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Water Content Effect on California Bearing Ratio of Cohesive Soil

Chigozie Okafor[1] & Clinton Aigbavboa[1]

SARChI in Sustainable Construction Management and Leadership in the Built Environment, Faculty of Engineering and the Built Environment, University of Johannesburg.

chigozie.okafor@unn.edu.ng

Abstract. The CBR test is a simple and well recognized method of assessing the strength of subgrade. There are also many other Geotechnical tests which can be used to ascertain the quality of the subgrade soil, the quality of the soil that is used for subgrade may differ and this may depend on the amount of water that seeps through the soil. In this study, the degree of soaking was varied in days starting from un-soaked (0 day) to soaked (day 1) up to (day 5) to enable the measurement of the saturation level in different types of soil in Awgu LGA. Furthermore, the Engineering features of the soils which included the CBR at different saturation levels were also studied. According to the results obtained, as the soaking period increases from day 1 to 5 for all the samples, there was remarkable decrease in the CBR of soil samples from 100% to 5% in all the samples.

Keywords: Moisture Content, California Bearing Ratio, Cohesive Soil.

1 Introduction

Nigeria, a country in the tropical region is characterized with heavy rainfall and high temperature. It is therefore appropriate to say that climatic factors affect its roads. Many of the roads are flooded with water after heavy rains due to inadequate drainage system. In other to design the pavement layers to be spread over the subgrade soil, the strength of subgrade must be estimated and the amount of traffic it's expected to carry as well.

The California bearing ratio is mostly the prevalent test used in estimating the strength of the subgrade, the subgrade which are considered weak usually needs thicker layers while stronger subgrade can make do with thinner layers. Due to varying environmental conditions like precipitation, capillary action, flooding etc. the subgrade always experiences varying change in saturation level. The subgrade strength changes due to change in moisture level and this is critical for Engineers to understand the extent which moisture affects the subgrade strength, this will enable Engineers make better design.

The California bearing ratio is one soil test which can be used to assess the strength of a subgrade. With this test, different strength of the subgrade materials can be compared and better design and maintenance decisions can be made.

2 Aims and Objectives

This study investigates the variations of CBR with water content for different days using cohesive soil from Awgu in Enugu Port-harcourt expressway, South East Nigeria.

3 Research Methodology

The soil samples for this study were dug from different pits which are located at a distance of 1km away from each other, the soil were dug up at a depth of 1m to ensure the best quality of samples were collected.

This study was conducted using two samples of soil. Some preliminary soil tests were done in other to determine the various features of the soil, the preliminary tests that were done are atterberg-limit test and sieve analysis.

In other to carry out the CBR test, compaction experiments were done to ascertain the OMC and its MDD. CBR experiments were conducted at varying water levels and the variations of the CBR with regards to various days of immersion in water, from un-soaked (day zero) - soaked (day five) were observed. Soil sample at various layers along various points (East-side; North-side; South-side; West-side) were collected and the moisture content obtained. See fig1, using this method, the moisture content at different days of soaking were also obtained. The diagram below (fig.1) represents the CBR mold and a depiction of how soil samples were collected from the mold.

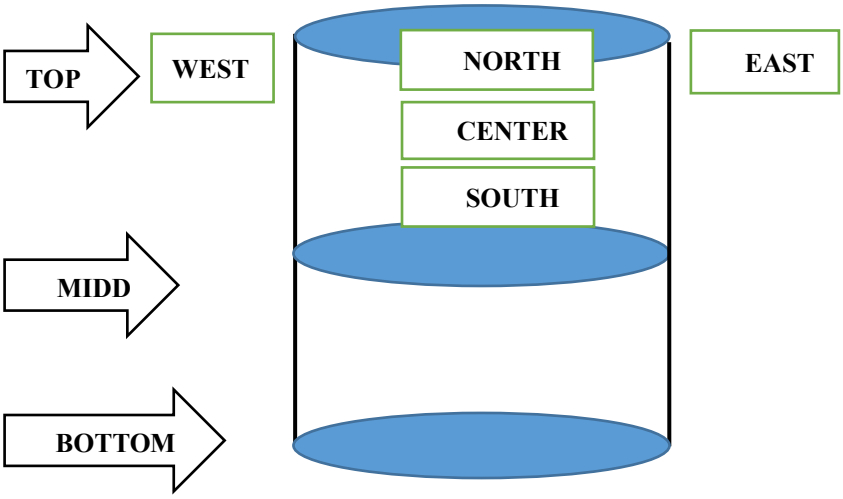

Figure 1: The figure above represents the horizontal and vertical positions of soil sample.

CBR TEST

A compaction test was conducted using the modified proctor mold to ascertain the OMC and the maximum dry density of the soil sample. The soil specimen were tested using the CBR apparatus, the tests were conducted on the sample from un-soaked (0 day) to soaked (day 1, 2, 3, 4 and 5). For each sample and each day, the moisture content were also determined for top, middle and bottom at North-side; South-side; East-side and West-side. (See fig1).

4 Results

Tables 1 & 2 represents the average moisture content in % of the two samples from Unsoaked (0 day) to soaked day (5)

Sample one

Table 1. Moisture content for sample 1

		Moisture content in %				
		North	South	East	West	Average
Unsoaked	Top	10	12	11	11	11
	Middle	13	12	14	13	13
	Bottom	11	11	12	11	11
Soaked day 1	Top	26	25	26	28	26
	Middle	19	19	19	19	19
	Bottom	21	23	24	24.41	23
Soaked day 2	Top	26	25	27	26	26
	Middle	22	23	23	23	23
	Bottom	20	25	26	23	24
Soaked day 3	Top	24	24	22	26	24
	Middle	22	22.22	20	20	21
	Bottom	24	24	32	25	26
Soaked day 4	Top	34	29	30	25	30
	Middle	22	22	27	18	22
	Bottom	21	26	21	26	24
Soaked day 5	Top	30	26	28	28	28
	Middle	22	25	23	21	23
	Bottom	26	25	26	28	26

Sample two

Table.2: Moisture content for sample 2

		Moisture content in %				
		North	South	East	West	Average
Unsoaked	Top	8	8	9	9	9
	Middle	9	9	10	8	9
	Bottom	9	8	8	7	8
Soaked day 1	Top	18	16	16	17	17
	Middle	16	13	14	10	13
	Bottom	16	16	12	12	14

	Top	29	26	26	30	28
Soaked day 2	Middle	26	27	25	26	26
	Bottom	31	32	31	28	31
	Top	31	37	36	31	34
Soaked day 3	Middle	30	30	30	26	29
	Bottom	35	33	35	35	35
	Top	35	37	32	33	34
Soaked day 4	Middle	29	31	33	29	31
	Bottom	35	33	33	34	34
	Top	35	36.03	35	35.04	35
Soaked day 5	Middle	32.4	33	31.3	33	32
	Bottom	42	37.3	39.3	36	39

The figures (1 & 2) below represents the California bearing ratio reading of the two samples which was plotted against days of soaking, from unsoaked (0 day) to soaked (day 5).

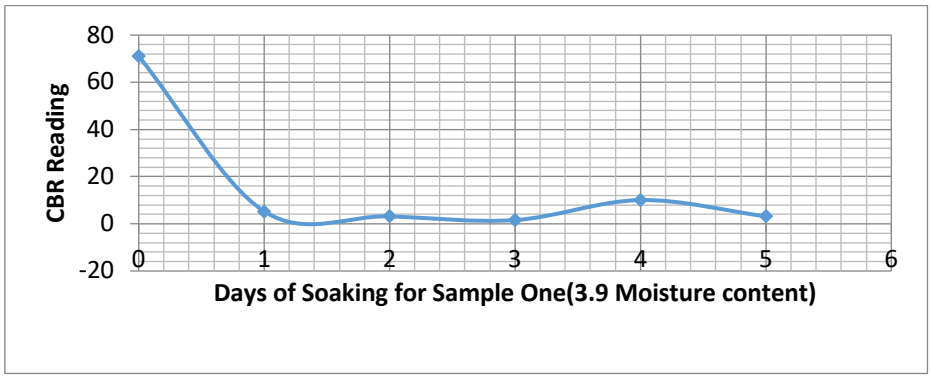

Fig. 2. CBR reading against days of soaking (sample 1)

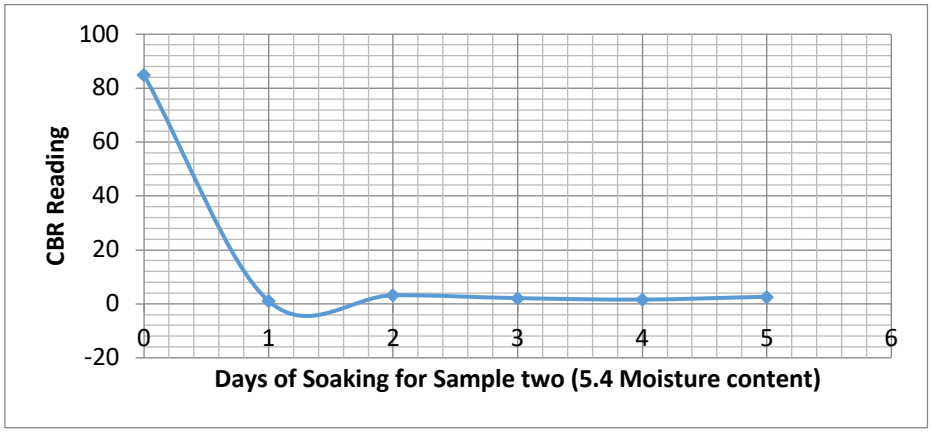

Fig. 3. CBR reading against days of soaking (sample 2)

5 Discussion

5.1 Moisture Variation in Soil Samples

Tomer and Mallick (2011) opined that the CBR of a given soil sample can decrease quickly when immersed in water for 24hours and when the number of days of immersion in water increases the California bearing ration of the given sample continues to decrease gradually. Talukdar (2008) also postulated that the CBR of a given soil sample can also depend on other factors like MDD; OMC and atterberg limit experiment etc.

Razouk & AL – Azawi (2003) also concurred in their study that when soil samples are soaked for a long period, it begins to lose its strength. Another study conducted by Alayaki and Bajomo (2011) showed that longer soaking period of a compacted soil sample decreases the CBR value, he also observed that the CBR of the top surface of the soaked soil is greater than the bottom face. Therefor in this study, the moisture content tables above for samples 1 & 2 respectively shows how moisture behaves across the cohesive soil samples from Awgu local government, South East Nigeria. The average moisture content for un-soaked (0 day) to soaked (5 days) were computed for North , South , East and West for the top , middle and bottom respectively. From table 1. Sample 1, it is observed that there was no much water movement within the soil at un-soaked state. At soaked (day 1, sample1) the average moisture at the top was 26% , at the middle was 19%, while at the bottom was 23%. At day 2, it was 26% at the top , 23% at the middle and 24% at the bottom. At day 3, it was 24% at the top, 21% at the middle and 26% at the bottom. At day4, it increased to 30% at the top , 22% at the middle and 24% at the bottom.

Then at day 5, it decreased by 2% to 28% at the top, 23% at the middle and 26% at the bottom. The same sequence of water movement continued in sample 2 only that the average moisture contents for sample 2 was higher than sample 1.

Furthermore, observations from sample 1 and sample 2 shows that there was continues increase in the average water content at the top, middle and bottom for samples 1 and 2 respectively as the days of soaking continued to increase, this shows that Awgu soil has high seepage of water which can be a critical problem for building foundation and highway construction.

5.2 Variation of CBR With Days of Soaking

A California bearing ratio test was conducted for the samples at un-soaked state (0 day) to soaked state (5 days) for both samples 1 & 2 respectively. Presenting the California bearing ratio readings on the diagram in fig.2 and fig.3 respectively below, it was observed that the California bearing ratio values for sample 1 (fig.2) was high at 70 in un-soaked state and after 24hours of immersion in water , the CBR value reduced to 6, on day two it went down further to 2, on day three it went down further to one, there was a slight increase to 10 in day 4 however in day 5 it reduced to 2.

These variations show that water greatly affected the CBR of sample 1.

For sample 2 (fig.3), the CBR values for samples (2) was the highest at 84 in un-soaked state however it reduced to 0 after 24hours of immersion in water , on the second day it rose to 2 and remained constant at 2 all through the remaining days. This equally shows that water greatly affected the CBR of the sample just like it did in sample 1.

6 Conclusions and Recommendation

In this study, attempt has been made to explore the effect of moisture on the California bearing ratio values of two samples of soil collected along the Enugu-Port Harcourt expressway, Awgu LGA.

The test results above showed that:

1. Higher moisture contents resulted at both top layers and lower layers.
2. The reduction in strength of California bearing ratio value was the same.
3. All the samples experienced decrease in CBR from un-soaked condition to 24hours soaking.
4. When the number of days of soaking increased, there was further reduction in the CBR which was gradual and at a slow rate.
5. From day one to day five, there was no significant difference.

RECOMMENDATIONS

1. To further substantiate the above findings, more research which will involve variety of samples and increased number of days of soaking need to conducted.
2. Other engineering features need to be determined using the direct shear experiment, unconfined compression experiment and triaxial experiment at varying levels of water saturation.
3. The engineering properties above and the corresponding results should be prepared in a database for variety of soil samples and locations, this will enable engineers to have a CBR bench mark which can be used for pavement design.

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