ASIAN JOURNAL OF CIVIL ENGINEERING (BUILDING AND HOUSING) VOL. 9, NO. 5 (2008)
PAGES 505-512

THE INFLUENCE OF RANDOMLY ORIENTED HAIR FIBRE AND LIME ON THE CBR VALUE OF DADRI FLY ASH

J.N. Akhtar*, J. Alam[a] and Sh. Ahmad[b]
[a]*Department of Civil Engineering, University Polytechnic, A. M. U. Aligarh 202002, India*
[b]*Department of Civil Engineering, A.M.U. Aligarh 202002, India*

Abstract

The objective of the experimental work is to study the influence of Fly ash mixed with lime having varying percentage of hair fibres on California Bearing Ratio values. The randomly oriented hair fibres were, 1.00, 1.50, 2.00 and 2.50% of cement by weight respectively. Thermal power plants generated different types of Fly ash. Fly ash is the most abundant of all the residues and its disposal not only needs enormous land, water and power resources but it also causes serious environmental hazards. In India about 82 such Power Plants produce nearly 106 million tons of Fly ash per year [1] and the Figure is likely to soar. This alarming increase in the production of Fly ash and its disposal in ecologically suitable manners has lately become a global concern. Efforts are being made to increase the use of Fly ash in every possible way. In this struggle scientists and engineers especially civil engineers are playing a remarkable role. A number of studies have been carried out to determine the influence of fibres on the physical properties of soil and Fly ash with and without Lime. However, no study has been found so far in the literature to investigate the effect of randomly oriented hair fibres on Fly ash mixed with lime. In this paper, results of an experimental study have been presented to determine the effect of randomly oriented Hair fibres in Fly ash and lime on the value of California Bearing Ratio and found encoraging.

Keywords: Fly ash; hair fibres; CBR test; proctor's compaction test

1. Introduction

The major source of energy in India is coal. The estimated current reserves of coal are sufficiently large to meet its demand for the next 250 years [2]. Fly ash, also known as pulverized ash, is a waste product of coal based thermal power plants. The coal in India, having relatively low calorific value of 2500 to 3500 kcal/kg and with high ash content of about 45%. Now, with the commissioning of super power plants (1000-2000 MW) and increasing use of coal the production has reached about 106 tons per year, which posses challenge for its safe disposal. This astounding increase and alarmingly low percentage of

* E-mail address of the corresponding author: jannisar_akhtar@rediffmail.com (J.N. Akhtar)

utilization 15% in India in 1999 [3] poses a potential threat to environment and economy.

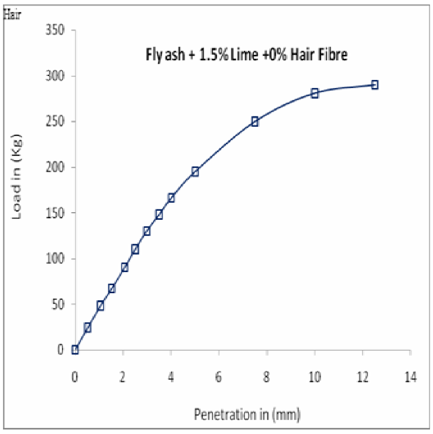

Figure 1. Load vs. penetration for Sample 1 (0% hair fibre)

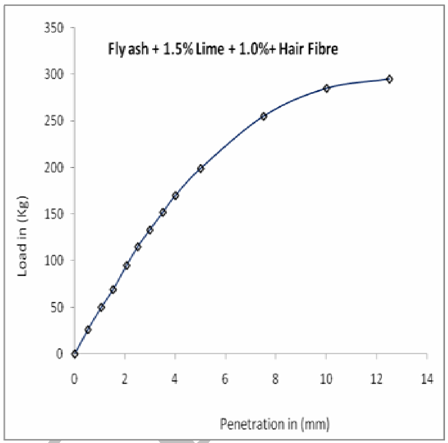

Figure 2. Load vs. penetration for Sample 2 (1.0% hair fibre)

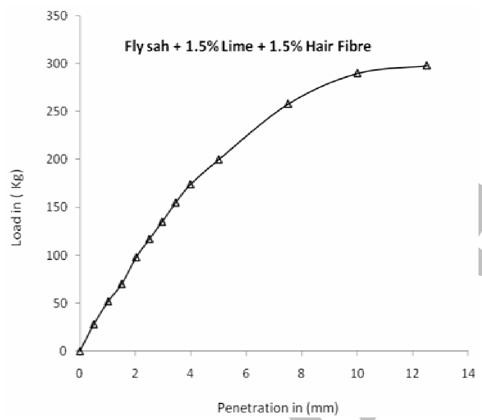

Figure 3. Load vs. penetration for Sample 3 (1.5% hair fibre)

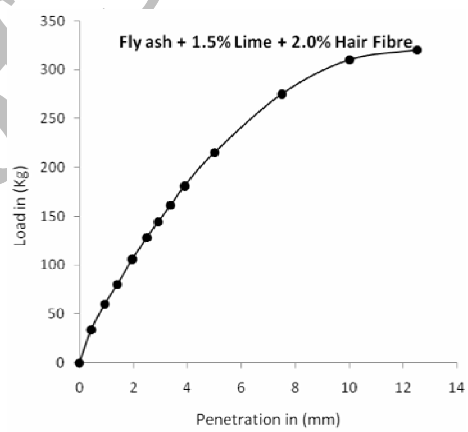

Figure 4. Load vs. penetration for Sample 4 (2.0% hair fibre)

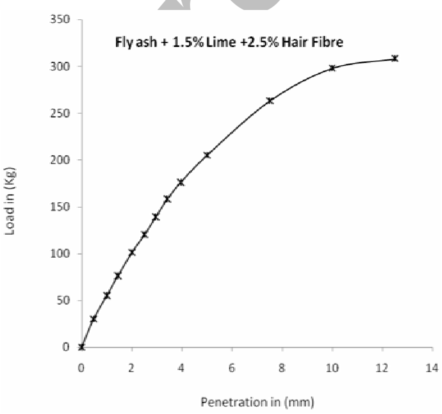

Figure 5. Load vs. penetration for Sample 5 (2.5% hair fibre)

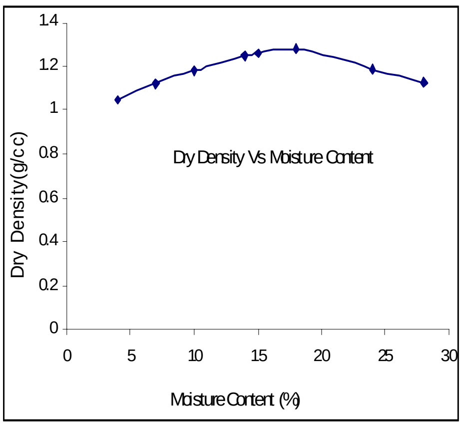

Figure 6. Dry density vs. moisture content for plain Fly ash

Fly ash is a non-crystalline Pozzolanic and slightly cementatious material. Though the Fly ash is being used as a construction material in the manufacture of bricks and as partial replacement of cement in cement concrete for many civil engineering projects, but its use as a general fill material on mass scale is not very popular. Its use in embankments for the construction of highways and railways, can serve the dual purpose of its mass utilization and preservation of ecological balance. The Delhi Metro Rail Cooperation (DMRC) has opted such an arrangement in its mass transit system for Delhi. In the present study an effort has been made to study the effect of lime with Hair fibre on the CBR value of Fly ash.

As reported above, Fly ash has great potential for important uses in various sectors, the main utilization being in building and construction industry. To the large extent of Fly ash utilization, further studies were also made on the Fly ash, which are discussed herewith. Several researchers have hovered their attention towards finding out various properties of Fly ash have also reasoned the drift in the values from the normal values of soil. Sherwood and Ryley [4] reported that most Fly ashes contain particles that are predominantly silt-sized with some sand-sized particle. The use of lime to treat Fly ash was suggested by Uppal et al. [5]. Dayal et al. [6] also reported low values of specific gravity values of Fly ash. The low values of specific gravity are attributed to particles being hollow spheres or cenosherical. Also there are other factors on which Specific Gravity value depends such as gradation, chemical composition of Fly ash, etc. Sridharan et al. [7] have reported the shear strength characteristics of some Indian Fly ashes under various conditions. Pandian et al. [8] studied the variation of specific gravity of Indian Fly ashes in great detail.

2. Experimental Set Up and Procedure

2.1 Materials used

In this experimental study Fly ash used was the portion of the ash collected from electrostatic precipitators of Dadri thermal power station, Dadri (U.P.), India. The grinded Limestone powder was used to augment the cementitious properties of Fly ash. The physical and Geotechnical properties of Fly ash and Hair Fibres used in the study are given in Table 2, because of that coal is supplied from different mines of Bihar the chemical properties also vary a great extent and the results of Chemical analysis of Fly ash along with their range for different materials are given in Table 1. The finely ground Calcium Hydroxide, a laboratory reagent, was used to augment the cementitious properties of the Fly ash. Its optimum amount with respect to Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) was determined in Table 3. It was done through Standard Proctor's Test or Standard AASHTO (T-99) Test.

2.2 Determination of OMC and MDD

In order to get the value of OMC and MDD light compaction test according to IS: 2720-VII is done. This test conforms to the specifications of SPCT or Standard AASHTO (T-99) Test. The curve shows OMC and MDD in Figure 7.

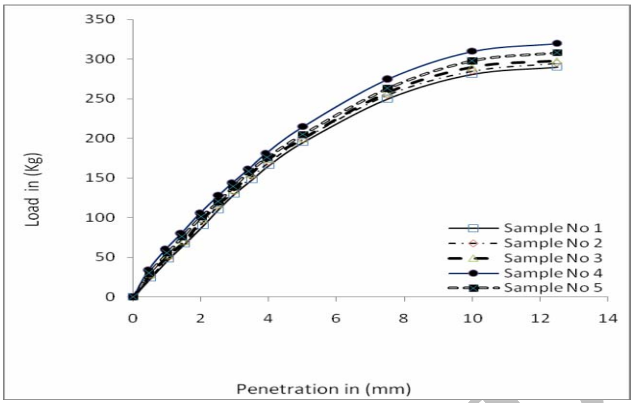

Figure 7. Load vs penetration curve for different % age of fibre

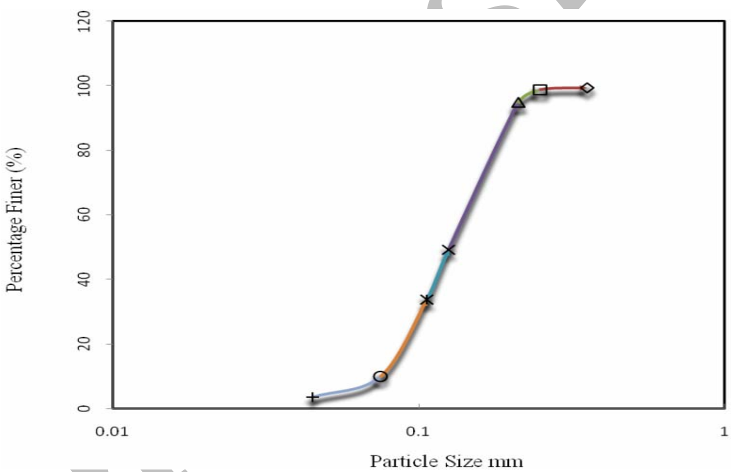

Figure 8. Particle size distribution curve of Fly ash

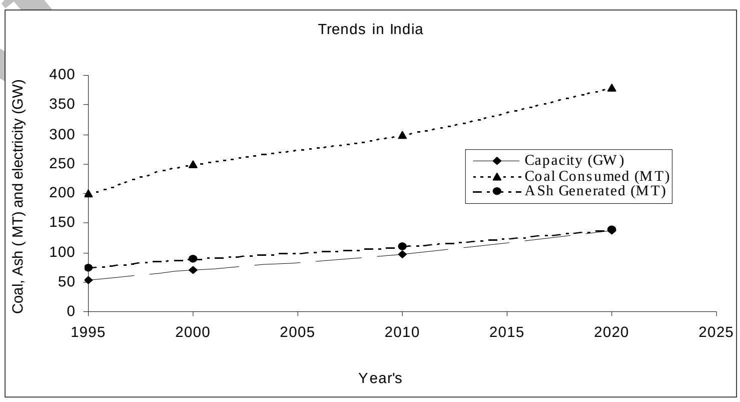

Figure 9. Trends of electricity generation, coal consumption and Fly ash generated in India

Table 1. Chemical analysis of along with the range for different materials

Components	**Range of percentage of component for different materials (ASTM-C-618)**	**Percentage of different component in the Fly ash used**
	Fly ash Class 'C'	
SiO_2	46-60	51.50
Al_2O_3	21-28	20.95
Fe_2O_3	05-09	8.50
CaO	0.5-6	5.27
MgO	0.2-4	3.85
SO_3	0-0.4	0.35
Na_2O	0-0.3	0.25
K_2O	0-0.2	0.18
LOI	0-0.2	0.15

Table 2. The physical properties of materials

S. No.	**Materials**	**Physical properties**	**Value**
1.	Fly ash	Specific gravity	1.85 at 28 ^{0}C
		Optimum moisture content (standard proctor test)	18.2%
		Maximum dry density	1.28*g/cc*
		Coefficient of uniformity, C_u	2
		Coefficient of curvature, C_c	1.13
		Direct shear test cohesion	0.0
		Angle of shear resistance	27^o
		Permeability	1.3x10^{-5} cm/sec
2.	Properties of hair fibres	Cross-section	Circular
		Diameter	Nil
		Elongation	Nil
		Length	5-30 mm
		Specific gravity	Nil
		Tensile strength	Nil

2.3 Determination of CBR

The specimens were prepared at OMC in cylindrical mould used for MPCT (Dia: 150 mm; Ht: 175 mm). The Sample was compacted in the mould in three equally thick layers; each layer is compacted by 56 blows imparted by a hammer of 2.6 kg weight. Finally, for penetration test two surcharge disks, each weighing 2.5 kg, were placed over the Sample and a plunger, 50 mm in diameter, was used to penetrate the Sample at a rate of 1.25 mm/min. The test was carried out in three stages.

a) With the help of Standard Proctor's Compaction test on specimens containing Fly ash and lime, the optimum percentage of lime was obtained in Table 3.

b) Second stage reveals CBR value of plain Fly ash specimen was determined.

c) In the third stage, Specimens were prepared by mixing of Fly ash with optimum amount of Lime, as obtained earlier with the percentage of Hair fibres varied for different Samples at OMC and thus the CBR values were observed in Table 4.

3. Results and Discussion

3.1 Loads verses penetration curves

The load-penetration curves for plain and lime treated Fly ash with varying percentage of Hair fibres were drawn. The curves generally conformed to the standard shape but the initial portion of curves was concave upwards. The curves were then corrected by shifting the origin to the point of intersection of a tangent drawn to the curves at the point of greatest slope with the penetration axis. Corrected loads were read from the corrected curves as shown in Figures corresponding to 2.5 mm and 5.0 mm penetrations.

Table 3. Optimization of lime with respect to OMC and MDD.

Sample No.	Fly ash with varying percentage of lime	Optimum Moisture content	Maximum dry density
1	0.5	18.46	1.16
2	1.0	19.2	1.08
3	1.5	18.2	1.28
4	2.0	18.4	1.17
5	2.5	20.1	0.99

*** OMC-Optimum Moisture Content, MDD-Maximum Dry Density**

It is observed from the CBR test results that the maximum value of CBR is obtained when the Fly ash Sample is mixed with 2.0% Hair fibre and 1.5% of lime both by weight of dry Fly ash. The relevant graphs and tabulated results of the test are as shown in Figures 1 to

8. The increase in CBR value may be due to shear transfer mechanism, which has been induced by the inclusion of Present Hair Fibres. Furthermore, upon inclusion of more than 2.0% of Hair fibres the CBR value tends to decrease which may be attributed to the formation of slip surface on account of increase in quantity of the Hair fibres. Also larger percentage of Hair fibre increases the difficulty in mixing and hence may not be effectively recommended.

Table 4. CBR Test result for plain Fly ash and reinforced Fly ash

Sample No.	**Percentage of hair fibres (%)**	**CBR value at 2.5 mm penetration**	**CBR value at 5.0 mm penetration**	**Ratio of CBR values of reinforced and lime treated Fly ash to plain Fly ash**	
1	Plain Fly ash	03.5	03.9	1.000	1.000
2	1.00	07.1	07.8	2.028	2.000
3	1.50	10.0	11.9	2.857	3.051
4	2.00	11.8	12.4	3.371	3.179
5	2.50	08.8	09.4	2.514	2.410

*** CBR- California Bearing Ratio**

5. Conclusions

- The addition of lime to the Fly ash increases the cementitious properties of Fly ash and it was found that at 1.5% of lime, the OMC is minimum and dry density is maximum.
- The addition of 2.0% hair fibres to the mixture of 1.5% lime and plain Fly ash gives the maximum value of CBR for both 2.5 mm and 5.0 mm penetration.
- The CBR value of the Fly ash mixed with 1.5% lime and 2.0% Hair fibre increases nearly 3 times that of the plain Fly ash, both at 2.5 mm penetration and at 5.0 mm penetration.

References

1. Kumar V. Fly ash Utilization Programe Workshop on Fly Ash and its Application ICET, December 2004.
2. Gray DH, Lin YK. Engineering properties of fly ash, *ASCE*, *Journal of SM and FE,* No. 4, **98**(1972)361-80.
3. Dayal U, Sinha R, Kumar V. Fly Ash Disposal: Beyond 2000AD, *Proceeding of the Workshop on Fly Ash Disposal and Deposition-Beyond 2000AD*, held at IIT Kanpur in

1999.
4. Sherwood PT, Ryley MD. Use of stabilized pulverized fuel ash in road construction, Road Research Laboratory Report, Ministry of Transport, UK, No. 49,1966, pp.1-44.
5. Uppal DH, Dhawan PK. A resume of the use of fly ash in soil stabilization, *Journal of Indian Roads Congress*, Vol. XXI-2. September 1968.
6. Dayal U, Sinha R, Kumar V. Fly Ash Disposal: Beyond 2000AD, proceeding, workshop on Fly ash Disposal and Deposition-Beyond 2000AD, held at IIT Kanpur in 1999.
7. Sridharan A, Pandian NS, Srinivasa Rao S. Shear strength characteristics of some Indian fly ashes, *Ground Improvement*, **2**(1998)141-6.
8. Pandian NS, Rajasekhar C, Sridharan A. Studies on the specific gravity of some Indian coal ashes, *Journal of Testing Evaluation*, *ASTM*, **26**(1998)177-86.