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# ENHANCEMENT OF STABILIZING WEAK SUB-GRADE BUILDING OF A PAVEMENT THROUGH FLY-ASH STABILIZED SOIL ADMIXTURE

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***Abstract: The quality of the sub-grade soil has a significant impact on the features of the pavement. In order to stabilize deteriorating sub-grades, the most lucrative stabilization technique is advocated. Studies have shown that enacting sub-grade stabilization with fly-ash is an effective method of enhancing the soil's quality. Fly-ash stabilization activities were put through a series of tests to see what effect they had on the geotechnical characteristics of sub-grade soils with poor geotechnical characteristics. The stabilization of the sub-grade soil is one of the most important steps in the building of a pavement. Soil mixing with fly-ash will be examined in this study to see what effect it has on the stability and strength of sub-grade pavements. The soil was amended with a range of fly-ash concentrations, including 9, 18, 27, and 36%. It has been tested for several features, such as Consistency limitations, CBR, Compaction and UCS. A fly-ash additive has a dramatic effect on the soil's quality, according to the test results. Soil quality and strength improved significantly when fly-ash was used at 18 percent; this was deemed to be the ideal proportion for fly-ash use. Plastic Limit (PL), Optimum Moisture Content (OMC), Unconfined Compressive Strength (UCS), Maximum Dry Density (MDD) & Plasticity Index (Pl) with the percentage of Fly-Ash contained in soil sub-grade are the beginning data for this investigation. CBR, Compaction, Specific Gravity, Sieve Analysis, and Water Absorption Test are used to examine fly-ash-stabilized soil. Plastic Limit, Liquid Limit, California Bearing Ratio, and Optimum Moisture Content are the properties that are being tested for. According to the findings, fly-ash admixture should be considered a realistic option for stabilizing weak sub-grades.***
***Keywords: CBR, OMC, MDD, Fly-Ash, UCS***

## I. INTRODUCTION

Mixing

Soil stabilization relies heavily on the ability to create a homogeneous and well-mixed slurry. Construction employs a variety of methods, including the following:
(1) Batch or continuous off-site mixing is possible.
(2) Mixing on the spot.
It is easier to manage the quantity of components batched for off-site mixing than for on-site mixing, which results in more consistent mixes. Self-cementing fly-ash sets in ten minutes or less, which reduces the strength of the material when it is not compacted immediately.

Application of Water

A vital phase in the building process is to include and monitor the mixing water during the stabilizing action. In order to get the desired density during compaction when using a mixing plant setup, common guidelines for water application suggest that it should be between 80 and 110 percent of the ideal moisture content. This is based on the moisture-density connection of the balanced out mixture. Before adding fly ash, water may be added to the sub-grade soils. However, the downside of this strategy is that the sub-grade might become unstable at times, making the remainder of the building process more difficult to complete. Water may be added to the combination after the fly-ash has been incorporated into the soil, although further runs of the mixing equipment are usually required, and the mixture strength decreases as the fly-ash is hydrated prior to final compaction. The pulvamixer's mixing water can best be controlled by lawfully adding more water to the mixing drum. On the other hand, this method produces the most equal mixing and the least amount of delay in the building.

Compaction of Fly-ash-Stabilized Soil

Equipment and procedures for expanding the total compaction of fly-ash soil ad-mixtures are available depending on the kind of soil. Fly-ash proven to be a good stabilizer for fine-grained and granular soils because of its self-cementing capabilities. A delay in compaction might weaken the balanced material since the fly-ash hydrates in an compacted form, therefore the time element should also be taken into account. It has been suggested that the most severe compaction delay period for Class F fly-ash stabilization operations is four hours.

Different stabilization techniques for soil

Natural soil may be stabilized in a variety of ways due to its complexity and irregularity. However, because to its widespread availability and low cost, it presents a tremendous opportunity for skilled usage as an engineering material. There are a variety of methods for stabilization, including:
Stabilization through mechanical means
- Stabilization of cement
- Stabilization of Lime
- Stabilization of bitumen
- Stabilization of chemical
- thermal processes
- Stabilization of electrical systems
- Grouting for stability.
- Stabilization With the help of geotextiles and textiles

Fly-ash stabilization

In 1998, Erdalcokca employed lime and fly ash as a stabilizer. Lime is applied to black cotton soils ranging from 0% to 8% to establish datum values in his study. The next fly-ash limit is between 0 and 25 percent. For his tests, the 7-day curing time is taken into consideration. Coal-fired heaters produce fly-ash as a byproduct of the combustion process. Fly ash is made up of iron oxide, silicon aluminum, and oxidized carbon spheres that are hollow within. As a result, action exchange utilizing fly-ash may stabilize expansive soils. The capacity to sell the product might be significantly reduced if there is an addition of 18 percent fly ash. When fly ash expands by 18 to 23%, swelling potential decreases somewhat. As a result, only around 18 percent of fly ash should be used. Swelling pressure and other soil properties improved when fly-ash was applied to black cotton fields. As a result, fly ash is now considered an effective stabilizer.

Hydration of fly-ash

Hydration is the process through which free lime (CaO) and pozzolans (AlO3, SiO2, Fe2O3) react with water to form cementations material. Using a cementations substance such as hydrated calcium silicate gel or calcium aluminates gel, static materials may be joined. Class C fly ash has siliceous and aluminous elements (pozzolans) that may react with the calcium oxide (lime) in the fly ash. Class F fly ash has a low lime concentration, thus expanding lime is needed to hydrate the fly ash's pozzolans. Soil siliceous and aluminous minerals are used by pozzolanic reactions to stabilize soils with lime. In many ashes, hydration of tricalcium aluminates generates one of the most significant cementations materials. The rapid hydration of tricalcium aluminate causes these materials to set quickly, resulting in low-strength materials that may be stabilized. In order for fly-ash stabilization to be successful, the chemical characteristics of the fly-ash need to be taken into account.

## II. EXPERIMENTAL RESULTS

As a consequence of poor soil quality,

The experiment's findings are summarized in the following table.

Table 1: Results of unmodified sub-grade soil

| S. No. | Property | Sub-grade soil(S.S) |
|---|---|---|
| 1 | Liquid limit | 36.05 |
| 2 | Plastic limit | 22.55 |
| 3 | Plasticity index | 13.85 |
| 4 | Shrinkage limit | 26.05 |
| 5 | Average Grain Size $D_{50}$ (mm) | 0.14 |
| 6 | Coefficient of Uniformity $C_u$ | 2.81 |
| 7 | Coefficien of Curvature $C_c$ | 1.51 |
| 8 | Maximum dry density | 19.75 |
| 9 | O.M.C. | 10.75 |
| 10 | U.C.S. | 58.75 |
| 11 | Classification According to Indian Standard Typical Soil Classification | SM Salty Sand |

As demonstrated in Table 1, the salty sand soil (SM) is the best candidate for inquiry based on the Indian standard soil classification system. Fly-ash is used in a variety of forms to help strengthen the soil. Table 2 lists a variety of fly-qualitative ash's characteristics.

91%Sub-grade soil (S.S) + 9%Fly-ash (F.A)

In this case, 9 percent of the Sub-grade soil was replaced with Fly-ash, and it was found that liquid limit decreased dramatically while UCS increased little. With the growth of fly-ash in the sub-grade soil, MDD and OMC decrease and increase, respectively,

Table 2: Results of soil sub-grade with 9% of fly-ash

| S. NO. | PROPERTY | 9% S. S. + 91% F. A. |
|---|---|---|
| 1 | Liquid limit | 33.75 |
| 2 | Plastic limit | 24.75 |
| 3 | Plasticity index | 14.45 |
| 4 | Shrinkage limit | 21.95 |
| 5 | Maximum dry density | 17.95 |
| 6 | O.M.C. | 13.77 |
| 7 | U.C.S. | 60.85 |

82%Sub-grade soil (S.S) + 18% Fly-ash (F.A)

Table 3: Results of soil sub-grade with 18% of fly-ash

| S. NO. | PROPERTY | 82% S. S. + 18% F. A. |
|---|---|---|
| 1 | Liquid limit | 31.85 |
| 2 | Plastic limit | 23.95 |
| 3 | Plasticity index | 11.75 |
| 4 | Shrinkage limit | 18.85 |
| 5 | Maximum dry density | 18.05 |
| 6 | O.M.C. | 13.99 |
| 7 | U.C.S | 90.85 |

The UCS and liquid limit both alter noticeably when the percentage of Fly-ash is increased by 9 percent further, for a total of 18 percent. In contrast to OMC and MDD, the UCS rises to an impressive 90.85 KN/m2.

73% Sub-grade soil (S.S) + 27% Fly-ash (F.A)

A decrease in UCS indicates that more fly-ash additions will result in a decrease in Strength, whereas a rise in OMC indicates an increase in Soil strength. The Plasticity Index decreases as the Fly-ash Percentage rises.

Table 4: Results of soil sub-grade with 27% of fly-ash

**Table 8 Results of soil sub-grade with 27% of fly-ash**

| S. NO. | PROPERTY | 73% S. S. +27% F. A. |
|---|---|---|
| 1 | Liquid limit | 32.75 |
| 2 | Plastic limit | 25.25 |
| 3 | Plasticity index | 11.63 |
| 4 | Shrinkage limit | 24.85 |
| 5 | Maximum dry density | 17.85 |
| 6 | O.M.C. | 14.4 |
| 7 | U.C.S. | 88.85 |

64% Sub-grade soil (S.S) + 36% Fly-ash (F.A)

Table 5: Results of soil sub-grade with 36% of fly-ash

| S. NO. | PROPERTY | 64% S. S. +36 % F. A. |
|---|---|---|
| 1 | Liquid limit | 35.75 |
| 2 | Plastic limit | 27.45 |
| 3 | Plasticity index | 9.54 |
| 4 | Shrinkage limit | 26.05 |
| 5 | Maximum dry density | 16.95 |
| 6 | O.M.C. | 15.75 |
| 7 | U.C.S. | 86.35 |

UCS further drops to 86.35kN/m2 with increasing fly-ash content, which is contrary to the goal of our project; hence the fly-ash percentage is halted.

  

## III. COMPARISON AND DISCUSSION

Comparison of results of various samples (LL, PL, PI & SI)

Table 6: Comparison of Sub-grade soil and stabilized sub-grade soil (LL,PL,PI & SI)

| S. No | Property | Sub-grade Soil | 91% S.S + 09 % F.A | 82 % S.S + 18 % F.A | 73 % S.S + 27 % F.A | 64 % S.S + 36 % F.A |
|---|---|---|---|---|---|---|
| 1 | Liquid limit (%) | 36.05 | 33.75 | 31.85 | 32.75 | 35.75 |
| 2 | Plastic limit (%) | 22.55 | 24.75 | 23.95 | 25.25 | 27.45 |
| 3 | Plasticity Index (%) | 13.85 | 14.45 | 11.75 | 11.63 | 9.54 |
| 4 | Shrinkage limit (%) | 26.05 | 21.95 | 18.85 | 24.85 | 26.05 |

Comparison of results of various samples (MDD, OMC & UCS)

Table 7: Comparison of Sub-grade soil and stabilized sub-grade soil (MDD, OMC, & UCS)

| S. No | Property | Sub-grade Soil | 91% S.S + 09 % F.A | 82 % S.S + 18 % F.A | 73 % S.S + 27 % F.A | 64 % S.S + 36 % F.A |
|---|---|---|---|---|---|---|
| 1 | Maximum dry Density (KN/m$^3$) | 19.75 | 17.95 | 18.05 | 17.85 | 16.95 |
| 2 | O.M.C. (%) | 10.75 | 13.77 | 13.99 | 14.4 | 15.75 |
| 3 | U.C.S.( KN/m$^2$) | 58.75 | 60.85 | 90.85 | 88.85 | 86.35 |

The numbers in the above table indicate the difference between the unmodified sub-grade soil property result and the changed result. The 82 percent S.S. + 18 percent F.A. combination provides the best results when compared to other sub-grade soil + fly-ash sets, since the value of UCS is the highest. It is just in this specific instance that the Liquid Limit is the lowest. When fly ash is 18 percent or more, the shrinkage limit is likewise low. Ninety-one percent of the three sets were standard deviation plus nine percent false alarms, while the remaining three sets were a combination of standard deviation plus 27 percent false alarms and a percentage of standard deviation plus 64 percent false alarm. Tables 10 and 11 indicate the most optimal outcomes when 82 percent S.S. + 18 percent F.A. are maintained as shown in the prior findings.

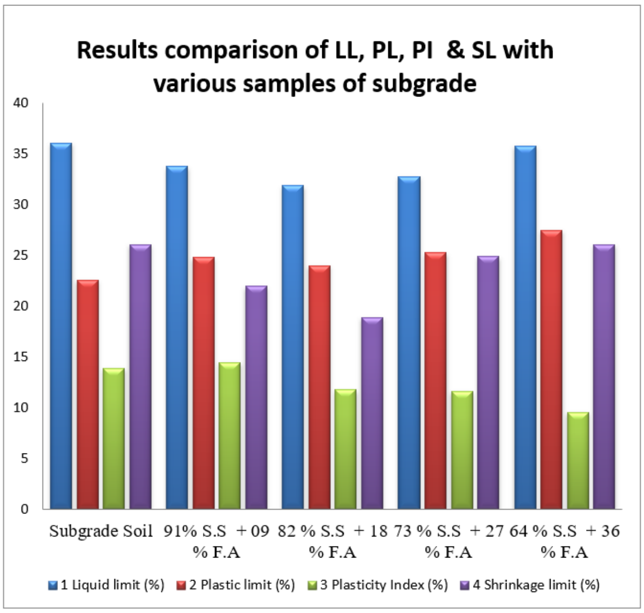


Fig. 1: Graphical comparison of soil sub-grade to the stabilized soil sub-grade (LL, PL, PI & SL)

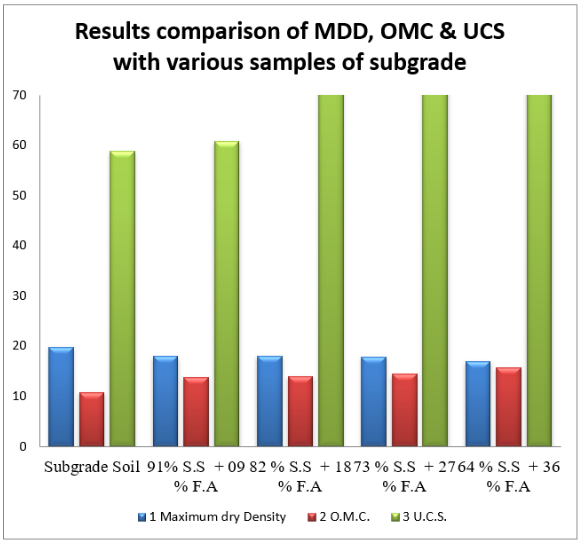


Fig. 2: Graphical comparison of soil sub-grade to the stabilized soil sub-grade (MDD, OMC & UCS)

## IV. CONCLUSION

- The OMC increases and the MDD decreases as fly-ash levels increase. It was also estimated that the fly-ash mix was around 18%.
- It has also been shown that UCS increases fly-ash blend by 27%, but thereafter fades away.
- As a result of this study, fly-ash has been shown to be a suitable balancing component.
- A combination of 82 percent S.S. and 218 percent F.A. is excellent for the sub-grade soil + by item mix.
- The liquid limit increased and the plastic limit decreased as fly ash concentrations rose.
- Additions of fly ash more than 18 percent reduce the soil's plasticity index as well.
- A balanced-out subgrade soil's unconfined compressive strength (UCS) increases by 18 percent as compared to the subgrade soil.
- The shrinkage limit of the stabilized sub-grade soil is also decreased as a result of the addition of 18 percent fly-ash. "

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