A REVIEW PAPER ON CORRELATION BETWEEN CALIFORNIA BEARING RATIO AND ANGLE OF REPOSE OF GRANULAR SOIL

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***Abstract*: The strength of subgrade is a predominant factor in the design of Highways. One of the methods to determine the subgrade strength is the well-known California Bearing Ratio (CBR) test. CBR test is grueling and prolonged, thence a method for correlating CBR value with a soil physical property is proposed. Since the Angle of Repose is one of the physical properties of soil and is relatively easy to determine, it is considered as the correlating factor. The Angle of Repose is determined from the Hollow Cylinder test. In this study, diverse soils samples are collected from various locations within the Eastern Province of Saudi Arabia. Laboratory soaked CBR, Gradation Analysis, and Hollow Cylinder tests were performed on the samples. Thereafter, linear relationship between the Angle of Repose and CBR value of the samples is initiated and scrutinized using simple linear regression analysis (SLRA), and furthermore, predictive equation estimating CBR from Angle of Repose value is developed.**

***Keywords:* Soaked CBR, Angle of Repose, SLRA, Correlation, Subgrade, Highways**

I. INTRODUCTION

Soil properties are predominant factors that affect all civil engineering projects such as highways, dams, tunnels and other structures. A competent ground layer is crucial for both stability and serviceability of any structure. Subsequently, an appropriate understanding and analysis of soil are required to ensure that the structure remains safe against subsurface failures. The Heterogeneous nature of the soil makes its behavior vary noticeably from site to another. Hence, exhaustive planned investigation for each site is a must for design purpose. Ambala highways system usually comprises of flexible pavement. Different flexible pavement design approaches have existed. The CBR test is an empirical method to design the flexible pavement. The bearing capacity of subgrade soil has a significant role in highway design, especially, in determining the thickness of the pavement. Namely, the lower the subgrade CBR value, the thicker the pavement. CBR values can be obtained directly from a laboratory test in accordance with ASTM-D1883 (Standard Test Method for California Bearing Ratio (CBR) of Laboratory Compacted Soils).

The drawbacks associated with performing a soaked CBR test including the long time consumed which may reach a week, making the CBR test costly, prolonged, and grueling. Therefore, only limited numbers of CBR tests are usually conducted along a proposed highway. As a result, such limited number of CBR tests may not commonly divulge the variance in CBR values along a proposed highway to ensure reasonable, safe and frugal design. To conquer these challenges, an endeavor has been made in the current study to correlate the soaked CBR value statistically to the Angle of Repose.

The test to determine the Angle of Repose is much easier than CBR test and can be conducted in laboratory in accordance with spreading of a granular mass on a horizontal plane method, which was improved lately by measuring the angle of repose of granular systems using hollow cylinders method and known as the Hollow Cylinder test. Alternatively, the Angle of Repose can be determined from a laboratory test in accordance with ASTM-C1444, or ASTM-D6393 which is known as Funnel test. The angle of repose of a granular material is the steepest angle of descent or dip relative to the horizontal plane to which a material can be filed without slumping. In other words, it is the angle which accumulated material forms with the horizontal. It is the maximum slope inclination at which the soil is barely stable. It is affected by the morphology of the material, solvents, and other factors. Usually, the Angle of Repose is almost equal to the critical internal friction angle of the material. Geotechnically, the Angle of Repose has many application fields, such as slope stability and the design of retaining structures. Generally, for sand, the angle of repose ranges from 300 to 350

II. LITERATURE REVIEW

Nelson (1955) [1] measured the angle of repose of sulfathiazole materials for a pharmacology application. In this case, the angle of repose was found to be equal to the angle of internal friction of the material only when the grains had a uniform shape and size, and the uncertainty in the measurement was reported as 1.0°

Miura, Maeda and Toki (1997) [2] introduced a funnel-type device to determine the angle of repose in which the pile of soil was formed on a cylindrical pedestal with a depression. They studied the relationship between the angle of repose and the angle of internal friction; examining different factors such as the roughness of the base, density of the soil, mean grain size, grain shape, dilatancy and lifting speed of the funnel. Their results indicate that the angle of repose tends to decrease with an increase in the amount of the material or the size of the conical heap and tends to increase with slower funnel lifting speeds during the experiment.

Rousé (2001) [3] compared six methods for measuring the angle of repose of six types of granular soil. She indicated that the highest value of the angle of repose was obtained from the ASTM International method. The differences between the six methods led to a difference in the factor of safety of approximately 82% for slope stability applications with considerable differences in the soils that require excavation.

E. Lajeunesse, A. Mangeney-Castelnau, and J. P. Vilotte (2004) [4] discussed that the spreading of a granular mass initially enclosed inside a tube and suddenly released on a horizontal surface.

Geldart et al. (2006) [5] studied the angle of repose of powders to investigate their flowability properties. A modified funnel method was used to measure the angle of repose of a slightly cohesive powder; the results being consistent with the Hausner ratio method.

Z. Liu (2011) [6] analyzed that the angle of repose of the granular systems was influenced by the degree of roughness of the base on which the grains come to rest. It was determined that the rougher the base was, the higher was the angle of repose.

Er. Devendra Kumar Choudhary and Dr. Y. P. Joshi (2014) [7] analyzed that the thickness of crust varies with the change in the value of C.B.R. With higher value of C.B.R. the crust thickness is less and vice versa. Also, from this laboratory test it has been observed that the soil Kopra is suitable for the construction purpose for soil sub grade in comparison with the Yellow soil (Clayey silt) on the basis of higher values of C.B.R.

Rackl and Hanley (2017) [8] subsequently, the surface profile was plotted and linearly approximated by using the least squares method, which can reduce the errors in the traditional direct measurements and increase the accuracy in the angle of repose values. In addition, they calculated the required statistical repetitions of the measurements for both the traditional and image-based methods and found out that the maximum number of repetitions needed for the image-based method is approximately 50% less than the maximum number of repetitions required for the conventional method (direct measurement by ruler and protractor or by using the height and diameter in the arctan method).

III. METHODOLOGY

- 10 disturbed soil samples are collected from different locations within the Ambala city. All of these samples are subjected to soaked CBR.
- After performing soaked CBR test, each and every sample goes through Gradation Analysis tests. After that, we will perform Angle of Repose tests and try to establish a relation between soaked CBR values and Angle of Repose by comparing various results.

It must be pointed out that for soaked CBR and Angle of Repose tests, the maximum particle size of the tested material is less than 19 mm.

IV. OBJECTIVES

The drawbacks associated with performing a soaked CBR test including the long time consumed which may reach a week, making the CBR test costly, prolonged, and grueling. Therefore, only limited numbers of CBR tests are usually conducted along a proposed highway. As a result, such limited number of CBR tests may not commonly divulge the variance in CBR values along a proposed highway to ensure reasonable, safe and frugal design. To conquer these challenges, an endeavor has been made in the current study to correlate the soaked CBR value statistically to the Angle of Repose.

V. CONCLUSION

Based on the linear regression analysis and experimental works conducted in this study, there is a high positive correlation between soaked CBR and Angle of Repose values. An empirical relation between the soaked CBR and Angle of Repose is derived from regression analysis equation. The relationship shows reasonably fitting between the predicted and experimental soaked CBR values. In general, as Angle of Repose increases CBR value increases.

VI. FUTURE SCOPE

The test to determine the Angle of Repose is much easier than CBR test and can be conducted in laboratory by the Hollow Cylinder test. Alternatively, the Angle of Repose can be determined from a laboratory test by the Funnel test. Since, this study shows that soaked CBR values are somehow correlated with the Angle of Repose thus provides an easy alternative to the CBR test. In general, the angle of repose of a granular material is the steepest angle of descent or dip relative to the horizontal plane to which a material can be filed without slumping.

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