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EFFECT OF WASTE PLASTIC AND CRUMB RUBBER ON PROPERTIES OF SEMI DENSE BITUMINOUS CONCRETE MIX

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Abstract- Plastic is used in day to day life. So, it's a well-known thing that more waste would be generated through plastic. It is discarded either by burning or by burying it in the soil. Due to the non-biodegradability of the plastic it's not easy to get rid of it through natural processes prevailing in the environment. So, one way in which plastic could be reused is by using it in pavement. An effort of using waste plastic in coating the aggregates is being engrossed in this study. Crumb rubber made from waste tires is also used in this study to modify the bitumen. Earlier studies have proven plastic and crumb rubber effective in increasing the strengths of pavements. So, taking this idea plastic coating is done in the aggregates and bitumen is modified with crumb rubber to check the results. The low-density plastic is taken in use. Temperature varying between 120 ˚C - 160 ˚C gives the softening point of the plastics being used. They do not produce any toxic gases during heating but they get often Edan laminate the aggregates. The study focuses on using different percentages of plastic in coating aggregates and different percentages of crumb rubber & study their behavior. The bitumen VG-30 is used as a binder in the mix. The performance tests including, Marshall Stability tests are to be conducted to find stability, density, optimum binder content and voids. The first phase of investigation focuses in the next study CRUMB RUBBER Modified Bitumen will be used in place of normal VG-30 bitumen.

Keywords: Marshall Stability, crumb rubber, semi dense bituminous mix, low density polyethene.

1. INTRODUCTION

Generally during rainy days the roads gets deteriorated due to penetration of water in the voids which cause discomfort to people and damage to vehicles. Many accidents are caused by the potholes which usually go wide and deep till the end of rainy season. In our country this is prevailing from many years. Many people lose their life due to such conditions of the roads and have become one of the concerns of Indian people. Road defects can be reduced by using plastic coated aggregate and crumb rubber modified bitumen. Recent studies have shown that the life span of the roads can be increased by adding plastic in the mix. The aggregates when coated with plastic can improve their properties and sometimes when proper quality aggregates are not available during construction the aggregates can be coated to use the poor-quality aggregates. The bitumen when modified by adding crumb rubber has shown improvement in the properties of bitumen which are effective to keep a road safe during rains. The present study is on the combined effect of plastic-coated aggregates and crumb rubber modified bitumen. This waste plastic partially replaced the conventional material to improve desired mechanical characteristics for particular road mix.

1.1 SDBC

Semi Dense Bituminous Concrete is a wearing course generally laid in single layer. It is used in rural roads where the traffic density is very less and it is porous because of voids in them. Bitumen used in this layer are VG-30, 40. The bitumen is modified with CRMB and coated aggregates with LDPE. Further few changes were seen in the properties.

Fig 1.1 Construction of SDBC pavement

1.2 Plastic

The menace of plastic will not be eradicated until the obvious steps are not implied at the zero level. The main concern is the abuse of plastic. People carelessly throw the plastic after they use it. The polyethylene is taken into the use in this study. Polythene is commonly used in life. The vegetables, fruits or peanuts etc. from shops are given in polythene. After taking out the items from it, plastic is thrown carelessly without even worrying about its aftermath. Polythene that clogs the drain and that causes the water to get stagnant in drain which leads to breeding of mosquitos and all sorts of things not good for our health are caused due to our negligence. Thus our study aims to use them in the pavement design and then see that polythene menace can be reduced to a certain level or not?

Fig 1.2 Plastic

Fig 1.3 Crumb Rubber

1.3 Crumb Rubber-

Crumb rubber is recycled rubber produced from automotive and truck scrap. Tires are often used and they are worn out thus get collected in scrap in large volume. Accumulation of such a huge amount of scrap can generate huge amount of toxic and chemical which are undesirable and are a threat to environment. In order to eliminate their ill effects recycling is important so that they can be used where their applications are in benefit of environment. From many years a lot of work in done in civil engineering by using this waste. Crumb rubber so made helps control deformation under high pavement temperature and when the load is quite heavy. It increases the life of a pavement under repeated loading. It helps in reduction of maintenance cost and also reduces the percentage of bitumen used. The property of the bitumen gets improved when the proper percentage of crumb rubber is added in bitumen. The rubber modified bitumen can also be helpful in reducing the cracks that arise beneath the surface. As it stops the cracks formation to a certain level, this helps us in keeping check on the capital invested in maintenance of roads. The lifespan of the roads increases even after daily use for a long period of time. Thus this works like an anti-aging effect for the pavement.

2. METHODS AND MATERIAL-

2.1 General-

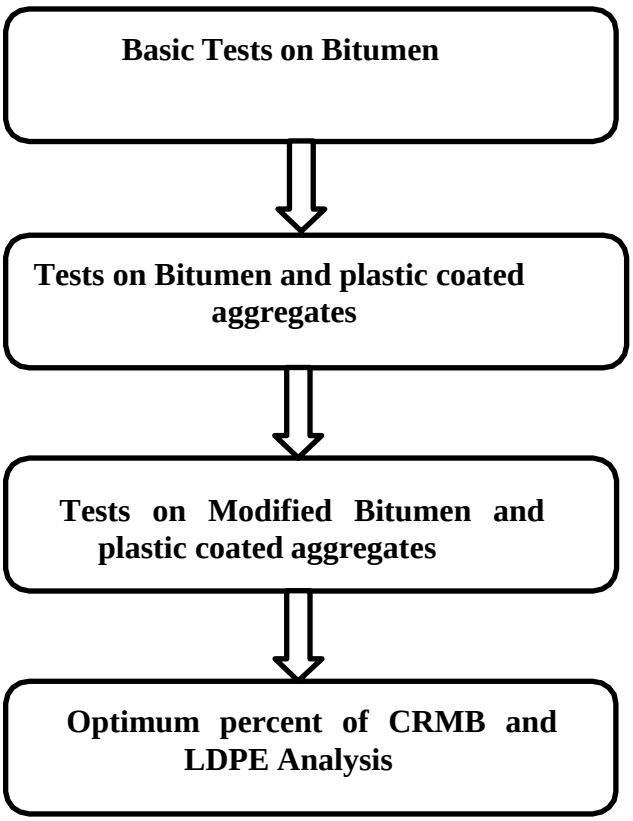
Present investigation is divided into four phases:

• Determination of properties of VG-30 bitumen

• Determination of properties of plastic-coated aggregates with normal bitumen

• Determination of properties of plastic-coated aggregates with partially replaced bitumen with crumb rubber.

• Determination of optimum percentage of crumb rubber bitumen required with the plastic coated aggregates.



2.2 Material's Properties-

2.2.1 Aggregates-

Aggregate plays an important role in the construction of pavement. Aggregates main motive is to absorb and transfer the live load from road to ground. Hence, it is important to know different qualities and features of the aggregate. They should resist abrasive action of load coming from wheels. Different types and grades of aggregates are used to make bituminous pavement. To know different properties of the aggregates,

Following tests are performed in the lab

1. Crushing test
2. Los angeles abrasion test
3. Impact test
4. Shape test
5. Soundness test
6. Specific gravity & water absorption test

➢ **TESTS ON AGGREGATES**

1. AGGREGATES CRUSHING TEST

- The test is executed according to IS 2386 Part 4. It is defined as the percentage by
- weight of aggregates (crushed) when submitted to specific load. The test is practiced so
- as to achieve the resistance value of aggregates when subjected to loads. The result
- from this test describes aggregates quality. Low Crushing Value is recommended for

- construction of road as it is durable and provides long life to the pavement. Aggregates
- which pass through 12.5mm sieve and left over 10mm sieve are taken. Then
- aggregates are put down in a crushing mould with 115mm diameter and 180mm length
- in about three coverings and every single covering is tamped. The aggregates are
- tamped 25 times with the help of tamping rod. Afterwards the aggregate sample is put
- into test cylinder and tampered again in three coverings or layers. Then the load of 40
- tons is applied to the sample at the rate of 4 tons per minute by universal testing
- machine (compressing machine). Then the crushed aggregate is passed through sieve
- of 2.36mm and its weight is noted. The result is shown in Annexure A.
- Aggregates Crushing Value = $\frac{W_1}{W_2}$X100

W =Weight of aggregates passing through 1

W =Weight of Aggregates used 2

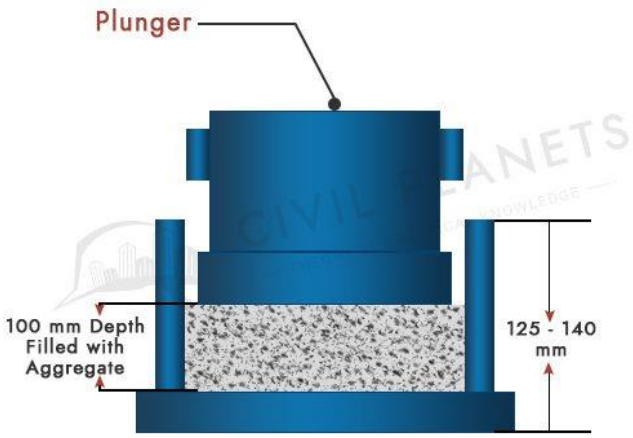


Figure 3.3- (a) Sample under Universal testing machine

2. LOS ANGELES ABRASION

The test is executed according to IS 2386 Part 4. LA test is done to measure the aggregate's hardness value. The main motive of the test is to know the amount of wear and tear due to rubbing and striking of aggregates and steel balls. Here steel balls are used as an abrasive charge. The test consists of a cylinder which is hollow from inside with 70cm diameter and length 50 cm and is arranged to rotate about horizontal axis. Steel balls comprises of 46-48mm diameter and weight of about 340-445g. This abrasive charge is set in the cylinder along with the aggregates. Steel balls are taken depending upon the grade pf aggregate being used. Generally, 5 to 10 kg of aggregates are used in this test.

The abrasion cylinder is then closed with the help of steel plate and screws and then rotated for about 500-1000 rotations according to the aggregate grading at the speed of 30-33 rpm. After completing the rotations, aggregates are taken out and passed through 1.7mm sieve. The proportion of aggregates passed from sieve is indicated inpercentage and called Los Angeles Abrasion Value.

Grading	No. of steel balls	Weight of charge in gm
A	12	5000±25
B	11	4584±25
C	8	3330±20
D	6	2500±15
E	12	5000±25
F	12	5000±25
G	12	5000±25

Table 3.1: Abrasive Charge

3. IMPACT TEST

Test goes as per IS code 2386 part IV. The test tells us about the extent to which an aggregate can resist to a striking. The one passing through 12.5 mm and retaining on 10 mm sieve are to be used. Then fill them in cup in III layers and tamping XXV times with tamping rod. The dimension of cup is 10.2 cm and a height 5 cm is joined with the testing machine. The gavel weighing 14 kg is dropped from 38 cm height for 15 times. Aggregates are then passed through 2.36 mm size sieve. At last ratio of passed aggregate to total aggregate is taken which is known as Aggregate Impact Value.

2.2.2 Bitumen-

From the fractional distillation of crude petroleum bitumen is obtained. It is a black viscous mix comprising hydrocarbons obtained as residue from petroleum distillation or naturally obtained in liquid, solid semi solid and in gaseous form and can be dissolved in carbon tetrachloride and carbon disulfides. It is commonly used for paving road and roofing. It is used in the road pavement due to its better binding quality and water resisting property. Type of bituminous construction depends upon the different characteristic properties of the bitumen to be used. There are different bitumen grades according to their viscosity grade. Here bitumen of Viscosity Grade 30 is used in the tests. To find various bitumen properties, following tests are performed -

1. Softening Point Test

The test is done in accordance to IS code 1205 1978. Softening point is the temp. At which ball passes through bitumen and falls through a height of 2.5 cm, obviously when heated under water keeping Standard conditions. The setup's name is Ring and ball Setup. Steel ball is kept on Bitumen test ring and water is heated at 5oc per minute. Temperature is jotted down when the ball touches the metal plate which is at a standard height underneath it. It varies between 35°C – 70°C.

Figure 3.9- (a) Beaker & Thermometer. (b) Rings (with & without bitumen)

2. PENETRATON TEST

The test runs in accordance with IS code 1203 1978. It tells us about consistency of bitumen. The given test is carried out using penetrometer. Initially bitmen is poured into the mould and cooling is done for 30 minutes carried by water bath at 25oC for an hour. It has a needle weighing 100 gm which penetrates into the sample of bitumen for 5 seconds. Three readings are taken and the reading should be taken within 10 mm distance of the first penetration. The measurement is done in 1/10th mm units.

Penetrometer with Needle

3. DUCTILITY TEST

The test runs in accordance with IS code 1208 1978. Ductility is important to prevent and resist cracking of binder(bitumen) under loads of the traffic wheels which may lead to penetration of water in it to cause breaking and failure in pavement. Sample is kept in the room temp. and water bath is given at 25o C for an hour. The briquette mould is placed in ductility test apparatus and pull is started at a rate of 5 cm per minute. The min. ductility value is between 50-75 cm depending upon viscosity grade of bitumen.

Ductility Test Apparatus

- **PLASTIC COATING METHOD**

After studying the papers discussed above, 8% plastic was added by weight of aggregates. In this case aggregates are heated and sprinkled shredded pieces of plastic into it. So this was the result after coating aggregates. Further tests will be conducted to see if the aggregates get better values or not.

Since most of the aggregate were stick with each other this idea was dropped and gone for Dipping method of coating aggregate.

Firstly, plastic was melted at 130°C and the result didn't come as expected. The plastic layer on aggregate was thick and was easily breakable by hands. The grey colored one aggregate in figure is the plastic after cooling down which has no strength.

Then plastic was melted at 170°C. This time the coating was thin, strong and favorable amount of plastic was covering the aggregates properly.

Mixing shredded plastic with aggregate

3. RESULTS AND DISCUSSIONS

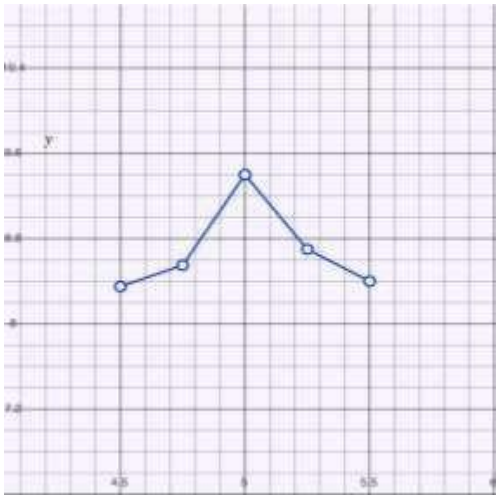
3.1 GENERAL

Basic tests on normal and modified bitumen and aggregates are performed in laboratory. The results of test performed on aggregates and bitumen are shown in Annexure A and the basic test values of plastic coated aggregates and crumb rubber are shown in Annexure B.

- **MARSHALL DESIGN MIX**

This section is showing the marshal stability values and other related values after conducting marshal test on the SDBC mix according to IS code 111:2009. The table for these graphs is given in Annexure C.

- **MARSHALL STABILITY FOR BITUMEN CONTENT**

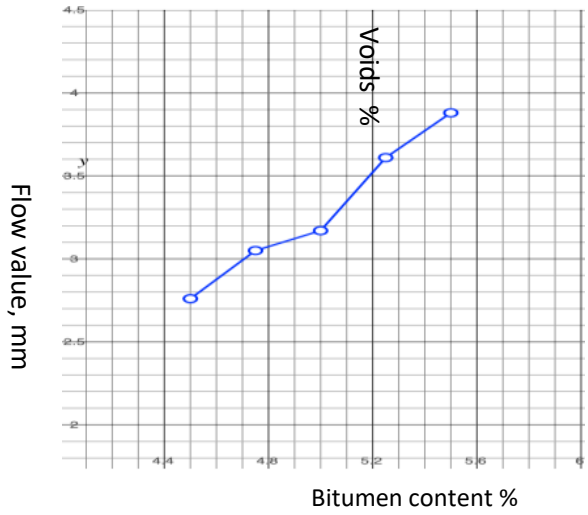


Graph between Marshall stability and different bitumen content

As appeared in the above figure with increment of bitumen, the stability first increasesand then decreases. This is so because first the bitumen fills the voids but later on theexcess bitumen

cannot take any load thus decreases the stability. Thus 9.35 kN is the highest stability the sample produced at 5% bitumen content.

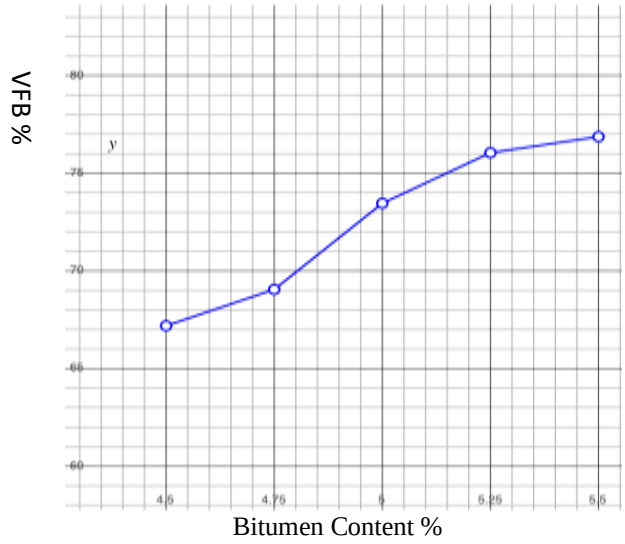
FLOW VALUE FOR BITUMEN CONTENT



Graph between Flow Value vs variable bitumen content %

As it is seen that with increasing bitumen content, the flow value increases which meanswith increase in bitumen content, the vertical deformation in sample is also increasing.

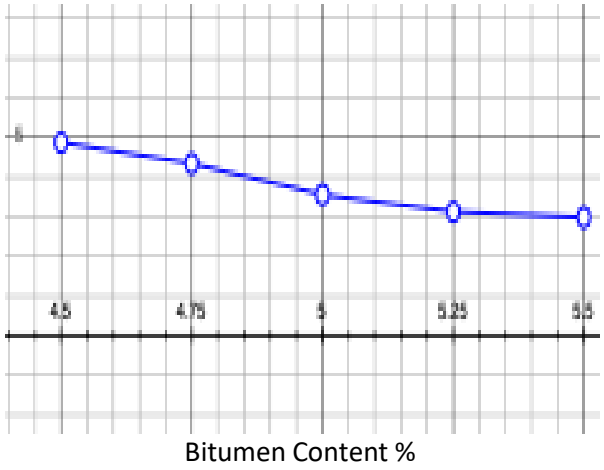
- **VOIDS FILLED WITH BITUMEN FOR BITUMEN CONTENT**



Graph between VFB% v/s Binder Content %

As seen in the above graph the increasing % of bitumen leads to increment of VFB andalso gets stagnant at the upper percentages of bitumen.

- **AIR VOIDS FOR BITUMEN CONTENT**



Graph between Voids % v/s Binder Content %

As seen from the above graph the increment of bitumen causes decrease in air voids percentages.

CONCLUSION

Adding LDPE and CRMB has increased properties of the mix such as Marshall stability, bulk density and in bitumen we observed positive result in penetration test, ductility test, softening point and flash and fire test. This can help making the SDBC layer last long. It was seen that as one of the content of modifiers keep on increasing the marshal stability keeps falling. This shows us that the strength is not achieved due to excess mixing of the modifiers. Thus, to reach the ideal quantity, nine samples were taken into account until the Marshall Stability curve showed us the best mix.

4. CONCLUSION

On the basis of the results obtained following points can be drawn

- Mixing of CRMB and LDPE the marshal stability & bulk density were increased in the mix whereas the individual properties of bitumen and aggregates were also enhanced by proper quantity of modifiers.
- Marshall Stability is at its maxima when 10% CRMB and 6% LDPE is used.
- Flash and Fire, softening point, ductility, penetration are increased due to the use of CRMB.
- Aggregate's impact value, crushing value, Los Angeles abrasion test value and specific gravity are increased due to the coating of LDPE.
- Aggregates of low quality coated with plastic can be used when on a site the quality of aggregate is not desirable.

- **RECOMMENDATIONS**

These are the recommendations on the basis of our results-

- CRMB can be recycled by mixing it in bitumen that too yield good results.
- LDPE is also taken into use in coating and that this decreases the waste plastic.
- Coating should be done at 1800C and below that the coating is brittle.

FUTURE STUDY

In future, there is always possibility for research in the field of bitumen modifiers. Hence future study may consider the following points-

- Other types of plastic can also be used to coat the aggregates.
- Other grade of CRMB (30 mesh size in this study) can be taken into consideration.
- Road costs analysis should be taken into consideration seeing the optimistic results of our study.

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