TechBrief

The Asphalt Pavement Technology Program is an integrated, national effort to improve the long-term performance and cost effectiveness of asphalt pavements. Managed by the Federal Highway Administration through partnerships with State highway agencies, Industry and academia the program's primary goals are to reduce congestion, improve safety, and foster technology innovation. The program was established to develop and implement guidelines, methods, procedures and other tools for use in asphalt pavement materials selection, mixture design, testing, construction and quality control.

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An Alternative Asphalt Binder, Sulfur-Extended Asphalt (SEA)

This Technical Brief provides an overview of the implications of the use of sulfur as a modifier/extender for asphalt concrete mixtures and the relationship to asphalt pavement performance.

Background

In the early 1970s, due to concern over asphalt cement supply issues and an anticipated over abundance of elemental sulfur, many organizations Société Nationale des Pétroles d'Aquitaine (SNPA), Gulf Oil of Canada, Sulfur Development Institute of Canada (SUDIC), Texas Chemical Company, U.S. Bureau of Mines, and the Texas Transportation Institute) began to evaluate the potential for sulfur to substitute for asphalt as a binder extender; this became known as Sulfur-Extended Asphalt (SEA). At the time, it was projected that there would be an abundant amount of sulfur from many sources: pyrite processing into sulfuric acid, natural gas recovery, crude oil refining, coal usage, other chemical processes, and desulfurization from smoke stack emissions. Sixty-eight test sections were constructed between 1975 and 1984; 18 of these were monitored under FHWA Demonstration Project No. 54 (DP54). This was initiated in 1979 and provided design, construction, and evaluation assistance (1). The Demonstration Projects Division organized a task force, with the Sulfur Institute to conduct a comparative performance review of the SEA pavements with that of conventional asphalt concrete (AC) pavement control sections. Twenty-six projects in 18 states were evaluated.

The results of this review indicated that sulfur could potentially be used as an asphalt extender with no significant deleterious effect on performance and durability (2). However, during the 1980's, increasing sulfur prices ended most of the interest in sulfur-extended asphalt (1).

Overview

The SEA mixes included in DP54 were comparable and in some cases out-performed the conventional control counterparts (1). A summary report on the follow-up evaluation stated that the overall performance and susceptibility to distress of the SEA pavements are not significantly different than those of the closely matched, control asphalt concrete (AC) pavement group and the results of this study imply that in most circumstances the use of sulfur as an extender in asphalt paving mixtures should perform in a satisfactory manner, if constructed to proper design (3). In an extensive laboratory study, cores taken from 18 of these projects located in 14 states throughout the US covering various climatic regions were tested for various properties (resilient modulus, creep (rutting resistance), moisture susceptibility, Marshall stability and flow, fatigue, and mixture composition). In general, these laboratory test results support the results of the field study which showed that there was no difference in overall field performance between the SEA and AC sections (4).

Many of the reasons in the 1970's for considering sulfur as an alternative binder source also exist today. Sulfur is currently expected to be in ample supply in the future (5), resulting primarily from tighter pollution abatement controls for gas emissions from power plant stacks, sulfur contents for fuels, and the greater exploitation of "sour" crude oil and natural gas.

What is SEA

Sulfur-extended asphalt has been used in dense-graded mixtures with sulfur/asphalt binder mass ratios from 20/80 to 40/60, and at times even up to 50/50 (3). The emulsified portion of sulfur performs as an asphalt extender while any excess sulfur performs as a mix filler or stabilizer. The allowable sulfur concentration in the binder depends on the properties of the asphalt (6). On a long-term basis, approximately 20 percent of the sulfur remains dissolved and/or dispersed as part of the binder. Free sulfur, above approximately 20 percent by weight, solidifies to a crystalline state (7).

The replacement of asphalt with sulfur is made on an equivalent volume basis, and an accounting for the higher specific gravity of sulfur is needed to maintain existing standards for mix impermeability and durability (6). The following simplified equation can be used to convert a conventional mix design to an equivalent volume of total binder (sulfur and asphalt); this is based on the Bureau of Mines work (8):

$$\textbf{Total Binder mass (\%)} = A \left\{ \frac{100\,R}{100R - P_S\,(R - G_{asphalt})} \right\}$$

Where:

A = Mass % asphalt binder in conventional mix design
R = Sulfur/asphalt specific gravity ratio
P_S = Mass % Sulfur in total "binder"
G = Specific gravity

Example Calculation

Assume that:

Optimum asphalt content is 5.3%
Sulfur:Asphalt mass replacement ratio is 20:80
G_{Sulfur} is 2.00
$G_{Asphalt}$ is 1.03

Therefore: $R = 2.00/1.03 = 1.94$

$$\text{Total Binder mass (\%)} = 5.3\left\{\frac{100\,(1.94)}{100(1.94) - (20)(1.94-1.03)}\right\} = 5.8\%$$

This total binder content is then divided accordingly:

20 x 5.8% = 1.16 % Sulfur
80 x 5.8% = 4.64 % Asphalt

How is SEA Used

SEA has been produced with minimal plant additions and modifications. Various methods such as in-line blending with liquid sulfur, direct feed with liquid sulfur, and direct feed with solid sulfur in pelletized form have been used (1). In the past, in-line blending with liquid sulfur was the most popular method but today solid sulfur may be much easier to handle at the mixing plant.

When hot sulfur paving mixtures are kept below 300°F (149°C), evolved noxious gases and pollutants, including H_2S, SO_2, SO_3, and organic sulfur materials, have been shown to be within safe limits. Therefore, the recommended maximum allowable upper temperature limit for continuous handling of sulfur modified paving materials is 300°F (149°C). Sulfur handling practices already established in the sulfur industry, as well as those common to the hot asphalt concrete community, are believed to provide adequate personnel safety (5). With the ever-growing popularity of warm-mix asphalt (WMA), these lower mixture temperatures are not unusual in current practice. However, SEA production is currently not recommended by suppliers in conjunction with any of the water foaming type of WMA technologies.

The biggest hazard is the storage area for the liquid sulfur and/or the pre-blended sulfur-asphalt blend. However, these areas are not generally accessible to most personnel and restricting access to appropriate personnel is advised (5). Sulfur in solid form is fairly inert, insoluble in water, and not readily dissolved by engine oil, grease, and gasoline (9). When constructing with SEA paving material for the first time, personnel should be given prior instruction on the nature of the material as well as techniques for handling it safely.

Engineering Properties of SEA

Stuart (4) at the FHWA Turner-Fairbank Laboratory, reported in 1990, on cores taken from 18 of the original SEA field projects and the associated AC control sections. He noted some minimal benefit and some potential areas of concern with the SEA. However, there were also some compositional issues with these cores which could explain the less than optimal results. Based on indirect tensile (IDT) resilient modulus (M_r) testing at 77°F (25°C), the impact of SEA on modulus was project specific and “sulfur had no effect on temperature susceptibility”. Based on IDT incremental creep testing, the impact of SEA on permanent deformation was project specific and “usually relatively better at 77°F (25°C) compared to 41°F (5°C)”. Overall, sulfur had little effect on creep moduli; but, there may be an overall trend for the SEA sections to have lower permanent deformations. Based on ASTM D 4867 moisture susceptibility testing (using tensile strength ratio, TSR, and resilient modulus ratio, M_rR) at the varying core air voids, “sulfur decreased both ratios”. Based on the visual observations of stripping, it was concluded that the lower ratios were related to a loss of cohesion rather than a loss of adhesion. The SEA binders were weakened by the conditioning processes. Sulfur decreased both the dry and wet tensile strengths but did not lead to visual stripping. Wet strengths were more affected than dry strengths and sulfur increased the dry M_r of the soft mixtures. Based on stress-controlled IDT fatigue testing conducted at 77°F (25°C), “when considering all projects, sulfur decreased the fatigue life”.

Stuart (4) also noted some possible reasons why many of these measured properties were poorer than expected. When considering all projects, sulfur increased the percent air void level, which could have contributed to the increased moisture susceptibility of SEA mixtures. The SEA binders in approximately 17 of the 29 field projects were designed on an equal volume of total binder (sulfur + asphalt) basis; however, the method of sulfur substitution in the mix design “was not consistent”. In most projects, the sulfur was simply substituted by mass for asphalt and the same design for the asphalt control mixture was used; with the higher specific gravity of sulfur, this would lead to drier mixes. The percent total sulfur by total binder weight was obtained by high temperature combustion and an IR absorption detector (ASTM D 4239). Most projects contained less sulfur than intended and some were significantly low in sulfur content. Some of the sulfur contents were so low compared to the target values that they were obviously deficient.

Regarding fatigue life, the fatigue curve of SEA mixtures typically indicate less cycles to failure at equal high strain values compared with similar AC mixtures; however, the level of strain occurring in the pavement used to determine pavement life from the fatigue curve tends to be lower because of the higher modulus of SEA mixtures, resulting in longer life overall. As Deme (6) points out, lower flexibility can be tolerated in SEA materials as the tensile stresses and strains developed at the underside of the pavement are lower than for an AC pavement of equivalent thickness and subjected to the same loading. Kennedy, et.al. (10) also found that flexibility should not be confused with fatigue resistance, which reduces the ability of a pavement to sustain repeated bending. This has been found to be satisfactory for a moderate range of sulfur-extended binder formulations. If required for certain applications, fatigue resistance, flexibility, and fracture resistance of SEA mixtures can be improved using higher binder contents and softer binder grades because these mixtures are also typically stiffer and more resistant to rutting.

The National Center for Asphalt Technology (NCAT) recently completed a study (11) of a standard 19 mm test track mixture made with various SEA mixtures. This investigated alternative base asphalt binder grades (PG 67-22 and PG 58-28), percent sulfur (30 and 40 percent of total binder), and total binder contents (mix designed at 3.5 and 2 percent air voids). Figure 1 shows an example comparison of the dynamic modulus (E*) measured with the Asphalt Mixture Performance Tester (AMPT) for these various sulfur mixtures at a frequency of 10 Hz and a temperature of 70°F (21°C) along with two control mixes designed at 4 percent air voids. The figure also illustrates the effect of curing time (14 days), during which the un-dissolved sulfur can crystallize in the matrix of the mixture and enhance E*. As shown, specific desired properties can be achieved by adjusting the binder content, base asphalt grade, and sulfur content in the mix design. NCAT and others observed that the addition of sulfur had no tangible impact on the low temperature cracking behavior; these properties are controlled by the asphalt binder. Figure 2 illustrates the potential for improvement in rutting resistance that can be achieved with SEA mixes relative to conventional mixes, based on flow number (F_N) measured in the AMPT with a deviator stress of 70 psi (480 kPa) and no confining stress. Finally, Figure 3 shows a comparison of fatigue curves measured for six of the NCAT mixtures. It is readily apparent that the asphalt binder grade and sulfur content can have a significant difference in fatigue behavior; in this case, the sulfur mixture made with PG 58-28 asphalt binder and 30 percent sulfur designed at 3.5 percent air voids provided the best curve of the sulfur mixes and even approached the performance indicated in the polymer-modified PG 76-22 control mixture curve.

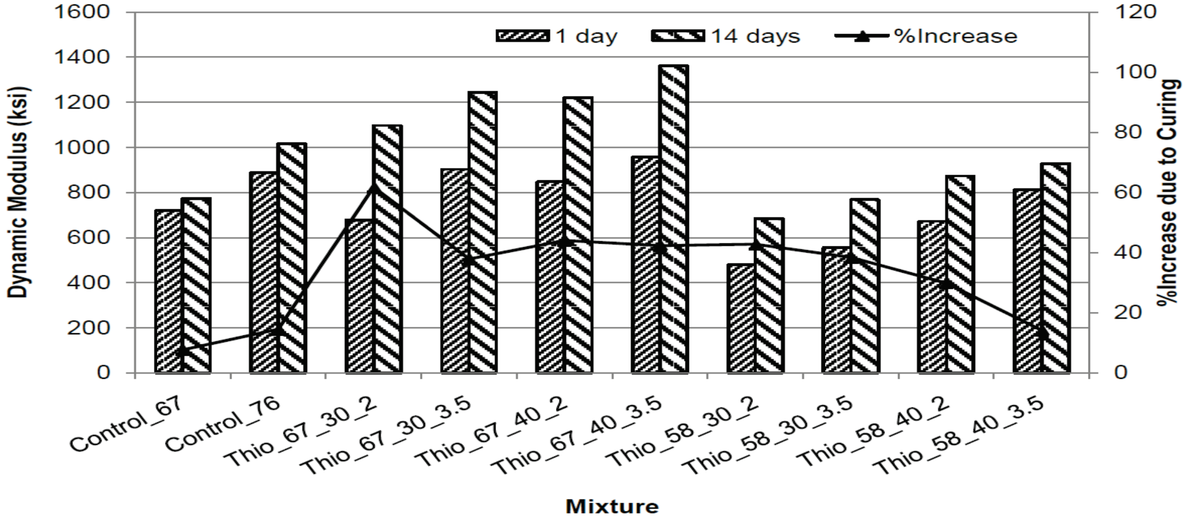

Figure 1: Average E* Results at 10 Hz, 70°F (21°C) for All NCAT Mixtures after 1 and 14 Days.

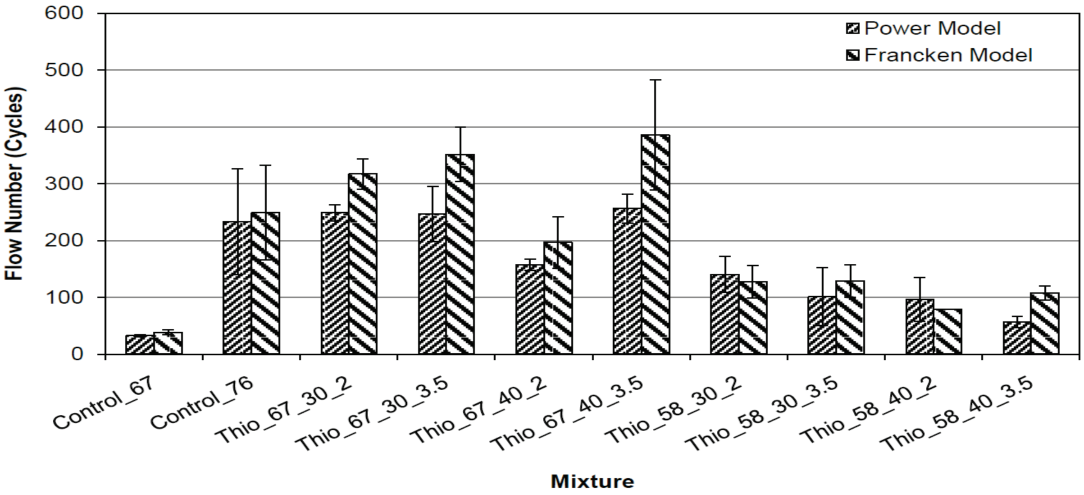

Figure 2: Average F_N Results at 70 psi (480 kPa) for All NCAT Mixtures after 14 Days.

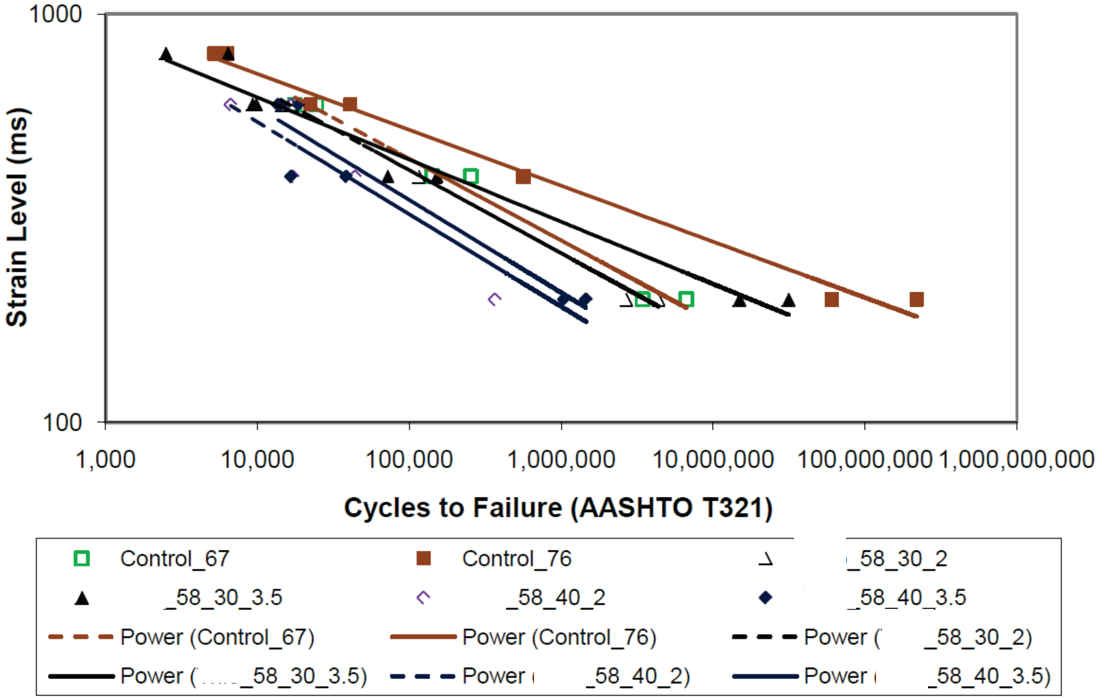

Figure 3: Fatigue Resistance for NCAT PG 58-28 Sulfur Mixtures after 14 Days.

It should also be noted that the moisture susceptibility of the NCAT sulfur mixtures, as measured with the AASHTO T-283 TSR procedure, with a freeze-thaw cycle, were below the desired 0.80 ratio. All of these mixtures, including the controls, incorporated a liquid anti-strip (LAS) agent, which may not have been the correct choice for the sulfur mixes. Later NCAT work has shown through experience that some LAS work better than others (12). To date, visual stripping has not been observed in the lab or on the two SEA mixes placed at the test track. Based on experience, it is strongly recommended that moisture susceptibility be evaluated as part of the mix design process and that an appropriate additive (LAS, lime, or other) be used with marginal mixtures.

Environmental, Health, and Safety

An FHWA sponsored study considered the safety and environmental aspects of storage and handling, formulation, construction, operation and maintenance of highway pavements containing sulfur (9). Airborne fumes and particulate (colloidal) elemental sulfur can be irritating to the eyes and throat but are not currently regulated as an emission health hazard. The primary hazards due to the presence of sulfur in pavement operations and handling situations are gaseous emissions of hydrogen sulfide (H_2S) and sulfur dioxide (SO_2). These primary hazards can usually be gauged in terms of temperature, time-duration under temperature, and dispersion factors. H_2S is the most critical concern as this gas can be readily detected at concentrations as low as 0.02 ppm (parts per million) by its “rotten egg” odor; but, at high concentrations (above 100 ppm) the smell cannot be detected. On the basis of the list of toxicity effects of the American Conference of Governmental Industrial Hygienists (ACGIH), a maximum allowable concentration (MAC) value of 5 ppm is normally specified as the upper threshold limit for continuous exposure to H_2S emissions in areas normally expected to be occupied by construction or plant personnel. In 2010, the ACGIH lowered their H_2S recommended threshold limit value short term exposure limit (TLV-STEL) for 15 minutes to 5 PPM and their TLV time-weighted average (TWA) over an 8-hour shift to 1 PPM. The current Occupational and Safety Health Administration (OSHA) permissible exposure limit (PEL) for TWA over an 8-hour shift for the construction industry is 10 ppm for H_2S.

Sulfur Dioxide (SO_2) is a colorless gas with a pungent odor, which unlike H_2S, gives ample warning of its presence. The MAC of 5 ppm is specified as the upper threshold limit concentration for SO_2 emissions in areas normally expected to be occupied by construction or plant personnel. This same level of SO_2 is the current OSHA PEL for TWA over an 8-hour shift for the construction industry.

Vapor given off during mixing and dumping operations contain a certain amount of un-dissolved elemental sulfur (9). As the vapors come in contact with air and cool, the sulfur vapor crystallizes into small particles which are carried by the wind in a manner similar to dust and fine sands. Since there is no practical way to eliminate these emissions, the effects on both environment and personnel need to be considered. Assessments of the environmental impact of this emission in SEA pavement construction do not exist. The principal problem associated with sulfur dust lies in its contact with eyes. This can be minimized by wearing safety goggles while working in close proximity (2 feet (0.6 meter)) to the paver hopper. Relatively little data is available regarding particulate sulfur and efforts to establish amounts of sulfur dust may be interfered with by asphalt fumes, showing a misleadingly high amount of particulates (13).

Concentrations of H_2S and SO_2 emitted in drawn air samples during the laboratory preparation of seven mix designs at 250°F, 300°F, and 350°F were measured (9). Both H_2S and SO_2 emissions increased with temperature and the rate of evolution increased greatly beyond 300°F, exceeding MAC values. Producing and paving at the lowest practical temperatures will reduce the potential of any adverse impact. In addition, storage time of hot sulfur-asphalt mixes in silos should be limited to a maximum of four hours. Overnight silo storage is not advised. Today, the emissions of H_2S are further diminished by the use of degassed sulfur in the pelletized solid form. “Degassed” sulfur is sulfur that has been processed to remove most of the H_2S that is entrained within the elemental sulfur.

Weathering of in-service pavements by naturally occurring conditions, as assessed by simulated laboratory and relatively short term outdoor exposure studies (including UV-light, freeze-thaw cycles, tire interaction, spills, and soil microbial activity) (9), showed no measurable impact on the environment. Although the SEA pavement surface would not readily ignite, in direct flame burn tests, black smoke and H_2S and SO_2 gases evolved while in direct contact with the flame; however, six seconds after the flame was removed, the smoke abated, the gases reduced to trace levels after 10 seconds, and the material self-extinguished. To simulate the impact of contaminated spills, saturated NaCl leach solution tests were conducted and it was concluded that the brine of saturated deicing salts would have a minimal impact on run-off waters emanating from sulfur-asphalt or asphalt pavements.

Practice has shown that personnel working around open ports or sulfur discharge valves of storage tanks for prolonged time periods should be equipped with a respirator. Aside from eye or skin irritation from sulfur dust, discomfort can also arise from odor. The extent of this discomfort is dependent on the specific sensitivity of each person.

Based on limited field studies (9), exposures to SO_2, SO_3, and H_2S are anticipated to be at levels considerably below the maximum allowable concentration (MAC) considered acceptable for continuous exposure during an 8-hour working day (5 ppm, 2 mg/m^3, and 5 ppm, respectively) when mixtures have been produced at less than 300°F. It has been established that the bulk of sulfur released from the construction of sulfur-asphalt pavement materials is inorganic sulfur in free elemental form. Due to its mass, elemental sulfur is usually only transported short distances via wind currents. H_2S, at the concentrations potentially emitted during the paving operation, are reduced with distance by dilution. The environmental impacts on soils, flora, and fauna are diminished by attenuation with distance, absorption, and short duration of exposure during paving.

Several field studies were also evaluated in the FHWA sponsored investigation by the Texas Transportation Institute (9). At the Lufkin and Kenedy County Texas sulfur-asphalt trials, with the exception of the area inside the liquid sulfur storage tank, all H_2S concentrations were well below MAC values (0.2 to 0.5 ppm in the paver area). The Bureau of Mines and the Texas Air Control Board (TACB) did extensive monitoring at the Kenedy County field trials in 1977. Probes were placed at distances which ranged from 1 to 12 inches from the surface of the material for "source data". These distances are much closer than that normally occupied by personnel, which normally range from 2 to 6 feet, the "normal data". As long as the temperature of sulfur-asphalt systems were maintained below a maximum of 300°F, H_2S emissions were found to be well below the suggested MAC value of 5 ppm. Source type emissions appeared to be excessively high; however, in an open-air environment these concentrations are rapidly reduced with distance. The paver screed, without suitable temperature controls, would appear to be the main source of potentially high H_2S and SO_2 emissions.

Evolved gas analyses were carried out at a number of other field trials, including Lufkin, TX (1975); Bryan, TX (1978), Boulder City, NV (1977), and Tucson, AZ (1979) (9). In general, the emissions detected were well within the MAC values and consistent with the anticipated concentrations as reported above. The air currents around the unloading truck and, in turn, around the paver, can carry minute particulates of sulfur even though temperatures of the loads are within the specified limits (13). At the Bryan, TX project, a number of "Hi-Vol" dust collection units were stationed at various locations in the vicinity of the hot-mix plant and at the paving site. These were analyzed in accordance with ASTM E30; the amount of total particulate sulfur present was so minute that it was not deemed to be a hazard even regarding eye irritation (9).

SEA Safety Practices

The second volume of the report prepared by the Texas Transportation Institute discusses methods and equipment for monitoring potential emissions and pollutants and recommends safety practices for the handling of sulfur and sulfur-modified asphalt mixtures and pavements

(13). In general, the equipment used for the preparation and placement of the sulfur-modified pavement mixtures has been the same as those used for asphalt hot-mix. Laboratory measurements of organic emissions under conditions intended to maximize emissions have shown that the amounts are negligible.

Short term exposure samples taken in the breathing zone of the laboratory worker during sample preparation showed peak levels of about 0.2 ppm H_2S and 0.1 ppm SO_2. Ample ventilation in the laboratory will control these exposures adequately. Toxic and explosive quantities of H_2S can collect in the domes of transports and in the domes of tanks containing liquid sulfur. No sparks, smoking, open flames, or welding should be permitted near any opening to a liquid sulfur container (13).

In continuous drum mixing plants, sulfur must be injected at a point downstream, where direct contact with the burner flame is avoided. Dispersion of the emissions after release from the stack prevents exposure of personnel to levels in excess of the maximum allowable concentration from this source, and these stack gases do not constitute a significant exposure to the personnel in the plant. However, monitoring stack emissions to determine compliance with appropriate laws, and installation of appropriate control devices is recommended, as the utilization of sulfur at the plant may raise the concentration of pollutants in the stack.

Care should be taken in maintaining screed temperature control. It is not necessary to excessively heat the screed to obtain good paving results because of the reduced viscosity of the mix obtained with SEA. In addition, higher screed temperatures also increase the level of undesirable emissions (SO_2) (1).

Surface heating of in-place pavement is sometimes employed for the maintenance and rehabilitation of asphalt pavements. Temperatures in excess of 400°F are likely at the pavement surface, indicating that H_2S and SO_2 emissions may be significant, but elevated temperatures are held over a specific pavement spot for only a short time, so H_2S and SO_2 emissions decrease rapidly. Wind and distance from the source will dilute the H_2S and SO_2 concentrations before it can reach the workers' breathing zone (13). Although exposures may be expected to be minimal, these direct heat application methods, used with planning, scarifying, and hot surface recycling, should be avoided with SEA pavement surfaces when possible.

Cold milling, diamond grinding, and grooving of pavement surfaces are being increasingly used. The process of crushing, grinding, or pulverizing may cause sulfur odors and sulfur gases to be present as well as dust particles with trace quantities of sulfur. After dispersion due to wind and distance, H_2S and SO_2 levels should be insignificant. Safety procedures followed in the asphalt industry are recommended (13).

The redesign of driers and drum mixers for the handling of reclaimed asphalt pavement (RAP) have virtually eliminated gaseous emissions from recycle mixes within the plant operations. The worker exposure to H_2S, SO_2, and particulate sulfur is expected to be the same as is common to the asphalt paving operation (hauling and placing), which has been shown to be minimal. Mix temperature in excess of 300°F will result in sharply increased H_2S and SO_2

emissions and should be avoided. Dispersion due to wind and distance from the source keeps H_2S and SO_2 emissions at low levels in the general area (13). However, recycling of SEA RAP at normal hot mix temperatures with superheated virgin aggregate should be avoided because of these increased emissions. Although most of these gases will be mitigated through the dryer drum heating and mixing process, some may escape to the stack or to the immediate area around the plant. Recycling of SEA RAP at warm mix temperatures (275°F ± 10°F) has been shown to result in non-hazardous levels of emissions around the plant and paver. SEA RAP can be easily identified with either a calcium chloride precipitate lab test or a simple blowing heater field test (14).

If issues arise in the field, a representative sample of paving personnel should be monitored to determine exposures. The results of the monitoring can be used to determine the need for additional monitoring and control of exposure with personal protective equipment (PPE).

History of Field SEA Construction Projects

The first SEA project paved on a public roadway was in Lufkin, TX, in 1975. From 1975 to 1984, 67 more test sections were built in 29 different states; the most (18) sections were constructed in 1981 (1). SEA projects were built in every US climatic zone and on all types of highway facility, from farm-to-market roads to interstate highways. Of these, 26 projects were evaluated in the field for pavement condition index (PCI) in 1985, when the projects were 3.2 to 8.9 years old (3). Based on statistical t-test results conducted on the SEA and AC pairs of sections, no significant differences existed between the SEA and the control AC pavement in terms of PCI, cracking deduct value, or rutting deduct value. In addition, it was found that the performance of the SEA pavement was not significantly influenced by the sulfur content of the paving binder. Only one SEA project (I-75 North of Gainesville, FL) was found to be in poor condition and this situation appeared to be the result of severe moisture damage to which the use of SEA was one of several contributory factors. The Johnson County, KS project was eventually dropped from the investigation due to stripping in the base layers of both the SEA and control AC (“more severe”) (4). The Loop 495 Nacogdoches, TX, project was the only reported open-graded friction course made of SEA.

Since 2002, numerous SEA sections have been paved in China, India, and the Middle East using solid sulfur pellets instead of molten sulfur during mixture production. In Canada, trial sections have been paved in British Columbia, Alberta, Ontario, and Quebec.

More recently, in the US, trial sections have been paved in Nevada, California, Missouri, Kansas, Texas, and Alabama. Several 50/50 SEA sections were paved in Clark County, NV between 2001 and 2003. In California, a few 40/60 SEA sections were paved in El Centro from 2001 to 2003 and a very heavy truck traffic 50/50 SEA pavement section was paved in Southgate in 2002; to date this has exhibited only minimal rutting. At the Port of Oakland, three full-depth 40/60 SEA test strips were constructed in 2004; these were evaluated in 2008 using Falling Weight Deflectometer (FWD) testing and laboratory testing of cores (15). Measured deflections were found to be 30 percent lower, backcalculated moduli were 30-50 percent greater (even higher at warmer temperatures), and critical horizontal and vertical strains were 30 percent lower in the SEA sections compared to the adjacent control AC section.

In Missouri on US 71 near Adrian, 15 miles of a 1.75 inch 30/70 SEA overlay was paved in 2009, a 30/70 SEA overlay was paved on a shoulder on Hwy 30 near St. Louis, and approximately 20 miles of a two-lift 30/70 SEA overlay with 15-20 percent RAP was paved in the summer of 2010 near Jasper. In Montgomery County, Kansas, six lane miles of 30/70 SEA overlay 1.5 to 2 inches thick with 15 percent RAP were paved in 2009 near Cherryvale. In Texas, several small projects were paved in 2009: 1.5 miles of 30/70 SEA overlay on a private road in Longview with and without conventional RAP and SEA RAP, an overlay using 40/60 SEA on the US 183 frontage road in Austin, and about a mile of 30/70 SEA frontage road along I-30 in Texarkana.

The National Center for Asphalt Technology (NCAT) operates a test track in Auburn, Alabama. The track is used to evaluate various mixtures and pavement sections for accelerated performance. In July 2009, two full-depth test sections (7 and 9 inches thick) were paved with SEA in the intermediate (40/60) and base (30/70) lifts. These sections endured 10 million equivalent single axle loads (ESALs) and have exhibited minimal rutting and no cracking. In addition, three 1.5 inch thick wearing course (30/70 and 40/60) SEA sections were paved on May 12, 2010 on milled out areas on the curves. With an average of over 40 inches per year of rain in this region, there has been no evidence of moisture damage on any of these SEA sections.

Summary

Much research has already been conducted on SEA design, material properties, construction, and evaluation of performance. There appears to be significant evidence that SEA pavement mixtures provide performance equal to conventional AC mixtures. Although some TSR laboratory testing on marginal mixtures has indicated the potential for moisture susceptibility issues, field projects have not shown stripping to be a concern under real pavement conditions. Evaluating stripping potential as part of the normal mix design process is recommended and should mitigate concern over this type of distress. Although pavement cracking is expected to be a concern in thin pavement high strain applications, in properly-designed pavements, cracking is not expected to be any more of a challenge than with conventional asphalt concrete. Because of the expected advantages in terms of modulus and rutting resistance, SEA mixtures can potentially be designed with softer PG asphalts and higher binder contents to also enhance durability. Industrial hygiene measurements have been made on a few projects, which indicate that with proper precautions, temperature monitoring controls (staying below 300°F (149°C)), and following normal asphalt paving safety standards, current ACGIH recommendations and OSHA environmental regulation threshold limits should not be exceeded for H_2S and SO_2. With the increasing use of WMA, the recommended target plant mixing temperature range for SEA is 275°F ± 10°F (135°C ± 4°C). Although these mixtures will smell differently (which may be noticeable in urban or residential settings) and may cause eye irritation to some during the paving operation, the potential economic benefits in terms of savings in asphalt binder costs, make SEA an alternative paving material worth considering.

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