STUDY ON ANALYSIS OF STABILITY OF SUB-GRADE SOIL OF A PAVEMENT USING FLY-ASH AS ADDITIVE

[1]Ismat Iqbal Bhat, [2]Nupur Subhashini, [3]Khan Abdul Basit

[1]M.Tech Scholar, [2]Assistant Professor, [3]Assistant Professor,
Department of civil engineering,
[1]CBS Group of Institutions, Jhajjar Haryana, India.

Abstract: Pavement characteristics are very sensitive to the qualities of the sub-grade soil. Due to that, frail sub-grade is augmented by espousing the most profitable stabilization strategy. This research aims to investigate the impact on the strength and stability of the sub-grade pavements of soil mixing with fly-ash. Various rates of fly-ash viz 9, 18, 27, and 36 per cent were added to the soil. It was discovered that the appropriate measurements of fly-ash is 18% uncovered in noteworthy improvement in quality and strength and decrease in swelling and plasticity properties of soil and hence this is considered as optimum percentage. For the examination of the soil stabilized with fly-ash, CBR, Compaction, specific gravity, sieve analysis, water absorption test is performed. Properties utilized for investigating are Plastic Limit, Liquid Limit, California Bearing Ratio and Optimum Moisture Content. In view of the outcomes, it is suggested that fly-ash admixture be viewed as an achievable choice for the stabilization of frail sub-grades.

Index Terms **– Fly-ash, Pavements, Compaction, CBR.**

I. INTRODUCTION

Foundation is the main part of any land-based construction and therefore should strengthen the entire system firmly. Stabilization of soil is the marvel by which certain properties of soil are overhauled so as to make the weak soil serve well for as an establishment or development material. The chemical process is additionally a soil reinforcement tactic, as it delivers a higher quality soil and solidness as compared to physical and mechanical methods. Fly-ash is generally connected to the electric force producing plants by a powdered coal burning procedure. Fly-ash is a fine residue of pozzolan, comprising of silica, alumina and different alkalin and oxides. It produced cementitious products after reacting with hydrated lime. Fly-ash is utilized so as to balance out the sub-grades and furthermore to balance out backfill to limit the horizontal earth pressures. Fly-ash is likewise utilized to alleviate dikes to meliorate slant support. Fly-ash is operated efficiently in numerous undertakings to meliorate the various qualitative characteristics of soils. Ordinary settled soil profundities are 15-46 cm (6 - 18 inches). The fundamental explanation of fly-ash utilized within soil reinforcement functions is that it improves the shearing and compressive quality of soils. Table 1 shows the physical properties of fly-ash and Table 2 presents its chemical composition.

Table 1: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

Table 2:Chemical composition of fly-ash

S. No.	Chemical component	Chemical content 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

Stabilization of soil means altering certain properties of the soil by chemical techniques or mechanical techniques, so as to accomplish superior quality soil material which have all the normal engineering properties. Stabilization of soil is mainly done to restrict dust formation & erosion or to enhance its durability & strength of soils. Its principle intention is to create a soil material or system which perfectly supports the planned existence of the engineering undertaking and under the design use conditions. Soil properties shift to a large extent at various areas or in specific situations at such one spot; the achievement of stabilization of soil is based on the soil testing. There are many techniques which is utilized for the stabilization of soil & all these techniques ought to be checked in the laboratory with the soil before being applied to the field.

II. METHODOLOGY

Obtaining a uniform and thorough mixture is an important factor in soil stabilization. Two methodologies that are normally utilized in construction: Off-site mixing involving batch or continuous type mixing and On-site mixing. The research center investigation was attempted to accomplish the targets of the investigation. Research center tests were performed over undisturbed soil samples and prepared soil fly-ash admixture. Weak soil settled with differing rates of fly-ash percentages, 9, 18, 27, and 36 percent were examined to decide their impact on designing properties of the soil. The tests were completed according to IS norms.

Compaction tests:

Compaction tests were carried out for different fly-ash proportions to decide the optimum moisture content (OMC) and maximum dry density (MDD). The Optimum Moisture Content (OMC) is the measure of water. After compaction, various estimations of moisture contents and the subsequent dry densities are gotten in the research center and both are drawn on arithmetic scale. Soil compaction improves shear strength, bearing capacity, density hence diminishing the gaps, permeability and settlement.

CBR tests:

The California Bearing Ratio (C.B.R.) test is a technique for ordering soils and obtained the sub-grades of soil and base courses for flexible pavements. For the field correlations of the thickness prerequisite of the flexible pavement the test has been widely calculated. A round and hollow plunger with a certain diameter is carried out to infiltrate the material component of a pavement with 1.25mm/min. Loads are observed for 2.5mm and 5mm. In order to obtain the C.B.R. value, load is verbalized as a standard load value at a particular deformation level.

Table 3: Standard loads for various penetration value

Penetration of plunger(mm)	Standard load(kg)	Unit standard load kg/cm^2
2.5	1370	70
5.0	2055	105
7.5	2630	134
10.0	3180	162
12.5	3600	183

Specific gravity:

Specific gravity of soil is characterized as the proportion of the weight of an equivalent quantity of refined water at this temperature. It is denoted by G. In order to determine the specific gravity of solid particles for coarse grained and fine grained soils as well, the Pycnometer technique can be utilized.

Sieve Analysis:

Grain size analysis is accomplished to find out the overall rates of numerous sizes of particles. The mechanical conduct of coarse grained soil is controlled by the particle size. Coarse-grained soils (CGS) are defined as the soil particles that are over and above 0.075mm size. Over and above half of the absolute material can pass through these types of soils by mass is 75 micron in thickness. Coarse grain soil contains sand, gravel, boulder and cobble.

III. RESULTS AND DISCUSSION

The outcomes attained from the experimental analysis are appeared in table.

Table 4: 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 Silty Sand

According to Indian standard soil classification system, the silty sand soil (SM) is chosen for investigation as shown in Table 4. To strengthen the soil, numerous extends of Fly-ash are utilized. Various qualitative properties of fly-ash are referenced in Table 1.

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

These are the results formed when 9% of the soil Sub-grade 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 expansion of fly-ash within sub-grade soil.

Table 5: 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 6: 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

On increasing the Percentage of Fly-ash by 9% more i.e. total of 18% it's found that there is a noticeable change in the UCS as Well as Liquid limit. The UCS shoots up to 90.85 KN/m^2 which is quite good, whereas OMC and MDD increases a little bit.

73% Sub-grade soil (S.S) + 27% 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 adding up of fly-ash in the Soil. When the Percentage of Fly-ash increases, the Plasticity Index lessens too.

Table 7: 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 8: 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

On further checking of the Effect of increasing the content of Fly-ash, it is noted that UCS further drop down to 86.35kN/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.

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

Table 9: 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 10: 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

In the above table the values represents the increases or decreases over the unmodified sub-grade soil property result. Analysis of test data in all the cases of sub-grade soil + fly-ash, the 82% S.S + 18% F.A. set gives optimized results than other as the value of UCS comes out to be Maximum In this case only and Also the Liquid Limit Is least in this case only. The Shrinkage Limit is also Low when the percentage of fly-ash is 18%. Three sets nearly 91% S.S + 09% F.A., 73% S.S. + 27% F.A &64% S.S. + 36% F.A. set. By observing the above results when 82% S.S + 18% F.A. are kept constant the most optimum results are obtained as shown in Table 9 and Table 10.

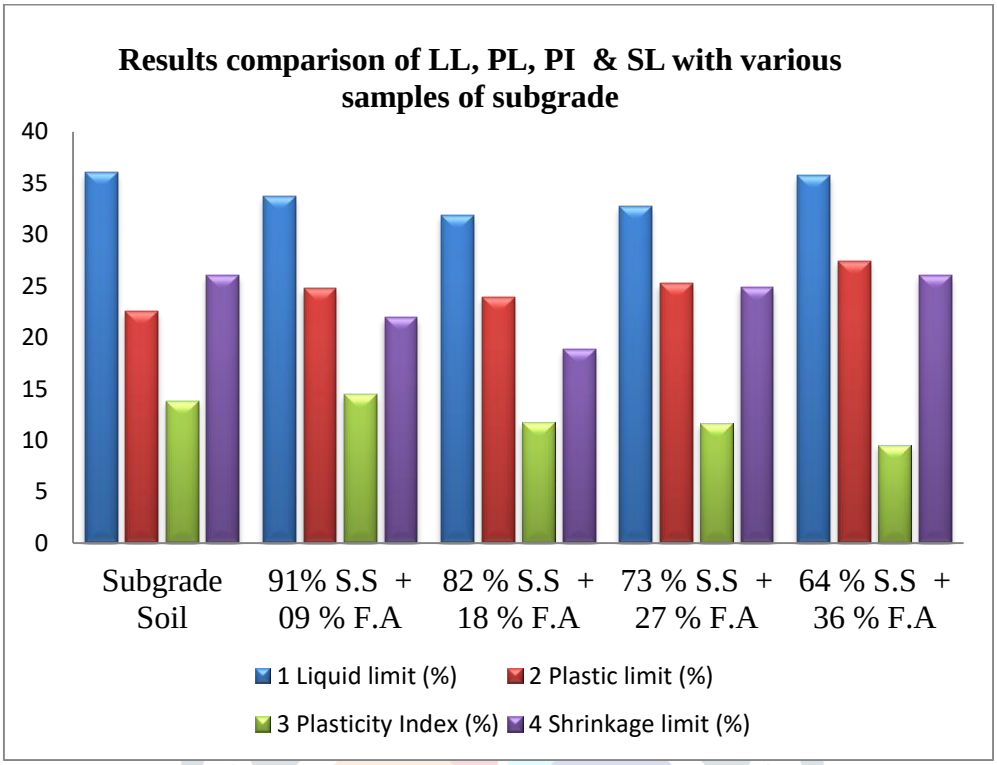

Fig. 1: Graphical comparison of soil sub-grade to the stabilized soil sub-grade (LL, PL, PI & SL)

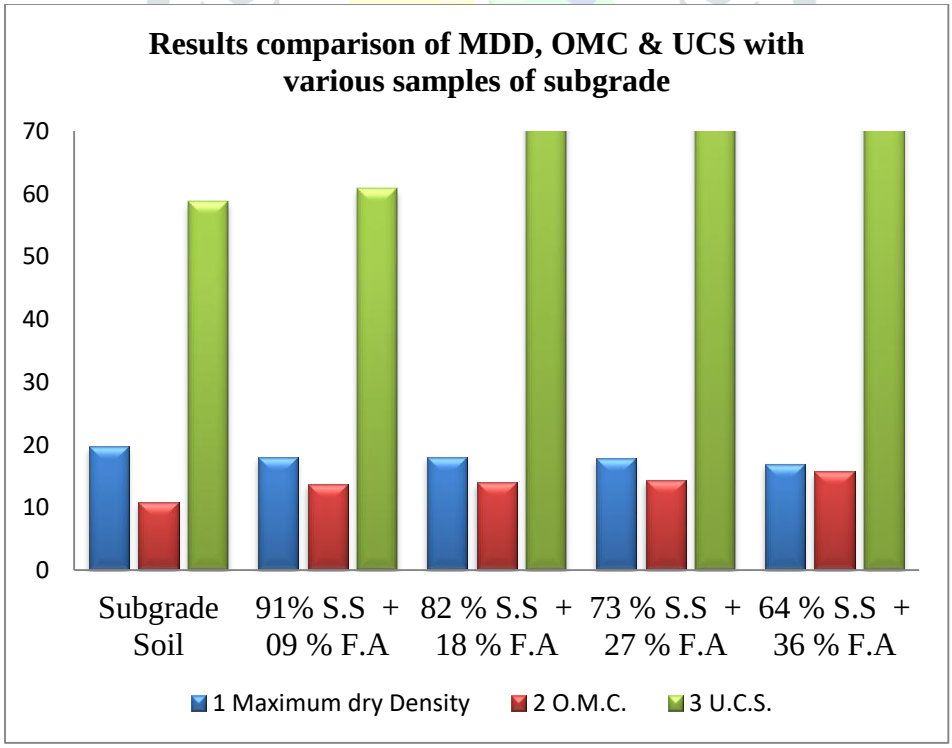

Fig. 2: Graphical comparison of soil sub-grade to the stabilized soil sub-grade (MDD, OMC & UCS)

IV. CONCLUSIONS

- The OMC shows increment and MDD diminishes with expanded level of fly-ash. Also the ideal estimate of the acquired fly-ash blend was roughly 18%.
- It is also seen that UCS increment approximately 27% of fly-ash blend but then just diminishes.

- Through this experimentation it is seen that the derivative fly-ash is additionally acceptable balancing out compound.
- The ideal extents for the blend of sub-grade soil + by item are 82% S.S + 218% F.A.
- As the level of fly-ash increased then the liquid limit increased and plastic limit diminished.
- The plasticity index of the soil is likewise diminished on adding fly-ash more prominent than 18%.
- The unconfined compressive strength (UCS) of the balanced-out sub-grade soil is expanded on adding 18% of fly-ash when compared to the sub-grade soil.
- With the addition of 18% of fly-ash, the shrinkage limit of the stabilized sub-grade soil is also reduced as compare to the sub-grade soil.

V. REFERENCES

1) RAMAKRISHNAN A.K., NATARAJAN K. and CHANDRAN R. K. (2001) "Stabilization of Annamalai Nagar clay with lime-fly ash" journal of I.G.C. pp-251- 254.
2) SHENBAGA and GAYATRI V. (sept-oct.-2003) "Factor influencing the strength of cement, fly ash base courses" journal of transportation engineering ASCE. pp. 538- 547.
3) Gosavi, M., Patil, K.A., Mittal, S., Saran, S., 2004. Improvement of properties of black cotton soil subgrade through synthetic reinforcement. Journal of the Institution of Engineers (India) 84, 257-262.
4) Mittal, S., Shukla, J.P., 2006. Soil Testing for Engineers. Khanna Publishers, Delhi.
5) Mohanty, B., 2006. Performance evaluation of randomly distributed fibre reinforced subgrade for pavements. M. Tech. Dissertation, IIT Roorkee, India.
6) Nayak, G.C., Jain, S.C., Omran, M.E., 1988. Use of fly ash for roller compacted concrete. In: Proceedings of the National Workshop on Utilization ofF1y Ash, Roorkee, India, pp. A-111-A-117.
7) Ranjan, G., Vasan, R.M., Charan, H.D., 1996. Probabilistic analysis of randomly distributed fiber-reinforced soil. Geotechnical Engineering, ASCE, 419-426.
8) Tang, C., Shi, B., Gao, W., Chen, F., Cai, Y., 2007. Strength and mechanical behaviour of short polypropylene fiber reinforced and cement stabilized clayey soil. Geotextiles and Geomembranes 25 (3}, 194-202.
9) Little, D., "Evaluation of Structural Properties of Lime Stabilized Soils and Aggregates", prepared for the National Lime Association, Arlington, Va., Vol. 3, Mixture Design and Testing Protocol for Lime Stabilization, Mar., 2000, p.4.
10) "Soil Stabilization for Pavements", Army TM 5-822-14, Oct., 1994, p.2-1.
11) "Lime Stabilization: State of the Art Report 5", Transportation Research Board, National Research Council, Washington, D.C., 1991, p. 1.
12) Little, D., "Evaluation of Structural Properties of Lime Stabilized Soils and Aggregates", prepared for the National Lime Association, Arlington, Va. Vol. 1, Summary of Findings, 1999, p. 49.
13) ASTM D 5102-90, "Standard Test Method for Unconfined Compressive Strength of Compacted Soil-Lime Mixtures", Vol. 04.01, 1990, p. 1199.
14) Newcomb, D.E., "A Perpetual Pavement Needs a Perpetual Foundation", Paving the Way, c/o Pennsylvania Asphalt Pavement Association, Harrisburg, Pa., Vol. 5, 2002, pp 1-3.
15) Lockhart, J. et.al, "Pennsylvania Turnpike Reconstruction – Part III: Lime- Pozzolan Meets the Reconstruction Challenge", Pennsylvania Asphalt Pavement Association, Website, Harrisburg, Pa., Sept. 2001.