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CBR Improvement of Soil by Adding Lime and Fly Ash

Kumar Sandeep[#1], Mahla R.P. [*2]
[1] M. Tech Student, Department of Civil Engineering, OITM/GJU- Hisar (125001), Haryana, India .
[2] Department of Civil Engineering, OITM/GJU- Hisar (125001), Haryana, India.

Abstract*— The quality and life of pavement is greatly affected by the type of sub grade ,sub base and base course materials. The most important of these are type and quality of sub grade soil. But in India most of flexible pavement are used to be constructed over weak and problematic sub grade. The California Bearing Ratio(CBR) of these sub grade have very low ,it need to more thickness of pavement. This paper represent a study of Lime and Fly Ash as the admixture in improving the maximum dry density(MDD),optimum moisture content(OMC), California Bearing Ratio(CBR),Liquid Limit, Plastic Limit. The percentage of lime and Fly Ash used is varied from 3% to 10% .The optimum moisture content(OMC), California Bearing Ratio(CBR) increased with an increase in Lime percentage but liquid limit, Plastic limit, maximum dry density(MDD) of soil decreased with increase in Lime percentage. The liquid limit, plastic limit and maximum dry density(MMD) of the soil decreased and the optimum moisture content(OMC), California Bearing Ratio(CBR) increased with an increase on Fly Ash content. The objective of this work is to estimate the effect of Lime and Fly Ash on some geotechnical properties of soil, in order to determine the suitability of Lime and Fly Ash for use as a modifier in the treatment of soil for roadwork. The aim of this investigation is to quantify the optimum quantity of Lime and Fly Ash on the performance in term of CBR especially when it is planned to be used as sub grade in highways.

***Keywords*— CBR value, Lime ,Fly Ash ,MDD ,OMC**

I. INTRODUCTION

The topic "Improvement in CBR value of Soil by adding Lime and Fly-Ash" aims at conducting laboratory investigations on some selected soils of Haryana with the addition of lime and fly ash in varying proportions to determine improvement in California Bearing Ratio of the soils. The soils used are from three different areas of Haryana. Improved sub grade soil with higher CBR value reduces the pavement crust requirements. California Bearing Ratio (CBR) test was developed by the California Division of Highways. The basic procedure of this test was developed by the corps of Engineers of the US Army. Certain modifications were made in the test procedure, and now the modified method is adopted by the corps of the Engineers and regarded as the standard method of determining the CBR value. The Bureau of Indian Standard (IS: 2720-Part 16, 1987) has also adopted the modified procedure. The study has been conducted on three different types of soils that are generally available in Haryana. These are ML type (silts of low plasticity collected from Kurukshetra), CL type (clays of low plasticity collected from Ambala) and SM type (silty sands collected from Fatehabad). The laboratory investigations are carried out with a view to improve CBR value of the soils.

II. REVIEW OF LITRATURE

Deepak Yadav (2014) suggested that California Bearing Ratio (CBR) is an indicator of sub grade soil strength. The soil classification and compaction parameters are routinely determined for in-situ and borrow soils used in the construction. The multiple regression analysis was performed on the results of laboratory tests for a large number of soil samples collected from different road projects of Madhya Pradesh (India). The basic soil properties, namely liquid limit, plastic limit, fine content, optimum moisture content and maximum dry density correlate with the soaked value of the CBR. The developed correlation equation is validated from a few independent test data reported in Soil Test Reports of rural roads of Madhya Pradesh and is found reasonably accurate. The conventional method of determining the soaked CBR of the fine grained soil is by laboratory test. The test requires careful preparation of soil samples and four days time for soaking before conducting the penetration test. When number of samples is large, determination of soaked CBR becomes cumbersome. The equation developed in the present work relates CBR to the soil classification and compaction parameters. It is simple and gives fairly good estimate of soaked CBR without actually performing the test. Further improvement in the developed equation is possible by incorporating large data for analysis or through the use of advanced machine learning tools like artificial neural network (ANN) methods. **M. M. E. Zumrawi (2014)** investigated that CBR can't be easily measured in the field, prediction of CBR from other simple tests such as Dynamic Cone Penetro meter (DCP) and soil properties is a valuable alternative. Various soils have been compacted at different initial state conditions (i.e. water content and dry density) then using laboratory and field equipment to enable the measurement of unsoaked CBR and DCP of these soils. Analysis of the experimental data indicated that there is a very good linear relationship of the measured soil strength (i.e. unsoaked CBR and DCP) with the soil initial state factor as described by the combination of initial dry density, water content and void ratio. Comparison of the measured and predicted values of unsoaked CBR and DCP using the developed equation clearly indicates the validity of this equation. This study showed that the DCP is the most simple and inexpensive test and is preferred to predict the in-situ CBR for the different pavement layers. Several correlations were developed between the DCP with the CBR. The results of this study indicated that the soil initial state factor can reliably predict the strength measured by CBR and DCP, and thus can be used to evaluate the strength characteristics of compacted soils, subgrade, base layers, and embankments for design purposes.The results of this study proved that the ratio CBR to DCP had very good linear relationship with the soil initial state factor. **S.P. Singh, A. Pani .(2014)** investigated that rapid growth of industrialization and large scale infrastructural development in India has resulted in scarcity of construction materials and unchecked increase in the environmental pollution. There is a thrust to investigate the feasibility of industrial waste materials to replace the conventional construction materials. Soil stabilization has been implemented for improving soils, which have inadequate engineering properties. This paper discusses the possibilities and ways of improving the strength properties of compacted flyash which is collected from the captive power plant of NSPCL-RSP stabilized with different percentages of lime. It describes a research that focus on the effect of lime content on compaction characteristics and CBR values of fly ash subjected to different compactive energies. The CBR(California bearing ratio) values at both soaked and un-soaked conditions , (OMC) optimum moisture content and (MDD) maximum dry density of compacted fly ash mixed with 1%,2%,5% and 10% lime after different curing periods were evaluated, and is compared with properties of virgin fly ash. With addition of lime maximum dry density increases and optimum moisture content decreases. Addition of lime results in filling the voids of the compacted fly ash thus increases the density. **Gati Sri Utami (2014)** studied that sub grade is a very important part to support all construction loads on it. If the clay sub grade that had unfavorable properties, such as low CBR, the high swelling when applied to the construction of the road sub grade soil would produce a soil that is easily damaged. For that, if used in the construction of CBR value should be towering so that it can withstand a load on it. The swelling would reduce the volume of soil that is stable when it rains the soil is not swollen, otherwise when the dry season does not shrink too high. Ground improvement methods used in this study was stabilization of lime-soil, using a mixture of percentage 5%, 10% and 15% of the lime. Tests performed on the Atterberg limits, Compaction (Standard Proctor Test), C.B.R laboratory, and Swelling. The results of the study about a large percentage of the value of lime plasticity (liquid limit, plasticity index) decreased with the increasing compaction. The average CBR value is increased for the natural soil to percentage 5% and 10% of lime, while the percentage of 15% decreased. For the swelling, the percentage of 15% lime with 24 hours immersion showed 45.28% increase in swelling of the normal soil (i.e. 31.67% to 17.33). **Ankit Singh Negi et al. (2013)** studied that the Soil stabilization can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality of the soil . The main objectives of the soil stabilization is to increase the bearing capacity of the soil ,its resistance to weathering process and soil permeability. The long-term performance of any construction project depends on the soundness of the underlying soils. Unstable soils can create significant problems for pavements or structures, Therefore soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure especially in case of soil which are highly active, also it saves a lot of time and millions of money when compared to the method of cutting out and replacing the unstable soil. Lime is used as an excellent soil stabilizing materials for highly active soils which undergo through frequent expansion and shrinkage. Lime acts immediately and improves various property of soil such as carrying capacity of soil, resistance to shrinkage during moist conditions, reduction in plasticity index, increase in CBR value and subsequent increase in the compression resistance with the increase in time.

III.EXPERIMENTAL PROGRAMME

Detailed investigations are carried out on three different soils collected from Haryana. Initially experiments were conducted to find out gradation, liquid limit, plastic limit and the plasticity index of these soils. Apparatus used for determining the Liquid Limit is Casagrande Apparatus. Specific gravity of these soils are determined using Pycnometer bottle. After assessing the index properties, proctor compaction tests were conducted to find out the optimum moisture content (OMC) and maximum dry density (MDD) for the soils and for soil mixed with different types of soil stabilizers. Lime and fly ash were used for soil stabilization. The CBR tests were conducted to evaluate the behavior of soils and soil mixed with different type of soil stabilizers i.e. lime and fly ash.

A. Methodology

Papers have been studied related to improvement in CBR value of soil. Literature review has been given about improvement in CBR value of soil using moorum, geo-grid reinforcement, jute fiber, rice husk ash, crushed coconut shells and Coir Fiber. Some more study will be done related to improvement in CBR value of soil and some experimental work on CBR value will be performed and analyzed in any industry or in any Institution. Steps to be followed for this work are:

1) Literature survey for improvement in CBR value of soil
2) Planning for the experiment work
3) Collection of data by conducting experiments as per the plan
4) Comparative study between actual and predicted results
5) Conclusion and Future Scope

B. Materials Used

Fly ash is a by-product of the pulverized coal combustion process. Fly ash has silica, alumina and various oxides and alkalies as its constituents. It is fine-grained and pozzolanic in nature. Fly ash is waste material imposing hazardous effect on environments and human health. Also, it cannot be disposed of properly and its disposal is not economically viable but if it is blended with other construction materials like clayey soil then it can be used best for various construction purposes like subgrade, foundation base and embankments.**Lime** is a very fine material used in many construction applications. Lime is produced by burning of calcium carbonate at elevated temperatures and is cooled up to obtain a homogeneous powder. There are many types of lime depending on its chemical composition and contents of calcium and magnesium.

C. California Bearing Ratio (CBR) Test

The California bearing ratio (CBR) is expressed as the percentage of force per unit area required to penetrate a soil mass with a circular plunger of 50 mm diameter at the rate of. 1.25 mm/min to that required for corresponding penetration in a standard material. The ratio is usually determined for penetration of 2.5 mm and 5.0 mm. Where the ratio at 5.0 mm is consistently higher than that at 2.5 mm, the ratio at 5.0 mm is used. This is the most widely used method for the design of flexible pavement.

C.B.R. = Test Load*100/Standard Load

According to O Flaherty (1988), the C.B.R. test is an empirical test and depends upon the condition of the soil at the time of testing. This requires that the soil must be tested in a condition that is critical to the designer. According to the state commission of roads and bridges (SCRB, 1999) specification the CBR must correspond to 95% of the maximum dry density of the modified AASHTO compaction.

1) *Equipment*

a) Cylindrical mould with inside diameter 150 mm and height 175 mm, provided with a detachable extension collar 50 mm height and a detachable perforated plate 10 mm thick.
b) Spacer disc 148 mm in diameter and 47.7 mm in height along with handle.
c) Metal rammer: **-** Weight 2.6 kg with a drop of 310 mm (or) weight 4.89 kg a drop 450mm.
d) Weights: **-** one annular metal weight and several slotted weights 2.5 kg each, 147 mm in diameter, with a central hole of 53 mm in diameter.
e) Loading machine: **-** With a capacity of at least 5000 kg and equipped with a movable head or base that travels at a uniform rate of 1.25 mm/min. Complete with load indicating device.
f) Metal penetration piston 50 mm diameter and minimum of 100 mm in length.
g) Two dial gauge with least count of 0.01 mm.
h) Sieves 4.75 mm and 20 mm IS sieves.
i) Miscellaneous apparatus, such as mixing bowl, straight edge, scales soaking tank or pan, drying oven, filter paper and containers.
j) The test may be performed on undisturbed specimen sand on remoulded specimens which may be compacted either statically or dynamically. Table 4.2gives the standard loads adopted for different penetrations for the standard material with a C.B.R. value of 100%.

TABLE - CBR VALUE OF ML SOIL MIXES

Type of Soil Mix	CBR value (%)	% increase in CBR
ML soil only	4.1	-
ML soil + 3% lime	5.3	29.3
ML soil + 5% lime	6.3	53.7
ML soil + 10% lime	7.5	82.9
ML soil + 3% fly ash	5.0	21.9
ML soil + 5% fly ash	5.7	39.0
ML soil + 10% fly ash	6.9	68.3

TABLE - CBR VALUE OF CL SOIL MIXES

Type of Soil Mix	CBR value (%)	% increase in CBR
CL soil only	2.8	-
CL soil + 3% lime	3.7	32.1
CL soil + 5% lime	4.5	60.7
CL soil + 10% lime	5.2	85.7
CL soil + 3% fly ash	3.5	25.0
CL soil + 5% fly ash	4.0	42.9
CL soil + 10% fly ash	4.8	71.4

TABLE - CBR VALUE OF SM SOIL MIXES

Type of Soil Mix	CBR value (%)	% increase in CBR
SM soil only	7.1	-
SM soil + 3% lime	8.5	19.7
SM soil + 5% lime	9.0	26.7
SM soil + 10% lime	9.6	35.2
SM soil + 3% fly ash	8.2	15.5
SM soil + 5% fly ash	8.7	22.5
SM soil + 10% fly ash	9.4	32.4

TABLE - INCREASE IN CBR OF SOILS WITH LIME AND FLY ASH

Soil type	% increase in CBR					
	Lime (%)			Fly Ash (%)		
	3	5	10	3	5	10
ML	29.3	53.7	82.9	21.9	39.0	68.3
CL	32.1	60.7	85.7	25.0	42.9	71.4
SM	19.7	26.7	35.2	15.5	22.5	32.4

IV. CONCLUSIONS

A. The selected soils belong to ML (silts of low plasticity), CL(clays of low plasticity) and SM (silty sands) type of soils. The sand content in the ML, CL and SM soils is found to be 27.1%, 18.3% and 50.2% respectively. The PI of ML soil is 2.01%, CL soil is 9.12% and SM soil is non-plastic.

B. With the addition of lime as well as fly ash the liquid limit and plasticity index of the ML and CL type soils are found to decrease. The more the proportion of these admixtures in the mix, more is the reduction in LL and PI.

C. The MDD of the selected soils decreases and the OMC of the soils increases with the addition of lime as well as fly ash. The reduction in MDD and increase in OMC is more with increase in the proportion of admixtures in the soils.

D. The addition of lime causes maximum reduction in MDD of CL type soil where as least reduction is observed in SM type soil.

E. The addition of fly ash with the soils exhibited similar trend as that of addition of limeon the values of MDD.

F. For the same proportion of admixtures in the soils, lime causes more reduction in MDD of the soil than fly ash.

G. In contrast to MDD of the soils, OMC of the soils increases with the addition of lime as well as fly ash in the soils. The increase in OMC is more with more proportion of admixtures in the soil.

H. The increase in OMC with the addition of same proportion of admixtures in the soil is more in respect of CL soil followed by ML and SM soils.

I. The results of the study show that both lime and fly ash are suitable for enhancing properties of the soils that are generally available in Haryana.

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