DESIGN OF RIGID PAVEMENT BY USING FLY ASH AS A STABILIZING MATERIAL

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Abstract:

This abstract focuses on the behavior of Fly ash as a stabilizing material in Rigid pavement design. Fly ash is the waste material, which is obtained after burning coal in thermal power plants.
The usage of fly ash as a stabilizing material reduces the quantity of lime in lime fly ash by the effective use of fly ash itself. Some percentage of fly ash without any additive was utilized to reduce the construction cost, which is a good disposal method.
If the locally available soil is good in nature pavement construction becomes easier and cheaper. But if the soil is weak instead of going for an alternative, which costs more the available soil can be modified by adding this type of stabilization which involves low cost.
Expansive soil treated with varying percentages of fly ash, 0, 5, 10, 15, and 20 percent combined. Consistency limits, compaction, and California Bearing Ratio will be conducted on treated and untreated soils.
Keywords: cement, fly ash, expansive soil, improvement, stability, subgrade, consistency limit, California bearing ratio, compaction, swell potential.

1.0 INTRODUCTION

Stabilization is the process of blending and mixing materials with soil to improve certain properties of the soil. The process may include the blending of soils to achieve a desired gradation or the mixing of commercially available additives that may alter the gradation, texture, or plasticity, or act as a binder for the cementation of the soil.
Protocols used by the road-building industry keep evolving and are updated due to several factors:
a. Advances in pavement design
b. More sophisticated testing to evaluate engineering properties more accurately
c. Introduction to new design technologies. Material quality in the top layers of the pavement is of the highest quality and this is to produce the most cost-effective flexible road pavement. New innovative designs are encouraged to use materials and modify them if necessary to obtain the most cost-effective road pavement. The use of recycled products and waste plays an important role in ways to produce effective ways for cost-effectiveness and to suit the advances in pavement design and new design technologies. New protocols are developed that would encourage the use of various new designs for an effective greener future.

Fly Ash is a by-product as a result of burning coal at thermal power stations, moreover known as residues of fine particles that rise with flue gases. Fly Ash solidifies while suspended in exhaust gases and is collected by electrostatic precipitators or filter bags.

Rigid payments are those that possess noteworthy flexural strength or flexural rigidity the reject pavements are generally made up of Portland cement concrete (CC) and are called CC pavements. Plain Cement concrete payment slaps made of specified strength characteristics are laid with or without steel reinforcement at the joints.

Rigid Pavement:

Rigid pavements have sufficient flexural strength to transmit the wheel load stresses to a wider area below. Compared to flexible pavement, rigid pavements are placed either directly on the prepared subgrade or on a single layer of granular or stabilized material. Since there is only one layer of material between the concrete and the sub-grade, this layer can be called a base or sub-base course in the rigid pavement, the load is distributed by the slab action, and the pavement behaves like an elastic plate resting on viscous medium Rigid pavements are constructed by Portland cement concrete (PCC) and should be analyzed by plate theory instead of layer theory, assuming an elastic plate resting on the viscous foundation.

Rigid Pavement advantages

- Deformation in the sub-grade is not transferred to subsequent layers
- Design is based on flexural strength or slab action
- Rigid pavement carries high flexural strength
- No such phenomenon of grain-to-grain load transfer exists
- Have low repairing cost but completion cost is high

2.0 LITERATURE REVIEW:

1. Kang et al., 2015;

Found that fly ash substantially reduces the swelling and shrinkage of various clay types. The mechanism of chemical stabilization occurs mainly by cation exchange, flocculation, pozzolanic reaction, and carbon cementation. The micro level and chemical processes of fly ash-stabilized soils have been studied using scanning electron microscopy

1. **S.K. Kaushik (2017)**

Discussed the quality of Indian fly ashes in general and the parameters involved in the production of ternary blend concretes with high fly ash contents. Experimental test results of the authors for a high slump 80-90 Mpa strength concrete with low calcium fly ash contents almost equal to those of cement are discussed—flow ability addition, pore refinement, and strengthening effects due to fly ash. Developments of poly carboxylate-based superplasticizers have helped in achieving Flow ability with low water-binder ratio concretes containing high volumes of fly ash.

2. N.P. Rajamane, J. Annie Peter and S. Gopala Krishna (2019)

Investigated concrete with 2days compressive strengths of about 85 Mpa and 105 Mpa were taken and a cement replacement level (CRL) of about 25 % was considered; these concretes were blended with both GGBS and silica fume keeping the total CRL at 25 %. The 90-day compressive strength of 94 to 116 Mpa was achieved. The use of Pozzolanas such as Ground Granulated Blast Furnace Slag (GGBS) and silica fume (SF) in cement concrete, individually as mineral admixture (MA).

3. **M.M. Prasad (2019)**

They investigated the effect of 17%, 22%, 27%, and 32% cement replacement by fly ash and silica fume on conventional M20 grade concrete. M20 grade of concrete has been considered as a reference mix. Specimens are cast and cured normally for 28 days and then tested for flexural strength and split tensile strength to failure as per IS specifications and the results have been compared.

4. Tang et al., 2018;

In pavement construction, the subgrade is natural soil/compacted soil on which other layers are placed. The subgrade functions as a foundation for the pavement, and poor subgrade soil conditions reduce a pavement's lifetime, especially if the subgrade contains expansive clay. Expansive clays contain various expansive minerals such as montmorillonite, smectite, and bentonite. Due to global climate change, the frequent occurrence of extreme drought and increased global warming cause volumetric shrinkage in expansive clays. This soil shrinkage during the drying period degrades the mechanical and hydraulic properties of the soils, resulting in the progressive formation of cracks

5. Yang et al., 2020;

Cement and lime are commonly used as chemical stabilizers to stabilize expansive clays. However, some road authorities are reluctant to invest in geosynthetics and traditional stabilizers such as cement and lime for soil treatment due to budget constraints. Furthermore, the production of cement generates about 7% of the world's carbon dioxide

6. Yuan et al., 2022;

Investigated the applicability of locally available materials for use as subgrade/base materials, including by-products and wastes such as fly ash, cement kiln dust, marble dust, risk husk ash, bottom ash, waste red mud, Ground Granulated Blast-Furnace Slag (GGBS) and construction and demolition waste

3.0 METHODOLOGY:

The following experimental program was made to find out the Properties of soil

1. Determination of Water Content
2. Determination of Specific gravity by Pycnometer
3. Determination of Liquid Limit
4. Determination of Plastic Limit
5. Determination of Compaction
6. Determination of Shear Parameters
7. California Bearing Ratio

1. LIQUID LIMIT

2. PROCTOR'SCOMPACTION

Design Procedure of Rigid Pavement

The first Sub-base: Where the traffic is light and pavement is designed for a wheel load of 30KN, the thickness of the sub-base may be reduced to 75 mm. The WBM and granular sub-base surface is finished smoothly. Provide a 75 mm thick W.B.M.

(IRC: SP 62-2004) Effective K value= 1.2×33.32×10-3 = 39.98×10-3N/mm3 = 40×10-3N/mm3

Thickness Critical Stress Condition: Concrete pavements in service are subjected to stresses due to a variety of factors, acting simultaneously. The factors commonly considered for the design of pavement thickness are traffic loads and temperature variations.

Temperature stress = Δt =17.30C, for 150 mm thickness road is of single lane so, in single lane road there is no need of longitudinal joint Assuming contraction joint spacing of 3.75m and 3.75m width, the radius of relative stiffness of 'l' is as under. L=3750mm, B=3750mm

Design Charts (Fig 1of part-I) give ready–to–use design charts for calculations of load stress in the edge and of rigid pavement slabs for a wheel load of 30 KN.

(IRC: SP: 62-2004)

For K= 40×10-3 N/mm3

Where, K=0.04 N/mm3,

Thickness =150mm (from Fig 1 of part I)

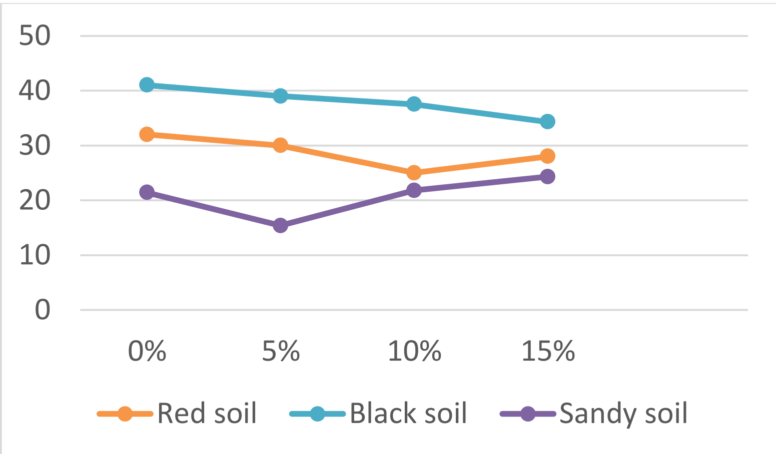
Edge load stress = 5.1Mpa

DESIGNED RIGID PAVEMENT

4.0 RESULTS AND DISCUSSIONS

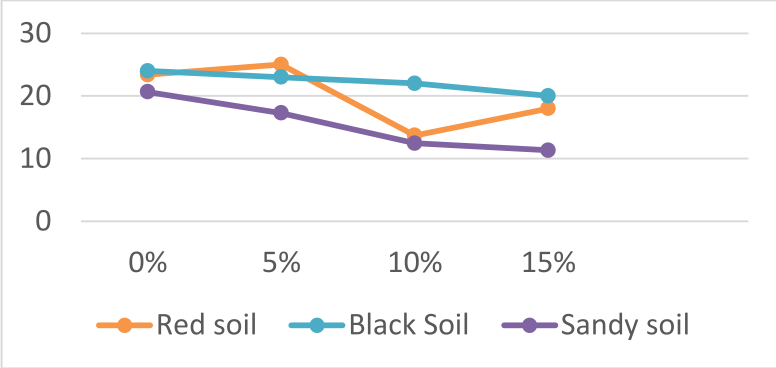
1. Liquid Limit Test

Percentage of Fly ash	Liquid Limit in percentage
0	32
5	30
10	25
15	27



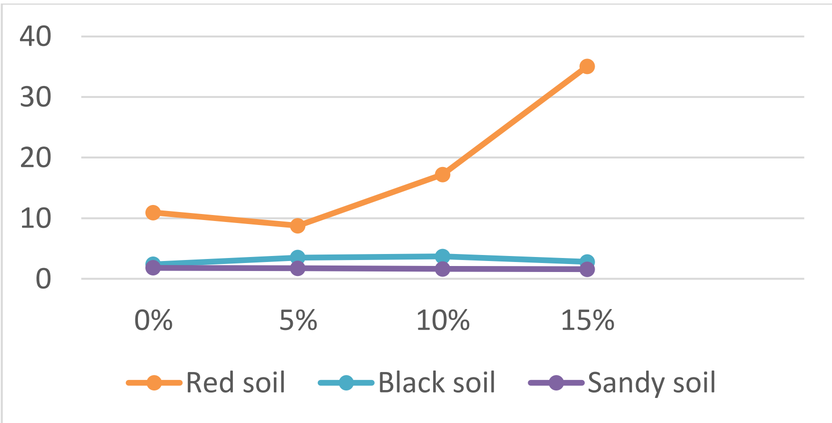
Percentage of Fly ash	Plastic Limit in Percentage
0	23.37
5	25
10	13.7
15	18

2. Plastic Limit Test



3. Proctors' compaction Test

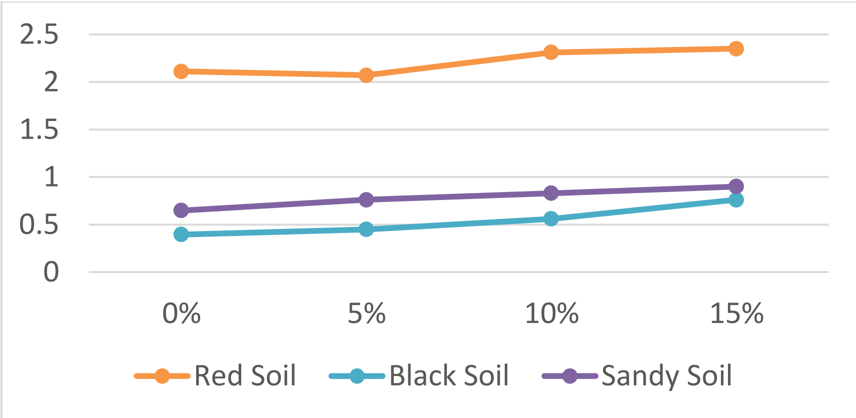
Percentage of Fly Ash	Bearing capacity (kg/mm2)
0	10.93
5	8.75
10	17.2
15	35.06



4. Direct shear Test

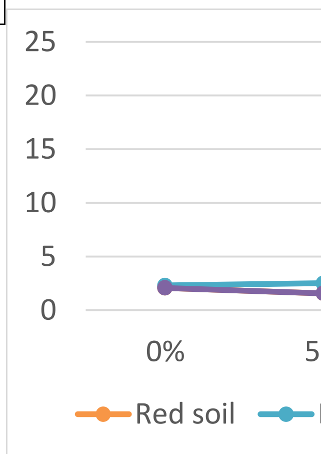
Percentage of Fly ash	Maximum dry density (Kg/m3)
0	2.11
5	2.07
10	2.31

15	2.35



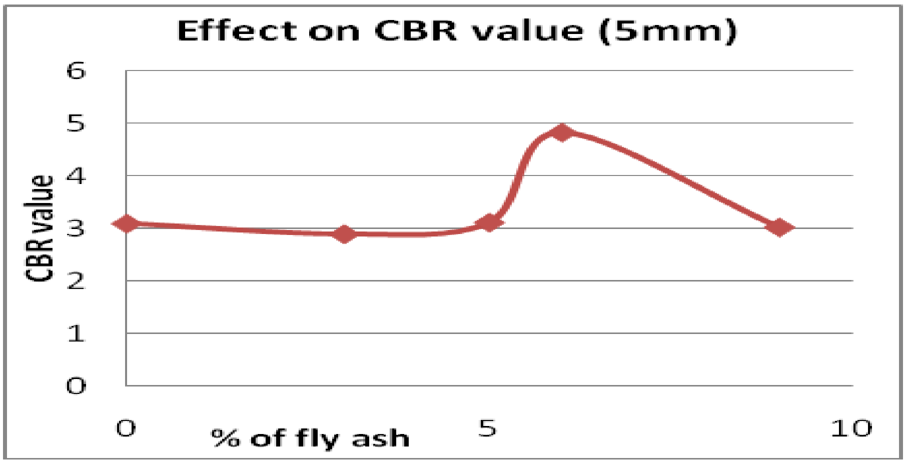
5. California Bearing Test

Percentage of Fly ash	Penetration at 2.5mm
0	2.08
5	1.56
10	1.51
15	3.75



Percentage of Fly ash	Penetration at 5mm
0	3.1
5	2.9
10	3.12

15	4.82



CONCLUSION:

1. From the results of the present study, it is concluded that soil stabilization using fly ash is a very effective process for the strengthening of soil. During comparison, the red soil obtains maximum strength i.e. 6.5 Mpa (up to 20% after stabilizing). Since fly ash are low-cost material, it obtains high strength and makes the structure strong and durable.
2. The Liquid limit, Plastic limit, compaction, CBR, and direct shear test have been conducted in various soils such as clay soil, alluvial soil, and red soil among these, the red soil has the best results and it can be used to strengthen the building and roads. Due to the stabilization of the soil, the bearing capacity of the soil gets increasing and any foundation can be constructed in the soil.
3. Compared to the Standard Specifications the Best Results were Obtained for the red soil and sandy soil.
4. The CBR value of borrowed red soil is 3.1. From the design curve in „A" type traffic, pavement thickness for cores flying soil is 12 inches.
5. The CBR value of stabilized soil is 4.82. Pavement thickness torrefying to this value is 8.5 inches.

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