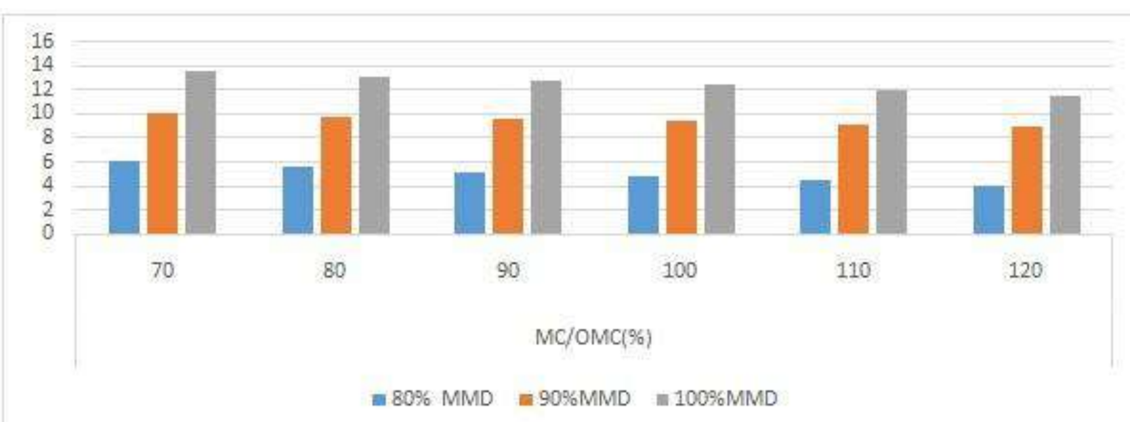

Figure 2: Plot of Unsoaked CBR at different MDD %age.

3.2. Soaked CBR

3.2.1. Effect of moisture

From the results it can be inferred that with increase in moisture content, the soaked CBR values of soil decreases for each level of compaction. A soil sample compacted at 90% degree of compaction prepared at water content of 90% of OMC resulted in approximately 6.8% higher soaked CBR compared to soil compacted at OMC. Likewise, a sample compacted at 120% of OMC,showed the decrease in the soaked CBR value by 13.6% compared to soaked CBR value at OMC.

3.2.2. Effect of Degree of Compaction

At constant moisture content, as compaction effort increases, the soaked CBR values also increase. By increasing the compaction effort from 80% to 90% at a moisture content of 90% of OMC 62% increase in soaked CBR value is noted. Likewise, an increase in degree of compaction from 80% to 100% at 110% of OMC (wet side of OMC), would result approximately 156% increase in soaked CBR. This implies that the effect of compaction on soaked CBR is more predominant than unsoaked CBR.

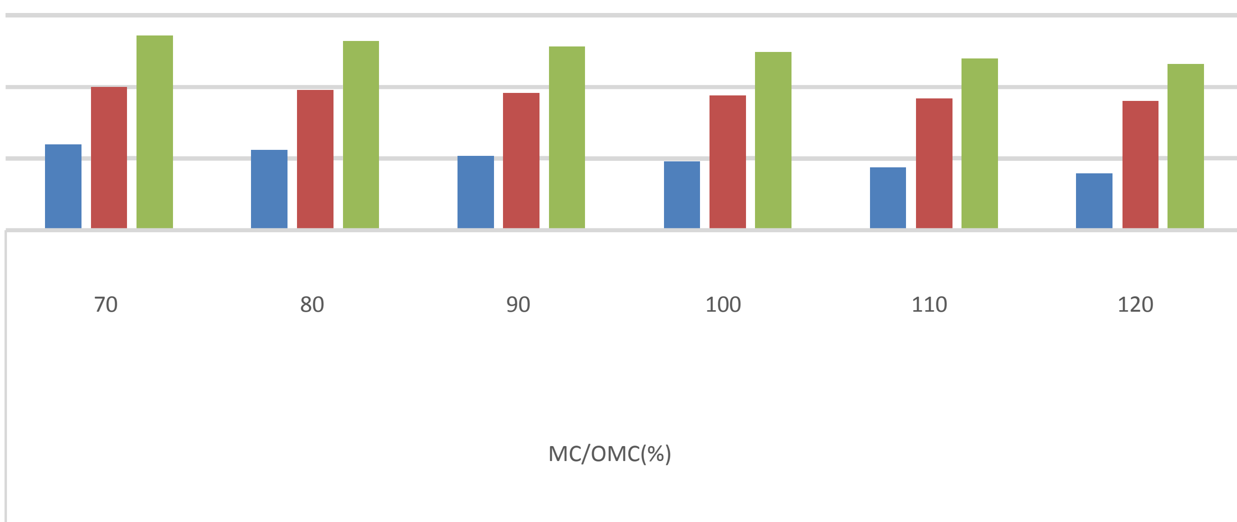

Figure 3: Plot of SCBR at different MMD %age

CONCLUSIONS

The study's goal was to calculate the wet and unsoaked CBR values of fine-grained subgrade soils at various moisture contents and compaction levels. Conclusions The following is a summary of the results obtained:

Changes in moisture content and compaction effort were shown to have a considerable impact on CBR value, both unsoaked and soaked. For the same moisture content change at constant compaction intensity, the dry side CBR value decreased by 4% to 28%, whereas the wet side CBR decreased from 25% to 59%, implying that the subgrade was always compacted on the dry side of the OMC. When compaction effort was increased from 80 percent to 100 percent for a soil sample compacted at 90 percent of OMC (dry side), Soaked CBR value increased by 62 percent. However, when compaction effort was increased from 80 percent to 100 percent for a soil sample compacted at 110 percent of OMC (wet side of OMC), Soaked CBR value increased by 156 percent. As can be observed, compaction has a stronger effect on damp CBR than it does on unsoaked CBR.

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