SOIL STABILIZATION USING PLASTIC STRIPS OF VARIED SIZES BY ENHANCING THE BEARING CAPACITY

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Abstract

In a country like India where the natality rate is 3 per second, availability of proper land for shelter and clean drinking water is a bizarre demand and hence economic methods are more acceptable than healthier methods which inturn leads to excessive use of chemically manufactured plastics for all kind of day to day activities. The undesirable effects of plastic use which consecutively leads to pollution which must be eliminated or at least reduced. Rapid improvements in the engineering world have influenced a lifestyle of human beings in utmost extends but day to day activities of mankind are augmenting risk in the environment in the same proportion. Plastic wastes have become one of the major problems for the world. The harmful gas which is being produced during manufacturing and burning of plastics leads to carcinogenic pollutants. So, effective consumption of plastic waste in engineering application has become one of the challenging jobs for environmental, geotechnical engineers. Plastic is considered as one of the most hazardous pollutants of environment as it would not decay or can't be destroyed rather interferes with the decaying of other components. So the only way to reduce these hazards of this non- biodegradable materiel is to use it in different application in engineering field beneficially. With the huge demand of construction render the civil engineers to use the weak lands as construction site after treating the soil medium by different stabilizers. Nowadays the civil engineers are using non-traditional stabilizing agent in ground improvement technique. Application of plastic waste in various forms is one of the emerging area of ground improvement technique. The implementation of plastic waste as stabilizer is economic and eco-friendly. In this paper plastic strips obtained from polythene bags have been used as stabilizer of soil after carrying out a series of tests which is conducted on fibre reinforced soil with varying fibre content and different aspect ratio. A detail analysis of their results depicts that it can be used in the fields effectively and economically as reinforcing materiel. Plastic strips of varying aspect ratio are were mixed randomly with the soil and California Bearing Ratio (CBR) tests were performed. Aspect Ratio is determined by changing its length and width. From the CBR on soil with and without plastic reinforcements it was found that after reinforcement the soil gained its strength appreciably.

Keywords— ***California Bearing Ratio (CBR), Environmental Hazard, Fibre Reinforcement, Non-biodegradable materiel, Plastic Waste, Stabilizing Agent, Strength of Sub Grade Soil.***

1. INTRODUCTION

Soil forms the integral matrix of land segregated in a number of layers. Soil around the world are of various compositions and has varied physical, chemical and physiological properties which invariably comes into action when soil is subjected to external loads or pressure. Some of them may respond positively from engineering point of view and some may not. Positive response will be considered only when the mass is stable against normal and shear failures under loads. Due to scarcity of land in the present day the weak lands cannot be eliminated and must be put to use and hence the soil has to make capable enough to bear the incomings loads and external pressure. Thus stabilization of soil is an important task to be done before a construction is started. For this purpose a number of methods can be used. We have here considered the usage of geo textiles and its effects on stabilizing. Usage of geo textiles is preferable as it is available around us abundantly and also very cheap rates.

Plastics are considered as one of the important invention which has remarkably assisted in different aspect of life whether it might be in scientific field or others. Due to omnipotent scope of plastic other different materials such as paper and other are being replaced with it which was used for different purposes like household packing purposes, used by restaurant and all. It has omnipotent use in today's context but the use of plastic and its effect in the environment has made the use of this material in an ambiguity. It has become one of the major problems for the environment. The use of plastic has to be limited by now otherwise there would be harsh circumstances that human and environment has to face in near future. It is the fact that we can reuse the plastic and make it usable for number of times so that its wastage will be reduced remarkably. This steps are still in progress but this only hasn't been able to paced up as per expectation because

the use of this materials has increased in such a way that it is very difficult to limit them instead the alternative for those must be identified and process must be taken accordingly. India itself has witnessed a substantial growth in the consumption of plastics and increased production of plastic waste. It has become very tedious job to limit it. It is fact that the plastic waste is now considered as environmental hazard due to the "Use and throw" mechanism. India itself produces a waste of plastic of around 40 million tons per year. The same case is there for china and other countries the production is ample but the management of this is very limited which has created many adverse effects. It is expected that out of total waste the plastic itself would be of around 5%, which is a huge amount and that need to be addressed. The work must be in collaboration with the environment instead of doing the work against the environment so this is important task to make the things better by using plastic for alternative uses.

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. Various experiments are performed for undertaking the mechanical behaviour of a soil reinforced with the plastic strips. There are innovative uses of these materials for the several candidate waste materials in geotechnical and pavement applications. There is various researches which are done on the basis of evaluating the compressive, split tensile and flexural strength characteristic of a material and also in order to determine the effectiveness of recycled plastic strips which ensures in enhancing the toughness characteristics of the material. To use it as an effective reinforcing material a dimensionless toughness index is also advised. This might ensure as a promising material for the alternative materials for civil engineering sectors. In the same way other things also can be implemented in which the plastic soil based geo plastic materials can be produced by heating and mixing simultaneously recycled plastic bottles with soil at a specific temperature to melt the thermoplastic materials so that uniform fused mix can be attended. This aid in permeability and strength result of open graded aggregates stabilized with the reinforced one. Stabilization was coined as to make anything in a stable condition which itself is a challenging task and improvement of anything in particular stabilization of soil by increasing the bearing ratio of the soil with the aid of the plastic material which is being used up for the soil. Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties. It may also be defined as improvement of stability or bearing power of the soil by the use of controlled compaction, proportioning and/or the addition of suitable admixture or stabilizers. Soil stabilization is a collective term for any physical, chemical, or biological method or any combination of such methods employed to improve certain properties of natural soil to make it serve adequately an intended engineering purpose.

The basic principles of soil stabilization are:

- Evaluating the properties of given soil.
- Deciding the lacking property of soil and choose effective and economical method of soil stabilization.
- Designing the stabilized soil mix for intended stability and durability values.

There are different researches going on for incorporating the waste to the soil and stabilized the soil and various good outputs are being reflected back which can have tremendous positive outcomes. In this paper we have done California Bearing Ratio test (CBR) to check bearing capacity of the unreinforced and reinforced soil and the conclusions are made accordingly.

2. METHODOLOGY:

Soil sample used has been collected from GIFT campus located at Bhubaneswar (Odisha). Even before we check for the strength carrying capacity of the soil sample certain routine tests has to be carried out in order to classify the type of soil and its various geotechnical properties.

3.1. Geotechnical properties of soil

S. No.	Property of Soil	Value
1	Liquid Limit	28
2	Plasticity Index	3
3	Specific Gravity	2.72
4	Coefficient of uniformity (Cu)	1.362
5	Coefficient of Curvature (Cc)	0.037
6	Optimum Moisture Content	14 %
7	Maximum Dry Density	1.97

From the above results and using the plasticity chart the soil was classified as ML (Inorganic silt with low plasticity)

The process of calculation of CBR test was done as per the prescribed IS code which was done in the remoulded soil by the mean of static compaction. A number of such compacted specimens were prepared and compared with normal unreinforced soil sample and the comparisons were tabulated. Firstly, the collection of soil sample and the plastic waste were collected from the site. Then required amount of the strips in their appropriate sizes were cut and weighed according to required percentage. The experimental study involved performing a series of laboratory CBR tests on unreinforced and randomly oriented plastic strip reinforced soil specimen. Required amount of strips as well as soil was first weighed and then the strips randomly mixed with dry soil at obtained moisture content. The soil mass formed must be a homogeneous specimen. The soil was compacted in five equal layers by applying 56 evenly distributed blows with 4.89Kg hammer at free fall height of 30 cm. Due care was taken to ensure a homogeneous mix. A surcharge weight of

2.5 Kg was placed over the specimen, clamped over the base plate and the whole mould with the weight is placed under the testing machine. The penetration plunger is seated at the canter of the specimen and is brought in contact with the top surface of the soil sample by applying a seating load of 4Kg. The dial gauge for measuring the penetration values of the plunger is fitted in position. The dial gauge of the proving ring (for load reading) and the penetration dial gauge are set to zero.

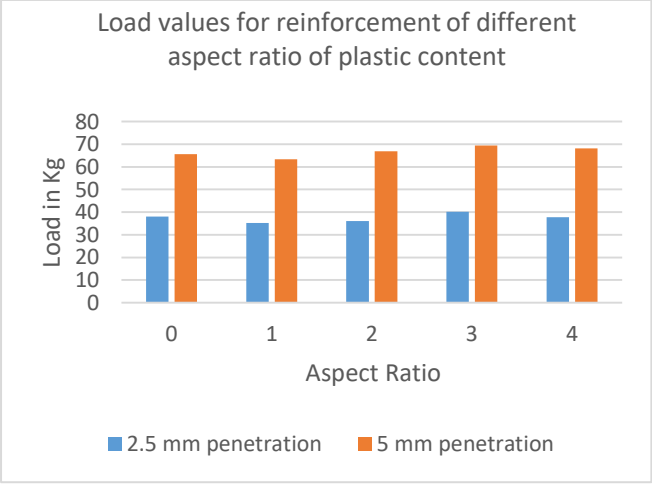
The load is applied through the penetration reading of deflection are taken with help of dial gauges of sensitivity 0.01mmfor 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 4.5, 7.5, 10.0 and 15.0mm.

The proving ring calibration factor is noted so that the load values can be converted into load in Kg. The proving ring states 1 division=13.12 Newton.

3. RESULTS & DISCUSSION:

3.1. Results for soil reinforcement with 0.25% of plastic strips:

Aspect Ratio	Penetration values for CBR evaluation	
	2.5 mm	5 mm
0	38.048	65.6
1	35.1616	63.3699
2	36.08	66.912
3	40.1472	69.4048
4	37.7856	68.224

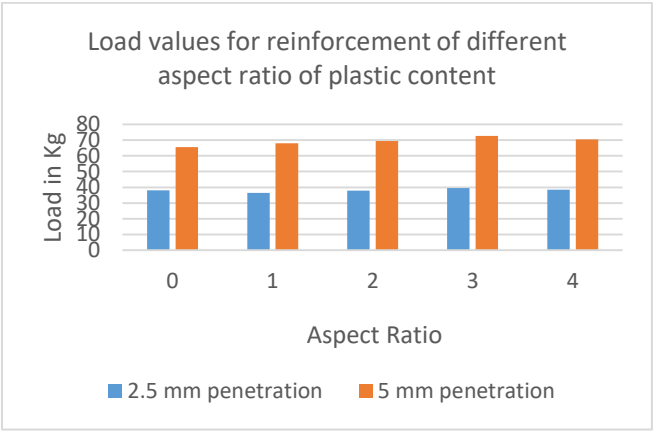


A consolidated graph is plotted by means of Microsoft excel which exhibits the different permissible loads for different values of reinforcements by means of short poly propylene fibres. In case of aspect ratio 1 s that the use of plastic has resulted in 4.1%increase for 2.5mm penetration and for 5 mm is about 3.6% of increase the value of CBR for values of reinforcements by means of short poly propylene fibres. In case of aspect ratio 1 it is seen that the use of plastic has resulted in decreasing the value of CBR for both penetrations by 7.6% and 3.4% respectively which is not desirable. So tests are carried on further. In case of aspect ratio 2 it is seen that the use of plastic has resulted in decreasing the value of CBR for penetrations of 2.5mm & 5mm by 5.17% and an increasing value by 2% respectively which again is not as desired. There is a stark difference between the 2 penetration values. In aspect ratio 3 it is seen that the use of plastic has resulted in increasing the value of CBR for both penetrations of 2.5mm & 5mm by 5.49% & 4.63% respectively which exhibits a better response as compared to the two previous cases. In case of aspect ratio 4 it is seen that the use of plastic has resulted in decreasing the value of CBR for penetrations 2.5mm by 0.7% which actually denotes negligible decrease and for penetration of 5mm it exhibits an increase of 4% thereby responds positively. Here it is seen that it is more effective than results of aspect ratio 1 and 2 but minutely lesser than the results of aspect ratio 4.

From the graph it can be easily said that maximum increase in CBR value is exhibited when the soil is reinforced with strips of aspect ratio 3 & 4. Though there is not much difference between the CBR values with tests of aspect ratio 3 and 4 but it can be noted that a slight decrease occurs in case of aspect ratio 4 which is due to excess cross sectional area covered by aspect 4 strips. But from tab-16 it is clearly notable that final load for 12.5mm penetration does not make much of a difference as compared to unreinforced soil mass. Another vital issue is that in case of aspect ratio 1 and 2 there is a considerable decrease in values even lesser than unreinforced soil sample. It is mainly due to the excess no. of strips that has to be used to keep the weight of 0.25% constant. This results in tearing off each layer of soil and they act as separate units instead of 1 single unit. So usage of 0.25% by weight of soil reinforcement is not an effective solution. We stopped at aspect ratio 4 because it is seen from the results that the increase in bearing capacity has started to decrease thereby stating that the remoulded soil has reached it extreme limits.

3.2. Results for soil reinforcement with 0.5% of plastic Strips

Aspect Ratio	Penetration values for CBR evaluation	
	2.5 mm	5 mm
0	38.048	65.6
1	36.47	68
2	37.92	69.536
3	39.39	72.82
4	38.44	70.58

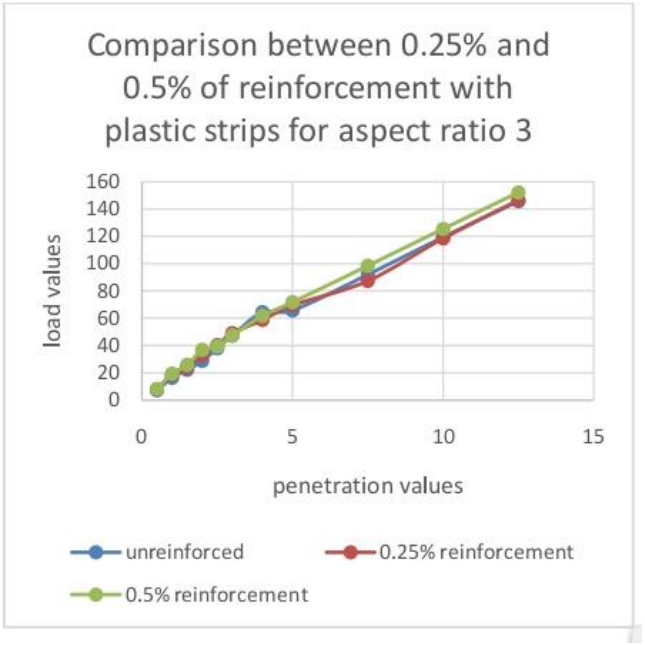


In case of aspect ratio 1 it is seen that the use of plastic has resulted in decreasing the value of CBR for penetrations of 2.5mm is 4.1% and for 5 mm is about 3.6% of increase. The results to some extent are very similar to the results 0.25% reinforcement because of nature of results as one increases while other decreases. In case of aspect ratio 2 it is observed that the use of plastic has resulted in decreasing the value of CBR for penetrations of 2.5mm is 0.33% & for 5mm it increases by 6% which is a desirable response. Here it can be said that for 2.5mm there is practically no change with soil bearing capacity but for 5mm there is a considerable enhancement. In case of aspect ratio 3it is seen that the use of plastic has resulted in increasing the value of CBR for penetrations of 2.5mm is 3.6% & for 5mm is 11% .These by far are the best responses. In aspect ratio 4it is seen that the use of plastic has resulted in decreasing the value of CBR for penetrations of 2.5mm is 1.05% and for 5mm is9%.These responses are good and better than those in aspect ratio 2 but slightly weaker than those in aspect ratio 3.

From the graph it can be easily said that maximum increase in CBR value is exhibited when the soil is reinforced with strips of aspect ratio. Though there is not much difference between the CBR values with tests of aspect ratio 3 and 4 but it can be noted that a slight decrease occurs in case of aspect ratio 4, which is due to excess cross sectional area covered by aspect 4 strips. Another vital issue is that in case of aspect ratio 1 and 2 there is a considerable decrease in values even lesser than unreinforced soil sample. It is mainly due to the excess no. of strips that has to be used to keep the weight of 0.25% constant. This results in tearing off each layer of soil and they act as separate units instead of 1 single unit.

After intensive analysis from the above discussions it is clear that the best fit case is achieved when reinforced with aspect ratio 3 in 0.25% and 0.5% plastic strips which is exhibited in the graph below.

Aspect Ratio	Penetration values for CBR evaluation			
	For 0.25% the increment w.r.t no reinforcement		For 0. 5% the increment w.r.t no reinforcement	
	2.5 mm	5 mm	2.5 mm	5 mm
1	0.75	0.96	0.96	1.04
2	0.94	1.02	0.996	1.06
3	1.055	1.06	1.035	1.11
4	0.99	1.04	1.01	1.08



In the above table it is seen that maximum increment occurs for aspect ratio 3 with plastic content 0.5% which is 11 % more with respect to unreinforced soil. Some of the increments are less than 1 which indicates that the addition of plastic is not beneficial in that particular case instead it reduces the bearing capacity. These studies indicated that stress strain strength properties of randomly distributed fibre reinforced soil are a function of fibre content and aspect ratio. Here it is seen that the increment values follow a particular pattern that is in case of aspect 1 and 2 the increment is negative whereas in aspect ratio 3 the increment is maximum and in case of aspect ratio 4 the increment is positive but it is lesser than that of aspect ratio 3.It has also been understood there are no exact empirical method to determine the required amount of plastic required for stabilization. It is a trial and error process. A number of tests for CBR values has to be calculated so that we can determine the optimum quantity of plastic strip and also the optimum size of the plastic to be used. It will vary for different types of soil. It is also clear that when the aspect value is further increased by definite proportion then in such a case CBR values improvement is remarkable.

4. CONCLUSION

The uses of plastic are in various field but after usage the waste has adverse effect in nature and it's not easy or possible to restrict its uses but it can be used as an soil stabilizing agent which would be economical and effective implementation in engineering field. Recently, many expensive methods for the stabilization process are carried on such as geo synthetic materials and other techniques. So, this technique can be replaced by the reinforcement with plastic strips which will make the construction process economical and also make the proper arrangement of plastic waste conserving the various component of the environment. The shear strength of fibre reinforced soil is improved due to the addition of the waste polymer fibres and it is a nonlinear function. Up to a critical fibre content shear strength increased considerably and later small

reduction is observed. However shear values are greater than unreinforced soil.

The feasibility of reinforcing soil with strips of reclaimed high density polyethylene has also been investigated to a limited extent It has been also reported that the presence of a small fraction of HDPE fibre can increase the fracture energy of the soil. Although, there has been a few studies on the subject of engineering behaviour of HDPE, reinforced soil needs a detailed study pertaining to its use in real life problems is still quite high.

5. FUTURE SCOPE

In future a number of variations can be done and iterated to find the different set of results. The same tests can be carried out with varying proportions and varying sizes. The orientation of the strips provided can also be altered (longitudinally or laterally or both or random distribution) plastics may also be used in combination with other geo textiles (jute) or sand or with different types of cement and other soil stabilizing agents like fly ash and rice husk . The test may also be iterated with waste or crushed plastic bottles filled with sand as a replacement of stone columns for stabilization. Here we have conducted only a lab test but later on we can also create a model of an embankment and check for its altered properties using the Universal Testing Machine (UTM). Then we can also account for the changes in improvement on field and in laboratory testing. Further studies can be done for improvement under different conditions of orientations and for different types of soil with plastics of different thickness. This technique can be effectively applied in construction of embankments proving it to be multipurpose because it not only strengthens but also preserves the environment.

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