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Experimental Evaluation of Modification in Expansive soil using AR Glass Fibre with Fly Ash under Compaction Characteristics

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Abstract — *Soil stability is one of the most challenging issues in Geotechnical engineering practice. Scarcity of suitable land and unavailability of good quality construction soil lead to the implementation of various Ground Improvement Techniques. Among the various 'GRIMTECH' fibre reinforcement is achieving more focus in ground engineering. In present study work various tests were conducted on treated and untreated soil as Compaction, CBR, UCS etc. The influence of additive like fly ash and AR glass fibre (12 mm) on expansive soil of south Gujarat region was highlighted. It has been established in this project work by experiments conducted on the soil sample by using fly ash (0%, 5%, 10%, 15% and 20%) and glass fibre (0%, 0.25% and 0.50% by weight of dry soil). The output of this study work is to evaluate the combine effect of fly ash and glass fibre with expansive soil is beneficial in soil modification.*

Keywords- *AR glass fibre, fly ash, Free swell Index, Maximum Dry Density, Soil Modification*

I. INTRODUCTION

Growth in population and economic development has challenged civil engineering to come out with solutions in the construction technology. All the types of soil are not suitable for the strong and sustainable structures. Hence many experimental researches are being carried out in the area of soil reinforcement. For this experimental study, the soil of region of south Gujarat in India has been selected. Due to tremendous economic development in this area because of textile and diamond industries, there is high growth in construction industry. This necessitates soil reinforcement efforts. The experiment was carried out using fly ash and randomly oriented Alkali Resistant (AR) glass fibres.

II. LITERATURE REVIEW

Dimpa Moni Kalita et.al [1] carried out various tests on red loam soil stabilized by coconut coir, glass fibre and cement bags in different content, in order to find out whether the particular soil-reinforcement mixture is beneficial or not. The aim of the experiment is to analyse the behaviour of soil, in accordance with different reinforcement, in different percentage.

Himadri Baruah [2] studied the effects of glass fibres on the properties of Red Loam soil extracted from Assam. The properties like liquid limit, plastic limit, and plasticity index, and Maximum dry density, optimum moisture content and unconfined compressive strength of the soil were evaluated, by using 0.5%, 1% and 1.5% Glass fibre content by the weight of dry soil.

Vikas Rameshrao Kulkarni et.al [3] attempted utilization of blast furnace slag and glass fibres as stabilizing agents and studied their effects on certain properties of soil such as Optimum moisture content (OMC), Maximum Dry Density (MDD), Differential free swell and California Bearing Ratio (CBR). The experiments were carried out on the soil samples by using blast furnace slag and glass fibres (6 mm and 12 mm). The tests were conducted on black cotton soil by varying percentage of blast furnace slag (0%, 5%, 10%, 15%, 20% 25%, 30%) and glass fibre with different length and proportions (0%,0.25% 0.50%, 0.75%, 1.00% and 1.25% by weight of dry soil with optimum percentage of slag).The results shows the improvement in strength and swelling behavior of soils.

Shivanand Mali et.al [4] carried out direct shear tests to find out the shear strength of fine sand reinforced with glass fibres. The results shows that the initial stiffness, peak shear strength and dilatancy properties of the sand are affected by the fibre inclusion.

J.A. Ige et.al [5] stabilized sandy soils by the addition of fly ash. The purpose of this experiment is to evaluate the optimum percentage of fly ash for stability of the soil. Thus, the tests like Sieve analysis, Compaction test, and unconfined compressive strength test were conducted. After performing above tests, it was observed that at 40% fly ash the value of compressive strength is found to be a maximum.

Kumar Sandeep et.al [6] studied the effect of Lime and Fly Ash as the admixture in upgrading the Maximum Dry Density (MDD), Optimum Moisture Content (OMC), California Bearing Ratio (CBR), Liquid Limit, and Plastic Limit. The percentage of lime and Fly Ash used is varied from 3% to 10% .With an increase in Lime percentage, Optimum Moisture Content (OMC), California Bearing Ratio (CBR) increased but liquid limit, Plastic limit, Maximum Dry Density (MDD) of soil decreased. With an increase in Fly Ash content; liquid limit, plastic limit and Maximum Dry Density (MDD) of the soil decreased and the Optimum Moisture Content (OMC), California Bearing Ratio (CBR) increased. The author tries to find out the optimum amount of Lime and Fly Ash, to improve CBR, especially in case of highway sub grades.

Naranagowda M J et.al [7] evaluated the effects of saw dust ash and fly ash on properties of laterite soil, which are plastic, compressible and expansive in nature. The tests like specific gravity, consistency limits, CBR, compaction, UCC and differential swell index were carried out on natural soil sample. On the treated soil, the same tests were carried out by adding 5%, 10%, and 15% of fly ash and saw dust ash.

Satyendra Singh Rajput et.al [8] used Fly-ash as a stabilizing agent to stabilize the expansive soil. The author tried to investigate the improvement in the properties of expansive soil with different percentage of fly-ash (10%, 20%, 30%, 40%, and 50%). The significant variation in liquid limit, plasticity index, and swelling index was found. The liquid limit decreased from 55.2% to 36.3% and plasticity index reduced from 27.1% to 18.1%, the Differential Free Swell (DFS) also decreased from 52% to 14%. There was an increment in optimum moisture content (OMC) from 19% to 23% and decrement in maximum dry density (MDD) from 1.63g/cc to 1.52g/cc. Test result shows that fly-ash has a potential to enhance the properties of expansive soil.

G Radhakrishnan et.al [9] studied the swelling properties of the expansive sub grade soil treated with chemicals like Magnesium Chloride ($MgCl_2$), Aluminum Chloride ($AlCl_3$) and also by adding fly ash in varying percentages. The swelling properties of the collected expansive soil samples were determined based on the parameters like Free Swell Index, Swell Potential and Swell Pressure. The results obtained from the experimental study shows that the measured Free Swell, Swell Potential and Swelling Pressure are reduced substantially with the increasing percent of chemicals and fly ash and remain stable after reaching certain concentration.

Karthik.S et.al [10] evaluated the effect of Fly Ash on soft fine-grained red soils of Tirupur district. The plasticity indices of soil were ranging between 25 and 30. At optimum water content of 9%, the soil–Fly Ash mixtures prepared. The fly ash content was taken in varying percentage of 0%, 3%, 5%, 6% and 9%. Addition of Fly Ash resulted in appreciable increases in the CBR of the soil.

Ashish Metha et.al [11] stabilized the black cotton of Maharastra state by using flyash. The soils were stabilized with different proportion of fly ash (0, 10, 20, 30, 40 & 50%). OMC, MDD and CBR values (under unsoaked & soaked conditions) of clay and fly ash mixture were obtained; the results show that the fly ash is proved to be an effective additive for enhancing the engineering properties of expansive soils.

Gyanen. Takhelmayum et.al [12] assessed the compaction and unconfined compressive strength of black cotton soil which was stabilized by fine and coarse fly ash mixtures. The amount of fine and coarse fly ash used, varied from 5% to 30%.According to the results obtained, there is an improvement in the strength of black cotton soil, with percentage addition of fine, coarse fly ash. Also the peak strength achieved by fine fly ash mixture was 25% more than coarse fly ash.

Mahesh G. Kalyanshetti et.al [13] examined different properties i.e. OMC-MDD, Atterberges limits, free swell index, swelling pressure, C.B.R (Soaked and Unsoaked) of expansive soil upgraded with fly ash. The result shows that there is a noticeable reduction, up to 40% to 50%, in the swelling characteristics of soils. With addition of fly ash, the CBR value is improved by 70% to 75%. It is also observed that addition of fly ash beyond 20% is not significant on many of above properties.

Bidula Bose [14] upgraded high plastic clay by using fly ash. The geo-technical properties like grain size distribution, Atterberg limits, linear shrinkage, compaction characteristics, swelling pressure, free swell index, UCS and CBR value of virgin clay and treated with fly ash were assessed. Expansive soil was stabilized with different percentage of fly ash i.e. at 0%, 20%, 40%, 60%, 80%, and 90 %. With increase in fly ash content, the free swell index value and swelling pressure of clay-fly ash mixture decreases.OMC reduces with addition of fly ash but the dry density rises up to 20% fly ash content, thereafter it reduces with further increase in fly ash content. The peak value of UCS was obtained at 20% fly ash content and above 20% content of fly ash it decreases. Hence 20% is the optimum fly ash content that provides better compressive strength. The maximum CBR values,under un-soaked conditions, was found at 20% and 80% ash content. The un-soaked CBR value is found to be about 80% of the soaked CBR value.

III. TEST MATERIALS

3.1. Soil Sample

The untreated soil sample was collected from Katargam zone of Surat city, India (below 2 to 3 m from ground level) for the experiment. Tests were carried out to determine the various properties of untreated soil. The results are tabulated in table 1 given below.

Table 1. Properties of untreated soil

Sr. No.	Properties	Values
1	Grain size distribution a) Gravel (%) b) Sand (%) c) Silt + Clay (%)	 0.00 5.39 94.61
2	Atterberg Limits a) Liquid Limit (W_L) (%) b) Plastic Limit (W_P) (%) c) Plasticity Index (I_P) (%)	 30.95 17.23 13.72
3	Differential Free Swell Index (%)	25
5	Specific Gravity (G)	2.506
6	pH Value	7.3
7	Compaction Characteristics a) M.D.D. (gm/cc) b) O.M.C. (%)	 1.76 19.8
8	California Bearing Ratio Value (%) a) 2.5 mm penetration b) 5.0 mm penetration	 6.02 7.54
9	Unconfined Compressive Strength (kg/cm^2)	2.66

3.2. Fly Ash

Fly ash was obtained from Ultratech Cement Ltd., Magdalla road, Surat, India.

3.3. AR Glass Fibre

The AR glass fibres were obtained from ‘Hindustan Mortar’, Near Pasodara Patiya, Surat Road, Kamrej, Dist- Surat. The Chemical & mechanical properties of AR glass fibre are tabulated in table 2&3 given below.

Table 2. Mechanical properties of AR glass fibre

Property	AR-glass
Specific Gravity	2.70-2.74
Tensile Strength, MPa	1700
Modulus of Elasticity, GPa	72
Strain at Break,%	2.0
Effect of Temperature	Non-Combustible, Softening Point 860°C

Table 3. Chemical properties of AR glass fibre

Component	Percentage by weight
SiO_2	61-62
Na_2O	14.8-15
CaO	-
MgO	-
K_2O	0-2
Al_2O_3	0-0.8
Fe_2O_3	-
B_2O_3	-
ZrO_2	16.7-20
TiO_2	0-0.1
Li_2O	0-1

IV. EXPERIMENTAL WORK

4.1 Mix Proportion

Soil with 5%, 10%, 15%, 20% Fly ash and 0.25% Glass Fibre (by weight of dry soil)
Soil with 5%, 10%, 15%, 20% Fly ash and 0.50% Glass Fibre (by weight of dry soil)

4.2 Method of mixing

The glass fibers were distributed randomly in the soil mass. The mixing was done manually until the soil and the reinforcement form a fairly homogeneous mixture.

4.3 Tests conducted

To study the effect of fly ash and glass fibres on soil, Standard Compaction Test was performed by adding these additives at different percentages with soil.

V. RESULTS

Table 2. Soil treated with fly ash (5%, 10%, 15%, 20%) and 12 mm glass fibre (0.25%)

Mix Proportion	OMC (%)	MDD (gm/cc)
Soil + Fly ash (5%) + Glass Fibre (0.25%)	19.53	1.73
Soil + Fly ash (10%) + Glass Fibre (0.25%)	19.37	1.72
Soil + Fly ash (15%) + Glass Fibre (0.25%)	19.22	1.70
Soil + Fly ash (20%) + Glass Fibre (0.25%)	18.54	1.69

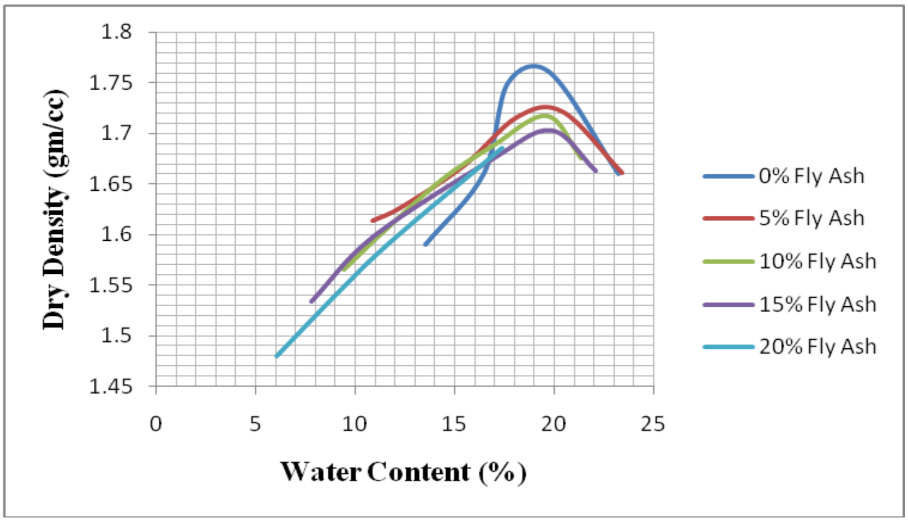

Figure 1 Compaction curves (0.25% Glass Fibre)

Table 3. *Soil treated with fly ash (5%, 10%, 15%, 20%) and 12 mm glass fibre (0.50%)*

Mix Proportion	OMC (%)	MDD (gm/cc)
Soil + Fly ash (5%) + Glass Fibre (0.50%)	19.75	1.69
Soil + Fly ash (10%) + Glass Fibre (0.50%)	18.88	1.68
Soil + Fly ash (15%) + Glass Fibre (0.50%)	18.54	1.67
Soil + Fly ash (20%) + Glass Fibre (0.50%)	18.48	1.66

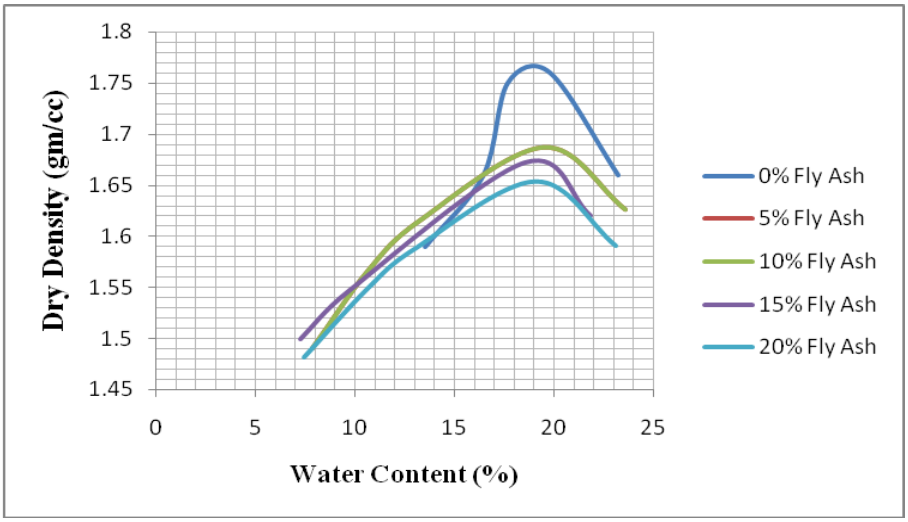

Figure 2 Compaction curves (0.50% Glass Fibre)

V. CONCLUSION

The value of OMC and MDD decreases with increase in fly ash and glass fibre content. The author has also conducted CBR and UCS tests in laboratory for the same combination of fly ash and glass fibre. The results shows variation in both the properties .i.e. soil can be modified with this type of GRIMTECH methodology.

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