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"Improvement in The CBR Strength of the Kabirdham District Soil Subgrade Afterwards the Inclusion of Waste Plastic Strip in Various Size"

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Abstract: ***There are several ground improvement strategies that may be used to increase the CBR strength of the soil subgrades, including stabilizing the soil and using reinforced earth techniques. Because it is inexpensive and easily adjustable, using waste plastic in soil sub grades might be regarded as successful ground improvement technique, as well as durability. An experimental investigation on the use of waste plastic on soil sub grade is presented in this publication. The subgrade soil is strengthened by the waste plastic strips. For the experiment, used plastic bottles from the local community are gathered and thinned down to uniformly sized strips. The soil sample are collected and combined with plastic strips of different sizes - 1cm x 1cm, 2cm x 2cm, 3cm x 3cm, and 4cm x 4cm in the appropriate ratios. With little reinforcement (1%, 2% and 3% by weight of sun-dried soil), the soil is compacted to the maximum density recommended by Indian Standard Heavy Compaction Test. CBR evaluations were undertaken on both reinforced and unreinforced soil to examine the variation in CBR strength properties between the two types of soil, The test findings indicate that, within the test's bounds, the addition of waste plastic strips arranged randomly and in varying lengths to the soil exhibits on increasing trend in the soil's CBR value and strength. In this investigation, waste plastic strips of various sizes and proportions were added to soil subgrade with the objective of improving its California Bearing Ratio (CBR) strength and finding ideal proportion and sizes. The results of the study show that adding plastic strips specifically, 2 cm size strips added at a 2% ratio can greatly improve the CBR strength of soil. With useful applications in infrastructure development and construction, this strategy offers an economical and environmentally benign way to stabilize soil.***

Keywords - Indian Standard Heavy Compaction Test , Maximum Dry Density, Optimum Moisture Content, California Bearing Ratio (CBR), Indian Standards (IS), Soil subgrade, Black Cotton Soil, PET&PP Bottels.

1. Introduction

Soil stabilization enhances the strength, durability, and performance of soil for construction, especially in roads and pavements. Techniques include mechanical compaction, chemical additives, and reinforcements. Introduced by Vidal in 1966, reinforced soil has advanced geotechnical applications like pavements, embankments, and foundations. Randomly dispersed reinforcements prevent weak points and improve soil properties. Synthetic materials, particularly recycled plastics, are increasingly used due to durability, cost-effectiveness, and sustainability. With India producing 3.5 million tonnes of plastic waste annually, according to the Central Pollution Control Board (CPCB) report of 2019-2020, this translates to around 9,600 tonnes per day. Currently generate approximately 9.3 million tones of plastic waste annually, according to CSIRO report, this is to about 26,000 tonnes per day. However, less than 10% of this waste is recycled, with the rest ending up in landfills, water bodies, or as litter, posing significant environmental and health challenges. Using discarded plastics in soil stabilization reduces project costs and supports sustainable development by repurposing non-biodegradable waste for long-lasting civil engineering applications.

1.1 Current Challenges in Kabirdham District Soil Subgrade

Kabirdham District, located in the Indian state of Chhattisgarh, faces significant challenges related to the strength and stability of its soil subgrade. The region's predominantly clayey soil is prone to issues such as swelling, shrinkage, and low load-bearing capacity. These characteristics pose difficulties in constructing durable and long-lasting pavements, necessitating the exploration of effective soil stabilization techniques.

1.2 Objectives of the Study

- The objective of this study is to investigate the improvement in the CBR strength load bearing capacity of the Kabirdham District soil subgrade through the inclusion of locally accessible plastic trash bottles strips of various sizes.
- To evaluate the optimal size and proportion of plastic strips for maximum improvement in CBR strength.
- To assess the environmental and economic implications of using waste plastic in soil stabilization.

1.3 Experiment Investigation

- Natural Water Content
- Specific Gravity of Soil
- Grain Size Analysis
- Liquid Limit, Plastic Limit and Plasticity Index of Soil
- Free Swell Index
- Maximum Dry Density (MDD) and Optimum Moisture Content (OMC)
- CBR Test

1.4 Litrature Review

M. Kumar, M. Azhar, S. Mondal & R.K. Singh (2022) perform laboratory experiments where specimens of composite block cotton soil mixed with different sizes and percentage of plastic strips by mass. The result were analyzed to study the influence of plastic strips of different aspect ratio for various properties such as compaction characteristics, CBR and shear strength of the expansive soil. The sample soil reinforced with waste plastic bag strips have shown improvement in its engineering property.

Bhargav Jyoti Borah (2022) CBR tests were conducted on un-reinforced as well as reinforced soil to compare the change in CBR strength characteristics of reinforced soil and un-reinforced soil. The test results reveal that the inclusion of randomly oriented waste plastic strips of different lengths in soil shows an increasing trend in CBR value/strength of soil within the limits of the test.

Kumar and Singh (2021) investigated the use of PET bottles cut into strips for soil stabilization. Their findings showed a substantial increase in CBR values, with optimal results achieved at a specific proportion of plastic inclusion.

Gupta et al. (2022) compared random mixing of plastic strips with systematic layering. Their study concluded that while both methods improved CBR values, systematic layering provided better control over the distribution of plastic, leading to more uniform improvement in soil strength.

Sharma and Bose (2023) conducted a comprehensive study on the impact of HDPE fibers on clayey soil. Their results demonstrated significant increases in both CBR and shear strength, with the most notable improvements occurring at specific fiber lengths and proportions.

Patel et al. (2020) highlighted the environmental advantages of using plastic waste in road construction. Their lifecycle analysis showed a reduction in carbon emissions and a decrease in the environmental impact of plastic waste disposal.

Jain and Roy (2022) conducted a cost-benefit analysis of using plastic strips for soil stabilization in rural road projects. Their findings indicated significant cost savings in terms of material costs and long-term maintenance.

Gupta and Sinha (2020) reported the successful implementation of plastic-stabilized soil in a road construction project in Northern India. The stabilized soil exhibited enhanced strength and durability, leading to reduced maintenance costs and extended pavement life.

2. Material Used

2.1 Black Cotton Soil

Location and Site Selection:- Soil samples are collected from the Mahali village, Kabirhdham District near the National Highway 130A. Soil samples were taken at several points. The selection of these sites was based on a preliminary survey identifying areas with problematic subgrade conditions characterized by high plasticity and low bearing capacity. The chosen sites were representative of the diverse soil conditions prevalent in the region. Soil type is a black cotton soil. For the experiment black cotton soil is considered because CBR value is poor for pavement design.

Collection Procedure:

Sampling Depth: To prevent contamination, surface dirt was scraped, and samples were taken 1 meter below the surface to capture the subgrade material typically used in pavement construction.

Sampling Equipment: Garden Hoe, Pick Axe, Mattock and shovels were used for manual excavation, ensuring minimal disturbance to the soil structure.

Sample Preservation: The collected soil samples were stored in airtight polyethylene bags to maintain their moisture content and prevent contamination. Labels indicating the sample location, depth were attached to bag.

Preparation:- Large particles and debris were eliminated from the acquired soil samples by air-drying, pulverizing, and sieving them using a 4.75 mm sieve. In order to preserve uniformity for testing, the treated soil was kept in sealed containers.

Characterization:- A variety of preliminary experiments were performed to assess the soil's characteristics, including moisture content, specific gravity, particle size analysis, soil classification, consistency limits (liquid limit, plastic limit, plasticity index), free swell index and maximum dry density (MDD) & optimum moisture content (OMC).

Fig. 1 (a) Collected Soil Sample (Black Cotton Soil), (b) Preparation of Soil Sample

2.2 Waste Plastic

Fig. 1 (a) Collected Soil Sample (Black Cotton Soil), (b) Preparation of Soil Sample

Source and Selection of Plastic Waste:- Polyethylene (PE) and polypropylene (PP) made up the majority of the waste plastic materials, which were obtained from neighborhood municipal waste collection centre and also collected from hotel, restaurant garden and park. These materials were selected because they are readily available and because prior studies have shown that they are useful for stabilizing soil and their mechanical properties better.

Preparing Plastic Strips:-

Sorting: The collected plastic waste was manually sorted to remove contaminants such as metal pieces, organic matter, and other non-plastic materials.

Cleaning: The sorted plastic waste was washed thoroughly with water and a mild detergent to remove dirt, grease, and other impurities. After cleaning, the plastic was air-dried.

Shredding: A hand operated shredder (scissors, sickle) was used to cut the cleaned plastic waste into strips.

Size Classification: The shredded plastic strips further cut into different sized strips (e.g., 1 cm x 1 cm, 2 cm x 2 cm, and 3 cm x 3 cm, 4 cm x 4 cm). To find out how size affects CBR improvement, the strips were made in four different aspect ratio.

Fig. 2 (a) Collected Waste Plastic after Cleaning, (b) Preparing Plastic Strip in Different Size, (c) Size of Plastic Strip

2.3 Water

Soil samples were kept at a constant moisture content throughout the studies by using distilled water. Because tap water contains pollutants, using distilled water avoided any potential chemical reactions.

2.4 Soil Properties-

Table 1 Properties of Soil

S. No.	Properties	Value
1.	Natural Water Content	13.43%
2.	Specific Gravity of Soil	2.60
3.	Grain Size Analysis - Gravel Sand Clay-Silt	 18.05% 76.73% 5.22%
4.	Liquid Limit Plastic Limit Plasticity Index of Soil	48% 27% 21%
5.	Free Swell Index	46.67%
6.	Coefficient of Curvature (Cu)	13.45
7.	Coefficient of Uniformity (Cc)	1.23
8.	Maximum Dry Density (MDD)	1.721 g/cc
9.	Optimum Moisture Content (OMC)	17.89%
10.	Soil Type	Clayey-Sandy (SC)

3. Research Methodology

The collected soil samples were sun-dried, broken into small pieces, and screened through a 4.75 mm IS sieve to remove roots, pebbles, and gravel. The prepared soil was weighed, and waste plastic strips of lengths 1 cm, 2 cm, 3 cm, and 4 cm were added in proportions of 1%, 2%, and 3% by weight of the soil.

Initial tests conducted on the unreinforced soil included specific gravity (IS 2720-Part 3), liquid and plastic limits, plasticity index (IS 2720-Part 5), grain size analysis (IS 383-1970), and modified Proctor tests for Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) (IS 2720-Part 8).

Reinforced samples were prepared by randomly mixing the dried soil with plastic strips of different lengths and proportions. Modified Proctor tests were repeated to determine MDD and OMC for these reinforced samples.

To evaluate the effect of plastic strips on subgrade strength and deformation, California Bearing Ratio (CBR) tests were conducted using the dynamic compaction method under soaked conditions (IS 2720-Part 16). The study analyzed variations in CBR values for both unreinforced and reinforced soil samples, highlighting the impact of varying strip lengths and proportions on subgrade performance.

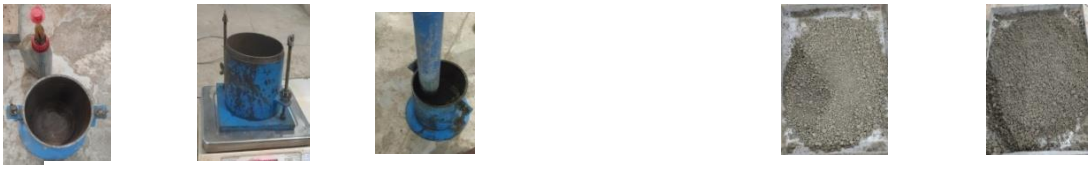


Fig. 3 (a) Mould for Compaction Test, (b) Preparation of Soil Sample for Compaction Test

Fig. 4 (a) Proportioning of Soil Matrix, (b) Uniform Dry & Wet Mixing of Soil Matrix

Fig. 5 Prepare Mould for CBR Test

3.1 Case Trail and Soil Matrix for the Research Under Consideration

In this research total 13 sample are prepared. 1 sample of S0, 3 sample of S1, 3 sample of S2, 3 sample of S3 and 3 sample of S4. Case trail for the study and proportion of soil matrix for 1 standard mould having volume = 2250 cc given below in table -

Table 2 Case Trail for Experiment (value in percentage)

S. No.	Description	Case ID	Soil	Plastic Strip	Total
1.	Origin Soil	S0	100	0	100
2.	Soil Matrix with 1% replacement of plastic strip size 1 cm	S11	99	1	100
	2% of size 1 cm	S12	98	2	100
	3% of size 1 cm	S13	97	3	100
3.	Soil Matrix with 1% replacement of plastic strip size 2 cm	S21	99	1	100
	2% of size 2 cm	S22	98	2	100
	3% of size 2 cm	S23	97	3	100
4.	Soil Matrix with 1% replacement of plastic strip size 3 cm	S31	99	1	100
	2% of size 3 cm	S32	98	2	100
	3% of size 3 cm	S33	97	3	100
5.	Soil Matrix with 1% replacement of plastic strip size 4 cm	S41	99	1	100
	2% of size 4 cm	S42	98	2	100
	3% of size 4 cm	S43	97	3	100

Table 3 Proportion of Soil Matrix for 1 Standard Mould having volume = 2250 cc.
(Take – 6000 gm soil required for mould and replace with plastic strip)

S.No.	Case ID	Weight of Soil in gm	Weight of Plastic Strip in gm	Weight of Water in gm
1.	S0	6000	0	6000× 17.89/100 = 1073.4
2.	S11	5940	6000 × 1/100 = 60	5940 × 18.10/100 = 1075.14
	S12	5880	6000 × 2/100 = 120	5880 × 18.36/100 = 1079.57
	S13	5820	6000 × 3/100 = 180	5820× 18.68/100 = 1087.18
3.	S21	5940	6000 × 1/100 = 60	5940×18.56/100 = 1102
	S22	5880	6000 × 2/100 = 120	5880 × 18.49/100 = 1087.21
	S23	5820	6000 × 3/100 = 180	5820 × 18.89/100 = 1099.398
4.	S31	5940	6000 × 1/100 = 60	5940 × 19.19/100 = 1139.89
	S32	5880	6000 × 2/100 = 120	5880 × 19.01/100 = 1117.79
	S33	5820	6000 × 3/100 = 180	5820 × 19.88/100 = 1157.02
5.	S41	5940	6000 × 1/100 = 60	5940 × 19.19/100 = 1139.89
	S42	5880	6000 × 2/100 = 120	5880 × 19.76/100 = 1161.89
	S43	5820	6000 × 3/100 = 180	5820 × 20.49/100 = 1192.52

3.2 Procedure Needed For Conducting Experiment

3.2.1 Mixing of Soil with Plastic Strips

Proportioning: A digital weight balance was used to weight the precise quantities of plastic strip in order to achieve the appropriate proportion, which were 1%, 2%, 3% by weight of the dry soil.refer table **3.8**
Uniform Mixing: The soil and plastic strips were mixed manually to ensure uniform distribution of the plastic strips within the soil matrix. Manual mixing also performed the homogeneity of the mixture.

3.2.2 Sample Compaction Procedure:

Mould Preparation: Standard CBR moulds with an internal diameter of 150 mm and a height of 175 mm were used. The molds were cleaned, dried, and lubricated to facilitate easy removal of compacted samples.
Compaction Procedure: The mixed soil samples were compacted in the molds in three layers, each layer receiving 25 blows from a standard Proctor hammer. This procedure was consistent with the Modified Proctor compaction method to achieve maximum dry density.
Unsoaked Sample: The compacted sample are unsoaked which are ready to perform test.

3.3 CBR Test and Procedure for Considered Study

This test is perform to determine the strength of subgrade soil as per IS: 2720 (Part 16) – 1987, Reaffirmed 2021.
The **California Bearing Ratio (CBR) Test** is a penetration test developed by the California Division of Highways to evaluate the strength of subgrade soils and other base materials for road construction. The CBR value is used in the design of pavements, helping engineers determine the thickness of the pavement layers required to support the anticipated load. In essence, it quantifies the soil's load-bearing capacity compared to that of a standard crushed rock material.

Procedure and Conduct Experiment:-

Calibration of Equipment: The CBR testing machine was calibrated to ensure accurate measurements.
Loading Setup: The unsoaked samples were placed in the CBR testing machine, and a surcharge weight of 2.5 kg was applied to simulate the weight of pavement layers.
Penetration Test: The plunger was positioned at the center of the sample surface, and the load was applied at a constant rate of 1.25 mm/min. The penetration resistance was recorded at specified intervals (0.5 mm, 1 mm, 1.5 mm, 2 mm, 2.5 mm, 5 mm, 7.5 mm, 10 mm, and 12.5 mm) in digital reading machine.
Calculation of CBR Value: The CBR value was calculated as the ratio of the load at a specified penetration to the standard load, expressed as a percentage. The standard load values are 1370 kg for 2.5 mm penetration and 2055 kg for 5 mm penetration.

The formula used was:

CBR (%) = [Corrected Load / Standard Load] × 100

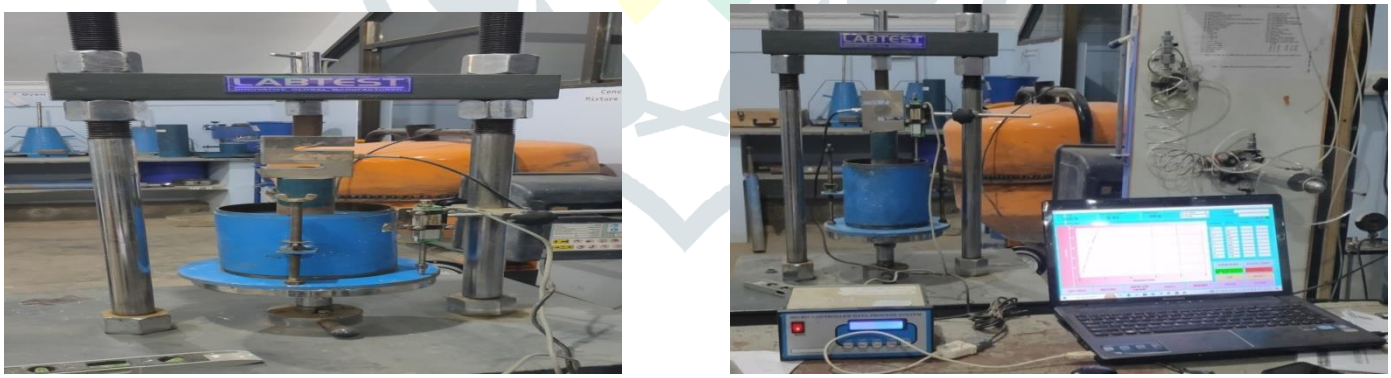


Fig. 6 (a) Mould & Loading Setup in CBR Machine, (b) CBR Test with Digital Reading Machine

4. RESULTS AND DISCUSSION

4.1 Effect of Different Sizes Plastic Strip at Varying Proportion on MDD & OMC

Depending on their size and amount, plastic strip addition to black cotton soil can affect the soil's maximum dry density (MDD) and optimal moisture content (OMC) in different ways. The impact of plastic strips on black cotton soil in various sizes (1 cm, 2 cm, 3 cm, and 4 cm) and proportions (1%, 2%, and 3%), is explained in detail below.

4.1.1 Properties of Black Cotton Soil:-

- **Maximum Dry Density (MDD)**: 1.721 g/cc
- **Optimum Moisture Content (OMC)**: 17.890%

4.1.2 Result Observed in Black Cotton Soil with Plastic Strip Reinforcement

❖ **Maximum Dry Density (MDD) Decrease:-**

- The MDD tends to decrease with increasing amounts and sizes of plastic strips. The plastic strips interfere with the soil compaction process by occupying space within the soil matrix, reducing the achievable density.
- Larger strips (e.g., 4 cm) typically cause a greater reduction in density compared to smaller strips (e.g., 1 cm), as they disrupt the soil structure more significantly.

❖ **Optimum Moisture Content (OMC) Increase:-**

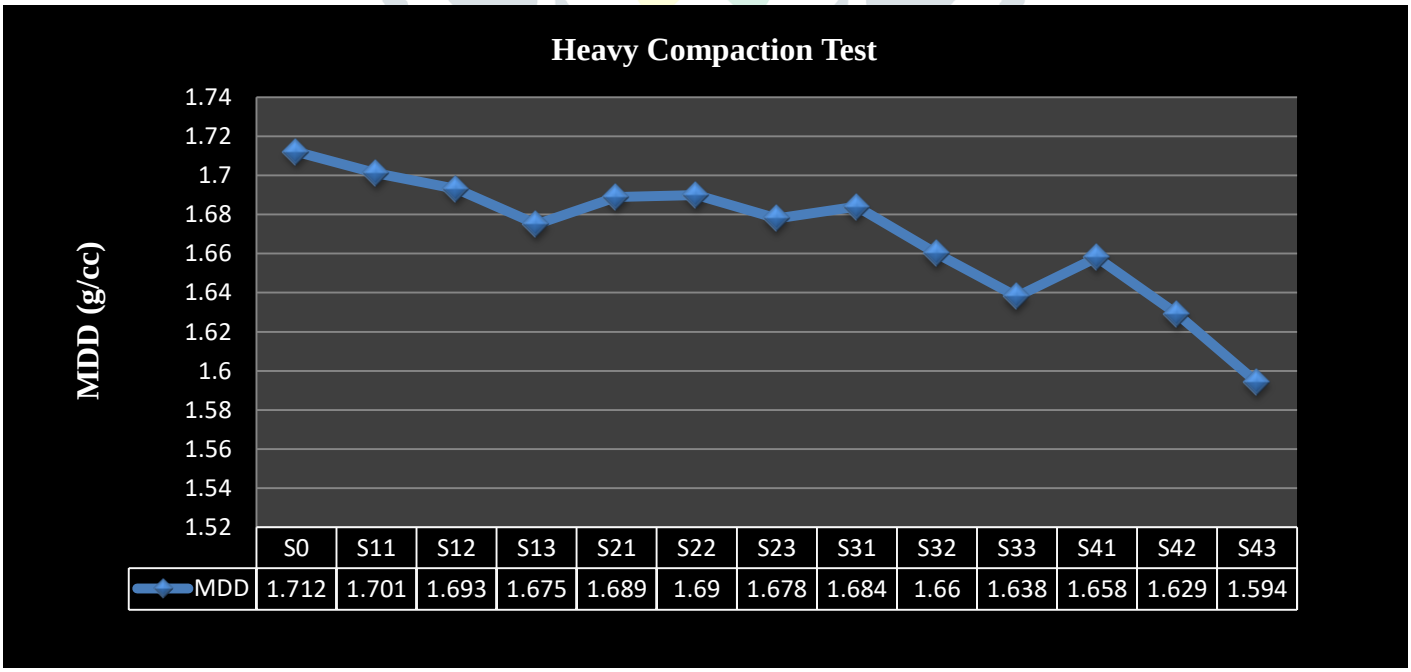
- The OMC tends to increase as plastic strips are added, requiring more moisture to achieve optimum compaction. This happens because plastic strips increase the void spaces in the soil, and additional water is needed to lubricate the soil particles for efficient compaction.

Table 4 MDD & OMC of Black Cotton Soil with Plastic Strip at various %

Plastic Strip Size (cm)	Case ID / % of Plastic Strip	MDD (g/cc)	OMC (%)
1	**S11** / 1%	1.701	18.10
	S12 / 2%	1.693	18.36
	S13 / 3%	1.675	18.68
2	**S21** / 1%	1.687	18.56
	S22 / 2%	1.690	18.49
	S23 / 3%	1.678	18.89
3	**S31** / 1%	1.684	18.60
	S32 / 2%	1.660	19.01
	S33 / 3%	1.638	19.88
4	**S41** / 1%	1.658	19.19
	S42 / 2%	1.629	19.76
	S43 / 3%	1.594	20.49

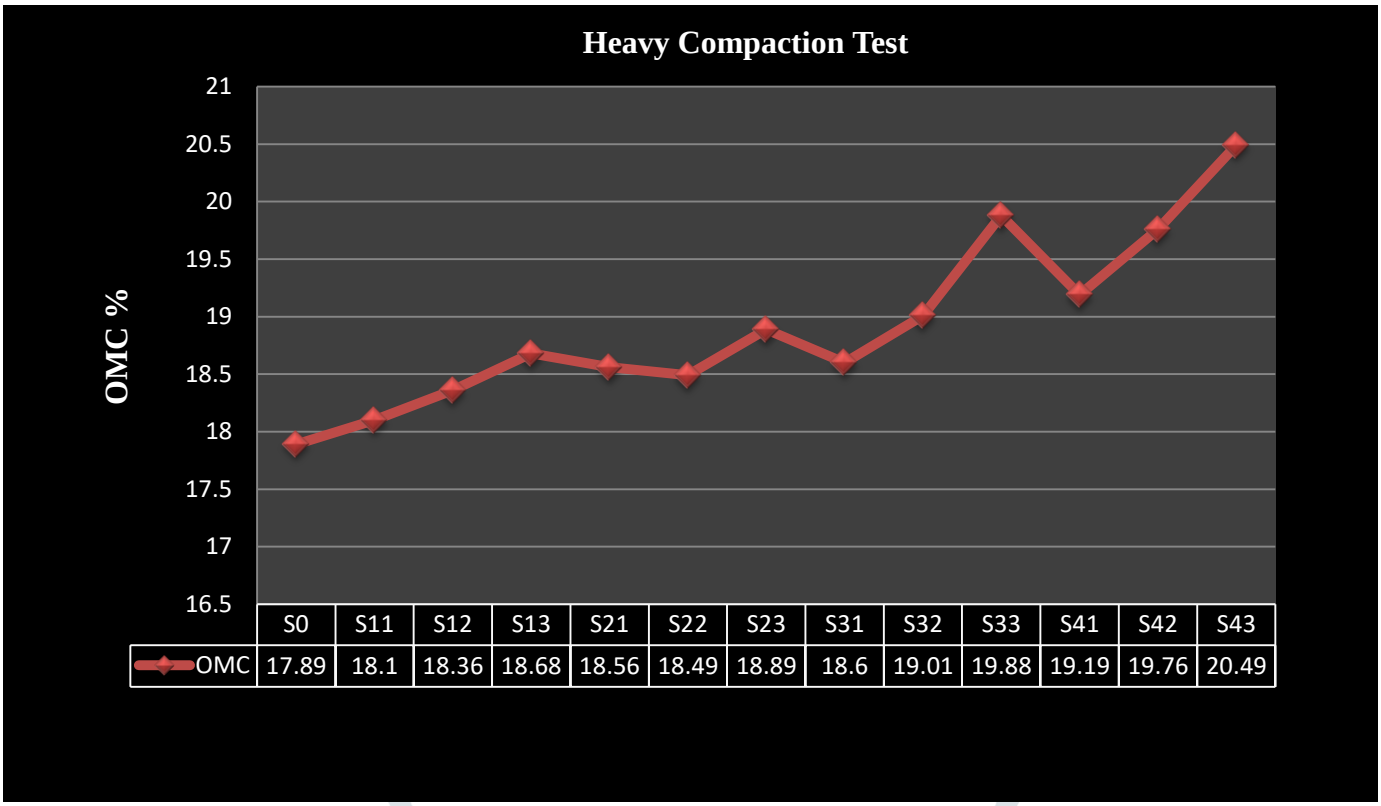
4.2 Graphical Representation of MDD & OMC Result:-

4.2.1 Graphical Representation of MDD-



Graph 1 Heavy Compaction Test for MDD on Black Cotton Soil with Different Sizes and Proportion of Plastic Strip

4.2.2 Graphical Representation of OMC-



Graph 2 Heavy Compaction Test for OMC on Black Cotton Soil with Different Sizes and Proportion of Plastic Strip

4.3 CBR value of Origin Soil

By evaluating the natural soil samples from the Kabirdham District, the CBR value for untreated soil was found. It was found that the average CBR value for untreated soil in unsoaked conditions was 6.57%, indicating low subgrade strength and emphasizing the necessity of soil stabilization.

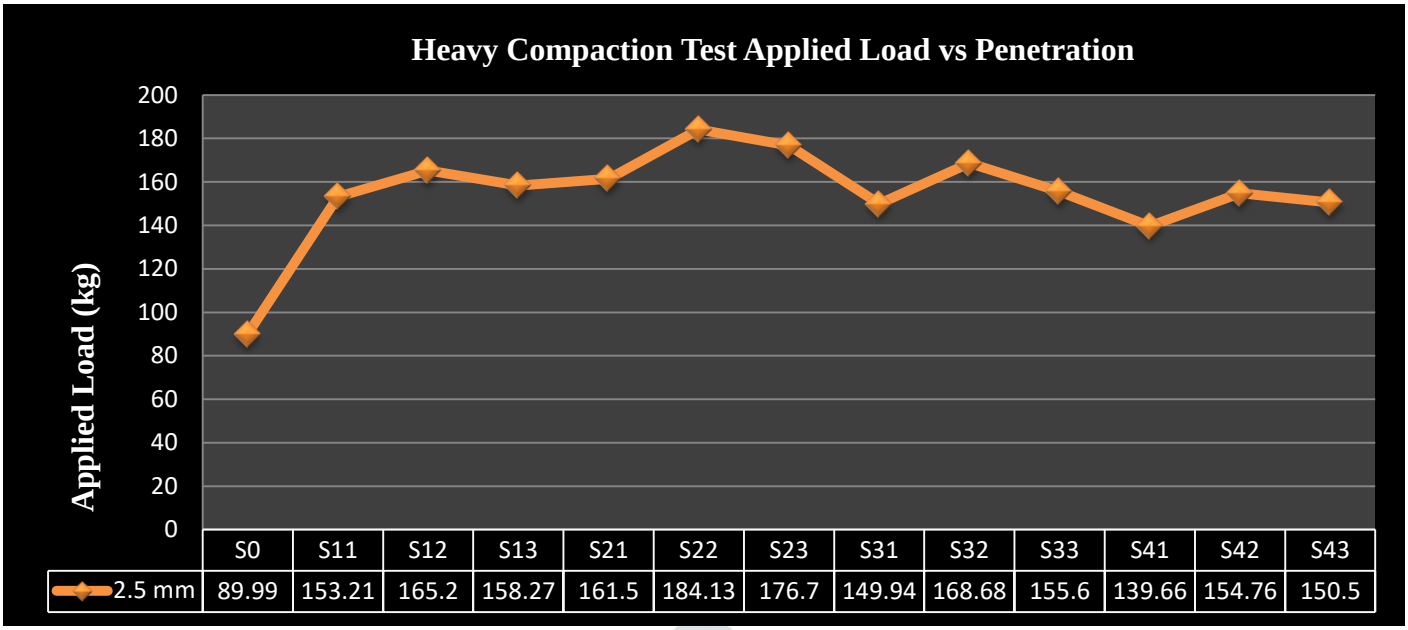
Table 5 CBR Value of Origin Soil

Case ID / Sample	CBR Value (%)
S0 / [Black Cotton Soil (Origin Sample)]	6.57

4.3.1 CBR Applied Load and Penetration for Black Cotton Soil with Plastic Strips

Table 6 Applied Load Value for 2.5 mm Penetration

S. No.	Penetration (mm)	Case ID	Corrected Load (kg)
1.	**2.5**	**S0**	**89.99**
2.		**S11**	**153.2**
3.		**S12**	**165.2**
4.		**S13**	**158.2**
5.		**S21**	**161.5**
6.		**S22**	**184.1**
7.		**S23**	**176.7**
8.		**S31**	**149.9**
9.		**S32**	**168.6**
10.		**S33**	**155.6**
11.		**S41**	**139.6**
12.		**S42**	**154.7**
13.		**S43**	**150.5**



Graph 3 Applied Load vs Penetration

4.3.2 CBR Value of Black Cotton Soil with Plastic Strips

The results of the CBR tests for each combination of plastic strip size and proportion are presented in the tables below. Each test was repeated for accuracy, and the average values are reported.

Table 7 CBR Value for Black Cotton Soil with 1 cm Plastic Strip

Case ID / Proportion of Plastic Strip	CBR Value (%)
S11 / 1%	11.18
S12 / 2%	12.06
S13 / 3%	11.55

Table 8 CBR Value for Black Cotton Soil with 2 cm Plastic Strip

Case ID / Proportion of Plastic Strip	CBR Value (%)
S21 / 1%	11.79
S22 / 2%	13.44
S23 / 3%	12.90

Table 9 CBR Value for Black Cotton Soil with 3 cm Plastic Strip

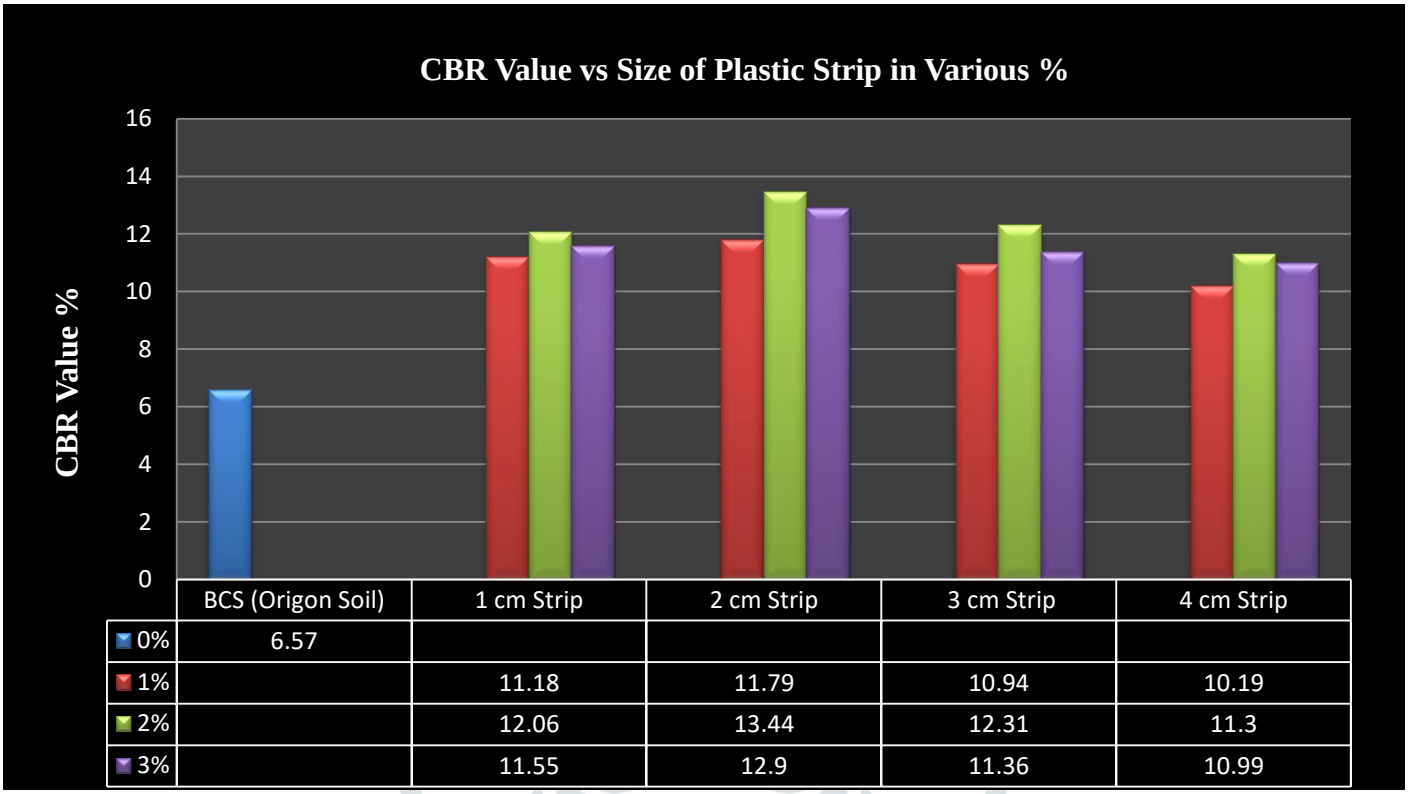
Case ID / Proportion of Plastic Strip	CBR Value (%)
S31 / 1%	10.94
S32 / 2%	12.31
S33 / 3%	11.36

Table 10 CBR Value for Black Cotton Soil with 4 cm Plastic Strip

Case ID / Proportion of Plastic Strip	CBR Value (%)
S41 / 1%	10.19
S42 / 2%	11.30
S43 / 3%	10.99

4.3.3 Graphical Representation of CBR Result

The CBR values for each size of plastic strip at the various proportions are shown graphically in the graphs



	BCS (Origon Soil)	1 cm Strip	2 cm Strip	3 cm Strip	4 cm Strip
0%	6.57				
1%		11.18	11.79	10.94	10.19
2%		12.06	13.44	12.31	11.3
3%		11.55	12.9	11.36	10.99

Graph 4 Effect of Different Sizes and Proportions of Plastic Strips on CBR Strength

4.4 Discussion on Result

4.4.1 Plastic Strip Sizes and Proportion's Impact on MDD & OMC

- **Impact of Plastic Strip Size**: As the size of the plastic strips increases (from 1 cm to 4 cm), the reduction in MDD becomes more significant. Larger strips create larger void spaces in the soil, disrupting the soil matrix and reducing compaction efficiency. This leads to a more considerable reduction in dry density. At the same time, larger strips increase the OMC because more water is required to fill the voids and facilitate the lubrication of soil particles during compaction.
- **Impact of Plastic Strip Proportion**: As the proportion of plastic strips increases (from 1% to 3%), both MDD and OMC are affected more significantly. Higher percentages of plastic reinforcement further reduce the soil's ability to compact, as more space is occupied by plastic strips, leading to a reduction in MDD. The OMC increases as more water is needed to achieve optimum compaction.

4.4.2 Decreases MDD and Increases OMC Impact on CBR Value

4.4.2.1 Decrease in Maximum Dry Density (MDD):

- **Effect on Soil Compaction:** A decrease in MDD indicates that the soil becomes less dense when compacted. This is likely because the plastic strips create voids in the soil matrix, preventing the soil particles from packing tightly together.
- **Impact on Soil Strength:** While MDD decreases, the plastic strips improve the internal friction and the bonding between the soil and plastic, particularly if the strips are of the right size and proportion. This friction compensates for the lower density by resisting deformation, which can still result in a higher CBR value despite the decrease in compaction.

4.4.2.2 Increase in Optimum Moisture Content (OMC):

- **Effect on Workability:** An increase in OMC means that more water is required to achieve the optimum compaction of the soil-plastic mix. This is because plastic strips are not absorbent and water acts as a lubricant to aid the compaction process.
- **Impact on CBR:** The increase in moisture content may reduce the compaction efficiency at higher moisture levels, but the inclusion of plastic strips helps in improving the overall load-bearing capacity. The plastic strips act as a reinforcement that enhances the soil's ability to resist penetration under load, thus potentially increasing the CBR value.

4.4.2.3 Overall Effect on CBR:

- Even though the MDD decreases, the reinforcing effect of the plastic strips (improved interlocking and resistance to shearing) and the increase in OMC (improving compaction at higher moisture levels) work together to increase the CBR value.
- The overall increase in CBR value is due to the reinforcement effect of plastic strips that provide additional tensile strength to the soil structure, which offsets the loss in density.

4.4.3 Plastic Strip Proportion's Impact on CBR Strength

Up to a certain point, the CBR strength of the soil is often improved by increasing the proportion of plastic strips, as the data clearly show. As the fraction was raised from 1% to 2%, the CBR values increased for all sizes of plastic strips. But around 3%, the CBR values either started to decline somewhat or steadied.

Ideal Proportion: The best CBR values were found at a proportion of 2% for all strip sizes, suggesting that this is the ideal amount to increase soil strength. Beyond this, a decrease in performance is probably due to the extra plastic material causing uneven distribution and lower inter-particle bonding.
For Example:-
At 2%, the CBR value for 2 cm strip packed at 13.44%.
At 2%, the CBR value for 1 cm strip packed at 11.18%.

4.4.4 Plastic Strip Size's Impact on CBR Strength

The CBR strength was also significantly influenced by the plastic strips' size. The CBR values improved most overall across all proportions using the 2 cm plastic strips, whereas the 4 cm strips had the least effect.

- **2 cm Strip:** The most successful strips measured 2 cm and had a maximum CBR value of 13.44% at 2% proportion. This shows that the 2 cm strips gave the soil particles the best possible interlocking, enhancing the soil's capacity for bearing loads.
- **1 cm Strip:** The CBR strength was also enhanced by the 1 cm strips, reaching a maximum value of 12.06% at 2%. Smaller strips might not produce as much interlocking with the soil particles as the 2 cm strips, regardless of their effectiveness.
- **3 cm Strip:** The 3 cm strips showed an improvement in CBR, but the values were lower compared to the 1 cm and 2 cm strips. The best CBR value for the 3 cm strips was **12.31%** at 2% proportion.
- **4 cm Strip:** The 4 cm strips, which had a maximum CBR value of 11.30% at 2%, were the least successful in increasing CBR strength. This indicates that the larger strips may not disperse uniformly inside the soil, resulting to localized weak patches and lower overall strength.

5. Conclusion & Future Scope

5.1 Conclusion

- CBR value of origin soil is 6.57%.
- Plastic strips are added to soil to increase its CBR strength; best results are obtained when the strips proportion for 2% of the soil's weight.
- Soil strength is greatly impacted by the size of the plastic strips; 2 cm strips showed the biggest CBR improvement, followed by 1 cm and 3 cm strips.
- The least amount of CBR strength is improved when 4 cm strips are used; this is probably because the soil's uneven distribution causes this.
- This technique solves the problem of disposing of plastic trash while enhancing subgrade strength in a sustainable manner.
- As plastic strip size and percentage, increase MDD decreases due to the interference with compaction, and OMC increases due to the need for more water to fill the voids created by the plastic strips.
- The effects are more pronounced with larger strips (4 cm) and higher proportions (3%) of plastic strips, leading to significant changes in both MDD and OMC.
- The decrease in MDD does not necessarily lead to a lower CBR value because the plastic strips improve soil strength through reinforcement and increased inter-particle friction.
- The increase in OMC allows the soil to achieve better compaction at higher moisture levels, which, combined with the reinforcing action of the plastic, leads to an increase in CBR value despite the changes in compaction characteristics.

Thus, even though MDD decreases and OMC increases, the inclusion of waste plastic results in an overall improvement in the CBR value, making the soil stronger and more suitable for subgrade applications.

5.2 Future Scope

- In this research only four trail cases are studied and investigation for different size and proportion is done for the CBR Strength. However, more trail cases can be perform to identify the optimal proportion and sizes of plastic strip can be determined with the help of different experiments. Future more research work by changing the soil collection location with types of plastic waste such that effectively results can be achieved with the wide range of experiments.

- The sustainability of soil stabilized using plastic may be ensured by conducting long-term performance and environmental impact assessments in future studies. This technique could address the problems with plastic waste worldwide and help promote more economical and ecological construction methods.
- The impact of varying plastic inclusion shapes, textures, and orientations on soil strength might be explored in more detail. This could make the best use of plastic waste possible for different kinds of soil and construction needs.
- It is important to look into how well plastic strips work to stabilize various soil types, such as sand, silt, and clay. Gaining knowledge about how different soil compositions react to plastic stabilization could increase the technique's suitability for use in a wider range of geographical locations and construction contexts.
- The investigation was carried out in a lab setting with strict controls. Future research should examine the performance of plastic-stabilized soils in actual road construction projects through field testing. This would support the validation of the lab results and offer perceptions into real-world implementation difficulties.
- Other waste materials that could be investigated for soil stabilization include rubber, glass, and industrial by-products, in addition to plastic. Mixing various waste materials could result in more adaptable and efficient stabilizing methods.

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