



Polymer Modified Asphalt Binders

Kenneth R. Wardlaw, Scott Shuler



Polymer Modified Asphalt Binders:

Polymer Modified Asphalt Binders Kenneth R. Wardlaw, Scott Shuler, 1992 ASTM Publication Code Number PCN 04 011080 08 Sponsored by ASTM Committee D 4 on Road and Paving Materials Foreword Includes bibliographical references and indexes Electronic reproduction W Conshohocken Pa ASTM International 2011 Mode of access World Wide Web System requirements Web browser Access may be restricted to users at subscribing institutions *Characterization of Polymer Modified Asphalt Binders Containing Processed Oil* Navid Hemmati, 2023 The current study investigates the impact of processed oil on asphalt binder PG 64 22 and conjugate of it with common modifiers such as Crumbed Rubber Modifier CRM Styrene Isoprene Styrene SIS Styrene Butadiene Styrene SBS and Petroleum Resin PE The binder was tested at different temperatures and different amounts of modifiers and processed oil were added to the binder The modified binders were also aged artificially using different procedures The study found that adding processed oil to polymer modified binders reduces viscosity and improves workability while the modifiers improve the rutting resistance of them however the addition of processed oil reduces the binder's rutting performance due to decrement of viscosity The study also found that the conjugating of modifying polymers and processed oil improves the low temperature cracking resistance The study's results indicate that co-modifying polymer binders with processed oil resulted in a significant reduction in viscosity values resulting in improved workability The results also showed that increasing the processed oil concentration from 6% to 12% caused a viscosity reduction in conjugation of CRM SIS SBS and PE Even though the addition of processed oil results in a reduction in the rutting performance of asphalt binder the addition of polymers significantly improved the rutting resistance of asphalt binders The modified asphalt binders containing 6% and 12% processed oil decreased the G sin values This reduction caused improvement of fatigue cracking resistance of all binders modified with CRM SIS SBS and PE The higher concentration of processed oil means 12% showed greater reduction rate compared to the asphalt binders containing 6% processed oil The BBR results for modified asphalt binders showed that the incorporation of CRM SIS SBS and PE and processed oil improved the low temperature cracking resistance significantly due to the high penetration rate of processed oil in asphalt binders during modification Rapra Review Reports , **SBS Polymer Modified Asphalt Binder and Its Implications on Overlay Design** PC. Hopman, AAA Molenaar, A. Srivastava, 1992 Substantially improved overlay mixes required by the modern road industry should be highly resistant to reflection cracking The mix must contribute significantly to the stiffness of the pavement even when it is applied in relatively thin layers The binder should possess a high softening temperature to reduce the sensitivity for rutting and corrugation and it should have a reasonable penetration value to minimize the chances of cracking In this paper attention is paid to the manner SBS polymer modified asphalt binders cope with this set of requirements The basic principles of this modification are outlined and emphasis is laid on the rheological and mechanical properties viscosity and penetration test results are presented Burgers model for viscoelastic materials is used in an attempt

to describe the visco elasticity Results of indirect tensile tests are reported including the tensile strengths and the elastic moduli Repeated loading tests have been done on polymer modified and plain asphaltic concrete mixes The results are mutually compared concerning fatigue behaviour elastic moduli and crack propagation characteristics The paper describes various trial sections with special attention to comparative tests carried out in an Australian accelerated loading facility

Evaluation of Polymer Modified Asphalt Binders in Hot Mix Asphalt Michael Shane Buchanan,1996 Detection of Polymer Modifiers in Asphalt Binder Stacey D. Diefenderfer,2006 This study addressed the evaluation of alternative test methods to identify the presence of polymer modifiers in performance graded binders for the purpose of quality assurance A method of identification is presented in AASHTO T302 Polymer Content of Polymer Modified Emulsions and Asphalt Binders that uses Fourier transform infrared FTIR spectroscopy to evaluate the constituent elements in binders or emulsions With proper calibration output from FTIR can be used to determine the presence and approximate content of polymers in an asphalt binder AASHTO T301 Elastic Recovery Test of Bituminous Materials by Means of a Ductilometer offers an alternative method to determine the presence of polymer by evaluating the elasticity of the binder Samples of binder were collected from contractor tanks and tested in accordance with AASHTO T301 and AASHTO T302 The performance grade was verified in accordance with AASHTO M320 Test results were evaluated to identify calibration needs test variability and choice of preferred methodologies for adoption into the quality assurance program Results of the study identified the use of either FTIR analysis or elastic recovery as a timesaving alternative to full fledged performance grading in the initial investigation of concerns about the presence of polymer Both methods identified binders containing varying polymer contents with no instances of false positive identification However based on the results of this study neither method is suitable to determine binder grade The investigator recommends that the elastic recovery and FTIR analysis be incorporated as quality assurance tests to verify the presence of polymer in mixtures that specify the use of polymer modified asphalt binders Following this the frequency of quality assurance sampling of polymer modified binders should be increased to ensure that inferior material is not being used in premium mixtures Further AASHTO T301 should be adopted in place of Virginia Test Method 104 for use with unaged binders Incorporating the use of elastic recovery testing and FTIR spectroscopy as alternatives to performance grading will benefit VDOT by allowing increased quality assurance testing of premium asphalt mixtures This will result in minimizing VDOT s risk of acceptance of inferior material and maximizing the benefits of using premium materials Typically performance grading is performed once per month on one binder sample from each active grade of binder in a VDOT district This is estimated to result in testing less than 5% of the binder lots used in any district during a typical month Although neither elastic recovery testing nor FTIR spectroscopy was shown conclusively to determine binder grade almost all PG 76 22 binders shipped into Virginia contain polymer modifiers Thus the detection of the polymer is a first level indicator for quality assurance The potential cost of these tests is approximately 200 per test for elastic recovery and approximately 120 per test

for FTIR spectroscopy Overall the increased testing is expected to result in improved pavement quality by reducing the acceptance of inferior material

Characterisation of Polymer Modified Asphalt Binders for Roads and Airfields IR. Arya, SS. Bose, PK. Jain, 1992 This paper elaborates on the characterisation of styrene butadiene styrene ethyl vinyl acetate low density polyethylene polypropylene wax and hydroxylterminated polybutadiene modified asphalts by penetration temperature sensitivity thermogravimetric analysis penetration ratio cohesion adhesion stability tensile strength and flexural fatigue test The benefits obtained by the modification of asphalt with polymers are improvement in quality of asphalt as defined by increased cohesion adhesion elastic recovery and reduced temperature sensitivity The significant characteristics of polymer modified asphalts are high stability tensile strength stiffness and extended fatigue life The effects of wax in waxy asphalts is reduced by incorporation of polymers

Rheological Properties of Polymer-modified Asphalt Binders J. Kent Newman, Transportation Research Board, 1997

Chemical, Physical, and Thermodynamic Properties of Neat and Polymer Modified Asphalt Binders Lawrence Michael France, 1997

Understanding the Performance of Modified Asphalt Binders in Mixtures Kevin D. Stuart, John S. Youtcheff, 2000 The overall objective of this study was to determine if the Superpave high temperature rheological properties of polymer modified asphalt binders correlate to asphalt mixture rutting resistance An emphasis was placed on evaluating polymer modified asphalt binders with identical or close high temperature performance grades PG s but varied polymer chemistries Eleven asphalt binders were obtained for this study two unmodified asphalt binders an air blown asphalt binder and eight polymer modified asphalt binders High temperature asphalt binder properties were measured by a dynamic shear rheometer DSR Mixture rutting resistance was measured by repeated shear at constant height RSCH and the French Pavement Rutting Tester French PRT The first objective was to verify the findings of a previous study using a different aggregate In the previous study it was found that the Superpave high temperature asphalt binder properties correlated to mixture rutting resistance with few outliers and a change in high temperature PG from 70 to 76 increased rutting resistance However the correlation between RSCH and asphalt binder $G^* \sin \delta$ depended on DSR frequency The data suggested that a low DSR frequency such as 0.1 rad/s might provide a better grading system than the standard DSR frequency of 10.0 rad/s This would require a change in the current asphalt binder specification A diabase aggregate was used in a previous study The data using a second aggregate a limestone aggregate in combination with four of the asphalt binders agreed with the findings from the diabase mixtures The second objective was to retest the diabase mixtures at 70 degrees Celsius using RSCH The test temperatures used in the previous study were 50 degrees Celsius for RSCH and 70 degrees Celsius for the French PRT The polymer modified asphalt binders had continuous high temperature PG s ranging from 71 to 77 Therefore it was recommended that the test temperature for RSCH be increased to 70 degrees Celsius Again the correlation between RSCH and $G^* \sin \delta$ was dependent on DSR frequency The data suggested that a low DSR frequency such as 0.1 rad/s might provide a better grading system However it is not known

whether this finding applies to pavements or is related to the accelerated nature of the RSCH test Furthermore $G^* \sin \delta$ at 0.1 rad/s did not clearly provide a better correlation to RSCH than the high temperature PGs of the asphalt binders The degree of correlation between the French PRT and $G^* \sin \delta$ at 70 degrees Celsius did not depend on DSR frequency and there was only one outlier A correlation between the French PRT and high temperature PG provided no obvious outliers No changes to the specification are recommended based on the French PRT results *Special Polymer Modified Asphalt Cements* Donna S. Harmelink, 1997 This study evaluated and compared the effectiveness of polymer modified asphalt mixes in improving the performance of the roadway in relation to rutting and cracking as compared to our standard mixes without modified binders The addition of various polymers used in this study did not enhance the rut resistance potential of the mix however the addition of the polymer did reduce the amount of transverse and longitudinal cracking to some extent

Evaluation of Polymer Modified Asphalt in Hot Mix Pavements Charles Ifft, 1989 Polymer modified asphalts have recently been the focus of much attention in the U S due to claims that polymer additives will lengthen the life of an asphalt pavement Much of the published research on this topic has been concentrated on the effects of polymer modifiers on binder and mixture properties The goal of this testing is to predict from laboratory testing the actual field performance of an asphalt concrete Over the years specifications have been developed for conventional asphalts that allow pavement performance to be predicted from certain binder tests These conventional binder tests do not fully address the special characteristics of polymer modified asphalt binders and need revision to be an effective tool in predicting pavement service life This paper presents the findings of a two part laboratory research program intended to relate binder and mixture properties of polymer modified asphalts The preliminary testing involved five asphalt binder types and a variety of binder and mixture tests Promising test procedures were further investigated in the final testing program where ten asphalt binders were examined Simple linear regression was used to determine the strength of a relationship between pairs of binder properties and mixture properties The preliminary testing showed penetration toughness and tenacity and force ductility to have the most promise in predicting mixture performance The final testing contained enough data to be analyzed with both simple linear regression and multiple regression Penetration toughness and tenacity force ductility again were the test procedures that had binder properties that correlated well with mixture properties **Development of a Long-term Durability Specification for Polymer**

Modified Asphalt Won Jun Woo, 2010 In recent years an increased use of polymers has occurred to modify asphalt binders mainly to decrease pavement rutting but also to improve binder failure strain in direct tension Whereas all of these effects positively impact the durability of polymermodified pavements a need exists to quantify these improvements and the duration in the presence of oxidative aging This research evaluated the durability of polymer modified asphalt PMA through a number of determinations that included the characterization of the original binder property and pavement aged binder for modified and unmodified binders Changes in styrene butadiene styrene SBS polymer modified binder properties from oxidation were

analyzed using dynamic shear rheometry ductility and force ductility Previous literature reports using size exclusion chromatography showed that degradation of the molecular weight profile of SBS accompanied the loss of PMA ductility Yet base binder embrittlement also occurred as evidenced by ductility and force ductility Testing aged PMA binders at higher temperatures to soften the base binder restored the polymer modulus to the force ductility measurements as did blending with a softer deasphalted oil These measurements indicate that the more significant cause of PMA degradation with aging is base binder embrittlement rather than polymer degradation Sixteen pavements in 11 Texas Districts plus four MnRoad pavements were evaluated in order to obtain a more detailed profile of binder oxidation in pavements Slices of each core provided detail on binder oxidation and air voids The data confirm that binders can oxidize at least several inches into the pavement However oxidation also can be significantly slowed apparently by very low accessible air voids Interestingly the data indicate that the air voids that are relevant to the binder at a specific depth of the pavement are those in the immediate vicinity of the binder low air voids above or below the binder do not seem to significantly affect the binder oxidation rate Furthermore that binders oxidize inches below the surface shows that temperature conducts well into the pavement consistent with a heat conduction model that is used to calculate ground temperatures as a function of depth **Polymer**

Modified Asphalt Durability in Pavements, 2007 The project was designed to develop 1 a better quantitative understanding of the relation between laboratory accelerated binder aging and field aging 2 a test procedure to measure properties of an aged binder that relate to failure on the road and 3 a proposed specification for estimating the relative durability of binders in the presence of oxidative aging Tests were conducted on original base and polymer modified binders laboratory compacted mixtures and pavement aged binders The project necessarily evolved to a more comprehensive approach to improving pavement service life Asphalt Pavements Patrick Lavin, 2003-09-02 Asphalt Pavements provides the know how behind the design production and maintenance of asphalt pavements and parking lots Incorporating the latest technology this book is the first to focus primarily on the design production and maintenance of low volume roads and parking areas Special attention is given to determining the traffic capacity required thickness and asphalt mixture type for parking applications Topics covered include material information such as binder properties testing grading and selection construction information such as mixing plant operation proportioning mixture placement and compaction and design information such as thickness and mixture design methods and guidelines on applying these to highways city streets and parking Areas It is an essential practical guide aimed at those engineers and architects who are not directly involved in the asphalt industry but who nonetheless need to have a good general knowledge of the subject Asphalt Pavements provides a novice with enough information to completely design construct and specify an asphalt pavement **Performance**

Properties of Polymer Modified Asphalt Binders (PMA) Containing Wax Additives Mithil Mazumder, 2016 The study presents an experimental evaluation of the rheological properties of control and polymer modified asphalt PMA binders

containing wax additives and a comprehensive comparison between these two binder types. The control and PMA binders with the additives were produced using two of the available warm asphalt processes i.e. LEADCAP and Sasobit and then artificially short term and long term aged using the rolling thin film oven RTFO and pressure aging vessel PAV procedures. Superpave binder tests were carried out on the binders through the rotational viscometer RV, the dynamic shear rheometer DSR and the bending beam rheometer BBR. In general, the results of this study indicated that 1. the addition of wax additives into the control and PMA binders decreases the viscosity as expected, 2. the reduction in viscosity was quite similar for both the binders with wax additives, 3. the percentage increase of rutting resistance due to the additives was much higher for the control binder compared to the PMA binder, 4. both the control and PMA binders showed the similar trends in terms of fatigue cracking and low temperature cracking behavior after the addition of wax additives.

Design and Construction of Asphalt Concrete Using Polymer Modified Asphalt Binders TS. Shuler, DI. Hanson, RG. McKeen, 1992. A full scale experimental pavement was constructed to compare low temperature cracking performance of asphalt concrete containing two types of styrene block copolymers and an ethylene based polymer each at two levels of concentration in a relatively soft asphalt cement. The experiment was designed to compare field performance with observed behavior in the laboratory.

Installation and Laboratory Evaluation of Alternatives to Conventional Polymer Modification for Asphalt, 2015. The Virginia Department of Transportation (VDOT) specifies polymer modified asphalt binders for certain asphalt mixtures used on high volume high priority routes. These binders must meet performance grade (PG) requirements for a PG 76 22 binder in addition to elastic recovery requirements. This typically results in the use of binders containing styrene butadiene styrene (SBS) modifiers. However, other polymer modifiers may also be used to achieve the PG 76 22 classification. One of these modifiers is a copolymer of SBS and polyethylene (PE). SBS/PE another modifier is ground tire rubber (GTR). This study was undertaken to investigate the suitability of SBS/PE modified PG 76 22 binder and GTR modified PG 76 22 binder for use in Virginia. Each modified binder was used in a 12.5 mm nominal maximum aggregate size mixture to pave approximately 2.3 lane miles. All mixtures were produced as warm mix asphalt using a foaming system. The binders evaluated included a typical SBS polymer modified binder as a control and binders modified with SBS/PE and GTR. During construction, all processes were documented and material was sampled for evaluation. Binder and mixture tests were performed. Binder testing included performance grading and multiple stress creep and relaxation testing. Mixture testing included volumetric analysis, dynamic modulus and flow number tests and cracking, rutting and fatigue analysis. Binder testing indicated that the control binder and SBS/PE modified binders met VDOT specifications for classification as a PG 76 22 binder. The GTR modified binder graded to a PG 70 22 binder as it did not meet the PG 76 22 high temperature specification and did not pass the elastic recovery requirement. Laboratory mixture testing indicated that the performance of the SBS/PE modified mixture should be similar to that of the control mixture. Laboratory test results for the GTR modified mixture were mixed with some indicating that the performance

was similar to that of the control mixture and some indicating that the performance may be less than that of the control. Based on the study, SBS/PE modified binders should continue to be allowed as an alternative to SBS modified binder provided specifications for PG 76-22 binders are met. However, further investigation of GTR modified binders is suggested before recommendations can be made. In addition, long-term evaluation of the field site is recommended for validation of the laboratory findings.

Characterization of Modified Asphalt Binders in Superpave Mix Design Hussain U. Bahia, 2001

Polymer/fiber Modified Asphalt Fracture Mechanisms and Microstructure Relationships to Distresses and Environmental Factors Edward Burton Scott, 1993

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