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A Review paper on Stabilization of Soil using Plastic waste as an additive

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Abstract: *Soil is a natural occurring building/construction material which is available in abundance. With the advancement in technology and construction activities the quality of soil has been degrading over time, moreover increasing the cost as well. Stabilization of soil is required to maintain the quality of soil to be used for the foundation work in the permissible limits. Various techniques ranging from physical to chemical has been developed to treat the soil and stabilize it for using the soil in the foundation work, But cost and environmental hazard do always come handy in those situations. So in order to fulfil the purpose of soil stabilization, there was a need for a more economic and eco-friendly alternative. Many researchers have studied and developed several such techniques of soil stabilization for increasing the bearing capacity, increasing shear strength, reducing the swelling properties of the soil. Mostly the techniques included using of plastic material, Fly ash and sometimes cement as well. This project has been developed by keeping in mind the two most important factors for soil stabilization (i.e.) Economic factors, and Eco-friendly nature of the project. Chips of High Density Polyethylene has been used as an soil additive for stabilizing the soil.*

Key Words: Soil, Soil stabilization, High Density Polyethylene (HDPE), Atterberg's tests, California Bearing Ratio (CBR), Economic, Eco-friendly.

1. Introduction:

Soil stabilization is the process of refining the physical and chemical parameters of soil up to a suitable extent where soil can show significant results in Bearing capacity, Shear strength, etc. All these properties of soil makes soil a foundation material. Soil stabilization includes procedure such as mixing different types of additives in soil such as plastic strips, moorum husk, fly ash, etc. in order to increase it's physical and chemical properties. Shrink-well properties, Shear strength, bearing capacity are improved. Plastic is a synthetic, non-renewable material which has a very negative impact on the natural environment. Plastic is the most common type of solid waste contributing almost 90% of total solid waste, and most of it being non-renewable in nature. Instead of dumping such kind of wastes into the clean environment. Various industries uses processes such as re-moulding of plastic and creating new articles out of it. But certainly all of the plastic can not be treated in the same way. Using these plastics for the stabilization of naturally occurring soil to increase its physical parameters and properties is one of a revolutionary method of reusing the waste plastic and reducing its content from nature. Stabilized soil is the one which has higher shear strength, higher California Bearing Ratio (CBR Value), and high bearing strength. Such type of soil is very useful in construction of different types of foundation works. If the foundation of a structure is strong, the structure will be less susceptible to a collapse. Plastic waste is fast becoming a widely recognized problem. While it is an important material for our economy, providing multiple benefits to modern day living, plastic can take thousands of years to biodegrade. It takes up valuable space in landfill sites and is polluting the natural environment, having a significant impact on our oceans. The majority of plastic waste does not get reused or recycled and experts believe that 50% of plastic is single-use, meaning it is used once before being discarded. Single-use plastic includes plastic water bottles, plastic packaging, plastic grocery bags etc. Most types of plastic are in fact recyclable, but most municipal governments do not have the infrastructure in place to carry out this energy-intensive process. Recycling plastic not only requires large amounts of energy but also uses large quantities of water. For many years, road engineers have used additives such as lime, cement and cement kiln dust to improve the qualities of readily available local soils. Laboratory and field performance tests have confirmed that the addition of such additives can increase the strength and stability of such soils. However, the cost of introducing these additives has also increased in recent years. This has opened the door widely for the development and introduction of other kinds of soil additives such as plastics, bamboo, liquid enzyme soil stabilizers etc. Soil stabilization using raw plastic bottles is an alternative method for the improvement of sub grade soil of pavement. It can significantly enhance the properties of the soil used in the construction of road infrastructure. Results include a better and longer lasting road with increased loading capacity and reduced soil permeability. This new technique of soil stabilization can be effectively used to meet the challenges of society, to reduce the quantities of waste, producing useful material from non-useful waste materials that lead to the foundation of sustainable society. It can be effectively used in strengthening the soil for road embankments and in preparing a suitable base for the upper pavement structure. Since it increases the bearing capacity of soil considerably, the land use can be increased. It can

lower the road construction and maintenance costs while increasing the overall quality of its structure and surface. The promise that soil stabilization technology can actually improve the mechanical qualities of local road soil so that stronger, more durable roads can be built has prompted national road ministries around the world to conduct extensive testing to verify that this new technology is truly cost-effective. The result is that this new advance in soil stabilization technology is increasingly being used in both constructing and improving/rehabilitating unsurfaced and paved roads worldwide.

2. Literature Review: The literature shows limited but sufficient work has been done on plastic waste mixed in soils in the recent past, researchers studied behavior of plastic reinforced soil by adopting various methods and approaches. Their main parameter of study were effect on shear strength, and compressibility characteristics of soils with randomly distributed plastic waste strips/chips in soil. The common results from the literature included the increase in shear strength, unconfined compressive strength and tensile strength of the soil.

1. **Babu, G.L. Sivakumar et.al (2010)** studied strength and compressibility response of plastic waste mixed soil. Based on experimental test results, it is observed that the strength of soil is improved and compressibility reduced significantly with addition of a small percentage of plastic waste to the soil. . According to his investigation, simple way of recycling plastic water bottles in the field of civil engineering as reinforcing material. The plastic waste mixed soil behaves as reinforced soil, similar to fiber reinforced soil. On basis of laboratory comparative study for clayey and composite soil. It shows that, there is improvement in engineering properties of clayey plain soil, due to randomly oriented optimum 2.0% plastic strips/ chips. This will be help to develop new pavement stabilization technique.

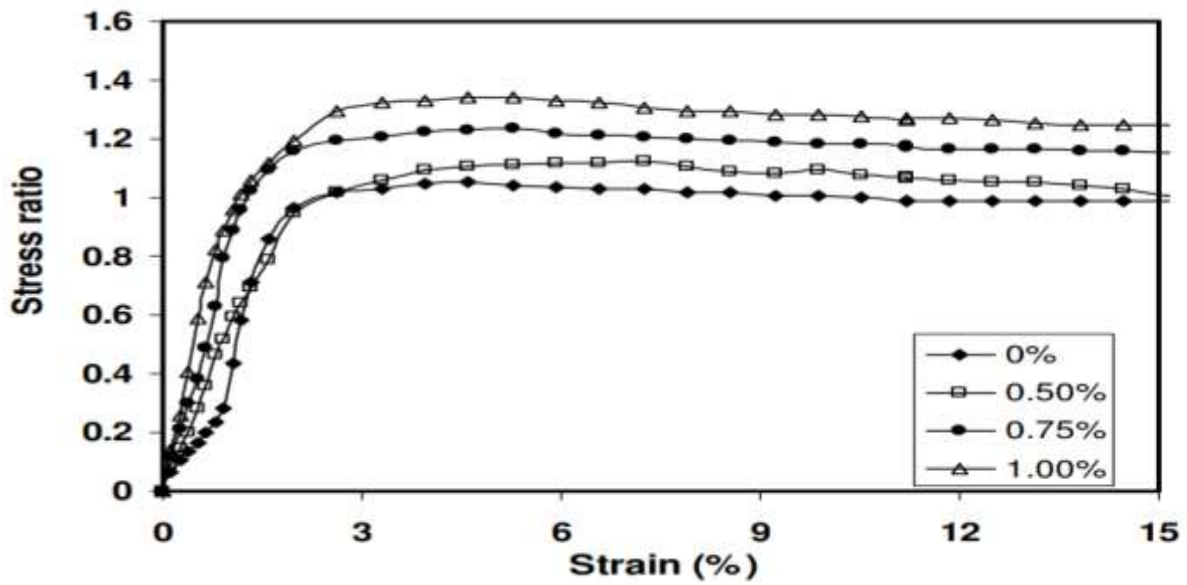

Figure 2.1: Stress versus Strain

2. **Choudhary A.K. et.al. (2010)** studied CBR behavior of waste plastic strip reinforced soil. In his study, a series of California Bearing Ratio (CBR) tests were carried out on randomly reinforced soil by varying percentage of HDPE strips with different lengths and proportions. Results of CBR tests demonstrated that inclusion of waste HDPE strips in soil with appropriate amounts improved strength and deformation behavior of subgrade soils substantially. The proposed technique can be used to advantage in embankment/road construction.

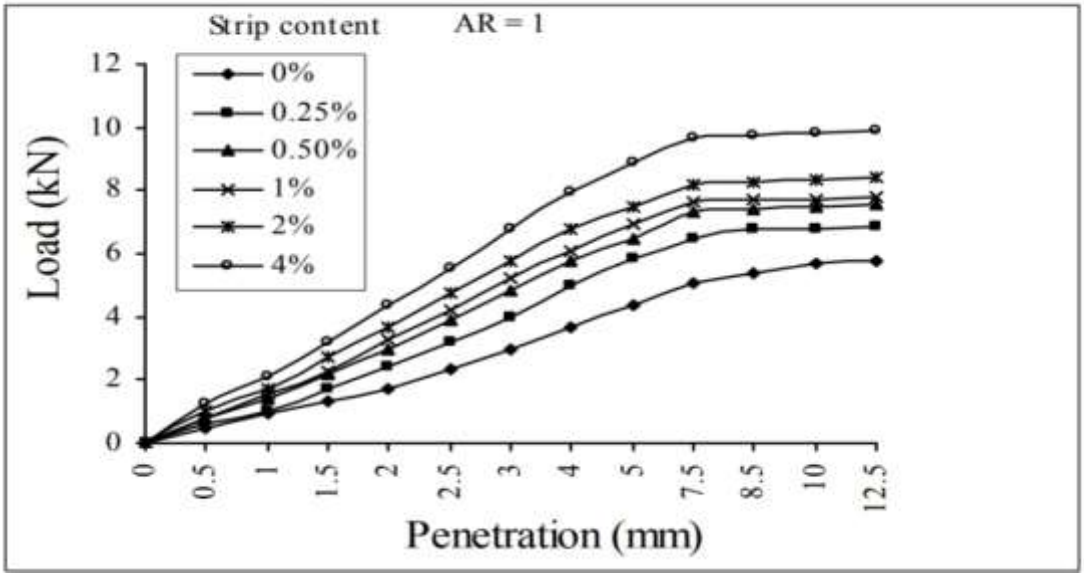

Figure 2.2: Load versus Penetration

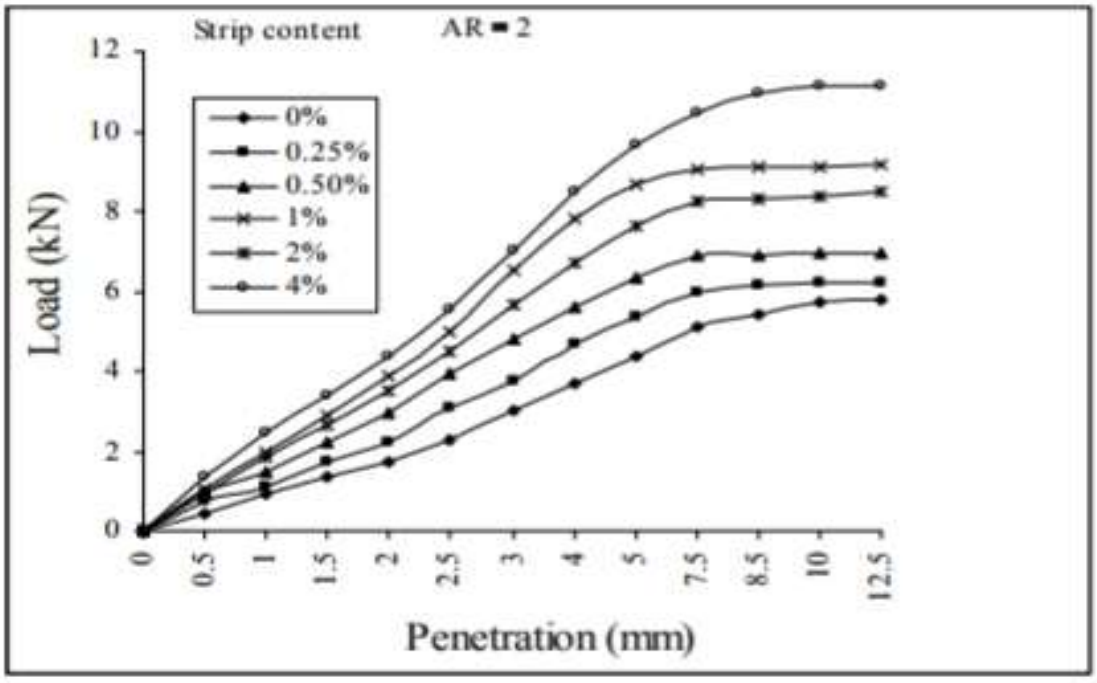

Figure 2.3: Load penetration curve for varying strip content having AR=2

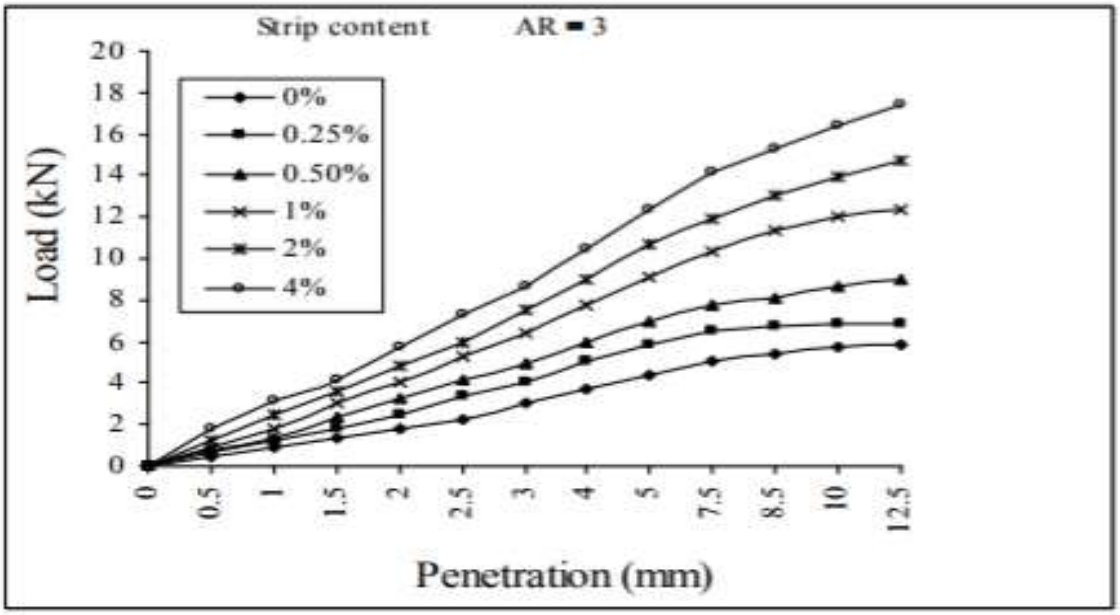

Figure 2.4: Load penetration curve for varying strip content having AR=3

3. **Anas Ashraf et.al (2011)** conducted experimental analysis on soil stabilization using raw plastic bottles. Their analysis was done by conducting plate load tests on soil reinforced with layers of plastic bottles filled with sand and bottles cut to halves placed at middle and one third positions of tank. The comparison of test results showed that cut bottles placed at middle position were the most efficient in increasing strength of soil. The optimum percentage of plastic strips in soil was found out by California Bearing Ratio Test and using that percentage of plastic, plate load test was also performed. The size and content of strips of waste plastic bottles have significant effect on the enhancement of strength of the soil.

4. **K.Geetha Manjari et.al. (2011)** presented paper on 'Compressibility and permeability behaviour of plastic waste mixed Sand'. According to their investigation, they provided experimental results on the one dimensional compression test and permeability for plastic waste mixed sand. Based on experimental test results, it was observed that the compressibility and permeability reduced significantly with addition of a small percentage of plastic waste to the soil. In his analysis, to investigate the effects of plastic waste on the engineering properties of soils, a series of tests were performed on sand. One-dimensional consolidation test was performed for different percentages of plastic waste mixed sand.

5. **Proff.Harish C, ashwini HM** also researched on soil stabilization using plastic waste. The waste plastic material i.e. plastic bottles are used in this project. The waste plastic bottles are taken and cut into small strips. The addition of these small strips in the soil by different percentage and conduct tests such as liquid limit, plastic limit, compaction test, CBR test etc. Then soil becomes stabilized i.e. increasing the load bearing capacity of the soil and also strength properties such as shear strength with a controlled compaction. Soil stabilization by using waste plastic bottles which significantly enhance the strength properties of the soil.

6. **Choudhary, Jha and Gill et.al. in 2010** demonstrated the potential of HDPE to convert as soil reinforcement by improving engineering properties of sub grade soil. From waste plastic HDPE strips are obtained and mixed randomly with the soil and by varying percentage of HDPE strips length and proportions a series of CBR tests were carried out on reinforced soil. There results of CBR tests proves that inclusion of strip cut from reclaimed HDPE is useful as soil reinforcement in highway application. Attempts have been made in the study to demonstrate the potential of reclaimed high density polyethylene strips (HDPE) as soil reinforcement for improving engineering performance of subgrade soil. HDPE strips obtained from waste plastic were mixed randomly with the soil. A series of California Bearing Ratio (CBR) tests were carried out on randomly reinforced soil by varying percentage of HDPE strips with

different lengths and proportions. Results of CBR tests demonstrated that inclusion of waste HDPE strips in soil with appropriate amounts improved strength and deformation behavior of subgrade soils substantially. The proposed technique can be used to advantage in embankment/road construction.

7. **Sharan Veer Singh, Mahabir Dixit** studies conducted by various researchers, it can be concluded. The plastic inclusions can improve the strength thus increasing the soil bearing capacity of the soil. Every year a lot of plastic waste is generated and occupied a lot of space. It is necessary to find a solution for this problem. Based on literature, one of the solutions is use of plastic waste in soil reinforcement and stabilization. Results of various researchers give positive indication to the possibility of using the versatile plastic products such as plastic bags, bottles, containers and packaging tapes etc. for reinforcement and stabilization of soil. Disposal of plastic waste without environmental hazards has become a real challenge for our society. Therefore, the use of plastic waste as a soil stabilizer is a cost effective and profitable use. Use of plastic waste as reinforcement is recommended to reduce the quantities of plastic waste, which creates the disposal problem. Successful application of plastic waste could help to reduce the amount of plastic waste which is disposed of to landfills and contribute to sustainable development by providing low cost material to the resource intensive geotechnical industry. Nominal research has been done in India to determine the availability of feasible waste materials and the suitability of these materials for Indian roads. The results are better and more durable with a higher strength and reduction of permeability of the soil. However further study is needed,To optimize the percentage of plastic waste content. Large scale test is also needed to determine the boundary effects influence on the test results.

8. **Achmad Fauzi et.al. in 2016** The performance of pavement depends upon the quality of soil-subgrade. A stable soil-subgrade and properly draining pavement helped to produce a long-lasting pavement. Subgrade soil provides support to the remainder of the pavement system. The quality of the subgrade would be greatly influence the pavement design and the service life of the pavement. Road running in expansive soils areas are known for bad condition and unpredictable behavior for which the nature of the soil contributes to some extent. The failures of pavement, in form of heave, depression, cracking and unevenness are caused by the seasonal moisture variation in the subgrade soil

9. **F.C. Chebet and D. Kalumba et.al. in 2014** This paper presents a laboratory investigation into the resultant increase in shear strength and bearing capacity of locally sourced sand due to random inclusion of strips of high density polyethylene material from plastic shopping bags.A series of direct shear tests and bench-scape plate loadingtests was undertaken on soil-plastic composites of two selected sandy soils: Klipheuwel and Cape Flats sands. Strips of shredded plastic material were used as reinforcement inclusions at concentrations of up to 0.3% by weight. The effect of varying dimensions of the strips was investigated by using strip lengths from 15 mm to 45 mm and strip widths from 6 mm to 18 mm. Soil strength parameters were obtained for composite specimen from which analyses were carried out to identify the extent of soil improvement.Laboratory results obtained favourably suggest that inclusion of this material in sandy soils would be effective for soil reinforcement in geotechnical engineering.

10. **Vijay Kumar Patidar, Dr. Suneet Kaur** - Soil stabilization alters the physical properties of soil in order to improve its strength, durability, or other qualities to meet the engineering requirements. It can be achieved by adding suitable admixtures like cement, lime and waste material like fly ash, gypsum etc or by other suitable stabilization method. the cost of adding these additives has tremendously increased in past few years; there for there is need for the development of other kinds of soil additive such as plastic, bamboo etc and these new techniques of soil stabilization using plastic waste which can be effectively used to solve the challenges of society, thereby reducing the amount of waste plastic material. Use of polythene bags, bottles, and other plastic products is exponentially increasing year by year due to which we are facing various environmental problems. Therefore the correct way disposing off of the plastic waste without causing any ecological hazard has become a real challenge today. A review paper in presented here to focus on soil stabilization methods by using waste plastic products.

4. Conclusion: Based on the investigations, following conclusions are drawn:

Addition of stabilizer (High Density Polyethylene) HDPE in the soil improves the engineering properties of the soil. HDPE being one of the most common type of plastic used in industrial applications, contributes almost 90% of the total plastic waste alone. But, HDPE due to its consistent density and physical properties is a very effective and economical choice to be used as an additive in the pavement construction. The volume occupied by the HDPE in the total volume of mortar/concrete used increases the physical properties of soil beneath which it is laid. The overall strength, bearing capacity and the value of CBR is also increased. As looking on to the larger scale the plastic use can save a lot of capital without compromising for the quality of work.

5. Future Scope of the project: The soil in the study is natural specimen brought from the Ghaziabad District (U.P). Pavement subgrade is a big problem sometimes. Due to this reason, the roads require periodic maintenance to take up repeated application of wheel loads. This process of maintenance is a bit costly for its execution and sometimes due to adverse weather conditions cannot be accomplished. Therefore, a thought on how to enhance the stability of roads by cheaper means demands appraisal. Soil stabilization can be done using different additives, but use of High Density Polyethylene which is a common plastic waste from industries is a more effective and economical choice.

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