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EXPERIMENTAL INVESTIGATION, ON HIGH EXPENSIVE BLACK COTTION SOIL BY USING PHOSPHOGYSPUM, LIME AND FLY ASH"

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Abstract:-Sustainable production and consumption, leading to increased resource efficiency, is now high on the political agenda. Various alternatives are developed inform of advanced materials and waste utilization for resource intensive activities such as the construction of infrastructure including highways. The range of materials incorporated includes recycled asphalt, recycled concrete, ashes, slags, foundry sand, glass, plastic, rubber and other chemicals. Feasibility studies concerning the potential for the use of these materials are plentiful and some studies exist which have considered the engineering as well as environmental credentials of such practices. This particular study summarizes work conducted to date and investigates the engineering as well performance of Fly ash Lime& Phosphogyspum to replace conventional materials in non-bituminous layers of flexible pavement. To study behavior of Fly ash, Lime & Phosphogyspum with Black cotton soil; samples are collected from surrounding area of Uttar Pradesh region (Jhansi, mahoba, Hamirpur, Lalitpur) and experimental works carried out for evaluation of Fly ash, Lime & Phosphogyspum. The study for soil characteristics, Free Swell Index, Standard Proctor Test, Specific Gravity, CBR and UCS are conducted for natural and treated soil samples.

Keywords: Experimental Investigation , Black Cottion Soil ,Phosphogyspum , political agenda.

INTRODUCTION

Roads are having different layers which provide strength for sustaining the heavy loads due to vehicular movement. Among these, Sub-grade is the most important one as it provides support to all the above layers. Sub grade is nothing but the natural soil and different types of soil are having different properties. If Sub grade soil has poor properties, it needs modification or stabilization to improve its properties. Soil stabilization is a process of treating a soil in such a manner as to maintain, alter or improve the performance of the soil as a construction material. The changes in the soil properties are brought about either by incorporation of additives or by mechanical blending of different soil types. Soil stabilization, in the broadest sense it is the alteration of any inherent property of a soil to improve its engineering performance. Improvement of stability or bearing power, density, shear parameter, reduce compressibility, permeability, swelling and shrinkage property by the use of controlled compaction, proportioning and/ or the addition of suitable admixtures or stabilizers. Along with improvement in engineering properties of soil, the stabilization is also used to achieve economy in terms of cost by reducing thickness of different layers of pavement. The project can be made more economically viable by using particular stabilization technique for a particular type of soil. For soil having higher Subgrade strength, sometimes people use stabilization technique in base and sub-base layers also to reduce the layer thickness which helps to reduce cost.The growth in industrial activities continued to produce huge quantities of wastes and by products such as fly ash, slag, waste plastic, scrap tires, slate and marble wastes, etc. Technological innovations like use of enzymes, copper slag, steel slag, lime, fly ash, waste plastics, blended bitumen, composite pavement technique etc. can be gainfully tried for cost-effective road construction. The locally occurring materials like soil, gravel, moored, late rite, sand, and emerging materials like mine waste, industrial slag like copper slag, steel slag, cement kiln dust, fly ash, do lime, jute geo-textile, soil-enzymes, etc. can be effectively used singly or in combination with other materials as an alternative to conventional materials, with significant economy after studying their physical and engineering properties for their suitability in road construction. Studies have revealed that substantial economy to the tune of 20% and more can be achieved by using these materials and by introducing innovative technologies.

SOIL STABILIZATION MATERIAL

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The waste material are fly ash ,lime, Phosphogyspum, Waste tyres used engine oil which are the industrial waste material posing problems in the disposal & being deposited near the industries in India. The waste material are very use full for highway engineers to design road pavement .

Following waste materials to use in research paper:

1)Fly ash
2)Phosphogypsum
3)Lime

1)Fly ash

Fly ash is a waste by product from Thermal power plants which use coal as fuel. Generally, fly ash can be classified as Class-C fly ash and Class-F fly ash. This classification is based on the percentage of calcium oxide available in fly ash. At present about 100 Thermal power plants in India produce about 130million tonnes of fly ash because of issues associated with its disposal and utilization but also because of threat to public health and Ecology. Some percentage of Fly ash without any additives was utilized so as to reduce the cost of construction and this is a good method for disposal of it. Initially the index properties of the soil were studied by conducting liquid limit, plastic limit, shrinkage limit, grain size analysis and specific gravity tests. CBR, OMC and swell index tests confirmed that the soil had taken was clay which is highly expansive in nature.

TABLE 1
CHEMICAL PROPERTIES OF FLY ASH (CLASS F)

Sr. No.	Parameters	Percentage (%)
1	Silicon oxide	32 - 35
2	Aluminium oxide	17 - 21
3	Iron oxide	5 - 6.5
4	Sulphur trioxide	1.5 - 2
5	Calcium oxide	26 - 29
6	Loss on Ignition	0.2 - 0.80

TABLE 2
PHYSICAL PROPERTIES OF FLY ASH (CLASS F)

Sr. No.	Parameters	Percentage (%)
1	Finesse	12 - 20
2	Soundness(Autoclave Expansion)	0.04 - 0.17
3	Drying shrinkage(at 28 days)	0.01- 0.02
4	Density	2.55 - 2.70

2)Phosphogyspum

Phosphogyspum is the by-product of phosphoric acid industry, consists of CaSO4.2 H2O and contains some impurities such as Phosphorus pent oxide (P2O5), F and organic substances. These impurities seriously restrict the industrial use of Phosphogyspum in cement industry as aretarder. The effects of Phosphogyspum and purified Phosphogyspum on the hydration of Portland cement and puzzolana cement were investigated by measuring setting time, strengths of pastes, and chemical analysis as well as the electron microscopic (SEM) observation of the hydration products. It was concluded that untreated Phosphogyspum can be used as a retarder directly in cement, whereas Portland cement requires purified Phosphogyspum.

Gypsum is a very soft sulphate mineral composed of calcium sulphate dehydrate, with the chemical formula CaSO4•2H2O. It can be used as a fertilizer, is the main constituent in many forms of plaster and is widely mined. Gypsum is the most common sulphate mineral and is usually found within evaporate sequences or associated with calcareous sedimentary deposits.

Phosphogyspum is being collected from the Birla copper Ltd, Bharuch of required quantity.The following table 2.6 & 2.7 shows the chemical & physical properties of Phosphogyspum.

TABLE 3
CHEMICAL PROPERTIES OF PHOSPHOGYSPUM

Sr. No.	Parameters	Percentage (%)
1	Calcium oxide (Cao)	40 – 43
2	Silica(sio_2)	1 - 3
3	Alumina (Al_2o_3)	1.5 – 3
4	Fe_2O_3	0.05 – 1.0
5	Magnesium oxide Mgo	0.01 0.05
6	Sulphate trioxide So_3	48 – 51

TABLE 4
PHYSICAL PROPERTIES OF PHOSPHOGYSPUM

Sr. No.	Parameters	Percentage
1	Hardness	2
2	Density	2.30 -2.45
3	Specific gravity	2.31 -2.33

3) Lime

A General term for burned (or claimed) limestone, also known as quicklime, hydrated lime, and Unslaked or slaked lime. Its predominant usage (90%) is as a basic industrial chemical. It still enjoys its traditional building uses.

it is manufactured from a mineral limestone, coral, oyster shell, all being sources of calcium carbonate. Lime is being collected from the local resources available nearby study area. The following table 2.8 & 2.9 shows the chemical & physical properties of Lime.

TABLE 5
CHEMICAL PROPERTIES OF LIME

Sr. No.	Parameters	Percentage (%)
1	Calcium oxide (Cao)	38 – 42
2	Silica(sio2)	20 – 25
3	Alumina (Al2O3)	2 – 4
4	Other oxides (Na, Mg)	1.5 – 2.5
5	Loss on ignition	30 – 32

TABLE 6
PHYSICAL PROPERTIES OF LIME

Sr.No.	Parameters	Percentage
1	Hardness	3 - 4
2	Density	2.5 - 2.65(%)
3	Compressive Strength	1800-2100 kg/sq.cm
4	Water absorption	>1%

III. EXPERIMENTAL ANALYSIS

To study the behaviour and classification of soil the following tests were conducted

1.Grain size Analysis test(wet sieve & dry sieve analysis)
2.Specific Gravity test
3.Unconfined compressive strength test

4.California Bearing Ratio

TABLE7
TEST MIX PROPORTIONS

Sr. No	M ix proportions
1	SOIL+25% FA+ 0%L + 0%PG
2	SOIL+25% FA+ 3%L + 0%PG
3	SOIL+25% FA+ 6%L + 0%PG
4	SOIL+25% FA+ 9%L + 0%PG
5	SOIL+25% FA+ 0%L + 0.3%PG
6	SOIL+25% FA+ 3%L + 0.3%PG
7	SOIL+25% FA+ 6%L + 0.3%PG
8	SOIL+25% FA+ 9%L + 0.3%PG

In above table gives the mix proportion for use in research paper to find out the strength and stability of black cotton soil.

(1) Grain size Analysis test(wet sieve & dry sieve analysis)

The grain size analysis is widely used in classification of soils. The data obtained from grain size distribution curves is used to determine suitability of soil for road construction. Information obtained from grain size analysis can be used to predict soil water movement. These tests are widely used in the preliminary stages of road to ensure that the soil will have the correct amount of shear strength and not too much change in volume as it expands and shrinks with different moisture contents. The knowledge of the soil consistency is important in defining or classifying a soil type or predicting soil performance when used a construction material.

TABLE 8
RESULTS OF GRAIN SIZE DISTRIBUTION

Sieve Size (mm)	Black cottion soil (%)
Gravel (>4.75)	66
Coarse Sand (4.75 – 2.0)	86
Medium Sand (2.0 – 0.425))	90
Fine Sand (0.425 – 0.075)	92
Silt& Clay (<0.002)	94

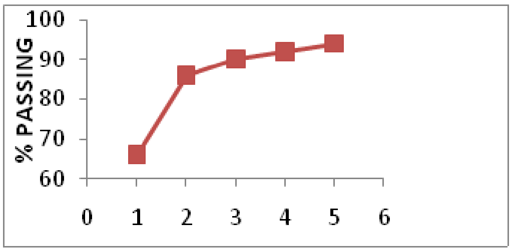

Fig. 1 Particle Size Distribution of Soil

2) Specific Gravity Test

The Specific Gravity of solid particles can be determined in a laboratory using density bottle fitted with a stopper having a hole .The density bottle of 50ml capacity is generally used [IS:2720(Part II) 1980].The density bottle is cleaned and at a temperature of 1050 to 1100 and cooled .The mass of the bottle ,including that of stopper is taken .

G = M2-M1/(M1-M2)-(M3-M4)
M1 =Mass of empty bottle
M2 =Mass of bottle and dry soil
M3 = Mass of bottle and dry soil, Water
M4 = Mass of bottle filled with water

3) California bearing ratio (CBR)

The California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of road Sub-grade and base courses. It is the ratio expressed in percentage of force per unit area required to penetrate a soil mass with a circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material. The CBR value of a soil can be considered to be an index which in some fashion is related to its strength. The value is highly dependent on the condition of the material at the time of testing.

For the study, CBR value of the soil is determined according to IS 2720 (Part 16) – 1987 (Laboratory Determination of CBR). The procedure for CBR test is adopted as per IS 2720 (Part16).The test mould has internal dimensions of 150 mm diameter and 175 mm height. The mould has a detachable perforated base. This perforated base can be fitted either at top or bottom. When filling the mould with soil, a disc 50 mm deep and 148 mm diameter is kept at the bottom and then the compaction is commenced. The material is compacted at optimum moisture content in five layers of approximately equal mass, each layer being given 55 blows from the 2.6 kg rammer dropped from a height of 310 mm above the soil.

TABLE 9
RESULTS OF CALIFORNIA BEARING RATIO TEST

Sr.No.	**MIX Proportions**	**Percentage**
1	SOIL+25%FA+0%L+0%PG	3.2
2	SOIL+25%FA+3%L+0%PG	3.8
3	SOIL+25%FA+6%L+0%PG	3.9
4	SOIL+25%FA+9%L+0%PG	4.6

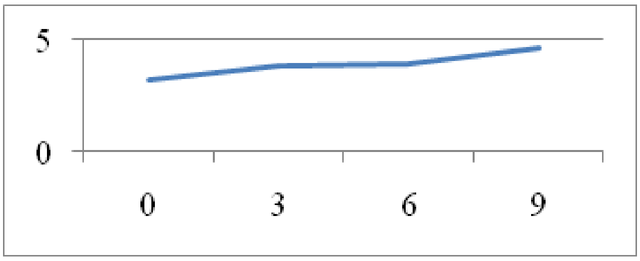

Fig. 2 Results of California Bearing Ratio Test (0% PG)

TABLE 10
RESULTS OF CALIFORNIA BEARING RATIO TEST

Sr. No.	MIX Proportions	Percentage
1	SOIL+25%FA+0%L+0.3%PG	4.6
2	SOIL+25%FA+3%L+0.3%PG	5.4
3	SOIL+25%FA+6%L+0.3%PG	6.2
4	SOIL+25%FA+9%L+0.3%PG	8.2

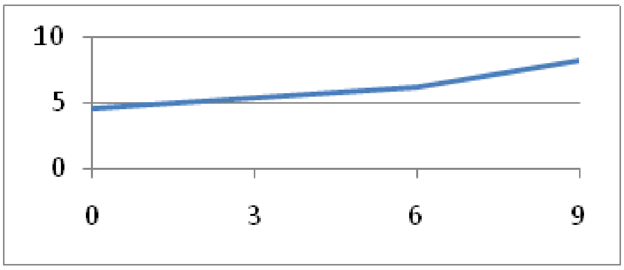

Fig. 3 Results of California Bearing Ratio Test (0.3% PG)

4) Unconfined Compressive Strength

The primary purpose of this test is to determine the unconfined compressive strength, which is then used to calculate the unconsolidated undrained shear strength of the clay under unconfined conditions. The unconfined compressive strength is defined as the compressive stress at which an unconfined cylindrical specimen of soil will fail in a simple compression test. The table 4.6 shows the result of UCS. Fig 4.7 shows UCS results with different mix proportions.

TABLE 11
RESULTS OF UCS TEST

Sr. No	MIX Proportions	MPa
1	SOIL+25%FA+0%L+0%PG	1.77
2	SOIL+25%FA+3%L+0%PG	1.89
3	SOIL+25%FA+6%L+0%PG	1.95
4	SOIL+25%FA+9%L+0%PG	2.09

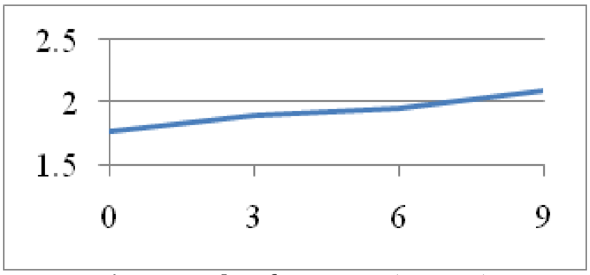

Fig. 4 Results of UCS test (0% PG)

TABLE 12
RESULTS OF UCS TEST

Sr. No	MIX Proportions	MPa
1	SOIL+25%FA+0%L+0.3%PG	2.18
2	SOIL+25%FA+3%L+0.3%PG	2.30
3	SOIL+25%FA+6%L+0.3%PG	2.36
4	SOIL+25%FA+9%L+0.3%PG	2.59

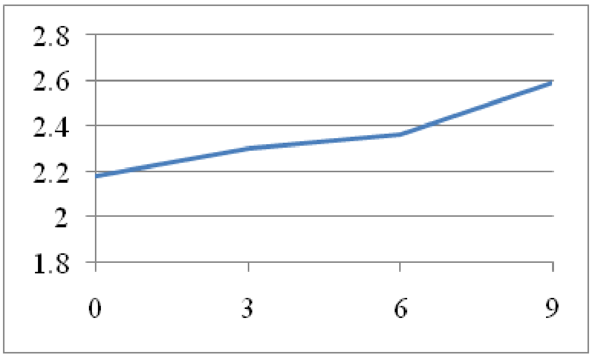

Fig. 5 Results of UCS test (0.3% PG)

CONCLUSION

This research work has uncovered the potentiality of Phosphogyspum, Fly ash & Lime as an effective road construction material. The study has focussed on finding the suitable application of Phosphogyspum, Fly ash & Lime in the non-bituminous layers of the flexible pavement based on the geotechnical characterization of mix comprising Phosphogyspum, Fly ash & Lime and soils. Black cotton soil was considered for the study purpose. The most probable laboratory investigations required to be performed and material specifications needed in order to explore its suitability were identified via a thorough literature review and available technical know-how.

For highway construction and maintenance world over including India, millions of tons of mineral aggregates are used. It is a well known fact that the naturally occurring materials are fast depleting because of their over-exploitation to meet the huge demand for construction of infrastructure projects. Fly ash, Lime, Phosphogyspum (waste material) has been successfully used in the road construction industry. The benefits from Waste material in the highway construction practices are manifold, as listed here:

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