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# REVIEW ON STABILIZATION OF SOIL USING POLYPROPYLENE FIBER WASTE

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**Abstract -** *There is fast increase in consumption, production of plastic all over the world leading to the large generation of waste plastic. The correct manner of disposing without occurring any ecological hazard is very challenging. Soil stabilization using admixtures like cement, lime, minerals etc. increases the cost tremendously in recent years, therefore there is a need for using plastic as an additive. Fiber reinforcement now a days emerged as an important method in geotechnical engineering for improving the strength of the soil. So, the main objective is to investigate the use of waste plastics (polypropylene fiber) reinforcement in stabilization of soil for enhancing the engineering properties of the soil, which also helps in reducing the plastic waste. Several tests such as compaction characteristics, unconfined compression test (UCS), direct shear test, and California Bearing ratio (CBR) tests are performed to determine the fiber's effectiveness and the result shows that waste fiber is very effective in enhancing properties of soil.*

***Key Words*: *Soil Stabilization, Polypropylene Fiber, Reinforcement, Engineering properties, Ecological Hazards.***

## 1.INTRODUCTION

Soil is a highly complex, diverse and unpredictable material that has been subjected to various effects of nature. Soil properties varies not only from one location to the next but also with the depth, loading, environmental and drainage conditions. The properties of soil depend on large number of factors as compared to other building materials.

The most important part of the entire structure is the foundation for any land-based structure. The soil surrounding the foundation is crucial to its strength. So, in order to increase the strength of soil, we should first get a proper knowledge of its properties and the factors that influence its behavior. Soil stabilization is a highly effective method for enhancing soil properties. The importance of enhancing soil properties very much increased as the population is growing very rapidly lead to increase in the demand of infrastructure, buildings etc. this also increases the demand of land having suitable engineering properties. Due to not having suitable bearing capacity or engineering properties the soil should be suitably treated or stabilized to improve the properties of soil.

As the demand of petroleum and aggregates are increasing which creates the shortage of these materials, so it became necessary for the engineers to look at other means to improve soil properties. With the increased demand for infrastructure, fuel, and raw materials, soil stabilization has started taking new shape and is emerging as a cost effective and popular solution due to the availability of better research, materials, and soil improvement equipment. The modern method of stabilization uses fibers as a reinforcement in the soil as it very effective in enhancing the properties of soil in a cost-effective manner. Using waste plastic (polypropylene fiber) also helps in reducing the waste and prevents environmental hazards.

The term "soil stabilization" refers to the use of controlled compaction, proportioning, and the addition of appropriate admixture or stabilizers to improve the soil's stability or bearing capacity. Physical, physio-chemical, and chemical processes are used to stabilize soil so that it can be used as an engineering material. Various methods of soil stabilization are:

**Mechanical method:** Soil of various gradations, i.e., different sizes of soil, is mixed and compacted in order to decrease voids and reach the desired density. This procedure can be used at the construction site or anywhere else where soil can be transferred. Cohesionless soil is rolled with a vibratory roller, while cohesive soil is rolled with a sheep foot roller.

**Chemical method:** In this process, specific additives are added in precise amounts to improve the soil's engineering properties. Some additives are Cement, lime, bitumen, fly ash, etc.

**Polymer stabilization:** In this method, to improve the physical qualities of soil, polymers are added. Various polymers have been found to promote water retention and prevent erosion, as well as boost soil shear strength and structure, at very low concentrations within soils.

In this study, waste polypropylene fiber is used as a reinforcement for stabilization of soil to study the effectiveness of the fiber in enhancement of properties.

## 2. PROBLEM INVESTIGATED

Stabilization of soil increases durability, strength, better soil gradation and reduction in voids. But the cost of stabilizing and improving the properties of the soil with the conventional methods (mechanical and chemical) such as compaction, use of admixture, injection of suitable grouts (cement, lime), etc. has become very expensive so, it is not used conveniently and economically. With the scarcity and high cost of the construction materials due to increasing demand, we can use plastic waste (polypropylene fiber) as a reinforcing material.

Plastic and materials made with plastic have become an integral part of our day-to-day life in various forms. The quantity of plastic waste is increasing very rapidly but the disposal and dumping of the plastic has become a major threat to the society. Disposing plastic waste by burning lead to large poisonous gases which pollutes air, land and water. It also decays or decomposes very slowly in the landfill. So, to tackle environmental pollution due to plastic it is used as a soil stabilizer as a reinforcing material.

So, the plastic waste (polypropylene fibers) was recycled and converted as fibers for reinforcement in the soil. It can be conveniently used as the fibers are cost effective, abundantly available and easy to use.

## 3. REVIEW OF LITERATURE

**K Bibhu Jyoti Patro, Satyapriya Senapti, Stabilization Of Clayey Soil By Using Polypropylene Fiber, Aug 2020.** Effects of polypropylene fiber on various mechanical behaviour of soft soil is investigated. To improve the plastic index and physical qualities of clayey soil, two distinct polypropylene fibres (BAJAJ fibre and CETEX fibre) of various tensile strengths were examined. They want to see how different percentages of four different types of fibre affect the results, such as 0.15 percent, 0.25 percent, 0.50 percent, 0.75 percent, and 1 percent. They use some parameters to calculate the proportion of reinforcement, such as tensile strength, compressive strength, and CBR value, which are all dependent on compaction properties. Both fibres were tested at 6mm and 12mm in length. They discovered that 12mm fibres have a higher tensile strength than 6mm fibres. They found that BAJAJ fibre (12mm) length has the highest compressive strength when compared to other fibres in this experiment.

**K. Yugandhara Reddy, SK. Rashid, V.M.V. Sai Krishna, Waste Plastic Fiber Reinforced Soil, July 2018.** Plastic waste disposal in the environment is seen as a major issue due to its low biodegradability and presence in vast numbers**.** They used waste plastic fiber (polypropylene fiber) to evaluate the strength by conducting California bearing ratio and unconfined compression test. This test was done to check the effectiveness of stabilization using fiber as a cost-effective method. The result shows that cohesion value increases by 19.19% and 19.50% for 0.4% and 0.8% reinforcement as compared to unreinforced soil. The unconfined compressive strength increases by 11.26% for 0.4 percent and 12.10% for 0.8 percent reinforcement. The result also shows that the CBR value of soil increases with the addition of plastic fiber reinforcement, this helps in reducing the thickness of subgrade for the flexible pavements.

**Sourav Pal, Joyanta Maity, B. C. Chattopadhyay, Application of waste plastic bottle for the improvement of alluvial soil, March 2018.** There is a fast increase in waste plastic bottles due to unavailability of proper disposal technique or low recycling ratio. They studied the stabilization with randomly distributed waste plastic fibers on clayey alluvial soil at different percentage of fibers by weight of soil. In this research waste plastics are added in 0.25%, 0.5%, & 0.75% by weight in different sizes of 1*1, 2*1 &3*1 cm in different proportion and then strength and compaction tests are done.

They found that maximum dry density increases of soil increase up to certain percentage of fibers. Optimum moisture content decreases with addition of fibers. CBR value also increases maximum for 0.25% of dimension 1*1 cm shows plastic strips reinforcement is very effective.

**Atiqur Rahman & Anwesha Gayan, Soil Stabilization Using Polypropylene Fiber, 2018.** Engineering constructions built on weak or soft soil are considered unsafe. A variety of ground enhancement procedures can be used to improve the ground's load bearing ability. In this study polypropylene fibers (0.1%, 0.2%, 0.3% by weight) are randomly distributed to form homogenous mixture and various test are conducted. The result shows that the unconfined compressive strength increases by 43.87% and 258.70% for 0.1% and 0.2% of fiber respectively. This study concluded that the use of fibers is very effective in engineering projects on weak soils

**Navdeep Singh Sodhi, Shish Pal, Vinod Kumar Sonthwal, Soil Strengthening Using Waste Materials, Dec 2017.** Huge amounts of structural concrete waste and the unusually long durations necessary for natural decomposition of waste plastic, they are frequently the most visible component in garbage dumps and open landfills, causing major environmental problems**.** In this study fines from structural waste and the plastic waste (Polypropylene) are added in the mixed soil in varying lengths of 10mm, 20mm, and 30mm at different percentages of 0 percent, 0.15 percent, 0.25 percent, and 0.35 percent of waste fibre material by weight of the dry soil sample. Maximum Dry Density at Optimum Moisture Content and Direct Shear Strength Parameters for 20 mm length and 0.35 percent weight of polypropylene fibre, the dry density increased by 5.03 percent, and the direct shear strength characteristics showed maximum increases in cohesion by 53.12 percent and angle of internal friction by 23.77 percent. The optimum amount of fiber for direct shear test is found to be of 20 mm length and 0.35% by weight of dry soil.

**Dr. Babitharani.H, Pavan siva kumar.Ch, Sindhu Shankar, Dimple Bahri, Koushik .B., Soil Stabilization Using Plastic, Sept 2017.** Plastic product use, such as polythene bags and bottles, is expanding, causing a variety of environmental hazards. As a result, disposing of plastic garbage without endangering the environment has become a major concern. As there is a scarcity of good soil for construction, employing plastic as a soil stabiliser is an ecological application. This study uses polypropylene fibre as a reinforcement in soil and investigated his direct shear strength parameters and unconfined compressive strength and the result shows that cohesion value increases by 100% and the increment graph for cohesion shows a decline in slope, the angle of internal friction shows a substantial increase a net of 20% and the graph shows alternate rise and fall. UCS value increases a net of 50%, and it was concluded that fiber reinforced soil can be considered to be good for enhancing engineering properties of soil. Fiber reinforcement can be used as a substitute for deep and raft foundation thus, reduces the cost.

**Prof. Harish C, Ashwini HM, Stabilization of Soil By Using Plastic Bottle Strips as a Stabilizer, Aug 2016.** Plastic material items such as bottles and polythene carry bags have become increasingly prevalent in our daily lives, resulting in increased waste of plastic material**.** Discarded plastic bottles are cut into small strips and these strips are added in small percentages to the soil (0, 0.2, 0.4, 0.6, and 0.8 percent) and various tests are conducted such as Atterberg limit test (liquid limit, plastic limit), compaction test, CBR tests. The soil become stabilised, i.e., its load bearing capacity and strength properties such as shear strength are increased through controlled compaction. Soil stabilisation using waste plastic bottles greatly improves the soil's strength properties. Result shows, it is one of the greatest solutions for re-using plastic waste because it is cost-effective and risk-free.

**Jasmin Varghese Kalliyath, Jithin Thomas Joy, Jeny Merin Paul Antony Mathew Vadakkel, Soil Stabilization using Plastic Fibers, June 2016.** Clayey soil has high swelling and shrinkage property causing decrease in strength of the soil in wet condition. The objective of this study is to analyze properties of soil after addition of plastic fibers in (0.25%, 0.5%, 1%, 1.5%). They studied the performance of plastic fiber as a soil stabilization material. The results showed that up to 0.5% plastic fibers in expansive clayey soil reduce OMC, increases MDD and unconfined compressive strength of the soil but after 0.5% decreases MDD and unconfined compressive strength. The optimum amount is 0.5% for maximum increase in engineering properties and also it proves to be economical.

**Satyam Tiwari & Nisheet Tiwari, Soil Stabilization using Waste Fiber Materials, Apr-May 2016.** Used waste polypropylene fiber as a reinforcement in soil in small percentages and the following conclusion were made: With mixing of 0.5% fibers, the specific gravity increases by 0.3%. For reinforced soil, the liquid limit decreases by 18.18 percent. The soil's plastic limit also decreases from 29.35 percent to 25.8 percent shows 12 percent fall in plastic limit. It also lowers the soil's shrinking limit. This ultimately lowers the swelling and shrinkage of soil.

**S. Saravanaganesh, R. Priyanka, S. Sinduja, K. Balakumar, A. Chellaiah, Experimental Study on the Stabilization of Soil by Using Plastic Wastes, 2016**. During the rainy season, the road pavements and sub-grades are severely damaged, resulting in road failure. Rainwater will infiltrate the subgrade's surface, weakening its stability. In this study they used different percentages (0%, 5%, 10%, 15%, 20% & 25%) of polypropylene granules of length 300 mm to 500 mm for stabilisation of soil, when varying percentages of plastic are added, the optimum moisture content increases, and the maximum OMC attained is 16 percent for 15% plastic granules with 1.72 dry weight. The compaction curve also illustrates that the addition of plastic fibre enhances the OMC. Also, the CBR value rises with the presence of plastic granules in the soil. According to the results of this study, red soil can be used as a subgrade soil. This strategy is both cost-effective and ecologically sustainable for increasing strength and plastic content.

**Shish Pal1, Vinod Kumar Sonthwal, Jasvir S Rattan, Soil Stabilisation Using Polypropylene as Waste Fibre Material, Nov 2015.** Plastic waste production is rapidly increasing as a result of increased economic activity and consumption. In the soil, waste polypropylene fibre was used as reinforcement. The MDD, direct shear strength, and unconfined compressive strength (UCS) of the soil were measured after polypropylene fibres of various lengths of 10mm, 20mm, and 30mm were mixed homogenously at different percentages of 0.15 percent, 0.25 percent, and 0.35 percent by weight of dry soil. The results

demonstrate a slight decrease in MDD with fibres, a maximum increase in direct shear strength parameters for 20mm length and 0.35 percent weight of polypropylene, and a 52.80% increase in UCS at 0.25 percent. The UCS also increases maximum for 20 mm length and 0.25% fiber.

**Soundara, B, Senthil kumar, K. P, Effect of Fibers on Properties of Clay, May 2015.** In countries such as India, where such materials are locally and economically available, the use of natural fibres such as coir for soil enhancement is particularly appealing in terms of environmental protection and cost effectiveness. The study showed a possible use of coir as a soil stabilising material, with the following conclusions: With increase in the fiber percentage optimum moisture content of the soil fiber mix increases and maximum dry density decreases. The addition of coir and polypropylene fibres to soil increases the CBR value. The CBR of reinforced soil is double that of unreinforced soil. And the result shows 1% fibre in soil is economically used in road pavement and embankments.

**Pramod, S. Patil, Innovative techniques of waste plastic used in concrete mixture, June -2014.** Plastic waste disposal is regarded as a major issue in the environment due to its low biodegradability and abundance. In recent years, industrial wastes such as polypropylene (PP) and polyethylene terephthalate (PET) have been investigated as possible replacements for some of the traditional concrete aggregates. Plastic recycling is taking place on a large scale in India. As much as 60% of both industrial and urban plastic waste is recycled, according to various authors. Masses in India have released plastic wastes on a large scale have huge economic value, as a result, recycling of waste plastics plays a significant role.

**Chebet, F.C. and Kalumba, D., Laboratory investigations on reusing polythene (plastic) bag waste material for soil reinforcement in geotechnical Engineering, June 2014.** The increased shear strength and bearing capacity of locally produced sand as a result of the random inclusion of strips of high-density polyethylene material from plastic shopping bags is described in this paper. The shear strength and bearing capacity of locally available sand are increased when random strips of HDPE (high density polyethylene) material from plastic shopping bags are mixed in. The enhanced strength of the reinforced soil is attributable to tensile strains mobilized in the reinforcements, according to a visual inspection of the plastic material by the tests and analyses. The plastic qualities (concentration, length, and width of the strips) as well as the soil properties were found to have an impact on the reinforcement material's efficiency (gradation, particle size, shape).

**Rajkumar Nagle, Prof. R. Jain, Prof. A.K. Shinghi, Comparative study of CBR of soil reinforced with natural waste plastic material, June 2014**. In this study, polyethylene, food wrappers, carry bags and bottles are reinforced and CBR studies are done to enhance the subgrade properties. They conducted the study on black cotton soil, yellow dirt and sandy soil. According to their result, the value of MDD and CBR increases as the amount of plastic garbage increases. Selected soil material's load bearing capacity and settling characteristics are also improved. As a result, it shows that using waste plastic strip as a soil stabilizing agent for sub-grade material can greatly reduce base course thickness. This shows that appropriate-sized plastic waste strips could be useful as soil reinforcement in roadways

**Akshat Mehrotra, Hadi Ghasemian, D.R. Kulkarni, and N.R. Patil, Effect of HDPE plastic on the unconfined compressive strength of black cotton soil, January 2014.** Black cotton soil is a type of expansive soil due to montmorillonite particles causing swelling in wet and forms cracks in dry condition. They examined the impact of HDPE plastic waste on soil UCS. HDPE plastic (40 micron) trash was added in proportions of 1.5 percent, 3 percent, 4.5 percent, and 6% of the weight of dry soil. They came to the conclusion that adding plastic garbage to black cotton soil raised its UCS. The greatest strength attained when 4.5 percent plastic garbage was mixed with soil was 287.32KN/$m^2$, which is higher than the natural soil strength of 71.35KN/$m^2$.

## 4. CONCLUSIONS

Following conclusions are drawn from the literature presented in this review:

(i). Various research work shown that the waste plastic (polypropylene) fibre reinforcement is very effective in improving the engineering properties of soil.

(ii). It will increase its unconfined compressive strength, ductility, shear strength, California bearing ratio etc.

(iii). It decreases the maximum dry density with increase in fibers percentage as the specific gravity of the fiber is very low.

(iv). In the case of flexible pavement, increasing the California bearing ratio reduces the thickness of the subgrade.

(v). It is also shown from the researches that the use of plastic products such as wrappers, bottles, and containers can also be used as a reinforcement in soil.

(vi). Experiments shows that the randomly oriented fibre reinforcement is advantageous than the oriented fibre reinforcement as in oriented it creates a failure plane along its orientation.

(vii). Using waste polypropylene fibre as a stabilizer is very economical and it also helps in reducing the wastes creating ecological hazards.

(viii). It is the most effective way to dispose non-biodegradable waste.

(ix). This new approach can effectively meet society's issues, and it may greatly improve the properties of soil used in road infrastructure, foundations, embankment stabilization, pavement subgrade, and other fields, depending on the needs and adaptability.

(x). Still a large amount of research is needed to determine its effectiveness and limitations in various fields.

**5. NEED FOR PRESENT STUDY**

According to review of literatures, polypropylene fiber is very advantages in enhancing the engineering properties of soil. As it is widely used all over the world leads to production of large amount of waste that can be easily used for stabilizing the soil cost effectively and also helps in reducing the amount of non-biodegradable and non-disposable waste creating ecological hazards, it also decreases the land requirement for waste disposal.

Therefore, in this paper study was done for the utilization of waste polypropylene fiber in the stabilization of soil.

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