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Lab Work And Investigations Of Bituminous Concrete Using Varoius Types Of Additives Which Improve The Result

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Abstract - India boasts of the third largest road network in the world. To keep up with the continuous infrastructure development, new roads are being constructed. The ever increasing population has further raised the vehicular density due to increased passenger traffic and freight transport over the last few decades. India and many other countries have more than 90 percent of roads which are constructed with flexible pavements or bituminous courses. So, to achieve the requirements, properties of asphalt binder and bituminous mixes are to be improved by using various additives. For a pavement section different types of additives are used such as Polymers, Crumb Rubber and other waste materials like waste plastic, discarded tyre tubes etc which increases the life of the pavement depending upon the degree of modification and type of additives used.

Due to increase in population, the vehicular traffic density is also increasing. Due to this, thewear and tear of tyres from these vehicles is undoubted due to which large number of scrap tyres are being generated. A large number of waste and worn out tyres are already in existence and with an annual generation rate of 15-20% each year. These tyres are discarded indiscriminately or stockpiled. The used tyres had a great threat to human health and environment, since it is non- biodegradable so it is having disposal problems also. Similarly, consumption of waste plastic is increasing day by day. More than 50% of the plastic is used as a packaging material. As plastic is a non-biodegradable waste so it does not under goes decomposition. In this, we projected to study the use of the waste tyre rubber and waste plastic as a blending material in bitumen, which is further used for road construction. If waste plastic and used tyre rubber can be added in bitumen for improving the properties of bituminous mixes.

The present research focuses at developing modified bituminous mixes for Bituminous Concrete Grade 1 by partially replacing the bitumen content with waste plastic and waste tyre tube. Also the study focuses on the different blends of Bituminous Concrete Grade 1 by using Polymer Modified Bitumen (PMB) and Crumb rubber Modified Bitumen (CRMB) and Stability-Flow analysis was done with modified binders and with the replacement of waste plastic and wastetyre tubes were done. It is found that out of two materials, replacement of optimum binder content (OBC) by 8% of waste plastic and 12% of waste tyre tube was observed. The optimum binder content for Polymer Modified Bitumen (PMB) for Bituminous Concrete Grade 1 is 5.2% and for Crumb Rubber Modified Bitumen (CRMB) is 5%.

***Key Words*:** Bitumen ,Aggregate ,Polymers ,Binders etc

1.INTRODUCTION

For developing country like India an efficient road network is pre-requisite for national integration, country's development and for socio-economic development. From last few years, the use of vehicles has increased, which has further increased the vehicular density on roads. Due to increase in vehicular traffic, there is a huge demand for improved pavement sections which can resist the increasing vehicular loads. A highway pavement is a structure consisting of different layers of prepared materials above the natural soil subgrade. The primary function of these layers is to disperse the applied vehicle load to the subgrade. The pavement surface should provide the acceptable riding quality, competent skid resistance i.e. adequately smooth. The main aim is to ensure that stresses conveyed due to wheel loads are adequately reduced, so that they will not go beyond the bearing capacity of the soil subgrade. There are mostly two types of pavements which are primarily recognized as, Flexible pavements and Rigid pavements.

- **Flexible Pavements**

Flexible Pavement is constructed with the bituminous treated top surface course and its pavement structure is composed of several layers. Flexible pavements are those which have low or almost negligible flexural strength. Flexible pavements conveys wheel load stresses to the lower layers of the pavement by grain-to-grain particles by the contact of the aggregate through the granular particles of the structure.

Bitumen.

The bitumen used for Bituminous Concrete layer is a paving bitumen of different viscosity grade (VG10, VG20,

VG30, VG40) following the IS specifications for "Paving Bitumen" IS 73:2013 and the penetration is specified by MORTH Specifications for Road & Bridge work (Fourth Revision, Reprint March 2007) for Bituminous Concrete

Different Viscosity grades of bitumen are as follows:

1 .VG-10 Bitumen: VG-10 is widely used in spraying applications such as surface- dressing and paving in very cold climate. It is also used to manufacture Bitumen Emulsion.

2 .VG-20 BITUMEN: VG-20 is used for paving in cold climate & high altitude regions.

3 .VG-30 BITUMEN: VG-30 is primarily used to construct extra heavy duty bitumen pavements that need to endure substantial traffic loads. It is also called 60/70 Penetration grade.

4 .VG-40 BITUMEN: VG-40 is used in highly stressed areas such as intersections, near toll booths and truck parking lots. Due to its higher viscosity, stiffer bitumen mixes can be produced to improve resistance to shoving and other problems associated with higher temperature and heavy traffic loads.

- Coarse Aggregates

The coarse aggregates for Bituminous Concrete (BC) mix consist of crushed rock, gravel and other stiff or hard material which is retained on 2.36 mm sieve.The aggregates should be classified according the standard limits which are indicated

- Fine Aggregates

Fine aggregates for BC layer consists of naturally occurring material or crushed aggregates passing through 2.36mm sieve and retaining on 75 micron sieve and should be free from dust and should be stiff and durable.

- Binder Content

The binder content shall be optimised to achieve the requirements of the mix set out in Table as per traffic conditions. The Marshall method is used for determining the optimumbinder content. The optimum binder content can be calculated as follows:

Various Additives used in the Bituminous Mixes

When various additives are used in the bituminous mixes, these are known as bitumen modifiers. The additives like polymers, rubber or the blend of the two or more should be selected in such a way that they should have the following properties (IS 15462 – 2004):

- Additives should be compatible with the bitumen.
- Can resist degradation at various mixing temperatures.
- Should capable of being processed by ordinary or conventional mixing & laying machinery.
- Should maintain properties like penetration, ductility, viscosity etc during application, in-service and storage.
- Produce required coating viscosity at application temperature.
- POLYMERS

Polymers are the substances having large molecule size and high molar masses and are composed of large number of repeating structural units. There are both naturally occurring as well as synthetic polymers with a large variety of properties.

- Plastic Waste

Plastic is a very common material used in day-to-day life. In present day, every vital industry uses plastic like PVC pipes, furniture industry, food, packaging and automobile because it is a very cheap and effective raw material. As plastic is a non-biodegradable material, it remains unchanged for thousands of years; so its disposal is a major problem in present time as it is a threat to human body and environment

Role of Polyethylene in Bituminous Pavements

Use of polythene in bituminous pavements is not new. These days it is mandatory to use waste polythene in the construction of bituminous pavements. Waste plastic or polythene is added to hot mix asphalt mixture and the process of laying mixture on the surface of road is similar to a normal tar road. Plastic roads consists mainly of waste plastic carry bags, water bottles, soft drink bottles, and disposal cups

1.1 LITERATURE REVIEW

- Dhara et al (2016) calculated the strength of different mixes of bituminous concrete using Marshall test method. Asphalt binder used in this case was VG-30 & VG-10 and their properties were compared. The optimum bitumen content for VG-10 and VG-30 are 6.0%, and 5.05% respectively. Stability of VG 30 at optimum bitumen content 5.05% of 2 % EpoxyResin was higher than VG-10 at Bitumen content 6.0% of 3% Epoxy Resin and Flow was decreased. In case of VG-30 bitumen, maximum stability value i.e. 1490.55 kg was attainedat 5% of bitumen, where

as in case of VG-10 bitumen, Maximum stability i.e. 1650.6 kg wasattained at 6% of bitumen. In this, it is also observed that Epoxy Resin was used as Modifier and shows improved results.

- Singh and Gupta (2015), evaluated the mix properties of bituminous mixes made by the use of different grading of bitumen binders like VG10, VG30 and VG40 and different grading of aggregates. Bituminous mix testing was done on these materials and their stability values, flow values were compared with each other and their optimum asphalt binder content was compared i.e. for VG10 (6%), VG30 (5.8%) and VG40 (5.6%) OBC was calculated and their stability value comes out to be i.e. for VG10 1650.6 kg, VG30 1867.6 kg and VG40 1993.5 kg.

- Bhargav and Gautam (2013), tried to find the optimum temperature by which the bituminous mix temperature was reduced by the warm mix asphalt technology. Rediset organic additive was used as an adhesive with the bitumen binder VG-30. There was significant difference in properties of mix with addition of additive with VG-30 asphalt binder. With addition of 2%, Rediset stability at 120˚C was calculated to be 1656 kg and at 2.5% Rediset at 120˚C, it reduces to 1272 kg. Results shows that there was a (30-40) °C reduction in mixing & compaction temperature of bituminous mixes by adding 2% of additive which satisfies all the volumetric requirement for both the asphalt binders resulting in better performance of the bituminous mixes at the lower temperature.

- Kazmi and Rao (2015) investigated the use of waste plastic material (Polyethylene Bags) [LDPE] in the shredded form which is used as a binding agent in the construction of Flexible Pavements. In this study, polyethylene was used as a binding agent with bitumen VG-30 grade as a replacement of bitumen with different proportions 5, 7, 9 and 11% and properties of mix is carried out. There was substantially increase in the stability value of blended material in comparison to normal VG-30 asphalt binder. The results showed that the waste plastic materials can be incorporated as a binding agent for the construction of flexible pavements. Addition of 9% LDPE was found to be the optimum binder proportion. Marshal stability with addition of 9% of LDPE comes out to be 1590.2 kg and it was 32.5% greater than the standard value of a minimum 1200 kg. The flow range of 2.9 - 3.0 was also well within the required range.

- Akinpelu et al (2013) used Polyethylene as a binder modifier. In this six different proportions of waste plastic by weight of optimum binder content was selected i.e. 2.5, 5.0, 7.5, 10.0, 12.5 and 15%. The waste plastic was incorporated using wet process as a replacement and various properties were tested like Bulk Density, Stability and Flow. The results showed the increased stability value, reduced density and slightly reduced flow value for all percentages. The optimum proportion of modifier was obtained at 12.5% by the weightof optimum binder content (OBC). The improvement in stability value of the modified asphalt binder using polyethylene is mainly due to an increase in adhesion and cohesion properties of the asphalt binder which will enhance the higher fatigue resistance value and reduce thermal cracking and rutting.

1.2 TESTS ON BITUMIN

Marshall Test for Bituminous Concrete Grade-1

Marshall Mix design method is a design methodology which is adopted worldwide for determining the strength and flow characteristics of the bituminous paving mixes. It is generally used for design of bituminous mixes which can withstand with heavy traffic loads even under adverse climatic conditions by fulfilling the requirements of the pavement surface characteristics. It is a very popular method in India for characterization of bituminous mixes and also used to calculate Optimum Binder Content (OBC) for different mixes and for studying the various Marshall Characteristics such as Marshall Stability value, Flow value, VMA, VFB, Unit Weight in a mixture etc The resulting mix should satisfy the following conditions:

- Sufficient binder should be used to ensure a strong and tough pavement by providing a water proofing coating on the surface of aggregate particles & binding them together under the suitable compaction.

- Provide sufficient stability for resistance to deformation under repeated loads. This resistance in the mixture is obtained from aggregate interlocking and cohesion which generally develops due to binder in the mix.

- Sufficient flexibility should be provided to withstand deflection and the bending without cracking. So, to obtain desired flexibility, it is necessary to have proper grade of bitumen

- Test Procedure and Set up is as per ASTM D6927-06 Standard Test:

- An oven for heating the bituminous mixture & specimen mould assembly at certain required temperature.
- Hot plates for heating compaction hammer having circular plate at bottom, spoon and spatula.
- A flat steel spatula is required with blade having size 25 mm wide and should be of length 150 mm and stiff enough to penetrate the entire bituminous mixture.
- Thermometer is essentially required to for determining the temperature of the hot bituminous mixtures. It should preferably be a dial type having temperature range of 10 to 200˚C.
- A balance or weighing machine for measuring the weight of the mix. The sensitivity of the balance should be at least one gram.
- Trowels for making the bituminous mix and for placing the bituminous mix in the mould assembly.
- A specimen extractor suitably fitted with a jack or compression machine, for extruding the compacted specimen from the mould. Testing head consists of upper & lower cylindrical segments of test head with an inside radius of 51 mm. The lower segment is mounted on the base having two vertical guide rods which facilitates insertion in the holes of upper test ead.

Marshall Stability testing machine consists of a motorized loading unit provided with a gear system to lift the base plate upward at the specified rate. It consists of calibrated proving ring of 10 tons capacity fitted with a dial gauge. The strain controlled loading machine produces a movement of the base plate at the rate of 50.8 mm/ min. at 60˚C The A water bath of sufficient depth is required for the complete immersion of samples. The samples are thermostatically controlled so as to maintain the water bath at 60±1°C.

Tests on Bitumen :

There are various of tests to calculate the properties of asphalt binders. The following tests were conducted to evaluate the different properties of asphalt binder which are to be used.

- Penetration Test [IS: 1203 - 1978]

Penetration test measures the hardness or softness of bitumen or asphalt binder by measuring the depth in tenths of a mille meter (mm) to which a standard loaded needle penetrates vertically in 5 seconds. The test was performed as per recommendations of Indian Standards (IS). The penetrometer consists of a needle assembly with a total weight of 100g of bitumen and a device for releasing and locking in any position. The bitumen is softened so that it can be poured easily, stirred thoroughly and poured into containers. The test should be conducted at a particular temperature of 25˚C. It may be noted that penetration value is largely influenced by any inaccuracy with regards to pouring temperature, size of the needle, weight placed on the needle and the test temperature. A grade of 40/50 bitumen means the penetration value is in the range 40 to 50 at standard test conditions. In hot climates, a lower penetration grade is preferred.

- Specific Gravity Test [IS: 1202 - 1978]

In paving jobs, density property is of great use to classify a binder. In most cases bitumen is weighed, but when used with aggregates, the bitumen is converted to volume using density values. The density of bitumen is greatly influenced by its chemical composition. Increase in aromatic type mineral impurities cause an increase in specific gravity .The specific gravity of bitumen is defined as the ratio of mass of given volume of bitumen of known content to the mass of equal volume of water at 27˚C. The specific gravity can be measured using Pycnometer as shown in the Plate 3.5. The specific gravity of bitumen varies from 0.97 to 1.02.

- Viscosity Test [IS: 1206 – 1978]

Viscosity denotes the fluid property of bituminous material and it is a measure of resistance to flow. At the application temperature, this characteristic greatly influences the strength of resulting paving mixes. Low or high viscosity during compaction or mixing has been observed to result in lower stability values. At high viscosity, Bitumen resists the compactive effort; thereby resulting mix is heterogeneous, hence low stability values. At low viscosityinstead of providing a uniform bending film over aggregates, bitumen will lubricate the aggregate particles, thereby reducing the stability values. A rotational viscometer gathers data on a material's viscosity behaviour under different conditions. The rotational viscometer basically consists of two parts – a head unit with a motor and a spindle that is driven by the motor. The viscosity is determined by measuring the resistance of a spindle rotating in the sample. Rotational viscometers can be used for the accurate measurement of viscosity for both Newtonian and non-Newtonian fluids. Newtonian fluids are those that are affected by temperature, such as water, kerosene, mineral oils etc. Non- Newtonian fluids are those that change viscosity when stirred, shaken or otherwise agitated. These include paint, gels, inks, milk, ketchup etc.

2. RESULTS

The results obtained from the laboratory testing of the Bituminous Concrete (BC) mixes designed using Marshall Mix method with and without the addition of various additives in certain proportions as the replacement of the asphalt binder. All the prepared Marshall mix specimens were subjected to compaction of 75 blows on each face to obtain the required density. The results were calibrated to determine the Optimum Binder Content (OBC) by performing the Stability-Flow analysis and Volumetric analysis for the prepared specimens. In addition to Marshall Mix method, other test was also conducted such as Indirect Tensile Strength Test on various asphalt binders to calculate the Resilient Modulus values.

- Sieve Analysis

Sieve analysis test was carried out for determining the gradation of aggregates preparation of the Marshall specimen. Through this sieve analysis test, the proportioning of aggregates such as coarse aggregates, fine aggregate and stone dust is determined by ensuring the proper blending of aggregates to satisfy the gradation limit as specified in MORTH for BC Grade 1. The sieve analysis test results on aggregates are presented in the Table

Sieve Size	% Passing 20mm	% Passing 10mm	% Passing 4.75mm	% Passing Stone Dust
26.5	100	100	100	100
19	93.8	100	100	100
9.5	15	55.13	100	100
4.75	10	23.23	89.33	100
2.36	0.54	5.19	70.66	100
0.300	0.54	1.06	30	96
0.075	0.54	1.06	10	35.5

MORTH Specified Gradation For Bituminous Concrete		
Grading	1	2
Nominal Aggregate Size	19 mm	13.2mm
Layer Thickness	50 mm	30-40 mm
IS Sieve, mm	Cumulative % by weight of total aggregate passing	
26.5	100	-
19	90-100	100
13.2	59-79	90-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58
1.18	20-34	34-48
0.6	15-27	26-38
0.3	10-20	18-28
0.15	5-13	12-20
0.075	b2-8	4-10
ontent % by mass of total mix	bMin 5.2*	Min 5.4**

- Results of BC Mix Design Grade - 1 without using any Additive

To decide the optimum binder content (OBC), Marshall Mix samples were prepared by varying the percentage of 60/70 asphalt binder without using any additive or modifier. Stability-Flow laboratory analysis and Volumetric analysis were performed for the Marshall mix samples with bitumen content varying from 4.5% to 5.5%. The test values were obtained and plotted graphically. The output results of stability and flow values are shown in Table no.

Test	Bitumen Content By Wt of Mix (%)	Bulk Density (gm/cc)	Air Voids (%)V_v	Voids in Mineral aggregate (%)VMA	Voids Filled With Bitumen (%)VFB	Corrected Stability (kN)
1	4.5	2.49	4.244	14.863	71.44	8.6
2	5.0	2.530	4.899	16.474	70.26	13.6
3	5.5	2.435	4.966	17.537	71.679	10.8

The above table signifies that the maximum Marshall Stability comes out to be 13.6 kN at bitumen content 5 percent and with addition of more, the stability value starts getting decreasing.

- Results of BC Mix Design Grade – 1 using Polymer Modified Bitumen (PMB 40)

To calculate the optimum binder content (OBC) of Polymer Modified mix, Marshall Mix samples were prepared by varying the percentages of PMB 40 asphalt binder. Stability-Flow laboratory analysis and Volumetric analysis were carried out for the Marshall Mix samples prepared with bitumen content varying from 4.5% to 5.5%. The test values were obtained and are plotted graphically.

Test	Bitumen Content By Wt of Mix (%)	Bulk Density (gm/cc)	Air Voids (%)V_v	Voids in Mineral aggregate (%)VMA	Voids Filled With Bitumen (%)VFB	Corrected Stability(kN)	Flow (mm)
1	4.5	2.466	5.15	15.65	67.09	16.112	2.20
2	5.0	2.50	4.69	16.28	71.19	18.40	3.48
3	5.5	2.463	4.16	16.87	75.34	15.13	3.63

The Result shows that the maximum Stability value of 18.40 kN is attained at 5% of Polymer Modified Bitumen (PMB) and with addition of more, the stability value starts getting decreasing and maximum Bulk Density is 2.50 at 5% bitumen content.

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Corrected Stability

Replacement of OBC with Plastic% (by weight of OBC)	Corrected Stability (kN)	Flow (mm)
2	19.9	3.88
4	23.12	3.56
6	25.67	3.47
8	26.50	3.36
10	24.79	2.86
12	21.97	

3. CONCLUSIONS

The major conclusions drawn from the study carried out on stability-flow analysis of BC mix (Grade-1) by using different additives are as follows:

- Initially, normal asphalt binder VG-30 is tested at different percentages for the BC mix grade -1 and optimum binder content (OBC) is calculated .The OBC occurs at5% and flow values are in the limits specified as per MORTH.
- The stability values for the BC grade-1 mix increase with the replacement of OBC up to 8% of waste plastic but it decreases further with the addition of waste plastic. This waste plastic only indicates that this percentage is the only suited level of replacement.
- For the addition of discarded tyre tubes, the stability values for the BC grade-1 mix increase with the replacement of OBC (5%) upto 12% of discarded tyre tubes with optimum binder content of 5% but decreases with the addition of tyre tube. However, the stability and flow values lie within the limits specified by MORTH for all % replacements of tyre tubes.

1. The OBC of PMB used in BC Grade-1 is 5.2%.
2. Out of the various materials used, replacement of OBC by 12% discarded tyre tube has the highest stability value.

REFERENCES

[1] AASTHO: T 315-10: Standard method of test for "Determining the Rheological Properties of Asphalt Binder using a Dynamic Shear Rheometer (DSR)".

[2] Adedimi1a A., Kennedy T.(1975) "Fatigue and Resilient characteristics of asphalt mixtures by repeated-load Indirect Tensile test".

[3] Akinpelu M., Dahunsi B., Olafusi O., Awogboro O. and Quadri A. (2013) "Effect of Polythene Modified Bitumen on Properties of Hot Mix Asphalt". *ARPN Journal of Engineering and Applied Sciences*, 8(4), pp. 290-295.

[4] Anwar S. (2014) "Studies On Marshall And Modified Marshall Specimens By Using CRMB" (International Journal of Structural and Civil Engineering Research-IJSCERISSN 2319 – 6009, 3(4)

[5] Archana M.R, Sathish H.S., Ashwin M, Hanamant Hunashikatti (2014) " Effect of waste plastic utilisation on Indirect Tensile Strength properties of Semi Dense Bituminous Concrete Mixes" *Indian Highways*. pp. 64-72.

[6] ASTM - D6931-12: Standard test method for Indirect Tensile (IDT) Strength of Bituminous mixtures.

[7] Bhargav N.Gautam (2013) "Warm mix Design of Bituminous Concrete using Rediset WMX" Global Research Analysis, 2(6), ISSn No 2277 – 8160. pp. 70-72

[8] Kalasariya D., Patel K., Raol H. (2016) "Study of Bituminous Concrete under Different Mix Conditions by Using Epoxy Resin as Modifier" IJSRSET, 2(3), ISSN :2395-1990, Online ISSN : 2394-4099

[9] Four Laning of National Highway from Rajkot to Somnath.

[10] Gawande A., Zamre G.S, Renge V.C., Bharsakale G. and Tayde S. (2012) "Utilisation of waste plastic in asphalting of roads" *Scientific reviews and Chemical communications, SRCC:* 2(2), 2012, ISSN 2277-2669, pp. 147-157.

[11] IRC:37-2012 "Guidelines for the Design of Flexible Pavements" (3rd Revision)

[12] IRC SP:98-2013 "Guidelines for the use of Waste Plastic in hot bituminous mixes".

[13] IRC SP:53 "Guidelines on use of Polymer and Rubber Modified Bitumen in Road Construction" IRC, New Delhi

[14] IS 15462:2004 "Polymer and Rubber Modified Bitumen". BIS, New Delhi.