A Critical Study on Using Fly Ash in NH Project (Kharar-Ludhiana) As an Embankment Fill Material

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Abstract: ***Development projects such as highway construction in modern scenario requires a huge amount of earth material. The borrow earth required for this purpose is not available easily in and around the urban areas due to difficulties in getting borrow land from where the required amount of soil can be extracted as the space availability is one of the major issues around urban areas and borrow land requires lot of space for soil extraction. This results in increased cost of construction. The solution for the above problem brings into the frame the use of mineral waste or by products as they are having a great potential to meet the growing demand and are also cost effective. Fly ash a waste byproduct obtained commonly from thermal power plants generally extracted by means of electrostatic/mechanical precipitator has been widely used in constructing highway embankments. Other than this it is also used in various other sectors such as cement manufacturing, brick making, mine filling, agricultural uses etc. One of the major reigons to bring fly ash in use in massive amount is to use it in embankment construction. This paper shows the results of both field and experimental investigation which was carried out to determine the suitability of using fly ash in a NH project as an embankment fill material and the cost which was incurred in constructing embankment using fly ash .Fly ash effect on compaction of soil used was also evaluated. The experimental results obtained showed that the increased percentage of fly ash led to an increased moisture content and a decreased maximum dry density of soil used. The field compaction test showed the better compaction of fly ash bed achieved.***

Keywords: ***California Bearing Ratio, embankment fill material, economical analysis, fly ash***

I. INTRODUCTION

With the growth in population and modernization the call for developing infrastructure has increased in a massive way. One such area is construction of highways. But highway construction requires an enormous amount of earth material which is not available in abundance near urban areas, so in order to counteract this problem and to meet the increasing demand use of waste material arising from any sector such as domestic, industrial and mining etc. in constructing highways is promoted. One such material is fly ash which is generally categorized as an industrial waste and is collected from the various thermal power plants situated across the country. This solid waste possesses potential to be incorporated as a filling material in national highway embankments. The term fly ash is used commonly as generic term to denote any type of coal ash. Coal generally used in India for generating electricity is a low grade coal having its ash content around 30-45% thereby producing large quantity of fly ash. As per Indian perspective present fly ash generation within the country is around 200 million tonne and by year 2031 it will be around 600 million tonne. Two important classes that are class C and class F fly ash has been classified by ASTMC- 618. Combustion of anthracite coal leads to the generation of fly ash which is categorized as Class F fly ash whereas that obtained from lignite combustion is of class C. Waste material disposal nowadays is becoming costly due to increased standards of safety and at the same time less area availability near urban areas. Using waste material beneficially decreases the large disposal area need and also provides the low cost construction resource. The environmental degradation caused by the use of top soil for constructing embankment is high. Moreover, the presence of many thermal power plants near urban areas provides an alternative that is environmentally preferable to natural borrow soil. This paper focuses on adopting fly ash as an embankment fill material in NH construction, its effect on compaction characteristics of soil and economy.

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II. MATERIALS AND METHODS

A. SOIL:

The earth material that is soil which is involved in constructing embankment in front of university gate no. 2 is borrowed from borrow pit situated at Salaura village on Morinda Ropar road.

Soil

Sr.No	Property Description	Value
1.	Gravel	0.2%
2.	Sand	96.8%
3.	Clay and Silt	3.0%
4.	Liquid Limit	23.81%
5.	Specific Gravity	2.68
6.	Coefficient Of Uniformity	2.88
7.	Coefficient Of Curvature	1.06
8.	IS Classification	Poorly Graded Sand

9.	Optimum Moisture Content	10.63%
10.	Maximum Dry Density	1.793 gm/cc

Table1. Earth material properties involved in experimentation

B. FLY ASH

For carrying out study fly ash was collected from project site near Chandigarh University. The source of fly ash is Thermal Power Plant situated at Ropar district of Punjab.

Fly Ash

Sr. No	Property Description	Value
1.	Colour	Grey
2.	Category	Class C
3.	Specific Gravity	2.11
4.	Liquid Limit	24.24%
5.	Optimum Moisture Content	28.26%
6.	Maximum Dry Density	1.195 gm/cc

Table2. Fly ash involved in experimentation properties

Sr. No	Compounds	Value
1.	SiO_2	40%
2.	Al_20_3	17%
3.	Fe_2O_3	06%
4.	CaO	24%
5.	MgO	05%
6.	SO_3	03%

Table3. Chemical compositions of class C fly ash [Source: Singh, G.Nitin and Kaur Navpreet (2015)]

III. TESTS AND RESULTS

The following tests were performed during the research work:

A. PARTICLE SIZE DISTRIBUTION:

Sieve analysis was carried out. A set of IS sieves was used for carrying out sieve analysis. The sample to be sieved was first oven dried and then placed on the top sieve and then shaken. The particles retaining on various sieves was observed and their weight was noted down

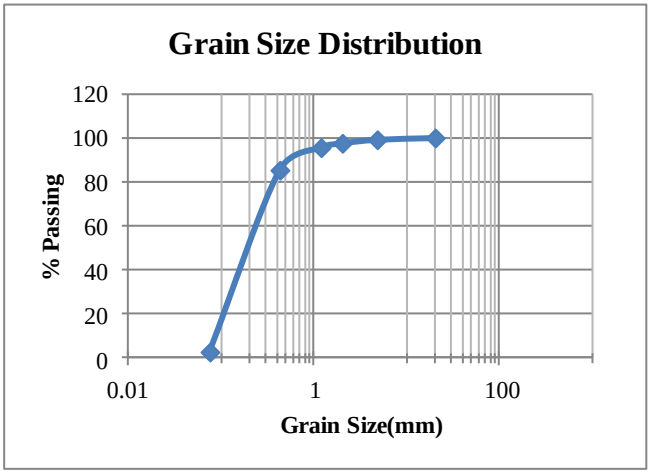

Figure1. Grain Size distribution of soil used for experimentation.

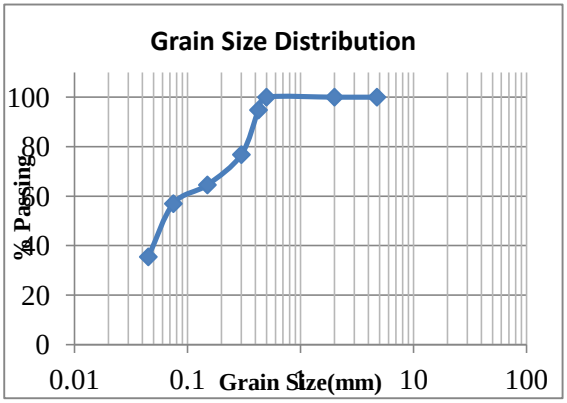

Figure2. Grain Size Distribution of fly ash used in experimentation

B. LIQUID LIMIT TEST:

Liquid limit test was performed and it was found that liquid limit of soil and that of fly ash was 23.81 and 24.23 respectively.

C. SPECIFIC GRAVITY TEST:

2.68 And 2.11 are the calculated values of soil and fly ash specific gravity respectively.

D. MODIFIED PROCTOR TEST:

The motive of the test was to determine optimum moisture content of a soil and its corresponding dry density as per IS: 2720(Part VIII). By changing a fixed percentage of soil by fly ash such as 2%, 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, 20%, 22% and 24% the test was performed again. It was observed that the soil mix containing high percentage of fly ash was requiring more water thereby increasing optimum moisture content and at the same time a downfall in its maximum dry density was observed.

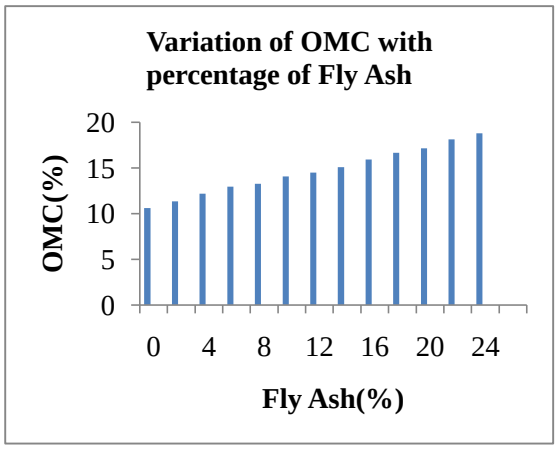

Figure3

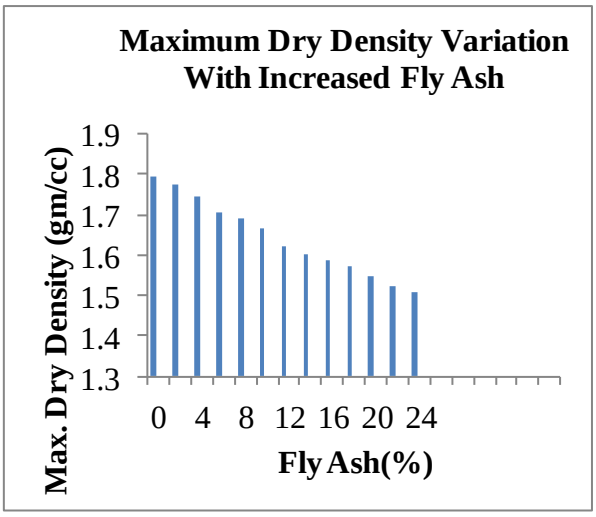

Figure4

E. SAND REPLACEMENT TEST:

Sand replacement test was performed on a 310 m long fly ash bed at chainage 14+750 to 15+060 as per IS 2720(Part28) to determine the field density using which compaction achieved was computed . It was observed that the average compaction achieved was 96.22% which is more than the minimum compaction required.

F . PERMEABILITY TEST:

Permeability test was performed on the fly ash sample using variable head method. It was found that the coefficient of permeability for the given fly ash sample was $1.60x10^{-9}$m/s.

G. CALIFORNIA BEARING RATIO TEST:

CBR of soil used was found to be 26.76% as per IS 2720(Part-16)-1987. The value obtained is within the required limits.

IV. ECONOMICAL ANALYSIS

The cost incurred in construction of embankment using fly ash was calculated considering three major costs involved i.e., material cost, equipment cost, manpower cost. All of these costs are then summed up to get the overall total cost involved in constructing the structure. The total cost (T) is the sum of material cost (M), equipment cost (E) and manpower cost (P).

T=M+E+P

Where, T = Total cost involved in constructing embankment.
M= Material cost including transportation charges.
E= Equipment cost/ Machinery cost.
P= Manpower cost involved for constructing embankment.

The volume of fly ash required for filling was calculated first by finding the average filling height and then multiplying this height with length and width of embankment. In present case the average filling height was 3.503m from chainage 14+750 to15+060 and the average filling height was3.684m from chainage 15+090 to 15+510.The length of embankment on one side is 310m and on the other side is 420m. The width of embankment in present case is 14.75m.This volume of fly ash used was multiplied by the transportation cost in order to get the total material cost. Transportation cost is included because the distance of plant from where fly ash is brought is around 37km from the construction site. Cost of equipment was calculated on the basis of market rate and duration of use. The total manpower cost was calculated on the basis of their salaries and wages given to them and duration. The total duration of embankment construction is 90 days.

In present case, the total volume of fly ash used=77572.01m^3
1 dumper brings around 18m^3 of compacted fly ash in one trip.

Therefore, total number of trips= Total used material Volume /Volume of material brought in 1 trip
=77572.01/18
=4310 trips.

Since Ropar is 37km from site location so the transportation cost will also be included in cost of material. Here, per trip cost=Rs. 3740

Since fly ash is a waste material so no cost is charged for its purchase except a yearly entry fee of Rs. 250 by the thermal plant authorities.

Therefore Total cost of fly ash becomes= (4310*3740) +250
=Rs. 16119650

Number of water tankers used in site= 2
Trips per day=9
Total number of trips=18
Cost of 1 trip =Rs.1200
Therefore cost of 1620 trips= Rs.1944000
Therefore total material cost=Rs.18063650

1 Fitter and 6 workers were present in construction site during the construction period.
Daily wages of fitter= Rs. 600
Daily wages of 1 worker= Rs.400
Total wages=Rs. (600x90) + (400x6x90)
Total wages=Rs. 270000

A site engineer and a supervisor were also present during the construction of embankment.
Salary of site engineer= Rs. 25000/month
Salary of supervisor= Rs.15000/month
Therefore total expenses on manpower during the construction of embankment was Rs. 390000

Now by adding all these expenses that is material, manpower and machinery cost the total cost of embankment construction in present case by using fly ash as a fill material was calculated and is found to be around Rs. 2.08 crores which

was quite acceptable in the present case.

Table4 shows the cost of machinery involved in embankment construction.

Sr.No	Machinery Used	Rate(Rs./month)	Total (Rs.)
1.	Grader	250000	750000
2.	JCB	180000	540000
3.	Baby Roller	65000	195000
4.	Vibratory Roller	100000	300000
5.	Hydra	100000	300000
6.	Carrier	100000	300000
7.	GRAND TOTAL		2385000

Table 4

V. CONCLUSION

Fly ash is generated in a massive amount every year as a waste product leading to many problems associated with it like its disposal, environmental problem. So its use in developing infrastructure such as highway construction should be promoted so as to reduce cost of construction as it is also available easily around the urban areas. The study shows that:

- Fly ash use in NH embankment construction in various NH projects stands to be a very good option as it possesses considerable properties which make it fit to be used as a fill material. Moreover a considerable reduction in construction cost of embankment by adopting fly ash as a fill material instead of earth material was observed.
- Filling material used in present case influences various properties of soil used in embankment construction which was studied experimentally. An increase in value of optimum moisture content of soil sample was seen with the increased amount of fly ash and at the same time fall in its maximum dry density was seen. Reason behind this is that soil-fly ash mix and soil have different specific gravity. Also capillary forces are found to be increased due to presence of fine particles (fly ash) developed as a result of addition of water.
- The sand replacement test done on the fly ash bed gave the field dry density. From this dry density the average compaction achieved was computed down and was observed as 96.22% which was as per the code requirement.
- The cost incurred in constructing embankment was around Rs.2.08 crores which was quite relevant according to the present rate of construction.

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