Research Paper E-ISSN NO : 2455-295X | VOLUME : 3 | ISSUE : 9 | SEP 2017

AN EXPERIMENTAL INVESTIGATION ON HYDRATED HYDRATED LIME AND FLY ASH IN IMPROVING CBR OF SOIL IN ANDHRA PRADESH

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ABSTRACT

The sub-grade, sub base and base course materials affects the quality and life of pavement greatly. The type and quality of sub grade soil is most important of these. But most of flexible pavements in India are used to be constructed over weak sub grade. The California Bearing Ratio (CBR) of these sub grade have very low, it need to more thickness of pavement. This paper represents a study of Hydrated 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 Hydrated Lime and Fly Ash percentages varied from 3% to 10% .The optimum moisture content(OMC), California Bearing Ratio(CBR) increased with an increase in percentage of Hydrated Lime but liquid limit, Plastic limit, maximum dry density(MDD) of soil decreased with increase in Hydrated 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 in percentage on Fly Ash. The objective of this work is to estimate the effect of Hydrated Lime and Fly Ash on some geotechnical properties of soil, in order to determine the suitability of Hydrated 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 Hydrated 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, Hydrated Lime, Fly Ash, MDD.

Introduction

The topic "an experimental investigation on hydrated lime and fly ash in improving CBR of soil in Andhra Pradesh" aims at conducting laboratory investigations on some selected soils of Andhra Pradesh with the addition of Hydrated 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 Andhra Pradesh. 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 Andhra Pradesh. These are ML type (silts of low plasticity collected from Krishna), CL type (clays of low plasticity collected from West Godavari) and SM type (silty sands collected from Guntur). The laboratory investigations are carried out with a view to improve CBR value of the soils.

Significance of Sub grade

Soil is a deposit of earth material, derived naturally from the breakdown of rocks or decay of undergrowth that can be excavated readily with power equipment in the field or disintegrated by gentle reflex means in the laboratory. Top 500 mm of naturally occurring local soil that is well compacted is generally termed as sub-grade. It is just beneath the pavement crust, providing a suitable foundation for the pavement. The loads on the pavements are ultimately transmitted to the ground below through the sub-grade. The sub grade, whether in cutting or in embankment, should be well compacted to utilize its full strength and to economize on the overall pavement thickness. The current MORTH specifications require that the sub-grade should be compacted to 97% of Maximum Dry Density (MDD) achieved by the Modified Proctor Test (IS 2720-Part 8). For the purpose of flexible pavement design, sub-grade soil is characterized on the basis of CBR. Better sub-grade means higher CBR which results in lower thickness requirement for a particular traffic.

Study topic and its importance

The topic "an experimental investigation on hydrated lime and fly ash in improving CBR of soil in Andhra Pradesh" aims at conducting laboratory investigations on some selected soils of Andhra Pradesh with the addition of Hydrated 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 Andhra Pradesh.

Objectives of the study

The study topic "an experimental investigation on hydrated lime and fly ash in improving CBR of soil in Andhra Pradesh" consists of conducting laboratory investigations on different types of soils generally available in Andhra Pradesh to evaluate their CBR value. These soils are tested without any admixtures and also with admixtures of Hydrated Lime and fly ash, to determine improvement in their properties. The main objectives of the study are:

To evaluate various properties of selected soils such as gradation, Atterberg limits, optimum moisture content (OMC), maximum dry density (MDD) and CBR value of the soils that are generally available in Andhra Pradesh.

- To mix these soils with varying proportion of Hydrated Lime and fly ash and evaluate above mentioned properties of the mixes.
- To study the effect of Hydrated Lime and fly ash on various properties of the selected soils and discuss the results of the study.
- To determine suitability of the admixtures for the soils selected for the study.

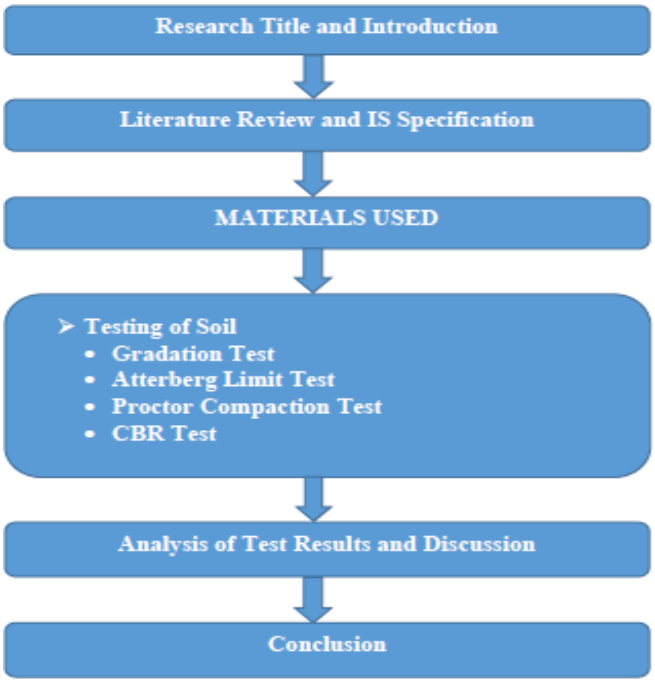
Scope of the study

The study has been conducted on three different types of soils that are generally available in Andhra Pradesh. These are ML type (silts of low plasticity collected from Krishna), CL type (clays of low plasticity collected from West Godavari) and SM type (silty sands collected from Guntur). The laboratory investigations are carried out with a view to improve CBR value of the soils. The admixtures used with the soils include slaked Hydrated Lime (available in powder form) and fly-ash (source Vijayawada thermal power plant). The results of the study are applicable for the given types of soils and given admixture as used in study. The methodology and procedure used for conducting the study, however, being general in nature can be applied to any other soil and admixture having similar properties. Investigations include evaluation of properties like specific gravity, gradation, Atterberg's limits, and wet sieve analysis, maximum dry density (MDD), optimum moisture content (OMC) and California Bearing Ratio (CBR) value of the selected soils. The Hydrated Lime and fly ash are mixed separately with the each of the soils at 3%, 5%, and 10% by the weight of dry soil.

Experimental Program

Detailed investigations are carried out on three different soils collected from Andhra Pradesh. 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. Hydrated 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. Hydrated Lime and fly ash.

Methodology



Methodology of the study

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.

Materials

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 sub-grade, foundation base and embankments.

Hydrated Lime is a very fine material used in many construction applications. Hydrated 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 Hydrated Lime depending on its chemical composition and contents of calcium and magnesium.

Analysis of results and discussion

General

In order to meet the objectives of the study, a series of experiments on three types of soils is carried out with two types of admixtures. Detailed experimental procedure has been explained in Chapter 4. Experimental results and their analyses are presented in this chapter as per testing program. Results are presented considering and comparing the effects of various soil admixtures on CBR value of the selected soils in the following sequence:

- Test results on three different type of soils
- Test result on Soil-Hydrated Lime mixes
- Test result on Soil-Fly ash mixes

The sub-grade testing is important for a highway engineer which includes Atterberg's limits, sieve analysis, proctor compaction tests and CBR tests. These tests have been carried out on three different types of selected soils first without any admixtures and then with admixtures of Hydrated Lime and Fly Ash. Hydrated Lime and fly ash have been mixed separately with the soils at a rate of 3%, 5% and 10% by weight of dry soil.

Test results of selected soils

Three types of soils have been selected for the study from three places in Andhra Pradesh i.e. Krishna, West Godavari and Guntur with a view that the soils represent the usual type of soils that are generally available in most parts of Andhra Pradesh. The various test results on the soils are given below:

Classification of the Selected Soils

Atterberg's Limit have been determined as per IS: 2720 (Part 5)-1985. These tests are performed to determine liquid limit, plastic limit and the plasticity index of the soil and soil mixes. The results are presented in Table 1.1.

Table 1.1 Atterberg's Limits

Index properties	*Observed value for Soil Type*		
	Krishna Soil	*West Godavari Soil*	*Guntur Soil*
L L (%)	*26.71*	*33.34*	-
P L (%)	*23.68*	*23.22*	-
P I (%)	*3.03*	*10.12*	*Non-plastic*

Wet Sieve Analysis

Wet sieve analysis is carried out on the soil sample as per IS 2720: Part 4 (1985). The results of the wet sieve analyses are given in Table 1.2.

Table 1.2 Grain size distribution of soils and admixtures

Soil Type	*Gravel Size (+4.75 mm)*	*Sand Size (4.75 mm – 0.075 mm)*	*Silt & Clay Size (<0.075 mm)*
Krishna Soil	*0*	*28.1*	*71.9*
West Godavari Soil	*0*	*19.3*	*80.7*
Guntur Soil	*0*	*51.5*	*48.5*
Hydrated Lime	*0*	*12.2*	*87.8*
Fly Ash	*0*	*10.1*	*89.9*

Classification of the Soils

From the results of the grain size distribution and plasticity properties of the soils, the classification of the soils has been made as per IS: 1498-1970 and given in Table 1.3.

Table 1.3 Classification of soils

Place of Collection of Soil Sample	*Soil type as per IS:1498-1970*
Krishna	*ML (silts of low plasticity)*
West Godavari	*CL (clays of low plasticity)*
Guntur	*SM (silty sands)*

Specific Gravity Test

Specific gravity is determined in the laboratory using Pycnometer bottle as per 2720: Part 3 (1980). Specific gravity is a dimension less parameter which indirectly tells us about the intra-particle voids (voids present within the solid particle) of the soil. Table 1.4 gives the observed specific gravity of the soils selected for the study. For good soils to be used for engineering purposes, the specific gravity is generally between 2.6 to 2.9.

Table 1.4 Specific Gravity of Selected Soils and Admixtures

Types of soil / Admixture	*Specific Gravity*
ML soil	*2.67*
CL soil	*2.69*
SM soil	*2.65*
Hydrated Lime	*2.20*
Fly Ash	*2.14*

The values of MDD and OMC obtained shown in Table 1.5.

Table 1.5 MDD and OMC of ML soil mixes

Type of Soil Mix	*MDD (g/cc)*	*% Decrease in MDD*	*OMC (%)*	*% Increase in OMC*

ML soil only	*1.992*	*-*	*12.60*	*-*
ML soil + 3% Hydrated Lime	*1.908*	*4.2*	*13.40*	*6.4*
ML soil + 5% Hydrated Lime	*1.875*	*5.9*	*13.76*	*9.2*
ML soil + 10% Hydrated Lime	*1.828*	*8.23*	*14.68*	*16.5*
ML soil + 3% fly ash	*1.958*	*1.7*	*12.92*	*2.5*
ML soil + 5% fly ash	*1.921*	*3.6*	*13.10*	*4.0*
ML soil + 10% fly ash	*1.881*	*5.6*	*14.05*	*11.5*

The values of MDD and OMC obtained shown in Table 1.6.

Table 1.6 MDD and OMC of CL soil mixes

Type of Soil Mix	*MDD (g/cc)*	*% Decrease in MDD*	*OMC (%)*	*% Increase in OMC*
CL soil only	*1.947*	*-*	*12.87*	*-*
CL soil + 3% Hydrated Lime	*1.828*	*6.1*	*15.21*	*18.1*
CL soil + 5% Hydrated Lime	*1.810*	*7.0*	*15.50*	*20.4*
CL soil + 10% Hydrated Lime	*1.770*	*9.1*	*16.50*	*28.2*
CL soil + 3% fly ash	*1.867*	*4.1*	*14.74*	*14.5*
CL soil + 5% fly ash	*1.847*	*5.1*	*15.20*	*18.1*
CL soil + 10% fly ash	*1.802*	*7.5*	*17.10*	*32.8*

The values of MDD and OMC obtained Table 1.7.

Table 1.7 MDD and OMC of SM soil mixes

Type of Soil Mix	*MDD (g/cc)*	*% Decrease in MDD*	*OMC (%)*	*% Increase in OMC*
SM soil only	*1.932*	*-*	*12.47*	*-*
SM soil + 3% Hydrated Lime	*1.914*	*1.0*	*13.13*	*5.3*
SM soil + 5% Hydrated Lime	*1.888*	*2.3*	*13.42*	*7.6*
SM soil + 10% Hydrated Lime	*1.875*	*3.0*	*14.11*	*13.2*
SM soil + 3% fly ash	*1.920*	*0.6*	*14.84*	*19.0*
SM soil + 5% fly ash	*1.892*	*1.5*	*15.21*	*22.0*
SM soil + 10% fly ash	*1.868*	*3.3*	*15.92*	*27.7*

Table 1.8 Decrease in MDD of soils with Hydrated Lime and Fly Ash

Soil type	*% Decrease in MDD*					
	Hydrated Lime (%)			*Fly Ash (%)*		
	3	*5*	*10*	*3*	*5*	*10*
ML	*4.2*	*5.9*	*8.23*	*1.7*	*3.6*	*5.6*
CL	*6.1*	*7.0*	*9.1*	*4.1*	*5.1*	*7.5*
SM	*1.0*	*2.3*	*3.0*	*0.6*	*1.5*	*3.3*

Table 1.9 Increase in OMC of soils with Hydrated Lime and Fly Ash

Soil type	*% Decrease in MDD*					
	Hydrated Lime (%)			*Fly Ash (%)*		
	3	*5*	*10*	*3*	*5*	*10*
ML	*6.4*	*9.2*	*16.5*	*2.5*	*4.0*	*11.5*
CL	*18.1*	*20.4*	*28.2*	*14.5*	*18.1*	*32.8*
SM	*5.3*	*7.6*	*13.2*	*19.0*	*22.0*	*27.7*

The values of CBR obtained shown in Table 1.10.

Table 1.10 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 1.11 CBR value of CL soil mixes

Type of Soil Mix	*CBR value (%)*	*% increase in CBR*
CL soil only	*2.8*	-
CL soil + 3% Hydrated Lime	*3.7*	*32.1*
CL soil + 5% Hydrated Lime	*4.5*	*60.7*
CL soil + 10% Hydrated 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*

The values of CBR obtained shown Table 1.12.

Table 1.12 CBR value of SM soil mixes

Type of Soil Mix	*CBR value (%)*	*% increase in CBR*
SM soil only	*7.1*	-
SM soil + 3% Hydrated Lime	*8.5*	*19.7*
SM soil + 5% Hydrated Lime	*9.0*	*26.7*
SM soil + 10% Hydrated 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 1.13 Increase in CBR of soils with Hydrated Lime and Fly Ash

Soil type	*% increase in CBR*					
	Hydrated 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*

Conclusions

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.

With the addition of Hydrated 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.

The MDD of the selected soils decreases and the OMC of the soils increases with the addition of Hydrated 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.

The addition of Hydrated Lime causes maximum reduction in MDD of CL type soil where at least reduction is observed in SM type soil.

The addition of fly ash with the soils exhibited similar trend as that of addition of Hydrated Lime on the values of MDD.

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

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

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. The results of the study show that both Hydrated Lime and fly ash are suitable for enhancing properties of the soils that are generally available in Andhra Pradesh.

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