STABILITY ANALYSIS OF SUBGRADE SOIL OF A PAVEMENT USING FLY ASH ADDITIVES

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Abstract: An experimental program was undertaken to study the effect caused by the action of fly ash stabilization on the geotechnical characteristics of inclusive subgrade soils. Expansive soil dealt with varying percentages of fly ash, 12, 22, 32, and 42 per cent were studied. Consistency limits, compaction, California Bearing Ratio, UCS tests were conducted on treated and untreated soils. The experimental results show that addition of fly ash admixture to the soil has great influence on its properties. It was found that the optimum dosage of fly ash is 22% revealed in significant improvement in strength and durability and reduction in swelling and plasticity properties of the soil. Based on the results, it is recommended that fly ash admixture be considered a feasible option for the stabilization of expansive subgrades.

Keywords: **Stabilization, Flyash, Consistency limits, Subgrade.**

I. INTRODUCTION:

Fly ash is a byproduct of the powdered coal combustion process usually connected with electric power generating plants. Fly ash is a fine dust which is pozzolanic in nature and composed of alumina, silica and various alkalies and oxides. It produced cementitious products after reacting with hydrated lime. The soil stabilization is the modification of soil properties to meliorate the engineering performance of soils. The properties most often modified are water content, density strength and plasticity. Modification of soil properties is the temporary enhancement of sub grade stability to expedite construction.

Fly ash can be used to stabilize the subgrades and also to stabilize backfill to minimize the lateral earth pressures. Fly ash can also be used to stabilize embankments to meliorate slope stability. Fly ash has been used successfully in many projects to meliorate the strength characteristics of soils. Typical stabilized soil depths are 15 to 46 centimeters (6 to 18 inches). The main reason of fly ash is used in soil stabilization applications is to improve the compressive and shearing strength of soils.

The overall strength and performance of a pavement is dependent not only upon its design (including both structural design and mix design) but also on the load-bearing capacity of the subgrade soil. Thus, the techniques that can be done to increase the load-bearing capacity (or structural support) of the subgrade soil will most likely meliorate the pavement load-bearing capacity and pavement performance and strength. The greater subgrade structural capacity can result in thinner and more economical pavement structures. Finally, the finished subgrade layer should meet grades, elevations and slopes specified in the contract base.

II. MATERIAL AND METHODOLOGY:

In his research works lime is added to black cotton soils at 0 to 8% to establish datum values. Next fly ash is at 0 to 25% limit. The curing period is considered at 7 days age for his experiments. Fly ash is defined as the material collected from the flue gases of a furnace fired with coal. Fly ash consists of often hollow spheres of silicon aluminum, iron oxide and UN oxidized carbon. Thus, expansive soils are likely to be stabilized effectively by cation exchange using fly ash. Addition of 20% fly ash can decreased the selling capability considerably. There is slight decrease in swelling potential from 20 to 25 % fly ash addition .therefore the optimum fly ash content is near 20% only. The plasticity index, activity, CBR, UCS, and swelling pressure etc. gave satisfactory results when black cotton soils are treated with fly ash. Thus fly ash is a good stabilizer now a days.

Table 1: Geotechnical properties of unmodified soil

S. No	Property	Value
1	Gravel	1.5%
2	Sand	32.5%
3	Fines	66.3%
4	Bulk Density	2.3g/cc
5	Specific gravity	2.66

6	Liquid limit	35.8%
7	Plastic limit	22.3%
8	Plasticity index	13.5%
9	Optimum moisture content	10.6%
10	Maximum dry density	19.3 kN/m^3

Table 2: Physical properties of fly ash

Colour	Dark gray
Specific gravity	2.74
Liquid limit	27%
Plastic limit	Non plastic
Maximum dry density	1.1g/cc
Optimum moisture content	32%
Swelling pressure	0.124kg/cm^2

III. RESULTS :

The results obtained from the experimental analysis are shown in table.

Table 3: Results of unmodified subgrade soil

S. No.	Property	Subgrade soil(S.S)
1	Liquid limit	36.4%
2	Plastic limit	22.9%
3	Plasticity index	14.2%
4	Shrinkage limit	26.4%
5	Average Grain Size D_{50} (mm)	0.14
6	Coefficient of Uniformity C_u	2.81
7	Coefficient of Curvature C_c	1.51
8	Maximum dry density	20.1 kN/m^3
9	O.M.C.	11.1%
10	U.C.S.	59.1 kN/m^2
11	Classification As per Indian StandardTypical Soil Classification	(SM) Silty Sand

The silty sand soil (SM) as per Indian standard soil classification system is selected for study as shown in Table 3. Different Proportions

of Fly-ash is used to reinforce the soil. The various properties of fly-ash are mentioned in Table 2.

- **88%Subgrade soil (S.S) + 12%Fly ash (F.A)**

These are the results formed when 12% of the soil Subgrade is replaced with the Fly-ash and it's observed that liquid limit reduces significantly while unconfined compressive strength (UCS) increases a little bit. MDD and OMC also decreases and increases respectively with the addition of fly-ash in the soil subgrade.

Table 4: Results of subgrade soil with 12% of fly ash

S. NO.	PROPERTY	88% S. S. + 12% F. A.
1	Liquid limit	34.1%
2	Plastic limit	25.1%
3	Plasticity index	14.8%
4	Shrinkage limit	22.3%
5	Maximum dry density	18.3 kN/m^3
6	O.M.C.	14.14%
7	U.C.S.	61.2N/m^2

- **78%Subgrade soil (S.S) + 22% Fly ash (F.A)**

Table 5: Results of subgrade soil with 22% of fly ash

S. NO.	PROPERTY	78% S. S. + 22% F. A.
1	Liquid limit	32.2%
2	Plastic limit	24.3%
3	Plasticity index	12.1%
4	Shrinkage limit	19.2%
5	Maximum dry density	18.4 kN/m^3
6	O.M.C.	14.34%
7	U.C.S	91.2 kN/m^2

On increasing the Percentage of Fly-ash by 10% more i: e total of 22% it's found that there is A noticeable change in the UCS as Well as Liquid limit. The UCS shoots up to 91.2 KN/m^2 which is quite good, whereas OMC and MDD increases a little bit.

- **68% Subgrade soil (S.S) + 32% Fly ash (F.A)**

In this case, the UCS Start reducing which clearly means further addition of fly-ash will result in lower Strength but OMC increases with the further addition of fly-ash in the Soil. The Plasticity Index decreases too as when increase the Percentage of Fly-ash.

Table 6 : Results of subgrade soil with 32% of fly ash

S. NO.	PROPERTY	68% S. S. +32% F. A.
1	Liquid limit	33.1%
2	Plastic limit	25.6%
3	Plasticity index	11.98%
4	Shrinkage limit	25.2%
5	Maximum dry density	18.2 kN/m^3
6	O.M.C.	14.75%
7	U.C.S.	89.2 KN/m^2

- **58% Subgrade soil (S.S) + 42% Fly ash (F.A)**

Table 7: Results of subgrade soil with 42% of fly ash

S. NO.	PROPERTY	58% S. S. +42% F. A.
1	Liquid limit	36.1%
2	Plastic limit	27.8%
3	Plasticity index	9.89%
4	Shrinkage limit	26.4%
5	Maximum dry density	17.3 KN/m^3
6	O.M.C.	16.1%
7	U.C.S.	86.7 KN/m^2

On further checking of the Effect of increasing the Fly-ash content it is noted that UCS further drop down to 86.7 kN/m^2 which means if we further replace the soil with fly-ash there will be a dropdown in the Strength of soil which is not the motto of our Project and hence we stop increasing the fly-ash percentage. The other parameters behaved accordingly.

IV. CONCLUSION:

- It was observed that OMC increases and MDD decreases with increased percentage of fly ash mixed with silty sand. The optimum value of fly ash mix was obtained to be approximately 22%.
- The variation of unconfined compressive strength (UCS) with percentage of fly ash mix expose that UCS increases up to 30% of fly ash mix and then it decreases.
- Through this experimentation it is observed that the by-product fly ash is also good stabilizing compound.
- The optimum proportions for the combination of subgrade soil + by product are 78% S.S + 22% F.A.
- When the percentage of fly ash increased then the liquid limit increased and plastic limit decreased
- With the addition of fly ash greater than 22%, the plasticity index of the soil is also decreased.

- With the addition of fly ash greater than 22%, the optimum moisture content of the soil is increased while the maximum dry density of soil decreased.
- With the addition of 22% of fly-ash, the unconfined compressive strength (UCS) of the stabilized subgrade soil is increased as compared to the subgrade soil.
- With the addition of 22% of fly-ash, the shrinkage limit of the stabilized subgrade soil is also reduced as compare to the subgrade soil.

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