USE OF CERTAIN ADMIXTURES IN THE CONSTRUCTION OF PAVEMENT ON EXPANSIVE CLAYEY SUBGRADES

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Abstract:
Due to rapid industrialization throughout the world, the production of huge quantity of produced waste materials creates not only the environmental problem but also the depositional hazards. Many procedures have been developed to improve the mechanical properties of soil by incorporating a wide range of stabilizing agents, additives and conditioners. In this paper, an attempt has been made to utilize industrial wastes like Rice Husk Ash (RHA), Fly Ash (FA) and Ground Granulated Blast furnace Slag (GGBS) as stabilizing agents. In addition to these, Lime was also added as stabilizing agent. The effect of Lime, RHA, FA and GGBS on certain properties of soil such as Optimum moisture content (OMC), Maximum Dry Density (MDD), Unconfined Compressive Strength (UCS) and California Bearing Ratio (CBR) has been studied. It has been established by experiments conducted on the samples that there is a maximum change in the properties with addition of lime up to 5%, RHA and GGBS up to 15% per cent and FA up to 20%. Of all the admixtures, Lime shows considerable increase in strength characteristics at an optimum lime content of 5% which gave maximum

Keywords Compaction, Unconfined Compressive Strength, California Bearing ratio, Expansive soil, Stabilization

1 Introduction

Some partially saturated clayey soils are very sensitive to variations in water content and show excessive volume changes. Such soils, when they increase in volume because of an increase in their water contents, are classified as expansive soils. Problem of expansive soils has appeared as cracking and break-up of pavements, railways, highway embankments, roadways, building foundations, channel and reservoir linings, irrigation systems, water lines, sewer lines etc.[1,2,3].It was reported that damage to the structures due to expansive soils has been the most costly natural hazard in some countries. In the United States damage caused by expansive clays exceeds the combined average annual damage from floods, hurricanes, earthquakes, and tornadoes[4]. Documented evidence of the problems associated with expansive clays is worldwide, which occurred in countries like United States, China, Australia, India, Canada, and regions in Europe[5].Changes in the moisture content of clay soils are generally accompanied by volume changes. On moisture uptake, there is generally a volume increase and moisture loss is accompanied by shrinkage[6].Expansion of soils is generally observed in unsaturated clays which are of certain mineralogical structures (eg. Smectites). Such soils have a high capacity of water absorption and thus they absorb water meanwhile their volume increase. Expansive soils are generally abundant in the arid or semi-arid regions where the rate of evaporation is much higher than rate of precipitation. An expansive soil will shrink when water (or moisture) content is reduced and will swell when the water content increases. Expansive soils cause more damage to structures, particularly to light buildings and pavements. Soil stabilization is the process by which a stabilizing agent is added to natural soil deposit to improve the engineering properties of soils by mechanical or chemical means or both. There are numerous stabilization methods and techniques currently in practice. The type of technique to be chosen for a particular site depends on the type of soil to be stabilized, the extent of required stabilization, the type of structure to be built, the availability of materials, and the environmental effects. Soil stabilization improves shearing resistance of the soil, stiffness, resistance to wear and water penetration of unsealed roads. Soil stabilization is a procedure where natural or manufactured additives or binders are used to improve the properties of soils. There are several methods that have been used to minimize or eliminate the ill effects of expansive soils on structures. These methods include chemical stabilization, soil replacement with compaction control, prewetting, moisture control, surcharge loading, and use of Geosynthetics. Chemical additives, such as lime, cement, fly ash, and other chemical compounds have been used in expansive soil stabilization for many years with various degrees of success [7].

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2 Materials and Methods

2.1 Soil

The soil used in this study was obtained from Gajulamandyam near Tirupati. Disturbed but representative soils were collected from trial pits at a depth of about 2.0m from ground level. The soil collected from the site was pulverized with wooden mallet to break lumps and then air-dried. Subsequently it was sieved through 2.36 mm IS sieve and then dried in an oven at 105^0C for 24 hours The properties of the soil along with classification are presented in Table 1. The soil falls under the CH category i.e., clay of high compressibility as per I.S Classification System (IS 1498-1970). The fine fraction has very high Liquid Limit and Plasticity Index. Based on Differential Free Swell Index, Liquid Limit and Plasticity Index, the soil comes under the category of High degree of Expansiveness.

2.2 Lime

The per cent lime to be added was determined from ASTM D 6276. The soil and lime were dry mixed together and then water was added to bring the moisture content up to the target per cent. Due care was taken to ensure a uniform soil-lime mixture. The soil- lime mixture was placed in an airtight container to mellow overnight.

2.3 Rice Husk Ash (RHA)

Rice husk ash is a predominantly siliceous material, annually generated about 4.73 mT after burning rice husk in a boiler or in open fire. But rice husk ash used in the present study was obtained from local rice mill.

*2.*4 Fly Ash (FA)

Fly ash is one of the residues generated in the combustion of coal. Fly ash is generally captured from the chimneys of coal tired power plants and is one of the two types of ash that jointly are known as coal ash the other bottom ash is removed from the bottom of coal furnaces. Depending upon the source and make-up of the coal being burnt, the components of fly ash vary considerably but all fly ash includes substantial amounts of silicon dioxide (SiO_2) and calcium oxide (Cao). Toxic constituents include cobalt, lead, manganese, mercury, arsenic, beryllium, boron, cadmium, chromium, Molybdenum, selenium, etc. In the present project, class F fly ash is used.

2.5 Ground Granulated Blast Furnace Slag (GGBS)

GGBS is the granular material formed when molten iron blast furnace slag is rapidly chilled by immersion in water. It is a granular product with very limited crystal formation.

Table 1. Properties of soil

CHARACTERISTICS	VALUE
Specific gravity	2.69
Particle Size distribution	
a) Gravel (%)	Nil
b) Sand (%)	12
c) Silt+Clay (%)	88
Liquid limit (%)	98
Plastic limit (%)	13
Plasticity index (%)	85
Differential Free Swell Index (%)	150
Classification of soil	CH
Maximum dry density (kN/m^3)	17.99
Optimum moisture content (%)	14
Unconfined Compressive Strength (kN/ m^2)	145

CBR (%) in Unsoaked condition	7

3 Tests Conducted

The compaction tests on untreated and admixed soil were conducted in accordance with I.S.2720:1980.UCC tests were conducted in accordance with I.S.2720:1973. CBR tests were conducted in accordance with I.S.2720:1979.

4 Results and Discussions

4.1 Untreated soil:

The test results obtained on untreated soil sample were given in Figs. 1, 2, 3.

Fig 1 shows the compaction curve. The OMC and MDD are 14% and 17.99 kN/m^3 respectively. The stress-strain plots obtained from unconfined compression strength is shown in fig 2.Average value of UCS obtained from the plots is 145 kN/m$^{2.}$ Fig 3 depicts load Vs penetration curve obtained from CBR tests carried out in unsoaked condition.CBR value computed is 7%.

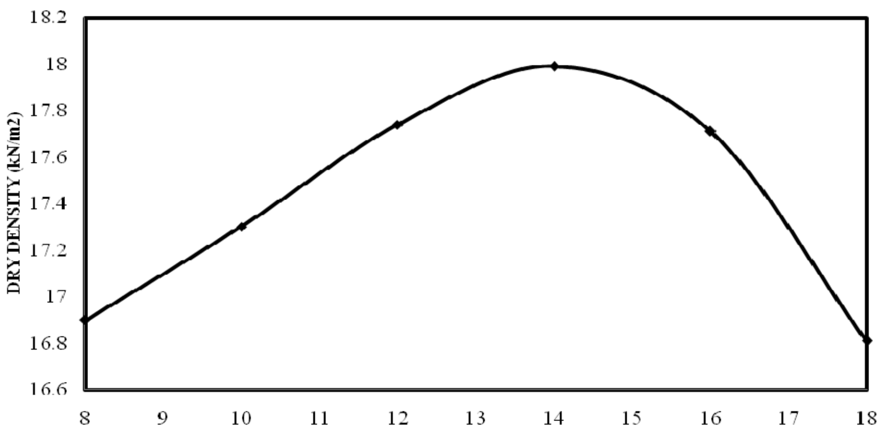

Fig 1. COMPACTION CURVE FOR UNTREATED SOIL

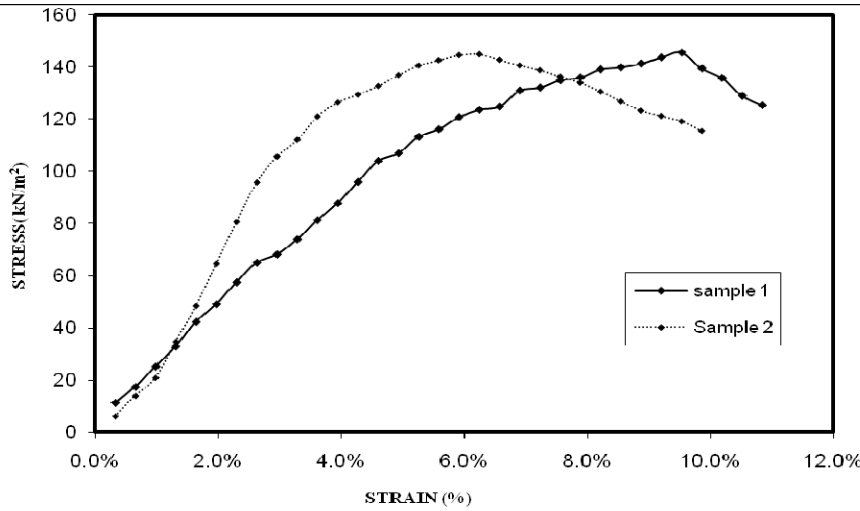

Fig 2 .STRESS -STRAIN PLOT OF UNTREATED SOIL

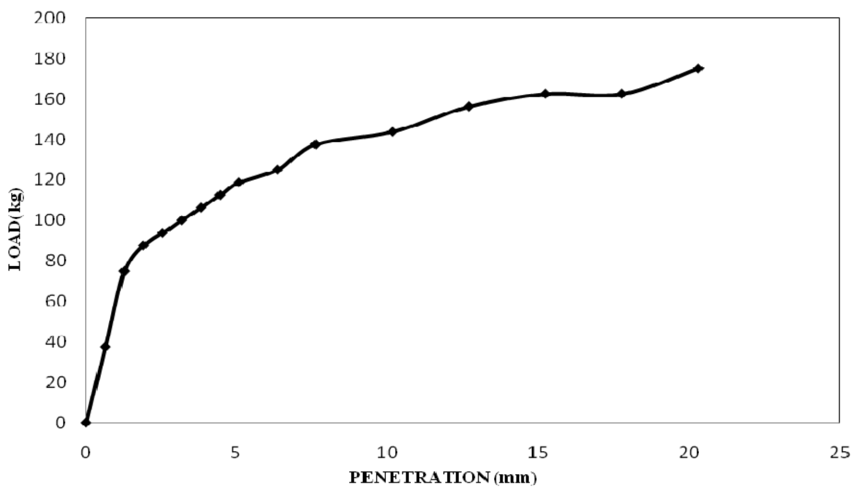

Fig 3. LOAD Vs PENETRATION CURVE FOR UNTREATED SOIL

4.2 Treated soil:

4.2.1 Compaction characteristics

The variation of OMC with percent admixture is shown in Fig 4.The curve shown towards the left is for lime whereas the curve towards the right is for FA .The curves lying in between these two curves are RHA and GGBS. It is observed from these curves that OMC increases with increase in per cent lime, RHA, FA and GGBS. Earlier studies had also observed that the addition of Lime, RHA, FA and GGBS leads to an increase in OMC. The increase in optimum moisture content is probably a consequence of additional water held within the flocculated soil structure resulting from interaction. The variation of MDD with percent admixture is presented in Fig 5.Top most curve corresponds to FA, whereas bottom most curve corresponds to lime. The curves for RHA, FA and GGBS lie in between these two curves. It is observed that as percentage of admixture increases, MDD decreases in the case of Lime, RHA and GGBS. The decrease in the MDD of the treated soil is reflective of increased resistance offered by the flocculated soil structure. But, in case of FA, MDD increases as percentage of FA increases in the soil.

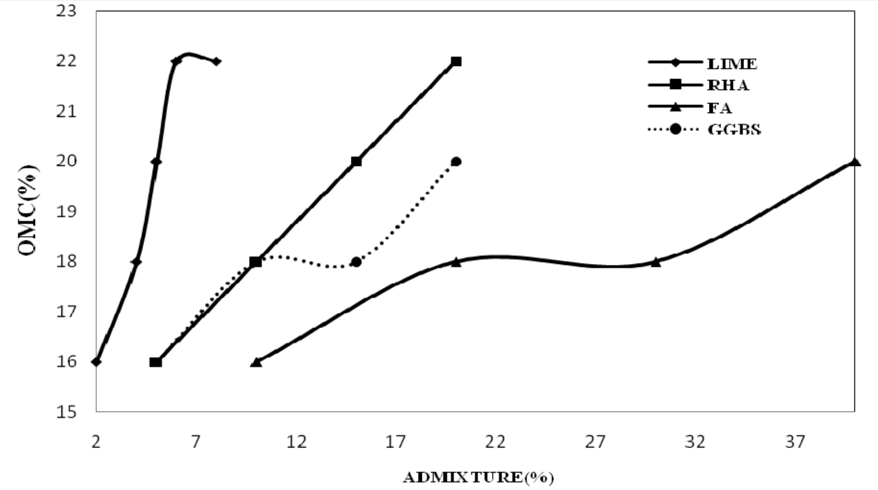

FIG 4. VARIATION OF OMC WITH PER CENT ADMIXTURE

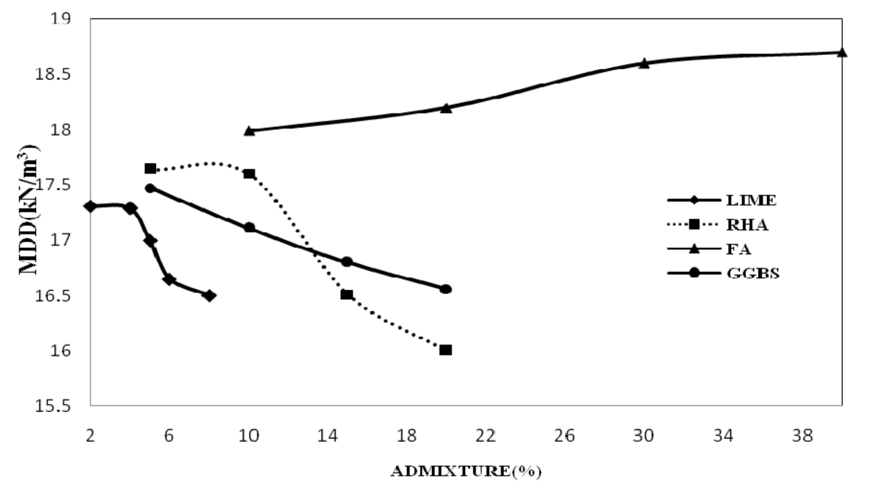

FIG 5. VARIATION OF MDD WITH PER CENT ADMIXTURE

4.2.2 Strength characteristics

Fig 6 shows the variation of unconfined compressive strength for soil at different percentages of all admixtures used. A general pattern is observed in which the strength develops rapidly with addition of admixture until an optimum condition is reached, beyond which the increase in strength is either nominal or there is marginal decrease in strength when compared to untreated soil. The optimum lime content is observed to be 5 % from UCS point of view. Maximum UCS value obtained was 251.83 kN/m^2 at 5% lime content. Further, it was observed that addition of 15% RHA gave a compressive strength of 174.6 kN/m^2. The optimum RHA content is observed to be about 15 %.The optimum FA content and GGBS content are observed to be 20% and 15% which gave a compressive strength of 193.72 kN/m^2 and 166.42 kN/m^2 respectively. The absolute values of UCS for lime, RHA, FA and GGBS at their respective content are given in Table 2.The percent increase in UCS is also shown in the same table. From the Table, it is observed that addition of admixture to soil improves the strength. The maximum improvement is found in the case of Lime, followed by FA, RHA and GGBS. Hence, it can be concluded that lime is more effective in improving the strength out of the admixtures chosen for the study. Therefore, stability of structures on expansive soils is more when soil is admixed with lime. In tropical countries where rice husks are abundant and considered as waste material, use of RHA, lime, FA and GGBS in the construction of roads, airfields and other earthworks may particularly become attractive, because of reduced construction costs, reduced disposal costs, environmental damage and conservation of high grade construction materials.

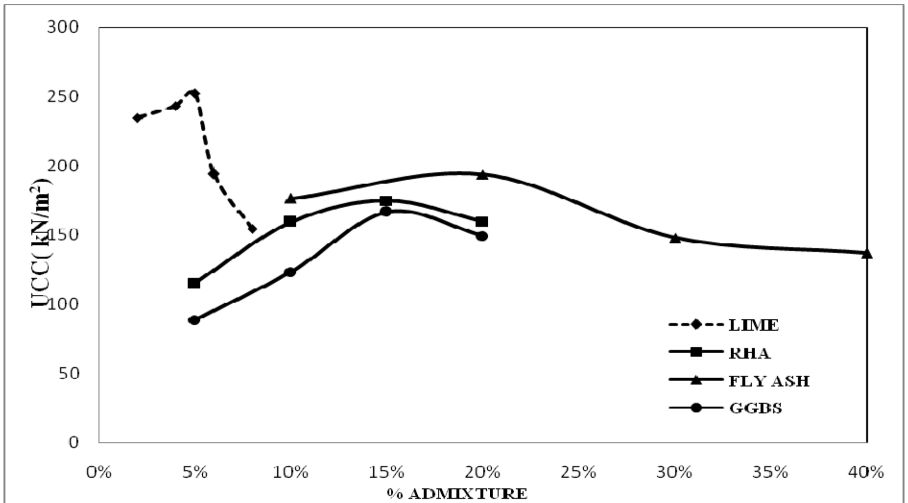

FIG 6. VARIATION OF UCC WITH PER CENT ADMIXTURE

4.2.3 California Bearing Ratio

Fig-7 shows the load versus penetration curve for various admixtures at their respective optimum content values. From these curves, CBR values were computed and presented in Table 2.The percent improvement is also shown in the same Table. CBR value at 5% lime was observed as 12.24%, at 15% RHA is 10.5%, at 20% FA is 12.16% and 15% GGBS is 9.57 % respectively, whereas CBR value of untreated soil is 7%. The increase in CBR value after addition of admixtures is due to the formation of various cementing agents due to pozzolanic reaction between silica present in soil and admixtures. The percent improvement in CBR value is 75% in case of lime, 74% for FA, 50% for RHA and 37% for GGBS. Both lime and FA are more effective in improving the CBR values. Hence, there are certain beneficial effects, when pavements, especially flexible pavements are constructed on expansive clayey sub grades stabilized with admixtures such as lime, FA, RHA and GGBS. Thus, utilization of industrial wastes such as FA, RHA and GGBS in the construction of pavements on expansive clayey sub grades reduces not only environmental problems, but also depositional hazards. Therefore the efficiency of stabilization may be greatly increased by the addition of admixtures.

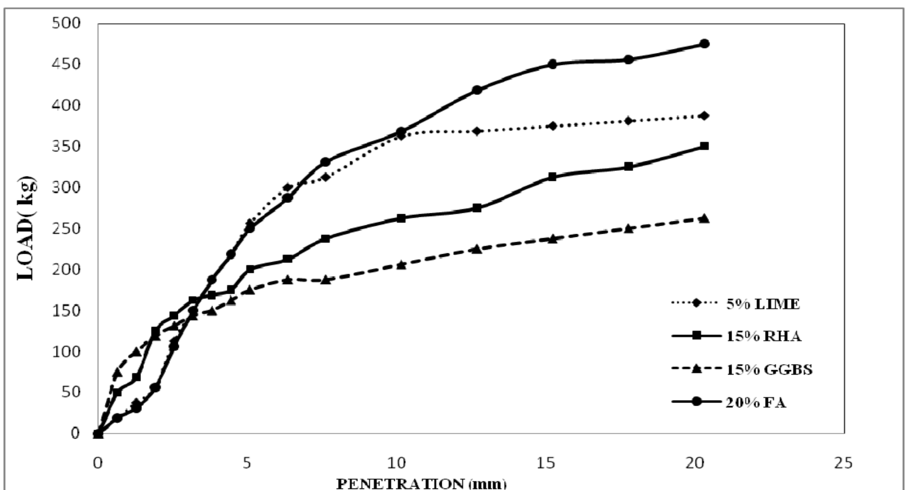

Fig 7. LOAD Vs PENETRATION CURVE AT OPTIMUM PER CENT OF ADMIXTURES

Table 2: UCC and CBR Values at Optimum Per Cent of Admixture

S no.	Type of admixture	Optimum per cent of admixture	UCC (kN/m^2)	% increase in UCC	CBR (%)	% increase in CBR
1	Lime	5 %	251.82	74	12.24	75
2	RHA	15 %	174.6	21	10.5	50
3	FA	20 %	193.72	34	12.16	74
4	GGBS	15 %	166.42	15	9.57	37

5 Conclusions

On the basis of the present study, the following conclusions are made:

- With the increase in Lime, GGBS and RHA content, MDD of soil decreases whereas OMC increases.
- Increase in FA content showed increase in both OMC and MDD.
- The optimum content for Lime is 5%, 10% for RHA and for FA and GGBS, it is observed at 20 %and 15% respectively based on strength. The study has been successfully conducted to assess the strength characteristics of admixtures which showed considerable improvement.
- Out of four admixtures considered in this study, lime is found to be more effective from stability and strength point of view.

6 References

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