CAREEREPISODE2 EXPERIMENTALINVESTIC'ATIONON PHYSICALPROPERTIES OF SBS ENHANCEDBITUMENUSINC.ADVANCEDCHARACTERIZATIONMETHODS 1 2.1 Introduction University College 1 Mcation pervisor Degree Email (Supervisor) Year/Semester Subject Department Duration 2J Background 2d.1 Overview Tribhuvan University National College ofEngineering Talchikhel, Lalitpur Insert Bachelor's Degree inCivil Engineering Insert HlfH Transportation Engineering 11 (CE703) Department ofCivil Engineering February 20 17— April 20 17 Bitumen is critical to construction of roads because of its binding and water resistance properties. Bitumen stabilization isa relatively sophisticated method in the improvement process that modifies the engineering properties of soil matrices through the systematic blending of bituminous contents. This technical process has enhanced many aspects of the soil's mechanical characteristics namely the stiffness properties and water resistance by the enhanced binding mechanisms. The stabilization methodology incorporates accurate determination of the quantity of bitumen that is to be added through mixing prcicedures, controlled compaction techniques that lead to development of improved given material characteristics. For its performance and suitability in particular applications several technical tests are conducted. The penetration test for example measures theabilit y of the needle to penetrate through thematerial that is bitumen by chance ofdetermining theextent of its hardness under conditions of standard tests. The softening point test assessesa particular softening state of bitumen, significant for heat resistance. Styrene Butadiene-Styrene (SBS) polymers when used increase the stabilit y of bitumen required when dealing with extreme temperatures and tough traffic conditions. The effects of SBS polymer modification on the characteristics of 40# & 60# asphalt were investigated. The stabilit y theories of bitumen modification and SBS effects as stabilizers were reviewed. Matrix asphalt grades 40#& 60# were selected alongside SBS dosages of0°/c, 3.5°/c, 4°/c, 4.5°/c& 5°/c. Standard penetration tests at varying temperatures between l0°C to25°C were conducted. The softening pnint tests through ring-&-ball method were performed. Ductility measurements at 25°C were carried out. Dynamic Shear Rheological(DSR) tests were executed to evaluate the rusting resistance. Brookfield v'iscosity tests were undertaken at temperatures ranging fromI 30°C toI 85°C. Bending Beam Rheometer(BBR) tests at I 9°C & I 3°C were implemented to assess low-temperature performance. The modified asphalt properties were characterized. 1 2d.2 Ob,jectives The study aim was to evaluate effect of SBS modification on the functioning characteristics of 40# & 60# matrix asphalt for pavement. Other goals were: • To hone thermal stabilit y and deformation resistance of asphalt binders viamodification. • To enhance low-temperature functioning& elasticity of the modified asphalt via BBR test. 2d.3 Nature ofWorks 1 reviewed stability theories of bitumen& modification effects.1 guided theselection of 40# and 60# matrix asphalt grades.1 led the laboratory testing with various modifier dosages ranging from 0°/c to 5°/c.1 performed penetration tests at different temperatures.1 directed the softening point analysis using ring-&-ball method. 1 executed ductility measurements at standard conditions.1 managed DSR testing for rusting resistance evaluation.1 conducted Brcinkfield viscosity measurements across various temperatures.1 oversaw BBR tests for low-temperature performance assessment.1 analyzed the test results for penetration.1 evaluated the outcomes of softening point measurements. 1 assessed the ductility parameters. 1 examined the elastic recovery values.1 interpreted the DSR data.1 dcicumented the viscosity variations& examined theBBR test findings.1 managed team& guided project activities. 1 2J.4 Organizational Chart 2d.5Duties Tribhuvan University National College of Engineering Department ofCivil Engineering Department Head Supervisor 1 BibekE anal (071fBCE/456) (TeamLeader) . I Figure 1: Administrative flow Other members • To review theoretical aspects of bitumen stabilit y & modification effects on binder performance characteristics under varying temperature and traffic conditions. • To select appropriate matrix asphalt grades & modifier dosages ranging for comprehensive evaluation. • To conduct penetration tests on samples using standard ASTM DSprocedures at varied temperatures between l0°C to25°C. • To analyze penetration values, softening points, and elastic recovery measurements for both 40f and 60f matrix asphalt samples. • To perform DSR testing using ASTM D7175for determining rusting factor& B rookfield viscosity measurements at specified temperatures. • To evaluate performance improvements inmatrix asphalt properties with increasing SBS dosages through comprehensive analysis. 2d PEAs 231 1 gotsome information on the necessary theories about bitumen stabilit y and the use of SBS asa stabilizer.1 realized what effect changes in temperature, traffic load, and bitumen aging had on the binder's performance characteristics.1 learned how vital it was to use the right grade of penetration of bitumen and other quality grades whenchorusing the appropriate grade. In order to assess properties of bitumen, different tests that1 underwent incorporated penetration test, softening point test and ductility test.1 lr›nked into the Dynamic Shear Rheological (DSR) test widely used tocapture the abilit y of the bitumen toperform under cyclic stress which is deemed crucial in the long run.1 perceived the essence ofB rookfield Rotary Viscosity Test in order to gain insight of how the bitumen flows at certain temperature level.1 collected information about benefits of SBS asa polymer modifier forimproving elasticity and strength of bitumen. From the formulations,1 understood how bitumen is stabilized and how it reacts to high temperature and traffic loads.1 investigated solubility, flash and fire pnint, and percentage loss on heating that affect safety and quality of the product.1 evaluated the role of these tests and SBS modification in achieving ultimate stabilit y for sustainable road construction projects.1 studied Bending Beam Rheometer (BBR) Test forstiffness. 26.2 1 decided toselect 40# & 60# matrix asphalt for its durability and performance under various stress conditions.1 decided to use SBS as stabilizer to improve elasticity & resistance to deformation.1 picked SBS dosages of 0°/c, 3.5°/c, 4°/c, 4.5°/c,& 5°/c to analyze its impact on asphalt properties.1 chose to conduct penetration tests at 0.15mm to evaluate consistency.1 resolved to measure thesoftening pnint to ensure thermal stability.1 selected ductility tests to assess flexibility.1 suggested DSR tests to analyze viscoelastic behavior.1 decided on viscosity to study flow properties.1 decided on resistance factor determination at temp. of 40°C, 45°C, 50°C, 55°C, 60°C,& 65°C totest temperature susceptibility.1 preferred viscosity evaluation at I 30°C, l35°C, l40°C, l45°C,I 50°C,I 55°C,I 66°C, l72°C, & I 85°C tooptimize mixing and 4 compaction.1 included creep stiffness from BBR test evaluation at-l9°C&- l3°C toassess low temperature performance.1 chose these parameters for precise characterization and enhanced performance evaluation. 2J.3 1 didpenetration test in order to determine the uniformity of 40# & 60# asphalt.1 treated it according tothestandard procedure described in ASTM DS. 3 1 heated theasphalt sample up tothe state where1 had topour it overa standard mold onto which1 shaped it. Then1 Jt it cool down at temp. of25°C foronehour.1 penetrated the samples usinga penetrometer at temperatures of l0°C, l5°C, 20°C,& 25°C witha 1009 needle for5 seconds.1 recorded the penetration in 0.15mm increments, in order to hone inon any differences in the depth of penetration in each subject.1 continued the same forSBS-modified asphalt with dosages of0°/c, 3.5°/c, 4°/c, 4.5°/c & 5°/c.1 undertook the softening point test in accordance with ring-&-ball method as perASTM D36.1 heated the asphalt samples and theplaced on them steel balls in water bath.1 increased the temperature with 5”C/min forheating beaker and waited forthe balls to drop by 25mm andthat was what made theasphalt to soften up.1 carried out the ductility test at 25°C using ASTMD 113 standard. 1 separated asphalt briquettes at a rate of 5cm/min in order to determine their elongation up to the point that these briquettes fractured.1 assessed the aspect of elastic recovery. 23.4 1 conducted penetration tests on 40# asphalt and observed values that varied across temperatures and SBS dosages.1 found that at l0°C, the penetration for 0°/c SBS was I .42849621mm, while for 4°/c SBS, it reduced toI .345159094mm.1 noticed similar trends at higher temperatures, where at 25°C, the penetration for 0°/c SBS was 2.0986882l2mm, and it decreased to I .9II l45658mm for4°/c SBS(table & figure2).1 repeated the penetration tests for 60# asphalt and recorded results.1 observed at l0°C, the penetration for0°/c SBS was I .46653944mm, while for4°/c SBS, it reduced toI .381043257mm.1 found that at 25°C, the penetration values were 2.l96363444mm for0°/c SBS and decreased to 1.845197201 mm for4°/c SBS(table2& figure3).1 measured the softening points and found that matrix asphalt 40# had a softening point of 47.780656l7°C at 0°/c SBS and increased to 60.460I 3869°C at 5°/c SBS.1 noticed for 60#, the softening point rose from 45.877233l7°C at 0°/r to 65.8292132°C at 5°/c SBS(table3& figure4). 1 observed ductility for matrix asphalt 40f at 4°/n SBS as 6.77469141I and matrix asphalt 60f at Table 4: Ductility results SBS(°/) 3.5 4 4.5 5 Matrix Asphalt 40# 5.996475 6.774691 7.551247 5.499553 Figure 5: Illustrate of Ductility comparison Table 5: Table forelastic recovery Matrix Asphalt 40# 39.5921S 45.25302 55.49057 63.07275 Matrix Asphalt 60# 6.574551 7.044109 5.163625 5.804459 Matrix Asphalt 60# 60.10752 63.61156 65.22911 70.3504 2J.5 1 further conducted tests on 60# matrix.1 also used theDSR test to determine therusting factor of the asphalt.1 used theASTM D7175standard methcd.1 prepared samples by melting asphalt and shaping the molten material into discs witha diameter of 25mm. 1 placed samples between parallel plates using the DSR equipment. For my experiments1 carried out oscillatory shear stress at 10 rad/s and tested at high service temperature.1 determined rutting factor (G\*/sink) to assess resistance to deformation.1 followed the ASTMD4402 toconductB rookfield viscosity test. For this study,1 heated the asphalt samples to l30°C,I 35°C, l40°C, l45°C,I 50°C,I 55°C, I 66°C, l72°C andI 85°C then recorded their viscosity. Usinga rotational viscometer,1 was able to find out the amount oftorque needed toturna spindle within the asphalt.1 did the Bending Beam Rheometer (BBR) test at I 9'C and- l3"C based on ASTM D6648 asillustrated below.1 aligned prismatic beams ofvarying thickness and secured them tobe tested for 240seconds. For characterization1 reported creep stiffness. 2J./i 1 found that at 40°C, matrix asphalt exhibited G\*/sink value of 22.75342466, which increased to 38.64383562 at 5°/c SBS dosage from DSR.1 noticed that at 60°C, G\*/sink value decreased to 7.739726027& reached 12.01369863 at 5°/c SBS dosage.1 observed that values consistently increased with higher SBS dosages across all temperatures, indicating improved 3.5°/ of SBS 4 °/ of SBS 4.5 °/ of SBS 5°/ of SBS sßs u mosaic ra » 4 '› Figure S: Vis. Evaluation for60# Table S: BBR test outcomes Temperature (deg C) 130 135 145 155 165 172 185 3.5°/c 1.654375 1.276767 0.911572 0.675404 0.453116 0.499775 0.525547 4°/c 4.935953 3.913271 2.640965 1.556079 1.432797 1.190096 0.915214 4.5°/c 9.131945 7.370755 4.755751 3.355755 2.355092 2.05463 1.436935 12.41S 16 10.09469 6.53295 4.524543 3.422206 2.533365 1.913052 12 I S S '.£ LOSOBO I 4 '. OCOGC 4." XSOBO Figure 9: BBR evaluation 2A Problem and Solution 1 had issue when conducting the sofiening point test was that bitumen samples sofiened at different rate.1 noted that with such variation stabilization couldn't be done. 1 shared this issue with my colleagues and team assumed that the issue is related to the heating- cooling system fluctuation.1 realized that the temperature of the beaker was increasing all the time and1 thought this situation could result in temperature fluctuations.1 explained what1 saw to my team members andwe all noted that this inconsistency could disadvantageously impact on our results. 1 talked to my supervisor asking foradvice regarding the experiments and1 was suggested was that1 needed tocontrol the heating rate.1 then followed instructions very closely and reran the heating setup configuration.1 wondered that to get better result the temperature must be maintained ata reasonable level.1 chose to follow my supervisor's suggestions of keepinga steady heating rate as she or he suggested.1 fine-tuned the apparatus to seta constant heat gradient of 5°C per minute so as to heat the apparatus.1 did the test again and got an identical sofiening point according to which we clarified our data. 2N Creative Works 1 regulated beaker to achieve constant increase of 5°C/minute with help of the apparatus during sofiening point test.1 prepared prismatic beams andthen loaded them fora time period equal to 240 seconds forBBR.1 placed the samples between two parallel plates for testing them inthe DSR equipment. 2.fi Team Management 1 ledteam inorder to ensure that all its members would focus on the tasks of the project and communicate frequently. Before starting every-team meeting,1 had to repnrt to my supervisor on the advancement and possible difficulties occurring at the process.1 also made group meetings in which everyone could express ideas and where the y could come upwith solutions.1 distributed the work on thebasis of individual capabilities so that everyone could work efficiently.1 guided all activities and ensured there was adherence to time toachieve the goals set for each project.1 always tried to cheer my team up when they encountered some problems inthecourse of their work.1 organized meetings to discuss the strategies to enhance them because the y neJed refinement. In order to report progress to the project,1 coordinated with our project guide ona weekly basis to check on the progress of the project and to tackle on any problems that may come across the way.1 also made sure to let everyone knew theadvice issued by our supervisor and ensure there was free flow of communication.1 made sure that this project was well ccinrdinated and helped my team members pursue theproject efficiently. 2 2.7 Codes 1 studied guidelines standardized by lS 1 201 to1 220 (1978) for understanding bitumen test criteria and adhered toASTM standards forconducting tests. 2.8 Summary 2.8.1 The study evaluated effects of stabilization on functioning characteristics of 40# & 60# matrix asphalt for pavement applications. The thorough review was done tounderstand bitumen stabilit y & SBS stabilization effects. Various compositions ranging from 0°/c to 5°/c of stabilizer were systematically tested. Penetration tests at 0.l5mrn depth were performed toevaluate consistency. Softening point tests determined thermal stability. Ductility assessments measured extensibility properties. DSR testing analyzed viscoelastic responses at temperatures between 40°C and 65°C. Brookfield viscosity measurements were taken from l30°C toI 85°C. BBR tests evaluated creep stiffness at- l9°C&-l3°C. The results demonstrated that 60f matrix asphalt exhibited superior performance characteristics. Higher SBS dosages consistently improved rutting resistance. The modification enhanced elastic recovery properties. The optimal stabilizer dosage was identified at 5°/c for balanced performance characteristics.B y SBS stabilization, thermal stabilit y was enhanced, as reflected by the enhanced softening points ofup to 65.82°C. Low-temperature performance was improved asevidenced by BBR tests on-l9°C and I 3°C temperatures. 2.8.2 1 improved my management skills by establishing gocd project schedule.1 boosted interpersonal abilities by updating my supervisors.1 enhanced my decision-making skills by deciding project activities.1 honed team coordination by assigning duties