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AN EXPERIMENTAL INVESTIGESTION ON STABILIZATION OF BLACK COTTON SOIL BY USING FLY ASH

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ABSTRACT

Expansive soils are a worldwide problem that poses several challenges for civil engineers. They are considered a potential natural hazard, which can cause extensive damage to structures if not adequately treated. Such soils swell when given an access to water and shrink when they dry out. One of the most effective and economical method is addition of stabilizing agents such as lime or fly ash to expansive soil. In this study, a high plastic commercial clay was stabilized using fly ash. The geoengineering properties such as Atterberg limits, free swell index, unconfined compressive strength and CBR value of clay and treated with fly ash were evaluated and reported. Expansive soil was stabilized with various proportion of fly ash i.e. at 0, 10, 20, 30, 40, 50%. Fly ash possesses no plasticity. Plasticity index of clay-fly ash mixes decreases with increase in fly ash content. Thus addition of fly ash makes expansive soil less plastic and increases its workability by colloidal reaction and changing its grain size.

Soil stabilization is a physical, chemical, biological or combined method of changing a natural soil to meet an engineering purpose. Expansive soil is a type of clay that is prone to large volume changes (swelling and shrinking) that are directly related to changes in water content. Soils with a high content of expansive minerals can form deep cracks in drier seasons .Such soils are called vertisols. Soils with smectite clay minerals, such as montmorillonite and bentonite, have the most dramatic shrink-swell behavior. Expansive soil is hard in dry state and loses its strength in wet state. Due to this property it causes massive damage to infrastructure and buildings. In this study the natural soil is mixed with certain percentage of bentonite for making it expansive and this expansive soil is stabilized using fly ash. Fly ash is a fine powder which is a byproduct from burning pulverized coal in electric generation power plants. This can overcome many foundation problems and increase the bearing capacity of soil.

KEYWORDS: *Expansive soil, Fly ash, Plasticity, Compaction, Stabilization.*

I.INTRODUCTION

There are three basic types of soil naturally occurring in this area: sand, silt and clay. Clay soils are generally classified as expansive. This means that a given amount of clay will tend to expand (increase in volume) as it absorbs water and it will shrink (lessen in volume) as water is drawn away. The effects can be dramatic if expansive soils supporting structures are allowed to become too wet or too dry. Building structures, foundations, driveways and walkways may crack and heave as the underlying expansive soils become wet and swell. Sometimes the cracking and heaving appear temporary as the soils dry and shrink back to their original position. Based on our study we finally decided to take waste material (Fly ash) as soil stabilizers for chemicals.

Stabilization of soil is the amendment of soils to intensify their physical properties. Shrink-swell properties and improvement of the load bearing capacity of a sub-grade by stabilization to support pavements and foundations. Subsoils which are not suitable for construction such as roadways, parking areas, site development projects, airports and many other situations can be stabilized with suitable methods. Wide range of sub-grade materials, varying from expansive clays to granular materials can be stabilized. This process is consummate using a wide variety of additives, including lime, fly-ash and Portland cement. Advantages of stabilization of soil includes: Increase in resistance, Plasticity reduction, Permeability reduction, Decrease in pavement thickness, elimination of excavation etc.

A rounded structure, with a hard outer layer and a porous inner layer is known as expansive soil. It is clay that is liable to large volume changes that are greatly related to changes in water content. High content of expansive minerals in the soil can form deep cracks in drier seasons such soils are called vertosols. Smectite clay minerals such as montmorillonite and bentonite in the soil have the most dramatic shrink-swell capacity. The very common cause of foundation problems is the shrink-swell soil. Based on the moisture content in the ground, shrink-swell soils will experience volume changes of up to thirty percent or more. Soils in the foundation which are expansive are heave and cause rising of a structure during periods of high moisture content. Expansive soil will collapse during the period of falling moisture content which results in building settlement. Expansive soils are found in USA, South Africa, Australia, Spain, Israel, Myanmar and India.

Due to difficulty in collecting the expansive soil, artificially prepare the expansive soil in laboratory. Bentonite clay of certain percentage when added to natural soil can convert natural soil into expansive soil. Bentonite is clay generated from the volcanic ash, consisting of smectite, usually montmorillonite. Due to the swelling properties of bentonite it is used to make expansive soil.

Fly Ash is used for the stabilization of expansive soil. Fly Ash is a waste material extracted from the gases emerging from coal fired furnaces, generally of a thermal power plant. Disposal of huge quantities of fly ash require large tracts of cultivable land which causes major environmental problems. Fly ash because of its pozzolanic property, free of cost and availability makes it a better stabilizer.

Expansive soil

Expansive soils, which are also called as swell-shrink soil, have the tendency to shrink and swell with variation in moisture content. As a result of this variation in the soil, significant distress occurs in the soil, which is subsequently followed by damage to the overlying structures. During periods of greater moisture, like monsoons, these soils imbibe the water, and swell; subsequently, they become soft and their water holding capacity diminishes. As opposed to this, in drier seasons, like summers, these soils lose the moisture held in them due to evaporation, resulting in their becoming harder. Generally found in semi-arid and arid regions of the globe, these type of soils are regarded as potential natural hazard – if not treated, these can cause extensive damage to the structures built upon them, as well causing loss in human life. Soils whose composition includes presence of montmorillonite, in general, display these kind of properties. Tallied in billions of dollars annually worldwide, these soils have caused extensive damage to civil engineering structures. Also called as Black Cotton soils or Regur soils, expansive soils in the Indian subcontinent are mainly found over the Deccan trap (Deccan lava tract), which includes Maharashtra, Andhra Pradesh, Gujarat, Madhya Pradesh, and some scattered places in Odisha. These soils are also found in the river valley of Narmada, Tapi, Godavari and Krishna. The depth of black cotton soil is very large in the upper parts of Godavari and Krishna, and the north-western part of Deccan Plateau. Basically, after the chemical decomposition of rocks such as basalt by various decomposing agents, these are the residual soils left behind at the place of such an event. Cooling of volcanic eruption (lava) and weathering another kind of rock – igneous rocks – are also processes of formation of these type of soils. Rich in lime, alumina, magnesia, and iron, these soils lack in nitrogen, phosphorus and organic content.

ADVANTAGES OF SOIL STABILIZATION

- Improves soil strength.
- Reduce expansiveness.
- Improves soil workability.
- Improve the engineering properties of soil and make it suitable for construction.
- Avoid unseen settlement.
- Reduce dust in work environment.

APPLICATIONS:

- Foundations.
- Dam and Reservoir.
- Road constructions.

Fly Ash

A waste material extracted from the gases emanating from coal fired furnaces, generally of a thermal power plant, is called fly ash. One of the chief usages of volcanic ashes in the ancient ages were the use of it as hydraulic cements, and fly ash bears close resemblance to these 5 volcanic ashes. These ashes were believed to be one of the best pozzolans (binding agent) used in and around the globe. The demand of power supply has exponentially heightened these days due to increasing urbanization and industrialization phenomena. Subsequently, this growth has resulted in the increase in number of power supplying thermal power plants that use coal as a burning fuel to produce electricity. The mineral residue that is left behind after the burning of coal is the fly ash. The Electro Static Precipitator (ESP) of the power plants collect these fly ashes. Production of fly ash comes with two major concerns – safe disposal and management of fly ash. Because of the possession of complex characteristics of wasters which are generated from the industries, and their hazardous nature, these wastes pose a necessity of being disposed in a safe and effective way, so as to not disturb the ecological system, and not causing any sort of catastrophe to human life and nature. Environmental pollution is imminent unless these industrial wastes are pre-treated before their disposal or storage. Essentially consisting of alumina, silica and iron, fly ashes are micro-sized particles. Fly ash particles are generally spherical in size, and this property makes it easy for them to blend and flow, to make a suitable concoction. Both amorphous and crystalline nature of minerals are the content of fly ash generated. Its content varies with the change in nature of the coal used for the burning process, but it basically is a non-plastic silt. For waste liners, fly ash is a potential material that can be employed; and in combination with certain minerals (lime and bentonite), fly ash can be used as a barrier material. In present scenario, the generation of this waste material in picture (fly ash) is far more than its current utilization. In other words, we are producing more of fly ash than we can spend.

II. LITERATURE REVIEW

J. Karthik and Ramkumar Thulasiram: Whioce Publishing Pte Ltd. 23 April 2018:

The objective of this paper is to determine the optimum fly ash content at which soil behavior is improved. Soil improvement is termed as soil stabilization. Soil stabilization depends on factors such as unconfined compression, cohesion, shear load, consolidation and permeability of soil and CBR value of soil. Fly ash is a thermal waste. Nearly half of the fly ash generated is not been used, hence usage of fly ash will reduce waste. Test conducted were sieve analysis, specific gravity, standard proctor compaction, unconfined compression, direct shear, free swell index, variable head permeability and consolidation for black cotton soil. Test also was conducted on soil. replaced with fly ash in the level of 5%, 10% and 15%. Among the various replacement tried out, better results were observed for soil replaced with 10% of fly ash. Beyond the 10% level of replacement a reduction in performance was observed. Hence fly ash can be used for soil stabilization up to 10% replacement.

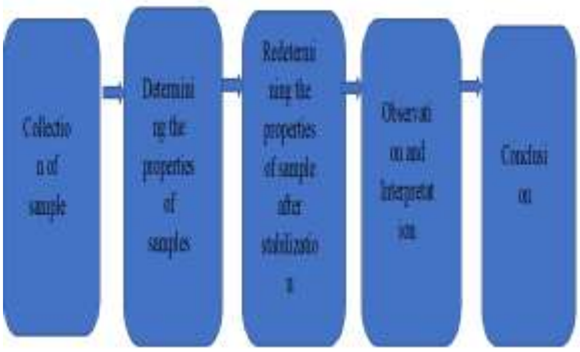
Bayshakhi Deb Nath, Md. Keramat Ali, and Grytan Sarkar: Hindawi International Scholarly Research Notices Volume 2017, Article ID 5786541, Published 11 September 2017:

The aim of this study is to investigate the effect of fly ash on the consistency, compactness, acidic properties, and strength of organic soil. The presence of organic content in the soil has detrimental impacts on the physical and strength behavior of soil. To investigate the effectiveness of fly ash in the stabilization of organic soil, two types of fly ashes (Type I and Type II) at different percentages were used. It is found that fly ash significantly reduces the plasticity index of the organic soil, whereas the liquid and plastic limits increase. The dry density of the fly ash-soil mixture increases significantly, while the water requirement reduces due to the addition of fly ash. The increase of dry density compromises higher strength. The increase of qu with the increase of fly ash content is mainly due to the pozzolanic reaction of fly ash, although the reduction in water content results from the addition of dry fly ash solid.

Shriful Islam, Nur Hoque, Md. Uddin and Mohammod Chowdhury: Jordan Journal of Civil Engineering, Volume 12, No. 2, 2018:

The presence of optimum fly ash content in soil to increase the unconfined compressive strength (UCS) of clayey soil has been studied in the present work. Two types of fly ash, collected from coal combustion in an electric power plant, are used; one is Bangladeshi and the other one is Indian. The soil, collected from paddy field of Shahjalal University of Science and Technology (SUST), is classified as a mixture of inorganic silts and organic clays of medium to high plasticity. UCS tests have been conducted on moulds prepared with soil only and with soil containing fly ash with optimum moisture content (OMC) of 19%~24% at a curing time up to 3, 7, 14, 28 and 90 days. Observations showed that maximum dry density (MDD) and OMC of pure soil are 1.615 g/cm3 and
20.30%, respectively. The addition of fly ash content decreases MDD and increases OMC of the soil. With the increase in fly ash content, two zones of strength development have been observed: the active zone and the deterioration zone. The optimum fly ash content is found as 5% for both types of fly ash.

III.MATERIAL AND METHODOLOGY
MODULE SPLIT UP



METHODOLOGY

Keeping in mind the general objectives of the project a detailed methodology for undertaking the project is proposed which consist of a set of task as given below:

i. Collection of materials such as natural soil, bentonite and fly ash.

ii. Performance of laboratory test on natural soil and bentonite.

iii. Preparation of the sample.

iv. Performance of laboratory test on the prepared sample and sample mixed with varying percentage of fly ash.

v. Comparison of results.

MATERIALS

Expansive soil

The black cotton soil obtained from different areas was carried to the laboratory in sacks. A small amount of soil was taken, sieved through 4.75 mm sieve, weighed, and air-dried before weighing again to determine the natural moisture content of the same. The various geotechnical properties of the procured soil are as follows:

Table:2 **Geotechnical properties of expansive soil**

Sl. No.	Properties	Code referred	Value
1	Specific Gravity	IS 2720 (Part 3/Sec 1) – 1980	2.44
2	Maximum Dry Density (MDD)	IS 2720 (Part 7) - 1980	1.52gm/cc
3	Optimum Moisture Content (OMC)	IS 2720 (Part 7) - 1980	22.65%
4	Natural Moisture Content	IS 2720 (Part 2) - 1973	7.20%
5	Free Swell Index	IS 2720 (Part 40) - 1977	105%
6	Liquid Limit	IS 2720 (Part 5) - 1985	65%
7	Plastic Limit	IS 2720 (Part 5) - 1985	37.08%

IV.EXPERIMENTAL DETAIL

This is an experimental project to improve the different properties of black cotton soil by adding fly ash. Here different amount of fly ash have been used in the black cotton soil. Black cotton soil Sample with addition of different proportion of fly ash has been prepared. Using these black cotton soil sample test specimens were prepared and tested as per the experimental matrix. All the laboratory tests conducted to determine the index properties and engineering properties of present soil. and also determine the engineering properties of modified soil. In our study we conducted experiments on varying percentages of fly ash.

1. The basic laboratory test are (Atterberg's limit,compaction,CBR ,UCS) were carried out on black cotton soil sample to determine the basic properties of soil.

2. The California bearing ratio and unconfined compressive strength tests were conducted to determine the strength behavior of black cotton soil with fly ash.

After removing impurities likes stones, vegetation etc the soil was mixed with fly ash in varying proportion by volume. The mixing of fly ash in black cotton soil carried out four times. The mixing was thoroughly carried out manually and the tests were conducted as per standard procedures.

V.CONCLUSION

Based on the results obtained and comparisons made in the present study, the following conclusions can be drawn:

- The Maximum Dry Density (MDD) value of the black cotton soil initially decreased with the addition of fly ash. Then, it showed increment with increasing fly ash content in the soil-fly ash mixture. The maximum value of MDD was observed for a mixture of soil and 30% of fly ash content by weight. The MDD values consistently decreased thereafter.
- The Unconfined Compressive Strength (UCS) of the soil with variation of fly ash content showed similar trend as that of the MDD values, except the fact that the peak value was observed for a fly ash content of 20% by weight.
- In California Bearing Ratio (CBR) tests of soil conducted with varying fly ash content, the CBR increased gradually with the increase in fly ash content till its valuation was 20% by weight of the total mixture; it decreased thereafter.
- With the increasing fly ash content in the soil-fly ash mixture, the decrease in value of free swell ratio was remarked. This decrease was also reciprocated by the plasticity index values. Plasticity index values are

directly proportional to percent swell in an expansive soil, thus affecting the swelling behavior of the soil-fly ash mixture.

- Thus, fly ash as an additive decreases the swelling, and increases the strength of the black cotton soil. Fly ash improves the stability of the soil. Shear strength increases with addition of fly ash. Adding fly ash as stabilizer decreases the hydraulic conductivity thus compressibility increases.
- Fly ash along with another additive like lime, murrum, cement, and other such materials can be used together, and may be varied in quantity to obtain the best possible stabilizing mixture.

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