ANALYSIS

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Strength and stiffness response of fiber reinforced lime stabilized fly ash

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ABSTRACT
Flyash is an end product left after the burning of coal in thermal power stations. Experiments are being carried out to find an effective solution for the safe disposal of flyash, and also to use it in other Civil engineering fields. In the present study, experiments were conducted on fiber reinforced lime stabilized flyash. SEM-EDAX, Index Tests, Compaction Test, Direct Shear Test etc. were conducted on varying percentages of lime and glass fibers. The present study gives a comparative analysis of results obtained for plain flyash ash to that of fiber reinforced lime stabilized flyash. The results indicate an improvement in the strength and stress-strain behaviour of flyash. This Fiber reinforced lime stabilized flyash can be used in embankment/structural fill, mine reclamation etc.

Keywords: Flyash, Glass fibers, Lime, Strength, Stress-Strain

1. INTRODUCTION

Fly ash, generated during the combustion of coal for energy production, is an industrial by-product which is recognized as an environmental pollutant[1]. In the thermal power stations tons of coal in its pulverised form is burnt leading to the production of a byproduct called flyash. An efficient and effective way of using this flyash is a challenge before the researchers. Liquefaction is one of the major problems associated with the flyash, which is under constant research. [2] have carried out extensive work by inclusion of plastic chips and reported an increase in Strength parameters. A lot of work has also been done on reinforcement of flyash with fibers by Tereza Čiháková[3], Shenbaga et al.[4] . By far flyash has been used in major quantities by cement industries as a partial replacement of cement. Use of flyash in embankments has been well explained in IRC SP 58. In the present case, study has been carried out on fiber reinforced lime stabilized flyash. Inclusion of fibers introduces a reinforcement effect leading to homogeneous improvement of soil properties. Also addition of lime triggers the pozzalonic reactions within the flyash leading to improvement of strength characteristics of flyash as a whole. It has been observed that there is a considerable improvement in the strength and stress-strain behaviour of flyash by addition of glass fibers and lime.

2. MATERIALS

2.1. Flyash

Fly ash was procured from KPCL Raichur site. EDAX test has been conducted on Flyash and the following chemical composition SiO_2 (55.71%), Al_2O_3 (24.26%), Fe_2O_3 (8.39%), CaO (3.47%), TiO_2 (4.23%), MgO (0.86%) were obtained. As the lime content of the flyash is below 10% so the flyash is classified as Class F flyash according to ASTM standards.

2.2. Lime

Varying percentages of lime from about 2 to 6 percent have been used for the stabilization of flyash and the respective variations in properties have been reported.

2.3. Glass Fibers

Varying percentages of Glass fibers from about 0.5 to 2 percent have been used as reinforcement in flyash and the respective variation in properties have been reported.

3. EXPERIMENTAL METHODS

3.1. Classification and index tests

Specific gravity test is conducted using density bottle method as per IS: 2720 (1980). The value of the specific gravity for fly ashes in India lies between 1.99–2.55 and for the fly ash studied, specific gravity is obtained as 2.11. Consistency test showed that the material is non-plastic in nature. The liquid limit of the flyash has been found to be about 27% as obtained from cone penetrometer test. From the grain size distribution curve it is observed that 90% of the materials are passing 75µ. For typical fly ashes, the maximum dry density lies between 9–16 kN/m^3 with optimum moisture content between 18–38%. In this case the MDD was found out as 13.7kN/m^3 and OMC as 20%. The DD-OMC curve is shown in Figure 1.

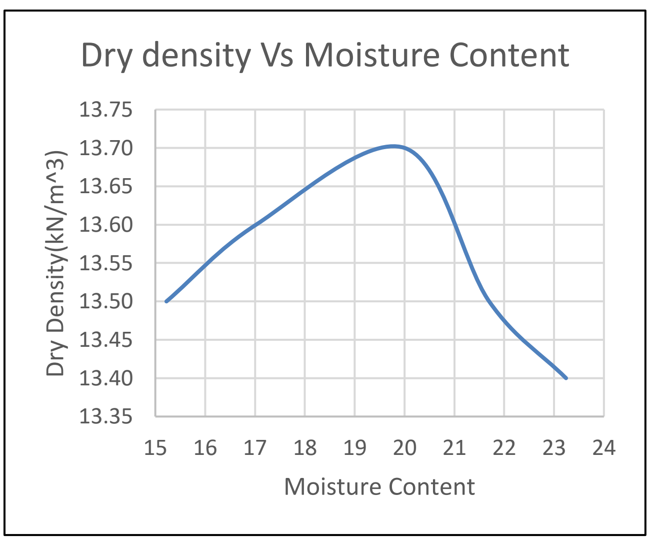

Figure 1 Dry density vs optimum moisture content curve for flyash done by Proctor compaction test.

3.2. Direct Shear Test

Direct shear tests were carried out on plain flyash, flyash mixed with glass fibers, fiber reinforced lime stabilized flyash. Tests were carried out at 0.5%, 1%, 1.5%, and 2% of glass fibers at three different normal stresses of 0.5 Kg/cm^2, 1 Kg/cm^2 and1.5Kg/cm^2. Figures 2, 3 and 4 show the variation shear stress vs shear strain for 0.5 Kg/cm^2, 1 Kg/cm^2 and1.5Kg/cm^2 respectively. An optimum value of 1.5% glass fibers has been found out through this experiment, at which the stress –strain behaviour of the samples were high compared to other percentages of glass fibers.

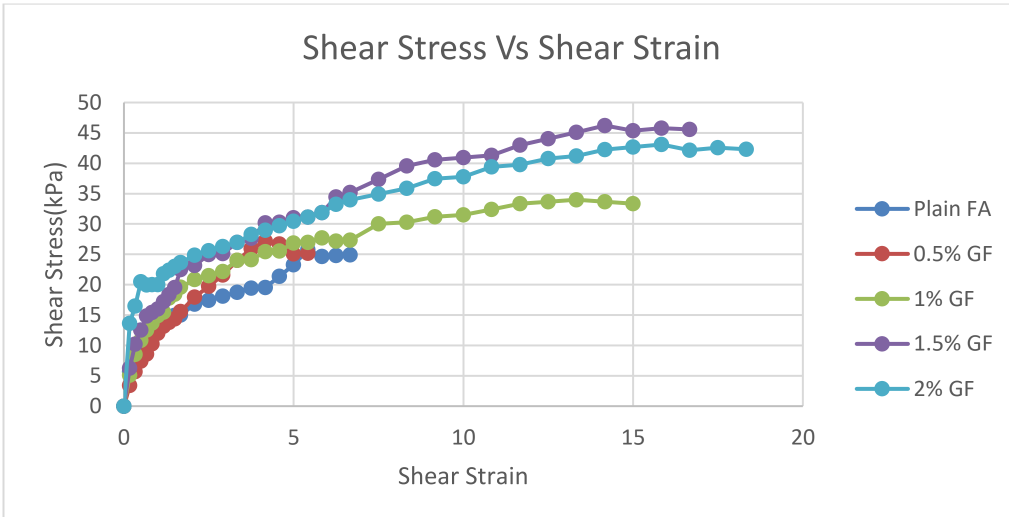

Figure 2 Shear Stress Vs Shear Strain Curve for 49 kPa

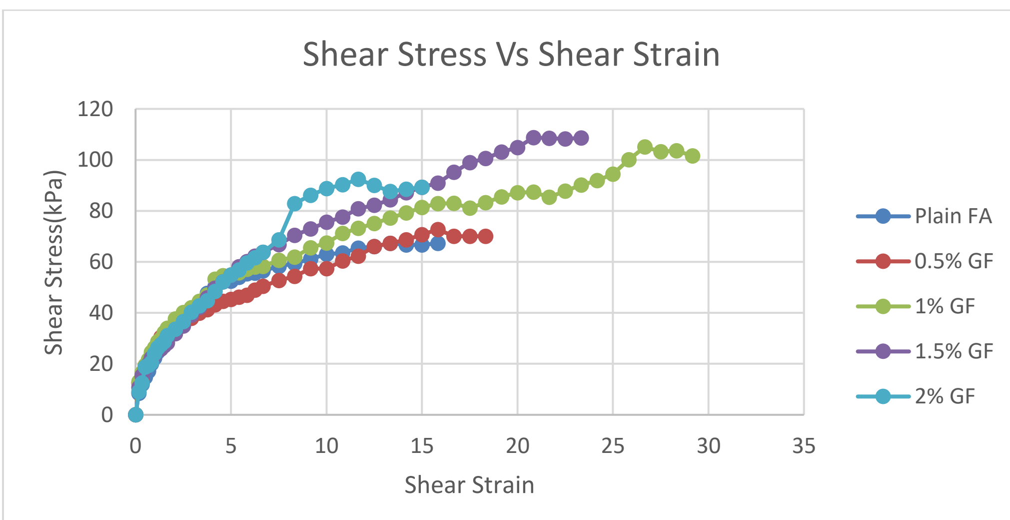

Figure 3 Shear Stress Vs Shear Strain Curve for 98 kPa

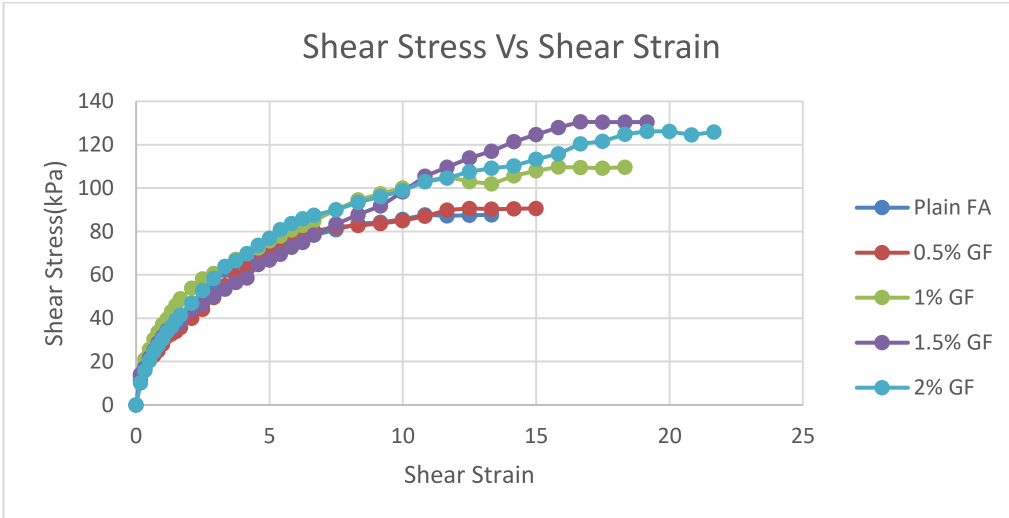

Figure 4 Shear Stress Vs Shear Strain Curve for 147 kPa

Tests were carried out at 2%, 3%, 4%, 5% and 6% lime along with 1.5% glass fibers (an optimum value obtained from previous tests) at three different normal stresses of 0.5 Kg/cm^2, 1 Kg/cm^2 and1.5Kg/cm^2. Tests have been done after one and three day curing periods and the subsequent results have been tabulated in table 1. Figures 5, 6, 7, 8, 9 and 10 show the variation of shear stress vs shear strain for 0.5 Kg/cm^2, 1 Kg/cm^2 and1.5Kg/cm^2 done at one day and three day curing periods respectively. From the figures it is clearly visible that there is a considerable improvement of stress-strain behaviour of flyash when combined with lime and glass fibers. Glass fiber's inclusion changes the gradation of flyash thereby increasing the strength behaviour of flyash. A further inclusion of lime stabilizes the flyash improving the cohesion values of the mix all together which is quite evident from the comparative analysis of results shown in table 1.

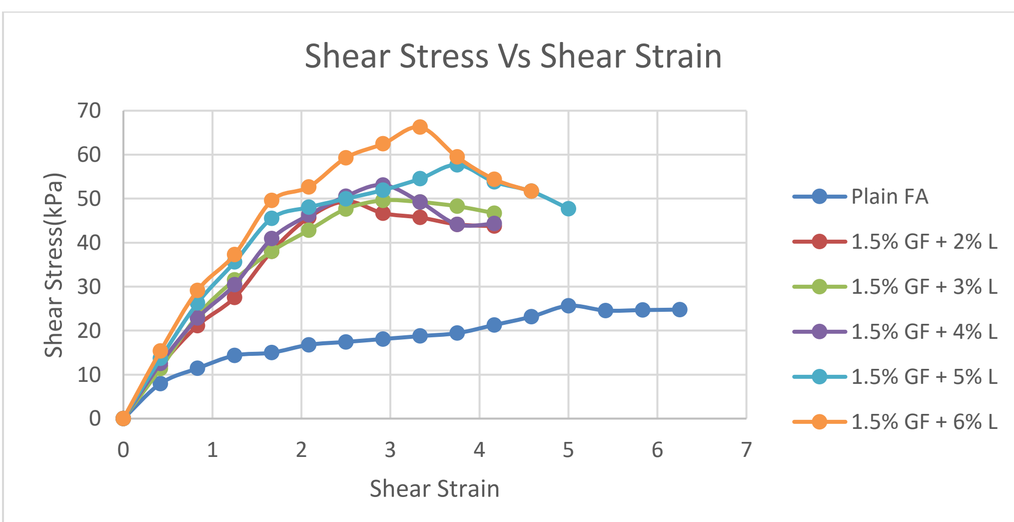

Figure 5 Shear Stress Vs Shear Strain Curve for 49 kPaat 1-day curing

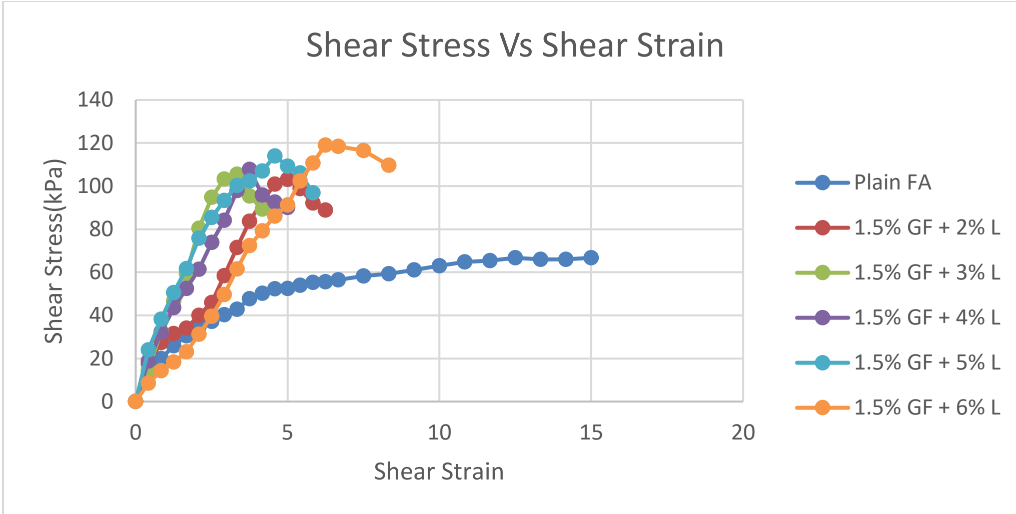

Figure 6 Shear Stress Vs Shear Strain Curve for 98 kPa at 1-day curing

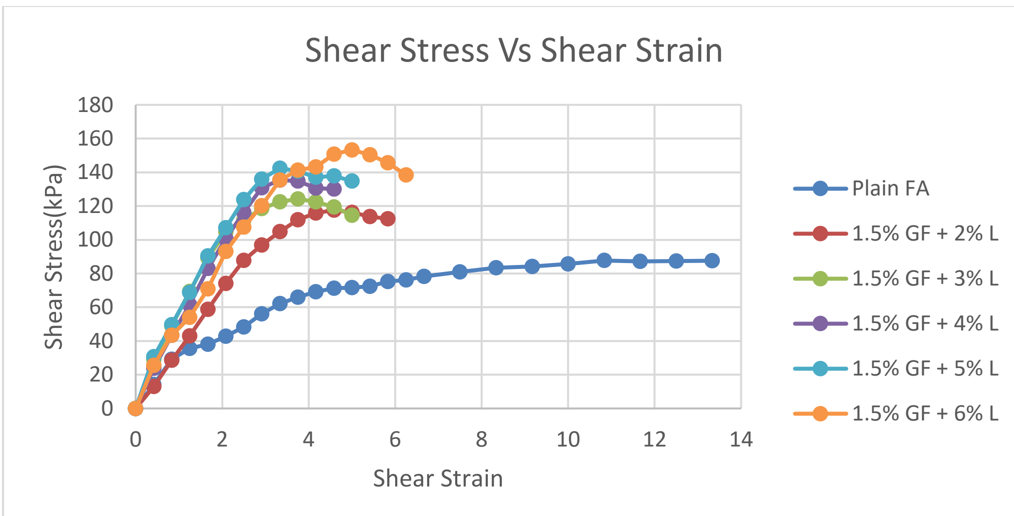

Figure 7 Shear Stress Vs Shear Strain Curve for 147 kPa at 1-day curing

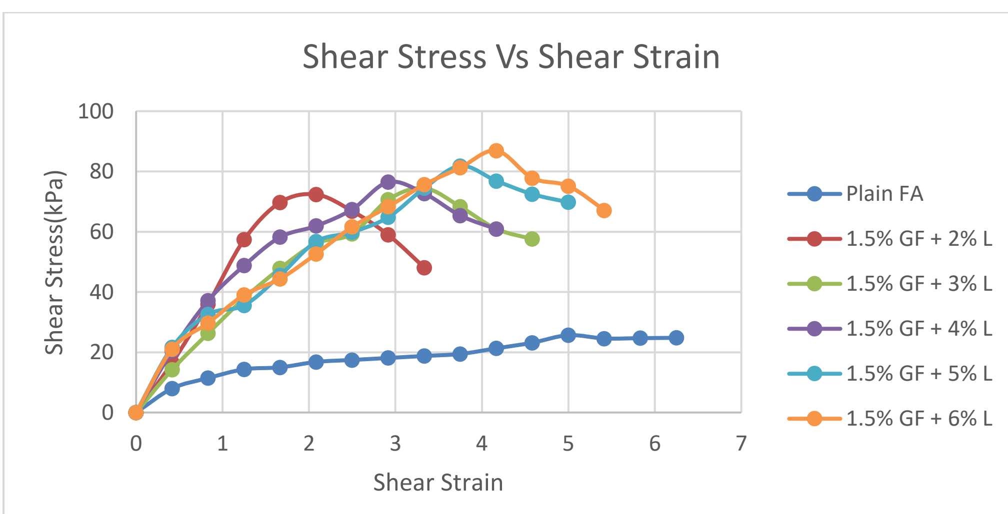

Figure 8 Shear Stress Vs Shear Strain Curve for 49 kPaat 3-day curing

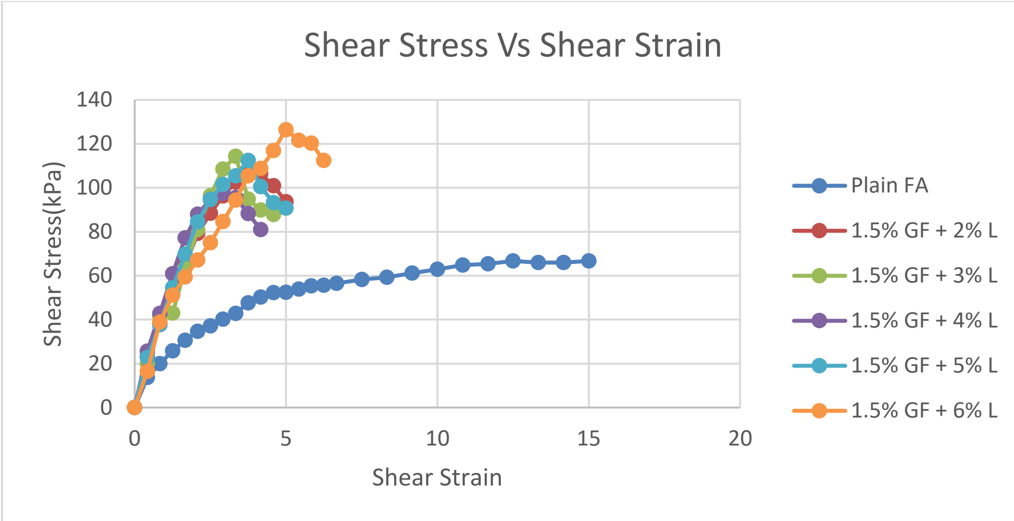

Figure 9 Shear Stress Vs Shear Strain Curve for 98 kPa at 3-day curing

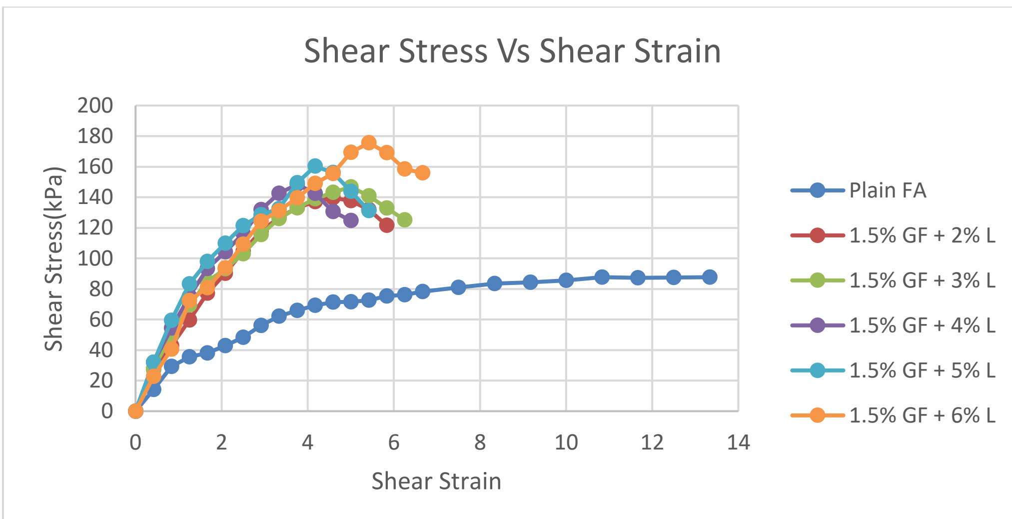

Figure 10 Shear Stress Vs Shear Strain Curve for 147 kPa at 3-day curing

Table 1 Shear Strength parameters for varying percentages of lime and glass fibers

Composition	Cohesion(kPa)	Angle of internal Friction	Secant Modulus(kPa)
Plain FA	0	30^0	1930
FA + 0.5% GF	0	33^0	2144
FA + 1% GF	7	38^0	2939
FA + 1.5% GF	11	41^0	3148
FA + 2% GF	1	40^0	2608
FA + 1.5% GF + 2% L @1-day curing	22	35^0	3510
FA + 1.5% GF + 3% L @1-day curing	19	37^0	4464
FA + 1.5% GF + 4% L @1-day curing	16	40^0	4483

FA + 1.5% GF + 5% L @1-day curing	20	41^0	4663
FA + 1.5% GF + 6% L @1-day curing	26	42^0	5211
FA + 1.5% GF + 2% L @3-day's curing	39	34^0	4185
FA + 1.5% GF + 3% L @3-day's curing	40	36^0	4472
FA + 1.5% GF + 4% L @3-day's curing	36	36^0	4650
FA + 1.5% GF + 5% L @3-day's curing	40	39^0	4859
FA + 1.5% GF + 6% L @3-day's curing	41	42^0	5784

*FA-Flyash; GF-Glass fibers; L-Lime

4. CONCLUSION

Flyash when mixed with glass fibers has shown a considerable improvement in the stress-strain behaviour. After getting an optimum value of glass fibers mixture from the tests, this optimum value of fibers has been used as reinforcement in the lime stabilized flyash. This fiber reinforced lime stabilized flyash has shown an increase in cohesion values to about four folds though there is no significant increase in the friction values. The increase in the cohesion values may be attributed to the pseudo-cohesion induced in the flyash due to the additives. This fiber reinforced lime stabilized flyash unto some extent can be a good alternative to embankment/structural fill, mine reclamation, a light weight fill behind the retaining walls etc. There is still a wide open scope on this topic for further studies to be carried out.

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