International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
(Vol. 32, Issue 01) and (Publishing Month: July 2016)
(An Indexed, Referred and Impact Factor Journal)
ISSN: 2319-6564
www.ijesonline.com

EFFECT OF POZZOLANIC MATERIAL AND JUTE FIBRE ON SOIL STABILIZATION

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ABSTRACT: In this project for making economical pavement following pozzolanic materials such as fly ash, jute, lime and water proofing compounds are used for improving the properties of black cotton soil. A series of Proctor Compaction tests and California Bearing Ratio (CBR) tests have been carried out including Atterberg's Limit on soil mixed with jute fiber of different diameters (2 to 9mm) and lengths (0.5 to 2.5 mm) in different percentage (0.3 to 1.0%) to find out the optimal quantity and also with different quantity of fly ash (10%, 15%, 20% and 25%) and lime (1% to 5%). It is concluded that mixing of 1% jute fiber, 20% fly ash and 5% lime together in a soil gives better result as compare to individually addition of each material for soil improvement and reduces the cost of road (black cotton soil) near about 48-62% and improves the C.B.R value near about 16-18 times.

INTRODUCTION:

Soil stabilization is a process by which we can improve the soil characteristics & its economy. Stabilization, in a broad sense, incorporates the various methods implement for modifying the properties of a soil and improves the engineering properties and performance of soil. Expansive soil is very sensitive to variation in moisture content and exhibit large volume change. These soil because more damage to light building and pavements, than any natural hazard. In India the black cotton soil is one of such soils .It is important to find a soil at particular site to be satisfactory for intended use but unfortunately it doesn't happens. For this project it was found that entire area was covered with soil having liquid limit varying from 25-38%. During summer extensive cracks were noticed also the CBR value was very low i.e 1.499 %. Until recently the lime and Portland cement has been used to stabilize these soil .In present study instead of borrowing material from long distance it was proposed to use material after stabilization with fly ash, jute fibers and lime along with water proofing compounds (WPC).

Various investigators have conducted studies regarding study of fly ash and lime like Mitchell [1], Maher et al [2,3], In 1972 Ingles & Metcalf [4] extensively described in his literature about physical and chemical mechanism of reactions involved in lime stabilization of soil or soil fly ash mixture. Dhariwal [5] carried out performance study on California bearing ratio (CBR) of fly ash reinforced with jute and non-oven fibers. Robert [6] recommended that Rice Husk Ash (RHA) content of 12% and a fly ash (FA) content of 25% suitable for strengthening the expansive sub-grade soil. A fly ash content of 15% is suggested for blending into RHA for forming a swell reduction layer. Emilliani et.al [7] and McLaren et.al [8] investigated standard Proctor Maximum Dry Densities (MDD) varied between 11.6 and 18.4 kN/m3 and the Optimum Water Contents (OMC) ranged from 12 to 34% for class F fly ash. National Cooperative Highway Research Report (NCHRP) [9], Washington DC report Foundry Sand Facts civil engineering states that fly ash can be used for ground improvement and many other civil engineering fields. The effect of polymer fiber inclusion on plain fly ash was studied by Chakraborty and Dasgupta [10] by conducting triaxial tests. The fiber content ranging from 0 to 4 % by weight of fly ash was used with constant fiber aspect ratio of 30. Kaniraj and Gayatri [11] indicated that 1% polyester fibers (6 mm length) increased strength of raw fly ash and change their

brittle failure into ductile. Bajaj et.al [12] recommends that in the cases of pozzolonic material like fly ash strength with respect to penetration first decreases and then increases and there is 23% reduction in cost with the replacement of clayey sand with fly ash.

In this investigation, an attempt is made to study in what way fly ash and fibers along with lime & WPC may be effectively utilized in combination with soil to get an improved soil material which may be used in various soil structures. Fly ash is obtained from NTPC Singrauli power plant (M.P.); locally available soil has been used in this experimental investigation. CBR characteristic individually as well as of most appropriate combination of the materials used have been studied at optimum moisture content and maximum dry density. The variation of California Bearing Ratio (CBR) value versus % combination of various materials used was studied. A series of Proctor Compaction tests and CBR tests have been carried out including Atterberg's Limit on soil mixed with jute fiber of different diameters (2 to 8mm) and lengths (0.5 to 2.0 mm) in different percentage (0.2 to 1.0%) to find out the optimal quantity and also with different quantity of fly ash (10%, 15%, 20% and 25%) and lime (1% to 5%). It is concluded that mixing of 1% jute fiber, 20% fly ash and 5% lime together in a soil gives better result as compare to individually addition of each material for soil improvement and reduces the cost of road (black cotton soil) near about 50-60% and improves the CBR value near about 18-20 times.

SCOPE AND OBJECTIVE

In the present study, an attempt is made to study how fly ash, lime and jute fibers may be effectively utilized in combination with locally available soils to get an improved quality of composite material which may be used in various soil structures. The soil used in investigation was obtained from Kappuri village In Rewa district of M.P , fly ash from NTPC singrauli (M.P)., lime and WPC from market. This research aims at investigation of various technical properties like specific gravity, liquid limit & plastic limit, particle size distribution and compaction characteristic of material individually. The objective of present work is to study the most appropriate combination

of soil, fly ash and lime with varying % of jute fiber at the optimum moisture content and maximum dry density.

ENGINEERING PROPERTIES OF THE MATERIAL USED

Soil and Fly Ash (FA) property

The soil used in the study was locally available soil and fly ash obtained from NTPC power plant. According to IS soil classification system soil was classified as sandy clay (SC) and fly ash was classified as poorly graded sand (SP). All the tests were carried out as per the relevant Indian standards. The chemical properties of FA and lime
[13] are shown in Table 1 and physical properties of the collected soil sample and fly ash used are listed in Table 2.

Table 1 Chemical Properties of FA used

Constituent	**FA**	**LIME**
Al_2O_3	26.8	7.25
SiO_2	55.3	25.32
Fe_2O_3	13.6	6.85
CaO	2.98	60.26
MgO	1.24	2.32
Loss on ignition	13.3	8.26

The lime used in this work is having plasticity index of 20 and is reactive with soil to form the quick lime with the soil moisture and used for soil improvement. Jute fibers (JF) of different diameters (2 to 8mm) and lengths (0.5 to 2.0 mm) has mixed with the black cotton soil for the improvement of its properties. Sodium carbonate and sodium sulphate is used as water proofing agent in this study. The material used are also shown in figure 1

Table 2 Physical properties of material used

Properties	Values	
	Soil	FA
Specific Gravity	2.64	2.36
MDD(g/cc)	1.84	1.23
OMC (%)	15.5	31.2
Coefficient of uniformity(Cu)	25.7	3.1-10.7
Coefficient of curvature	5.73	0.61-

(Cc)		3.70
Liquid Limit (%)	35.67	63.5
Plastic Limit (%)	25.68	46.2
Permeability (m/sec)	2.14E-07	1.5E-04
Angle of internal friction (°)	-	35
Shear Strength (kPa)	23.5	-
Unsoaked CBR (%)	10.32	9.25
Soaked CBR (%)	-	8.82

Fig.1 Material Used

METHODOLOGY

The laboratory studies were carried out in two phases

1. Test for the index properties of the soil along with the CBR value.
2. Modification of soil for CBR determination as per table 3

The blending operation was carried out manually and care was taken for uniform mixing. Laboratory tests are carried out in accordance with relevant Indian standards. In the first phase index properties such as specific gravity (IS 2720: Part 3), liquid limit & Plastic limit (IS 2720: part 5), Grain size analysis (part 4), Standard proctor test, and the CBR (soaked) are evaluated for soil blended with all materials.

Table 3 % of material used

Method	% of each material				
	JF	Lime	FA	WPC	Water
M11	1	2.5	10	2	OMC
M12	1	2.5	15	2	OMC
M13	1	2.5	20	2	OMC
M14	1	2.5	25	2	OMC
M21	0.5	2.5	10	2	OMC
M22	0.5	2.5	15	2	OMC
M23	0.5	2.5	20	2	OMC
M24	0.5	2.5	25	2	OMC
M31	1	5.0	10	2	OMC
M32	1	5.0	15	2	OMC
M33	1	5.0	20	2	OMC
M34	1	5.0	25	2	OMC
M41	0.5	5.0	10	2	OMC
M42	0.5	5.0	15	2	OMC
M43	0.5	5.0	20	2	OMC
M44	0.5	5.0	25	2	OMC

RESULT AND DISCUSSION

Compaction Characteristics

IS Light compaction tests were carried out on different proportions of fly ash and soil in accordance with the procedure laid in IS:2720 (Part VII) 1980/87 so as to study their moisture –density relationship. IS-2720 recommends that a mould of 1000 ml capacity having an internal diameter of 100 mm and an internal effective height of 127.5 mm should be used. The rammer has a mass of 2.6 Kg with a drop of 310 mm. In this test sample is compacted at various water contents in three layers. Each layer is given 25 blows. Fig. 2 & 3 shows the variation in the maximum dry density (MDD) and corresponding optimum moisture Content (OMC) for different percentages of fly ash and lime content respectively. The MDD value increased initially and then it started decreasing. The MDD was found maximum for 75% soil and 25% fly ash proportion. It has seen that MDD of FA and lime as 1.795 kg/m^3 and 1.6 kg/m^3 respectively. The MDD value is affected by grain size distribution factor. It is evident from the grain size distribution that increase in fly ash content up to 25% in soil results into a well graded mixture and it results in increase in density of soil blend. The value of OMC increases with increase in fly ash and lime content. With the addition of fiber content in the blend of soil with 25% fly ash, the MDD value initially increased and then it went on decreasing. The value of OMC initially decreased then it went on increasing. Increase in the MDD value might be because of the reason that when fiber was added it occupied the void spaces present in soil fly ash mixture. When fiber content was increased beyond the optimum value the MDD

value got decreased. The fiber cross-section is circular and surface area is more so when fiber content is increased beyond the optimum value more void spaces were created resulting decrease in value of MDD. MDD value was found maximum. Fig. 4 shows the variation in MDD and OMC with fiber content.

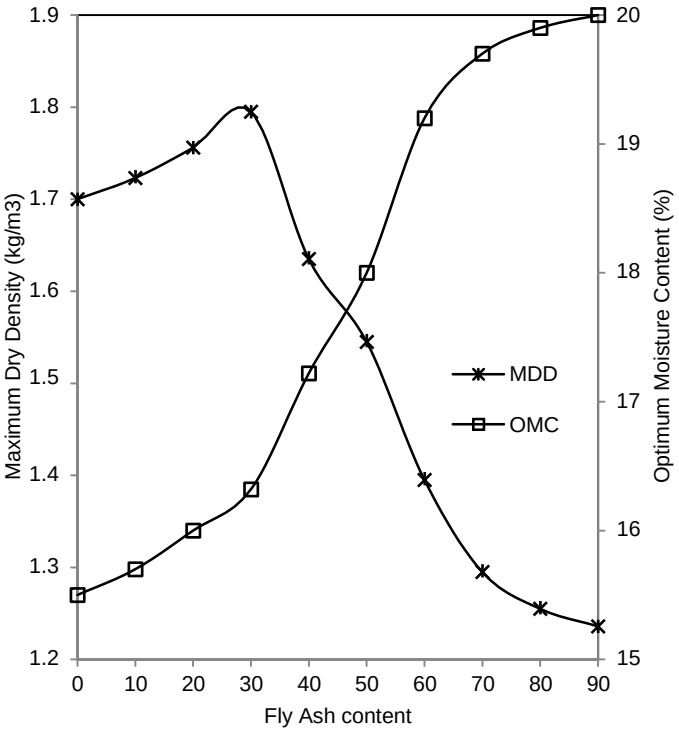

Fig.2 Variation of OMC and MDD with FA

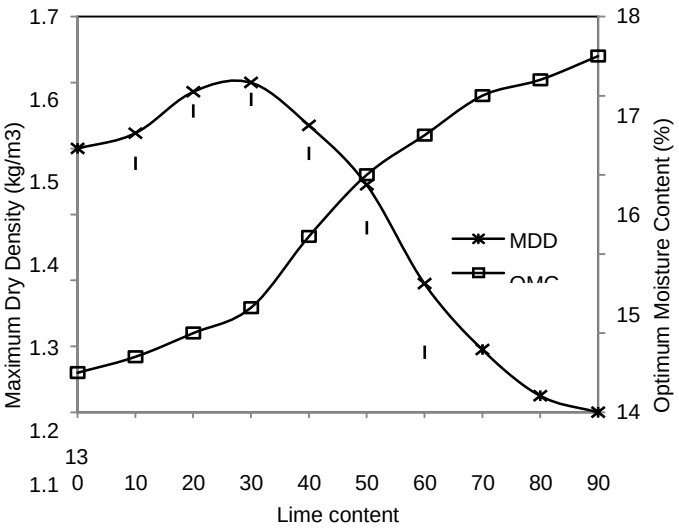

Fig.3 Variation of OMC and MDD with Lime

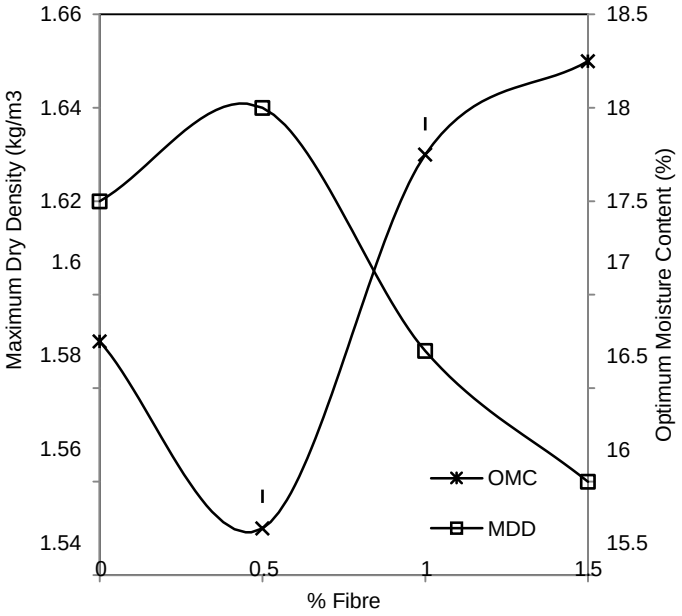

Fig.4 Variation of OMC and MDD with fiber

The compaction test between all the mixtures as per table 3 is performed to find the OMC of all the mixes. The compaction curves shown in figure5 is between first eight samples as per table 3 in which lime content remains constant as 2.5% and fiber changes from 15 and 0.5% with the change in fly ash content as 10%, 15%, 20% and 25% by weight of total soil sample.

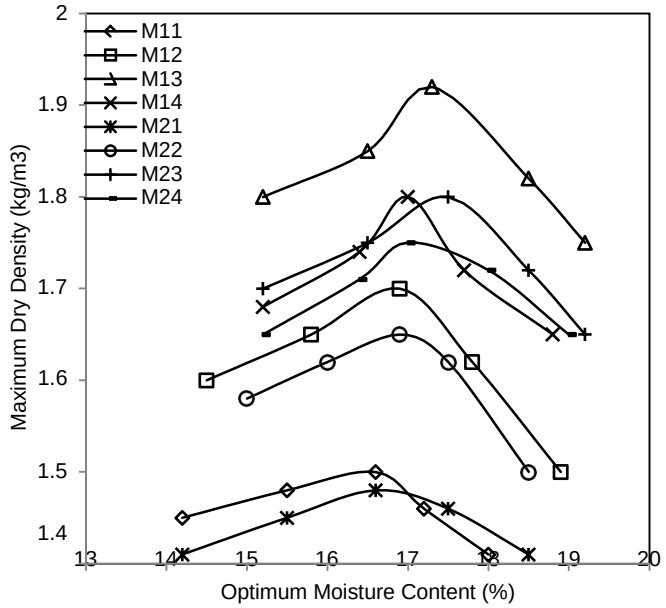

Fig. 5 compaction curve of M11 to M24 as per table 3

The compaction curves shown in figure6 is between next eight samples as per table 3 in which lime content remains constant as 5% and fiber changes from 15 and 0.5% with the change in fly ash content as 10%, 15%, 20% and 25% by weight of total soil sample.

It has been seem from figure 5 and 6 that for the mix having fly ash content as 20% (M34 and M43) with lime content as 5% weight of the soil mass has approximately same MDD. Similar pattern is seen for the M14 and M23. The mixture having fly ash as 20%, fiber 1% and lime content 5% i.e. M33 having the uppermost MDD of 2 kg/m3. It has also seemed that with the increase in FA content from 20% the MDD goes on decreasing. For the mix M12 and M32 with change in lime content from

2.5 to 5%, the MDD increased by 5%. Similarly for the increase in fiber content the MDD also increases for the same content of fly ash and lime.

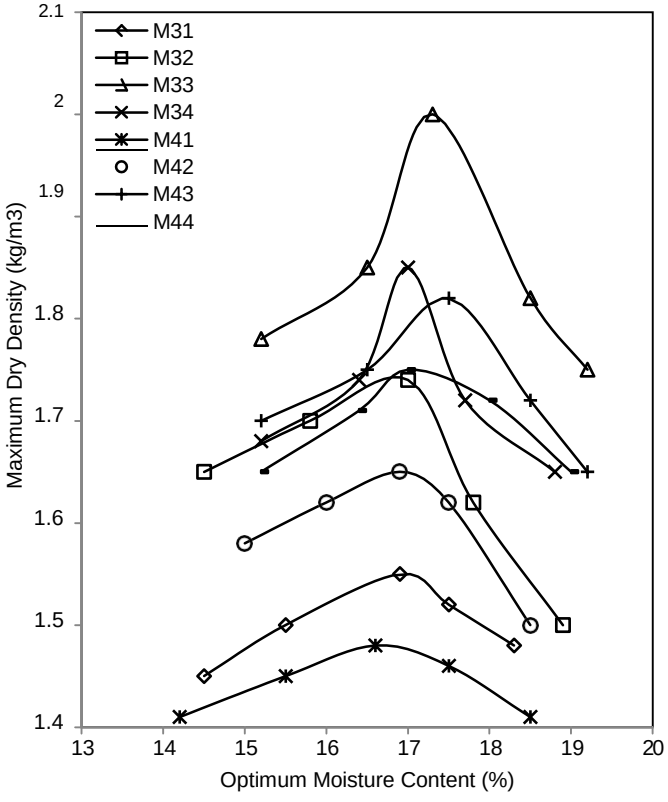

Fig. 6 compaction curve of M11 to M24 as per table 3

Strength Characteristics

California bearing ratio tests (CBR) were carried out on soil, soil mixed with lime, soil mixed with fly ash and with different proportions of soil, fly ash, and lime and jute fiber along with WPC.

For this experiment 5 kg of crushed black cotton soil is taken passes from 2.75 mm IS sieve and mixed with pozzolonic material and jute fiber at OMC getting from compaction test as per table 3. The mix was soaked for 96 hours and after that CBR test was performed on all. Load is applied on the sample by a standard plunger with diameter of

50 mm at the rate of 1.25 mm/min. A load penetration curve is drawn. The load values on standard crushed stones are 1370 kg and 2055 kg at

2.5 mm and 5.0 mm penetrations respectively. As in many cases CBR value at 5.0 mm is more than

2.5 mm, test was repeated and 5.0 mm penetration CBR value was taken. It has seen from figure 7 that M12 is having more strength upto 5.0 mm penetration but the flexibility is less as compared to M13, similar result has been shown from the figure 8 and 10 also.

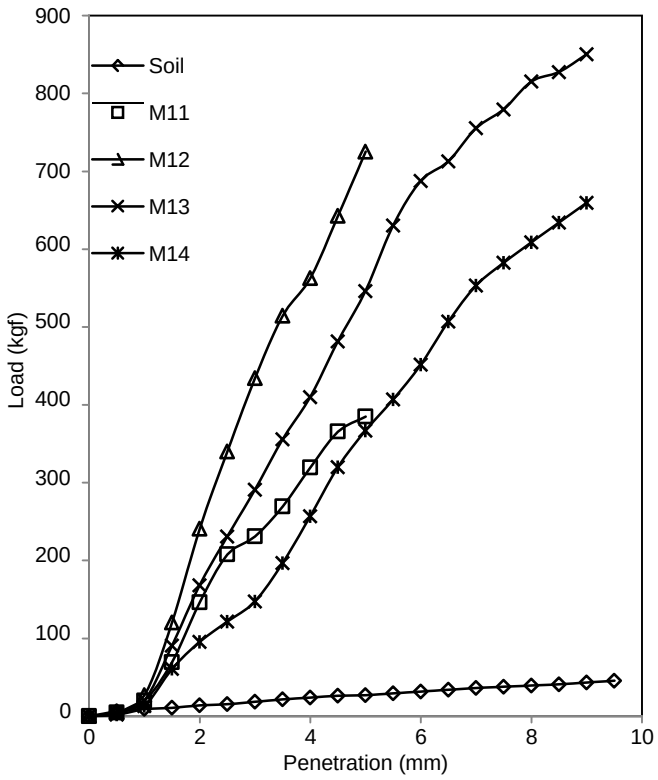

Fig. 7 Load-Penetration curve for M11 to M14 as per table 3

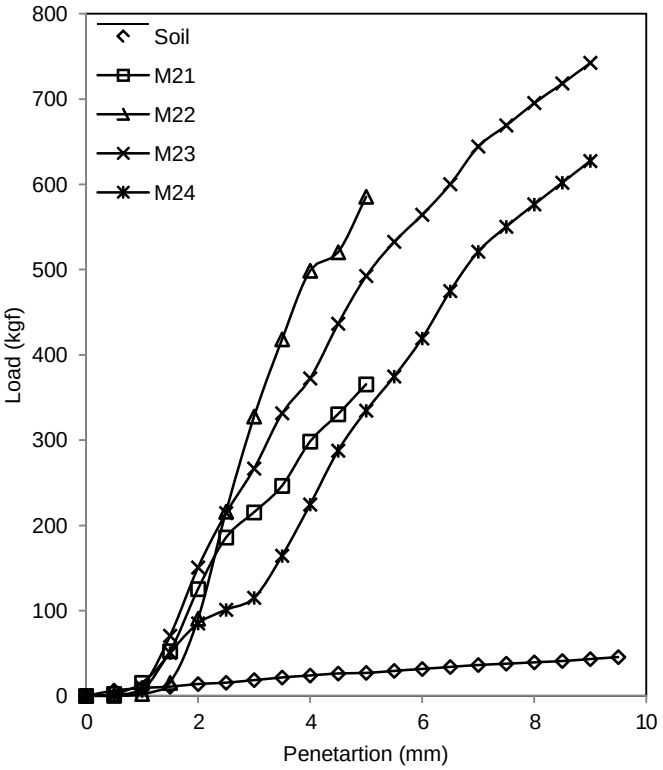

Fig. 8 Load-Penetration curve for M21 to M24 as per table 3

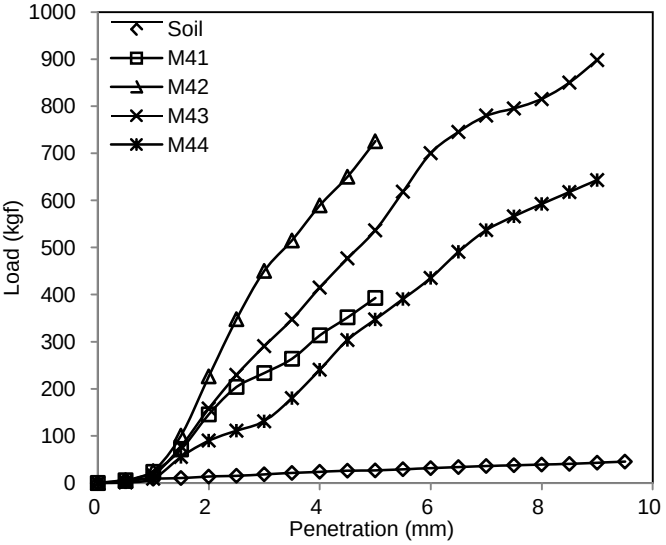

Fig. 10 Load-Penetration curve for M41 to M44 as per table 3

It has seemed from the figure 9 that M33 has maximum load and flexibility as compared to other three mixes. So from the CBR test of all the mix it
has been concluded that M33 is having maximum CBR values as compared to other mixes as shown in table 4.

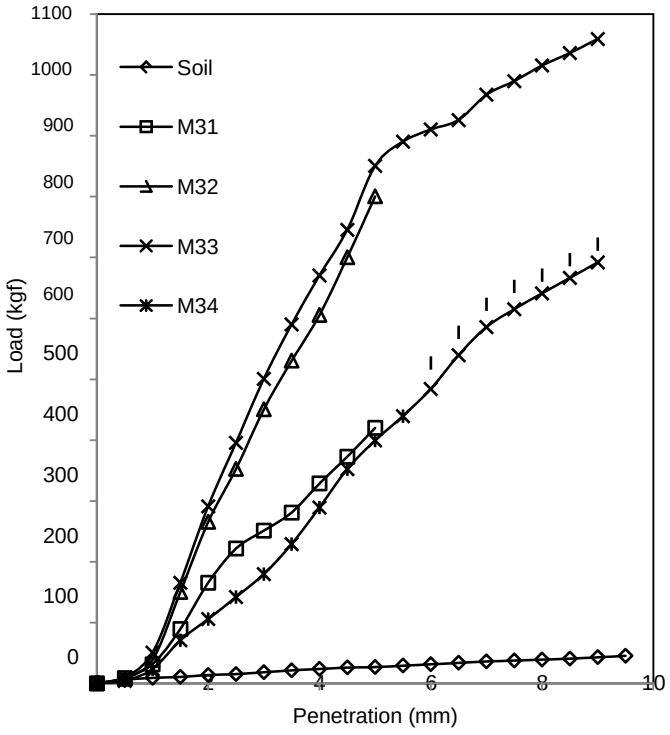

Fig. 9 Load-Penetration curve for M31 to M34 as

Table 4 CBR value of all Mix

Mix as per table 3	CBR Value	
	2.5 mm	5 mm
Soil	1.124088	1.311436
M11	15.17518	18.73479
M12	24.81679	35.29219
M13	16.83778	26.56949
M14	8.858781	17.84679
M21	13.56058	17.77518
M22	23.91387	31.64234
M23	15.64308	23.95989
M24	7.372285	16.27745
M31	16.17372	20.43796
M32	25.71971	38.94204
M33	28.84891	41.3781
M34	10.34528	19.41614
M41	14.88569	19.11893

It has found that with M33 the CBR value increases upto 28 % which indicates that, the soil thickness can be reduced by at least 50%.

CONCLUSION

Fly ash is waste material imposing hazardous effect on environment and human health, also it can't 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. The present study is aimed at improving the properties of soil suitable for road construction. Based upon the above study following conclusion can be drawn:

- It has seen that MDD of FA and lime as 1.795 kg/m^3 and 1.6 kg/m^3 at 20% and 5% of the total soil content respectively
- It has seemed that M33 has maximum load and flexibility as compared to other three mixes.
- It has determined that with change in lime content from 2.5 to 5%, the MDD increased by 5% as seen from mix M12 and M32.
- The value of OMC increases with increase in fly ash and lime content. With the addition of fiber content in the blend of soil with 25% fly ash, the MDD value initially increased and then it went on decreasing. The value of OMC initially decreased then it went on increasing.
- It has found that with M33 the CBR value increases upto 28 % which indicates that, the soil thickness can be reduced by at least 50%.
- M12 is having more strength upto 5.0 mm penetration but the flexibility is less as compared to M13, similar result has been shown between M22 & M23 and M42 & M43.
- For the same amount of fly ash and lime, by decreasing the fiber content from 1% to 0.5%CBR value decrease by 38.46%.
- As lime content increased from 2.5% to 5%, the CBR value goes on increases by 37.56% for the same content of fly ash and fiber as seen from mix M13 to M33.

- The inclusion of fibers had a significant influence on the engineering behavior of soil-fly ash mixture. There is optimum percentage of fiber content that increases the MDD of soil-fly ash mixture as seen from mix M13 and M23.
- Based upon the study it was concluded that proportion of 1% jute fiber+ 20% fly ash and 5% lime together in a soil is the best combination of materials having maximum CBR value. Hence this proportion may be used in road embankments.

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