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SOIL STABILIZATION USING PLASTIC WASTE

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Abstract: The process of improving the physical and engineering properties of soil such as shear strength and bearing capacity is known as Soil Stabilization. Indian terrain is mostly occupied by black cotton soil. It is highly expansive soil which shows more swelling, shrinkage and settlement problems. Thus, Construction of buildings and other Civil Engineering structures on this soil is risky. Use of compaction technique or suitable admixtures like cement, lime and waste material like fly ash, phosphagypsum etc can bring out the soil stabilization. But these are expensive additives. The research papers that we studied here suggest and proved that the use of plastic waste for stabilization of soils would reduce the problem of disposing plastic waste and also reduce environmental problems. It is seen that CBR test, Proctor test, Sieve analysis are performed to check the suitability of plastic waste as soil stabilizer. Sieve Analysis gives the physical properties of the soil sample. Modified Proctor Test gives the OMC and Dry Density of soil sample. CBR Test results the Optimum Plastic content. Optimum Plastic content is the percentage of plastic added in the soil sample above which the CBR value falls. Modified Proctor Test is recommended than Standard Proctor Test because the soil which is tested will be used for road construction which requires high compaction. This review paper concludes that soil stabilization is possible by plastic waste which is a cheap method of soil stabilization. This review paper motivates for the further studied with the change in dimensions of plastic strips and performing Plate load test may speak on the effect of plastic strips on bearing capacity of soil.

Keywords: Optimum Plastic Content, Plastic Waste, Dry Density, Plastic strips, Shear strength, California Bearing Ratio (CBR) test, Compaction test.

1.INTRODUCTION

Soil stabilisation is the process of development of strength or load bearing power of the soil by the adopting compaction techniques, addition of suitable admixture or stabilisers. The essential principles of soil stabilisation are:

- Studying the properties of given soil.
- Deciding the physical property of soil and choosing the effective and economical methods for soil stabilisation.
- Analysing the stabilised soil for intended stability and sturdiness values.

Stabilisation are often wont to treat a good range of sub-grade materials from expansive clays to granular materials. In wet weather, stabilisation can also be wont to provide a working platform for construction operations. These sorts of soil quality improvement are mentioned as soil modification. The determining factors related to soil stabilisation could also be the prevailing moisture content, the top use of the soil structure

and ultimately the value benefit provided [5]. The black cotton soil having good bearing capacity is scarcer and its location becomes harder and expensive, thus the necessity to enhance bearing capacity of soil using soil stabilisation is must. Using raw plastic bottles is non-traditional and alternate method for the development of subgrade soil of pavement. The properties of utilized soil can be significantly enhanced by the raw plastic bottles in the development of road infrastructure.

2. LITERATURE REVIEW

This enlists the work done by the Professors, students about Soil Stabilization by using Plastic wastes. The past research works on soil stabilization using plastic wastes are highlighted briefly from their work. This literature survey is arranged in a chronological order based on the year of publication and grouped as per the plastic wastes used.

2.1 Use of Plastic Bottles Cut to Halves

Anas Ashraf *et al* (2011) [2]: This paper showed that the soil stabilisation enhances the physical properties of soil such as increasing bearing capacity, shear strength etc. which can be carried out by use of compaction or the addition of other suitable admixtures like cement, lime and waste products such as fly ash, phosphogypsum and many others. The price to introduce these types of additives has also monotonously increased in the recent years which has opened the door to develop other kinds of soil additive materials such as plastics, bamboo and several others. Use of plastic products such as polythene products, bottles, PVC, etc. has increased hazardous urge to various environmental burdens which is why the disposal of the plastic wastes without causing any ecological hazards and ramifications has become a real plight. Thus, using plastic bottles as a soil stabilising material is an economical utilization since there is famine of good quality soil for embankments. Results are as shown in below table 1.

table 1 CBR values of soil with varying percentages of plastic content

% of Plastic Content	0.0	0.2	0.4	0.6	0.8	1.0
CBR Value	1.9	1.7	1.8	2.5	1.3	1.3

It was observed from the test results shown in table 1 that for soil which is mixed with plastic strips, the soaked CBR values have increased from 1.967 to 2.479 with 0.6% of plastic content and then gradually decreased. Therefore, the optimum value in percentage of plastic strip in the soil is found to be 0.6%. One peculiar aspect which was observed, that there was a cutback in the CBR value for plain soil i.e. 1.967 to 1.687 on addition of 0.2% plastic. This is because of the inclusion of very small amount of plastic strips into soil leading to a dispersed and disturbed structure of soi mass when compared to its compacted form. Also, the optimum moisture content was maintained the same as the initial value so as a consequence it also affected the decrease in the value.

Dr. Babitharani H. *et al* (2017) [4]: With the discussion on plastic wastes this paper mentioned the utility of plastic for improving soil stability. The cost of introducing plastic wastes additives has also increased in recent deacades which has opened the door for the non-conventional ways to improve soil stability. This new technique of soil stabilization can be effectively used to meet the challenges of the society to reduce the quantities of waste, producing useful stabilization from plastic waste. Hence, the disposal of plastic wastes without causing any ecological ramifications has become a real problem. Thus, using plastic as soil stabilizing material is an ecological utilization since there is scarcity of good soil for construction purposes.

There was an increase in cohesion which was found to be 50%,34.6%,22.4%,3.9% and 6.1% on Direct shear test with fiber reinforcement of 0.05%,0.15% and 0.25% respectively.There was an increase in the angle of internal friction (φ) which was estimated to be 10%, 3.9% and 6.1% respectively. As the net increase in the value of c and φ was found to be 100%, from 0.02kg/cm^2 to 0.04kg/cm^2 and 20%, from 35 to 42 degrees net increment, for such type of soil, the author recommends a randomly distributed polypropylene fiber reinforcement. The results from the Unconfined Compressive Strength test for the soil sample are also quite similar, for reinforcement of 0.05%, 0.15% and 0.25%, there is an increase in UCS value from the initial value which is found to be 35.31%,1.1% and 8.8% respectively. This increment is substantial and applying it for soil sample is recommended by the author.

2.2 USE OF PLASTIC STRIPS

Prof. Harish C., Ashwini H. M. (2016) [6]: This paper comprises of the advancement of suitable admixtures such as plastic wastes. Waste plastic materials i.e. plastic bottles in the form of strips are used in this paper work. The addition of these small strips of plastic in the soil mass by varying percentages and conducting tests such as liquid limit test, plastic limit test, compaction test, CBR test etc has proved out to be very efficient. The soil becomes stabilized i.e. the load bearing capacity of the soil has increased drasticaly and the strength properties such as shear strength were also improved with a controlled level of compaction. Soil stabilization by using waste plastic bottles which significantly boost up the strength properties of the soil. The results of the tests performed are shown in table 2 and table 3.

table 2 CBR values of red soil

% of Plastic Content	0.0	0.2	0.4	0.6	0.7	0.8	1.0
CBR Value	2.3	2.0	2.1	2.4	2.9	1.8	1.7

table 3 CBR values of black cotton soil

% of Plastic Content	0.0	0.2	0.4	0.5	0.6	0.8
CBR Value	2.7	2.5	2.6	3.3	2.1	2.1

The author used both Red soil and Black cotton soil which were collected from the flexible pavement. The composition of soil is as follows- 4% gravel, 88% sand and 8% silt &clay. After experimentation it was found out that the soil has a maximum dry unit weight of 20.12kN/m^3 and 20.03kN/m^3 and an optimum moisture content of 14% and 11% respectively was found out under standard proctor and modified proctor condition. Black cotton soil comprises of 2.6% gravel, 15.1% sand and 82.3% silt & 0.18% clay. It was found out that the soil has a maximum dry unit weight of 15.56kN/m^3 and 18.33kN/m^3 and an optimum moisture content of 13.63% and 10.78% under standard proctor and modified proctor condition respectively.

Arpitha G.C, Dayanandha B.V, Kiran Kumar Patil (2017) [3]: This paper exhibit that plastic such as shopping bags are used as a reinforcement to perform the California Bearing Ratio (CBR) studies in which the plastic is mixed with soil for improving engineering properties of sub grade soil. Plastic strips obtained from waste plastic were mixed randomly but uniformly throughout the soil mass. A series of California Bearing Ratio (CBR) tests were implemented on randomly reinforced soil by varying percentage of plastic strips with different lengths and proportions. The Results of these CBR tests demonstrated that the inclusion of waste plastic strips in soil mass in an appropriate amount has improved the strength and deformation behaviour of sub grade soils substantially. The graphs shown in figure 1 presents us the CBR value at varying percentages of plastic content.

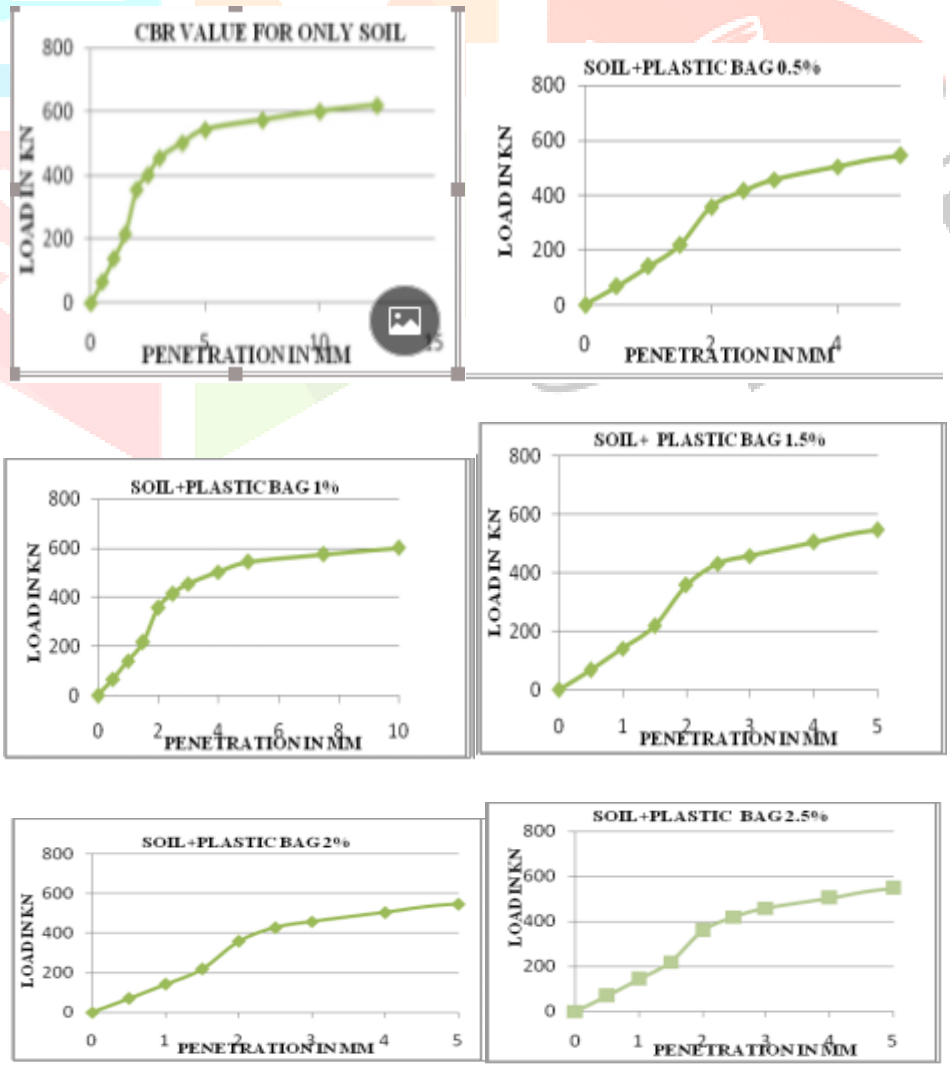

figure 1 CBR ratio of soil

In this study done by the author we can quite evidently see that the maximum CBR value was found out when 2%of plastic bottle strips were added to the soil strata but it decreased when the plastic strips were added any further amount. So, from this study, we found out that 0.75% is optimum amount of the strips that can be added to soil in order to have a profitable use.

Rituparna Das *et al* (2017) [10]: The implementation of plastic waste as stabilizer is economic and eco-friendly. In this paper, the author used plastic strips from polythene bags to use it as stabilizer of soil. Also, several tests were after carried out which were conducted on fibre reinforced soil with varying fibre content and different aspect ratio. A detailed analysis of their results interprets that, plastic can be used in the fields effectively and economically as reinforcing material. In the experiments performed by author, plastic strips of varying aspect ratio were mixed randomly throughout the soil and California Bearing Ratio (CBR) tests were performed. Aspect Ratio was found by changing the length and width of strips. From the CBR tests performed on soil with and without plastic reinforcements it was found that after reinforcement the soil increased its strength appreciably.

This paper is concentrating on the review of performance of plastic fiber as a soil stabilization material. The replacement of 0.5% plastic fibers to the expansive clayey soil reduce its OMC and increased the Maximum Dry Density. The unconfined compressive strength of the soil was found to be increased for 0.5%. With 1% replacement it was observed that the MDD & UCC was less than the 0.5% replacement but was greater than the untreated soil. Further increase in the plastic replacement showed decrease in the MDD and the Unconfined Compressive Strength of the soil. Based on the non-problematic soil criteria, the optimum percentage of plastic is recommended as 0.5% which will enhance the engineering properties of the silty clay.

N. Vijay Kumar *et al* (2017) [8]: This paper examines the problem of foundation with the loose soil specially with the black cotton soil. The problems in the soil were swelling, shrinkage and unequal settlement throughout the density. Plastic wastes are one of the major problems in this ever-changing world. Use of plastic bags, bottles and other plastic products is exponentially increasing over last few decades. Due to this fact we are facing various environmental ordeals. This review paper focuses on soil stabilization by using waste plastic products.Several tests such as liquid limit test, plastic limit test, standard proctor compaction test, California bearing ratio (CBR) test and unconfined compressive strength (UCS) were conducted by author to check for any improvement in the properties of black cotton soil. This paper reviews the work of various researchers on stabilization of soil and use of plastic and bottle strips materials in improving its strength. Table 4 and graph shown in figure 2 shows the variation of CBR value in accordance with the length of strips as a aftermath of the experiments execute out by the author.

table 4 comparison of CBR value and length of strips

CBR Value	3.34	5.23	6.20	5.24
Length of Strips (Cm)	0	2.5	5	7.5

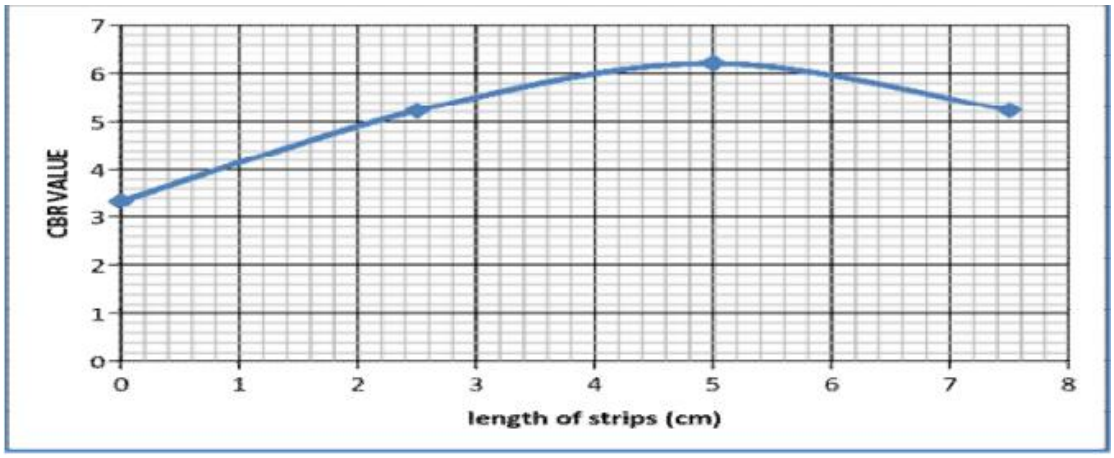

figure 2 graph CBR value vs length of strips (cm)

Values with different lengths like 2.5cm, 5.00cm and 7.5cm, in this 2.5cm to 5.00cm has CBR value 5.23 to 6.20 respectively increases and 5.00cm to 7.50cm length has CBR values which decreases from 6.20 to 5.24 respectively. So, from the results shear strength of the soil increases up to 5.00cm length of strips and after decrement vice–versa. CBR value for 5.00cm is 6.20 which is optimum length of strips used for sub grade design.

A. Burman, (2018) [1]: This paper presents a detailed study on the behaviour and use of waste plastic strips in soil enhancement. Several experimental investigations were performed on reinforced plastic soil and the results showed that, we can use plastic as an effective stabilizing material in order to come across the waste disposal situation as well as an economically sound solution for stabilizing poor soil framework. The soil which is reinforced with plastic content behaves in exactly the same way as fiber reinforced soil. This study involves the investigation and thorough analysis of the aftermath of plastic bottle strips on silty sand for which a series of compaction, direct shear and California bearing ratio (CBR) tests were performed with different percentages of plastic strips content and having different aspect ratios in terms of its size. The results show that there is a significant increase in maximum dry unit weight, Shear Strength Parameters and CBR value with plastic reinforced in soil mass. The leap of improvement in the soil properties depends on the type of soil used, plastic content n soil mass and size of strip used. It is observed from this study that, the improvement in properties of silty sand is achieved at 0.4% plastic content with strip size of (15 mm 9 15 mm).

In this paper it was cited that the dry seive analysis was performed and it is observed that the percentage of soil passing through 0.075 mm is more than 50%, so soil is classified as fine grained soil. Standard proctor test was also performed and it was found that the MDD and OMC values of silty sand are 16.75kN/m3 and 16.8% respectively.Direct shear test was performed on the natural soil specimen and it is observed that the cohesion and angle of internal friction are 19kN/m2 and 23.2 degrees respectively.

Sagar Mali, Sachin Kadam, Sagar Mane (2019) [11]: In this paper it is mentioned that expansive soils such as black cotton soil has often showed problems of swelling, shrinkage, & unequal settlement. Plastic waste has become one of the major problems of this ever-developing world. So, it is naturaly recommended that the use of plastic waste in any form for stabilization of various soils and using plastic content as soil stabilizing material would significantly reduce the trouble of disposing plastic waste and also helps in reducing fenvironmental issues. These evaluates the researches on stabilization of soil using waste plastic material in studying and improving its strength.

There was no experiment performed with regard to this paper. It was a study research paper on various methodologies and experimental investigations needed to improve different soil properties.

2.3 Use of General Plastic Wastes

I.Varshik Manikanta *et al* (2018) [7]: This paper discussed the problems of black cotton soil like - the black cotton soil is highly expansive which will show more swelling and shrinkage and settlement concerns. If we need to tackle this predicament, the soil properties need to be enhanced by a phenomenon known as soil stabilization. This can be done by pouring some external agents to it like coal, fly ash, bagasse and plastic. Various soil experiments such as- the liquid limit test, plastic limit test, California bearing ratio (CBR) test are conducted for the stabilized soil which will be show us the improved results in the properties of soil when compared.

The results of CBR values for Red soil are shown in Table 2.5 and graph shown in figure 3. Also, the results of CBR values for Black cotton soil are shown in table 6 and figure 4.The paper is mainly focused on the performance of plastic waste as a soil stabilization material. The improved CBR values of the soil are due to the addition of plastic strips If the plastic mixing percentage is exceeding 1% the CBR values are getting reduced.

table 5 CBR value for red soil

% of Plastic Content	0.0	0.2	0.4	0.6	0.7	0.8	1.0
CBR Value	2.5	2.1	2.2	2.4	2.95	1.9	1.68

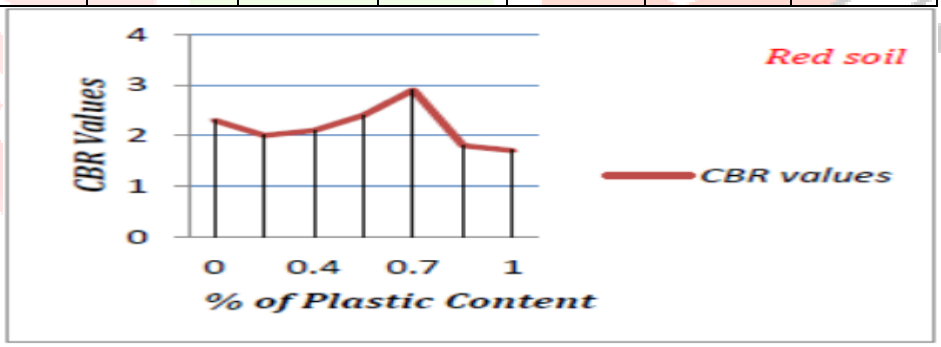

figure 3 graph of CBR value vs plastic content for red soil

table 6 CBR value of black cotton soil

% of Plastic Content	0.0	0.2	0.4	0.6	0.7	0.8
CBR Value	2.85	2.51	2.5	3.31	2.2	2.1

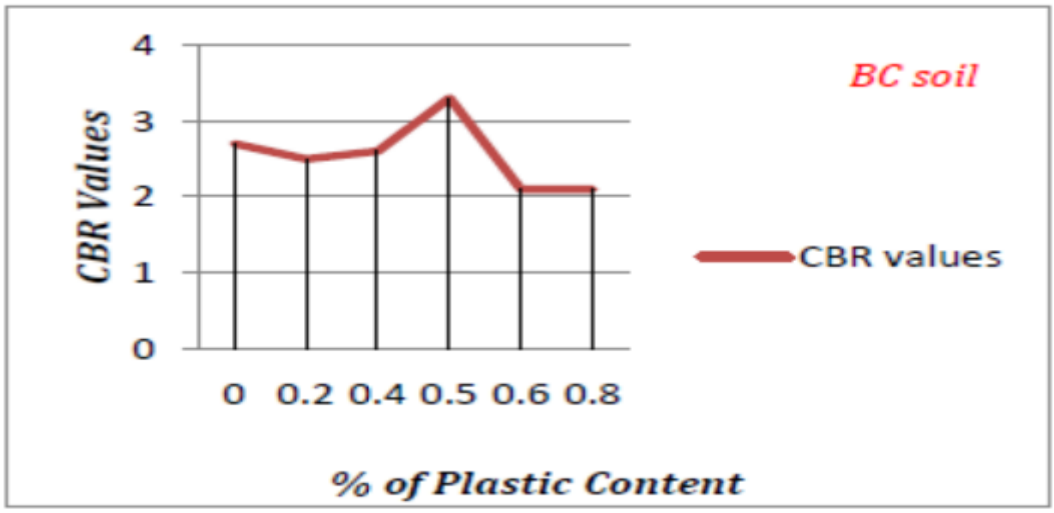

figure 4 graph of CBR value vs plastic content for black cotton soil

P. Mohan Kumar (2018) [9]: In this ever-developing world, engineers need to face different kinds of errors like construct heavy structure and tedious mobility of resources. But in some places on earth soil mass has poor engineering properties like bad Workability, extremely low bearing capacity and very strong compressibility. So, in this paper the author tells us that in order to improve the strength of soil, we have to add some stabilizers. Clayey soils are very poor in strength and they will result in bad pavement support and ultimately affect its life period. The soil stabilization is used to increase the strength of the soil by using the waste plastic material. The testing result are shown in table 7 and table 8.

table 7 comparative study of specific gravity

Sr. No.	Description	Specific Gravity
1	Clay	2.33
2	Clay+ waste Plastic (0.6%)	2.35
3	Clay + waste plastic (0.8%)	2.37
4	Clay + waste plastic (1%)	4

table 8 comparative study of standard proctor test

S. No.	Description	OMC	MDD
1	Clay	11.67	1.37
2	Clay + waste plastic (0.6%)	13.96	1.45
3	Clay + waste plastic (0.8%)	14.75	2.01
4	Clay + waste plastic (1%)	15.01	2.75

3. Discussion

we have discussed the work of various researchers through the table no 9.

table 9 comparative study of various researchers' work

Sr. No.	Research paper	CBR value and optimum plastic content		Form of plastic used	Compaction test OMC	MDD
1	Anas Ashraf et al (2011)	3.4	0.5%	Strips	14.8%	13 kN/m^3
2	Dr, Babitharani H *et al* (2017)	-		polypropylene	-	-
3	Arpitha G C *et al* (2017)	15	0.75%	plastic strip	14.5%	14 kN/m^3
4	Prof. Harish. C., Ashwini H. M. (2016)	3.3	0.45%	strips	-	-
5	Rituparma Das *et al* (2017)	-		Plastic fiber	32.43 %	129.5 kN/m^3
6	N. Vijay Kumar et al (2017)	6.2	0.5%	strips	37.4%	176 kN/m^3
7	A. Burman (2018)	16.5	0.4%	strips	16.8%	16.85 kN/m^3
8	Sagar Mali *et al* (2019)	-		strips	-	-
9	I. Varshik Manikanta	3.31	0.39%	strips	-	-

All the references taken into consideration have performed various tests such as CBR test, compaction test and plate load test among others. According to N. Vijay Kumar (2017), the strength of the soil was increased when 0.7% plastic strips were added to red soil and 0.5% plastic strips were added to black cotton soil. Harish C, Ashwin H M (2016) found exactly the same kind of results. Similar results were obtained ranging from 0.6% to 0.75% optimum

plastic content in all the reviewed papers. Also, plastic was used in different forms such as strips, powder, sheets etc.

Plastic waste is a major issue in a country like India. It needs to be taken care of in such a way that there are no health and natural ramifications. According to the research papers that we have studied, it can be said that plastic is a very good soil stabilizer. Use of plastic, thus can help to solve the major plastic crisis in the country and also can improve the soil properties.

4. CONCLUDING REMARKS

From the above literature survey, we understand that the plastic wastes especially plastic bottles improve the stability of black cotton soil. Results driven by the researchers make us understand that the soil with plastics bottles has less settlement and high ultimate bearing capacity than plain soil. Having all these understanding we are going to test the soil stability with the use of plastic strips from plastic bottles.

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