ISSN 2250-3153

A Laboratory Investigation on the Compaction Properties of Soil mixed with Fly ash and Gypsum

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Abstract- Fly ash is one of the numerous substance that cause air, water and soil pollution, disrupts ecological cycles and set off environmental hazards. Fly ash produced during the burning of powdered coal in thermal power plants is a hazardous waste. Disposal of this enormous amount of fly ash faces problem of huge land requirement, transportation, and ash pond construction and maintenance, which can be reduced by utilizing fly ash as a construction material for civil engineering structures. Soil stabilization has been implemented for improving soils, which have inadequate engineering properties. An attempt has been made in this present paper to highlight on the pollution hazards due to the disposal of fly ash into the environment and its utilization in civil engineering activities by conducting some laboratory investigations. This paper describes a research that is carried out to study the effect of gypsum and fly ash on compaction properties and California bearing ratio values of silty sand. Different percentages of fly ash (i.e. 10, 15 and 20%) alone and with combination of gypsum (i.e. 2 and 4%) were added to the soil in order to evaluate the optimum moisture content and maximum dry density. The given result of specimens illustrate that the combination of gypsum and fly ash in soil is more effective than fly ash treatment alone.

Index Terms- Compaction, CBR, Gypsum, Fly ash.

I. INTRODUCTION

The wastes generated from different industrial processes are of complex characteristics and composition and hence, their safe management and disposal is also intricate and complex. The disposal and storage of these wastes without treatment leads to contamination of surface and groundwater through long term leachate accumulation from the disposal sites and ultimately disturbs the ecological and environmental balance. One of the industrial wastes is fly ash having disposal problem. In India, about 76% of electrical energy is generated using coal as fuel in thermal power plants. Presently in India, more than 70 millions tones of fly is being generated by the thermal power plants, out of which a vast majority is fly ash having low lime content. Researchers have tried since sixties to transform fly ash from liability to asset. The solution of this problem may be achieved through bulk utilization of the fly ash as a construction material in different civil engineering and infrastructural projects.

Fly ash is known to have self hardening characteristics depending upon the availability of free lime in it for pozzolanic reaction. To enhance the strength, fly ash may be stabilized with proper additives (lime and gypsum) in suitable amount. Several investigators have reported the influences of the addition of fly ash on soil properties. The effect of fly ash is noted mainly through the pozzolanic reactivity. The percentage increase of fly ash content in fly ash-soil mixtures leads to a decrease in the dry density due to the low specific gravity of fly ash.

Fly ash from thermal power plants can be considered either as a waste or as a resource yet to be fully utilized. Indian coals have very high ash content. The fly ash content of coal used by thermal power plants in India varies between 25 and 45%, with average fly ash content being 40%. As a consequence, a large amount of fly ash is generated from thermal power plants, causing several disposal related problems. In spite of initiatives taken by the government, several non-governmental and research and development organizations for fly ash utilization, the level of fly ash utilization in the country was estimated to be less than 10%. Globally, less than 25% of the total annual fly ash produced is utilized. Two methods are in practice to dispose of the generated fly ash. They are wet disposal and dry disposal methods with ash ponds being the most common methods of disposal in India

A review of the literature revealed that various laboratory investigations have been conducted independently on fly ash / lime stabilization of soil. Studies concerning fly ash and lime utilization for soil stabilization have been conducted in the past years by many investigators like Mitchell and Katti (1981), Consoli et al. (2001) and Edil et al. (2006) indicated the effectiveness of fly ashes for stabilization of fine grained soils. It is revealed from the previous studies that there is wide variation of the geotechnical properties of fly ash when it is stabilized with soil and any binding material.

II. MATERIALS AND METHODS

The experimental program in this investigation was conducted with silty sand, fly ash and gypsum. The soil was taken from Baini River, situated at Pantnagar, district Udhamsingh Nagar and classified as light brown silty sand (SM) as per IS:1498-1970. The specific gravity (Gs) of the soil is 2.45 and it does not exhibit any plasticity. The fly ash used in this study was low calcium class F fly ash obtained from Century Pulp and Paper Mill situated at Lalkuan, district Nainital. The fly ash had a dark grayish colour with a carbon content of (6-8%). The specific gravity of fly ash was 2.04 and it also does not exhibit any plasticity. The gypsum used in this study was locally available.

Different percentages of fly ash (i.e. 10, 15 and 20%) and gypsum (i.e. 2 and 4%) were added to the soil and the tests were performed. Proctor compaction tests were performed to determine the maximum dry density (MDD) and optimum

moisture content (OMC) for soil-fly ash and soil-fly ash-gypsum mixtures. The tests were conducted in accordance with Indian Standard test method (IS: 2720-Part 7).

III. TEST RESULTS AND DISCUSSIONS

Observations from standard proctor tests have been analyzed to study the effect of fly ash and gypsum on the engineering behaviour of soil.

Standard Proctor Test

The standard proctor tests were carried out on the soil sample with different percentages of fly ash and gypsum. The optimum moisture content and maximum dry density of the samples were determined. The test results shows that with the increasing proportion of fly ash in soil sample the optimum moisture content increases and maximum dry density decreases and same pattern were observed with the varying percentages of gypsum.

Table I: OMC and MDD of soil +fly ash + gypsum mixes

OMC (%)						Max. Dry Density (kN/m^3)			
Fly Ash		0%	10%	15%	20%	0%	10%	15%	20%
Gypsum	0%	11.0	14	16	17	15.60	15.40	15.30	14.91
	2%	---	18	20	21	---	15.99	15.70	15.30
	4%	---	19	21	22	---	15.99	15.40	15.11

California Bearing Ratio

CBR-value is used as an index of soil strength and bearing capacity. This value is broadly used and applied in design of the base and the sub-base material for pavement. California Bearing Ratio tests (CBR) were carried out on soil mixed with different proportion of fly ash and gypsum so as to study their bearing capacity.

Table II: CBR values for Unsoaked and Soaked condition

Soaked						Unsoaked			
Fly Ash		0%	10%	15%	20%	0%	10%	15%	20%
Gypsum	0%	4.92	4.98	5.99	6.46	13.07	13.34	14.89	15.56
	2%	---	5.05	5.41	6.34	---	13.81	16.30	16.50
	4%	---	5.19	5.54	6.35	---	20.61	20.82	20.95

IV. CONCLUSIONS

Soil stabilization as a cost-effective method is utilized in order to improve the properties of poor soil by adding the binder and by-products. The experiments conducted to study the effect of fly ash and gypsum addition on the geotechnical behaviour of soil.

Based on the experimental results and discussions as presented above the following conclusion can be drawn:

- With an increase in the percentages of fly ash in soil specimens the optimum moisture content increases and maximum dry density decreases.
- On addition of gypsum in soil –fly ash mixtures firstly an increase in both optimum moisture content and maximum dry density is observed. Further by increasing the percentage of gypsum the optimum moisture content increases and maximum dry density decreases.
- At optimum content, the CBR values of soil alone and soil – fly ash mixtures increases from 13.07% to 15.56% for Unsoaked condition. By increasing the percentages of fly ash and gypsum in soil samples the CBR value increases up to 20.95%.
- For soaked condition, the CBR values of soil and soil – fly ash mixtures increases from 4.92% to 6.46%. On addition of gypsum in soil – fly ash mixtures the CBR value decreases to 4.39%. With increase in percentage of gypsum the CBR value again increases.
- The CBR values for unsoaked conditions are more than the CBR values for soaked conditions.

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