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Use of Plastic in Road Construction

Kamakashi Jamwal[1], Er. Avtar Singh[2], Er.Sunil Priyadarshi[3]

M. Tech., Dept of Civil Engineering, Rayat Bhara University, Kharar, India[1]

Assistant Professor, Dept of Civil Engineering, Rayat Bhara University, Kharar, India[2,3]

Abstract: We know the disposal of plastic waste is very serious issue all over the world. But for India it is more serious than any other country. Because we have 1.3 billion people and we are also a developing country. Plastic need is increases day by day in India. And as we know we don't have proper plastic waste management and when the demand of plastic is going to increase. For this we have to adopt some smart technique to get rid of this problem. Best way to deal with this problem is we can use plastic in our road construction. It can help us for enhance the properties of roads and deal with various road problems like rutting, corrugation, pot holes. In this method we first shred the plastic waste and coated over the aggregate & mix with bitumen.

Keyword: Plastic, Aggregate, Bitumen, Waste Management.

I. INTRODUCTION

The first commercial plastic was developed over one hundred years ago, but the plastic became major consumer material only after the growth of the petrochemical industry in the 1920s.

Now plastics have not only replaced many wood, leather, paper, metal, glass, and natural Fibre products in many applications, but also have facilitated the development of entirely new types of products that are so versatile in use that their impacts on the environment are extremely wide ranging Once hailed as a 'wonder material', plastic is now regarded as a serious worldwide environmental and health concern essentially due to its non-biodegradable nature. Careless disposal of plastic bags chokes drains, blocks the porosity of the soil and causes problems for groundwater recharge.

Plastic disturbs the soil microbe activity, and once ingested, can kill animals. Plastic bags can also contaminate foodstuffs due to leaching of toxic dyes and transfer of pathogens.

The rapid rate of urbanization in India has led to increasing plastic waste generation. India generates 1, 88,000 tons of garbage every day. Plastic Waste in different forms is found to be almost 9% to 12% 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 poor biodegradability it creates stagnation of water and associated hygiene problems.

In order to contain this problem, experiments have been carried out to know whether this waste plastic can be reused productively. The experimentation at several institutes, private organizations indicate that the waste plastic, when added to hot aggregate bituminous mix will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give higher strength to the road, higher resistance to the water and better performance of the road over a period of time. Waste plastic such as carry bags, disposable cups and laminated pouches like chips, pan masala, aluminum foil and packaging material used for biscuits, chocolates, and milk and grocery items can be used for surfacing roads. Roads using plastic waste have been constructed through simple process innovation in various states like Tamil Nadu, Karnataka, and Himachal Pradesh and to a lesser degree in Goa, Maharashtra and Andhra Pradesh. The concept of "Use of Plastic Waste in Road Construction" was implemented in 2001 as a solution to the serious problem of disposal of Plastic Waste in India.

With the above benefits in the background, CIPS has embarked on the documentation of the usage of waste plastic in road construction is intended for creating a document on prevalent technologies and its related economic and environmental, structural and technological issues together at one place for the dissemination of this innovation and possible replication in other states for the betterment of society as a whole. Globally, each year nearly 140MT of plastics is produced.7% study in Western.

II. OBJECTIVE

The main objective of this project is to find out the hazardous impact of plastic in our environment and the serious steps that should needed to take to deal with plastic. And also find out the loop holes of various country in Asia that are responsible of 86% of marine plastic waste .out of Asian continent our prime focus is on India. Because as we know that India is Taking serious step in UN to ban single use of plastic. So we have to look the ground steps that are taken by India. And provide ideas how can we use plastic material in construction.

III. LITERATURE REVIEW

Dr. R. Vasudevan (2007) - investigated that the coating of plastics reduces the porosity, absorption of moisture and improves soundness. The polymer coated aggregate bitumen mix forms better material for flexible pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient. Hence the use of waste plastics for flexible pavement is one of the best methods for easy disposal of waste plastics. Use of plastic bags in roads help in many ways like we can easily use this plastic waste in a productive manner with the help of which we can prevent pollution.
Dr. R.Vasudevan and S. Rajasekaran, (2007) - stated that the polymer bitumen blend is a better binder compared to plain bitumen. Blend has increased Softening point and decreased Penetration value with a suitable ductility.
Raji et al.(2007) - Investigated the "utilization of marginal materials as an ingredient in bituminous mixes. They concluded that when plastic wastes can be used as additives on bituminous pavements. Hence in their study, the properties of bituminous mix when modified with shredded syringe plastic waste were investigated. The work was carried out by mixing shredded autoclaved plastic syringes with heated aggregates by dry process.
(Ngoc & Schniizer, 2008) "ASEAN countries have been practicing open dumping as major management option for municipal solid wastes in contrast to European countries where recycling and composting is ma-jor practice. Except some highly developed countries of Asia like Japan still in many coun-tries open dumping and uncontrolled burning is utilized as waste management technique". Rhian Tough (2007) used a mixed comparative approach to investigate the environmental impacts of plastic shopping bags and consumption patterns, in relation to international practice, alternatives to plastic shopping bag, and policy options. The mixed comparative approach used in this research was a combination of the philosophies underlying cost benefit analysis, sustainable development, and triple bottom line reporting, case studies and policy analysis. Economic instruments while achieving modest to high reductions in plastic shopping bag use, were moderately costly, and also face acceptance and implementation constraints. However, due to strong public pressure for government intervention, and potential implications for future climate change and sustainability initiatives, it was suggested that economic instruments and regulatory options were the most likely choices for government policies to address plastic shopping bags.
Gawande et al. (2012) - Summarized an overview on waste plastic utilization in asphalting of roads. They reviewed techniques to use plastic waste for construction purpose of roads and flexible pavements.
Sultana et al. (2012) - Investigated the utilization of waste plastic as a strength modifier in surface course of flexible and rigid pavements. They concluded that the potential use of waste plastic as a modifier for asphalt concrete and cement concrete pavement.
Zahra Niloofar Kalantar (2012) - Many researches on PMA mixture have been conducted for the past two decades. Although addition of virgin polymers to asphalt for the purpose of enhancing the properties of asphalt over a wide temperature range in paving applications was contemplated quite some time ago, recycled polymer added to asphalt have also shown almost the same result in improving the road pavement performance as compared to virgin polymers. This paper is a review of the use of polymers in asphalt pavement. In this study, acritical review on the history and benefit so fusing waste and virgin polymeric asphalt is presented followed by a review of general studies on using polymers in asphalt in order to improve the properties of pavement.
S.Rajasekaranetal (2013) Explains that by coating the aggregate with the polymer has many advantages and which ultimately helps in improving the flexible pavement quality not only it improve the pavement quality but also improve the aggregate quality. This technology also helps in the disposal of waste plastic obtained from the domestic and industrial packing materials. The dry process is more valuable as it disposes the 80 % of waste polymer in eco-friendly way. And use of polymer reduces the equivalent bitumen quantity and therefore reducing the construction cost of road.
Athira R Prasad etal (2015) Says that the bitumen which is conventional material used in the road construction can be partially replaced by the waste plastic and rubber. They added rubber and PET in 3%, 4.5%, 6%, 7.5%and 8% in bitumen and found that the optimum content was obtained at 6%. Thus, according to their study, the use of plastic in 6% by weight of bitumen improves the pavement stability. And they found the use of PET bottle is best. Therefore, the disposal of rubber and PET is best in the road construction.

IV. COMPARATIVE STUDY

The comparative study is done by testing the normal aggregates & plastic-coated aggregates, & the bitumen and modified bitumen (10% of bitumen replaced by plastic). The various tests that are carried out for the comparative study are

Test on Aggregates

a) Sieve analysis test
b) Aggregate crushing test
c) Los Angeles abrasion test
d) Impact test

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Test on Bitumen

a) Penetration test
b) Softening point test
c) Viscosity test
d) Marshall Stability test.

4.2 Tests on Aggregates

Sieve Analysis

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves.

i) A set of IS Sieves of sizes – 80mm, 63mm, 50mm, 40mm,31.5mm, 25mm, 20mm, 16mm, 12.5mm, 10mm, 6.3mm,4.75mm, 3.35mm, 2.36mm, 1.18mm, 600µm, 300µm, 150µm and 75µm.
ii) Balance or scale with an accuracy to measure 0.1 percent of the weight of the test sample.
The weight of sample available should not be less than the weight given below:
The sample for sieving should be prepared from the larger sample either by quartering or by means of a sample divider.

Procedure

- The test sample is dried to a constant weight at a temperature of 110 + 5ºC and weighed.
- The sample is sieved by using a set of IS Sieves.
- On completion of sieving, the material on each sieve is weighed.
- Cumulative weight passing through each sieve is calculated as a percentage of the total sample weight.
- Fineness modulus is obtained by adding cumulative percentage of aggregates retained on each sieve and dividing the sum by 100.

Specific gravity test of aggregates is done to measure the strength or quality of the material while water absorption test determines the water holding capacity of the coarse and fine aggregates.

Result

I.S SEIVE SIZE	Wt. RETAINED (gm)	Wt. RETAINED (gm)	PERCENTAGE OF cum. RETAINED	PERCENTAGE OF cum PASSED	PERMISSIBLE LIMIT
40 mm	**0**	**0**	**0**	**100**	**100**
20 mm	**315**	**315**	**6.3**	**93.7**	**85-100**
10mm	**4635**	**4950**	**99**	**1**	**0-20**
4.75mm	**35**	**4985**	**99.7**	**0.3**	**0-5**
Pan	**15**	**5000**	**100**	**0**	

Aggregate Crushing Test

The strength of the coarse aggregate may be assessed by aggregate crushing test. The aggregate crushing value 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 aggregate crushing value preferred.

Procedure of aggregate crushing test

- A steel cylinder 15 cm diameter with plunger and base plate.
- A straight metal tamping rod 16mm diameter and 45 to 60cm long rounded at one end.
- A balance of capacity 3 kg readable and accurate to one gram.
- IS sieves of sizes 12.5mm, 10mm and 2.36mm
- A compression testing machine.
- Cylindrical metal measure of sufficient rigidity to retain its from under rough usage and of 11.5cm diameter and 18cm height.
- Dial gauge.

Result without plastic coating

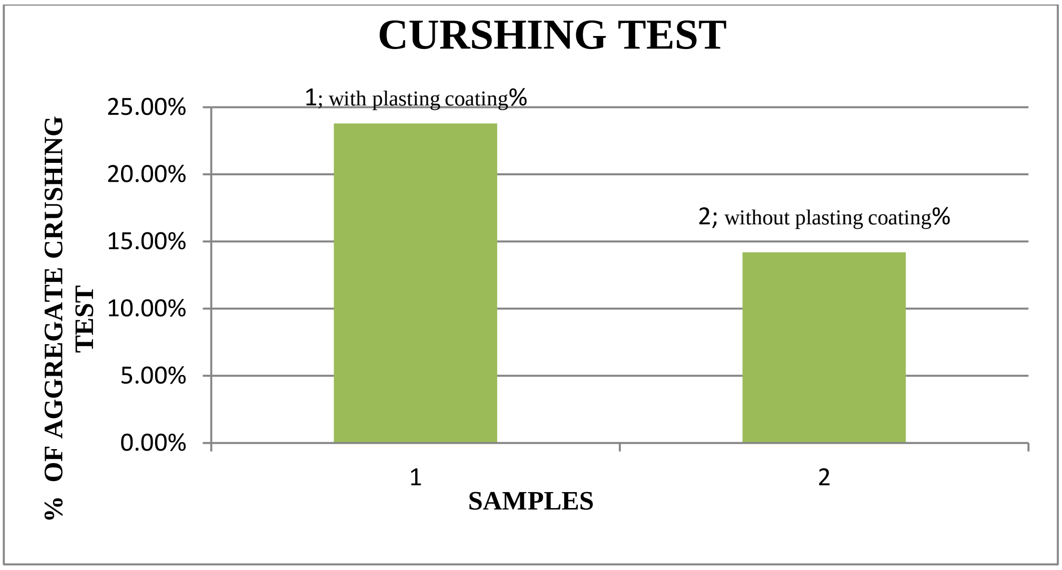
Weight of aggregate (W1) = 2534gm
Weight of aggregate passed through 2.36mm sieve (W2) = 682gm
FORMULA W2/W1 = 26.91%
As per Indian standard the wear should not exceed 45%

Result with plastic coating

Weight of aggregate with plastic coating (w1) = 2892 gm

Weight of aggregate with plastic coating passed through 2.36mm sieve (w2) = 563gm

FORMULA $W2/W1$ = 19%



Abrasion Tests

Due to the movements of traffic, the road stones used in the surface course are subjected to wearing action at the top. Hence road stones should be hard enough to resist the abrasion due to traffic. Abrasion tests are carried out to test the hardness property of stones and to decide whether they are suitable for the different road construction works. The abrasion test on aggregate may be carried out using any one of the following three tests

However Los Angeles abrasion test is preferred as the test results have been correlated with pavement performance.

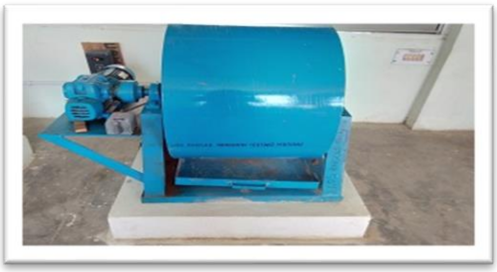
Los angeles abrasion test

The principle of Los Angeles abrasion test is to find the percentage wear due to the relative rubbing action between the aggregate and steel balls used as abrasive charge. Pounding action of these balls also exists during the test and hence the resistance to wear and impact is evaluated by this test.

Procedure on abrasion test

- Select the grading to be used in the test such that it conforms to the grading to be used in construction, to the maximum extent possible.
- Take 5 kg of sample for grading A, B, C & D and 10 kg for grading E, F & G.
- Choose the abrasive charge as per Table 2 depending on grading of aggregates.
- Place the aggregates and abrasive charge on the cylinder and fix the cover.
- Rotate the machine at a speed of 30 to 33 revolutions per minute. The number of revolutions is 500 for grading A, B, C & D and 1000 for grading E, F & G. The machine should be balanced and driven such that there is uniform peripheral speed.
- The machine is stopped after the desired number of revolutions and material is discharged to a tray.
- The entire stone dust is sieved on 1.70 mm IS sieve.
- The material coarser than 1.7mm size is weighed correct to one gram.

Result



Aggregate without plastic coating

Grading selected	Sample 1
Original weight of sample (w1)	**5000**
Wt. of aggregate retained (w2) 1.70mm IS sieve	**2345**
Loss of wt.(W1-W2)	**2655**

$$=\frac{\text{weight of fraction passing1.7mm seive}}{\text{weight of total material}}$$

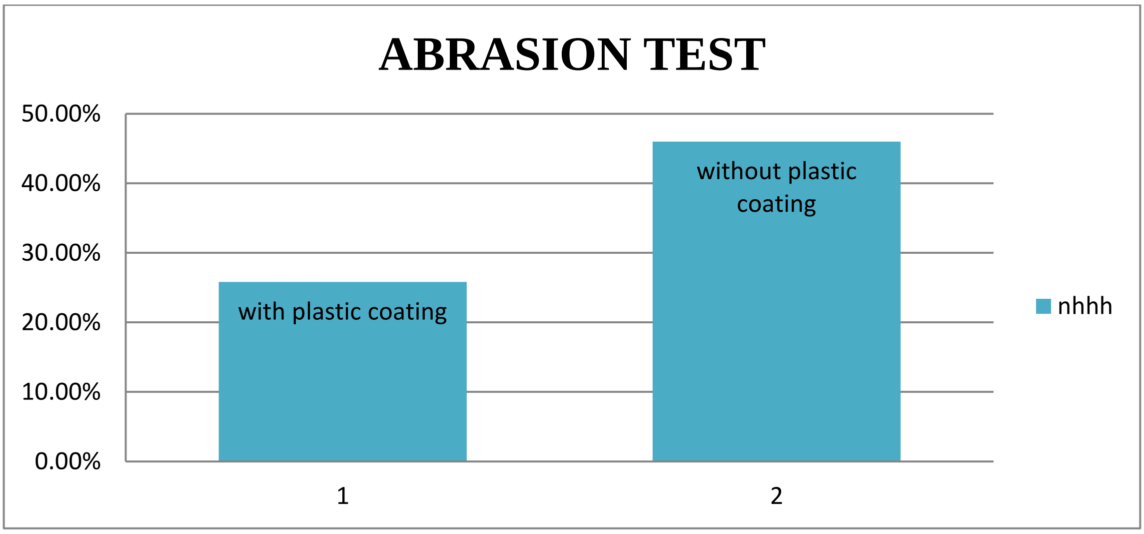
$$=\frac{2345}{5000}x100 = 46\%$$

Result

Aggregate with plastic coat

Grading selected	Sample 1
Original weight of sample (w1)	**5000**
Wt. of aggregate retained (w2) 1.70mm IS sieve	**1291**
Loss of wt.(W1-W2)	**3709**

$$=\frac{1291}{5000}x25.8\%$$



In order to determine physical characteristics of the road constructed using plastic modified bitumen mixes, some important tests have been recommended by Dr. Vasudevan. These tests are Benkelman Beam test, Sand Texture Depth test, Skid resistance, Merlin test and Field Density. Besides above-mentioned tests, plastic waste is checked for impurity and melts flow value for each day work or in cases when the source of plastic waste is changed. Rigid pavements have also been modified using waste plastic. M20 concrete, commonly used for constructional work, has been modified using waste plastic. The optimum modifier content was found to be 5% and the strength of the road constructed was found to be enhanced in comparison to plain cement concrete road. Following are the advantages of rigid pavements laid using optimum quantities of Waste Plastic Modified Cement Concrete (WPMCC).
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Impact Test

The test is designed to evaluate the toughness of stone or the resistance of the aggregates to fracture under repeated impacts is called impact test. The aggregate impact test is commonly carried out to evaluate the resistance to impact of aggregates and has been standardized by ISI. The aggregate impact value indicates a relative measure of aggregate to impact, which has a different effect than the resistance to gradually increasing compressive stress. The aggregate impact value should not normally exceed 30% for aggregate to be used in wearing course of the pavements. The maximum permissible value is 35% for bituminous macadam and 40% for water bound macadam base course.

Procedure on impact test

- Aggregates for the test sample can be decided by passing it through 12.5 mm sieve and retained on 10 mm sieve.
- The sieved aggregates should be dried in an oven and then filled in a cylindrical steel cup and tamped with 25 strokes by temping rod.
- The test sample is filled in 3 layers and each layer is tamped for 25 numbers of blows.
- Metal hammer (weighing approx. 14 kg) is pre-arranged to drop with a free fall of 380mm. The test specimen is subjected to 15 numbers of blows each at not less than 1 second.
- The crushed aggregate is removed from the test specimen and sieve it through the 2.36 mm IS sieve.
- An impact value is measured as % of aggregates passed through the 2.36mm sieve (W2) to the total weight of the sample (W1).
- Aggregate impact value (The value of aggregate impact test) = (W1/W2)*100

Result without plastic coating

Weight of aggregate (w1) = 336gm
Weight of aggregate pass through 2.36mm sieve (w2) = 80gm
FORMULA

$$\frac{w2}{w1} = 23.80\%$$

Result with plastic coating

Weight of aggregate with plastic coating (w1) = 483 gm
Weight of aggregate with plastic coating pass through 2.36mm sieve (w2) = 69gm

$$\frac{w2}{w1} = 14.2\ \%$$

Tests on Bitumen penetration Test

Penetration test is to determine the hardness of the bitumen. The penetration of bitumen is the distance in tenths of millimeter that a standard needle will penetrate into the bitumen under a load of gm applied for seconds at penetration value indicates the softness of bitumen higher the penetration softer is the bitumen.

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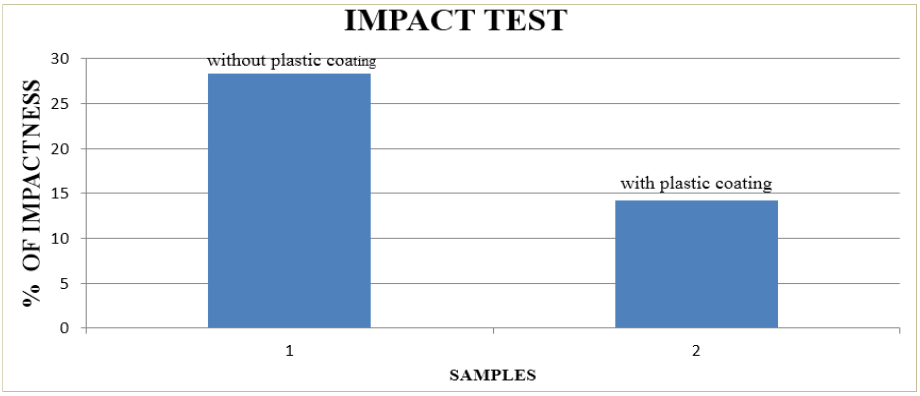
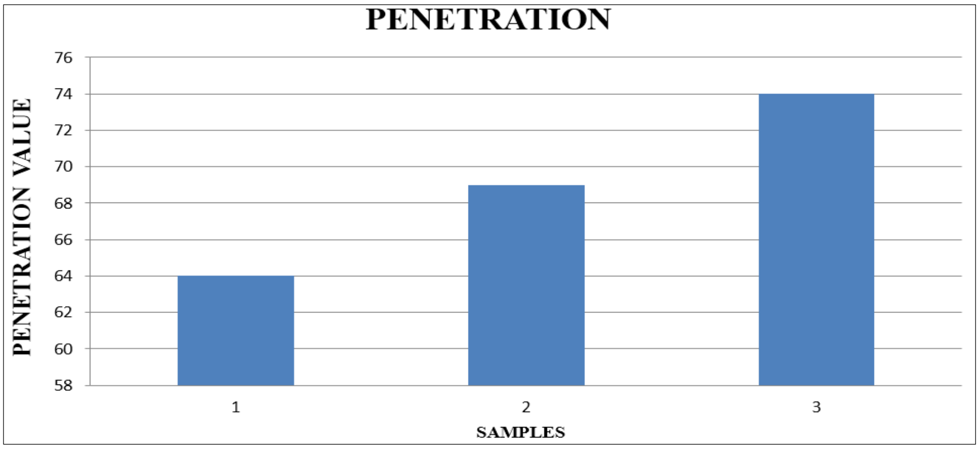


- **Preparation of test specimen:** Soften the material to a pouring consistency at a temperature not more than 60°C for tars and 90°C for bitumen above the approximate softening point and stir it thoroughly until it is homogeneous and is free from air bubbles and water.
- Pour the melt into the container to a depth at least 10mm in excess of the expected penetration. Protect the sample from dust and allow it to cool in an atmosphere at a temperature between 15° to 30° C for one hour. Then place it along with the transfer dish in the water bath at 25° ± 0.1 °C, unless otherwise stated.
- Fill the transfer dish with water from the water bath to depth sufficient to cover the container completely, place the sample in it and put it upon the stand of the penetration apparatus.
- Clean the needle with benzene, dry it and load with the weight. The total moving load required is 100 ± 0.25 gm, including the weight of the needle, carrier and super-imposed weights.
- Adjust the needle to make contact with the surface of the sample. This may be done by placing the needlepoint in contact with its image reflected by the surface of the bituminous material.

Result

Penetration	Table 1	Table 2	Table 3
Initial	200	264	333
Final	264	333	407
Penetration value	64	69	74



Softening Point Test

The softening point of bitumen or tar is the temperature at which the substance attains particular degree of softening. As per IS: 334-1982, ASTM E28-67 or ASTM D36 or ASTM D6493 – 11, it is the temperature in ºC at which a standard ball passes through a sample of bitumen in a mould and falls through a height of 2.5 cm, when heated under water or glycerin at specified conditions of test. The binder should have sufficient fluidity before its applications in road uses.

Procedure of softening point test

- After cooling for 30 minutes in air, level the material in the ring by removing the excess material with a warmed, sharp knife.
- Assemble the apparatus with the rings; thermometer and ball guides in position
- Fill the bath with distilled water to a height of 50mm above the upper surface of the rings. The starting temperature should be 5° C.

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Note: Use glycerine in place of water if the softening point is expected to be above 80° C; the starting temperature may be kept 35° C.

- Apply heat to the bath and stir the liquid so that the temperature rises at a uniform rate of 5 ± 0.5 °C per minute.
- As the temperature increases the bituminous material softens and the balls sink through the rings carrying a portion of the material with it.
- Note the temperature when any of the steel balls with bituminous coating touches the bottom plate.

Results

Temp	1	2
Temperature when the ball touches bottom o_c	**69.2**	**70**

Average = 69.6° *c*.
Softening point of bitumen = 69.6° *c*.

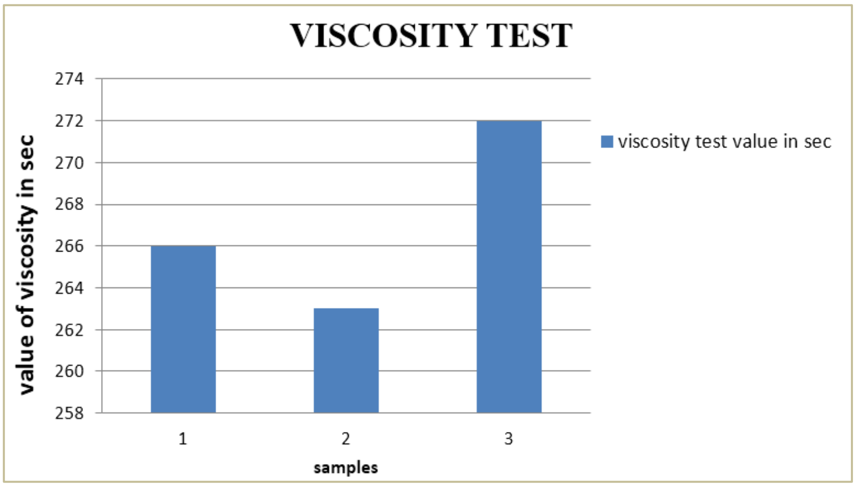
Viscosity Test

Viscosity is defined as the inverse of fluidity. Viscosity thus defines the fluid property of bituminous material. Viscosity is the general term for consistency and is the measure of resistance to flow. Many researchers believe that grading of bitumen should be by absolute viscosity units instead of the conventional penetration units. The degree of fluidity of the binder at the application temperature greatly influences the strength characteristics. The tar cup is properly levelled and water in the bath is heated to the test temperature. Stirring is also continued. Material is heated to 20°C above the test temperature and material is allowed to cool. During this material is continuously stirred. When temperature reaches 40°C, it is poured into cup of the tar viscometer until levelling peg on valve rod is just immersed. Receiver is placed under the orifice. Valve is opened after applying kerosene in the receiver. Stop watch is started when cylinder records 50 ml. Time is recorded for flow upto a mark of 100ml.

Result

Details of sample	No. of observation1	No. of observation 2	No. of observation 3
Temperature	100	100	100
Time taken to flow 50 mm	4 min 26 sec	4 min 23 sec	4 min 26 sec
Viscosity	266 sec	263 sec	272 sec

Mean viscosity = 267 sec



Marshall Stability test

Marshall Stability Test Apparatus -The Marshall stability of mix is defined as a maximum load carried by a compacted specimen at a standard test temperature of 60ºC. The flow value is deformation the Marshall Test specimen under goes during the loading up to the maximum load, 0.25 mm units.

Limitation of the study:

- Toxic present in the co-mingled plastic wastes would start leaching.
- But the presence of chlorine will definitely release HCL gas.

Percentage of bitumen content

S.No	Bitumen content (%)	Modified bitumen(gm)
1	4.5	5.9
2	5.0	6.0
3	5.5	6.6
4	6	7.2

Test results of Marshall Stability test

S. No	Bitumen Content (%)	Weight of mix(g)	Weight in air(g)	Weight in water (g)	Stability of bitumen modified		Stability of Flow (mm)	Diameter (cm)	height (cm)
					Plain bitumen	Modified bitumen			
1	4.5	1255.5	1256.5	733	14.7	17.95	1.99	10	6.3
2	5	1253	1255.5	734	19.47	23.44	2.38	10	6.4
3	5.5	1257	1259	736	13.46	18.21	2.88	10	6.5
4	6	1268	1270	748	8.9	13.10	2.59	10	6.4

CONCLUSION

The plastic mixed with bitumen and aggregates is used for the better performance of the roads. The polymer coated on aggregates reduces the voids and moisture absorption. This results in the reduction of ruts and there is no pothole formation. The plastic pavement can withstand heavy traffic and are durable than flexible pavement. The use of plastic mix will reduce the bitumen content by 10% and increases the strength and performance of the road. This new technology is eco-friendly. The use of smoke absorbent material (titanium di-oxide) by 10% of polymer content can reduce the vehicular pollution.

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