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Stabilization of Expansive Soil Using Plastic Fibers and Fly Ash

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ABSTRACT: Soil Stabilization is the alteration of soils to enhance their physical properties. Soil is very important in civil engineering constructions. The poor engineering properties of the local soils may present many difficulties for construction and therefore need to improve their engineering properties. In civil engineering, soil stabilization is a technique to refine and improve the engineering properties of soils such as mechanical strength, permeability, compressibility, durability and plasticity. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. In this paper we study the impact of fly ash and plastic Fibres to improve the strength of soil.

KEYWORDS: Soil, Stabilization, Plastic Fibres, Fly Ash, Civil Engineering, Bearing Capacity, permeability, compressibility, durability

I. INTRODUCTION

The process of soil stabilization collectively refers to various techniques of modification changing the physical and/or mechanical properties of soil for a specification application and in order to improve its strength, durability, or other qualities through alterations in texture and plasticity of the soil.

Generally Soil is a peculiar material. The Fly Ash use to make the soil to be stable. It can increase the physical and chemical properties of the soil. Some expecting properties to be improved are liquidity index, plasticity index, unconfined compressive strength and specific gravity etc. For any type of structure, the foundation is very important and it has to be strong to support the entire structure. In order for the strong foundation the soil around it plays a very critical role.

Needs & Advantages:

Soil properties vary a great deal and construction of structures depends a lot on the bearing capacity of the soil, hence, we need to stabilize the soil which makes it easier to predict the load bearing capacity of the soil and even improve the load bearing capacity. The gradation of the soil is also a very important property to keep in mind while working

with soils. The soils may be well-graded which is desirable as it has less number of voids or uniformly graded which though sounds stable but has more voids. Thus, it is better to mix different types of soils together to improve the soil strength properties. It is very expensive to replace the inferior soil entirely soil and hence, soil stabilization is the thing to look for in these cases.

- It improves the strength of the soil, thus, increasing the soil bearing capacity.
- It is more economical both in terms of cost and energy to increase the bearing capacity of the soil rather than going for deep foundation or raft foundation.
- It is also used to provide more stability to the soil in slopes or other such places.
- Sometimes soil stabilization is also used to prevent soil erosion or formation of dust, which is very useful especially in dry and arid weather.
- Stabilization is also done for soil water-proofing; this prevents water from entering into the soil and hence helps the soil from losing its strength.

- It helps in reducing the soil volume change due to change in temperature or moisture content.
- Stabilization improves the workability and the durability of the soil.

SOIL STABILIZATION: In the Soil stabilization process, soil properties are improved the engineering performance of the soils. The properties are mostly density, water content, plasticity and strength. Changes in the soil properties is the temporary enhancement of sub grade stability. Stabilization can be used to treat a wide range of sub-grade materials from expansive

clays to granular materials. The main advantages of soil stabilization process have higher resistance, reduces in plasticity, lower permeability, and reduction of pavement thickness. Stabilization of expansive soils its controls the potential of the soils for changes in volume, and improves the strength. In the field of geotechnical engineering. Expansive soils are known as shrink swell or swelling soils.

BENEFITS OF SOIL STABILIZATION: Benefits of Soil Stabilization process can include:

- Higher resistance (R) values
- Reduction in plasticity
- Lower permeability
- Reduction of pavement thickness
- Aids compaction

Soil Stabilization using Plastic:

Soil stabilization is the process of improving the physical and chemical properties of soil. Stabilization helps to increase the shear strength and controls the shrink-swell properties of soil.

It also improves the load-bearing capacity of the soil to support pavements and foundations. In the construction field, soil stabilization plays a vital role especially during the design and construction of foundations. There are many existing techniques or materials available to achieve soil stabilization. The use of plastic waste as a stabilizer make the soil stabilization process more cheap and eco-friendly.



(Fig 1: Soil Stabilization by Using Plastic Waste Granules Materials)

For many years, researchers developed a lot of new additives like lime, cement kiln, and fly-ash to improve the physical properties of soil. But in recent days, these stabilizers are becoming more expensive to use in the soil stabilization process. This problem demanding an alternative stabilizer to make the soil stabilization cheap. Using the plastic waste fibers as soil stabilizers is an economical way to overcome this problem.

Soil stabilization using plastic waste fibers will improve the strength of soils. This method will results in better and longer lasting structures with increased loading capacity. This technique also helps to meet the various social challenges like reducing the quantity of waste, producing useful materials from non-useful waste materials and others. It can be efficiently used for improving the embankment soils, preparation of suitable base for upper pavement structure, etc..

Applications of Soil stabilization using plastic:

- Reduce the permeability of soil.
- Increase the bearing capacity of soil.
- Increase the shear strength of soil.
- Improves the durability.
- Avoids disposal problems of plastic.
- Reduction in cracks and swelling.
- Increase CBR values.
- Reduction in consolidation settlement.

COMPACTION OF SOIL FLY ASH MIXTURES: The density of soil with coal ashes are important parameter, since it controls the strength, Compressibility and permeability. Generally the compacted weight of the material is based on the amount and the method of energy application, grain size distribution and moisture content at the compaction. The variation of dry density with moisture content is less compared and also both having the same grain size. In the fly ash are to be less sensitive to variation in moisture content than the soil is due to higher air void content of fly ash.



(Fig 2: Fly Ash used in Soil Improvement)

FLYASH COMPOSITION: Mainly the flyash composition, the effect of the fly ash content on the swelling pressure, compaction, strength, and hydraulic conductivity characteristics of expansive soil. The components of fly ash vary considerably, but all fly ash includes silicon dioxide (SiO₂), aluminium oxide (Al₂O₃) and calcium oxide (CaO), the main mineral compounds in coalbearing rock strata.

II. LITERATURE REVIEW

Few research scholars carried their investigations on mixing soil with polypropylene, polyester fibers, coir fibre, Bamboo fibre and fly ash. Plenty of work has been done by different researchers; some of them are as follows:

1. Beeghly J. H. et al. (2003) investigated for appropriate soils, lime- fly ash can offer cost saving by reducing material cost by up to 50% as compared to Portland cement stabilization. For low cohesive soil used with lime and fly ash stabilization can be economically engineered for long term performance.

2. Bhuvaneshwari et al. (2005) investigated the study in the properties of expansive soil with fly ash in varying percentages. Both laboratory test and

field tests have been carried out and results are reported in this paper. One of the major difficulties in field application is thorough mixing of the two materials such as expansive soil and fly ash is required proportion to form a homogeneous mass. The proper describes a method adopted for placing these materials in layers of required thickness and operating a “Disc Harrow”. The trial embankment of 30m length by 6m width by 0.6m high was successfully constructed and the in-situ tests carried out proved/proved its suitability for construction of embankment, ash dykes, highway constructions filling low-laying areas, etc.

3. Mehul and Kulkarni (2013) used fibrillated polypropylene fiber of length 12mm and diameter 34 micron and low density of 0.9 kN/m³, in percentages of 0.5%, 1% and 1.5% in high strength concrete. Super plasticizer Conplast-Sp430 was used. They investigated the compressive strength of concrete increased with added of fibers.

4. Kumar et al. (2006) investigation to highly compressible clay in UCS test with 0%, 0.5%, 1.0%, 1.5% and 2.0% flat and crimped polyester fibers with Three lengths like 3 mm, 6 mm and 12 mm were chosen for flat fibers, while crimped fibers were cut to 3 mm long. The results indicate that as the fiber length and /or increase the percentage of fiber, the UCS value will improve. Crimping of fibers leads to increase of UCS slightly.

5. Nithin and Sayida (2012) reports the results of the laboratory study performed on silty sand admixed with fly ash and reinforced with coir fibres and demonstrates that discrete and randomly distributed coir fibres are useful in improving the bearing capacity of soil. The silty sand (low plasticity soil) has been considered using different percentage of fly ash ranging from 5 to 20% by weight of given soil and the impact of curing period is also considered. Coir fibres are added ranging from 0.5 – 5% and having different aspect ratio such as $l/d=40, 80, 120, 160$ to investigate the relative strength gain in terms of unconfined compression.

6. Hejazi et al. (2012) examined the improve the engineering characteristics of soil. In this way, using natural fibers like grass, leaf etc. to reinforce soil is an old and ancient idea. Consequently, randomly distributed fiber reinforced soils have recently attracted increasing attention in civil engineering and geotechnical engineering for the second time. The main aim of this paper, therefore, is to review the history, advantages, applications; and possible executive problems of using different types of natural and synthetic fibers in soil reinforcement through reference to published scientific data. As well, predictive models used for short fiber (or aspect ratio) soil composite will be discussed. On other words, this paper is going to investigate different fiber different methods and different percentages fibers have been used in soil reinforcement projects.

7. In 2013 Meshram et al. solved a variety of problems related to drainage, separation and reinforcement of pavement structure. They investigated that the geo-textiles made of natural fibers such as coir, jute etc., are emerging as alternatives to polymeric geotextiles. They also described that in dry weather conditions, cracks develop at the soil surface due to tensile stresses induced as a result of drying and shrinkage and in wet weather conditions the water starts to rise in the subbase by capillary action from soil sub-grade. For pavement they described that material like coir, lime etc. are needed to improve the compressive, tensile strength and permeability characteristics of the sub-base for a better performance of the pavements.

8. Momoh et al. (2013) investigated the use of coir fibre reinforcement to improve the strength properties of black cotton soil sub-grade and cement kiln dust (CKD) as stabiliser. Black cotton soil was mixed with optimum of CKD along with different proportions of discrete coir fibres (0%, 0.25%, 0.5%, 0.75% and 1.0% by dry weight of soil cut to 25mm size). Test results indicated that the inclusion of fibre in stabilised specimens resulted in reduced maximum dry unit weight, higher optimum moistures content relatively to UCS and therefore increases load carrying capacity of the sub-grade. The results further demonstrated that randomly distributed coir fibres can be used to reduce the brittleness of stabilised soil which is the drawback associated with high lime content stabilisers. Thus, strength of black cotton soil can be successfully improved by the combined action of CKD and coir fibre.

9. Tiwari et al. (2014) analyzed the characteristics of soil such as Atterberg's Limits, Proctor Compaction test (O.M.C. and M.D.D.), Shrinkage Limit, California Bearing Ratio test, Swelling Pressure, Permeability test and direct shear test, effect of Fly Ash, Coconut fiber and crushed Glass with various percentages with Black cotton Soil, combination on the above proportion of ingredients, use of waste products instead of conventional construction materials like cement, lime, etc. and how to increase cost benefit ratio. To achieve the experimental data with 48 trial soil samples test were carried in two phase such as in first phase, the physical properties of soil such as specific gravity, Atterberg's limits, grain size analysis, proctor compaction test, swelling pressure, CBR test, Direct shear test and permeability test values are determined. In second phase, all test performed for black cotton soil using different percentages of Fly Ash, coir fiber and crushed glass fiber (FA: 10%, 15%, 20% and 25%, CF: 0.25%, 0.5%, 0.75% and 1%, CGF: 3%, 5% and 7%, glass crushed to have gradation of sand size).

10. Asaduzzaman and Islam (2014) investigated the soil improvement by reinforcement having a length of 12 inch and 0.5 inch in diameter distributed in soil (uniform medium dens) at different depths (0.75 inch, 1.5 inch and 2.25

inch) below the footings. The three square footings have been used (3x3 inch, 3.5x3.5 inch, 4x4 inch) to carry the above investigation for such purposes. They found that the initial vertical settlement of footing was highly affected in the early stage of loading in unreinforced soil with compared to bamboo reinforced soil. The failure load value for their model in any case of loading increased compared with the un-reinforced soil by increasing the depth of improving below the footing. The load carrying capacity of single layer of reinforced soil is increased up to 1.77 times and 2.02 times for multiple reinforced soil system than the load carrying capacity of unreinforced condition of soil. Improvement in load carrying capacity was observed considerable in reinforced soil over the unreinforced soil. For single layer system, load carrying capacity is maximum and settlement is minimum when the reinforcement layer placed at 0.30B. For multilayer system, BCR increases with increasing number of reinforcing layer.

11. Recently John and Rachel (2016) investigation the effect of random distributed of bamboo fibers on strength behavior of fly ash improving black cotton soil. The optimum percentage of fly ash was found to be 20% by weight of soil. Bamboo fiber of average diameter 0.45 mm and 25 mm length is used in this study. It was randomly included into the fly ash treated soil at four different percentages of fiber content, i.e. 0.25, 0.5, 0.75 and 1% (by weight). The reinforced soil samples were subjected to unconfined compression test and compaction tests. They found that strength properties of optimum combination of BC soil-fly ash specimens reinforced with bamboo fibers is appreciably better than untreated BC soil. An optimum fiber content of 1% (by weight) is recommended for strengthening fly ash treated BC soil.

III. MATERIAL USED

Fly Ash:

A class-F Fly ash having (CaO - 0.17%, Al₂O₃ - 22.26%, SiO₂- 75.39%, Fe₂O₃ - 0.51%) available in Nagpur, India is used in the experimental programme.

Polypropylene Fiber:

Polypropylene fibers having lengths 6, 12 and 24 mm, and aspect ratio of 150,300 and 600 respectively were purchased from the market for use in experimental programme.

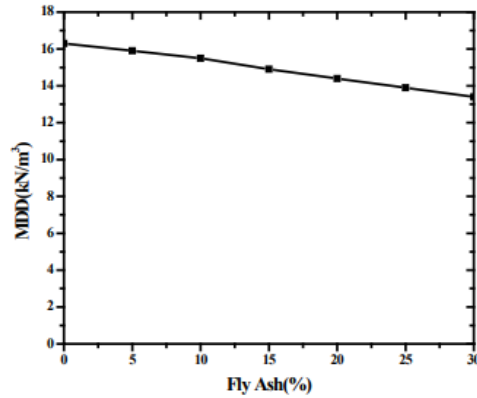
IV. PROPOSED METHODOLOGY

1. Collect the soil sample and perform the laboratory test to find the initial characteristics of soil sample.
2. Determine the specific gravity, grain size analysis and index properties of soil.
3. Perform the test with various proportions of soil, plastic fibers and Fly Ash.
4. Continue the test until you find the optimum proportion.
5. Conduct the CBR, compaction and index properties tests to find the increase in strength of soil.

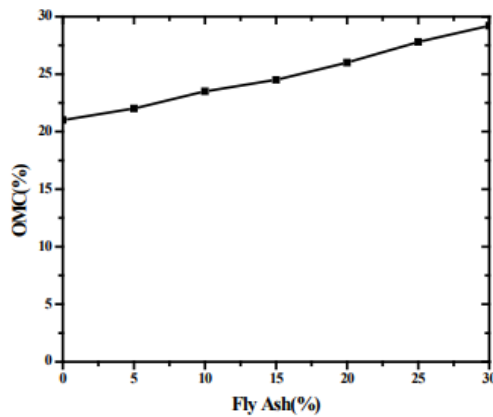
First of all soil- fly ash mixes were prepared. The fly ash was varied from 0 to 30% at an increment of 5%. Standard Proctor compaction tests were conducted on these soil-fly ash mixes to find optimum moisture content (OMC) and maximum dry density (MDD) to prepare samples for UCS, CBR, and swelling pressure tests to find, optimum percentage of fly ash for stabilization of expansive soil. Standard Proctor compaction, UCS, soaked CBR and swelling pressure tests were conducted on these mixes/samples. After getting the optimum percentage (20%) of fly ash for stabilization of expansive soil, soil-fly ash –fiber mixes were prepared. The amount of fibers varied were 0 to 1.5% at an increment of 0.25% by replacement of soil with fiber. Different samples were prepared for different length (6 mm, 12 mm and 24 mm) of fibers. Standard Proctor compaction tests, UCS tests, soaked CBR tests, swelling pressure tests were conducted on soil-fly ash-fiber mixes. For each tests 3 samples were prepared and average of the three values is reported. Different tests were conducted according to the relevant Indian standard Codes.



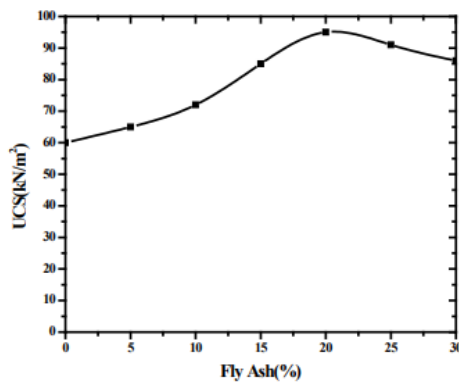
ANALYSIS OF TEST RESULTS AND DISCUSSION:



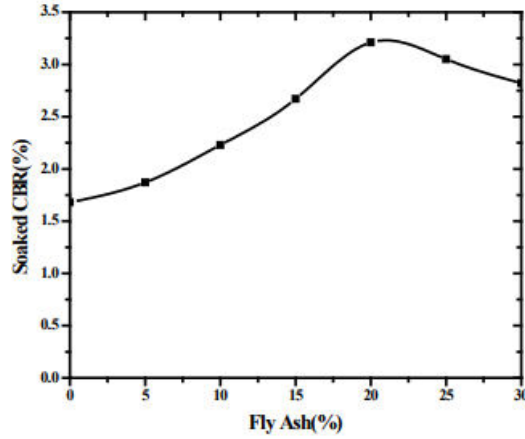
(Fig 3: Variation of MDD with percentage of Fly ash)



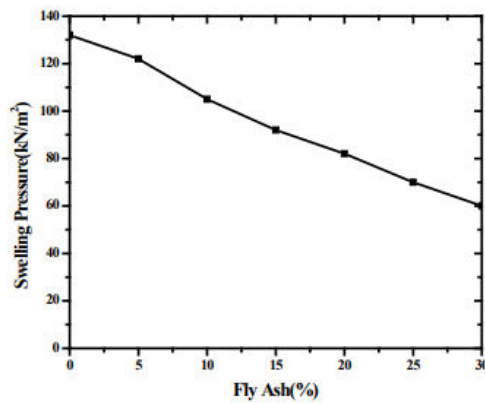
(Fig 4: Variation of OMC with percentage of Fly ash)



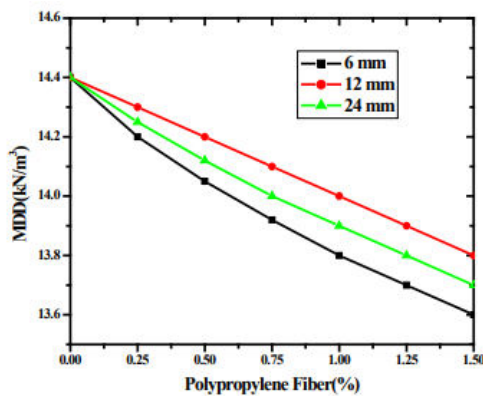
(Fig 5: Variation of UCS with percentage of Fly ash)



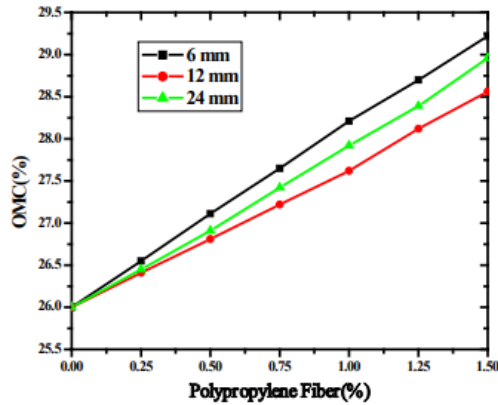
(Fig 6: Variation of soaked CBR with percentage of Fly ash)



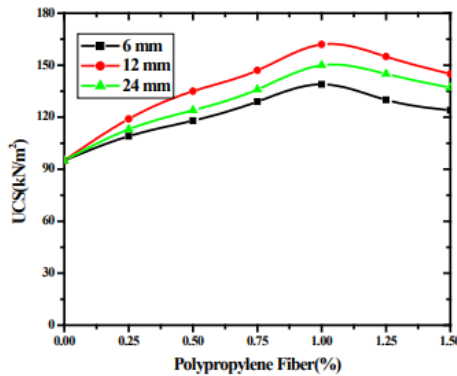
(Fig 7: Variation of swelling pressure with percentage of Fly ash)



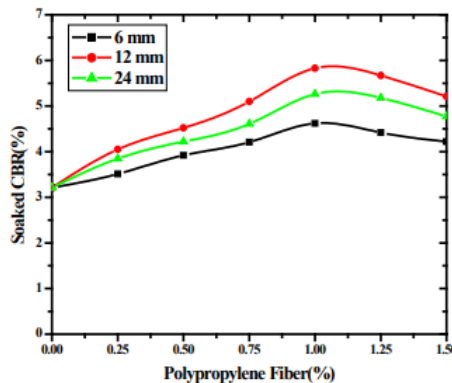
(Fig 8: Variation of MDD of Fly ash stabilized soil with percentage of Polypropylene Fiber)



(Fig 9: Variation of OMC of Fly ash stabilized soil with percentage of Polypropylene Fiber)



(Fig 10: Variation of UCS of Fly ash stabilized soil with percentage of Polypropylene Fiber)



(Fig 11: Variation of soaked CBR of Fly ash stabilized soil with percentage of Polypropylene Fiber)

Fig.11 shows the variation of soaked CBR of fly ash stabilized soil with different percentages of polypropylene fiber. From the figure it is observed that with increase in percentage addition of polypropylene fiber, the soaked CBR of soil goes on increasing up to certain percentage of polypropylene fiber, thereafter it decreases, irrespective of the length of the polypropylene fiber. The soaked CBR increases to 4.62%, 5.83% and 5.26%, when the percentage addition of polypropylene fiber is 1% and the lengths of the polypropylene fiber are 6 mm, 12 mm, and 24 mm respectively thereafter the soaked CBR decreases. The maximum value of soaked CBR is achieved with sample reinforced with 12 mm length fiber. There is 81% increase in soaked CBR as compared to fly ash stabilized soil and 247% increase in soaked CBR as compared to virgin soil.

V. CONCLUSION

Plastic is one of the major toxic pollutants in recent days. Using plastic as soil stabilizer will drastically eliminate this problem. And also improves the soil performance in the design of pavements and foundations.

- The optimum percentage of fly ash for stabilization of expansive soil is found to be 20%. At 20% addition of fly ash to expansive soil there is, 58% increase in UCS, 91% increase in soaked CBR and 38% reduction in swelling pressure.
- The MDD of fly ash stabilized expansive soil goes on decreasing and OMC goes on increasing with increase in percentage addition of polypropylene fiber, irrespective of the length of the polypropylene fiber.
- The UCS of fly ash stabilized expansive soil goes on increasing up to 1% addition of polypropylene fiber, thereafter it decreases irrespective of the length of the polypropylene fibers. The maximum value of UCS is achieved with sample reinforced with 12 mm length fiber. There is 70% increase in UCS as compared to fly ash stabilized soil and 170% increase in UCS as compared to virgin soil.
- The soaked CBR of fly ash stabilized expansive soil goes on increasing up to 1% addition of polypropylene fiber thereafter it decreases irrespective of the length of the polypropylene fiber. The maximum value of soaked CBR is achieved with sample reinforced with 12mm length fiber. There is 81% increase in soaked CBR as compared to fly ash stabilized soil and 247% increase in soaked CBR as compared to virgin soil.

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