PILOT STUDY PROJECT FOR IMPACT OF FLY ASH ON PROPERTIES OF EXPANSIVE SOIL

Madhusudan R Vaidya[1], Dr. R. V. Shetkar[2], Dr. G. R. Gandhe[3]

[1]*Research Scholar, Civil Engineering Department, MIT Aurangabad, Maharashtra, India*
[2] *Professor, Civil Engineering Department, Government College of Engineering, Aurangabad, Maharashtra, India*
[3] *Professor, Civil Engineering Department, DIEMS Aurangabad, Maharashtra, India*

ABSTRACT

The Expansive soil is one which swells or strains excessively due to changes in moisture state and when associated with an engineering structures to experience either settlement or have depending on the stress level and the soil swelling pressure. Design and construction of civil engineering structure on and with expansive soil is a challenging task for geo technical engineers. The technique of improving the soil increases the strength and load carrying capacity of the soil through frictional interaction between the soil and the industrial waste. Improving black cotton soil or locally available weak soil by industrial waste is of great importance in the field of road construction. The well built and maintained roads plays measure role in the development of the nation. If the weak sub grade is improved, the crust thickness required will be less. Use of industrial waste in sub grade improvement techniques assumes a great promise and will be comparatively easier for construction. The main objective of this work is to study fly ash for soil stability. It is an attempt made to use the Industry waste product, which is available in various parts of India in huge amount. Stabilization of soil is an efficient method of improving the soil characteristics. In the laboratory tests are conducted on soil samples and industrial wastes Fly Ash. The soil is mixed with various proportions of Fly ash as 5%, 10%, 15%, 20% and 25%. The value of California bearing ratio of soil by addition of 15% fly ash is increased due to increase in density of modified soil mix, which leads to soil mask having more strength.

Keyword: - *Expansive Soil, Fly ash, CBR, Industrial waste, Stabilization*

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1. INTRODUCTION

A natural soil deposit is quite unlike any other material of construction known to man. Soil may be considered an incidental material obtained from geologic cycle vise goes on continuously in nature. Compacted soil are used in several geo-technical and engineering structure example highway embankment, earth dams highway and runway sub grades, land field barriers and many other structures. Compaction of soil is generally carried out to reduce permeability and increases the strength characteristic of soil which in turn increases the bearing capacity of foundation constructed over them. More recently, the high cost of waste disposal techniques have been sparked an interest in the possible use of waste material such as rice husk ash, fly ash, red mud, copper slag, shredded waste tyres, lime sludge, petroleum drilling waste etc. These materials may be added individually all in combination with soils in various geo technical engineering works to reduce the quantum of waste required to dispose off. Utilization of waste material is being given prime importance all over the world. During last 35 years, the capacity of nation to produce, consume and discard waste has grown dramatically requiring innovative techniques of management of complicated and varying type of waste. Waste / bi-products fly ash, rice husk ash, red mud, press mud, lime sludge, petroleum drilling waste, incineration residue, phospogypsum, construction industry waste can be used as an artificial geo material in many ways in civil engineering applications especially in construction of embankment for dams and roads which can utilize a huge quantity of these wastes or by products.

The purpose of amending the soil with waste material is to increase strength, reduce deformability provide volume stability, lower permeability, minimize erodability, enhance durability. Use of waste helps in solving dual problem firstly a problem of disposal of waste and secondly leading in improvement in the properties of soil with economy. A review of literature indicates that industrial waste have potential to be utilized in soil improvement. The Soil from Rotegaon, Maharashtra, Industrial waste such as fly ash is useful in this regards in the present study the industrial waste fly ash from thermal power station Parli, Maharashtra.

2. MATERIAL USED

2.1 Soil:

The locally available soil collected from Rotegaon area Tal.Vaijapur Dist. Aurangabad and soil is collected from a depth of 1.5 meter from the ground surface.

2.2 Fly Ash:

Fly ash is industrial waste as well as a fine powder thrown out as a waste material in huge quantities at the thermal power plants using pulverized coal for raising steam in the boiler. It is finally discharged either as a dry powder or in the form of a wet mass or slurry.

2.3 Physical Properties of Soil Used:

Table -1: Physical Properties of Soil

Sr. No.	Property	Soil
1.	Specific Gravity	2.61
2.	Atterberg's Limits : %	
	Liquid Limit	72.24
	Plastic Limit	30.35
	Plasticity Index	41.89
3.	Maximum Dry Density (KN/m3)	15.38
	Optimum Moisture Content (%)	25.30
4.	Unconfined Compressive Strength (KPa)	153.82
5.	California Bearing Ratio % (Unsoaked)	5.16

2.4 Physical Properties of Fly Ash Used:

Table -2: Physical Properties of Soil

Sr. No.	Property	Fly Ash
1.	Specific Gravity	2.14
2.	Atterberg's Limits : %	
	Liquid Limit	44.10
	Plastic Limit	Non plastic
	Plasticity Index	Non plastic
3.	Maximum Dry Density (kN/m3)	14.9
	Optimum Moisture Content (%)	31.1
4.	Unconfined Compressive Strength (KPa)	41.57
5.	California Bearing Ratio % (Unsoaked)	3.19

3. MI X PREPARATION:

The mix has been prepared with different percentage such as 5%, 10%, 15%, 20% and 25% dry weight of black cotton soil with FA. The designations for mixture soil and soil are detailed in Table-3. Soil is modified by using fly ash in the range of 0-25%. Table-3 shows details of soil mix and symbols used for them

Table -3: Symbol of Modified Soil and its proportions

Symbol	Proportion Soil : Fly Ash
SF_0	100 :00
SF_1	95 : 05
SF_2	90 : 10
SF_3	85 : 15
SF_4	80 : 20
SF_5	75 : 25

Experimental Tests:

In the laboratory the different tests are conducted on black cotton soil. Similarly the tests conducted on soil samples and industrial wastes like Fly Ash with 15% addition. The different tests conducted as per IS code are as

- Consistency limits
- Standard Proctor test
- Unconfined Compressive strength test
- Laboratory UnSoaked CBR test

3.1 Consistency limits:

Consistency means relative ease with which the soil can be deformed and this term is mostly used for fine grained material. In 1911 Swedish agriculturist Atterberg divide the entire range in four stages –Liquid state, Plastic state, Semi Solid state and Solid state. Liquid limit and Plastic limit is determined in the laboratory with the help of liquid limit apparatus designed by Casagrande as per I.S. 2720 part five – 1970. The liquid limit for soil is 72.46, fly ash 44.13.

3.1.1 Consistency limits for mix (Soil + Fly Ash)

The effect of fly ash addition in varying proportion with soil has been studied and the variation in consistency limits for various mixes are presented in Table-4 and Fig1.

Table -4: Effect of Fly ash addition on Atterberg's limit for soil

Sr. No.	**Property**	**Soil + Fly Ash mix**					
		S_1F_0	**S_1F_1**	**S_1F_2**	**S_1F_3**	**S_1F_4**	**S_1F_5**
	Proportion Soil : Fly Ash	100:00	95:5	90:10	85:15	80:20	75:25
1.	Atterberg's Limits :(%)						
	Liquid Limit	72.24	65	60.2	56.2	51	48.5
	Plastic Limit	30.35	29.2	27.5	26	24.5	24
	Plasticity Index	41.89	37.2	36	32.5	29.9	25.9

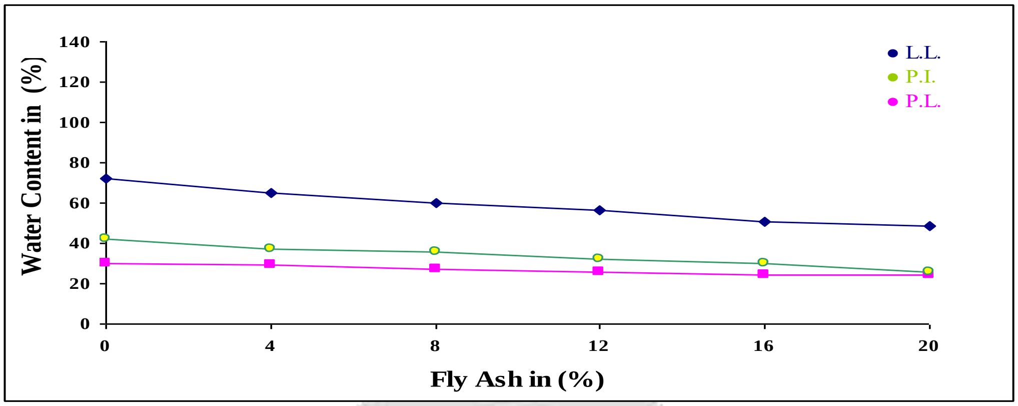

Fig -1: Effect of Addition of Fly Ash on Atterberg's Limit for soil

Soil has been modified by addition of fly ash in the range of 5 to 25%. The liquid limit, plastic limit and plasticity index of Soil, without modification is found to be 72.24%, 30.35% and 41.89% respectively. After modification with 5%, 10%, 15%, 20% to 25% of fly ash the liquid limit is found to be reduced by 10.02%, 16.66%, 22.20%, 29.40% and 32.86% respectively. The probable reason for reduction in liquid limit of modified soil may be the use of non plastic material for modification.

The result shows that on addition of fly ash as the percentage of fly ash increases the liquid limit of the mix decreases and plastic limit increases. The above results indicate that the expansion characteristics are reduced on addition of fly ash.

3.2 Standard Proctor test:

Compaction is that method of soil densification by reducing air voids. The degree of compaction of a given soil is measured in terms of dry density. The dry density is maximum in the optimal water content. A curve is established between the moisture content and the dry density to obtain the maximum dry density and the optimum moisture content.

3.2.1 Compaction behaviour for soil + fly ash

The Standard Proctor's test for soil with fly ash mixes are performed and presented in Table-5. Typical curves for moisture content and dry density for various combinations are presented in Fig -3. Similarly effect of addition of fly ash with soil for MDD is present in Fig -2.

Table-5: Effect of Fly ash addition on Maximum Dry Density for soil

Sr. No.	Property	Soil + Fly Ash mix					
		S_1F_0	S_1F_1	S_1F_2	S_1F_3	S_1F_4	S_1F_5
	Proportion Soil : Fly Ash	100:00	95:5	90:10	85:15	80:20	75:25
1.	Maximum Dry Density (kN/m^3)	15.38	18.8	19	19.89	18.1	19.2

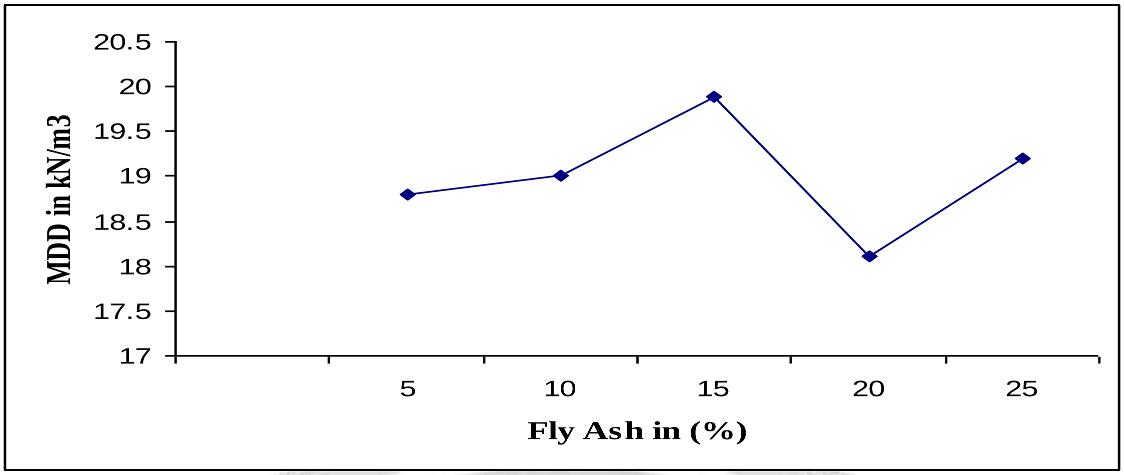

Fig -2: Effect of addition of fly ash on MDD

From the Table -4 it is found that as the percentage of fly ash is increased the value of MDD is also increased. As the percentage of fly ash is increased up to 15% the value of maximum dry density of soil mix is increased by 29%.

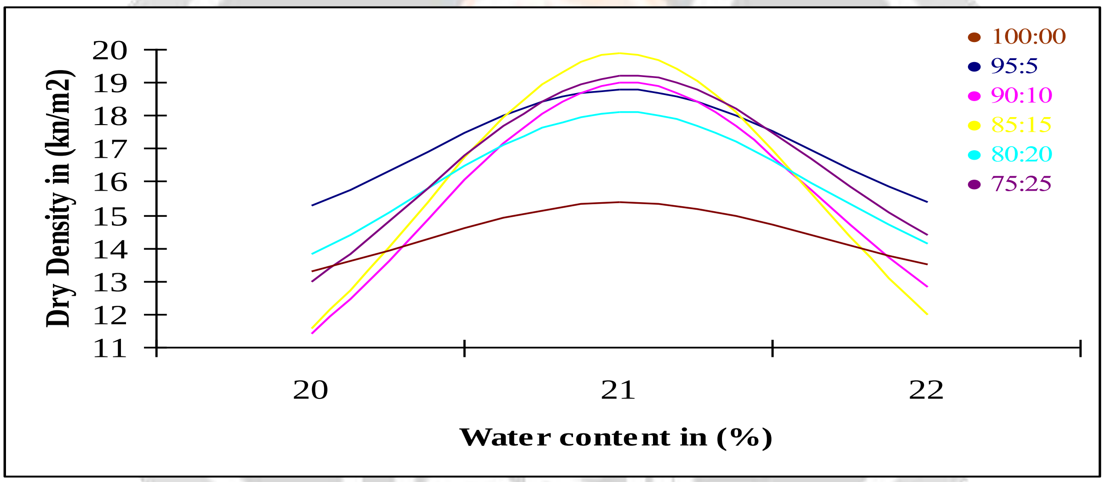

Fig -3: Effect of fly ash addition on dry density and moisture content

The maximum dry density of soil without modification is found to be 15.38 KN/m^3. After modification with 5%, 10%, 15%, 20% and 25% respectively of fly ash the maximum dry density is found to be increased by 22%, 23%, 29%, 17% and 24% respectively. The probable reason for increase in maximum dry density of soil by addition of fly ash in comparison with original soil may be proper rearrangement of modified soil mix and improved binding capacity.

The Standard Proctor's test for soil with fly ash mixes are performed and presented in Table -6. similarly effect on addition of fly ash for soil in OMC is presented in Fig -4.

Table -6: Effect of Fly ash addition on Optimum Moisture Content for soil

Sr. No.	**Property**	**Soil + Fly Ash mix**					
		S_1F_0	**S_1F_1**	**S_1F_2**	**S_1F_3**	**S_1F_4**	**S_1F_5**
	Proportion Soil : Fly Ash	100:00	95:5	90:10	85:15	80:20	75:25
1.	Optimum Moisture Content (%)	25.30	24.20	22.64	18.40	19.20	20.87

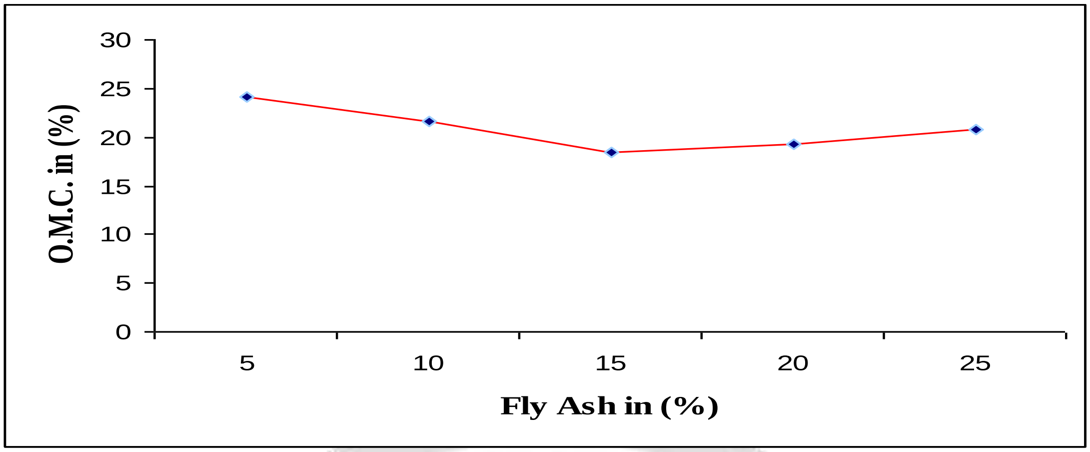

Fig -4: Effect of addition of fly ash on OMC

Similarly it is found that the value of optimum moisture content is reduced as the percentage of fly ash is increased. As the percentage of fly ash is increased up to 15% the value of optimum moisture content is reduced by 27.27%. Further if the percentage of fly ash is increased up to 25% the value of optimum moisture content is reduced by 17.51% in comparison with original soil.

The Optimum moisture content of soil without modification is found to be 25.30%. After modification with 5%, 10%, 15%, 20% and 25% of fly ash, the optimum moisture content is found to be reduced by 4.35%, 10.51%, 27.27%, 24.11% and 17.51% respectively. The probable reason for reduction in optimum moisture content of soil by addition of fly ash in comparison with original soil may be proper rearrangement of soil particles of modified mix which may be reducing the voids.

3.3 Unconfined compressive strength

The unconfined compressive strength test results for various combination of soil with fly ash are presented in Table -7. The results in graphical form are also presented in Fig -5. Shear strength is the principal engineering property which controls the stability of soil mass under the load. It governs bearing capacity, stability of slope etc. The test is conducted in laboratory on unconfined compression machine as per IS: 2720 part 10-1973.

Table -7: Effect of Fly ash addition on unconfined compressive strength for soil

Sr. No.	Property	Soil + Fly Ash mix					
		S_1F_0	S_1F_1	S_1F_2	S_1F_3	S_1F_4	S_1F_5
	Proportion Soil : Fly Ash	100:00	95:5	90:10	85:15	80:20	75:25
1.	Unconfined compressive strength (kPa)	153.82	151.87	173.56	195.26	216.95	195.26

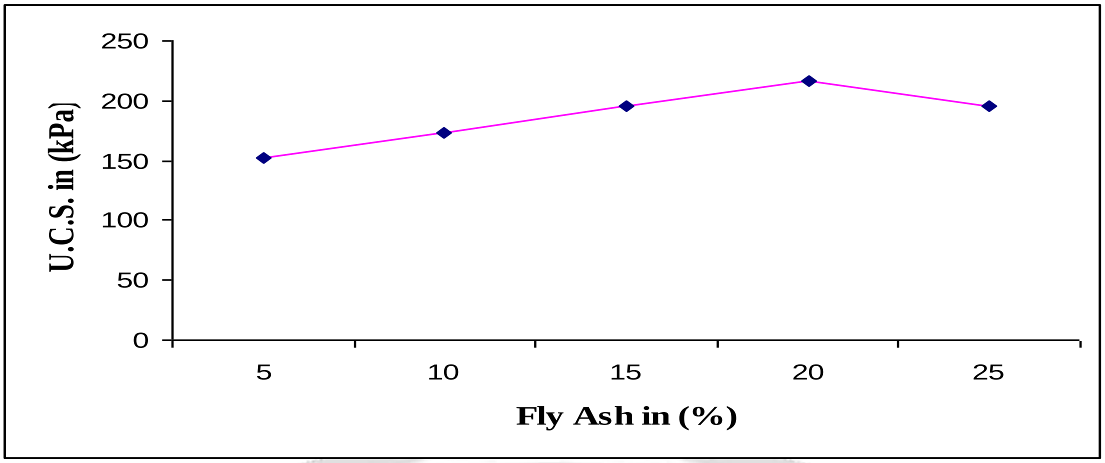

Fig -5: Effect of addition of fly ash on UCS

From the Table-8, it is found that if the percentage of fly ash is increased the value of unconfined compressive strength is also increased. If the value of fly ash is increased up to 15% the value of unconfined compressive strength is increased by 29.97%.

The unconfined compressive strength of soil without modification is found to be 153.82 kPa. After modification with 5%, 10%, 15%, 20% and 25% of fly ash, the value of unconfined compressive strength is found to be increased by 1.26%, 12.83%, 26.94%, 41.04% and 26.94% respectively. The probable reason for increase in unconfined compressive strength of soil by addition of fly ash in comparison with original soil may be increase in the density of modified soil mix.

3.4 California bearing ratio value

The California Bearing Ratio test results for various combinations of soil + fly ash presented in Table-8. Same results in graphical forms are also presented in Fig -6.

Table -8: Effect of Fly ash addition on California Bearing Ratio for soil

Sr. No.	Property	Soil + Fly Ash mix					
		S_1F_0	S_1F_1	S_1F_2	S_1F_3	S_1F_4	S_1F_5
	Proportion Soil : Fly Ash	100:00	95:5	90:10	85:15	80:20	75:25
1.	California Bearing Ratio % (UnSoaked)	5.16	6.20	6.39	6.57	6.39	6.20

The California bearing ratio test is a type of test developed by California division of highways in 1929. This test is used for evaluating the suitability of sub grade and the materials used for sub base and base courses.

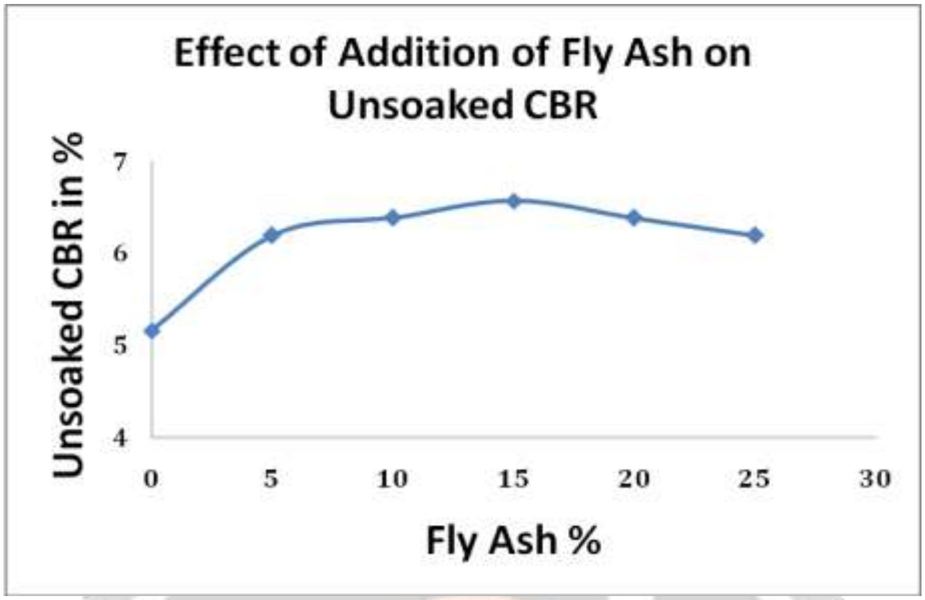

Fig- 6: Effect of addition of fly ash on CBR

From the Table-8 it is found that if the percentage of fly ash is increased the value of California bearing ratio is increased. If the percentage of fly ash is increased up to 15% the value of California bearing ratio is increased by 27.32%. The California bearing ratio of soil without modification is found to be 5.16%. After modification with 5%, 10%, 15%, 20% and 25% of fly ash, the value of California bearing ratio is found to be increased by **20.15%**, **23.83%, 27.32%, 23.83%,** and **20.15** %. The probable reason for increase in California bearing ratio of soil by addition of fly ash in comparison with original soil may be increase in the density of modified soil mix, leads to soil mass having more strength.

4. RESULTS AND CONCLUSIONS

On the basis of the results obtained in the experimental investigation, the following conclusions have been drawn:

- Soil is modified with fly ash by 5%, 10%, 15%, 20% and 25%. The value of CBR is found to be increased by 20.15%, 23.83%, 27.32%, 23.83%, and 20.15%. The maximum increase in CBR is by addition of 15% fly ash due to increase in the density of modified soil mix it leads to have more strength.
- By addition of 15% of fly ash in soil, the value of liquid limit, plastic limit and plasticity index of modified soil is reduced due to use of non-plastic material for modification.
- By addition of 15% fly ash in soil, the value of maximum dry density of modified soil is increased due to proper rearrangement of modified soil mix and due to improved binding capacity.
- The optimum moisture content of soil by addition of 15% fly ash is reduced due to proper rearrangement of soil particles of modified soil mix, which may be reducing the voids.
- The value of unconfined compressive strength of soil by addition of 15% fly ash is increased. The probable reason for this may be due to increase in the density of modified soil mix.
- The value of California bearing ratio of soil by addition of 15% fly ash is increased due to increase in density of modified soil mix, which leads to soil mask having more strength.
- From the practical consideration the modified soil mix (soil : fly ash) 85:15 percentage is recommended to be used for road sub grade similarly modified soil mix with soil & rice husk ash in proportion 85:15 percentage is recommended.

5. SCOPE FOR FUTURE WORK

The new Agro-Industry waste material may be used along with fly ash which helps to improve the index properties of soil. And this fashion other type of waste material can be utilized.
The work can be extended to study as

- Performance of soil with Agro-Industry waste and fly ash in combination
- Performance of soil with Agro-Industry waste and fly ash in combination under different environment conditions.

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