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Some Geotechnical Properties of Coal Fly Ash and Sand Mixtures with Different Ratio using in Highway & Embankments

By Dilip Kumar, Ashish Gupta & Neetesh Kumar
Madan Mohan Malviya University of Technology, India

Abstract- Fly ash is very effectively used in various civil engineering projects. Fly ash is a by-product of coal burning thermal power plants plant. The quantity of coal ash produced depends upon the quality of coal and the method of burning of the coal. In India less than 20% of ash is used in the manufacture of brick, cement, concrete and other product. Sand particles are much coarser than the fly ash. Here we are using different proportion as 100%S, 80%S+20%FA, 60%S+40%FA, 40%S+60%FA, 20%S+80%FA, 100% FA. Different test like Grain size analysis Specific gravity, Standard proctor test, Permeability test, direct shear test, California Bearing Ratio test were done on different proportions. MDD increases while dry density decreases as Sand increases. Permeability decreases as fly ash content increases. CBR value decreases for both soaked and unsoaked condition as fly ash content increases.

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Dilip Kumar [α], Ashish Gupta [σ] & Neetesh Kumar [ρ]

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I. Introduction

Fly ash and Sand are very effectively used in various civil engineering projects. The quantity of ash produced depends upon the quality of coal and the method of burning of the coal. In India less than 20% of coal ash is used in the manufacture of brick, cement and other products. Coal fire power plants produce millions of tones of fly ash annually but only a small quantity is used. Consequently thermal power plant coal ash is "negative cost" material. Coal ash has many uses in civil engineering project. Sand is often angular sand and gravel size particles, are employed as aggregate in highway construction and icing control. The main disposal problem is with fly ash, the finer silt size fraction recovered from stack emissions. Fly ash is often a component in concrete mixtures, but it is also used in stabilized road and highway embankment, landfill linear and waste stabilizations.

Fly ash and Sand was collected from Rihandnagar Thermal Power Project (U.P.) and has been used in present investigation. The fly ash and Sand were mixed in different proportions and their physical, chemical and geo-technical characteristics were investigated. Fly ash and Sand fulfill the technical properties required for various use. However experimental inadequate awareness among the user at various levels has resulted in limited use of fly ash and Sand material as fill.

Environmentally safe disposal of large quantities of fly ash and Sand is not only tedious but also expensive. To reduce the problem of disposal of fly ash and Sand great efforts are being made to utilize fly ash and Sand. The properties of fly ash and Sand that is important for use in geotechnical engineering applications.

a) Fly Ash

Fly ash obtained from thermal power station is a by-product available in abundant quantity and ought to be converted into meaningful and useful products. Fly ash is nothing but the finely divided residue resulting from the combustion of powdered coal Fly ash is the by-product of coal combustion thermal power plant. Due to its pozzolonic nature it can be used effectively for variety of purpose.

Coal Fly ash obtained as the by-product from pulverized coal consists of predominantly small spherical particle, which differs in shape and size due to its difference in degree of pulverization of coal and efficiency of collecting system. One of the major factors hindering the utilization of fly ash has been an economic system for collection, handling and transportation of fly ash at thermal power station and facilitate for handling and storage at the user end and its economics.

Coal fly ash has been successfully used as highway road embankment fill material for highway construction projects in a number of different locations throughout the world. When compared with the conventional soil used as embankment.

b) Sand

Sand is a common type of soil, which is having very fine particle size. The physical properties of sand include-It is made of silica, quartz with traces of other substances like titanium It is usually having irregular particle shape. Particle size is usually very small, but not so small that it can pass through a sieve. It is a loose granular substance yellowish brown in colour found

Author α: Assistant Professor, Department of Civil Engineering, Madan Mohan Malviya University of Technology, Gorakhpur, India.
e-mail: dilip.itbhu@gmail.com
Author σ: Assistant Professor, Department of Civil Engineering. B.I.E.T., Jhansi, India. e-mail: shi_g2000@rediffmail.com
Author ρ: PG Student, Department of Civil Engineering, Madan Mohan Malviya University of Technology, Gorakhpur, India.
e-mail: niteshmmmec@gmail.com

from the erosion of siliceous and other rocks and forming a major constituent of beaches, river beds, the seabed, and deserts The engineering properties make sand is an ideal material in design construction of dam and for other civil engineering applications. Sand also exhibits a relatively high permeability and grain size distribution that allows the design engineer to use it in direct contact with impervious material. Sand proved to be an economical material because it has demonstrated to have not only good engineering property but also to have constructability benefits.

c) Utilization of fly ash and Sand in India are

- Land Development
- Bricks
- Mine Filling
- Ash Dyke Raising Roads/Embankments
- Concrete
- Fill Matrix

II. Material Used

a) Fly Ash

For the present study the source of fly ash is Anpara Thermal Power Project, Anapara (U.P.). The total production of fly ash at Anpara Thermal Power Project is about 2.5 million tons per year.

Table 3 : Physical Characteristics of Rihandnagar fly ash

Color	Grey
Physical State	Powder with traces of unburnt carbon
Sp. Gravity	2.12
Particles size	-
Clay size particles % (<0.002mm)	2.30%
Silt size particles % (0.002-0.075 mm)	4.65%
Sand size particles % (0.075-4.75 mm)	93.05%

Data as supplied by Rihandnagar Thermal Power Plant Authority.

Table 4 : Chemical characteristics of Rihandnagar fly ash

Constituents	Percentage (by weight)
SiO_2	68.0
Al_2O_3	24.0
$Fe_2O_3 + Fe_3O_4$	2.18
TiO_2	2.64
CaO	1.49
MgO	0.06
SO_4^{--}	Nil
Loss on ignition	1.63

b) Sand

The Sand used in the study was locally available local sand.

Table 5 : Physical Characteristics of sand

Property	Values
Color	Light Yellow Brown
Specific Gravity	2.67
Particle size distribution	
Clay size particle % (< 0.002mm)	0.0%
Silt size particle % (0.002-0.075 mm)	2.5%
Sand size particle % (0.075-4.75 mm)	95.5%
Gravel size particle % (4.75-80 mm)	0.00
Fines	3.00
Liquid Limit	NP
Plastic Limit	NP
Proctor Compaction Test	
Optimum moisture content (OMC) (%)	32 .01
Maximum dry density (MDD) (g/cc)	1.081
Coefficient of Uniformity (C_u)	11.58
Coefficient of Curvature (Cc)	1.45
Angle of internal friction	34^0
Cohesion	0.20

III. Preparation of Fly Ash and Sand Mixture

The following procedure was adopted for preparation of fly ash and Sand mixtures in all tests. The materials were first dried for 24 hrs and brought to room temperature. Fly ash and Sand were then mixed together in the required proportions (by dry weight) in dry form. Different proportions of Rihandnagar fly ash and Sand and their mixed designation are given in table: 3.

Table 3 : Fly Ash and Sand Mix Designation

Mix Designation	% of Fly Ash + % Sand
0%FA+100% S	0% Fly Ash + 100% Sand
20% FA + 80% S	20% Fly Ash + 80% Sand
40% FA + 60% S	40% Fly Ash + 60% Sand
60% FA + 40% S	60% Fly Ash + 40% Sand
80% FA + 20% S	80% Fly Ash + 20% Sand
100% FA+0%S	100% Fly Ash+ 0% Sand

IV. Testing Programme

Since fly ash generate in huge quantity from thermal power plants. mainly work has been done on fly ash not on Sand so in the project we want to investigate that what is the effect of engineering property on mixing of fly ash and Sand in different proportions and how Sand can be safely used with fly ash in geotechnical applications and other civil engineering projects. So following testing is done on fly ash and Sand and its mixtures in different proportions.

- Grain size analysis
- Specific gravity
- Standard proctor test
- Permeability test
- Direct shear test
- California Bearing Ratio test

V. Results and Discussion

This investigation has been carried out to find the effect of fly ash and Sand mixture on optimum moisture content, maximum dry density, permeability, shear strength, particle size analysis and CBR values. In the present investigation fly ash and Sand has been taken from Rihandnagar Thermal Power Plant, Sonbhadra (U.P.) The results of these investigations have been presented in the form of tables and graphs in this chapter. Brief discussions on the laboratory test results are given below.

a) Characteristics of Mix Proportion

Table 5 : Different properties of Fly Ash, Sand and its Mix Proportions

Mix designation	MDD (g / cc)	OMC (%)	Coefficient of Permeability (cm/sec)	Cohesion (c) Kg/cm^2			Angle of shearing resistance (ϕ)	CBR Value (Unsoaked Condition) %	CBR Value (Soaked Condition) %
				Dry	Wet	Dry	Wet		
100% FA	1.40	18.56	5.570×10^{-4}	0.205	0.01	25.7^0	23.0^0	15.75	7.67
80% FA +20% S	1.342	20.90	6.115×10^{-4}	0.255	0.026	33.4°	32.0°	18.10	10.80
60% FA +40% S	1.296	23.12	6.60×10^{-4}	0.250	0.04	34.4°	31.5°	22.05	14.31
40% FA +60% S	1.223	25.96	7.10×10^{-4}	0.230	0.021	30.2°	29°.	24.21	17.42
20% FA +80% S	1.152	28.97	7.410×10^{-4}	0.220	0.005	31.7°	26.5°	27.11	20.69
100% S	1.081	32.01	7.68×10^{-4}	0.205	0.021	36.2°	34.0°	29.61	23.15

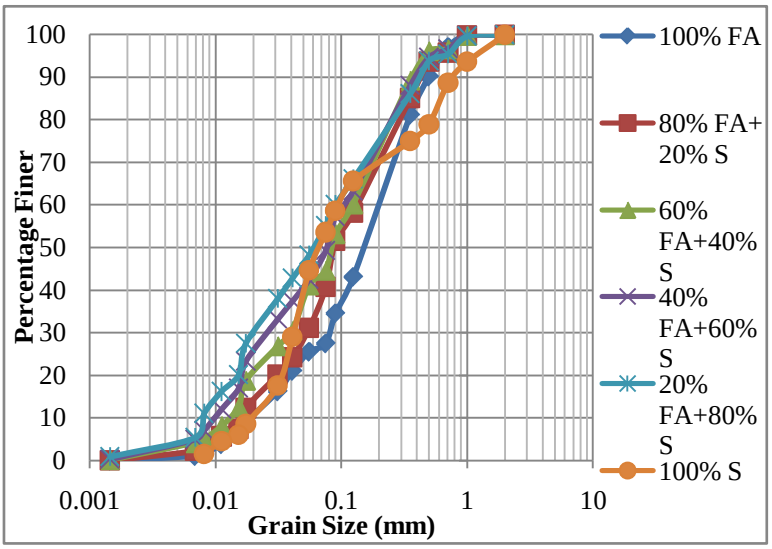

Fig. 1 : Grain Size distribution curve of Fly Ash and Sand mixtures

b) Specific Gravity

The specific gravity was found out for fly ash, Sand, and fly ash and Sand mixtures in different proportions and it is presented in Table 10. The specific gravity of fly ash is 2.15 and for Sand it is 2.27.

Table 10 : Specific Gravity for mixtures of Fly Ash and Sand

Mix designation	Specific Gravity
100% FA	2.10
80% FA + 20% S	2.20
60% FA + 40% S	2.37
40% FA + 60% S	2.45
20% FA + 80% S	2.58
100% S	2.66

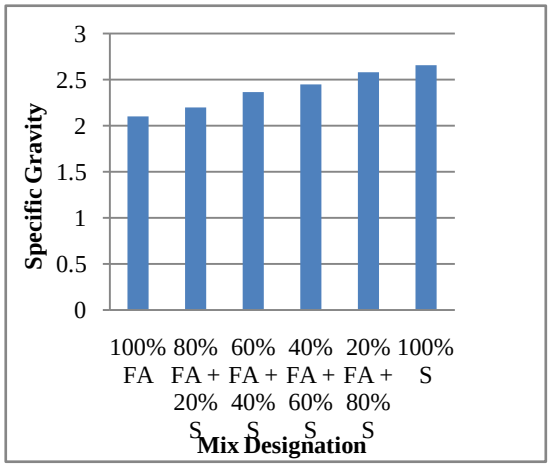

Fig. 2 : Specific gravity of fly ash and Sand mixtures

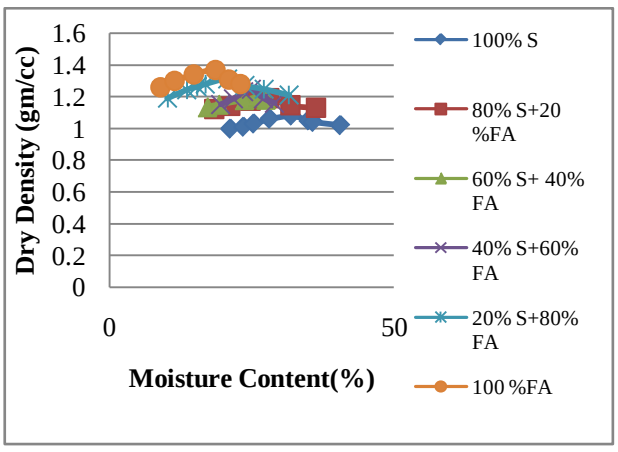

Fig. 3 : Compaction Curve of Fly Ash and Sand Mixtures

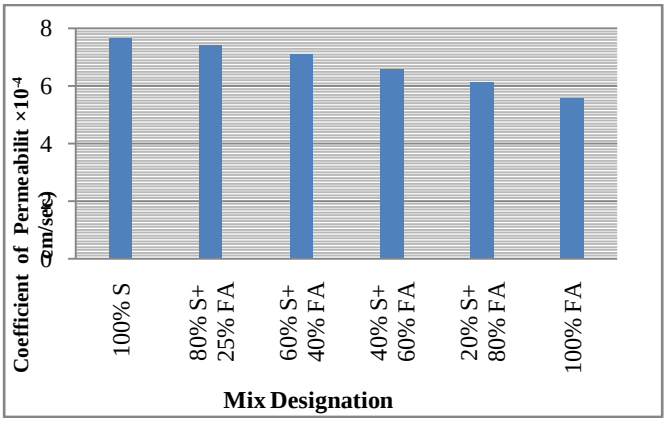

Fig. 4 : Coefficient of permeability of Fly Ash and Sand mixtures

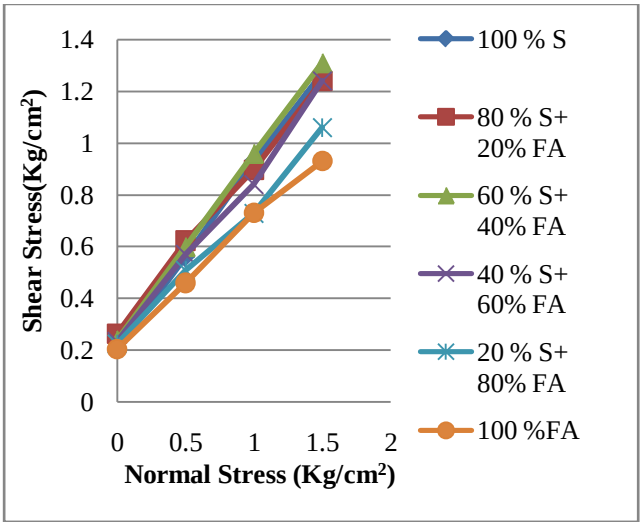

Fig. 5 : Direct shear test of Fly Ash and Sand Mixtures in Dry Condition

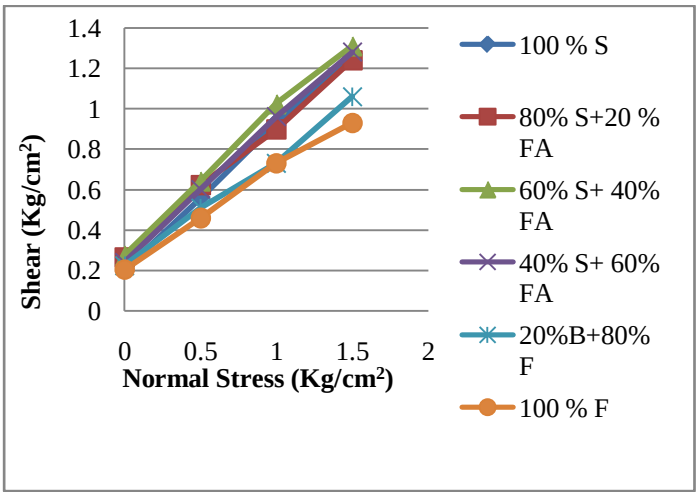

Fig. 6 : Direct shear test of Fly Ash and Sand Mixtures in Wet Condition

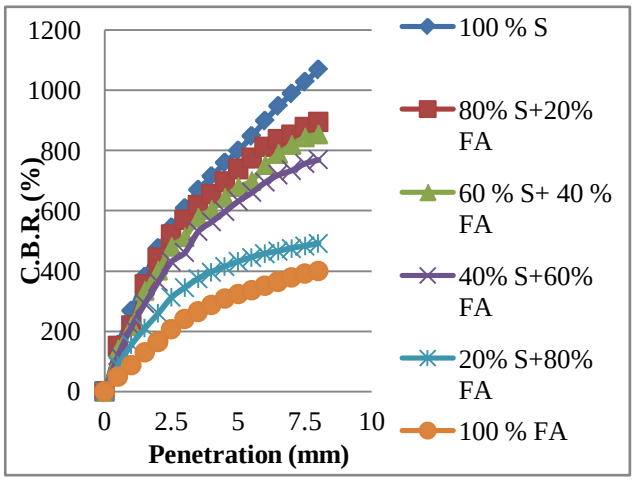

Fig. 7 : CBR value of Fly Ash and Sand Mixtures in Unsoaked Condition

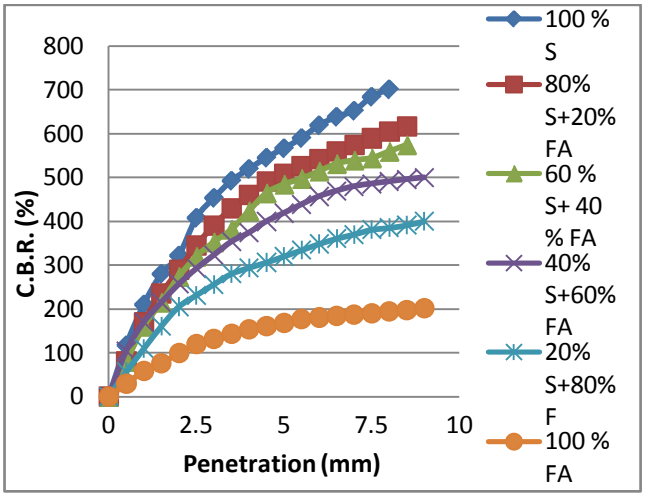

Fig. 8 : CBR value of Fly Ash and Sand Mixtures in Soaked Condition

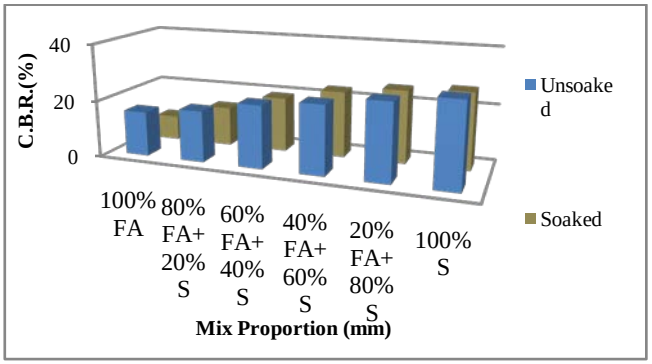

Fig. 9 : CBR value of mixtures of Fly Ash and Sand in soaked and Unsoaked Condition

VI. Conclusions

- Maximum dry density of fly ash and Sand mixture decreases with increasing Sand content while optimum moisture content increases.
- The permeability of compacted coal ash sand mixtures was found to decrease slightly with increasing fly ash content. This may be due to the increasing specific surface with increasing content of the fines, which creates more resistance to flow of water through voids between their particles. Overall range of the values was similar to that of a fine sands/ silts mixture or silts.
- Permeability of fly ash and Sand is 5.570 x 10^{-4} cm/sec and 7.68 x 10^{-4} cm/sec, as such fly ash and sand mixtures can be used as a filling material in core of dyke and mixtures of fly ash and Sand in different proportions can be used in highway embankment as a fill matrix.
- Shear strength parameter of fly ash and Sand shows a variation in cohesion from 0.01 to 0.021 kg/cm^2 and angle of internal friction from 23^o to 34^0 in wet condition it can be safely used in construction of embankment and also body of dyke for water disposal.
- Sand exhibits lower density as compared to fly ash but strength characteristics is better than fly ash under as compacted.
- In soaked condition the CBR value of fly ash and Sand is 7.67 % and 23.15% respectively. While in 80%S+20%FA, 60%S+40%FA, 40%S+60%FA, 20%S+80%FA proportions CBR is 20.69%, 17.42%, 14.31% and 10.80% respectively. The recorded value of CBR for sub-base is 7-20 %. Therefore fly ash and Sand mixtures can be used as sub-base of road construction as well as fill materials for highway embankments.
- Based on the results obtained in this investigation, it is found that high volume coal fly ash mixtures are suitable for use in highway embankment; if proper design and construction procedures are follow. The coal fly ash and Sand mixtures can provide fill materials and fill matrix of comparable strength to most soils typically used as fill materials, while having the advantage of smaller dry unit weights.
- Sand alone or in combination with fly ash at equal or similar proportion can be used as construction material in most geotechnical application where borrow soil is presently used, thus solving an important environmental hazardous problem of disposal of coal fly ash to great extent. Further, this will help reducing degradation of valuable land affected by dumping of unutilized coal ash produced and mining of soil for geotechnical construction.

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