INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

DEPARTMENT OF POLYMER AND PROCESS ENGINEERING

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Report: Inputs on IS Standard: IS 15462: 2019

Comment 1: The current IS 15462 standard is heavily reliant on MSCR parameters.

Justification:

The current IS 15462: 2019 standard is mainly adopted from AASHTO standards. The standard relies heavily on MSCR parameters, which is not an ideal scenario. 3 case studies are presented below, clearly showing significant deviation in the prediction between the MSCR parameters and rut depth. SBS polymer, reactive terpolymer, wax, and polyethylene (PE) are used in the 3 case studies.

Case 1: Terpolymers consist of functional groups that form chemical bonds with the asphalt binder and require a lower polymer dosage. The higher reactivity of terpolymer provides phase-stable PMBs along with improved performance. Terpolymer and SBS polymers are widely used to prepare PMBs. Hence, using terpolymer is a good way to evaluate the MSCR procedure critically.

Case 2: Low molecular weight waxes with melting temperatures below 140 °C are commonly used to improve the workability of asphalt mixture. Above their melting temperature, wax in the molten state significantly reduces the viscosity of the binder. However, wax crystallizes below its melting temperature and increases the stiffness of the binder at upper service temperatures. A stiffer binder at upper service temperatures results in a lower strain value during the creep cycle in MSCR, which inherently results in higher elastic recovery properties. Though waxes enhance the elastic recovery characteristics of SBS-MBs, they fail to improve the rutting performance. Commercially, a large variety of waxes from several manufacturers are available. In this study, sasobit wax is utilized to depict the role of wax in artificially altering the MSCR parameters.

Case 3: Unlike SBS polymer, a thermoplastic elastomer, polyethylene is a thermoplastic polymer. Polyethylene is extensively used in day-to-day applications owing to its low cost and good mechanical properties. Polyethylene is a highly inert and stiff material that increases the stiffness of the modified binder but fails to develop the required elasticity. Though polyethylene-modified binders will have poor elastic recovery, they can reduce rut depth in asphalt mixes by enhancing the stiffness of the binder. Hence, polyethylene was selected along with SBS, terpolymer, and sasobit wax to demonstrate the effectiveness of MSCR analysis in predicting the rut depth reduction by changing the polymer and using an additive.

MSCR test and rut depth analysis was carried out at 60 °C. In the 1st case study, two samples, 4.25 wt.% SBS_L and 1.5 wt.% commercial-grade reactive terpolymer in AB_2 binder were compared. It can be observed that the two PMBs had similar % elastic recovery and non-recoverable creep compliance values, but the rut depth in asphalt mixes was different. In the 2nd case study, it can be observed that the addition of 2 wt.% wax significantly enhances the % elastic recovery and non-recoverable creep compliance values, but the rut depth values in asphalt mixes were similar. In the 3rd case study, SBS_L and polyethylene (PE) modified binders had significantly different MSCR parameters but had similar rut depth.

MSCR parameters and rut depth of different PMBs.

Case studies	PMBs	% ER	Rut depth at 60 °C (mm)	Conclusion
1.	4.25 wt.% SBS_L in AB_2 binder	88	3.75	Similar values of % ER and Jnr but rut depth is considerably different
	1.5 wt.% reactive Ter-polymer in AB_2 binder	89	6.2	
2.	2.5 wt.% SBS_L in AB_1 binder	35	7.8	% ER and Jnr very different but rut depth is similar
	2.5 wt.% SBS_L in AB_1 binder + 2 wt.% wax	57	8.0	
3.	3 wt.% SBS_L in AB_1 binder	65	7.2	% ER and Jnr very different but rut depth is similar
	4.5 wt.% PE in AB_1 binder	< 10	7	

Proposal: A grading system must not rely only on one parameter. Currently, only one value of softening point and %ER values by ductility is provided for different PMB grades (S, H, V, and E). For different PMB grades (S, H, V, and E), the corresponding softening point and %ER by ductility should be specified.

Comment 2: The upper limit to G*/sinδ should be specified.

Justification:

In the current standard, only a minimum value for G*/sinδ (1000/2200 Pa, for unaged/RTFO aged) has been specified. It has been observed in commercial PMB samples that the G*/sinδ value reaches as high as 6000/10000 Pa, unaged/RTFO aged.

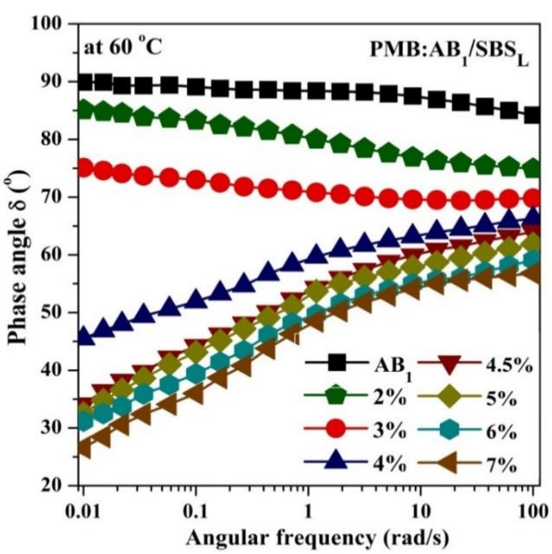
Proposal: The upper limit to G*/sinδ should be specified in the standard.

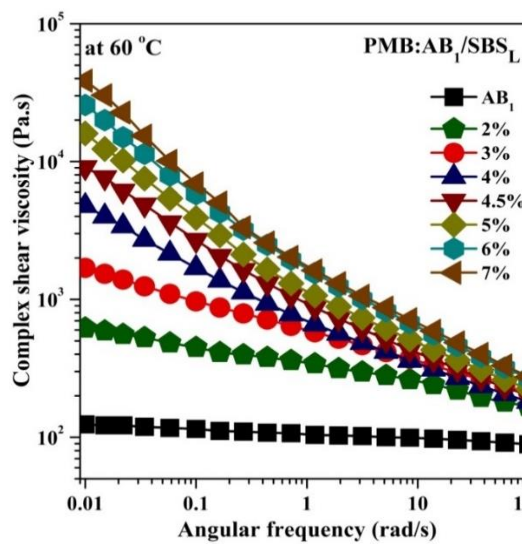
Comment 3: Reduce the angular frequency from 10 rad/s to lower values.

Justification:

In the current standard, G*/sinδ and values are determined at 10 rad/s. Literature studies have indicated that the rheological signature of the polymer molecules in the binder is primarily observed at lower frequencies (≤ 0.1 rad/s). The polymer molecules primarily respond at longer time scales of measurement due to their sluggish dynamics. Hence, the difference among PMBs as a function of polymer content, polymer structure, additives, and short-term aging, increases as frequency decreases. Importantly, the correlation of rheological variables with rut depth improves significantly at frequencies ≤ 1 rad/s. On the other hand, at higher frequencies (≥ 10 rad/s), the brittle-like response from the polystyrene segments and the smaller units of the polymer molecule dominate the rheological signal. Therefore at frequencies ≥ 10 rad/s, the evidence of varying polymer content, polymer structure, additive, and short-term aging was inadequate.

Proposal: Literature studies reveals that the upper service temperature rheological properties of PMBs are better evaluated and quantified at lower frequencies (≤ 1 rad/s). For effective grading, quality control, and good correlation with rut depth, a rheological parameter at a frequency ≤ 1 rad/s is essential in polymer modified binders.





Phase angle vs. angular frequency (ω) at 60 °C for SBS_L-MBs with 2-7 wt.% SBS_L content in AB_1 binder.	Complex shear viscosity vs. angular frequency (ω) at 60 °C for SBS_L-MBs with 2-7 wt.% SBS_L content in AB_1 binder.

- *Materials and Structures, 55, 88, 2022* https://doi.org/10.1617/s11527-022-01922-y
- Radhakrishnan V, Ramya S M, and Sudhakar RK (2018) Evaluation of asphalt binder rutting parameters. Const and Build Mater 173:298–307.

- Shenoy A (2001) Refinement of the Superpave specification parameter for performance grading of asphalt. J of Transp Engin 127:357-362

Comment 4: Specification after PAV ageing has to be reviewed.

Justification:

It has been observed that G*.sin values of PMB samples after PAV ageing rarely fail. Also, the PAV ageing of PMB samples is mostly relevant for subzero temp conditions, which is less relevant in India. Hence, the current parameter needs evaluation.

Best Regards,

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