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Administration of Stabilized Flyash Stratum in Flexible Pavements

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Abstract

Expansive soils are major source of heave stimulated structural agony. Swelling of expansive soils cause grave problems and create damage to structures. Extensive work has been carried out on waste materials concerning the feasibility and environmental suitability. Flyash, a waste byproduct from coal burning in thermal power stations is bountiful in India causing health, environmental and dumping problems. Stabilization process with model test tracks over expansive subgrade in flexible pavements is one of the solutions. Cyclic plate load tests along with heave measurements are carried out on the tracks with chemicals like lime and cement introduced in flyash subbase laid on expansive subgrades. Test results show that maximum load carrying capacity is obtained for treated alternatives compared to untreated alternatives.

Keywords: Expansive soil, Flyash, Lime, Cement,Flexible pavement

1. Introduction

Soils, which exhibit a peculiar exchange of swell-shrink behavior due to moisture fluctuations, are known as expansive soils. The soil cracks very badly and in the worst cases, the width of cracks are almost 150 mm and travel down to 3 m below ground level (Picornell and Lytton, 1989).

Flyash is a waste derivative from thermal power plants, which use coal as fuel. It is estimated that about 100 million tons of flyash is being generated from different thermal power plants in India consuming several thousand hectares of costly land for its disposal causing major health and environmental hazards (Singh and Murthy 1998, Suryanarayana, 2000). In order to utilize flyash in large quantities, ways and means are being discovered all over the world to use it for the construction of embankments and roads (Boominathan and Ratna Kumar 1996). Flyash settles less than 1% during the construction period and not afterwards. Its low density makes it suitable for high embankments (Irene Smith, 2005). Flyash has a tendency to react with lime to form different lime bearing silicates/aluminates hydrates due to its pozzolanic properties. These hydrates possess cementitious properties and are responsible for the development of strength in flyash-lime compacts which are used as structural products (Maitra et al, 2005).

Krupavaram (Krupavaram, 2004) has made an attempt to use lime stabilized flyash subbase course in model field pavement stretches. It is observed that lime stabilized flyash stretch has shown better performance in load carrying capacity and reduction of heave compared to untreated flyash subbase.

In the present work, an attempt is made to study the performance of lime-cement stabilized flyash layer in subbase course of the flexible pavement system in comparison to the flyash subbase layer.

1.1 *Materials Used:*

1.1.1 **Expansive Soil**

The soil used for subgrade is expansive soil collected from 'Godilanka' near Amalapuram, East Godavari District. This soil is classified according to I.S. classification as inorganic clay of high compressibility (CH). The properties are given in Table 1.

1.1.2 **Fly ash**

Flyash is used as subbase material collected from Vijayawada thermal power station. The properties of flyash are given in Table 1 and the chemical properties in Table 2.

1.1.3 **Road Metal**

Road metal of size 20 mm confirming to WBM – III is used in base course for the laboratory investigation.

1.2 Chemicals Used:

1.2.1 Lime

Commercial grade lime mainly consisting of 58.67% of CaO and 7.4% Silica is used in the study.

1.2.2 **Cement**

Ordinary Portland cement with Raasi brand 43 grade was used in the investigation. The properties of Portland cement as supplied by the manufacturer are given below.

Normal consistency : 30% by weight of cement
Percentage Fineness : 8%
Initial setting time : 30 minutes
Final setting time : 125 minutes
Specific gravity : 3.14

1.3 **Laboratory Investigations:**

1.3.1 **California Bearing Ratio (CBR) tests**

Different percentages of lime is mixed with flyash and compacted to OMC and MDD of untreated flyash. Soaked CBR tests, after a curing period of 7 days, are conducted in the laboratory as per IS specification. It has been found from the laboratory results that flyash with 2% lime+0.5%cement is giving a CBR value of 20%.

1.4 **Field Experimentation:**

In this investigation two Test Tracks of 3m long and 1.5m wide are laid on expansive soil subgrade as shown in the Fig 1 in the campus of JNTU Engineering College. The two test tracks with expansive soil subgrade are considered in this study. The two alternative subbases viz., alternative-1: Flyash subbase and alternative-2: Lime-Cement stabilized flyash subbases are constructed on expansive soil Subgradeas shown in Table 3. Above all the subbase courses, WBM base course III is laid uniformly. Details of procedure followed in the construction of test tracks are given in the following section.

1.5 Construction procedure of Test track on expansive soil subgrade:

Two test tracks are prepared on expansive soil subgrade, with different subbases the details of which are presented below.

1.5.1 Flyash subbase (Alternative – 1)

Excavation of test pit: A trench of size 3m long and 1.5m wide is excavated to an average depth of 0.8m. Out of which 0.5m is for laying sub-grade, 0.15m is for laying subbase and 0.15m for laying base course.

Preparation of sub-grade material: In this stretch, the expansive soil brought from 'Godilanka' is spread in the field, allowed to dry sufficiently and then pulverized to small pieces with wooden rammers.

Laying of subgrade material: In the prepared trench, the pulverized expansive soil mixed with water at OMC is laid in layers of 5cm compacted thickness, to a total thickness of 50cm. The compaction corresponding to MDD is done using hand-operated roller.

Subbase: On the prepared subgrade flyash mixed with water at OMC is laid, in the three layers, of 5cm compacted thickness to a total thickness of 15cms. Each layer is compacted to MDD using hand-operated roller.

Basecourse: On the prepared subbase three layers of WBM – III each of 5 cm compacted thickness, is laid to total thickness of 15cm.

1.5.2 **Lime-Cement stabilized flyash subbase** (Alternative – 2)

This stretch is also constructed similar to alternative-1, but instead of flyash, lime-cement stabilized flyash is used as subbase material. Based on the laboratory soaked CBR tests 2% lime+05% cement, giving 20% CBR is used for preparation of lime-cement stabilized flyash layer. Accordingly, 2% of lime+0.5% cement is mixed separately with flyash in dry state and then water is added to the mix corresponding to OMC and the mix is laid in three layers of 5cm compacted thickness to a total thickness of 15cm. Each layer is compacted to MDD using hand operator roller. After sufficient curing of the subbase, 15cm thick compacted basecourse is laid.

1.6 IN-**SITU TESTS**

1.6.1 HEAVE MESUREMENTS ON TEST TRACKS

On each test track, 1-inch thick marble blocks are placed in level with the top of the pavement surface laid on expansive soil subgrade, for the purpose of taking heave readings. Reduced levels are taken on different alternatives of test tracks periodically on the top of concrete block, for the measurement of heave.

1.6.2 **CYCLIC PLATE LOAD TESTS**

Cyclic plate load tests using 300mm diameter plate with varying pressure intensities, simulating the tyre contact pressures of 500,560,630, 700 and 1000 kPa, are carriedout. In this procedure a loading frame as shown in Fig 2 is arranged centrally over the model pavement stretch. The loading frame is loaded with the help of sand bags to the required weight as shown. A steel plate of 300 mm diameter is placed centrally over the test pit. Hydraulic jack of capacity 100 KN is placed over the plate and attached to the loading frame. A load corresponding to the pressure at 5 k Pa is applied as a seating load with the help of the hydraulic jack. The required load corresponding to different tyre pressures are applied through the hydraulic jack and the corresponding settlements are recorded. The settlement of the plate is measured by a set of three dial gauges of sensitivity 0.01mm.

The process of loading and unloading, for each pressure intensity is continued in a cyclic manner until the difference in deformation levels between successive cycles is negligibly small.

In the similar lines, the cyclic load tests are conducted for all the treatment alternatives for the two subgrades.

1.7 **LABORATORY TEST RESULTS:**

1.7.1 **Effect of Lime on CBR of flyash**

Different percentages of Lime are mixed with the flyash and compacted at OMC of untreated flyash. Soaked CBR tests are conducted in the laboratory as per IS specifications. Based on the results, it is observed that the mix having 2% lime+0.5% cement in flyash is giving a soaked CBR value of 20%, which is desirable for subbase material as per IRC specifications. Hence, the same mix is adopted as one of the subbase material, for the construction of pavement sections.

1.8 **RESULTS OF FIELD STUDIES**

1.8.1 In-situ Heave-Time studies

It is observed that the maximum heave values are 5.94mm and 2.40mm for the test track stretches with flyash and lime-cement flyash subbase respectively. It can be seen that there is a maximum reduction in heave values for lime-cement stabilized flyash subbase with respect to flyash subbase. These results are in conformity with the previous works carried out with stabilized flyash as cohesive material in arresting heave (Sreerama Rao et al., 2003).

1.8.2 Cyclic load test results for different alternative test stretches.

Cyclic plate load tests are carried out on all the test stretches laid on clayey subgrades for the two different subbases viz. flyash and lime-cement stabilized flyash. All the tests are carried out for different tyre pressures during wet season. For expansive soil subgrade the total deformation at 500 KPa is decreased by 66.66 % for treated lime-cement flyash subbase as compared to untreated flyash subbase stretch.

It was observed that lime-cement stabilized flyash stretch has shown improvement in load carrying capacity.

Further it can be seen that heaving of the expansive soil considerably decreases the load carrying capacity of the pavement system. The improvement in the load carrying capacity could be attributed to the improved load dispersion through stabilized subbase on to the subgrade. This in turn results in lesser intensity of stresses getting transferred on to subgrade, thus leading to lesser subgrade distress.

CONCLUSIONS

The following inferences are drawn based on the experimental studies carried out in this investigation.

1. The load carrying capacity of the flexible pavement system is significantly increased for lime-cement stabilized flyash subbase stretch with respect to the flyash subbase stretch.
2. The total deformation values of the flexible pavement system are decreased considerably for the lime-cement stabilized flyash subbase stretch, when compared with flyash subbase stretch.
3. Maximum reduction in heave values are obtained for the lime-cement stabilized flyash subbase stretch compared to other stretch on expansive soil subgrade.
4. Heaving of the expansive soil has considerably decreased the load carrying capacity of flexible pavement system.

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Table 1.Properties of Materials

Properties	Expansive Soil	Flyash
Specific Gravity	2.63	1.94
Sand (%)	3	25
Silt (%)	35	75
Clay (%)	62	
Maximum Dry Density(KN/m^3)	16.0	14.4
O.M.C. (%)	24	19
Liquid Limit (%)	75	26
Plastic Limit (%)	35	
Plasticity Index (%)	40	
Shrinkage Limit (%)	12	
Free Swell Index (%)	140	
IS Classification:	CH	
Soaked CBR (%)	2	3

Table.2 Chemical Properties of Flyash (Courtesy VTPS, Vijayawada)

S.No.	Name of the Chemical	Symbol	Range of % by Weight
1	Silica	SiO_2	61 to 64.29
2	Allumina	Al_2O_3	21.6 to 27.04
3	Ferric Oxide	Fe_2O_3	3.09 to 3.86
4	Titanium Dioxide	TiO_2	1.25 to 1.69
5	Manganese Oxide	MnO	Upto 0.05
6	Calcium Oxide	CaO	1.02 to 3.39
7	Magnesium Oxide	MgO	0.5 to 1.58
8	Phosphorous	P	0.02 to 0.14
9	Sulphur Trioxide	SO_3	Upto 0.07
10	Potassium Oxide	K_2O	0.08 to 1.83
11	Sodium Oxide	Na_2O	0.26 to 0.48
12	Loss of ignition		0.20 to 0.85

Table 3 Details of the Model Flexible Pavements

Alternative	***Subgrade***	**Subbase**	**Base**
1	Expansive soil	Flyash	WBM - III
2	Expansive soil	Flyash +2% lime+0.5% cement	WBM - III

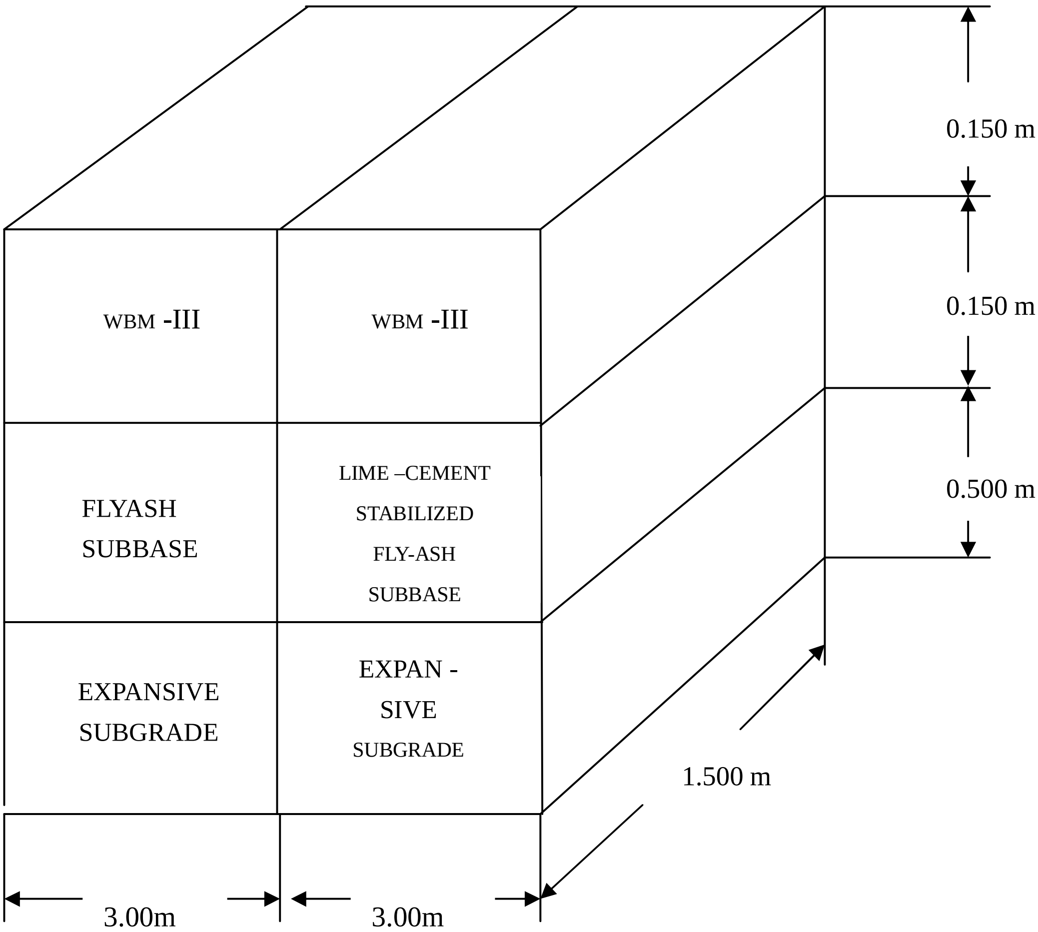

FIG 1 FLEXIBLE PAVEMENT TEST TRACKS ON DIFFERENT SUBGRADES

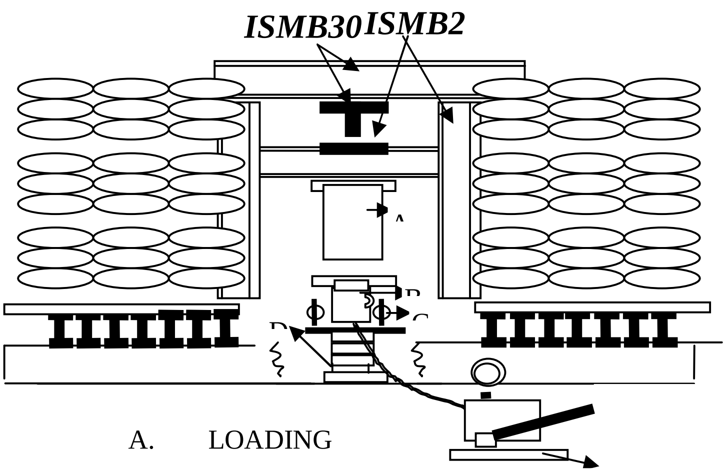

Fig 2 SCHEMATIC DIAGRAM OF PLATE LOAD TEST SETUP