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LITERATURE REVIEW ON THE EFFECT OF FLY ASH, STEEL SLAG AND GLASS FIBER ON LATERITIC SOIL

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ABSTRACT

The study on the topic `literature review on the consequence of fly ash, steel slag, and glass fiber on lateritic soil' is focused on evaluating the effect of fly ash, steel slag and glass fiber on lateritic soil. These soils tend to have low shear strength and further it may lose shear strength in presence of moisture. This undesirable engineering property of the soil may cause potential natural hazard. These soils are plastic, compressible and expansive in nature which has the tendency to swell in presence of moisture and shrink in dried condition. Fly ash and saw dust ash which are disposed materials from industries are used in the stabilization process to improve the properties of soil. They are disposed material from industries, direct melt process, marble re-melt process or in furnace. It influences to the strength and compressibility characteristics of soil. The study is carried out through large scale tests to stimulate field condition such as specific gravity (G), atterberg's limit, maximum dry density (MDD), optimum moisture content (OMC), hydraulic conductivity (K) and unconfined compressive strength (UCS). The obtained result gives the effect on geotechnical properties on lateritic soil.

Keywords: Fly ash, Glass fiber,Hydraulic conductivity, Optimum moisture content (OMC),Steel slag, Specific gravity.

I. INTRODUCTION

Soil used as foundation material and subgrade material should be strong enough to bear the load. The laterite soil used in this study is expansive in nature. Laterite soil in India is found in Eastern Ghats of Orissa, southern parts of Western Ghats, Malabar coastal plains and Ratnagiri of Maharashtra and some parts of west Bengal. Laterite soil is rich in aluminium and iron formed in wet and hot tropical region. Almost all laterite soil are red in colour due to presence of iron oxide. Laterite soil in Karnataka are mainly found in Udupi, Kodagu, Shivamogha, Kolar, Belgaum, Chikkamangalur, Bangalore, Bidar, Dharwad. For any construction activities in these regions, the soil needs to be stabilized.

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In order to cope up with rapid increasing demand of power throughout the world, the production of fly ash is rising hand in hand. Now-a-days it has become a global concern and major challenges to dispose and reuse the fly ash safely, not only for environment but for geotechnical engineers also because ─

i) Disposal of enormous amount of ash involves consumption of huge land and

ii) Generate the problem of leaching and dusting in wet and dry condition respectively.

Therefore, the best way of disposing fly ash is to utilize it with some additives and converting it into a non-hazardous material and apply them in eco-friendly way. Fly ash possesses a wide range of chemical composition and ph values depending on the nature of coal and process of coal burnt. It is concluded that fly ash containing maximum hollow particles of lower apparent specific gravity than most of the solid particles.It is accepted that specific gravity value of pond ash amended soil and coal ashes are less than soil.The affinity of non-plastic fly ash to react (flocculation/agglomeration) with soil and reduces the plasticity of soil-fly ash mixtures.Many previous researchers have explained the reason behind variation in MDD and OMC in soil-fly ash mixed samples on laboratory experiments. in additives the hydraulic conductivity gets increased in mixed samples due to flocculation and agglomeration of ash.

To prevent these problems, stabilization of these soils is required. A par from mechanical compaction and soil reinforcement methods, the different soil stabilization materials are available i.e. lime, cement, fly ash, blast furnace slag, rice husk ash, etc. to stabilized and improve the strength of soil. Cement and lime does not prove suitable for soils because of presence of sulphates. At present the use of various industrial waste products for stabilizing the soft soil have attained considerable attention in view of increasing cost of waste disposal and environmental aspects. Various soil stabilization techniques including fibre reinforcement have been in use for a while and the results in some of them has been quite satisfactory. Reinforcing soils using tension resisting elements is an attractive means of improving the performance of soil in a cost effective manner. Practicing engineers are employing this technique for the stabilisation of thin layers of soil, repairing failed slopes, soil strengthening around footings and earth retaining structures. However, more research is needed to further understand the potential benefits and limitations and to allow its application to more complex geotechnical structures . Direct shear tests, unconfined compression tests and conventional triaxial compression tests have demonstrated that shear strength is increased and post-peak strength loss is reduced when discrete fibres are mixed with the soil. Three different lengths (6.0mm, 12.0mm, and 19.0mm) and two fiber dosages (i.e. 0.5% and 1.0% by dry weight of soil) were considered. The testing results indicated that the effect of fiber dosage on the stress-strain behavior is superior to the effect of fiber length.

II.LITERATURE REVIEW

A lot of research has been done on fiber, fly ash, granulated blast furnace slag reinforced soil and concluded that the enhancement in strength and stiffness of the soil matrix can be attributed to fiber characteristics such as aspect ratio, skin friction, weight fraction and modulus of elasticity, on the soil characteristics and also on the test condition such as confining stress.Some of the literatures are represented here as:

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Table No. – 2

Sr. no.	Topic of research paper	Workdone(methodology)	Summary	Result
1.	Effect of saw dust ash and fly ash on stability of expansive soil	-study of soil sample -study of fly ash -testing method -atterberg's limit -proctor compaction.	Lateritic soil, fly ash with varying properties of fly ash were tested.	-OMC improved on addition of 10% fly ash and dust ash. -MDD improved on addition of fly ash and dust ash. -Plasticity index improved on addition of 10% fly ash and dust ash.
2.	Influence of steel slag and fly ash on strength properties of soil: A comparative study.	-Study of soil behavior -Study of steel slag and fly ash -Atterberg's limit -Compaction test -CBR test.	Result showed that on soil sample on increment of steel slag and fly ash there is reduction in LL & PI of clay.`	-LL of soil is reduced by 22.96% for SS& 17.19% for FA. -PI of soil is decreased by 65.76% for SS and 25.69% for FA. -MDD is increased by 9.20% for (40%) SS & decreased by 19.62% for (50%) fly ash.
3.	Effect of flyash on geotechnical properties of local soil-fly ash mixed sample	-Specific gravity test -LLand PL -Grain size distribution analysis -Hydraulic conductivity test -UCS -Compaction Test	It is accepted that specific gravity value of pond ash amended soil and coal ash are less and react with soil to reduce plasticity	-Decrease in SG, PI and LS of soil on addition of fly ash -MDD decreases and OMC increases with increase of ash content
4.	Effect of granulated blast furnace slag in	Evaluated the potential of GBS to stabilized soft soil and use physical and strength	The soft soil tested as per bureau of Indian standard was mixed	-MDD increases while OMC decreases with

	engineering behavior of stabilized soft soil.	performance test.	with various % of GBS (3,6,9& 12%)	addition of GBS to soft soil -Reduction in swelling behavior of soil
5.	Effect of polypropylene fiber in stabilization of expansive soil	- In the research laboratory test were conducted to study effects - Compaction test - UCT	Effect of fiber on soil compaction Effect of fiber on UCS Effect of fiber on % swell.	-OMC does not show any significant change -MDD reduced as fiber content increase in compaction test
6.	Effect of glass fiber on red soil	-Soil sample study -Study of glass fiber -OMC &MDD is found with and without fiber.	LL & PL determined UCS determined PI, OMC, MDD of red soil found out.	-OMC increases &MDD reduces on addition of fiber UCS increased on addition of fiber.

III.MATERIALS AND METHODOLOGY

3.1 Materials :

3.1.1. Laterite Soil: Laterite soil is a type of soil that has a red to reddish yellow tinge due to presence of iron compounds mainly iron oxide. This soil can form from iron-rich sediments or the compounds may develop in the soil as it weathers. On account of heavy rainfall there is an excessive leaching of soil colloids and silica hence the soils are porous.

Table – 3.1: Properties Of Lateritic Soil

Property	Values
Specific gravity	2.66
Liquid limit	40.2
Plastic limit	18.24
Plasticity index	21.96
Optimum moisture content	15.7
Maximum dry density	17.85

3.1.2. Glass Fibers: Fiberglass is a lightweight, extremely strong, and robust material. Glass fibers are among the most versatile industrial materials known today. The glass fibers used in this study was locally available, found in the form of mesh.

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Table – 3.2: Properties Of Glass Fiber

Tensile strength as per IS 2270 at 1.8% elongation break	1.53
Youngs modulus as per IS 2270	112.3
Specific gravity	2.57
Diameter	0.15

3.1.3 Fly Ash: Fly Ash is the waste by-product material that must be disposed of or recycled. Fly ash mainly comprises of SiO2, Al2O3 Fe2O3, CaO, MgO, SO3 .Specific gravity of fly ash is 1.97 Saw dust is a by-product of Timber milling industry, Saw dust ash is obtained from burning of Saw dust and the Specific gravity of saw dust ash is 2.10.

Table – 3.3: Properties Of Flyash

Properties	Fly Ash
Specific gravity	2.10
MDD (kN/m³)	1.40
OMC (%)	19
Gravel Size particles (%)	0
Sand Size particles (%)	27
Fines Size particles (%)	73

3.1.4 Steel Slag: Blast furnace slag is produced as a by- product during the manufacturing of iron in a blast furnace. It results from the fusion of limestone flux with ash from coke and the siliceous and aluminious residue remaining after the reduction and separation of iron from the ore. Iron blast furnace slag consists essentially os silicates and alumino-silicates of lime and other bases.

3.2METHODOLOGY:

3.2.1. Testing Methods For Fly Ash : The sample preparation and conducting experiments are done according to the IS2720 referred under:

1. Specific gravity test
2. Grain size distribution analysis
3. Liquid limit and plastic limit tests
4. Linear shrinkage test
5. Standard Proctor compaction test
6. Hydraulic conductivity test
7. Unconfined compressive strength test
8. Free swelling index test
9. Swelling potential test

3.2.1(A) Linear Shrinkage Test (L-S) : As per IS 2720 tests conducted to determine the linear shrinkage of local soil, fly ash and local soil mixed with fly ash specimen. A semi cylindrical mould as its dimensions is specified in code is used to record this parameters. Drying of sample is completed at oven temperature of 105 to 110°C.The linear shrinkage of the samples shall be calculated from the following formula:

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L-S (%) = {1-length of over dried sample/ initial length of specimen } *100

In these tests fly-ash samples cannot give any result as they possesses lack of plasticity.

3.2.1(B)Standard Proctor Compaction Test: Standard Proctor tests (IS 2720) have been carried out to determine the maximum dry density and optimum moisture content for all the nineteen number of the samples. Figs. shows all the curves of local soil and soil-fly ash mixed samples. The results show that the ash samples attain significantly lower dry unit weight than the soil soil-ash mixtures at relatively lower water content.

3.2.1(C) Hydraulic Conductivity Test: Falling head permeability is conducted in laboratory as per IS 2720. Samples compacted in mould at MDD and OMC. It was assumed that the specimen was saturated under water pressure of 1.5 m height and stationery valuereachedat 7 days.

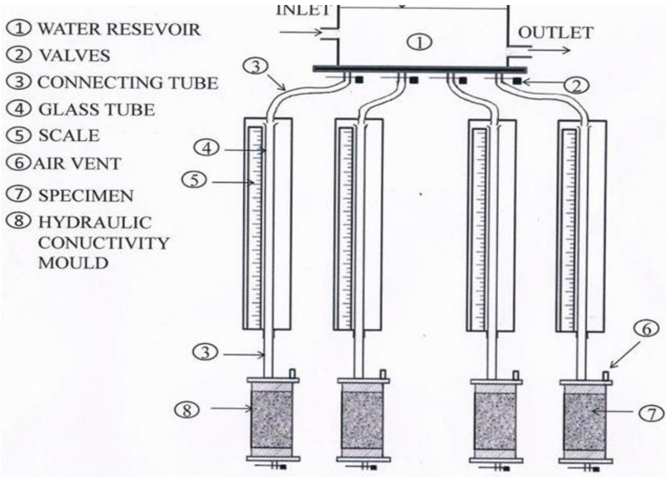

Fig no.3.2.1(a): Hydraulic conductivity test

3.2.1(D) Unconfined Compressive Strength Test: The compressive strength is conducted in accordance with IS 2720 and each sample is compacted with predetermined MDD and OMC. At least three specimens are tested for each combination of variables and applied strain rate is 1.5 mm/min and 0.5mm/m for local soil, soil-ash mixed samples, and fly ash samples respectively. The unconfined compressive test is performed immediately on fresh samples and on cured samples (stored in moist-proof container) after 7 days. The ash inclusions and curing age have a significant effect on the stress–strain behaviour.

3.2.1(E) Free Swelling Index (Fsi): As per IS 2720 tests conducted to determine the free swell index ofall the nineteen samples. FSI is obtained as the ratio of the difference in the final volume of soil in water (Vw) and in kerosene (VK) to the final volume in kerosene *(*Vk) and expressed in percentage. In this test fly-ash samples do not respond as they are non-swelling by character.

3.2.1(F) Swelling Potential (Sp) : As per IS 2720 tests conducted to determine swell potential for each combination of variables as stated previously. The samples are compacted in the consolidation ring at MDD and OMC.

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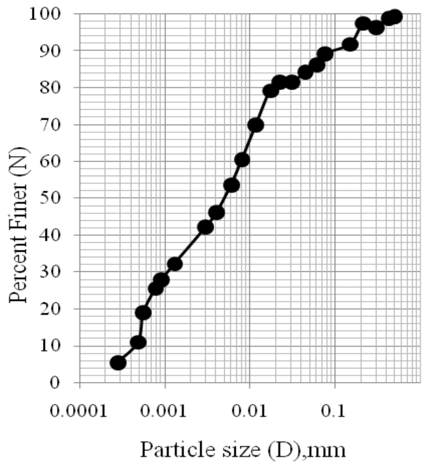

Fig no. 3.2.1(b):Percent finer vs. particle size for local silty-clay soil sample

3.2.2. Testing Method For Steel Slag: The laboratory tests carried on the natural raw soil includes atterberg's limits, pH value, specific gravity, compaction, free swelling index,swelling pressure, CBR and UCS. The engineering properties of the soil were determined in accordance with Bereau of Indian standards (BIS). Specimens for swelling pressure, unsoaked and soaked CBR and UCS tests were conducted as specified by Indian code IS:2720(part 41)-1977.compacted specimens were cured for 96 hrs for conducting the soaked CBR test.Laboratory tests were carried out to find the index andengineering properties of unmodified soil. Based on the testresults, from the ISclassification the obtained soil sample isdesignated as clay of intermediate plasticity.

***Blended Mix Proportion:** GBS used in this study was soft soil in different proportions i.e. 3,6,9 and 12% by weight of soft soil to obtain the optimum amount for stabilization. Physical and strength properties of the blended mix was evaluated in the laboratory and compared with the properties of the soft soil to obtain the optimum amount of GBS.

3.2.3.Testing Method For Glass Fiber: The procedure used for this project is as follows:

1. At first the soil sample obtained from the site is cleaned from any visible unwanted matter like leaves, plastic etc.
2. Then the various index properties of the soil like sieve analysis, liquid limit, plastic limit and moisture content are found out as per IS: 2720 respectively.
3. The maximum dry density and optimum moisture content is found out using the Standard proctor test.
4. Using the O.M.C found in proctor test, the test sample for the Unconfined Compressive Test is prepared and the related strength parameters are found.
5. Now using 0.5%, 1% and 1.5% fibre content by dry weight of the soil, the same tests are performed for each fiber content.

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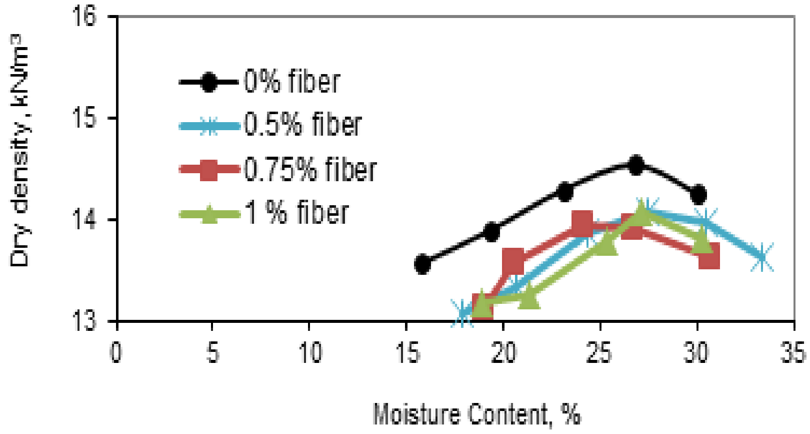

Fig no.3.2.3Effect of fiber content on maximum dry density-optimummoisture content of the soil

IV. RESULTS AND DISCUSSIONS

4.1. Results For Fly Ash :

The value of specific gravity of local silty-clay is 2.635. With the increase of fly ash contents in mixed samples, the G values are decreased. The values of G are within the range of 2.603– 2.589,2.580– 2.565, 2.55– 2.531, 2.534– 2.501 and 2.511– 2.481 for three types of fly ash content in the mix with fly ash of 10, 15, 20, 25 and 30%respectively.

The results of the liquid limit (LL), plastic limit (PL), plasticity index (PI) for the local silty-clay soil and soil-fly ash mixed samples are presented in Figs. 5 to7 respectively. The LL, PL and PI of the local silty-clay soil are 36.9, 22.4 and 14.5% respectively. With the increase of fly ash contents in mixed samples, the LL and PL are decreased and PI are increased. The values of LL are within the range of 35.90 - 35.60, 35.60– 35.16, 34.45– 34.20, 34.15– 33.70 and 34.01– 33.41% for fly ash content in mix10, 15, 20, 25 and 30% respectively. The values of PL are within the ranges of 23.46 - 24.08, 23.91 - 24.47, 24.04– 25.00, 24.25– 25.32 and 24.25– 25.41% forfly ash content in mix 10, 15, 20, 25 and 30% respectively.

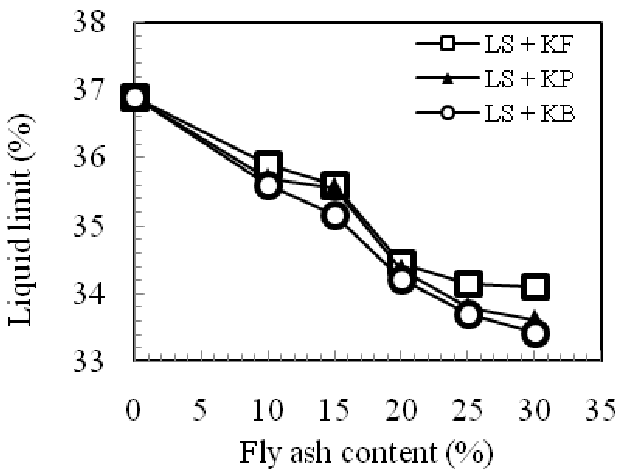

Fig no.4.1.2(a)

Liquid limit vs. fly ash content in local soil and soil-fly ash mixed samples.

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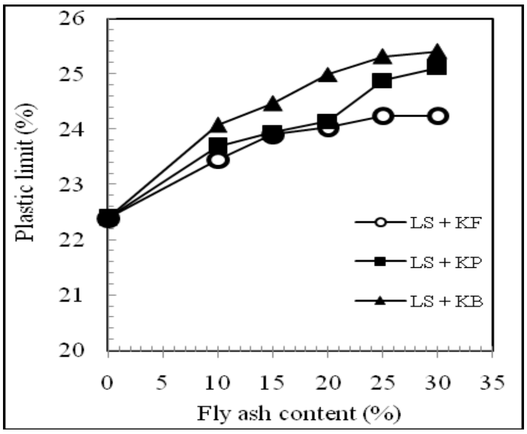

Fig no. 4.1.2(b)

Plastic limit vs. fly ash content in local soil and soil-fly ash mixed samples.

4.1.3 Effect Of Fly Ash On Linear Shrinkage Of Local Soil And Soil-Fly Ash Mixed Samples: The linear shrinkage (L-S) values for the local silty-clay soil and soil-fly ash mixed samples are revealed in Fig. 8. The value of linear shrinkage for the local silty-clay is 10.57%. With the increase of fly ash contents in mixed samples, theshrinkage values are decreased. The ranges of linear shrinkage values are within the range of 9.28– 8.80,8.56– 7.96, 7.81– 6.32, 6.81– 6.03 and 5.90– 4.88% for fly ash content in mix 10, 15, 20, 25 and 30% respectively. The lower the shrinkage, the more flocculation in soil structure occurs in presence of coal fly ash. The addition of non-shrinking and cohesion less fly ashes in local soil decrease the tendency of the mixed samples to shrink. The reductions in linear shrinkage may be due to the ingress of comparative less percentages of water which can be viewed from liquid limit values.

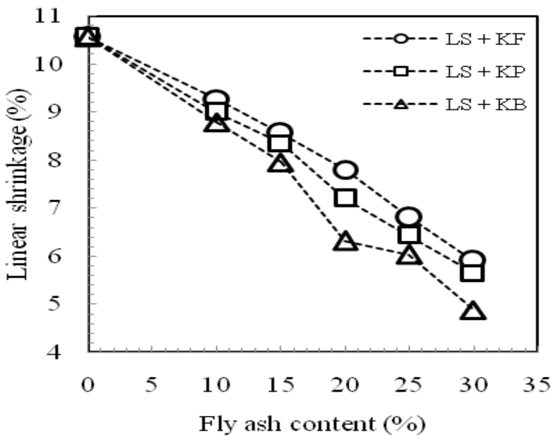

Fig no.4.1.3

Linear shrinkage vs. fly ash content in local soil and soil-fly ash mixed samples.

4.1.4 Effect Of Fly Ash On Maximum Dry Density (Mdd) Andoptimum Moisture Content (Omc) Of Local
The typical values of maximum dry density (MDD) and optimum moisture content (OMC) of local soil and mixed samples depending on the percentages of fly ash content are revealed in Figs.12 and 13 respectively. The MDD and OMC of local silty -clay soil are 16.20 kN/m3 and 18.91% respectively. The MDD and OMC values of fly ash samples are within the range of 11.00– 12.30kN/m3 and 34.00– 25.32% respectively.

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The significance of these changes depends upon the amount of ash added and the chemical composition of the clay minerals and ash.

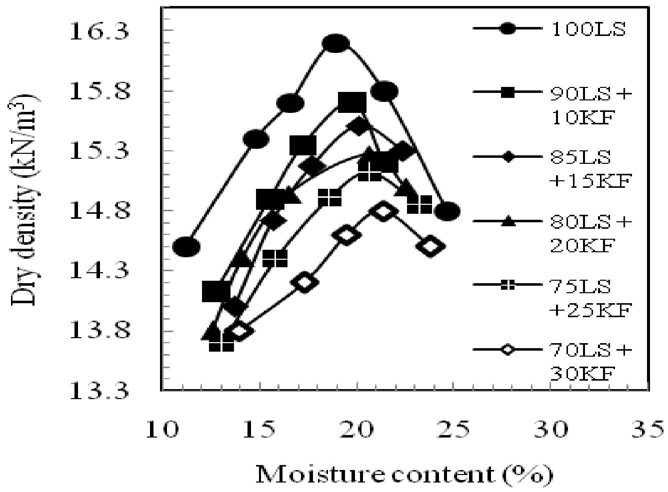

Fig no. 4.1.4

Dry density vs. moisture content in local soil and soil-fly ash mixed samples

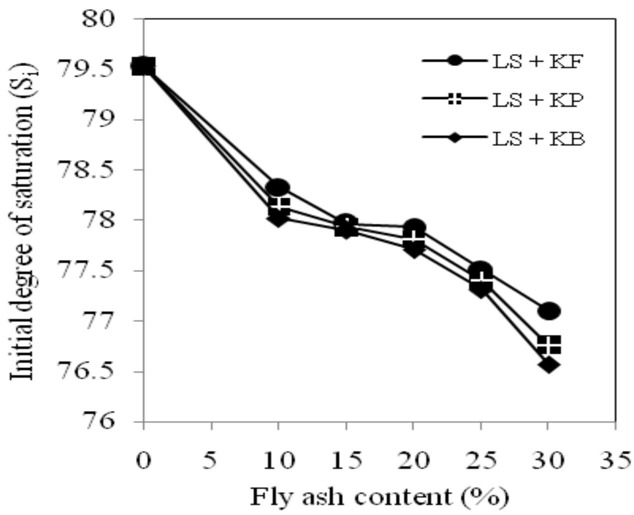

Fig no. 4.1.6

Initial degree of saturation vs fly ash content in local soil and soil-fly ash mixedsamples.

4.2.Results For Steel Slag:

4.2.1 Atterberg's Limit Test: It is observed that as thepercentage of Steel slag and fly ash increases, there is amarked reduction in liquid limit and plasticity index of claythat was tested.

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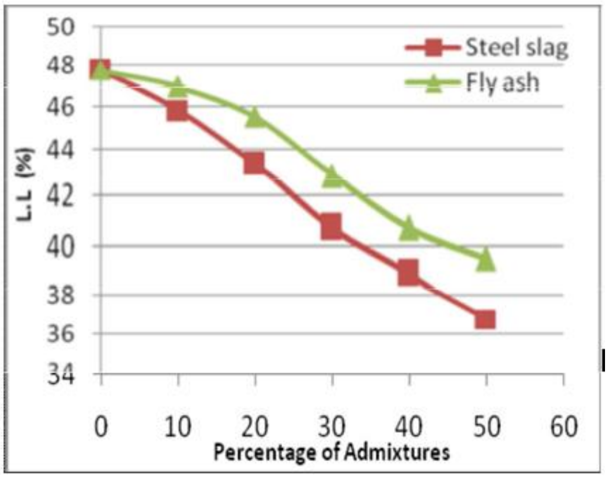

Figure no. – 4.2

Fig no. 4.1.7: Influence of Steel Slag and Fly Ash on Liquid Limit

The addition of the Steel slag to the unmodified soil reducesthe clay content and thus increases the percentage of coarserparticles, in turn reducing the Liquid limit and Plasticity indexof soil. The liquid limit of the modified soil at 50% addition offly ash and Steel slag is reduced to 36.75% and 39.5%respectively.Plasticity characteristics of the soil sample are graduallydecreasing with increase in the percentage of Steel slag andfly ash. The plasticity index of modified soil is reduced to16.39% and 7.55% respectively with addition of (50%) of Flyash and (50%) steel slag.

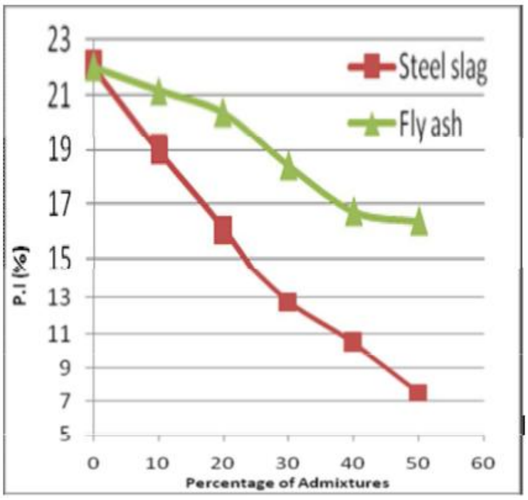

Fig no. 4.1.8

Influence of Steel Slag and Fly Ash on Plasticity Index.

4.2.2. Compaction Test: The variations of compaction characteristics such as OMC andMDD for the clay treated with fly ash and Steel slag arepresented.

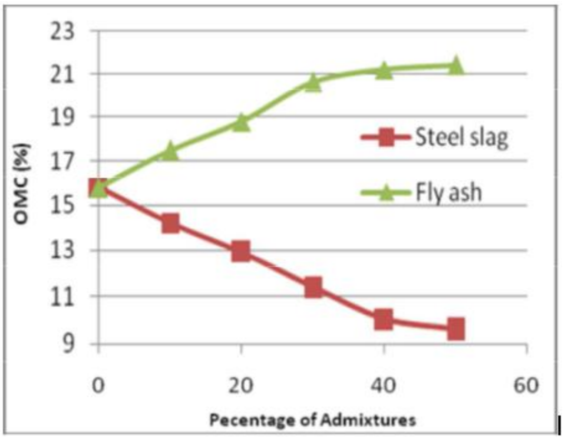

Fig no. 4.1.9: Influence of Steel Slag and Fly Ash on OMC

It can be seen that there is a decrease in OMC and increase inMDD value with increase in percentage of Steel slag.

4.3. Results For Glass Fiber:

The compaction curves for reinforced and unreinforced soilspecimens indicate optimum moisture content does not show a significant change by addition of polypropylenefiber whereas maximum dry density reduces as fiber contentincreases. This reduction can be explained with the reductionof average unit weight of solids in the mixture of soil and fiber.

V. CONCLUSION

A series of tests were conducted to study the effects ofpolypropylene fiber, fly ash, steel slag on swelling characteristics of expansivesoil from the place of Apa-Hotamış conveyance channel. Theeffects of fiber on compaction, unconfined compressivestrength and swelling characteristics of expansive soil weredetermined. The following are the conclusions from thesetests.

1. OMC is reduced by 39.24% for steel slag and it is increased by 35.44% for fly ash whereas it does not show change on addition on glass fiber with little increase.
2. LL is reduced by 22.96% for steel slag and 17.19% for fly ash whereas it is increased on addition of glass fiber.
3. MDD is increased by 9.20%for (40%) steel slag and decreased for (50%) fly ash by 19.26% whereas reduces for glass fiber.

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