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Performance Studies Of Bituminous Mixes Using Co-Polymers And Tyre Waste

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Abstract

Six percent HDPE and ten percent waste tyre samples have the best consistency and flow performance, whereas the typical combination performs similarly. A 61 percent increase in blend consistency means that the new BC mix is far more resistant to deformation under load. The Marshall Quotient has improved by 63 percent, despite the fact that the flow value is nearly comparable to the standard mix. The greater this number is, the stiffer the BC blend is. To increase the BC mix's lifetime, HDPE and tyre waste (TW) must be used. According to results from a binary mix, it can be seen that flow rate increases exclusively with percentage increase of tyre flow intensity, but HDPE % declines when HDPE is added to a mix with a same TW flow rate. At low humidity, the HDPE permits a more brittle mixture, but the TW provides for a more strong mixture in general and reduces pavement cracking at high temperature pressures.

Keywords: *HDPE; tyre waste; Stability; Marshall quotient; conventional mix.*

Introduction

Owing to its extensive usage in lightweight pavements, waterproof coatings, binders or other engineering disciplines, the market for bitumen extracted a by-product of crude petroleum only through fractional distillation becomes gradually rising. The data assessed shows that global bitumen manufacturing is currently 113 metric tons per year, which would be estimated to rise 135 metric tons by 2020 at a rate of 2.7 per cent annually [1-2]. Bitumen comprises of volatile hydrocarbons and has been made up of components such as Sulphur, copper, calcium, and oxygen. The composition and commutability of bitumen depends on the location from which the crude petroleum is collected and the manufacturing process. The binder's inner surface relies on all of those factors. Hence the characteristics of bitumen are influenced also by circumstances of manufacturing.

These days, different methods are being used to solve this issue, but perhaps the most popular is the chemical and physical alteration by polymers of bitumen. There are many other polymers that could be used for bitumen alteration, including such APP (Atactic Polypropylene), SBS, SBR, Ethylene Vinyl Acetate etc. Such polymers contribute to enhance the binder's stability properties and reliability however the alteration should really be done with the economic things in mind.

Along with emergence of urban development, the production of abundance of discarded waste goods such as scrapped rubber tyres, polythene holding bags, plastic containers etc. Plastic goods are becoming an integral part of our everyday lives. Its volume is really big globally, which is more than 150 million tons each year. A recent survey was carried out by the "Central Pollution Control Board" CPCB (2013) [3-5] which approximated waste production in India to be around 8 million metric tons per year. It is widely utilized in film bundling, material packaging, shopping and garbage packs, clothing and toys, liquid purchasers, construction materials, commercial and domestic articles etc. Plastic is regarded as waste following the use of it. And be non-biodegradable plastics just cannot be disposed in landfills and although those who make it back to the environment via water and air erosion, which would suffocate the drainage systems and might trigger their disease and death if consumed by animal species [6-8].

Some plastics can be recycled but they became more poisonous to a natural atmosphere after processing due to adding fire retardants, stabilizers, chemicals and shades etc. Plastic can also be reused only three or four times, as the thermal recycling process tends to cause the composite material to deteriorate owing to those whose life is decreased. As such recycling can never be the even dependent alternative for secure treatment and disposal of plastic material [9-13].

In recent years, numerous studies have been made on using recycled waste products in the modification of bitumen instead of virgin polymers so that there will be both cost reduction in pavement construction and environmental protection. It will also improve the structural behavior of the pavement which helps in reducing the maintenance work during the service life of the pavement and reduce the life cycle cost of the flexible pavement. So problems related to the flexible pavements can be dealt in a better and effective way by the amalgamation of recycled waste materials to binder.

Materials and Methodology

Bituminous combination stakeholders play a vital part in this. The efficiency of paving relies indirectly on the property of certain constituents. Their collection is rendered until each mix design as the characteristics are discovered which will satisfy the stated needs. The following components are being used in this analysis to produce the thick graded bituminous mixture:

- Bituminous binder
- Coarse aggregates
- Fine aggregates
- Filler
- Modifiers: Waste tyre and High Density Polyethylene (co-polymer)

Bituminous Concrete (BC) surface course layer have been introduced in the present study for alteration. Various tests such as softening level, ductility, penetration strength, specific gravity and flash point test was conducted to find certain characteristics of VG 30. They noticed the characteristics inside the defined limits. Bituminous mix concept was performed just after collection and processing of different components of BC blend. First, that OBC of a unmodified BC mix has been calculated and then the updated BC mixes was ready by choosing various percentage of reused TW (10%, 12%) and reused HDPE (3%, 4%) by OBC weight. The change was made by partially removing the bituminous binder essential of mix preparation.

Results and Discussion

For this analysis, the separate amounts of TW (10 percent, 12 percent) and HDPE (3 percent, 4 percent) were used to change the BC blend. The adjustment was performed to shape the existing BC blends through using them individually and through their combination. The OBC of the traditional combination was sought, as well as the optimal binder were partly substituted by a various amount of adjustments to achieve changed BC blends. Study of stability and density were conducted mostly on material, as well as the "Optimum adjusted BC" combination was discovered.

Conventional BC Mix

The classification assigned to a built traditional BC mix throughout the current study is classified A1. We received the OBC 4.5 percent for such a blend. The findings obtained for both the mixture were contrasted with definition given by MORTH as shown in Table 1 and had been identified inside the defined limits apart from vacuums loaded with bitumen, which aren't really any higher than to the stated limits, so agreed.

Table 1 Comparison of Results with Specifications

Properties	**Results (4.5% OBC)**	**Specifications for non-modified BC mix (MORTH 5th Revision)**
Stability (KN) 60°c	9.37	8
Flow Value(mm)	2.56	2.0 to 4.0
V_V (%)	2.89	3.0 to 5.0
VFB (%)	66.59	65.0 to 75.0
MQ	2.06	2.0 to 5.0
VMA (%)	15.29	> 14.0

Modified BC Mixes

Marshall Stability Check on adjusted BC mixes (B1 to C4) was conducted. Analysis of stability, flow and density was carried out, and the findings obtained were displayed in Table 2 with the following sequence:

Table 2 Marshall Test Results of Non-modified and Modified BC Samples

Identity	**Sample composition**	**Stability (kN)**	**Flow value (mm)**	**Vv (%)**	**Gb (gm/cm³)**	**VMA (%)**	**MQ**
A1	100% VG 30	10.28	3.23	3.99	2.41	17.2	3.01
B1	97%VG3O + 3% HDPE	11.83	3.53	4.59	2.328	17.319	3.46
B2	92% VG30+ 8% HDPE	14.39	3.54	4.62	2.419	17.323	4.24
B3	90% VG30 + 10% CR	12.10	2.86	4.42	2.291	17.092	4.09
B4	87% VG30 + 13% CR	13.63	3.80	4.81	2.345	17.501	3.56
C1	85%VG 30 + 5% HDPE + 10% CR	15.72	3.69	3.53	2.362	16.249	4.21
C2	**83% VG 30 + 7% HDPE + 10% CR**	**16.23**	**3.38**	**4.12**	**2.342**	**16.513**	**4.53**
C3	83% VG30 + 5% HDPE + 12% CR	15.79	3.443	4.93	2.312	17.54	4.36
C4	81% VG30 + 7%HDPE + 12%CR	15.43	3.389	5.53	2.296	18.012	4.48
Specified limits for modified mixes MORTH 2013	BC mix (Grading 2)	12	2.5 – 4	3 – 5	_	>14	2.5 – 5

Marshall Stability value

In Marshall Research, to get some kind of combination of various types, three tests were produced as well as the mean stability value was taken. Marshall Stability value of traditional mix (OBC 4.0 percent per wt. of mix) is 9.37 KN, which again is better than that of the minimum value reported for BC mix (MORTH, 2013). For C2 mix of Group C tertiary mix, i.e. 16.23 kN, full stability was reached in the changed mixes. For B2 i.e. 14.39 KN, maximal stability was achieved in binary mixture of Category B. Marshall Tertiary mix C2 (61 percent) and binary mix B2 (38 percent) have a significantly higher stability rating than unmodified BC mix. It shows that greater consistency could be achieved by changing the binder of CR and HDPE compared with the standard BC combination.

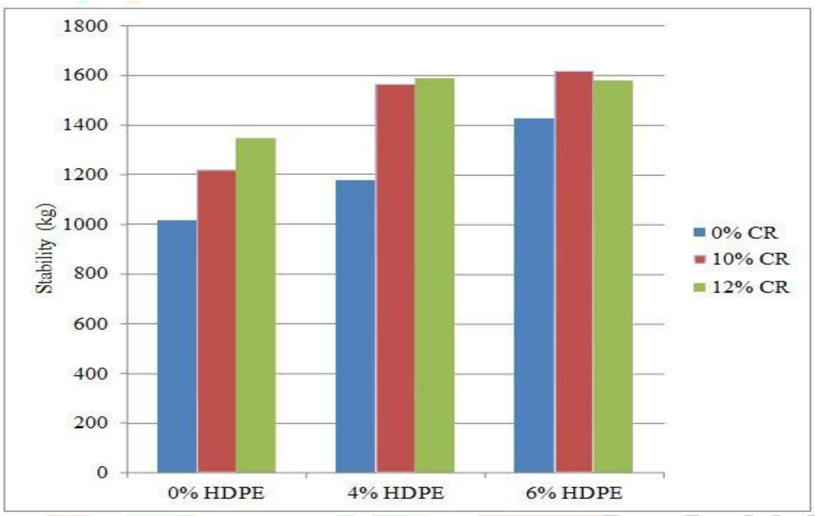

Fig. 1 Marshall Stability of BC Mix before and after Modification

Flow value

Marshall The flow density of standard BC mix (A1) is 3.23 mm while that of category C optimal mix is 3.23 mm. C2 is 3.38 mm, that for adjusted BC mix according to MORTH 2013 is still within the defined limits i.e. 2.5-4 mm. Flow Quality of optimal Category B blend i.e. B2 is 3.54 that also comes under the limits defined. In tertiary mix division C it is found that there is still a decline throughout the flow value at such a fixed ratio of CR with a rise in the amount of HDPE while there is no variation throughout the flow value via a rise in the amount of CR at a similar rate of HDPE as seen in figure 5.8. For binary combination type B the flow factor decreases with amount of CR rise.

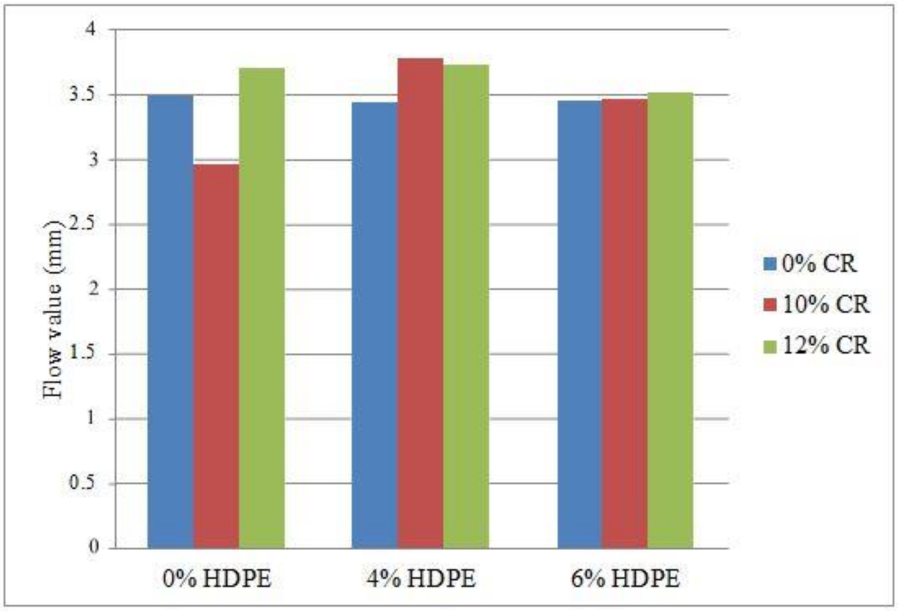

Fig. 2 Marshall Flow value of BC Mix before and after Modification

Air voids (V_v)

The proportion of Vv in the standard BC mix (A1) was 3.99 percent, which is within the allowable range. The findings revealed that when the amount of modifiers grows, so does the percentage Vv. The air voids of the optimal category C mix, i.e. C2, were determined to be 4.12 percent, which is within the required limitations. With a larger amount of CR and HDPE in the tertiary mix, i.e. C4, the air voids increase to 5.53 percent, which is not allowed according to MORTH 2013.

Bulk density (G_b)

Gb of regular BC mix (A1) is 2.41 gm / cm3. The maximum density for B3 were observed in the binary mix of category B, i.e. 2,29gm / cm3, whereas for C1 i.e. 2,36 gm / cm3 the maximum density were observed in the tertiary mix of category C. The bulk density becomes reducing with a rise in the amount of modifications.

Voids in mineral aggregates (VMA)

For the A1 mix, VMA is 17.20 percent, while for the maximum Group C mix i.e. C2 peaked at 16,513%. The research findings fall beyond the allowable range based on the amount of air voids and total aggregate scale.

Marshall quotient (MQ)

It is 3.01 for the standard combination (A1). Category B (B2) optimum mix and Category C (C2) optimum mix have such a Marshall Quotient rating of 4.24 and 4.53, overall. They consider the values inside the defined limits. It was found that the MQ value decreased by 40 percent in binary mixes, however in tertiary mixes its number increases by 55 percent, which suggests a stronger stiffness might be produced by adding CR and HDPE.

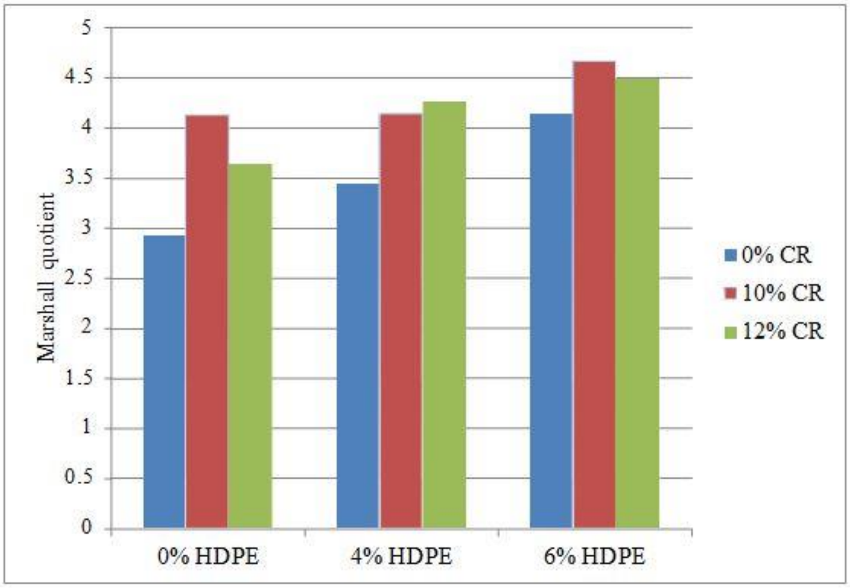

Fig. 3 Marshall Quotient of BC Mix before and after Modification

Optimum Modified BC Mix

It was found from the tests mostly on updated BC mixes that C2 BC mix is the "Optimum optimized BC blend" The "6 percent HDPE and 10 percent CR" are also the optimal rates for BC blend adjustment. By adding this proportion of modifiers, the stability factor increases by 61 per cent. The flow value is almost the same as traditional, but MQ has risen by 63%. The VMA, VFA and Vv values were located within the specified limits array as seen in table 3.

Table 3 Comparison between Optimum Modified BC mix and Conventional Mix

Properties	Results		Specifications for modified BC mix (MORTH 5th Revision)
	Optimum modified mix (6 % HDPE+ 10% CR)	Conventional BC mixes	
Stability (KN)	16.23	10.28	12.0
Flow Value (mm)	3.380	3.23	2.5 to 4.0
% Air Voids	4.12	3.99	3.0 to 5.0
% Voids filled with bitumen	74.83	76.79	65.0 to 75.0
Marshall Quotient	4.53	3.01	2.5 to 5.0
% Voids in mineral Aggregates	16.513	17.201	> 14

Conclusions

The samples prepared with 6% HDPE and 10% CR have the greatest consistency while the flow performance is about the same as with the traditional mix. The consistency of a blend is improved by 61 percent; this stabilization high gain that the changed BC mix has excellent resistance to load deformation. While the flow value is about identical as traditional mix but thanks to a higher stability factor, Marshall Quotient has improved by 63 percent. This higher value shows increased BC blend stiffness. Hence reused HDPE and CR must be used to boost the BC mix 's longevity. First from findings on binary mix it is observed that now the flow rate increases only with percentage rise of CR flow intensity while in tertiary mix with such a similar rate of CR, the flow decreases with an change in percentage of HDPE. It means that the CR allows a mix robust in general and decreases the pavement's cracking potential under high temperature pressures, whereas the HDPE allows a mix somewhat more fragile in general at low humidity. When incorporating CR and HDPE, the rutting activity of the BC combination is increased when 51 per cent. The mixture would also be effective at higher temperatures and resist deformation under repeated load motion.

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