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Soil Stabilization by using fly ash and Ferric Chloride

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***Abstract:** The soil is stabilized with fly ash and ferric chloride mixtures in this research paper. The Serviceability of the pavement is very tractable to the soil sub-grade properties. For that reason, a weaker sub-grade can be improved by using the most effective stabilization method. Based on the literature review, stabilization with fly ash activated sub grade has been found to be an effective option for improvement of soil properties. Stabilization of the soil is mostly done in soft soils such as organic soil, clayey peat, silt. Some of the wastes used are fly ash, marble dust, foundry sand, rice ash and so on. These materials not only provide an alternative to the use of conventional materials but also help control environmental pollution. In many places, the waste is dumped into the open air, which can be very problematic for the people in the area and the workers working in these areas. Using these waste materials not only reduces pollution but also reduces human credibility on natural resources, leading to a more sustainable process of construction. It was found from the literature that the optimum dose of fly ash and ferric chloride revealed essential enhancement in strength and durability characteristics and declination in the swelling and plasticity properties of the soil. Based on that result, it is suggested that a mixture of fly ash and ferric chloride should be take into consideration a workable option for the stabilization of broad subgrades.*

I. INTRODUCTION

Fly ash is a by-product of the powdered coal ignition process generally associated with electric force creating plants. Fly ash is a fine residue which is pozzolanic in nature and made out of alumina, silica and different alkalis and oxides. It come up with cementitious product subsequent to responding with hydrated lime. (Braja M. Das). Type C fly ash is acquired from the ignition of coal preliminary. It contains a lot of free lime with the expansion of water that will respond with other fly ash mixes to frame cementitious products. This may dispense with the need to include produced lime (raja M. Das). Soil consolidation is the modification of soil properties to alter soil texture. Constantly transformed properties are water content, durability and plasticity. Land reform is a temporary development of low reliance on accelerating development. Fly ash can be the speed of settling soil for the foundations of a highway. Notwithstanding, restricted data opposes on the reuse of high carbon fly ash in development of thruway asphalts.

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This is especially significant when high carbon fly debris is calcium-rich and non-cementitious activators are required to create pozzolanic responses. In this manner, there is a need to assess the firmness and quality of base layers balanced out with high carbon fly ash. Fly ash can be utilized to balance out the subgrades and furthermore to settle inlay to limit the horizontal earth pressures. Fly ash can also be used similarly to adjust banks to stabilize the slope. Fly ash has been used successfully in many applications to improve soil quality. Stable soil depth is 15 to 46 centimetres (6 to 18 inches). The basic cause of fly ash is used in soil preparation programs to improve the quality and soil texture. In order to remedy fly ash, the selection of fly ash mixture, soil and water content depends on which person may donate the proposed land in terms of the existing structure.

The long-haul execution of fly debris settled is to progressive distinctive climate cycles, for example, freeze-defrost or wet-dry cycles are regularly disregarded. The enduring cycles impact on common soils and soils balanced out with other settling materials, for example, lime and additionally concrete presume that the enduring activity may markedly affect the long-haul execution of fly ash settled soils. The general quality and execution of asphalt is needy not just upon its plan (counting both basic structure and blend structure) yet in addition on the heap bearing limit of the subgrade soil. Along these lines, the methods that should be possible to extend the heap bearing limit (or auxiliary help) of the subgrade soil will in all likelihood correct the asphalt load-bearing limit and asphalt execution and quality. The more noteworthy subgrade basic limit can bring about slenderer and progressively conservative asphalt structures. At last, the completed subgrade layer should meet evaluations, heights and inclines determined in the agreement base.

Need and advantages

Soil properties vary from place to place depending upon the climatic and geographical conditions of that area. They are not suitable for construction always and need to be modified so that they do not cause any damage to the structure built on them. The main need of stabilizing the soil is to improve the bearing capacity so that they are able to withstand the load applied on them. The advantages of soil stabilization are:

- If during the development stage frail soil strata are experienced, the typical practice followed is supplanting the powerless soil with some other great quality soil. With the use of soil adjustment system, the properties of the locally accessible (soil accessible at the site) can be upgraded and can be utilized adequately as the subgrade material without supplanting it.

- The cost of setting up the subgrade by supplanting the frail soil with a decent quality soil is higher than that of setting up the subgrade by balancing out the locally accessible soil utilizing diverse adjustment methods.
- The quality giving parameters of the soil can be successfully expanded to a necessary sum by adjustment.
- Improves soil quality, in this way, increases the soil carrying capacity.
- Slow tolerance and durability are required to increase the surface area rather than to drill deep or pontoon formation.
- It is also used to give extra stiffness to the slides or other such surfaces.
- Sometimes soil preparation is also used to prevent cracking or development of residues, which is especially useful in dry and wet climates.
- Reinforcement is also done to hold the soil in water; this keeps the water from getting into the soil and henceforth helps pollution lose its quality.
- It helps to reduce soil volume fluctuations due to improved content or softness.

II. MATERIALS AND METHODS

The materials used in this research are clay soil, fly ash and ferric chloride.

A. Clay soil

Soil has been taken from the Khaleri near Gharuan, Tehsil Kharar District Mohali.

The various properties of Virgin soil are enlisted in Table 1.

Table 1 properties of Virgin Soil

Sr. No.	Clayey soil Properties	Value
1.	Specific Gravity (G)	2.69
2.	Liquid Limit (%)	45%
3.	Plastic Limit (%)	26%
4.	Plasticity Index (%)	18.91%
5.	MDD	1.43
6.	OMC	19
7.	CBR	4.35
8.	UCS	94.8 KN/m^2

B. Fly ash

It is a non-crystalline pozzolanic substance with a bit sticky property. It contains solid and dangerous pollutants that surrounded it. That produced in the bulk when coal is burnt in thermal power plants. At present, in India alone, total ash output has reached 95 million tonnes each year with a biomass charge of around 1000-2000 MW and increasing coal consumption. This dramatic enlargement and the frighten low rate of consumption of 7.5% in India in 1998 indicate the potential risks to the economy and the economy. Based on its drying properties (Nayak et al., 1988; Mittal, 1998) it was doubtful to try it as a mix with the soil used now. A fly ash was collected from a nearby hot power station. Fly ash is a component used in minerals that is not completely dissolved due to the dissolution of land or powdered coal in the electricity generating industry.

Fly ash contains the oxides of silicon, calcium and Aluminium iron while Magnesium, Potassium, Sodium, Titanium, and Suffer are present there in small amounts. In a situation where fly ash utilized as mineral ingredient in concrete fly ash is called Class C or Class F fly ash depending on its material properties. The dissolution of the resulting ash is likely to be attributed to the active nature of the coal bending and the brittle force of the coal itself. A coarser degree can bring about acceptable waste and can counteract high carbon materials. Detention points are provided by ASTM and details of the state transport office. The physical properties and material properties of the fly milling machine are given in Table 2 and Table 3.

Table 2: Physical properties of fly ash

Sr. No.	Colour	Dark Grey
1.	Specific gravity (G)	2.74
2.	Liquid limit (%)	27%
3.	Plastic limit (%)	Non plastic
4.	Maximum Dry Density	1.1g/cc
5.	Optimum Moisture Content	32%
6.	Swelling pressure	0.124kg/cm2

Table 3: Chemical composition of fly ash

S.No.	Composition	Composition by wt.%	
		Class C	**Class F**
1.	Silica (SiO_2)	40	55
2.	Alumina (Al_2O_3)	16.5	26
3.	Ferric Oxide (Fe_2O_3)	6.5	7
4.	Calcium Oxide (CaO)	24	9
5.	Magnesium Oxide (MgO)	2.3	2
6.	Sulfate Oxide (SO_3)	3	1
7.	Loss of Ignition (LOI)	6	6

C. Ferric chloride

Ferric chloride is an orange to dark coloured dark strong. Ferric chloride is totally dissolvable in water. Ferric chloride is non-combustible. Ferric chloride is destructive to Aluminium and most metals when it is wet. Get and expel spilled strong before including water. From prior investigations it was discovered that FeCl3 was very compelling in limiting growing of broad soils. The properties of ferric chloride are recorded in Table 4.

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Table 4 Properties of ferric chloride

Chemical formula	Molecular weight	appearance	odour	Solvent in water	Crystal structure	Other anions	Affiliated coagulants
$FeCl_3$	162.2 g/mole (anhydrous) 270.3 g/mole (hex hydrate)	Green-black by reflected light; Purple-red by transmitted light;	Slight HCl	74.4 g/100 mL (anhydrous, 0°C) 92 g/100 mL (hex hydrate, 20°C)	Hexagonal	Iron (III) fluoride Iron (III) bromide	Iron (II) sulphate Poly aluminium chloride
Density	Melting point	Boiling point	Viscosity	Solubility in acetone Methanol Ethanol Diethyl ether	GHS hazard statements	Other cations	-
2.898 g/cm^3(anhydrous) 1.82 g/cm^3(hex hydrate)	306°C (anhydrous) 37°C (hex hydrate)	315°C (anhydrous, decomp) 280°C (hex hydrate, decomp) (Partial decomposition to $FeCl_2 + Cl_2$)	40% solution: 12cP	63 g/100 mL (18°C) Highly soluble 83 g/100 mL Highly soluble	H290, H302, H314, H318	Iron (II) chloride Manganese (II) chloride Cobalt (II) chloride Ruthenium (III) chloride	-

D. Experimental programmed/ methodology

In this research compaction test, UCS test, and CBR tests are performed and MDD of Mixture of Clayey soil sample and Fly ash by Compaction test. In first attempt properties of soil is found out. In second attempt added Fly ash in Clayey soil were in different ratios i.e. 10%,15%,20%, 25%.UCS and CBR value is found out. In Third attempt Ferric chloride is added in soil mixture i.e. (Fly ash and clayey soil) in different ratios 0.5%, 1%,1.75%,2.5% OMC, MDD, UCS and CBR value is found out.

Compaction test: This test was conducted according to IS:2720, MDD and OMC value is found out.

- UCS test: This test was conducted according to the IS2720-10,
- CBR test: This test was conducted with following the ASTM D 1883.

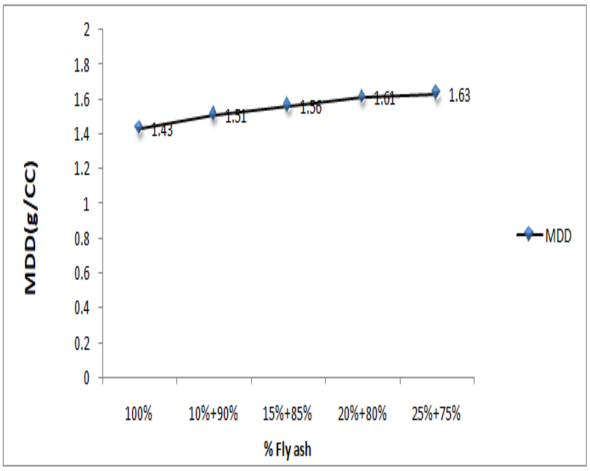

Fig 1: MDD Variation with replacement of soil with % Fly ash.

III. TEST RESULTS ANALYSIS AND DISCUSSION

Composition % fly ash + Clayey soil	Maximum Dry Density (MDD) (g/cc)	Optimum Moisture Content (OMC) (%)	CBR (%)		UCS KN/m^2
			Unsoaked	Soaked	
100%	1.43	19	4.35	1.50	94.8
10%+90%	1.51	18.1	7.6	2.55	165.55
15%+85%	1.56	17.4	8.41	2.821	220.612
20%+80%	1.61	16.8	10.87	3.611	275.72
25%+75%	1.63	15.9	10.42	3.40	233.23

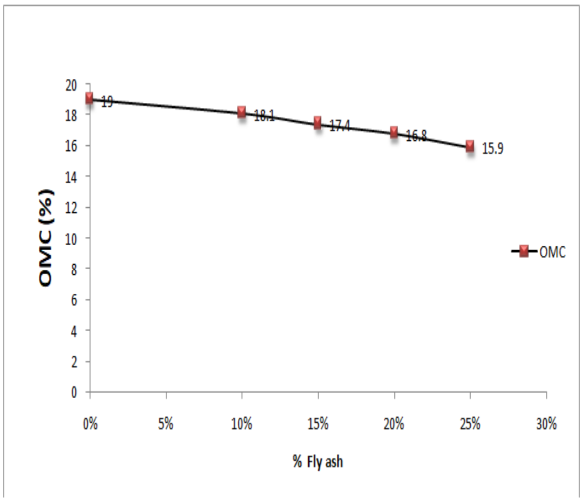

Fig 2: OMC variation with replacement of soil %Fly ash

I). Effect on the MDD and OMC on adding the Fly ash. In this Research the maximum dry density of Clayey soil is increased from 1.43g/cc to 1.63g/cc on addition of fly ash in various percentages i.e. 10%,15%,20%,25% as shown in Fig.1. There is an increment in MDD because of

II). Impact on the CBR and UCS behaviour of soil on adding Fly ash. The CBR and UCS has shown an increase with the increment in %age of Fly ash. This increase is due to cementitious product subsequent to responding with hydrated lime.

Present in the Fly ash, it acts as cementitious material Due to that the bond between clayey particle and Fly ash becomes stronger and its load bearing capacity has been increased.

Fig 3 shows that the CBR value of Fly ash and soil mix initially increased from 4.35% - 10.87% at 20%of fly ash and then decreases up to 10.42 % at 25%. The UCS of Fly ash soil mix initially increased from 94.8 KN/m^2 for virgin soil to 275.72 KN/m^2 and then decreases up to 233.23 KN/m^{2}at 25% of Fly ash.

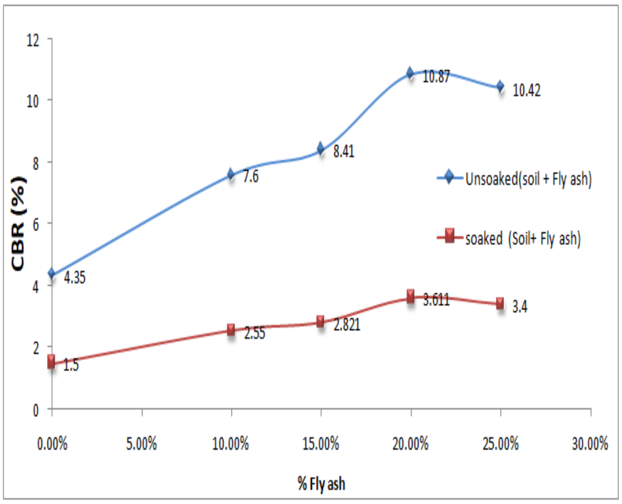

Fig 3: CBR variation with replacement of soil %Fly ash.

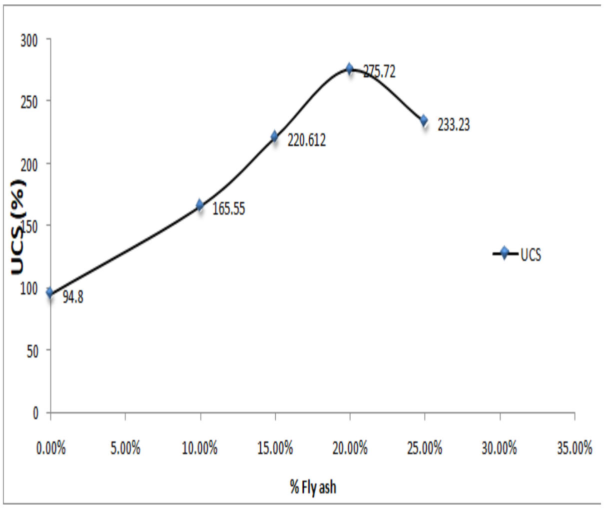

Fig 4: UCS variation with replacement of soil %Fly ash.

Table 5: properties of soil stabilized with fly ash and ferric chloride

Composition % fly ash Ferric Chloride + Clayey soil	Maximum Dry Density (MDD) (g/cc)	Optimum Moisture Content (OMC) (%)	CBR (%)		UCS KN/m^2
			Unsoaked	Soaked	
20%+0.5%+79.5%	1.64	15.5	10.92	3.702	315.72
20%+1%+79%	1.66	15.8	11.09	3.75	398.63
20%+1.75%+78.25%	1.71	16.1	12.89	4.35	475.85
20%+2.5%+77.50 %	1.70	16.4	11.95	3.98	395.72

III). Effect of fly ash and Ferric chloride soil mix on MDD and OMC. In this study the MDD has shown as increase from 1.64g/cc to 1.71g/cc with the increase of Ferric Chloride %age up to 1.75% and then decreases up to 1.70g/cc at 2.5% of $FeCl_3$ as shown in Fig.5.And the OMC increased with the increment of Ferric chloride %age. This is due to the fact that the Ferric Chloride itself absorbs water at first instants Fig 6 shows that the OMC value of fly ash ferric chloride soil mix increased from 15.5 to 16.4.

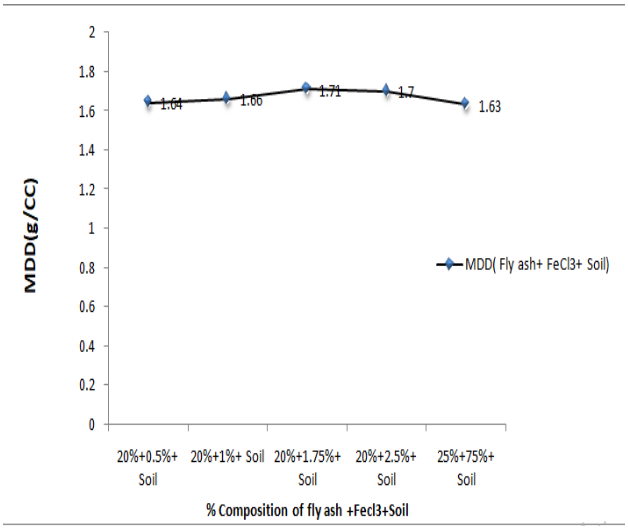

Fig 5: Variation in MDD with %composition of Ferric chloride in optimum Soil Fly ash mix.

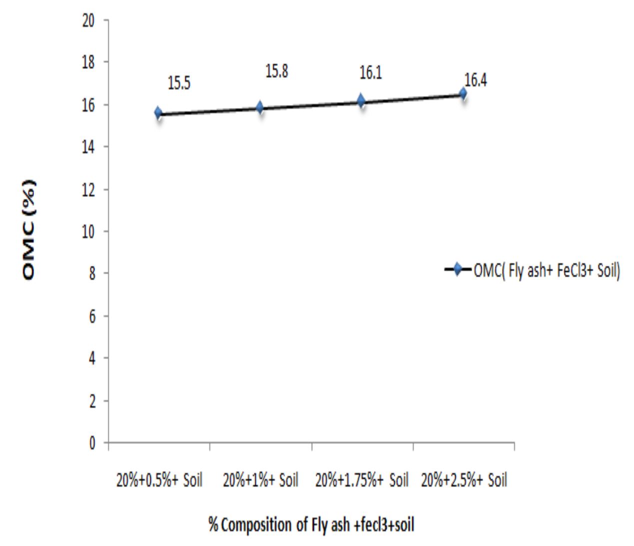

Fig 6: Variation in OMC with %composition of Ferric chloride in optimum Soil Fly ash mix.

IV). Effect of fly ash and Ferric chloride soil mix on CBR and UCS. The CBR and UCS of Mix is increased at 1.75% of Ferric Chloride in the mixture of Fly ash and soil and then decreased at 2.5% of Ferric Chloride. The CBR of Fly ash ferric chloride soil mix is increased from 10.92% to 12.89% at 1.75% of ferric chloride as shown in Fig.7 and then decreased up to 11.95%. The UCS of fly ash ferric chloride Soil mixture is initially increased and then decreased. The UCS is increased from 315.72 KN/m^{2}to 475.85 KN/m^2 at 1.75% of Ferric Chloride in the mixture and then decreased up to 395.72 KN/m^{2}at 2.5% of ferric Chloride in the mixture as shown in Fig.8.

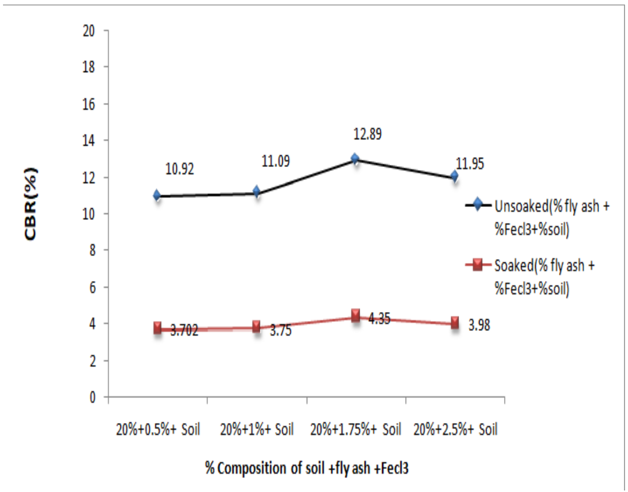

Fig 7: Variation in CBR with %composition of Ferric chloride in optimum Soil Fly ash mix

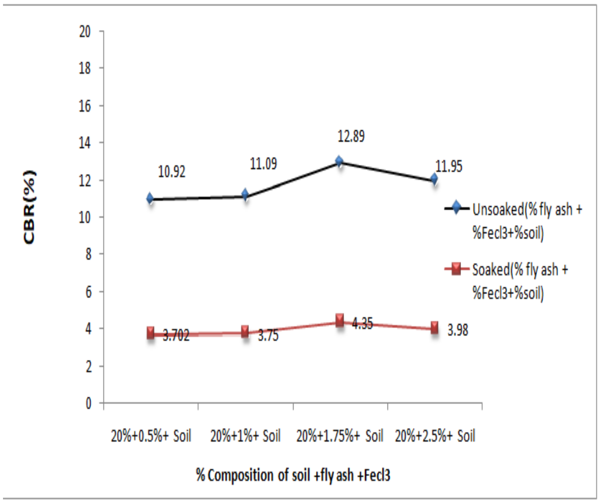

Fig 8: Variation in UCS with %composition of Ferric chloride in optimum Soil Fly ash mix.

IV. CONCLUSION

CBR and UCS of Soil Fly ash Ferric Chloride mix is investigated in this Research program.

The major conclusions are as follows:

- The MDD of soil fly ash mix initially increased in virgin soil 1.43(g/cc) to 1.63(g/cc) and Optimum Moisture Content decreased from 19% for virgin soil to 15.9%.
- The un soaked CBR value initially increased from 4.35% for virgin soil to 10.87% up to 20% of fly ash and after that it decreased upto10.42% at 25% of flash.
- The UCS of mix initially increased from 94.8KN/m^2 for virgin soil to 275.72KN/m^2 at 20% of Fly ash and then decreased up to 233.23KN/m^2 at 25% of Fly ash when Cured for 7 days.
- The Maximum dry density of Ferric Chloride Fly ash mixes initially increased 1.64(g/cc) to1.71(g/cc) and decreased up to 1.70(g/cc) at 2.5% ferric chloride and Optimum Moisture Content increased from 15.5% to 16.4%.
- The Un soaked CBR value of ferric Chloride Fly ash soil mix initially increased from 10.92% to 12.89% at 1.75% Ferric Chloride and decreased up to 9.76% at 2.5% ferric chloride.
- The UCS value of ferric Chloride Fly ash soil mix initially increased 315.72KN/m^2 to 475.85 KN/m^{2}at 1.75% of Ferric Chloride and decreased up to 395.72 KN/m^2 at 2.5% of Ferric Chloride on 7 days curing.
- The optimum Value of ferric chloride is 1.75%.
- Thus, the optimal mixture of 78.25% soil 20% Fly ash1.75% Ferric Chloride is recommended for successful use in soil stabilization.

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