ABSTRACT
Soil stabilization is the method used for improving the engineering properties of soil thereby increasing the stability and durability of soil and reducing the permeability of the soil. There are various materials used in the process of soil stabilization such as lime, Fly-ash, cement, bitumen and other chemicals. Ground improvement techniques such as lime columns, cement grouting, chemical stabilization, even though found to give promising results in stabilizing the soil, their environmental effects could not be solved. Hence in this investigation an attempt has been made to use natural materials for the improvement of problematic clays. This review paper discusses about the various natural materials that are being used for soil stabilization like coir, combination of jaggery and fruit waste, egg shells, tamarind, vegetable waste etc., in the form of liquid or powder. The use of natural materials is used in soil as they are non-toxic, environment friendly, easy to use, reduces compaction effort, increase density etc.

KEYWORDS:
Natural Materials, Tamarind Kernel Powder, Egg Shell Powder, Jaggery, Soil stabilization

INTRODUCTION
Soil stabilization is method used to modify the existing engineering properties of the soil using various methods and additives thereby increasing strength and reducing the permeability of the soil. Soil stabilization also helps reducing the water absorption percentage of the soil. The scarcity of good soil has become a serious concern and this has been an important factor leading to soil stabilization. The advantages of soil stabilization are as follows:

- It increases the stability of the soil
- It also increases bearing capacity of the soil
- Geotechnical properties enhance during soil stabilization
- It helps reducing adhesion in highly adhesive soil
- It increases the adhesion in low adhesive soil
- It reduces the plasticity index

Ground improvement technology became the driving force for all land reclamation work as a result of rapid urbanization and industrialization. Natural materials and their use in ground improvement is one such area of potential and promise. In this review, an attempt has been made to explore the possibilities of using natural materials for the beneficial improvement of soils.

1.1 Objective of the study
- To study the various work done for the soil stabilization using the natural materials
- Compare the methods and outcome of the study
- Propose the suitable methods depending upon the feasibility
1.2 Scope

Various studies are carried out to stabilize the soil and there is a need to compare these studies and their optimum applicability in soil stabilization. The review clearly reveals that there is a considerable research gap due to the absence of large-scale investigations on fiber-soil reinforcing technique, as most of the investigations performed up to now are small-scale laboratory studies. But, it is very essential to carry out in-depth investigations in the field of soil stabilization. Therefore, this review highly recommends more and more future investigations in order to promote the reinforcing mechanism. Also, different percentages of various natural reinforcing materials can be incorporated into the soil to check their suitability at different field conditions. Further, it can be stated that the cost of the naturally obtained fibers is low compared to the man-made synthetic fibers. However, more detailed experiments are required to analyze the field applications and performance evaluation in order to quantify the economic benefits of this green approach.

2. Quality improvement due to stabilization

The process of stabilization had led to better soil gradation, increase in durability, increase in strength, reduction of plasticity index swelling potential. It also improves the properties of construction materials and gives the following attributes:

- Even after saturating with water substantial proportion of their strength is retained.
- Resistance to erosion.
- Surface deflection is reduced.
- Increase in elastic moduli of layers constructed above stabilized layer
- Increase in the stiffness and strength of soil layer

3. Natural materials

3.1 Coconut husk (Coir)
Coconut husk is the fibrous material consisting of cellulose, pectin, tannin, lignin and other water-soluble substances. The fibers have a diameter of 0.1–0.6mm and 50–350mm in length. Coir exhibits its tensile strength in wet condition. The degradation of the coir depends on the method of embedment and climatic conditions. It retains 80% of its tensile strength after a period of 6 months of embedment in clayey soil. Researchers have stated that Coir fiber shows better response against the synthetic fibers.

3.2 Sisal
Sisal is a lingo-cellulose fiber which is traditionally used as the reinforcement for gypsum plaster sheet in building industries. Sisal fibers are produced in Indonesia, east Africa and Brazil. They are extracted from plant leaves having 6–10 cm width, 50–250 cm length and 0.06–0.4 mm diameter. Sisal has a water absorption property of 60–70%. Sisal was used in varying proportion i.e., 0.25%, 0.5%, 0.75% and 1% by weight of raw soil with different lengths 10, 15, 20 and 25mm as the reinforcement. They found that the sisal fiber reduces the dry density of the soil. And further increase in the length also showed increase in dry density. The sisal reinforcement with an increased length also showed a non-linear increase in shear stress. Shear strength was also noticed to be increased with increase in fiber content up to 0.75% after which the shear strength reduces with increase in fiber content.

3.3 Palm Fibers
Palm fibers are extracted from the palm trees that are decomposed and are found to be brittle, having high water absorption, low tensile strength and modulus of elasticity. These fibers have certain benefits such as plenitude in the region, low cost, durability, relative strength against deterioration and tension capacity. Several tests have
been performed on soil with embedded fibers as the reinforcement such as Un-confined compressive strength (UCS), California bearing ratio (CBR) and compaction tests. It was found that constant length fibers with an inclusion of 9% to 1% resulted in increase of the residual and maximum strengths, while a decrease in the difference between residual and maximum strengths. An experiment with constant inclusion and varying fiber length (from 20mm to 40mm) also showed similar behavior.

3.4 Egg Shells
The egg shell consists of 90% of calcium, 6% of magnesium, 1% of phosphorus and very small amount of potassium and sodium. A mix of Egg shell powder (ESP) and lime was used in comparison with pure lime to find out the optimal quantity of ESP followed with optimal percentage of lime. The results of the experiment indicated that the mixture of lime and ESP gave marginal results to that of pure lime stabilization. From this work it was concluded that ESP can be replaced with no much loss in strength and thereby making the process economical. Another study confirmed that albumin (Egg whites) results in improvement of soil strength and durability, but artificially manufacturing of albumin is costly. Therefore, use of albumin with small quantities of ESP can make it economical.

3.5 Jaggery
Jaggery is sweetener which is produced from sugarcane. When pure sugarcane is boiled it leaves behind, called as jaggery. It contains a mixture of sugar and molasses, jaggery is usually available in the form of granular, solid and liquid. Jaggery is usually composed of 10 to 15% reducing sugars, 0.6 to 1% minerals, 3 to 10% moisture, 65 to 85% sucrose, 0.1% fat and 0.4% proteins.

4. Literature review
Saikrishnamacharyulu and Vinod Kumar (2017) had conducted an experimental study on soil stabilization using waste fiber materials. They found that the MDD of modified soil is maximum at 0.75% coir, which shows an increment of 0.6% and OMC is maximum at 0.25%, which shows an increment of 10%. The UCS value of modified soil gets increased with increase in coir content with an increase of 66.66%. From the work, it was observed that The UCS value of modified soil is maximum at 2% tyre, which shows an increment of 44.4%. The CBR value of modified soil is maximum at 8% tyre, which shows an increment of 82.05%. Also, the CBR and UCS values of coir obtained at 1% are higher compared to that of tyre. Hence coir is more reliable than tyre.

Indrani, et.al (2016) had conducted a comparative study of soil reinforced with natural fibers, synthetic fibers & waste materials. They found that all the three types of reinforcement increased the strength of soil with increase in percentage and the maximum strength was obtained when 1% of cement bag was used.

Jijo James and P. Kasinatha Pandian (2013) had conducted a performance study on soil stabilization using natural materials. They found that Tamarind Kernel powder (TKP) resulted in the deterioration of the index properties of the soil, but the ability of TKP to absorb and retain moisture can be adopted in areas where permeability needs to be controlled.

Abhinav Rawat and Anupam Mital (2015) had conducted a review on soil stabilization using different traditional and non-traditional additives. They found that traditional additives like cement, lime, fly ash can improve soil properties by themselves. Non-traditional additives like rice husk ash, crumb rubber, marble dust, blast furnace slag can also improve soil properties but are less efficient. Combining two or more non-traditional additives can improve their effectiveness.

Venkata Sai., et.al. (2020) had conducted an experiment on stabilization of red soil by using coconut coir fiber and rice husk ash. Adding of RHA and coconut coir fiber increases soil strength and we got optimum value at 15%, then strength of soil decreases. In UCC test we got maximum compression strength at 15% of RHA and 5% of coconut coir fiber, after 15% the strength of the soil reduces.
Brahmachary and Rokonuzzaman (2018) had conducted an investigation of random inclusion of bamboo fiber on ordinary soil and its effect CBR value. The results revealed that CBR value of soil increases with the addition of bamboo fiber. There is high impacts of length and diameter of bamboo fiber on the unsoaked and soaked CBR test value of normal soil. When bamboo fiber quantity is increases, CBR value of soil also considerable increase and this increase is occurred up to 1.2% of bamboo fiber dosage.

Sayyed Mahdi Hejazi and Mohammed Sheikhzadeh (2011) had conducted a simple review of soil reinforcement by using natural and synthetic fibers. They found that all of the fibers discussed have generally shown that strength and stiffness of the composite soil is improved by fiber reinforcement. Vidhya. A. Carmel and Twinkle Vinu (2015) had conducted Stabilization of Soft Clay using Lime and Jute Fibers. From the experiment, optimum fiber content was obtained as 6%, that is, the fiber content beyond this causes reduction in strength. As the diameter and strength increases the compressive strength of the soil also increases.

Hanifi Canacki and Fatih Celik (2016) had conducted stabilization of soft clay using beverage can. They found that Adding aluminum beverage cans to the expansive soil increase MDD; therefore, less effort could be considered during compaction and stabilizing expansive soil. Adding aluminum beverage cans to the expansive soil decreases OMC; therefore, for specific project with low water content the stabilized expansive soil with aluminum could be recommended.

5. Discussion

It was observed that the addition of glass fiber, coconut fiber and cement bag paste has increased the unconfined compressive strength of the soil. Also, maximum strength was obtained when 1% of cement bag was used as the reinforcing material. In general, it is observed among the natural materials used with clay, ESP gave promising improvements in the index properties of clay. However, J: C: L gave good performance at lesser combinations. Though TKP resulted in the deterioration of the index properties of the soil, the ability of TKP to absorb and retain moisture can be adopted in areas where permeability needs to be controlled. The strength of the soil is increases according to the per cent of rice husk ash added to the soil. In the stabilization of soil with lime and jute fibers, it can be concluded that optimum fiber content is 6% that is the fiber content beyond this causes reduction in strength. It was also observed that the diameter and length of fiber influences the strength of soil. As the diameter and strength increases, the compressive strength of the soil also increases. The addition of lime to the soil at different percentages such as 2%, 4%, 6% and 8% has resulted in the increase of shear strength. As lime content increases upto 6% the shear strength also gets increased after that a decrease in strength were noticed. So the optimum amount is 6%. Lime is a pozzolonic material as time increases they will undergo chemical reaction. So the curing effect is also noticed. It was observed that the addition of lime has decreased compressibility of the soil. Traditional additives such as cement, lime, fly ash can improve soil properties by themselves. The non-traditional additives like rice husk ash, crumb rubber, marble dust, blast furnace slag can also improve soil properties but are less efficient. But combination of these two additives can improve their effectiveness. RHA imparted strength combining marble dust increased the durability of soil specimen. Non-traditional additives should be used as soil stabilizer as they provide an economical alternative and also help in waste disposal.

6. Conclusions

- This review article has discussed the concept of using different natural materials and their behavior on problematic soil.
- Use of natural materials in soil has showed improvement in the stability and durability of the soil.
- The use of ESP resulted in reduction of compressibility of the soil due the granular nature.
The benefits of using natural materials are feasibility of using in all weather and conditions, availability, economical benefit, easy to use, rapid to perform.

This method would help in controlling certain factor such as formation of cracks, failure due to weight of building, failure of pavement layer, swelling index and decreasing brittleness of soil.

The addition of ESP has modified and improved the soil positively by improving the characteristics and hence its use in soil stabilization can be recommended with further related studies on its other characteristics such as water absorption, permeability etc.

Based on the review, research gaps have been identified and useful suggestions and recommendations have been given for the future development and promotion of natural fiber-soil reinforcement technology.

From the sustainable engineering point of view, this soil stabilization technique is not only an effective resource/waste management approach but it also helps in achieving soil with better properties.

So more detailed experiments can be done in soil using various combinations of natural materials so as to improve the strength characteristics of soil.

7. References
