A
Project Report
On

IMPROVEMENT OF HIGHWAY MATERIALS

Under guidance of
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CERTIFICATE

This is to certify that the work titled "**IMPROVEMENT OF HIGHWAY MATERIALS USING PLASTIC STRIPS AND JUTE**" submitted by Arpit Somani, Robin Jasuja and 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.

Sign of Supervisor ……………………..
Name of Supervisor Mr. Saurabh Rawat
Designation Assistant Professor
Date ……………………..

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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. *Rubberized 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. *Recycled aggregates* encompass industrial by-products and reused construction products, all of which were once considered wastes and dumped in landfill.

Keywords: *HDPE, Jute, CBR, Bitumen, Aggregate, Recycled aggregates, Rubberized bitumen*

Table of Contents

List of Figures

CHAPTER 1: 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 immortal. 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. Crumb rubber binders have been used very successfully in sprayed seals for many years. The presence of rubber improves the properties of the binder, and also permits a higher application rate to be used. Thicker binder films are more resistant to reflection cracking and any cracks are more liable to heal during the summer months.

There is increasing demand and interest in aggregates from non-traditional sources such as from industrial by-products and recycled construction and demolition (C&D) wastes. Recycled aggregates encompass industrial by-products and reused construction products, all of which were once considered wastes and dumped in landfill. The recently introduced European Standards for aggregates do not discriminate between different sources, and are for 'aggregates from natural, recycled and manufactured materials'. The focus is on fitness for purpose rather than origin of the resource. Recycled aggregates are aggregates derived from the processing of materials previously used in a product and/or in construction. Examples include recycled concrete from construction and demolition waste material (C&D), reclaimed aggregate from asphalt pavement and scrap tyres.

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 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. 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.

As per study in the paper by (Aslam et al, 2010) Polymer modified bitumen is emerging as one of the important construction of flexible pavements. The polymer modified bitumen show better properties for road construction and plastics waste can find its use in this process and this can help solving problem of pollution. An alternate method to use higher percentage of plastic waste in flexible pavement is by using plastic coated aggregate (PCA). This method is known widely as dry process. The aggregate coated with plastic was used as the raw material. The bitumen was not blended with plastic waste

(Baraiya, N.D., 2013) states that the use of four wheeler, two wheeler vehicles etc. is increasing day by day. As a result amount of waste tyres also increasing. Waste tyres in India are categorized as solid or hazardous waste. It is estimated that about 60 per cent of waste tyres are disposed via unknown routes in the urban as well as rural areas. This leads to various environmental problems which include air pollution associated with open burning of tyres (particulates, odor, visual impacts, and other harmful contaminants such as polycyclic aromatic hydrocarbon, dioxin, furans and oxides of nitrogen) and aesthetic pollution. Therefore, it is necessary to utilize the wastes effectively with technical development in each field. The waste tyres can be used as well sized aggregate in the various bituminous mixes if it is cut in the form of aggregate and can be called as rubber aggregate. This not only minimizes the pollution occurred due to waste tyres but also minimizes the use of conventional aggregate which is available in exhaustible quantity.

According to (Way, G., 2006) rubberized 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. It significantly reduces noise as opposed to concrete pavements, and also is quieter than bituminous pavements; rubber bitumen makes urban environments more habitable. It creates less of a "heat island" effect than with concrete pavement at surface. It is a hugely beneficial use for post-consumer waste tyre materials, using about 1,000 waste passenger tyres per lane-mile.

(Formosa et al, 2009) indicates an increasing trend and incentive for the greater use of manufactured and recycled aggregates in construction. There are, however, limitations to the use such materials. This report focuses on known benefits and limitations of a range of manufactured and recycled aggregates. Successful strategy must be based on both cost and performance. In terms of performance, 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. However, the processing and quality control cost associated with their use plus the premium paid for mix design adjustment to achieve the same strength grade as concrete with natural aggregates can vary considerably.

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.

- ✓ Rubberized bitumen has many advantages including reduced long-term road maintenance and expense, significant noise reductions, 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 OF DAILY USE.*

CHAPTER 4: OBJECTIVES OF THE PROJECT

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 analyse the effect of addition of crumbed rubber on bitumen properties such as:
   i. Penetration value
   ii. Ductility
   iii. Softening point

6. To analyse the effect of changing aggregates by reused concrete on varrious properties such as:
   i. Hardness
   ii. Toughness
   iii. Strength

CHAPTER 5: 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.

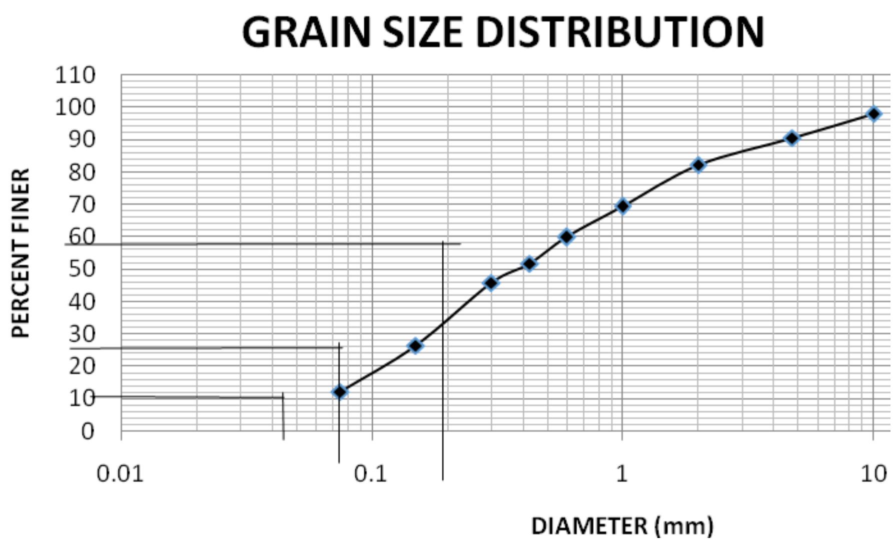

Fig. 1 Grain size Distribution Curve

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, γd (kN/m^3)	2.1
7	Optimum Moisture Content, OMC (%)	13.5

Fig.2 : Soil Sample Used In The Project

B) Black cotton 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 2.

Black cotton soil (BC soil) is a highly clayey soil. It is so hard that the clods cannot be easily pulverized for treatment for its use in road construction. This poses serious problems as regards to subsequent performance of the road. The black color in Black cotton soil (BC soil) is due to the presence of titanium oxide in small concentration. The Black cotton soil (BC soil) has a high percentage of clay, which is predominantly montmorillonite in structure and black or blackish grey in color.

Table 2: Black Cotton Soil Properties

S. no.	Particulars	Value
1	Liquid limit (%)	73
2	Plastic limit (%)	38.6
3	Plasticity index (%)	34.4
5	Maximum Dry Density, γ_d (kN/m^3)	1.84
6	Optimum Moisture Content, OMC (%)	27

C) 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

D) 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

E) 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.

Fig 6: Bitumen

F) 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.

Fig 7: Plastic cut in fine pieces

G) Crumbed Rubber: Rubberized bitumen, a binder in hot mix asphalt and chip seal applications that results from the proper addition of crumb rubber to hot bitumen and then left in a heated state to react. It is a material that can be used to seal cracks and joints, be applied as a chip seal coat and added to hot mineral aggregate to make a unique asphalt paving material. The presence of rubber improves the properties of the binder, and also permits a higher application rate to be used. Thicker binder films are more resistant to reflection cracking and any cracks are more liable to heal during the summer months. Also, due to its sound absorbing properties, it significantly reduces noise as opposed to concrete pavements, and also is quieter than bituminous pavements; rubber bitumen makes urban environments more habitable.
Rubber used in this project is waste tyre rubber obtained from a tyre shredder in solan. The rubber pieces are approximately 1.5 to 2 mm thick and about 2 to 6 mm in length.

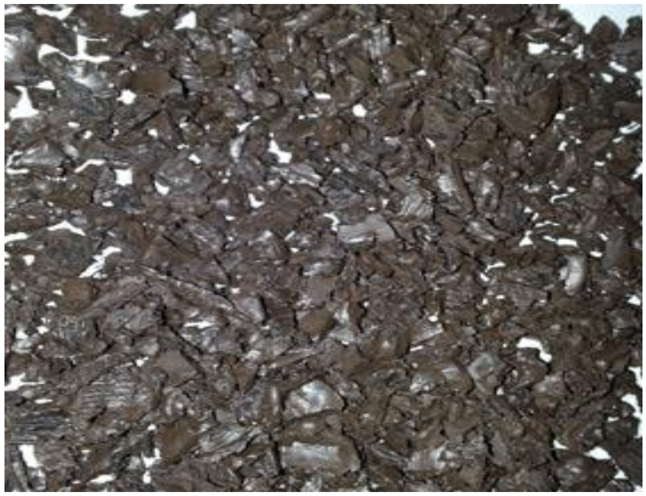

Fig 8: Crumbed Rubber

H) Reused Concrete: recycled concrete aggregates (RCA) have been proven to be practical for low-strength concretes and to a limited extent for some structural grade concrete.
The concrete aggregates used in the project were obtained from a demolition site in waknaghat and then broken in appropriate size.

Fig 9: Concrete Aggregates

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.

$$\text{CBR, \%} = \frac{\textit{Load sustained by specimen at 2.5 or 5mm penetration}}{\textit{Load sustained by standard aggregatesat the corresponding penetration}} \text{x100}$$

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

Table 3: standard loads adopted for different penetrations for the standard material

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

<u>Fig 10: CBR test apparatus and sample</u>

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

A) 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.

Fig 11: Penetration Test Apparatus

Testing procedure of Penetration test:

1. Heat the sample until it becomes fluid.
2. 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.
3. Allow it to cool in an atmospheric temperature.
4. Clean the needle and place a weight above the needle.
5. Use the water bath to maintain the temperature of specimen.

6. Mount the needle on bitumen, such that it should just touch the surface of bitumen.
7. 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.
8. Result will be the grade of bitumen.
9. Take at least three reading.

B) 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.

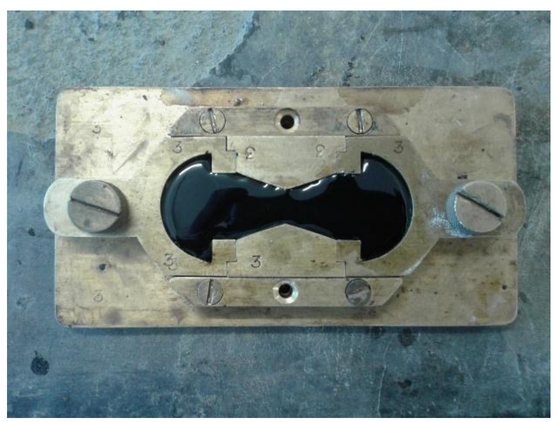

Fig 12: Ductility test apparatus and briquette

Testing procedure of Ductility test:

a. Completely melt the bituminous material to be tested by heating it to a temperature of 75 to 100oC 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 ± 0.5oC of the specified temperature.

C) 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.

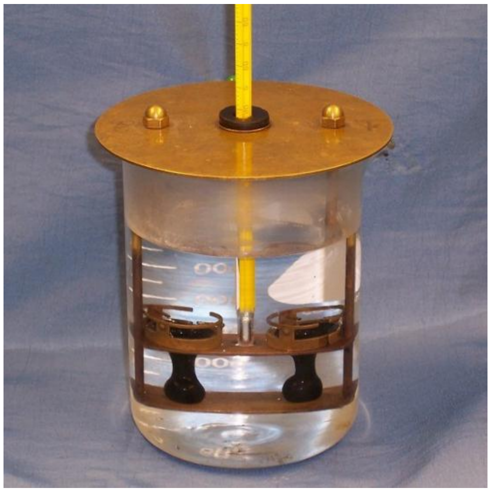

Fig 13: Ring and Ball test apparatus

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^{o}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 ± 0.5^{o}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 ± 0.5^{o}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: TESTS TO BE PERFORMED ON AGGREGATES

A) Crushing test:

The strength of coarse aggregate may be assessed by aggregate crushing test. The test provides a relative measure of resistance to crushing under gradually applied compressive load. To achieve a high quality of pavement, aggregates possessing high resistance to crushing or low crushing value are preferred.

This test helps to determine the aggregate crushing value of coarse aggregates as per IS: 2386 (Part IV) – 1963. The apparatus used is cylindrical measure and plunger, Compression testing machine, IS Sieves of sizes – 12.5mm, 10mm and 2.36mm.

Testing procedure of Crushing test:

i) The aggregates passing through 12.5mm and retained on 10mm IS Sieve are oven-dried at a temperature of 100 to 110oC for 3 to 4hrs.

ii) The cylinder of the apparatus is filled in 3 layers, each layer tamped with 25 strokes of a tamping rod.

iii) The weight of aggregates is measured (Weight 'A').

iv) The surface of the aggregates is then leveled and the plunger inserted. The apparatus is then placed in the compression testing machine and loaded at a uniform rate so as to achieve 40t load in 10 minutes. After this, the load is released.

v) The sample is then sieved through a 2.36mm IS Sieve and the fraction passing through the sieve is weighed (Weight 'B').

vi) Two tests should be conducted.

$$\text{Aggregate crushing value} = \frac{B}{A} \times 100$$

A=weight of sample

B= weight of sample passing 2.36mm sieve

B) Abrasion Test: (Los angeles abrasion test)

This test helps to determine the abrasion value of coarse aggregates as per IS: 2386 (Part IV) – 1963.

The apparatus used in this test are Los Angles abrasion testing machine, IS Sieve of size – 1.7mm, Abrasive charge – 12 nos. cast iron or steel spheres approximately 48mm dia. and each weighing between 390 and 445g ensuring that the total weight of charge is 5000 +25g and Oven.

Fig 14: Los Angeles Abrasion Test apparatus

Sample Preparation

The test sample should consist of clean aggregates which has been dried in an oven at 105 to 110oC to a substantially constant weight and should conform to one of the grading shown in the table below:

Grading of test samples

Sieve size (Square hole)		Weight in g of test sample for grade						
Passing through (mm)	Retained on (mm)	A	B	C	D	E	F	G
80	63	-	-	-	-	2500*	-	-
63	50	-	-	-	-	2500*	-	-
50	40	-	-	-	-	5000*	5000*	-
40	25	1250	-	-	-	-	5000*	5000*
25	20	1250	-	-	-	-	-	5000*
20	12.5	1250	2500	-	-	-	-	-
12.5	10	1250	2500	-	-	-	-	-
10	6.3	-	-	2500	-	-	-	-
6.3	4.75	-	-	2500	-	-	-	-
4.75	2.36	-	-	-	5000	-	-	-

Testing procedure of Los angeles abrasion test:

a) The test sample and the abrasive charge should be placed in the Los Angles abrasion testing machine.

b) The machine rotated at a speed of 20 to 33 revolutions/minute for 1000 revolutions.

c) At the completion of the test, the material should be discharged and sieved through 1.70mm IS Sieve.

$$Los\ Angeles\ Abrasion\ Value = \frac{B}{A} \times 100$$

A= weight of sample

B=weight of sample passing 1.7mm sieve

C) Impact test:

This test is done to determine the aggregate impact value of coarse aggregates as per IS: 2386 (Part IV) – 1963. The apparatus used for determining aggregate impact value of coarse aggregates.

Impact testing machine conforming to IS: 2386 (Part IV)- 1963,IS Sieves of sizes – 12.5mm, 10mm and 2.36mm, A cylindrical metal measure of 75mm dia. and 50mm depth, A tamping rod of 10mm circular cross section and 230mm length, rounded at one end and Oven.

Fig 15: Impact Value Test apparatus

Preparation of Sample

i) The test sample should conform to the following grading:

- Passing through 12.5mm IS Sieve – 100%

- Retention on 10mm IS Sieve – 100%

ii) The sample should be oven-dried for 4hrs. at a temperature of 100 to 110oC and cooled.

iii) The measure should be about one-third full with the prepared aggregates and tamped with 25 strokes of the tamping rod.

Testing procedure of Impact test:

a) The cup of the impact testing machine should be fixed firmly in position on the base of the machine.

b) The whole of the test sample placed in it and compacted by 25 strokes of the tamping rod.

c) The hammer should be raised to 380mm above the upper surface of the aggregates in the cup and allowed to fall freely onto the aggregates.

d) The test sample should be subjected to a total of 15 such blows, each being delivered at an interval of not less than one second.

$$Aggregate\ Impact\ Value = \frac{B}{A} \times 100$$

A= weight of sample

B=weight of sample passing 2.36mm sieve

CHAPTER 9: RESULTS 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 fiber 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:

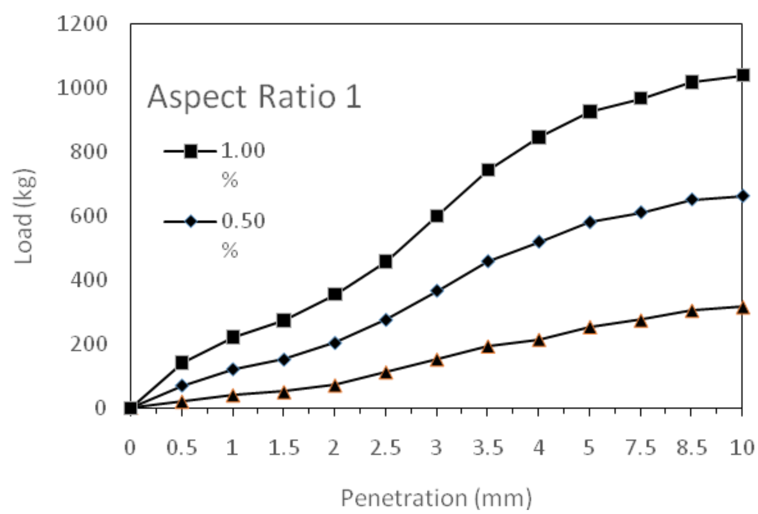

Fig.16:CBR Load Vs Penetration curve(HDPE) AR=1

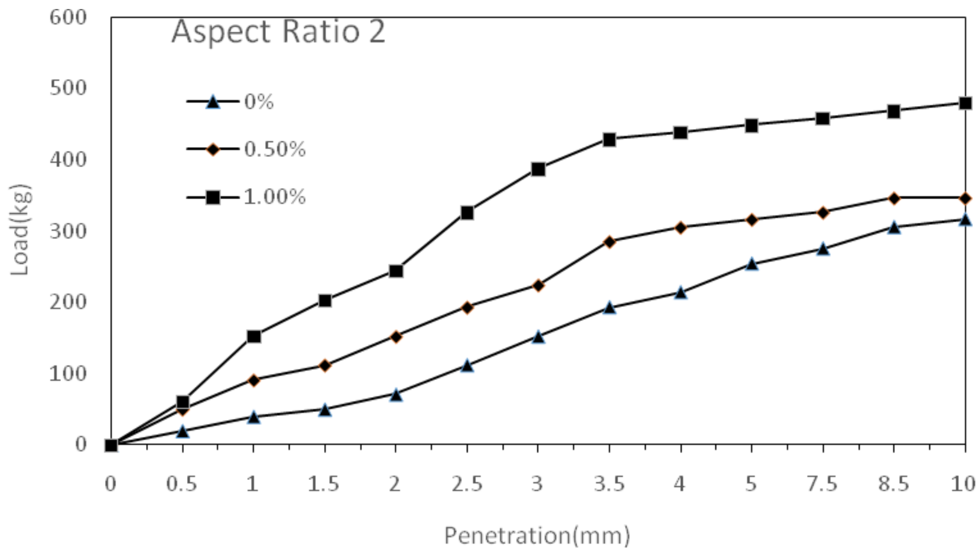

Fig.17: CBR Load Vs Penetration curve(HDPE) AR=2

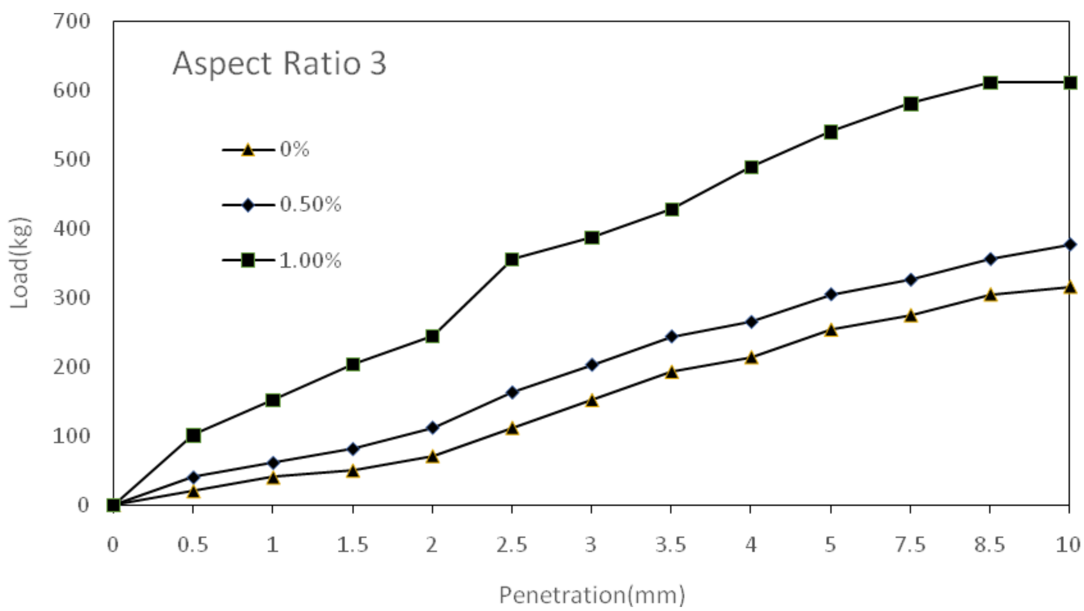

Fig.18: CBR Load Vs Penetration curve(HDPE) AR=3

Table 4: 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
		0.50%	15.86	28.31
		1%	16.83	36.16
2	20	0%	12.36	0
		0.50%	15.37	24.35
		1%	21.8	76.37
3	30	0%	12.36	0
		0.50%	14.84	20.06
		1%	26.27	112.54

Jute Threads on Soil:

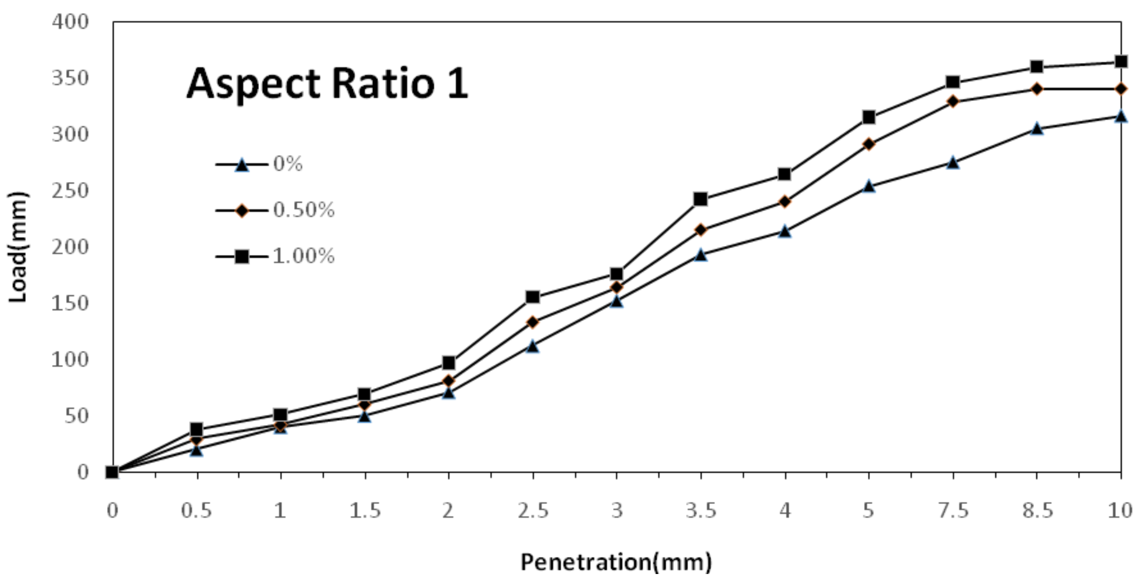

Fig.19: CBR Load Vs Penetration curve(Jute Threads) AR=1

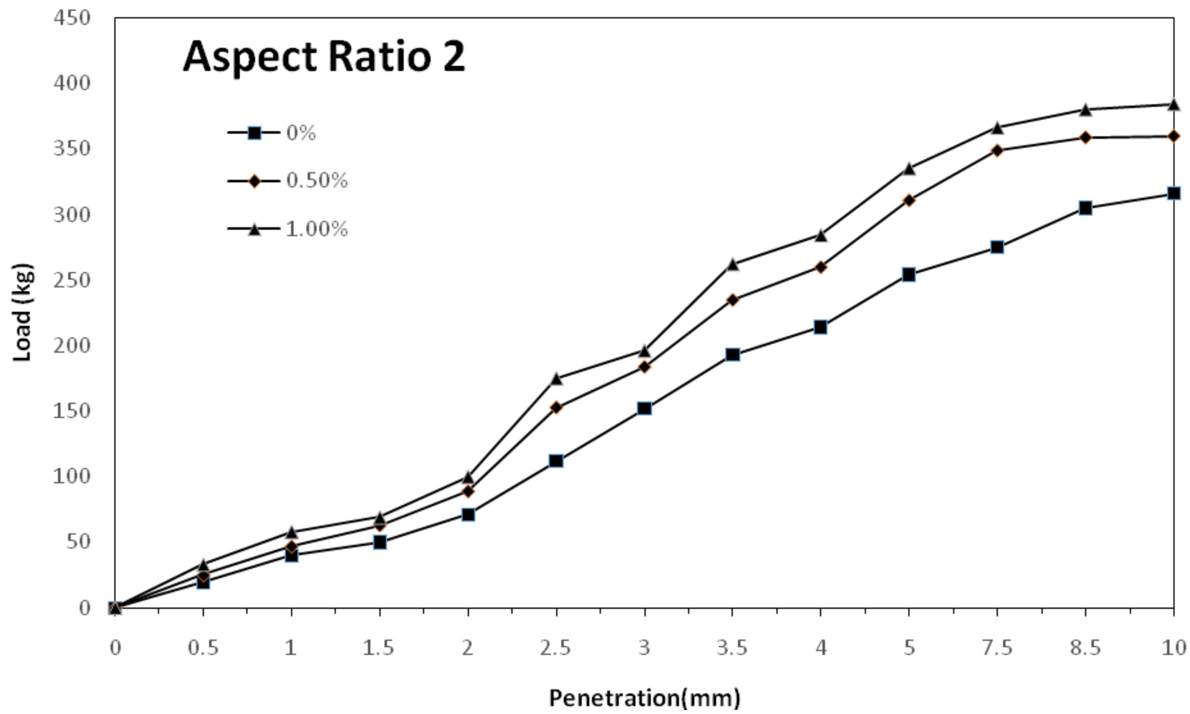

Fig.20: CBR Load Vs Penetration curve(Jute Threads) AR=2

Table 5: 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

NORMAL SOIL VS BLACK COTTON SOIL:

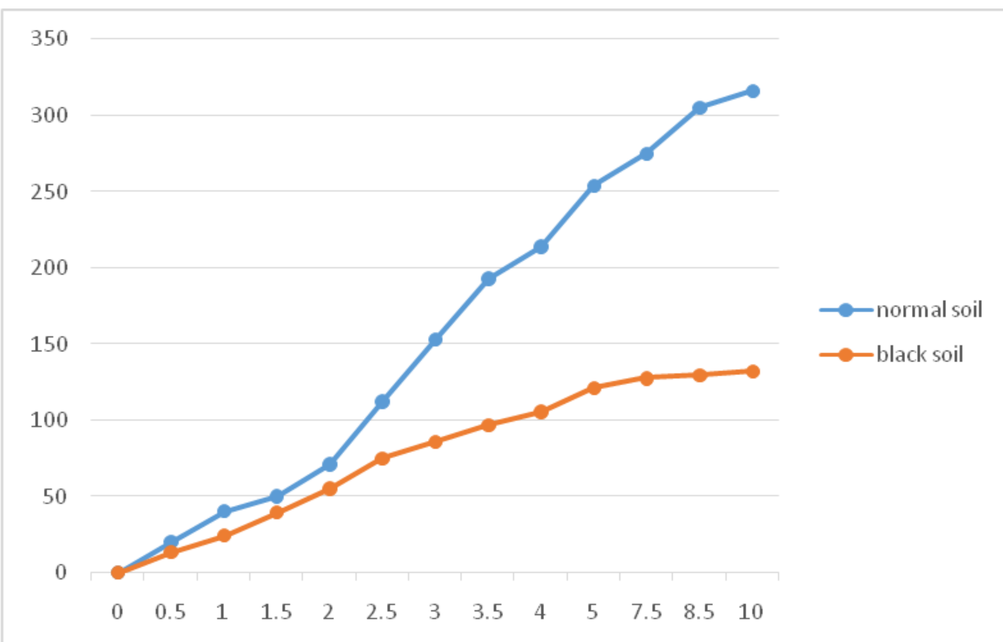

Fig. 21: CBR of black normal soil vs black cotton soil

Testing On Bitumen:

Table 6: Penetration value of Bitumen without and with plastic

Sample no.	**Average Penetration Value, 1/10th of mm**		
	Bitumen only	*with plastic*	With rubber
1	45	42	37
2	47	40.33	38
3	48	38	38
Avg.	**46.67**	**40.11**	**37.33**
% change		**-14.05**	**-20.01**

Table 7: Ductility value of Bitumen without and with plastic

Sample no.	**Average Ductility Value, cm**		
	without plastic	**with plastic**	**With rubber**
1	62	74	78
2	64	78	80
3	67	77	81
Avg.	**64.34**	**76.34**	**79.66**
% change		**18.7**	**23.8**

Table 8: Softening point value of Bitumen without and with plastic

Sample no.	**Softening Point, ^{0}C**		
	without plastic	**with plastic**	**With rubber**
1	45	53	55
2	47	55	55
3	49	53	56
Avg.	**47**	**53.67**	**55.33**
% change		**14.19**	**17.7**

TESTING ON AGGREGATE:

Table 9: Aggregate Crushing Value

	Stone aggregate	Reused concrete
Total wt. of aggregate sample	3.25	3
Wt. of aggregate passing 2.36mm sieve	0.72	0.51
Wt. of aggregate retained	2.53	2.49
Aggregate crushing value, %	22.1	17
% change		5.1

Table 10: Aggregate abrasion Value

	Stone aggregate	Reused concrete
Total wt. of aggregate sample	5	5
Wt. of aggregate retained on 1.7mm sieve	3.1765	3.575
Loss in wt due to wear	1.8235	1.425
LAAV, %	36.47	28.5
% change		7.97

Table 11: Aggregate impact Value

	Stone aggregate	Reused concrete
Total wt. of aggregate sample	650	650
Wt. of aggregate passing 2.36mm sieve	101.5	70
Wt. of aggregate retained	348.2	580
Aggregate impact value, %	22.1	17
% change	15.61	10.77

CHAPTER 10: 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. It also be shown that CBR value decreases as we replace normal soil by black cotton soil.

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 crumbed rubber 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 rubber improves bitumen properties, mixing rubber shows tremendous improvement in bitumen properties.

Aggregate which is limited in nature, can also be replaced by reused concrete wherever possible. Results shows that reused concrete serves as better substitute for stone aggregates.

Conclusions drawn from the experiments are as follows:

1) There is a decrease in the aggregate crushing value when aggregates are replaced by concrete. It shows increase in strength of aggregates.

2) There is a decrease in the aggregate abrasion value when aggregates are replaced by concrete. It shows increase in hardness of aggregates.

3) Impact value is also decreased considerably showing increased toughness when stone aggregates are replaced by concrete.

CHAPTER 11: 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 s	44.5	55.08	49
wt of container+ dry so	42.9	52	46
w%	11.35	12.89	15.71
bulk density(gm/cm3)	2.08	2.14	2.013
dry density(gm/cm3)	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

APPENDIX D: CBR COMPARISON OF NORMAL AND BLACK COTTON SOIL

	Load in kg	
Penetration(mm)	**normal soil**	**black soil**
0	0	0
0.5	20	13.2
1	40	24.2
1.5	50	39.6
2	71	55
2.5	112	74.8
3	153	85.8
3.5	193	96.8
4	214	105.6
5	254	121
7.5	275	127.6
8.5	305	129.8
10	316	132

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