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ANALYSIS OF PAVEMENT DESIGN USING FLY ASH IN SUBGRADE SOIL

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ABSTRACT: Fly Ash is a type of industrial trash that is produced as a by-product of a thermal power plant. It's a non-reactive, inert particle that can float in the air for a few seconds to several months. There have been multiple researches conducted on the influence of fly ash on pavement construction. The objective of this study is to investigate how the load bearing capacity of soil changes when differing percentages of fly ash are added to the soil. The data was obtained from NTPC Badarpur. If the available soil is good in nature, we can easily create pavement; however, if the available soil is poor in nature, we can use Instead of an expensive route, fly ash can be considered as an alternative for improving soil condition. To begin, soil parameters were considered using different tests of soils, and then Atterberg Limits were estimated. On soil, a MPT (Modified Proctor Test) was used to determine the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD). A sample is compacted at OMC for the CBR test, and the results are assessed in percentages of 8%, 10%, 12%, and 13% based on the dry weight of the soil. To determine the load bearing capability of soil, CBR test is used in both wet and dry situations so that the pavement can endure even the worst conditions and the thickness of the pavement can be determined.

Key Words: Fly ash, CBR, MPT, Soil, OMC

1. INTRODUCTION

Thermal power facilities produce fly ash as a by-product. When powdered coal is burned, a major portion of it is transformed into fly ash, a fine powdered form. According to a survey report, In India, roughly ninety million tonnes of fly ash are produced each year, with just 13% of this being appropriately managed. It is abundantly available in areas near power plants, but due to poor management, it is rarely used. Most power plants are experiencing major disposal challenges as a result of a lack of dumping space. (Azan, Verma, Kumar, & Mukesh, 2020). The industrial waste product fly ash can be considered as an environmental pollutant. It is formed during the energy production by combustion of coal. Because of the environmental issues that fly ash poses, extensive research has been conducted on the subject all around the world. It is also a potential adsorbent for the discardation of various contaminants. The adsorption capacity of fly ash can be enhanced after chemical and physical activation. Fly ash was also discovered to have a lot of promise in the construction business. Ion exchange, molecular sieves, and adsorbents can all benefit from the conversion of fly ash into zeolites. Converting fly ash to zeolites solves the problem of disposal as well turns the waste product into a marketable commodity. (Fuel and Energy Abstracts, 2010). Fly ash is very useful. It can be utilised as a SCM (Supplementary cementitious material) in the manufacturing of Portland cement concrete. It can be applied in conjunction with Portland cement, as a supplementary cementitious ingredient contributing to the qualities (hardened concrete) by hydraulic activity. The heavier unburned material that settles at the bottom of the furnace, as a cementitious material that is not suitable for use for concrete, is bottom ash. It can also be used in the manufacturing of concrete masonry blocks. (Gali & Rao, 2018). By burning of pulverised coal in an electric generating facility, fly ash is produced. Stone dust from construction site crusher machines is an environmental threat. Stone dust disposal is a significant issue. The main objective of this work is to analyze the effectiveness of stone dust as a stabilising agent. The influence of stone dust on soil engineering qualities is investigated in an experimental study. The engineering properties that are taken into account were MDD, OMC, and CBR. (Mandal, Ramudu, & Sinha, 2018). Expansive soils cause a lot of structural damage in civil engineering, especially in low-rise structures. Clay minerals, which attract and absorb water, are common in these swelling soils. For their widespread usage in the building of highway/runway pavements, embankments, and other structures, some intrinsic features of these expansive soils must be modified. (Sharma)

The best combination for soil stabilisation varies greatly depending on the locality, kind of soil, and type of fly ash used. Fly ash utilisation in road construction has a lot of promise because the roads in Western Orissa are in bad shape and there are a lot of huge power plants going up in these areas. (Subbarao & Siddhartha, 2011. Furthermore, several studies have indicated that fly ash has a necessary function to play in the discipline of Civil Engineering. It's employed in a variety of applications in highway engineering, including pavement subgrade stabilisation, Portland cement concrete, asphalt filler, and many more. (Zorluer, 2017). Road pavements quality play an important role in the country's overall development, therefore the transport authority takes various maintenance measures to avoid safety hazards and traffic disturbance. However, most maintenance approaches are ineffective due to a lack of complete understanding of existing pavement conditions. We should take into account the road conditions and pavement design. By adding fly ash in the soil for pavement construction, it optimizes the cement required. The pavement can be constructed by less cement when fly ash is added to it. (lal, Alam, & Kiran, 2014). Because of the high overall cost of road construction, proper selection of locally accessible materials can be severely limited. If the local soil is not strong enough to support the wheel loads, soil stabilisation measures can help to enhance the engineering properties. A low-cost road always makes use of the materials that are readily available in the area. Because of the spherical silt size particles, it is useful in filling cavities in the soil mass, increasing the load bearing strength of the soil. It also has self-cementing qualities, making it an excellent soil stabiliser. (IRC, 2018)

2. METHODOLOGY

MATERIAL USED IN STUDY

2.1 SOIL

The soil which was used in this study was gathered from Karala , Delhi (where new has been constructed linking Rohini Helipad and Rohtak Highway) . Soil which was used in subgrade was the same as that of farmlands of that area (to reduce transportation cost) . Various laboratory experiments were performed (as per IS Code) to determine the basic properties of soil which were stated in Table-1 and picture of sample as figure-1 .

Properties	Values
Soil type as per IS : 1498-1970	SW
Specific Gravity	2.64
Liquid Limit (%)	25%
Plastic Limit (%)	14%
Plasticity Index (%)	7.5%
OMC	12.41%
MDD	2.007 kN/m^3
CBR value for unsoaked	12.84

Table 1 : Basic Properties of Soil

Fig 1 : Soil Sample (collected from Karala underconstrucion highway joining Rohtak Highway)

2.2 FLY ASH

Flyash which was used as a inert in testing is a waste residue product from Thermal Plants so its cost is almost negligible , so using flyash effectively in concrete mix for highway and subgrade mix for soil strengthening will be very economical and beneficial . Various laboratory experiments were performed (as per IS Code) to determine the basic properties of flyash which were stated in Table-2 and picture of sample as figure-2 .

Table 2 : Basic Properties of flyash

Properties	Values
Colour	Grey
Specific Gravity	1.98
% finer from 300 µ	97.3
% finer from 150 µ	78.9
% finer from 75 µ	46.5

Fig 2 : Fly ash sample

3. EXPERIMENTS CONDUCTED

Sieve analysis of particles of soil and fly ash is determined as per IS : 2720 (Part 4) - 1985 .

3.1 MODIFIED PROCTOR USED

On soil specimens, a modified Proctor or heavy compaction test was performed according to IS: 2720 (Part -8) 1983. The test is used to determine the relationship between the dry density of the soil and its water content. The compaction curves for the soil-fly ash mixture were obtained, and the OMC and MDD values are listed in Table. The OMC and MDD results produced from this test are then utilised in further tests.

3.2 CALIFORNIA BEARING RATIO TEST

IS: 2720 (Part 16) - 1987 was used to conduct CBR testing on soil-fly ash specimens in both unsoaked and wet circumstances. CBR is a crucial criterion for estimating overall thickness of construction above subgrade for pavement construction under various traffic circumstances. A laboratory test was carried out for varied settings to understand CBR fluctuations with different fly ash content. For wet conditions, the Indian Roads Congress recommends CBR. Pavement thickness has been determined using the received value and for a specific traffic condition using the chart provided by IRC:37- 2018 as shown in Table 5.

Figure 3: MPT TEST

Figure4: Testing Of Sample

4. RESULTS AND DISCUSSIONS

4.1 Grain size distribution

Sieve Analysis test was performed to study the properties of fly ash and soil as per IS 2720 - 1985. The results are shown below which are showing that the voids of soil are very effectively filled by fly ash as graph showing where high range of soil particles was not passing from sieve fly ash was passing easily which means fly ash will act as a goof filler material for this subgrade soil and enhance/increase the stability and strength of subgrade soil .

4.2 Compaction Results

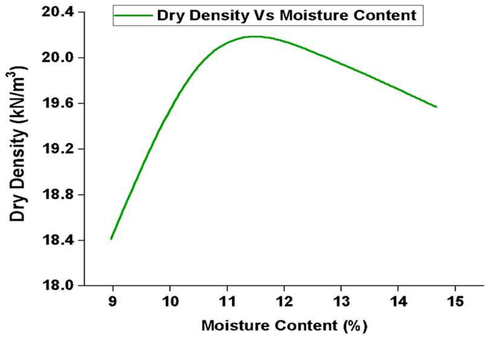

Fig. 6 : Moisture content-dry density curve for soil specimen

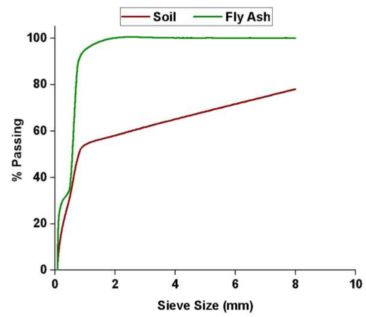

Figure 5 the void of soil

Table 3 : Thickness of pavement wrt different CBR %

Effective CBR (%)	Pavement Thickness (mm)
6	600
7.89	589.45
9.34	581.70
10.31	576.55
9.92	584.6

Table 4: OMC,MDD test results

Water Content (%)	Dry Density (kN/m3)
8.96	18.41
10.52	19.94
12.41	20.07
14.66	19.57

4.3 CBR Results

4.3.1 Unsoaked Condition

0% Fly Ash

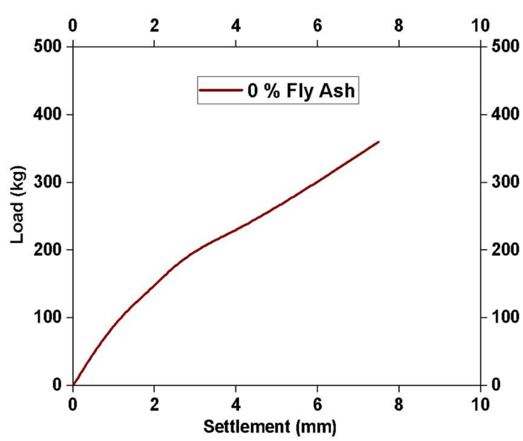

Fig. 7: Penetration curve for 0% fly ash

Combined CBR curve for unsoaked condition

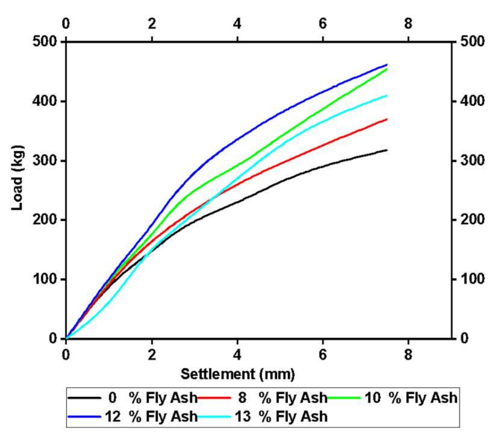

Fig 8 : Combined CBR curve for unsoaked condition of different proportion of fly ash

4.3.2 Soaked Condition

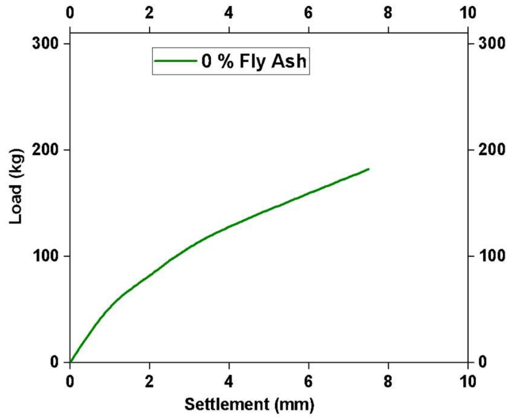

FIG. 9: Penetration curve for 0% fly ash

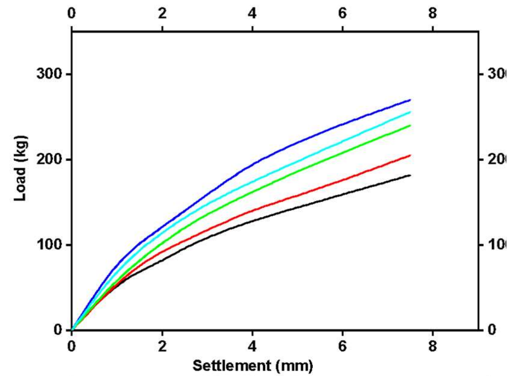

Fig 10: Combined CBR curve for soaked condition of different proportion of fly ash

Table 5: Comparative table of CBR Value for Unsoaked and Soaked Conditions

Fly Ash Content (%)	CBR Value (%)	
	Unsoaked Condition	Soaked Condition
0	12.85	6.01
8	14.06	7.89
10	15.91	9.34
12	17.81	10.31
13	14.50	9.92

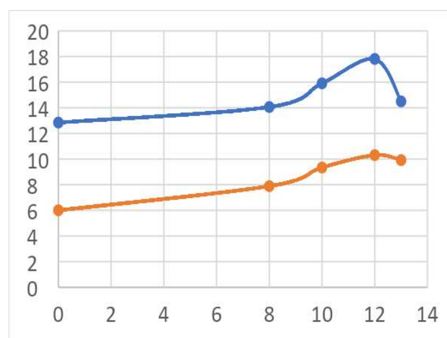

Figure 11: Combined CBR curves

Pavement is designed with respect to different CBR% as per IRC 37 - 2018 , where different kinds of pavement thickness are given using different materials for different CBR% and different traffic flow .Here , traffic assumed was 30msa .Pavement contains of a bituminous surface course with granular base and sub-base.In this design surface course (40mm) , WMM(250mm) , GSB(200mm) remains the same , only Base / Binder Course decreases from 110mm to 86.45mm by addition of 12% FA in subgrade soil .

5. CONCLUSION

From the tests and figures we have conclude the following :

1.According to the graphs, adding Fly ash to our soil sample increases the CBR value to 17.81 percent, which is 1.38 times the CBR value of the soil sample obtained in the unsoaked condition, and to 10.31 percent, which is 1.71 times the CBR value of the soil sample taken in the soaked state.

2. For a dry condition -The CBR value is observed to be increasing when the percentage of fly ash is increased from 0% to 12%. The CBR value decreases as the amount of fly ash added to the soil exceeds 12%.

3. In a wet state -The CBR value is observed to be increasing when the percentage of fly ash is increased from 0% to 12%. CBR is used when the amount of fly ash added to the soil exceeds 12 percent.

4. Because there is a lack of efficient fly ash management and disposal is also a concern, soil stabilisation with fly ash is one of the most environmentally friendly and cost-effective disposal techniques.

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