Use of Waste Materials in Road Construction

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Abstract
Bituminous Concrete (BC) is a composite material mostly used in construction projects like road surfacing, airports, parking lots, etc. It consists of asphalt or bitumen (used as a binder) and mineral aggregate which is mixed together & laid down in layers then compacted. Now a days, the steady increment in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature put us in a demanding situation to think of some alternatives for the improvisation of the pavement characteristics and quality by applying some necessary modifications which shall satisfy both the strength as well as economical aspects. . The present work depicts the use of a new modifier (liquid form) for the development of cost-effective and high performance modified binder and its mixes application for construction and maintenance of asphalt roads. The goal of improving bitumen properties is achieved using 0.5 percent of a copolymer Vinyl Acrylic. the need for the current hour is to use the waste polythene in some beneficial purposes. Lime & fly ash was used as a filler in modified bituminous concrete mixes. Various volumetric properties e.g. air voids, VMA, VFB and mechanical properties like Indirect tensile strength (ITS), Tensile strength Ratio (TSR), Retained stability, Marshall Stability, Flow value, are determined. Performance tests like Rutting, Resilient Modulus, Dynamic creep and fatigue were also conducted on conventional and modified mixes of VG-30.

Various percentages of polythene are used for the preparation of mixes with a selected aggregate grading as given in the IRC Code. The role of polythene in the mix is studied for various engineering properties by preparing Marshall Samples of BC mixtures with and without polymer.

Keywords: Bituminous Concrete (BC), Marshall Stability, Flow value, Optimum Binder Content.

Introduction
Polymer modification of bitumen is the incorporation of polymers in bitumen by mechanical mixing or chemical reaction. During the last 40 years, more and more researchers began to concentrate on polymer modification of bitumen and a rapidly increasing number of research articles have been published since the 1970s. In these, the various investigated polymers included plastomers (e.g. polyethylene (PE), polypropylene (PP), ethylene-vinyl acetate (EVA), ethylene-butyl acrylate (EBA)) and thermoplastic elastomers (e.g. styrene-butadiene-styrene (SBS), styrene-isoprene-styrene (SIS), and styrene/ethylene/butylene-styrene (SEBS)), although none of these were initially designed for bitumen modification. These polymers were reported to lead to some improved properties of bitumen, such as higher stiffness at high temperatures, higher cracking resistance at low temperatures, better moisture resistance or longer fatigue life. An effective polymer modification results in a thermodynamically unstable but kinetically stable system in which the polymer is partially swollen by the light components of bitumen. Some important factors, including the characteristics of the bitumen and the polymer themselves, the content of polymer and the manufacturing processes, determine the final properties of polymer modified bitumen (PMB). As polymer

content increases, phase inversion may occur in some PMBs: from bitumen being the dominant phase to polymer becoming the dominant phase. However, an ideal microstructure for PMB contains two interlocked continuous phases, which determines the optimum polymer content for bitumen modification. With these two interlocked continuous phases; PMB usually shows better overall performance with respect to mechanical properties, storage stability and cost-effectiveness.

Experimental Work

1. Characterization of aggregates

Aggregate constitutes the granular part in bituminous concrete mixtures which contributes up to 90-95 % of the mixture weight and contributes to most of the load-bearing & strength characteristics of the mixture. Hence, the quality and physical properties of the aggregates should be controlled to ensure good pavement. The properties that aggregates should have to be used in the pavement are shown below:

1. Aggregates should have minimal plasticity. The presence of clay fines in bituminous mix can result in problems like swelling and adhesion of bitumen to the rock which may cause stripping problems. Clay lumps and friable particles should be limited to utmost 1%.
2. Durability or resistance to weathering should be measured by sulphate soundness testing.
3. The ratio of dust to asphalt cement, by mass should be a maximum of 1.2 & a minimum of 0.6.
4. It is recommended AASHTO T-209 to be used for determining the maximum specific gravity of bituminous concrete mixes.
5. Aggregates are of 2 types-

A. Coarse Aggregate

The aggregates retained on 4.75 mm Sieve are called as coarse aggregates. Coarse aggregate should be screened crushed rock, angular in shape, free from dust particles, clay, vegetations, and organic matters. They should have the following properties.

B. Fine Aggregate (FA)

Fine aggregate should be clean screened quarry dust. It should be free from clay, loam, vegetation or organic matter. FA should have the following properties.

The Properties of coarse and fine aggregates for preparation of BC (Grade I) mix shall conform to Table -1 of MoRTH Fifth Revision, 2013. The test results of the aggregates used in this study are given in Table-2.1.

Table2.1 Physical Requirements for Course Aggregate for Bituminous Concrete

Property	Test	Specification as per MoRTH ,2013	Value obtained
Particle Shape	Combined Flakiness and Elongation Indices	Max 35%	25%
Durability	Soundness in Sodium sulphate	Max 12%	9%

Water Absorption	Water absorption	Max 2%	0.35
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	97%
Water Sensitivity	Retained Tensile Strength	Minimum 80%	82%

2. Characterization of bitumen

Bitumen VG-30 is tested as per IS-73, 2013 and test properties are given in Table-2.2

Table 2.2 Properties of Bitumen (VG-30)

Property Tested	Test Result	Requirement as per IS 73:2013 for VG-30
Penetration at 25℃,100g,5s 0.1mm	64	45(Min)
Softening point(R&B),℃	48	47(Min)
Absolute Viscosity at 60℃	2570	2400(Min)
Kinematic Viscosity,135℃,cSt	725	350(Min)
Solubility in trichloroethylene, % by mass	99.34	99.0(Min)
Viscosity ratio at 60℃,Test on residue from thin –film oven test/RTFOT	3.5	4.0(Max)
Ductility at 25℃, after thin-film oven test/RTFOT	52	40(Min)
Complex Modulus (G/sin£) as Min 1.0 kPa at 10 rad/s, at a temperature, ℃	76	Not Specified

Design for Polymer Modified BC Mix with Lime.

The individual gradation of selected component aggregates their proportioning achieved by trial and error method is given in Table 3.10. The designed gradation along with the specified limits is shown in Figure 3.5

Table 3.10 Aggregate Gradation and Blend Proportion

Sieve Size	Percentage of aggregates passing through sieve size						
	Nominal size of aggregates					Blend Proportion by wt. of aggregate A: B: C: D:E 12:22:24:40:2	Specified Limits for 50mm BC (MORTH,2013)
	A 20mm	B 10mm	C 6mm	D Stone Dust	E Lime		
19	100.00	100.00	100.00	100.00	100	100	100
13.2	30.00	99.00	100.00	100.00	100	91.38	90-100
9.5	10.23	61.00	100.00	100.00	100	80.65	70-88
4.75	0.00	4.00	70.00	100.00	100	59.68	53-71
2.36	0.00	0.00	36.00	97.00	100	49.44	42-58
1.18	0.00	0.00	10.32	79.00	100	36.08	34-48
0.6	0.00	0.00	8.92	55.00	100	26.14	26-38
0.3	0.00	0.00	0.00	42.00	99.4	18.79	18-28
0.15	0.00	0.00	0.00	26.00	96	12.32	12_20
0.75	0.00	0.00	0.00	13.00	64	6.48	4_10

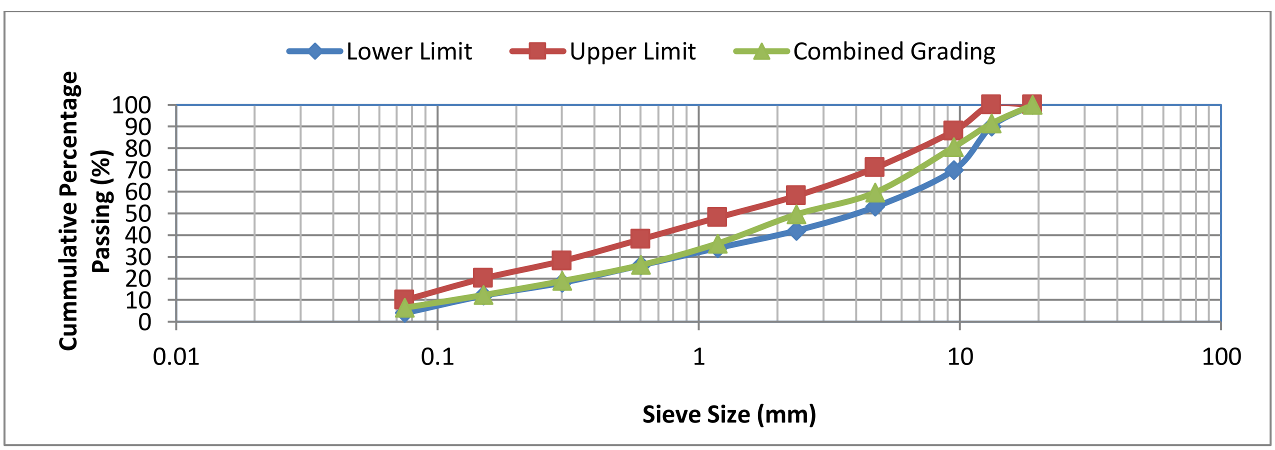

Figure 3.1Gradation Adopted and Specification Limits for BC Mix

Determination of Optimum Binder Content (OBC)

To determine the optimum binder content (OBC), Marshall Samples were prepared at varying percentage of VG-30 bitumen. Volumetric and mechanical parameter for BC with VG-30 Bitumen such as Bulk density, Marshall Stability, Flow, and other volumetric properties were then obtained which are given in Table 3.10.The test values obtained are plotted graphically and shown in Figure 3.2. Using the above parameters, Optimum Binder Content (OBC) was found to 5.3 percent by weight of aggregates.

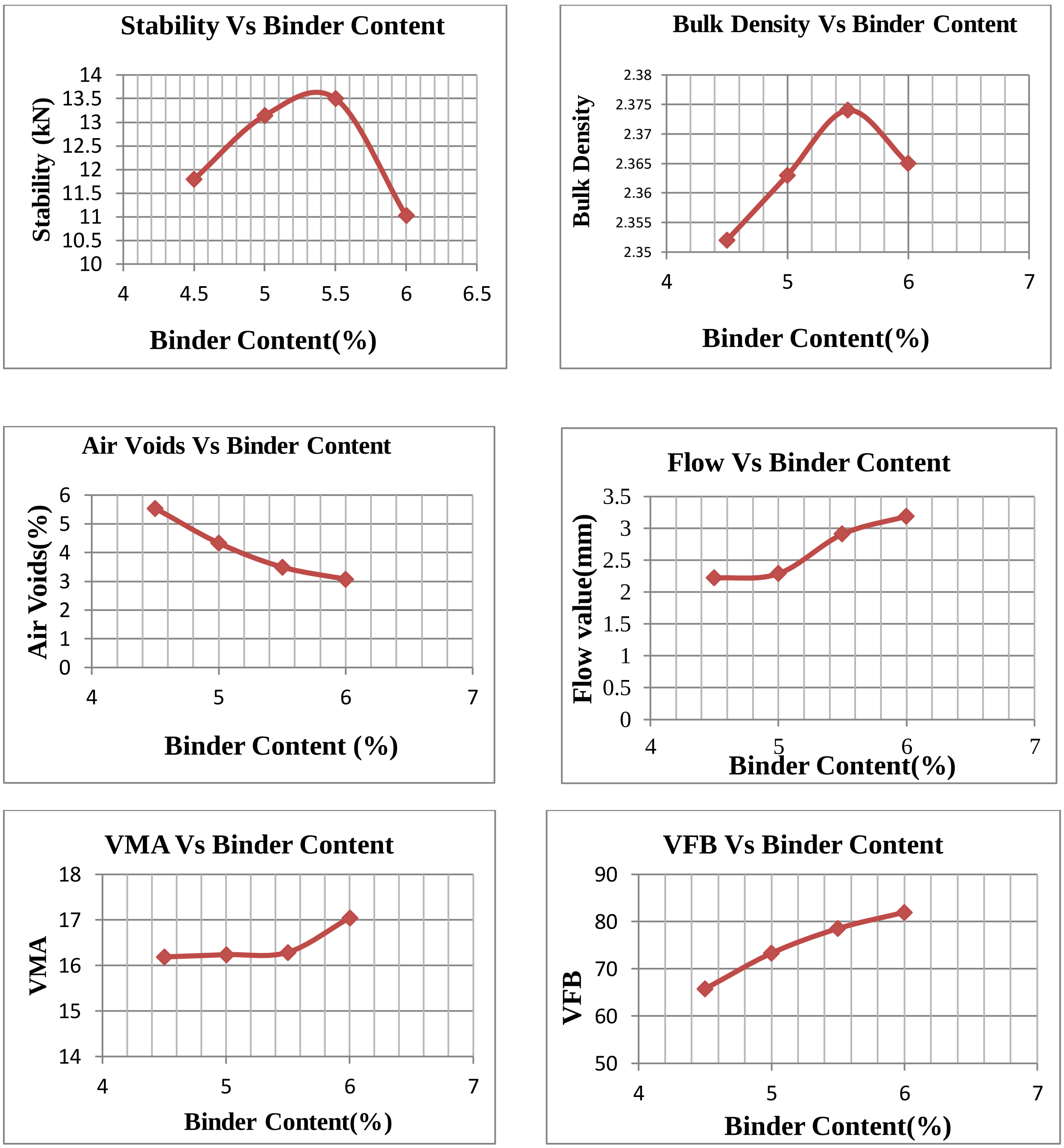

Figure 3.2 Properties of mix with respect to binder content.

Results and Discussion

The results obtained through various tests, as mentioned above, are discussed and presented in this section of the report.

- The physical properties of aggregate used lies within the limit as specified in MoRT&H for Marshall Mix design ensuring its further use for preparation of bituminous mixes.
- The VG 30 bitumen met all the required properties and satisfies limits as described in IS 73-2013 and LPMB met all the required properties and satisfies limits as described in IRC SP- 53- 2010.
- Similar trend is found for mix prepared by Fly ash with liquid polymer when compared to for bituminous mix prepared by Fly ash with VG30 at different temperature. Overall the resilient modulus value for bituminous mix prepared by Lime with liquid polymer at both the temperature 25 ° C and 35° C as compared with other mixes.

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