

A
Project Report
on

IMPROVEMENT OF HIGHWAY MATERIALS

Under guidance of
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MAY, 2014

CERTIFICATE

This is to certify that the work titled **PART-1 – “IMPROVEMENT OF HIGHWAY MATERIALS USING PLASTIC STRIPS AND JUTE” AND PART-2 - “IMPROVEMENT OF HIGHWAY MATERIALS USING SULPHUR”** submitted by Anish Sharma in partial fulfilment for the award of degree of B. Tech. Civil Engineering of Jaypee University of Information Technology, Waknaghat has been carried out under my supervision. This work has not been submitted partially or wholly to any other University or Institute for the award of this or any other degree or diploma.

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ABSTRACT

The performance of paved and unpaved roads is often poor after every monsoon and, in most cases; these pavements show cracking, potholes and serious differential settlement at various locations. Therefore, it is of utmost importance considering the design and construction methodology to maintain and improve the performance of such pavements. Attempts have been made in our project to demonstrate the potential of reclaimed *High Density Polyethylene strips (HDPE)* and *Jute Fibre* as soil reinforcement for improving engineering performance of subgrade soil. HDPE strips obtained from waste plastic were mixed randomly with the soil. Jute fibres (in the form of jute threads) were obtained from waste jute bags. A series of *California Bearing Ratio (CBR)* tests were carried out on randomly reinforced soil by varying percentage of HDPE strips and jute threads with different lengths and proportions. Results of CBR tests demonstrated that inclusion of waste HDPE strips and jute threads in soil with appropriate amounts improved strength and deformation behaviour of subgrade soils substantially. The proposed technique can be used to advantage in embankment/road construction. The experimentation at several institutes indicated that the waste plastic, when added to bitumen will form a fine coat of plastic over the bitumen and such bitumen, when mixed with the aggregate is found to give higher strength, higher resistance to water and better performance over a period of time. *Sulphur added bitumen* can be a far better substitute of bitumen used in road construction. It is a less expensive application when used as a thin top course over failed pavement that would otherwise need replacement

Keywords: *HDPE, Jute, CBR, Bitumen, Aggregate, Sulphur*

ACKNOWLEDGEMENT

We express sincere appreciation to Mr. Saurabh Rawat for his guidance throughout the research and preparation of the project. We would like to thank him for his helpful comments, suggestions and giving me the chance to work together.

We would also like to thank Mr. Jaswinder for his support throughout the project and his constant guidance in our lab works so that we could achieve accurate results.

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CHAPTER1: INTRODUCTION

The performance of paved and unpaved roads is often poor after every monsoon and, in most cases; these pavements show cracking, potholes, and wheel path rutting and serious differential settlement at various locations. Therefore, it is of utmost importance considering the design and construction methodology to maintain and improve the performance of such pavements. The various pavement materials that need improvement are soil, bitumen and aggregate.

Soil has been used as a construction material from time immemorial. Being poor in mechanical properties, it has been putting challenges to civil engineers to improve its properties depending upon the requirement which varies from site to site. Much work has been done on strength deformation behavior of plastic and jute fiber reinforced soil and it has been established beyond doubt that addition of these materials in soil improves the overall engineering performance of soil. Nowadays, plastic containers usually made of high density polyethylene (HDPE) are being increasingly used for storage and marketing of various liquids. Most of these containers are specifically made for spot use, having short life span and are being discarded immediately after use. Use of natural material such as Jute, coir, sisal and bamboo, as reinforcing materials in soil is prevalent for a long time and they are abundantly used in many countries like India, Philippines, and Bangladesh. The best way to handle such wastes is to utilize them for engineering applications. The main advantages of these materials are they are locally available and are very cheap. Processing of these materials into a usable form is an employment generation activity in rural areas of these countries. If these materials are used effectively, the rural economy can get uplift and also the cost of construction can be reduced, if the material use leads to beneficial effects in engineering construction.

Plastic in different forms is found to be almost 5% in municipal solid waste, which is toxic in nature. It is a common sight in both urban and rural areas to find empty plastic bags and other type of plastic packing material littering the roads as well as drains. Due to its biodegradability it creates stagnation of water and associated hygiene problems. In order to contain this problem experiments have been carried out whether this waste plastic can be reused productively in the construction of roads. The experimentation at several institutes indicated that the waste plastic, when added to hot aggregate will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give higher strength, higher resistance to water and better performance over a period of time. Therefore, it is proposed that we may use waste plastic in the construction of Roads.

India is a very vast country, having widely varying climates , terrains, construction materials and mixed traffic conditions both in terms of loads and volumes. The flexible roads constitute about 98 percent of the total roads network. The use of quality binder is one of the requirements for the satisfactory pavement performance. The aim of binder modification is to produce new binders with better mechanical characteristics which allow the manufacturing and application of road bituminous mixes with improved performance. Increased traffic factors such as heavier loads, higher traffic volume and higher tyre pressure demand higher performance pavements. The purpose of bitumen modification using polymers is to achieve desired engineering properties such as and reduced plastic flow at high temperatures and increased resistance to thermal fracture at low temperatures.

In the present study the effect of addition of sulphur on the physical properties of bitumen is studied . The sulphur has been added in various percentage contents. With the addition of sulphur the properties of bitumen has been improved considerably.

Though detailed performance studies were not systematically planned and done on all such roads, generally it has been found that the roads constructed using addition of sulphur in bitumen are found to perform better compared to those constructed with conventional bitumen. Further it has been found that such roads were not subjected to stripping when come in contact with water.

CHAPTER 2: LITERATURE REVIEW

According to (Choudhary et al, 2010), Soil fiber composites have been found effective in improving the CBR value as reported in the literature. These studies indicated that stress-strain strength properties of randomly distributed fiber reinforced soil are a function of fiber content and aspect ratio. Considerable improvement in frictional resistance of fine grained soil was also reported by roughened HDPE. The tests show that reinforcing sand with waste HDPE strips enhances its resistance to deformation and its strength. The addition of reclaimed HDPE strips, a waste material, to local sand increases the CBR value and secant modulus. The maximum improvement in CBR and secant modulus is obtained when the strip content is 4%. This suggests that the strips of appropriate size cut from reclaimed HDPE may prove beneficial as soil reinforcement in highway sub-base if mixed with locally available granular soils in appropriate quantity.

As per the study in paper by (Singh et al, 2010), use of natural fibre in civil engineering for improving soil properties is advantageous because they are cheap, locally available, biodegradable and eco-friendly. The natural fiber reinforcement causes significant improvement in tensile strength, shear strength, and other engineering properties of the soil. Over the last decade the use of randomly distributed natural and synthetic fiber has recorded a tremendous increase. The effects of lengths and diameters of fiber on CBR value of soil were also investigated. Tests result indicates that CBR value of soil increases with the increase in fiber content. It was also observed that increasing the length and diameter of fiber further increases the CBR value of reinforced soil and this increase is substantial at fiber content of 1 % for 90 mm fiber length having diameter 2 mm. Thus there is significant increase in CBR value of soil reinforced with Jute fiber and this increase in CBR value will substantially reduce the thickness of pavement subgrade.

Singh, 2012 stated that the CBR value of soil increases for both soaked and unsoaked conditions as the number of Jute geotextile layers is incorporated into the soil. As the number of JGT sheet increases the CBR value of soil increase. The improvement in CBR value is maximum corresponding to 4 number of JGT sheets. The preparation of identical soil sample corresponding to 5 layers of JGT sheets is not possible and CBR value of soil decreases due to decrease in density of soil sample. The maximum improvement in unsoaked CBR value of soil is observed to be 586 % corresponding to 4 layers of JGT sheets. In case soaked test the improvement in CBR value is 520 % for the same number i.e. 4 layers of JGT sheet. Thus there is significant improvement in the CBR value of soil reinforced with Jute Geotextile sheets.

Frirsey and Chambu(1981) modified the bitumen by treatment with 2% sulphur at 160 centigrades. The chemical bonding of bitumen with sulphur produce a new kind of binder which asphaltene presents more of a gel like type of structure resulting from higher ability to form aggregates. The improve in the mechanical properties of bitumen is due to parent plastification of the material.

Gawel(2008) report that the sulphur substituted asphalt mixes exhibit significantly higher fatigue life than comparable conventional mixes. The behaviour of sulphur containing pavement is more elastic compared with conventional pavement(at the same loading time). The addition of sulphur makes it possible for softer asphalt to be used in reduce low temperature cracking without the high temperature deformation which occurs when virgin asphalt is used. It has been founded that the use of sulphur extended asphalt with 30% to 40% sulphur in paving mixes leads to reduction in deformation approximately by half. Paving material based on sulphur asphalt and binder exhibit better resistance to water as compared with conventional mixes. The use of sulphur in asphalt aggregate mixes permits the design of impervious materials being suitable for hydraulic applications. A saving of 20% asphalt can be reached by incorporating sulphur into an asphalt paving mix.

Ghaly(2008) reported that the storage stability of TR(tyre rubber)/SBS modified asphalt after vulcunaization process has been achieved at 160 degeree while the critical degradation temperature reached to 200 degree. Marshall stability and resistance to plastic deformation of TR/SBS were increased after addition of sulphur. The best improvement were obtained at 4% TR/SBS and 1% sulphur.

CHAPTER 3: CRITICAL OBSERVATIONS FROM THE LITERATURE REVIEW

- ✓ Soil fiber composites have been found effective in improving CBR value as reported in literature.
 - ✓ Stress strain strength properties of randomly distributed fiber reinforced soil are a function of fiber content and aspect ratio.
 - ✓ Base course thickness can be significantly reduced if plastic strip reinforced sand is used as sub-grade material.
 - ✓ The plastic coated aggregate bitumen mix and plastic modified bitumen forms better materials for flexible pavement construction as mixes show improvement in strength.
 - ✓ Hence the use of waste plastic for flexible pavements is one of the best methods of easy disposal of waste plastic.
 - ✓ Sulphur added bitumen has many advantages including reduced long-term road maintenance and expense, better resistance to water, improved traction and reduced accident rates in wet road conditions.
 - ✓ Many countries are focusing on recycled concrete aggregates (RCA) which is proven to be practical for non-structural concretes and to a limited extent for some structural-grade concrete.
- **IN THE PROJECT, FOCUS WILL BE ON THE IMPROVEMENT OF
STRENGTH OF COMPONENTS OF PAVEMENT BY SOME COMMON
MATERIALS**

CHAPTER 4: OBJECTIVES OF THE PROJECT

Based on the summary of the literature review the following objectives were determined:

1. To analyse the effect of different percentage of plastic strips on CBR value of soil.
2. To analyse the effect of different percentage of jute threads on CBR value of soil.
3. To compare CBR values of normal and black cotton soil.
4. To analyse the effect of addition of plastic strips on bitumen properties such as:
 - i. Penetration value
 - ii. Ductility
 - iii. Softening point
5. To analyze the effect of different percentage of Sulphur on bitumen properties such as:
 - i. Penetration value
 - ii. Ductility
 - iii. Softening point

CHAPTER 5: MATERIALS AND METHODS

MATERIALS USED IN THE PROJECT:

A) Soil: The soil used in the project is obtained from civil engineering lab in JUIT. The various index properties and compaction properties (maximum dry density and optimum moisture content) of soil were determined in the laboratory which is given in table 1. The grain size distribution is shown in fig 1.

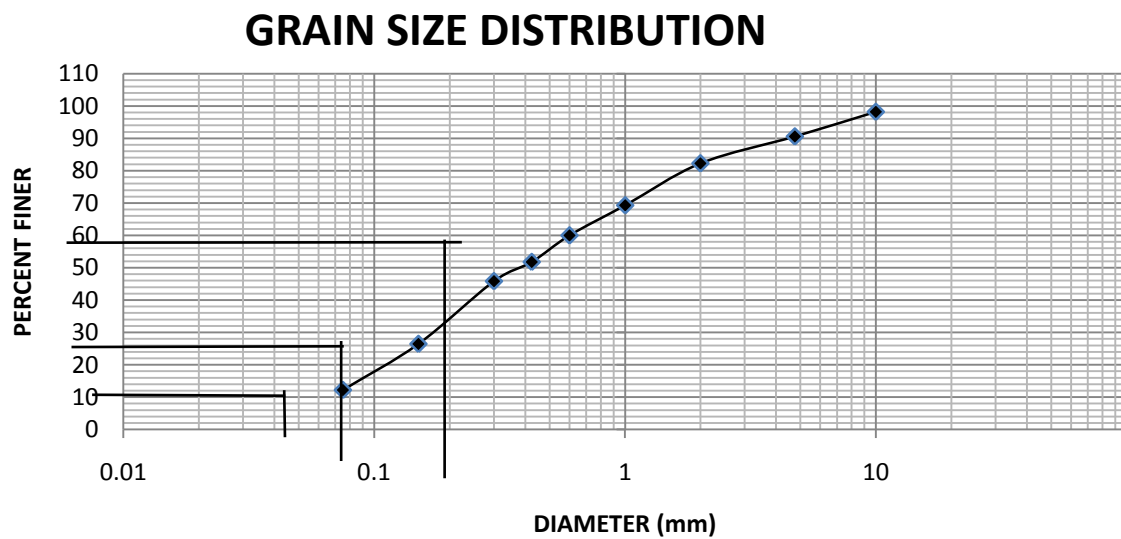


Fig. 1 Grain size Distribution Curve

Table 1: Soil Properties

| S. no. | Particulars | Value |
|--------|--|-------|
| 1 | Specific gravity | 2.30 |
| 2 | Liquid limit (%) | 22.6 |
| 3 | Plastic limit (%) | 14.29 |
| 4 | Co-efficient of uniformity (Cu) | 7.5 |
| 5 | Co-efficient of curvature (Cc) | 1.3 |
| 6 | Maximum Dry Density, γ_d (kN/m ³) | 2.1 |
| 7 | Optimum Moisture Content, OMC (%) | 13.5 |



Fig.2 : Soil Sample Used In The Project

- B) HDPE: The waste plastic used in the project was obtained from rag pickers at JUIT. The plastic strip is of thickness 1.5mm (approx.) and these strips were cut into lengths of 12, 24 and 36mm respectively. The tests were conducted at various strip content of 0.0%, 0.50% and 1%.



Fig.3: view of HDPE strips

- C) Jute threads: Use of natural fiber in civil engineering for improving soil properties is advantageous because they are cheap, locally available, biodegradable and eco-friendly. The natural fiber reinforcement causes significant improvement in tensile strength, shear strength, and other engineering properties of the soil. Over the last decade the use of randomly distributed natural and synthetic fiber has recorded a tremendous increase.

Keeping this in view an experimental study was conducted on locally available (Doimukh, Itanagar, Arunachal Pradesh, India) soil reinforced with Jute fiber. The reinforcing material used in this study is natural jute fibers of diameter 1mm. The length of fiber was taken as 40mm and 60mm.



Fig. 4: view of jute threads



Fig 5: jute threads, Length= 3mm

D) Bitumen: is a sticky, black and highly viscous liquid or semi-solid form of petroleum. It may be found in natural deposits or may be a refined product; it is a substance classed as a pitch. The primary use (70%) of asphalt/bitumen is in road construction, where it is used as the glue or binder mixed with aggregate particles to create asphalt concrete. Its other main uses are for bituminous waterproofing products, including production of roofing felt and for sealing flat roofs.

The bitumen used in the project was obtained from civil engineering lab in JUIT.



Bitumen In a tank

- E) Plastic strips: Plastic in different forms is found to be almost 5% in municipal solid waste, which is toxic in nature. It is a common sight in both urban and rural areas to find empty plastic bags and other type of plastic packing material littering the roads as well as drains. Due to its biodegradability it creates stagnation of water and associated hygiene problems. In order to contain this problem experiments have been carried out whether this waste plastic can be reused productively in the construction of roads.

Plastic carry bags were obtained from rag pickers at JUIT. These plastic bags were cut into very fine pieces. The thickness of these plastic bags was up to 0.5mm approximately.



F) *SULPHUR(S8)*: Sulphur used in the project is yellow coloured available in powdered form



CHAPTER 6: TESTS TO BE PERFORMED ON SOIL

A) California Bearing Ratio:

The California bearing ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement. It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material.

$$\text{CBR, \%} = \frac{\text{Load sustained by specimen at 2.5 or 5mm penetration}}{\text{Load sustained by standard aggregates at the corresponding penetration}} \times 100$$

The following table gives the standard loads adopted for different penetrations for the standard material with a C.B.R. value of 100%

| Penetration of Plunger(mm) | Load (kg) |
|----------------------------|-----------|
| 2.5 | 1370 |
| 5 | 2055 |
| 7.5 | 2630 |
| 10 | 3180 |
| 12.5 | 3600 |



Testing procedure of CBR test:

- a. Weigh the empty mould.
- b. Add water to the first specimen (compact it in five layer by giving 10 blows per layer)
- c. After compaction, remove the collar and level the surface.
- d. Take sample for determination of moisture content.
- e. Weight of mould + compacted specimen.
- f. Place the mold in the soaking tank for four days (ignore this step in case of unsoaked **CBR**.)
- g. Take other samples and apply different blows and repeat the whole process.
- h. After four days, measure the swell reading and find %age swell.
- i. Remove the mould from the tank and allow water to drain.
- j. Then place the specimen under the penetration piston and place surcharge load of 10lb.
- k. Apply the load and note the penetration load values.
- l. Draw the graphs between the penetration (mm) and penetration load (kg) and find the value of **CBR**.
- m. Find the CBR value.

CHAPTER 7: TESTS TO BE PERFORMED ON BITUMEN

Penetration test: It measures the hardness or softness of bitumen by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in 5 seconds. Penetration test is used to measure the consistency of bitumen, so that they can be classified into standard grades. Greater value of penetration indicates softer consistency. Generally higher penetration bitumen is preferred for use in cold climate and smaller penetration bitumen is used in hot climate areas.

At least three penetration tests are made on the sample by testing at a distance of at least 10mm apart. The mean value of three measurements is reported as a penetration value.



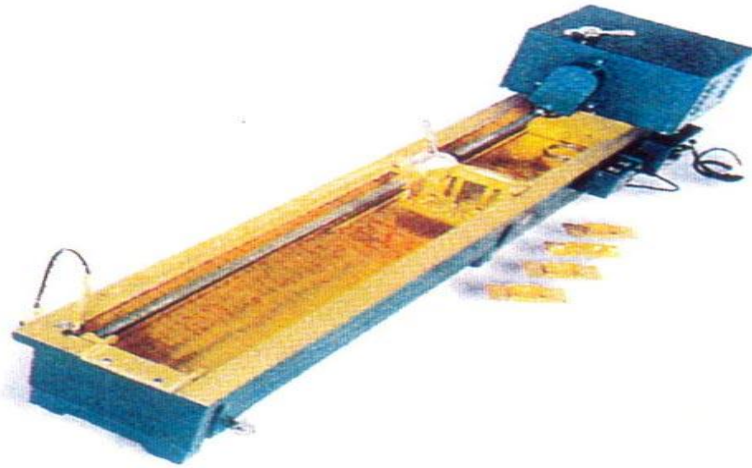
Testing procedure of Penetration test:

- i. Heat the sample until it becomes fluid.
- ii. Pour it in a container to a depth such that when cooled, the depth of sample is at least 10mm greater than the expected penetration.
- iii. Allow it to cool in an atmospheric temperature.
- iv. Clean the needle and place a weight above the needle.
- v. Use the water bath to maintain the temperature of specimen.
- vi. Mount the needle on bitumen, such that it should just touch the surface of bitumen.

- vii. Then start the stop watch and allow the penetration needle to penetrate freely at same time for 5 seconds. After 5 seconds stop the penetration.
- viii. Result will be the grade of bitumen.
- ix. Take at least three reading.

- Ductility Test:

This test is done to determine the ductility of distillation residue of cutback bitumen, blown type bitumen and other bituminous products as per IS: 1208 – 1978. The principle is that the ductility of a bituminous material is measured by the distance in cm to which it will elongate before breaking when a standard briquette specimen of the material is pulled apart at a specified speed and a specified temperature.



Testing procedure of Ductility test:

- a. Completely melt the bituminous material to be tested by heating it to a temperature of 75 to 100°C above the approximate softening point until it becomes thoroughly fluid.
 - b. Assemble the mould on a brass plate and in order to prevent the material under test from sticking, thoroughly coat the surface of the plate and the interior surfaces of the sides of the mould with a mixture of equal parts of glycerin and dextrin.
 - c. Leave it to cool at room temperature for 30 to 40 minutes.
 - d. Place the brass plate and mould with briquette specimen in the water bath and keep it at the specified temperature for about 85 to 95 minutes
 - e. Remove the briquette from the plate; detach the side pieces and the briquette immediately
 - f. Attach the rings at each end of the two clips to the pins or hooks in the testing machine and pull the two clips apart horizontally at a uniform speed, as specified, until the briquette ruptures.
 - g. Measure the distance in cm through which the clips have been pulled to produce rupture.
 - h. While the test is being done, make sure that the water in the tank of the testing machine covers the specimen both above and below by at least 25mm and the temperature is maintained continuously within $\pm 0.5^\circ\text{C}$ of the specified temperature
- Softening Point Test:

Softening point (ring and ball) test is a method for the determination of the softening point of bitumen and bituminous binders, in the range 30 °C to 150 °C. Two horizontal discs of bituminous binder, cast in shouldered brass rings, are heated at a controlled rate in a liquid bath while each supports a steel ball. The softening point is reported as the mean of the temperatures at which the two discs soften enough to allow each ball, enveloped in bituminous binder, to fall a distance of (25.0 ± 0.4) mm.

The principle behind this test is that softening point is the temperature at which the substance attains a particular degree of softening under specified condition of the test.



Testing procedure of Softening Point Test:

- a. The sample should be just sufficient to fill the ring. The excess sample should be cut off by a knife.
- b. Heat the material between 75 and 100°C. Stir it to remove air bubbles and water, if necessary.
- c. Heat the rings and apply glycerine. Fill the material in it and cool it for 30 minutes.
- d. Remove excess material with the help of a warmed, sharp knife. Assemble the apparatus with the rings, thermometer and ball guides in position.
- e. Fill the beaker with boiled distilled water at a temperature $5.0 \pm 0.5^\circ\text{C}$ per minute.
- f. With the help of a stirrer, stir the liquid and apply heat to the beaker at a temperature of $5.0 \pm 0.5^\circ\text{C}$ per minute.
- g. Apply heat until the material softens and allow the ball to pass through the ring.
- h. Record the temperature at which the ball touches the bottom, which is nothing but the softening point of that material.

CHAPTER 8: RESULT AND DISCUSSION

TESTING ON SOIL:

The most important engineering parameter to evaluate a sub-grade or sub-base materials for pavement design is the CBR value. Deformation of the soil specimen being predominantly shear in nature, the CBR value can be regarded as an indirect measure of strength. The load-penetration curves obtained from the CBR tests for un-reinforced and randomly reinforced system with strip and jute fibre contents of 0.5% and 1% for different aspect ratios (AR=1 to 3) are shown in Figures below. It can be observed from these figures that mixing of randomly distributed HDPE strips and jute threads in soil increased the piston load at a given penetration considerably. The figures further reveals that the initial slope of the load-penetration curve is significantly improved due to the incorporation of strips and jute threads in soil. It is also evident from these figures that inclusion of waste plastic and jute threads increased the CBR value significantly.

HDPE Strips On Soil:

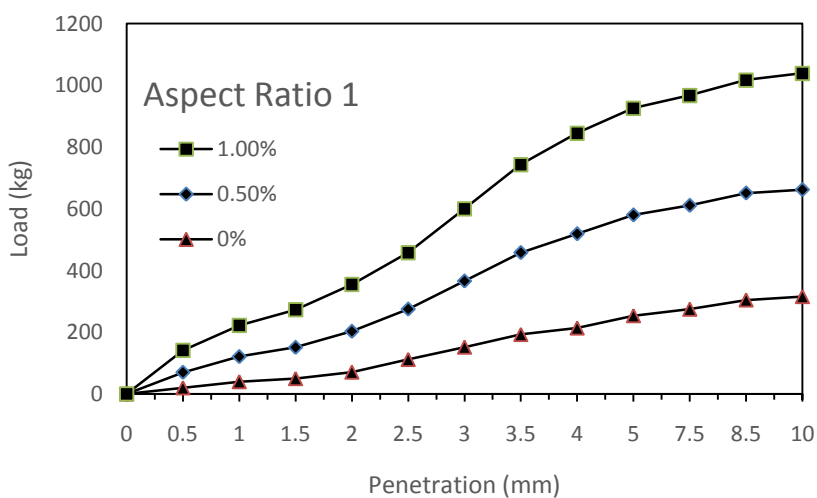


Fig.6: CBR Load Vs Penetration curve(HDPE) AR=1

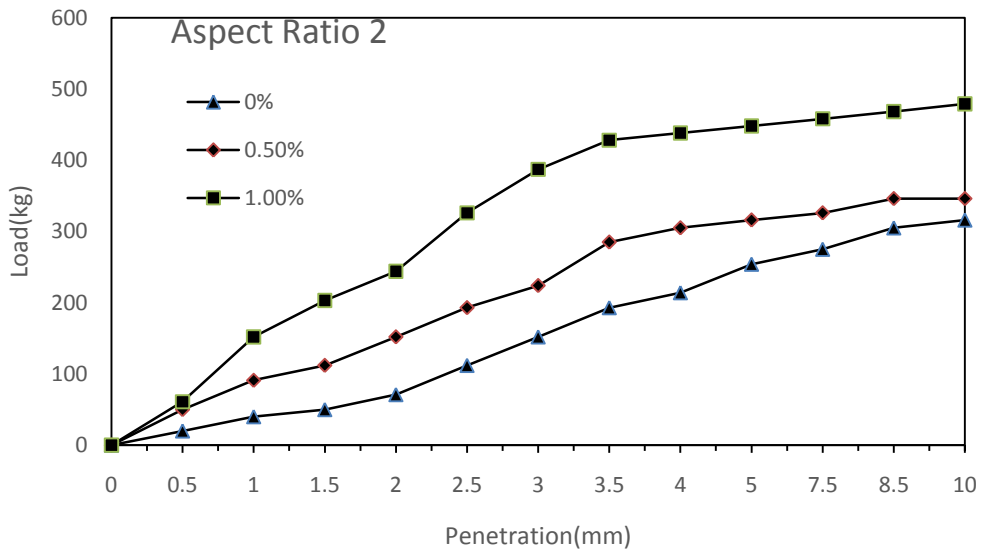


Fig.

7: CBR Load Vs Penetration curve(HDPE) AR=2

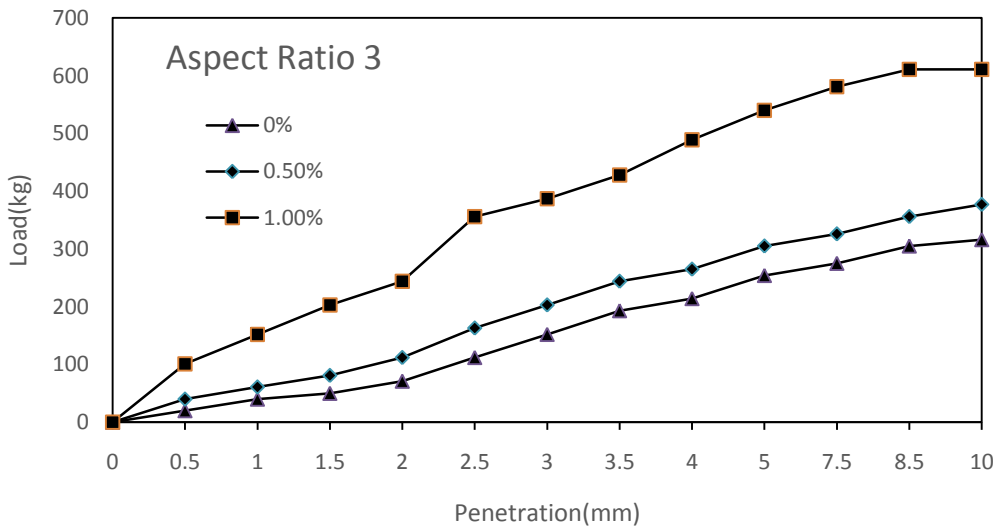


Fig.8: CBR Load Vs Penetration curve(HDPE) AR=3

Table 2: CBR value of soil at various strip content and aspect ratio

| Aspect Ratio | Length of Plastic Strips(mm) | Percentage of Strips | CBR(%) | Percent Increase in CBR |
|--------------|------------------------------|----------------------|--------|-------------------------|
| 1 | 10 | 0% | 12.36 | 0 |
| | | 0.5% | 15.86 | 28.31 |
| | | 1% | 16.83 | 36.16 |
| 2 | 20 | 0% | 12.36 | 0 |
| | | 0.5% | 15.37 | 24.35 |
| | | 1% | 21.8 | 76.37 |
| 3 | 30 | 0% | 12.36 | 0 |
| | | 0.5% | 14.84 | 20.06 |
| | | 1% | 26.27 | 112.54 |

Jute Threads on Soil:

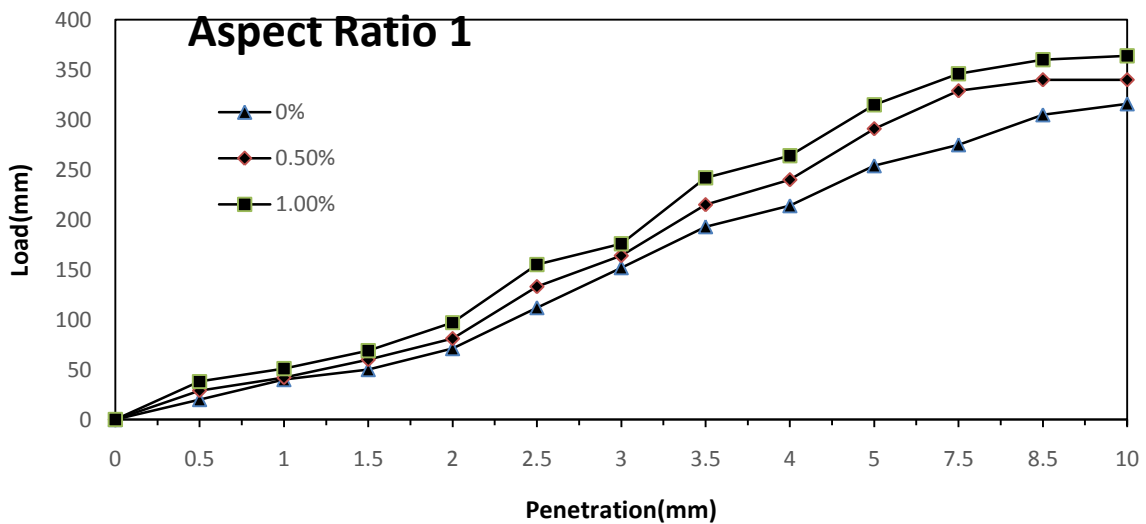


Fig.9: CBR Load Vs Penetration curve(Jute Threads) AR=1

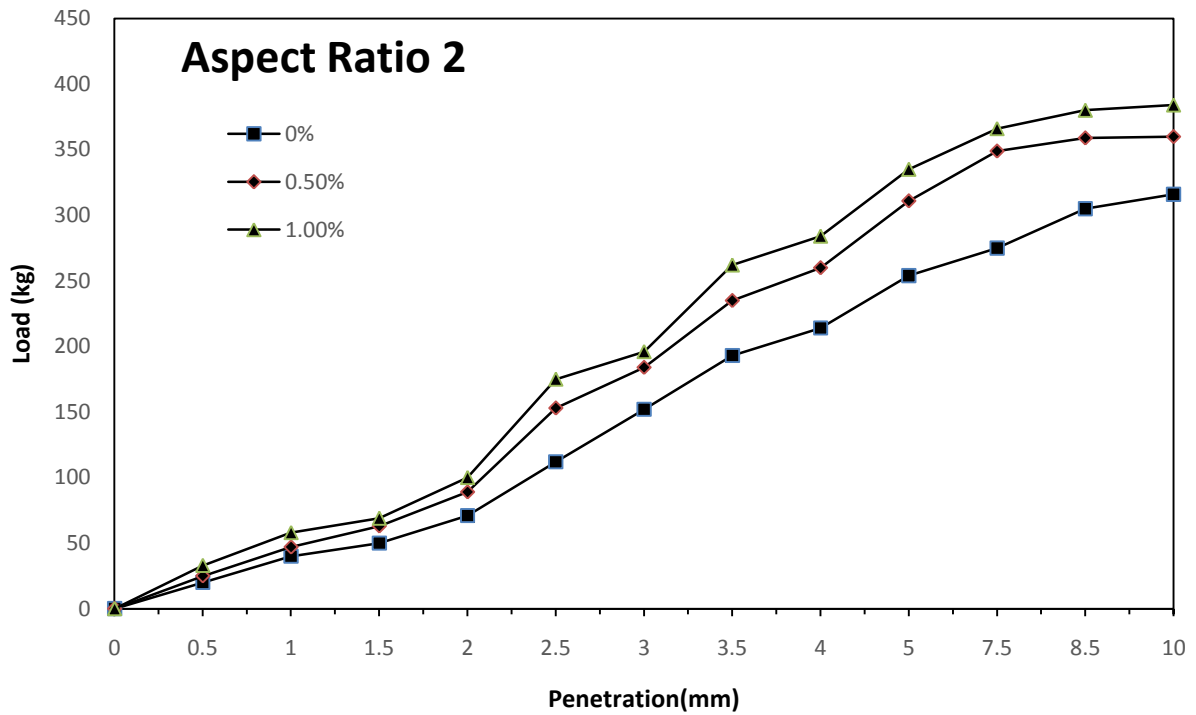


Fig.10: CBR Load Vs Penetration curve(Jute Threads) AR=2

Table 3: CBR value of soil at various Thread content and aspect ratio

| Aspect Ratio | Length of Jute Fibre | Percentage of Fibre | CBR | Percent Increase in CBR |
|--------------|----------------------|---------------------|-------|-------------------------|
| | | 0% | 12.36 | 0 |
| 1 | 40mm | 0.50% | 14.16 | 14.56 |
| | | 1% | 15.33 | 24.03 |
| | | 0% | 12.36 | 0 |
| 2 | 60mm | 0.50% | 15.13 | 22.41 |
| | | 1% | 16.3 | 31.87 |

Testing On Bitumen:

- **Penetration Value**

Table 4: Penetration value of Bitumen without and with plastic

| Sample no. | Average Penetration Value, 1/10th of mm | | % change in penetration |
|-------------|---|-------------------------|-------------------------|
| | <i>without plastic</i> | <i>with plastic(5%)</i> | |
| 1 | 45 | 42 | |
| 2 | 47 | 40.33 | |
| 3 | 48 | 38 | |
| Avg. | 46.67 | 40.11 | -14.05% |

Table 5: Penetration value of Bitumen without and with Sulphur

| Sample no. | Average Penetration Value, 1/10th of mm | | % change in penetration |
|-------------|---|-------------------------|-------------------------|
| | <i>without Sulphur</i> | <i>with Sulphur(5%)</i> | |
| 1 | 45 | 18 | |
| 2 | 47 | 19 | |
| 3 | 48 | 18 | |
| Avg. | 46.67 | 18.33 | -60.72% |

- **Ductility Value**

Table 7: Ductility value of Bitumen without and with plastic

| Sample no. | Average Ductility Value, cm | | % change in ductility |
|-------------|-----------------------------|------------------|-----------------------|
| | without plastic | with plastic(5%) | |
| 1 | 62 | 74 | |
| 2 | 64 | 78 | |
| 3 | 67 | 77 | |
| Avg. | 64.34 | 76.34 | 18.65% |

Table 8: Ductility value of Bitumen without and with Sulphur

| Sample no. | Average Ductility Value, cm | | % change in ductility |
|-------------|-----------------------------|-------------------|-----------------------|
| | without Sulphur | with Sulphur (5%) | |
| 1 | 62 | 81 | |
| 2 | 64 | 83 | |
| 3 | 67 | 84 | |
| Avg. | 64.34 | 82.66 | 28.48% |

- **Softening Point Value**

Table 10: Softening point value of Bitumen without and with plastic

| Sample no. | Softening Point, °C | | % change in softening point |
|-------------|---------------------|------------------|-----------------------------|
| | without plastic | with plastic(5%) | |
| 1 | 45 | 53 | |
| 2 | 47 | 55 | |
| 3 | 49 | 53 | |
| Avg. | 47 | 53.67 | 14.91% |

Table 11: Softening point value of Bitumen without and with Sulphur

| Sample no. | Softening Point, °C | | % change in softening point |
|-------------|---------------------|------------------|-----------------------------|
| | without Sulphur | with Sulphur(5%) | |
| 1 | 45 | 82 | |
| 2 | 47 | 83 | |
| 3 | 49 | 84 | |
| Avg. | 47 | 83 | 76.56% |

CHAPTER 9: CONCLUSIONS

The feasibility of reinforcing soil with strips of reclaimed HDPE and jute threads was investigated in this study. Strips of HDPE and jute threads were mixed with local soil and tested to determine CBR values. The tests show that reinforcing soil with waste HDPE strips and jute threads enhances its resistance to deformation and its strength

Based on the results, the following conclusions can be drawn:

- 1) The addition of reclaimed HDPE strips and jute threads to local sand increases the CBR value.
- 2) The maximum improvement in CBR is obtained when the strip content is 1% and the aspect ratio 3.
- 3) The reinforcement benefit increases with an increase in waste plastic strip and jute thread content and length.
- 4) The maximum CBR value of a reinforced system is approximately 3 times that of a unreinforced system.
- 5) Base course thickness can be significantly reduced if HDPE strip or jute thread reinforced soil is used as sub-grade material. This suggests that the strips of appropriate size cut from reclaimed HDPE and jute threads may prove beneficial as soil reinforcement in highway sub-base if mixed with locally available granular soils in appropriate quantity.
- 6) CBR value decreases as we replace normal soil by black cotton soil. This shows that strength of black cotton soil is very less as compared to normal soil. Thus it is not preferred for construction purpose.

Also, mixing of bitumen with plastic and sulphur improves various properties of bitumen.

Conclusions drawn from the experiments are as follows:

- 1) Penetration value of bitumen has decreased indicating its improved resistance to temperature.
- 2) Ductility of bitumen has been improved on addition of plastic implying its improved resistance to cracking.
- 3) Softening point of bitumen has also gone up. This indicates that the bitumen mixed with plastic and rubber can be used as a binder material for a region where temperature is high and can help the pavement surface from deformation.
- 4) Although both plastic and sulphur improves bitumen properties, mixing sulphur shows tremendous improvement in bitumen properties.

CHAPTER 10: SCOPE FOR FUTURE WORK

The results of this projects shows that mixing of hdpe strips and jute threads in soil and plastic pieces in bitumen may prove useful in improvement of highway materials and highway constructions. However, further study is needed:

- 1) To optimize the size and shape of plastic strips.
- 2) To assess the durability and aging of plastic strips and jute threads.
- 3) To assess the strength of soil reinforcements used in soaked conditions.
- 4) Large scale test is also needed to determine the boundary effects influence on test result
- 5) To assess the durability of various materials used in the project

APPENDIX A: SOIL PROPERTIES

Grain size distribution

| SIEVE NO | WT OF SIEVE(gm) | WT OF SIEVE + SOIL(gm) | SOIL RETAINED(gm) | %AGE OF SOIL RETAINED | CUMULATIVE %AGE | % FINER |
|----------|-----------------|------------------------|-------------------|-----------------------|-----------------|---------|
| 10 | 503.1 | 521.5 | 18.4 | 1.84 | 1.84 | 98.16 |
| 4.75 | 418.6 | 494.5 | 75.9 | 7.59 | 9.43 | 90.57 |
| 2 | 402.7 | 486.1 | 83.4 | 8.34 | 17.77 | 82.23 |
| 1 | 374.8 | 504.2 | 129.4 | 12.94 | 30.71 | 69.29 |
| 0.6 | 362.4 | 455.8 | 93.4 | 9.34 | 40.05 | 59.95 |
| 0.425 | 349.9 | 431.8 | 81.9 | 8.19 | 48.24 | 51.76 |
| 0.3 | 354.3 | 413.8 | 59.5 | 5.95 | 54.19 | 45.81 |
| 0.15 | 358 | 551.6 | 193.6 | 19.36 | 73.55 | 26.45 |
| 0.075 | 328.4 | 471.1 | 142.7 | 14.27 | 87.82 | 12.18 |
| pan | 255.9 | 375.8 | 119.9 | 11.99 | 99.81 | 0.19 |

Specific gravity

| Sample | 1 | 2 | 3 | |
|---------------------------------|-------|------|-------|------------|
| Wt of bottle(gm) | 35.5 | 29.9 | 33.2 | |
| Wt of bottle + soil(gm) | 52.2 | 50.1 | 51.5 | |
| Wt of bottle + soil + water(gm) | 95.9 | 90.6 | 98.1 | |
| wt of bottle + water(gm) | 86.2 | 79.3 | 88 | |
| sp gravity | 2.386 | 2.27 | 2.232 | avg= 2.296 |

Liquid limit

| Sample | No. of blows | wt of empty container (gm) | wt of cont + wet soil (gm) | wt of container + dry soil (gm) | water content(%) |
|--------|--------------|----------------------------|----------------------------|---------------------------------|------------------|
| 1 | 18 | 27.85 | 95.15 | 84.37 | 19.07 |
| 3 | 45 | 28.2 | 70.2 | 63.05 | 20.52 |
| 4 | 55 | 28.5 | 67.45 | 60.6 | 21.34 |
| 2 | 125 | 27.4 | 55.52 | 50.17 | 23.5 |

LL= 22.6%

Plastic limit

| Sample | wt of empty container (gm) | wt of cont + wet soil (gm) | wt of container + dry soil (gm) | water content(%) |
|--------|----------------------------|----------------------------|---------------------------------|------------------|
| 1 | 27.3 | 39.3 | 37.8 | 14.29 |

PL= 14.29%
PI= 5.21%

Optimum moisture content

| Determination | 1 | 2 | 3 |
|-----------------------------------|-------|-------|-------|
| wt of mould(gm) | 5550 | 5550 | 5550 |
| wt of mould+ soil(gm) | 7630 | 7690 | 7563 |
| vol of mould(cm ³) | 1000 | 1000 | 1000 |
| wt of container(gm) | 28.8 | 28.1 | 26.9 |
| wt of container+ wet soil | 44.5 | 55.08 | 49 |
| wt of container+ dry soil | 42.9 | 52 | 46 |
| w% | 11.35 | 12.89 | 15.71 |
| bulk density(gm/cm ³) | 2.08 | 2.14 | 2.013 |
| dry density(gm/cm ³) | 1.87 | 2.1 | 1.74 |

APPENDIX B: CBR WITH PLASTIC STRIPS

Aspect ratio 1 : length : 10mm thickness:1.5mm

| Penetration(mm) | Load in kg at varrious strip contents | | |
|-----------------|---------------------------------------|-------|-------|
| | 0% | 0.50% | 1.00% |
| 0 | 0 | 0 | 0 |
| 0.5 | 20 | 50 | 71 |
| 1 | 40 | 81 | 101 |
| 1.5 | 50 | 101 | 122 |
| 2 | 71 | 132 | 152 |
| 2.5 | 112 | 163 | 183 |
| 3 | 152 | 214 | 234 |
| 3.5 | 193 | 265 | 285 |
| 4 | 214 | 305 | 326 |
| 5 | 254 | 326 | 346 |
| 7.5 | 275 | 336 | 356 |
| 8.5 | 305 | 346 | 366 |
| 10 | 316 | 346 | 377 |

Aspect Ratio 2: length=20mm, thickness=1.5mm

| Penetration(mm) | Load in kg at varrious strip contents | | |
|-----------------|---------------------------------------|-------|-------|
| | 0% | 0.50% | 1.00% |
| 0 | 0 | 0 | 0 |
| 0.5 | 20 | 50 | 61 |
| 1 | 40 | 91 | 152 |
| 1.5 | 50 | 112 | 203 |
| 2 | 71 | 152 | 244 |
| 2.5 | 112 | 193 | 326 |
| 3 | 152 | 224 | 387 |
| 3.5 | 193 | 285 | 428 |
| 4 | 214 | 305 | 438 |
| 5 | 254 | 316 | 448 |
| 7.5 | 275 | 326 | 458 |
| 8.5 | 305 | 346 | 468 |
| 10 | 316 | 346 | 479 |

Aspect Ratio 3: length= 30mm, thickness=1.5mm

| Penetration(mm) | Load in kg at varrious strip contents | | |
|-----------------|---------------------------------------|-------|-------|
| | 0% | 0.50% | 1.00% |
| 0 | 0 | 0 | 0 |
| 0.5 | 20 | 40 | 101 |
| 1 | 40 | 61 | 152 |
| 1.5 | 50 | 81 | 203 |
| 2 | 71 | 112 | 244 |
| 2.5 | 112 | 163 | 356 |
| 3 | 152 | 203 | 387 |
| 3.5 | 193 | 244 | 428 |
| 4 | 214 | 265 | 489 |
| 5 | 254 | 305 | 540 |
| 7.5 | 275 | 326 | 581 |
| 8.5 | 305 | 356 | 611 |
| 10 | 316 | 377 | 611 |

APPENDIX C: CBR WITH JUTE THREADS

Aspect ratio 1: length=30mm, diameter=1mm

| Penetration(mm) | Load in kg at various thread contents | | |
|-----------------|---------------------------------------|-------|-------|
| | 0% | 0.50% | 1.00% |
| 0 | 0 | 0 | 0 |
| 0.5 | 20 | 29 | 38 |
| 1 | 40 | 42 | 51 |
| 1.5 | 50 | 60 | 69 |
| 2 | 71 | 81 | 97 |
| 2.5 | 112 | 133 | 155 |
| 3 | 152 | 164 | 176 |
| 3.5 | 193 | 215 | 242 |
| 4 | 214 | 240 | 264 |
| 5 | 254 | 291 | 315 |
| 7.5 | 275 | 329 | 346 |
| 8.5 | 305 | 340 | 360 |
| 10 | 316 | 340 | 364 |

Aspect ratio 2: length = 60mm, diameter =1mm

| Penetration(mm) | Load in kg at various strip contents | | |
|-----------------|--------------------------------------|-------|-------|
| | 0% | 0.50% | 1.00% |
| 0 | 0 | 0 | 0 |
| 0.5 | 20 | 25 | 33 |
| 1 | 40 | 47 | 58 |
| 1.5 | 50 | 63 | 69 |
| 2 | 71 | 89 | 100 |
| 2.5 | 112 | 153 | 175 |
| 3 | 152 | 184 | 196 |
| 3.5 | 193 | 235 | 262 |
| 4 | 214 | 260 | 284 |
| 5 | 254 | 311 | 335 |
| 7.5 | 275 | 349 | 366 |
| 8.5 | 305 | 359 | 380 |
| 10 | 316 | 360 | 384 |

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