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Utilization of Ash as a Structural Fill in Low-lying Areas

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ABSTRACT: Thermal power stations using pulverised coal as fuel, generate large quantity of ash as waste by product, which poses dual problem of environment and disposal. Flyash is a versatile material with many possible applications such as land filling and in land reclamation of low lying areas. An experimental investigation has been carried out to study the behaviour of compacted ash overlying sand deposit. The upper layer of ash is deposited at a relative density of 64% and 81% respectively on natural water content and lower layer of sand is deposited at relative densities of 40% and 70% respectively. Plate load test were conducted in plane strain conditions on footing for D/B = 0,1,1.5, 2, and 4 where 'D' is thickness of upper flyash overlying sand deposit have been studied. From the study it can be concluded that the settlement of footing decreases as D/B ratio increases and also with the increases of relative density of ash and sand.

Key Words: Ash, lowlying areas, Utilisation, Modulus of deformation

INTRODUCTION

With the commissioning of new thermal power stations and increasing use of pulverized coal as fuel with high ash contents, currently about 70Mt per year is likely to go upto 100Mt by the end of this century. Punjab being one of the highest per capita income states of india, has high per capita power demand. This power demand is supplemented through three thermal power stations at Ropar, Bhatinda and Leharmohabat. Ropar being a super thermal power plant, generates highest amount of ash which is estimated to be 1.7 millions tons per annum. Each unit of thermal power plant consists of seven fields refered to as F1 to F7. The composited ash collected from F1 to F7 may be called as flyash. The coal ash produced from furance bottom, known as bottom ash, is around 20 to 25% of the total ash produced.The ash is disposed off into a pond by mixing the bottom ash with field ashes to form a slurry with water. The slurry contains 20% solid by weight. The quantity of ash produced depends upon quality of coal used, the performance of washeries and the efficiency of the furance This huge amount of flyash poses dual problem of its disposal and environmental degradation. Most of the flyash generated from the power plant is disposed in the vicinity of the plant as a waste material covering several hectares of valuable land. Only about 20% of flyash produced in the world is being utilized in various beneficial applications and the balance is dumped as a waste material. Commercially the bulk use of flyash in construction industries are : (1) in manfacture of portland pozzolana cement; (2) in brick manufacturing; (3) as a structural fill and (4) in pavement and subgrade construction. The properties of flyash are such that it is possible to utilize it to construct structural fills, embankments, dams and dykes. However , in order to enhance the utilization of flyash, low lying areas can be raised by providing a layer of flyash over natural soil in foundation.Due to this composition, each layer may exhibit different characteristics such as bearing capacity , cohesion , angle of internal friction, settlement, pore water pressure distribution etc. The bearing capacity of such layered system depends upon number of factors such as density of layers, thickness of top strata and so on. The present work aims to study the behaviour of strip footing resting on flyash layer compacted at different relative densities overlying sand deposit of different relative densities, when subjected to vertical loads upto failure.Number of plate load tests were performed to predict the pressure-settlement characteristics, bearing capacity and deformation modulus.

1.1 CHEMICAL COMPOSITION

The chemical, physical and engineering properties of ash are dependent on the type and source of coal, method of coal preparation, cleaning and pulverisation, type and operation of power generation unit, ash collection, handling and stroage methods. Ash properties may vary due to changes in boiler load.The ASTM classification of coal ash relates to the percentage of calcium oxide in the ash. Class F flyash are derived from bituminous coal and class C flyashes are obtained from lignite. Flyash particles usually have grain size similar to silty soils for liginite flyashes.Most of the ash produced at Ropar Thermal plant may be classified as class F. The chemical composition of typical Ropar ash samples is given in Table 1 (Verma 1997)

TABLE 1. Chemical composition of typical Ropar ash sample

S.No.	Chemical Components	% by weight
1.	SiO_2	57.5
2.	Al_2O_3	27.2
3.	Fe_2O_3	5.4
4.	CaO	3.1
5.	Unburnt carbon	4.1
6.	Other Oxides	2.3

2.0 MATERIALS

2.1 Ash Data:

The fly ash used for study was pond ash obtained from Guru Gobind Singh Super Thermal Power Plant, Ropar. The properties of Pond ash are shown In the Table 2.

TABLE 2. Ash Data

Properties	Value
Sand size, %	64
Silt size, %	36
Clay size, %	0
Maximum dry unit weight, kN/m^3	9.6
Optimum moisture content, %	37
Specific gravity of solids	1.86
Maximum void ratio, e_{max}	1.384
Minimum void ratio, e_{min}	0.771
Cohesion , kN/m^2	5.10
Angle of internal friction , °	38-41

2.2 Sand Data:

The sand used for studies was Ghagger sand. The properties of sand are shown in Table3.

TABLE3. Sand data

Properties	Value
D_{60}	0.2
D_{10}	0.10
Specific gravity of solids	2.67
Maximum void ratio, e_{max}	0.992
Minimum void ratio, e_{min}	0.673
Angle of internal friction , °	28 -34

2.3 Experimental Set up and Testing Techniques:

The tank used for depositing soil was made up of cast iron having dimension 1.0mx0.60mx0.60m.The sand was deposited in the tank by rainfall method in three equal layers upto height of 30cm.The desired densities were achieved by rainfall method.Then pond ash of desired relative densities of 64% and 81% was filled in the tank in three equal layers at natural moisture content . Each layer was compacted with a hammer of 2.6 kg, internal diameter 0.50cm having a free fall of 31cm. The load test were conducted on a footing of 60cmx15cm at different D/B ratios as shown in Table 4.

TABLE 4. Parameters used

Parameter	Values
Size of footing	60cmx15cm
D/B ratio	0, 1, 1.5, 2, 4
Relative density of sand	40% , 70%
Relative density of pond ash	64% , 81%

3.0 RESULTS AND DISCUSSION :

At 64% relative density of compacted ash over sand of 40% relative density, as D/B ratio increases from 0 to 2, the settlement reduces by 38%. While at 81% relative density of compacted ash over sand of 70% relative density, the settlement reduces by 50%.(Fig.1&2).

Fig 3 shows the pressure- settlement characteristics for fly ash layer deposited at 81% relative density overlying sand of relative density of 40%. As the D/B ratio increases from 0 to 2, the settlement decreases by 45%. Fig. 4 & 5 shows the bar charts of deformation modulus and % improvement in deformation modulus corresponding to settlement of 6mm. As the D/B ratio increases the deformation modulus increases with percentage improvement of around 500%, when the fly ash is compacted to a higher relative density.

4.0 CONCLUSIONS :

Based on the experimental study carried out on footings resting on compacted fly ash on sand layer the following conclusions have been drawn

- With the increase in D/B ratio of fly ash layer , there is a considerable percentage reduction in settlement.
- There is also significant percentage reduction in settlement, when the relative density of both , the top fly ash layer and bottom sand deposit changes to a denser state.
- With increase of D/B ratio from 0 to 4 , the modulus of deformation increases to about 4 to 5 times , at ths relative density of 64% and 81% of top fly ash deposited over sand of 40% relative density. While the increase is 2 to 3 times when the sand is deposited at relative density of 70%.

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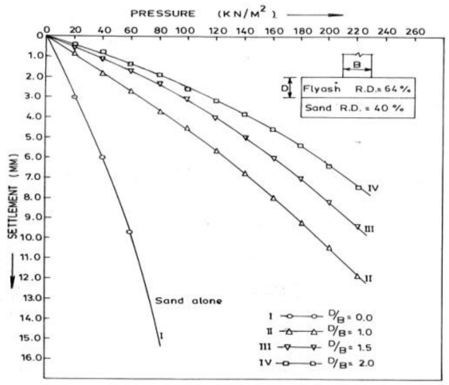

Fig.1 Pressure-Settlement for fly ash over sand for different relative densities

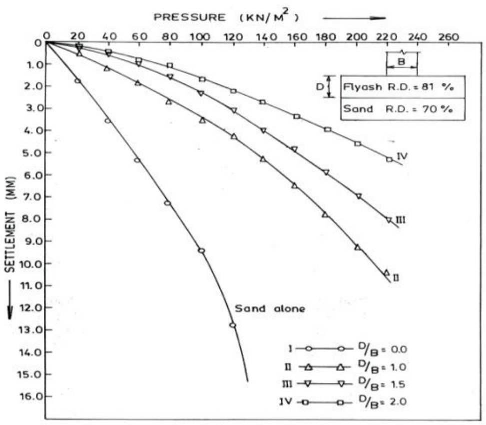

Fig.2 Pressure-Settlement for fly ash over sand for different relative densities

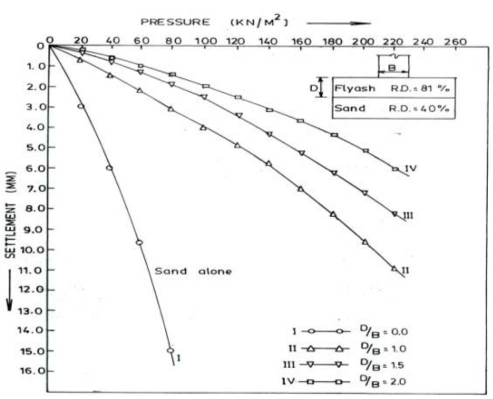

Fig.3 Pressure-Settlement for fly ash over sand for different relative densities

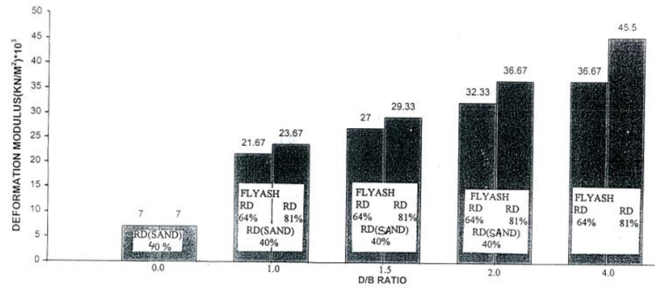

Fig.4 Comparison in modulus of deformation for D/B ratio and relative densities

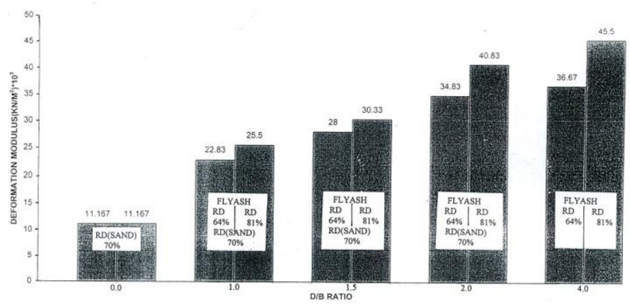

Fig.5 Comparison in modulus of deformation for D/B ratio and relative densities