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APPLICATION OF LIME STABILIZED FLYASH LAYER AS SUBBASE COURSE IN FLEXIBLE PAVEMENT CONSTRUCTION

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ABSTRACT:
Expansive clay is a major source of heave induced structural agony. Swelling of expansive soils causes serious problems and produces harm to many structures. Many research organizations are doing extensive work on waste materials concerning the viability and environmental suitability. Flyash, a waste derivative from coal burning in thermal power stations is plentiful in India causing severe health, environmental and dumping problems. Attempts are made to investigate the stabilization process with model test tracks over expansive/sand subgrade in flexible pavements. Cyclic plate load tests along with heave measurements are carried out on the tracks with chemicals like lime, cement and lime-cement introduced in flyash subbase laid on sand and expansive subgrades. Test results show that maximum load carrying capacity is obtained for treated flyash subbase compared to untreated flyash subbase.

Keywords: Expansive soil, Flyash, Lime, Flexible pavement

1.0 Introduction

Soils, which exhibit a peculiar alternate swell-shrink behavior due to moisture fluctuations, are known as expansive soils. This behavior is attributed to the presence of clay minerals with expanding lattice structure. Among them, Montmorillonite clay mineral is very active and absorbs water many times more than its volume. The soil is hard as long as it is dry but loses its stability almost completely on wetting. On drying, the soil cracks very badly and in the worst cases, the width of cracks is almost 150 mm and travel down to 3 m below ground level (Uppal, 1965; CBRI-1978; Kasmalkar, 1989; Picornell and Lytton, 1989).

Flyash is a waste byproduct from thermal power plants, which use coal as fuel. It is estimated that about 100 million tons of Flyash is being produced from different thermal power plants in India consuming several thousand hectares of precious land for its disposal causing severe health and environmental hazards (Singh and Murthy 1998, Suryanarayana, 2000). In spite of continuous efforts made and incentives offered by the government, hardly 5-10% of the produced ash is being used for gainful purposes like brick making, cement manufacture, soil stabilization and as fill material (Murthy, 1998, Boominathan and Hari, 1999).In order to utilize Flyash in bulk quantities, ways and means are being explored all over the world to use it for the construction of embankments and roads.(Hausmann,1990 Veerendra Singh et al, 1996, Boominathan and Ratna Kumar 1996; Murthy, 1998). However when it is used as subbase in flexible pavements, it is completely confined and also the thickness of such layer is relatively small, where by the above problems can be eliminated. 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. Cyclic plate load tests are conducted on flyash subbase and on lime stabilized flyash subbase stretches constructed on different subgrades (i.e., Sand and Expansive soil). 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, laid on both subgrades.

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

2.0 MATERIALS USED

2.1 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.

2.2 SAND SOIL

The sand soil is used as subgrade material for the test track. The properties obtained from the laboratory tests are furnished below in Table 1.

2.3 FLYASH

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.

Table 1.Properties of Materials

Properties	Expansive Soil	Sand Soil	Flyash
Specific Gravity	2.64	2.65	1.95
Grain-Size Distribution:			
Gravel (%)		1	
Sand (%)	3	96	25
Silt (%)	35	3	75
Clay (%)	62		
Maximum Dry Density(KN/m^3)	16.0	17.0	14.5
O.M.C. (%)	24	11	19
Liquid Limit (%)	75		26
Plastic Limit (%)	35		
Plasticity Index (%)	40		
Shrinkage Limit (%)	12		
Free Swell Index (%)	140		
IS Classification:	CH	SW	
Soaked CBR (%)	2	7	3
Coefficient of Uniformity(C_u)		6.15	
Coefficient of Curvature(C_c)		1.24	

The Chemical Properties of Flyash are furnished below in the Table 2

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

2.4 ROAD METAL

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

2.5 CHEMICALS USED

2.5.1 LIME

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

2.5.2 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 : 130 minutes
Specific gravity : 3.15

3.0 LABORATORY INVESTIGATION

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 8 % Lime is giving a CBR value of 20%.

TABLE 3 DETAILS OF THE MODEL FLEXIBLE PAVEMENTS

Alternative	Subgrade	Subbase	Base
1	Expansive soil	Flyash	WBM - II
2	Expansive soil	Flyash +2% lime+0.5%flyash	WBM - II
3	Sand	Flyash	WBM - II
4	Sand	Flyash +2% lime+0.5%	WBM - II

4.0 FIELD EXPERIMENTATION

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

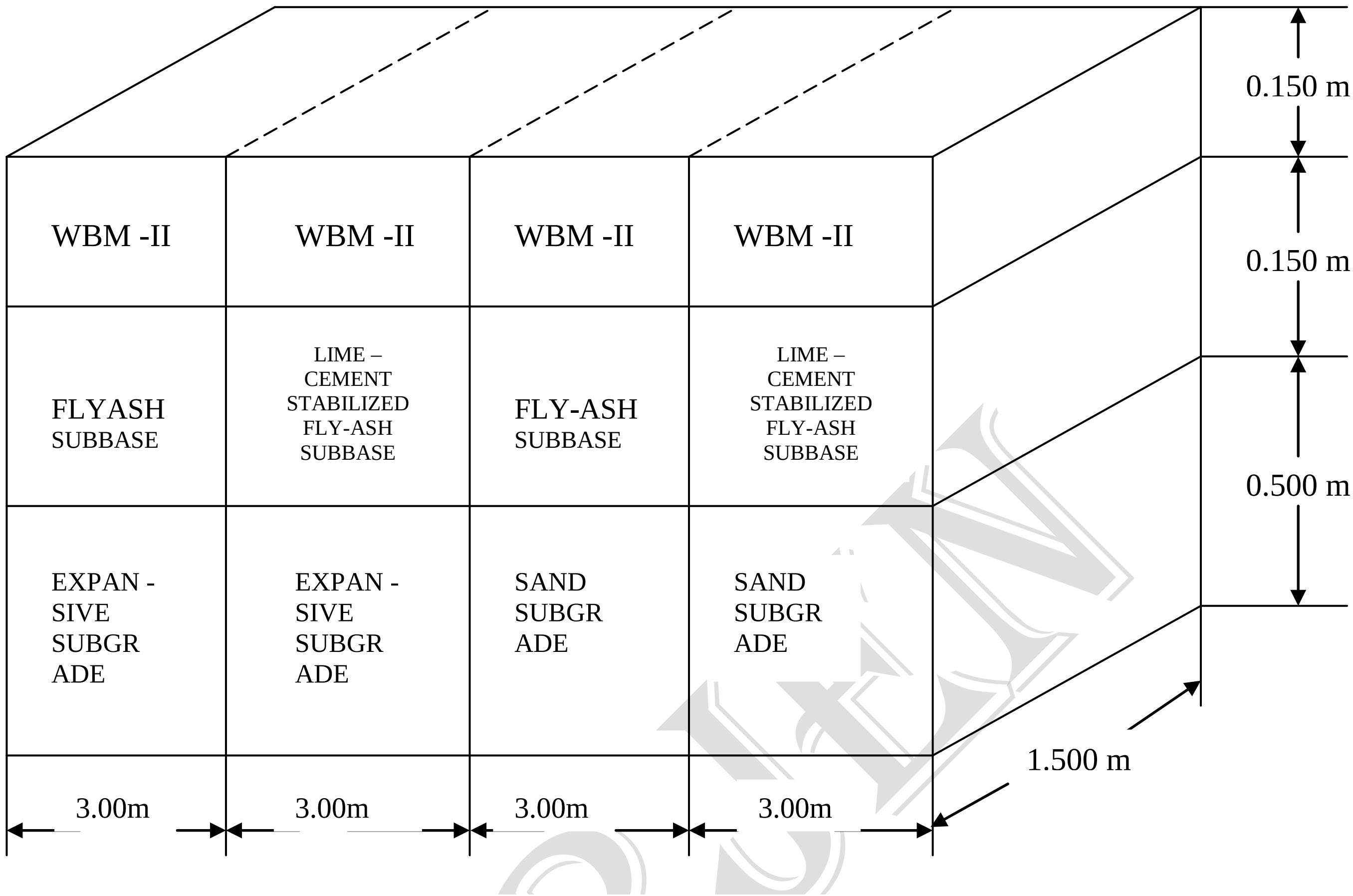

FIG 1 FLEXIBLE PAVEMENT TEST TRACKS ON DIFFERENT SUBGRADES

4.1 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.

4.1.1 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 sub-grade 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 – II each of 5 cm compacted thickness, is laid to total thickness of 15cm.

4.1.2. LIME STABILIZED FLYASH SUBBASE (ALTERNATIVE-2)

This stretch is also constructed similar to alternative-1, but instead of flyash, lime stabilized flyash is used as subbase material. Based on the laboratory soaked CBR tests 8% lime, giving 20% CBR is used for preparation of lime stabilized flyash layer. Accordingly, 8% of lime 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.

4.2 CONSTRUCTION PROCEDURE OF TEST TRACK ON SAND SUBGRADE:

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

4.2.1 FLYASH SUBBASE (ALTERNATIVE – 3)

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 for laying subgrade, 0.15m is for laying subbase and 0.15m for laying base course.

Subgrade: In the prepared trench, sand mixed with water at OMC is laid in layers of 5 cm compacted thickness to a total thickness of 50 cm. The compaction corresponding to MDD is done using 2t hand operated roller.

Subbase: On the prepared sub-grade, 15cm thick flyash subbase consisting of 3 layers of 5cm compacted thickness is laid.

Basecourse: Over the prepared subbase, 15cm compacted WBM – II base course in three layers of 5 cm thick is laid.

4.2.2. LIME STABILIZED FLYASH SUBBASE (ALTERNATIVE- 4)

This stretch is also constructed similar to alternative-3, but instead of flyash, lime stabilized flyash is used as a subbase material.

4.3 IN-SITU TESTS

4.3.1 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.

4.3.2 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 subgrade

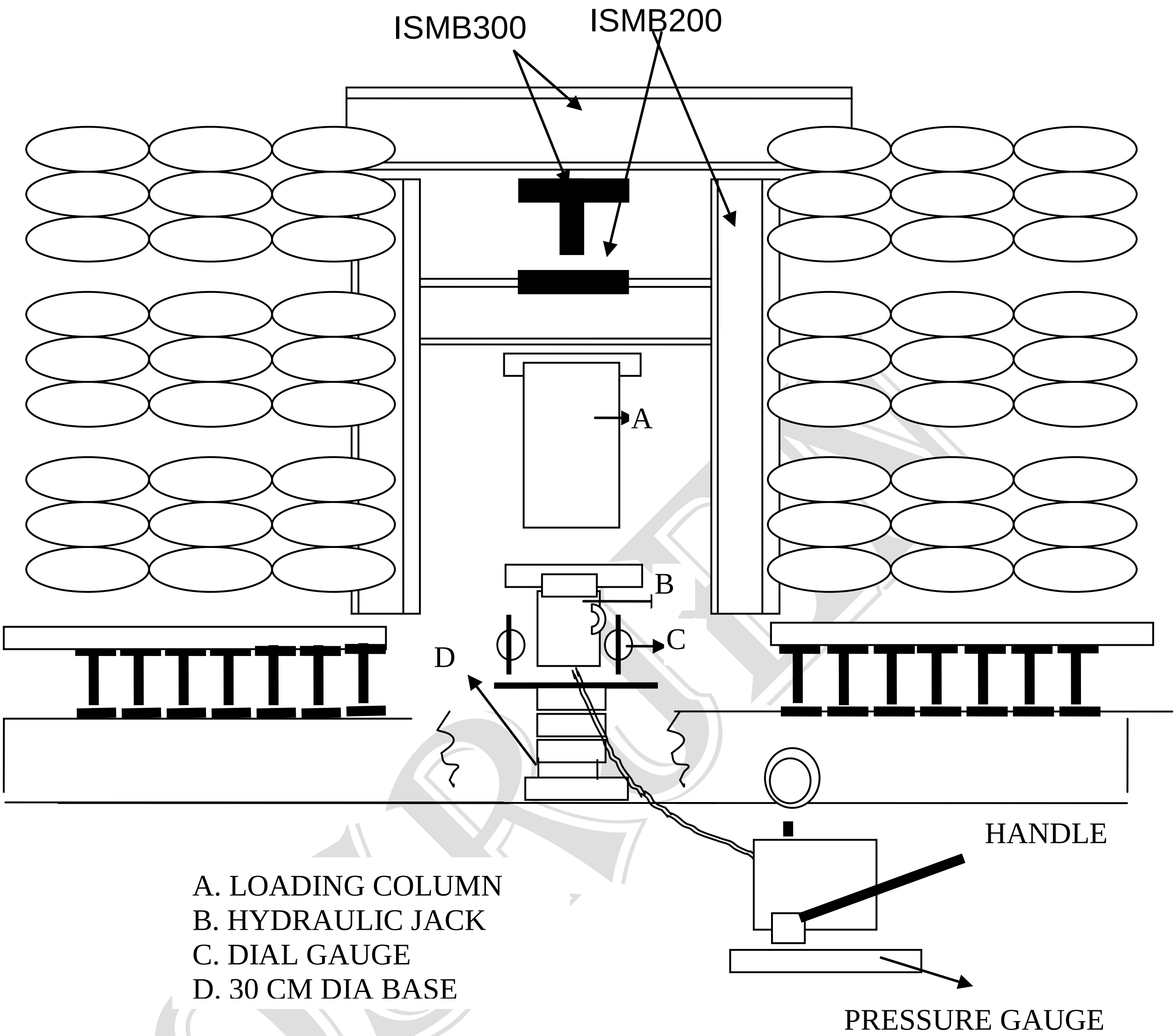

Fig 2 SCHEMATIC DIAGRAM OF PLATE LOAD TEST SETUP

5.0 LABORATORY TEST RESULTS

5.1 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 8% lime 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, i.e. Lime stabilized flyash, for the construction of pavement sections.

5.2 Results of Field Studies

5.2.1 In-situ Heave-Time studies

The influence of different alternatives laid on expansive sub-grade in respect of heave is shown in Fig 3.

From the Fig 3, it is observed that the maximum heave values are 5.96mm and 2.42mm 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; Sudhakar, 2002; Nanda kishore, 2003).

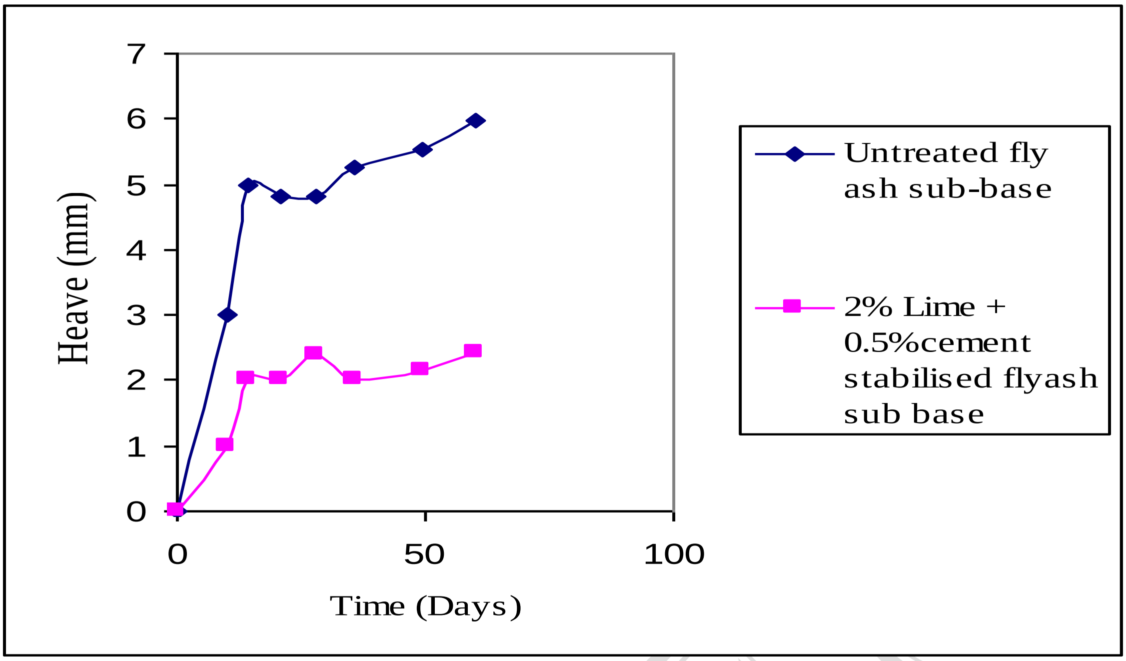

Fig 3 Heave-Time Plots for different tracks laid on Expansive soil subgrade in the field

5.2.2 Cyclic load test results for different alternative test stretches.

Cyclic plate load tests are carried out on all the test stretches laid on sand sub-grade and Clayey sub-grades 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.

From Fig 4 it is observed that the total deformation at 500 KPa is decreased by

52.73% for treated lime-cement flyash subbase when compared to untreated flyash subbase laid on sand subgrade. For Expansive soil subgrade the total deformation at 500 KPa is decreased by 65.07 % for treated lime-cement Flyash subbase as compared to untreated Flyash subbase stretch.

It can be seen from the Fig 4 that lime-cement stabilized Flyash stretch has shown improvement in load carrying capacity. The improvement in load carrying capacity is more prominent in the test stretch laid on sand soil sub-grade compared to expansive soil sub-grade.

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 sub-grade. This in turn results in lesser intensity of stresses getting transferred on to sub-grade, thus leading to lesser sub-grade distress.

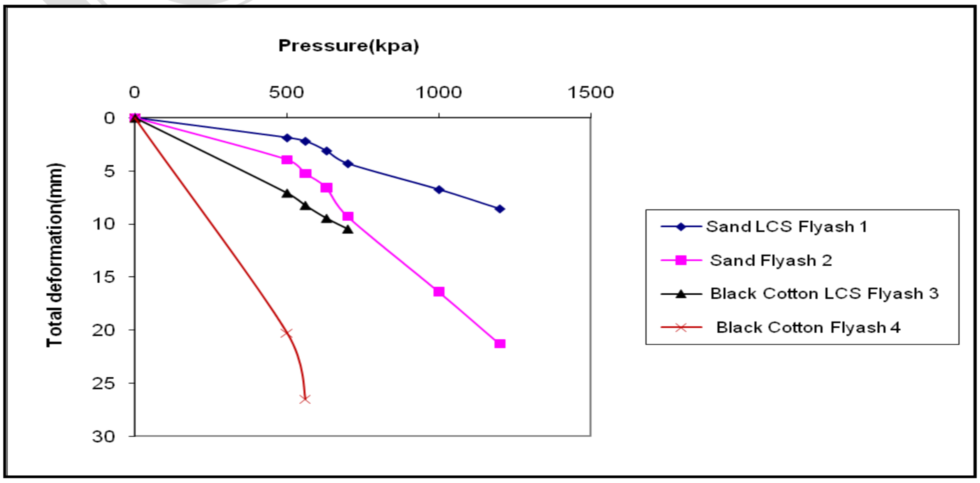

Fig 4 Pressure total deformation curves of all the stretches on different subgrades in the field

CONCLUSIONS

The following conclusions 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, on sand sub-grade and expansive sub-grade.
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 both on sand sub-grade and expansive sub-grade respectively.
3. Maximum reduction in heave values are obtained for the lime-cement stabilized flyash subbase stretch compared to other stretches 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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