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

SANJAY KUMAR SHARMA, AMIT GOEL, AMANPREET TANGRI

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 regions 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 ASTM- 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.

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.

<table>
<thead>
<tr>
<th>Property Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>0.2%</td>
</tr>
<tr>
<td>Sand</td>
<td>96.8%</td>
</tr>
<tr>
<td>Clay and Silt</td>
<td>3.0%</td>
</tr>
<tr>
<td>Liquid Limit</td>
<td>23.81%</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>2.68</td>
</tr>
<tr>
<td>Coefficient Of Uniformity</td>
<td>2.88</td>
</tr>
<tr>
<td>Coefficient Of Curvature</td>
<td>1.06</td>
</tr>
</tbody>
</table>

Revised Manuscript Received on June 05, 2019
Sanjay Kumar Sharma, M.E. in Transportation Engineering, Chandigarh University, Mohali, India.
Dr. Amit Goel, Prof. Civil Engineering Department, Chandigarh University, Mohali, India.
Er. Amanpreet Tangri, Assistant Professor Civil Engineering Department, Chandigarh University, Mohali, India.

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication

Retrieval Number: H6599068819/190BEIESP
A Critical Study on Using Fly Ash in NH Project (Kharar-Ludhiana) As an Embankment Fill Material

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

Table1. Earth material properties involved in experimentation

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

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.

Table2. Fly ash involved in experimentation properties

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Compounds</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>SiO₂</td>
<td>40%</td>
</tr>
<tr>
<td>2.</td>
<td>Al₂O₃</td>
<td>17%</td>
</tr>
<tr>
<td>3.</td>
<td>Fe₂O₃</td>
<td>06%</td>
</tr>
<tr>
<td>4.</td>
<td>CaO</td>
<td>24%</td>
</tr>
<tr>
<td>5.</td>
<td>MgO</td>
<td>05%</td>
</tr>
<tr>
<td>6.</td>
<td>SO₃</td>
<td>03%</td>
</tr>
</tbody>
</table>

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.

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.
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 3.503 m from chainage 14+750 to 15+060 and the average filling height was 3.684 m from chainage 15+090 to 15+510. The length of embankment on one side is 310 m and on the other side is 420 m. The width of embankment in present case is 14.75 m. 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 37 km 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 = 77572.01 m³. 1 dumper brings around 18 m³ 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 37 km 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. (600×90) + (400×6×90)

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

Table 4 shows the cost of machinery involved in embankment construction.

<table>
<thead>
<tr>
<th>Sr.No</th>
<th>Machinery Used</th>
<th>Rate (Rs./month)</th>
<th>Total (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Grader</td>
<td>250000</td>
<td>750000</td>
</tr>
<tr>
<td>2.</td>
<td>JCB</td>
<td>180000</td>
<td>540000</td>
</tr>
<tr>
<td>3.</td>
<td>Baby Roller</td>
<td>65000</td>
<td>195000</td>
</tr>
<tr>
<td>4.</td>
<td>Vibratory Roller</td>
<td>100000</td>
<td>300000</td>
</tr>
<tr>
<td>5.</td>
<td>Hydra</td>
<td>100000</td>
<td>300000</td>
</tr>
<tr>
<td>6.</td>
<td>Carrier</td>
<td>100000</td>
<td>300000</td>
</tr>
<tr>
<td>7.</td>
<td>GRAND TOTAL</td>
<td></td>
<td>238500</td>
</tr>
</tbody>
</table>

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.

ACKNOWLEDGMENT
The authors are highly thankful to Ashoka Buildcon Limited, MAP Constructions and Department of Civil Engineering of Chandigarh University for supplying the material required for carrying out research work that is fly ash and soil, laboratory to carry out the experiments and also for their precious guidance during the entire period.

REFERENCES
15. IRC (2001), Guidelines for use of Fly Ash in Road Embankments. Indian Road Congress Special Publication 58

AUTHORS PROFILE
Sanjay Kumar Sharma is pursuing M.E. in Transportation Engineering from Chandigarh University, Gharuan, Mohali. India. He received his Bachelor’s Degree in Civil Engineering from H.P.T.U, Hamirpur, India. He received his Diploma in Civil Engineering from Govt. Polytechnic Banikhet, India.

Dr. Amit Goel is currently working as Prof. in Civil Engineering Department at Chandigarh University, Gharuan, Mohali, India.

Er. Amanpreet Tangri is currently working as Ass. Prof. in Civil Engineering Department at Chandigarh University, Gharuan, Mohali, India.