Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 1, No. 1, January : 2024

A STUDY ON HIGH EXPENSIVE BLACK COTTON SOIL TO FIND OUT THE PROPERTIES WITH THE HELP OF MIXING OTHER SOIL STABILISING MATERIAL

Mr.Shelendra Kumar, Email-shelendrace11hcst@gmail.com, Assistant Professor, Dept. of Civil Engg.IIMT College Of Engineering,Gr Noida
Mr.Harendra Singh Bhati, Email-**harrybhati1993**@gmail.com **,**Assistant Professor, Dept. of Civil Engg.IIMT College Of Engineering,Gr Noida
Mr Rishiv Kr Ray,Mr.Rakesh kumar, Dept.of civil.IIMT College of Engg.

Abstract
In this research paper we study the behaviour of Fly ash, Lime & Phosphogypsum with Black cotton soil. The samples are collected from Jhansi,Mahoba,Hamirpur,Lalitpur and experimental works carried out for evaluation of Fly ash, Lime & Phosphogypsum. The study for soil characteristics, Free Swell Index, Standard Proctor Test, Specific Gravity, CBR and UCS are conducted for natural and treated soil samples. Following the relevant established standards, geotechnical investigations and stability analysis was undertaken for characterization of the materials and exploring their feasibility in respective pavement layers.. The Soak CBR for CH type of soil earlier is 3.1% which improves about 16.5% With Fly ash, Lime & Phosphogypsum Treatment. UCS Value with CH type of soil earlier is 1.5 Mpa which improves to 5.1 Mpa with Fly ash, Lime & Phosphogypsum .

Key Words: UCS,Atterberg Limit,FSI

Introduction

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. 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 geotextile, 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.

Potential uses of waste materials:

As per the past studies, there are many research works have been carried out with the utilization of waste materials in pavement construction here below in table 1 listed the possible usage of different waste materials
Addition to these waste materials Phosphogypsum have also found successful application in road construction history.

Table 1 Potential Uses Of Waste Materials

Waste Product	Possible Usage
Fly Ash	Bulk fill, filler in bituminous mix, artificial aggregates

Blast Furnace Slag	Base/Sub-base material, binder in soil stabilization
Construction & demolition waste	Base/Sub-base material, bulk fill, recycling
Colliery spoil	Bulk fill
Spent oil shale	Bulk fill
Foundry sands	Bulk fill, filler for concrete, crack relief layer
Mill tailings	Granular base/sub-base, aggregates in bituminous mix, bulk fill

Material use for research:

Soil: Some Uttar Pradesh District (Jhansi, Mahoba Hmairpur, Lalitpur). All Districts they have mainly Black cotton soil. The property of volumetric changes with the change of atmospheric conditions makes black cotton soil dangerous to be founded in Highway pavement.

Demerits of Black Cotton soil

This soil contains fine clay particles. This property induces a great affinity to water of such type of soil. Alternate swelling and shrinkage in extensive limit during wet and dry process respectively results cracks in soil without any warning.

These cracks may sometimes extent to severe limit like ½" wide and 12" deep. So building to be founded on this soil may suffer severe damage with the change of atmospheric conditions.

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.

Phosphogypsum:

Phosphogypsum is the by-product of phosphoric acid industry, consists of $CaSO_4.2\ H_2O$ and contains some impurities such as Phosphorus pent oxide (P_2O_5), F and organic substances. These impurities seriously restrict the industrial use of Phosphogypsum in cement industry as a retarder. Gypsum is a very soft sulphate mineral composed of calcium sulphate dehydrate, with the chemical formula $CaSO_4 \cdot 2H_2O$. 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

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.

In order of decreasing size uses are: steel fluxing, water treatment, nonferrous metals (alumina, magnesium, copper, and others), pulp and paper, refractories, soil stabilization, sewage and trade waste treatment, chemicals, and glass manufacture.

Data analysis and discussion:

Specific gravity:

Specific gravity G is defined as the ratio of the weight of an equal volume of distilled water at that temperature both weights taken in air $G_s=P_s/P_w$. This test is useful in determining the specific gravity of the materials and is carried out according to IS: 2720 (part 3, section I). The results of specific gravity on the respective material are summarised under in Table 2

Table 2 Results Of Specific Gravity Test

Sr. No	Specific Gravity test	
1	Jhansi (Uttar Pradesh)	2.58
2	Fly Ash	2.42
3	Phosphogypsum	2.33

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 1, No. 1, January : 2024

Free Swell Index:

Free Swell Index is the increase in volume of a soil, without any external constraints, on submergence in water. A free swell test is commonly used for identifying expansive clays and to predict the swelling potential. Free Swell Index of the soil is investigated according to IS: 2720 (part 40).

Table 3 Results Of Free Swell Index Test

Sr. No	MIX Proportions	FSI (%)
1	SOIL+25%FA+0%L+6%PG	44
2	SOIL+25%FA+3%L+6%PG	41
3	SOIL+25%FA+6%L+6%PG	43
4	SOIL+25%FA+9%L+6%PG	45

Table 4 Results Of Free Swell Index Test

Sr. No	MIX Proportions	FSI (%)
1	SOIL+25%FA+0%L+1.0%PG	44
2	SOIL+25%FA+3%L+1.0%PG	46
3	SOIL+25%FA+6%L+1.0%PG	45
4	SOIL+25%FA+9%L+1.0%PG	45

Atterberg Limits:

The Atterberg limits are a basic measure of the nature of a fine-grained soil. Depending on the water content of the soil, it may appear in four states: solid, semi-solid, plastic and liquid. In each state the consistency and behaviour of a soil is different and thus so are its engineering properties.

Table 5 Results Of Atterberg Limits Test

Sr.No.	Mix Proportions	L.L.%	P.L.%	P.I.
1	SOIL+25%FA+0%L+0.6%PG	45	20	25
2	SOIL+25%FA+3%L+0.6%PG	43	19	24
3	SOIL+25%FA+6%L+0.6%PG	44	16	28
4	SOIL+25%FA+9%L+0.6%PG	47	21	26

Fig. 3 Results of atterberg limits test (0.6% PG)

Table 6 Results of Atterberg Limits Test

Sr.No.	Mix Proportions	L.L.%	P.L.%	P.I.
1	SOIL+25%FA+0%L+1.0%PG	45	25	20
2	SOIL+25%FA+3%L+1.0%PG	40	21	21
3	SOIL+25%FA+6%L+1.0%PG	39	17	22
4	SOIL+25%FA+9%L+1.0%PG	39	17	22

Compaction Characteristics:

Compaction characteristics are studied by Standard and modified proctor test. The test helps to determine the maximum dry density and optimum moisture content of the specimen. The compaction test was carried out according to IS: 2720 (part 8). Optimum moisture content and maximum dry density for soils are obtained from the respective compaction curves.

Table 7 Results of Modified Proctor test

1	SOIL+25%FA+0%L+0.6%PG	1.76
2	SOIL+25%FA+3%L+0.6%PG	1.65
3	SOIL+25%FA+6%L+0.6%PG	1.83
4	SOIL+25%FA+9%L+0.6%PG	1.95

Table 8 Results of Modified Proctor test

1	SOIL+25%FA+0%L+1.0%PG	1.89
2	SOIL+25%FA+3%L+1.0%PG	1.65
3	SOIL+25%FA+6%L+1.0%PG	1.76
4	SOIL+25%FA+9%L+1.0%PG	1.8

Result

This research work has uncovered the potentiality of Phosphogypsum, Fly ash & Lime as an effective road construction material. The study has focussed on finding the suitable application of Phosphogypsum, Fly ash & Lime in the non-bituminous layers of the flexible pavement based on the geotechnical characterization of mix comprising Phosphogypsum, 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.

- **Recommendations for future work:**

Although this work successfully covered a wide area of research on the potentiality of Phosphogypsum as a road construction material, there are still some important areas to be covered in future research studies. The most important research points are summarized as following:

- The current work is limited to study the feasibility of Fly ash, Lime, Phosphogypsum in non-bituminous layers of flexible pavement. Further investigations should be carried out to study its feasibility in rigid pavements as well as in bituminous layers of flexible pavement.

On the basis of research study Fly ash, Lime, Phosphogypsum can be recommended as effective soil treating agent for improvement of soils for sub grade course its need some performance data of the pavement for better application

Conclusion

This research work has uncovered the potentiality of Phosphogypsum, Fly ash & Lime as an effective road construction material. The study has focussed on finding the suitable application of Phosphogypsum, Fly ash & Lime in the non-bituminous layers of the flexible pavement based on the geotechnical characterization of mix comprising Phosphogypsum, 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.

- Recommendations for future work:

Although this work successfully covered a wide area of research on the potentiality of Phosphogypsum as a road construction material, there are still some important areas to be covered in future research studies. The most important research points are summarized as following:

- The current work is limited to study the feasibility of Fly ash, Lime, Phosphogypsum in non-bituminous layers of flexible pavement. Further investigations should be carried out to study its feasibility in rigid pavements as well as in bituminous layers of flexible pavement.

References

[1] I.S. Dunn.L.R. Anderson, F.W. Kiefer 2008 ,Fundamentals of Geotechnical analysis..

[2] geofabrics, R. D. Gupta, Javed Alam, Mohd. Farooqi 2011 Effect on CBR values and other Geotechnical properties of Fly ash mixed with lime and non woven.

[3] National lime association, Consideration of Lime- Stabilization layers in Pavement design,.

[4] , K. R. Arora ,Soil mechanics and Foundation engineering.

[5]) Edil, T.B., H.A. Acosta, and C.H. Benson (2006), Stabilizing soft fine grained soils with fly ash. Journal of Materials in Civil Engineering,

[6] Gray, D.H. and T. Al-Refeai (1986), Behaviour of fabric versus fibber reinforced sand. Journal of Geotechnical Engineering,
[7] Gray, D.H. and H. Ohashi (1983),Mechanics of fiber reinforcement in sand. Journal of Geotechnical Engineering,
[8] O.G., and J.B. Metcalf (1972),Soil stabilization principles and practice, Butterworth, Sydney, Australia,Ingles,
[9] Kumar, S. and E. Tabor (2003) Strength characteristics of silty clay reinforced with randomly oriented nylon fibers. Electronic Journal of Geotechnical Engineering .
[10].Kaniraj, S.R. and V. Gayatri (2003) ,Geotechnical behavior of Fly Ash mixed with randomly oriented fiber inclusions. Geotextile and Geomembrane Srisruthi, S.; Swarna, N.; Ros, G.M.S.; Elizabeth, E. Sustainable agriculture using eco-friendly and energy efficient sensor technology. In Proceedings of the 2016
.