Commonwealth of Pennsylvania
Department of Transportation

Office of Research and Special Studies

Research Project 79-2

DISCARDED TIRES IN HIGHWAY CONSTRUCTION
(Construction Report)

May 1981

Prepared by:
Dale B. Mellott, P.E.
Materials & Testing Division
Bureau of Contract Quality Control
DISCARDED TIRES IN HIGHWAY CONSTRUCTION

CONSTRUCTION REPORT

by

daLE B. MELLOTT, P.E.
Materials Engineer

Research Project No. 79-2

for

Demonstration Project No. 37

Conducted by
PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF CONTRACT QUALITY CONTROL
MATERIALS AND TESTING DIVISION
MATERIALS EVALUATION GROUP

In Cooperation with
U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

"The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or the policies of the State or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation. The Pennsylvania Department of Transportation does not endorse products, equipment, processes or manufacturers. Trademarks or manufacturers' names appear herein only because they are considered essential to the object of this report."

MAY 1981
This report covers the construction of two stress-absorbing membrane interlayer (SAMI) projects in Pennsylvania. The SAMI material consisted of either an AC-20 or H-1 class asphalt with 33 percent granulated, reclaimed rubber added. Different contractors, using slightly different processes, applied the SAMI at the two sites. Both projects consisted of base repairs, a leveling course, SAMI, and one and one-half inches of ID-2 wearing surface course material. However, on one project an additional two inch layer of ID-2 binder course material was placed directly on the SAMI and beneath the ID-2 wearing surface course material. These projects had control sections that were constructed without SAMI for comparison purposes. These control sections were selected and placed randomly throughout the project.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF METRIC CONVERSION FACTORS</td>
<td>iii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>v</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>vi</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>BACKGROUND</td>
<td>2</td>
</tr>
<tr>
<td>OBJECTIVE</td>
<td>2</td>
</tr>
<tr>
<td>SCOPE</td>
<td>3</td>
</tr>
<tr>
<td>LOCATION</td>
<td>3</td>
</tr>
<tr>
<td>GENERAL INFORMATION</td>
<td>10</td>
</tr>
<tr>
<td>MATERIALS</td>
<td>13</td>
</tr>
<tr>
<td>CONSTRUCTION PROCEDURES</td>
<td>14</td>
</tr>
<tr>
<td>EVALUATION SECTIONS</td>
<td>18</td>
</tr>
<tr>
<td>COST DATA</td>
<td>18</td>
</tr>
<tr>
<td>OBSERVATIONS</td>
<td>19</td>
</tr>
<tr>
<td>DISCUSSIONS</td>
<td>21</td>
</tr>
<tr>
<td>FUTURE EVALUATIONS</td>
<td>22</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>23</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>25</td>
</tr>
<tr>
<td>APPENDIX A SPECIFICATION FOR STRESS-ABSORBING MEMBRANE INTERLAYER (SAMI)</td>
<td>41</td>
</tr>
<tr>
<td>B SPECIFICATION FOR STRESS-ABSORBING MEMBRANE (SAM)</td>
<td>44</td>
</tr>
</tbody>
</table>
### METRIC CONVERSION FACTORS*

<table>
<thead>
<tr>
<th>To Convert from</th>
<th>To</th>
<th>Multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>foot</td>
<td>meter (m)</td>
<td>0.3048</td>
</tr>
<tr>
<td>inch</td>
<td>millimeter (mm)</td>
<td>25.4E</td>
</tr>
<tr>
<td>yard</td>
<td>meter (m)</td>
<td>0.9144</td>
</tr>
<tr>
<td>mile (statute)</td>
<td>kilometer (km)</td>
<td>1.609</td>
</tr>
<tr>
<td><strong>Area</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>square foot</td>
<td>square meter (m²)</td>
<td>0.0929</td>
</tr>
<tr>
<td>square inch</td>
<td>square centimeter (cm²)</td>
<td>6.451</td>
</tr>
<tr>
<td>square yard</td>
<td>square meter (m²)</td>
<td>0.8361</td>
</tr>
<tr>
<td><strong>Volume (Capacity)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cubic foot</td>
<td>cubic meter (m³)</td>
<td>0.02832</td>
</tr>
<tr>
<td>gallon (U.S. liquid)**</td>
<td>cubic meter (m³)</td>
<td>0.003785</td>
</tr>
<tr>
<td>gallon (Can. liquid)**</td>
<td>cubic meter (m³)</td>
<td>0.004546</td>
</tr>
<tr>
<td>ounce (U.S. liquid)</td>
<td>cubic centimeter (cm³)</td>
<td>29.57</td>
</tr>
<tr>
<td><strong>Mass</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ounce-mass (avdp)</td>
<td>gram (g)</td>
<td>28.35</td>
</tr>
<tr>
<td>pound-mass-(avdp)</td>
<td>kilogram (kg)</td>
<td>0.4536</td>
</tr>
<tr>
<td>ton (metric)</td>
<td>kilogram (kg)</td>
<td>1000</td>
</tr>
<tr>
<td>ton (short, 2000 lbm)</td>
<td>kilogram (kg)</td>
<td>907.2</td>
</tr>
<tr>
<td><strong>Mass per Volume</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pound-mass/cubic foot</td>
<td>kilogram/cubic meter (kg/m³)</td>
<td>16.02</td>
</tr>
<tr>
<td>pound-mass/cubic yard</td>
<td>kilogram/cubic meter (kg/m³)</td>
<td>0.5933</td>
</tr>
<tr>
<td>pound-mass/gallon (U.S.)**</td>
<td>kilogram/cubic meter (kg/m³)</td>
<td>119.8</td>
</tr>
<tr>
<td>pound-mass/gallon (Can.)**</td>
<td>kilogram/cubic meter (kg/m³)</td>
<td>99.78</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>deg Celsius (C)</td>
<td>kelvin (K)</td>
<td>( t_k = (t_c + 273.15) )</td>
</tr>
<tr>
<td>deg Fahrenheit (F)</td>
<td>kelvin (K)</td>
<td>( t_k = (t_F + 459.67)/1.8 )</td>
</tr>
<tr>
<td>deg Fahrenheit (F)</td>
<td>deg Celsius (C)</td>
<td>( t_c = (t_F - 32)/1.8 )</td>
</tr>
</tbody>
</table>

*The reference source for information on SI units and more exact conversion factors is "Metric Practice Guide" ASTM E 380.

**One U.S. gallon equals 0.8327 Canadian gallon.
LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Annual Summary of Local Climatological Data</td>
<td>34</td>
</tr>
<tr>
<td>2</td>
<td>Asphalt Cement Data</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>Granulated Rubber Gradations</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>Coarse Aggregate Gradations</td>
<td>36</td>
</tr>
<tr>
<td>5</td>
<td>Field Test Data - SAMI Blending</td>
<td>37</td>
</tr>
<tr>
<td>6</td>
<td>Locations and Dimensions of Evaluation Sections</td>
<td>38</td>
</tr>
<tr>
<td>7</td>
<td>Construction Cost Data</td>
<td>39</td>
</tr>
<tr>
<td>FIGURE</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>1</td>
<td>Location of Project #1 (Centre County)</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Location of Project #1 (Centre County)</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Location of Project #2, Section 303, (Cambria-Indiana Counties)</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>Location of Control Sections, Project #2 Section 303, (Cambria-Indiana Counties)</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>Location of Project #2, Section 305, (Cambria County)</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>Location of Control Sections, Project #2, Section 305, (Cambria County)</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>Typical Section, Project #2, Section 303, (Cambria-Indiana Counties)</td>
<td>11</td>
</tr>
<tr>
<td>8</td>
<td>Typical Section, Project #2, Section 305, (Cambria County)</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>Special Asphalt Distributor (Location #1, Centre County)</td>
<td>28</td>
</tr>
<tr>
<td>10</td>
<td>Completed SAMI (Location #1, Centre County)</td>
<td>28</td>
</tr>
<tr>
<td>11</td>
<td>Before Construction (Location #2, Cambria County)</td>
<td>29</td>
</tr>
<tr>
<td>12</td>
<td>After Preparation (Location #1, Centre County)</td>
<td>29</td>
</tr>
<tr>
<td>13</td>
<td>Placing SAMI (Location #2, Cambria County)</td>
<td>30</td>
</tr>
<tr>
<td>14</td>
<td>Placing Cover Aggregate (Location #2, Cambria County)</td>
<td>30</td>
</tr>
<tr>
<td>15</td>
<td>Completed SAMI (Location #2, Cambria County)</td>
<td>31</td>
</tr>
<tr>
<td>16</td>
<td>Streaking of SAMI (Location #2, Cambria County)</td>
<td>31</td>
</tr>
<tr>
<td>17</td>
<td>Adhesion Variations (Location #2, Cambria County)</td>
<td>32</td>
</tr>
<tr>
<td>18</td>
<td>Rubber-Asphalt (SAMI) Penetrating ID-2 Wearing Surface (Location #2, Cambria County)</td>
<td>32</td>
</tr>
</tbody>
</table>
ABSTRACT

This report covers the construction of two stress-absorbing membrane interlayer (SAMI) projects in Pennsylvania. The SAMI material consisted of either an AC-20 or H-1 class asphalt cement with 33 percent by weight of granulated reclaimed rubber added. Different contractors, using slightly different processes, applied the SAMI at the two projects sites. Both projects consisted of base repairs, a leveling course, SAMI, and one and one-half inches of ID-2 wearing surface course material. However, on one project, an additional two inch layer of ID-2 binder course material was placed directly on the SAMI layer and beneath the ID-2 wearing surface course material. Each project had control sections, without the SAMI, that were randomly selected and constructed for comparison purposes.
INTRODUCTION

Discarded tires have created vast quantities of solid waste that litter the countryside and numerous areas of our cities and towns. This quantity, estimated in excess of two billion tires, is currently increasing by approximately 200 million tires each year (1). Many landfill operators reject the disposal of tires, because the buried tires continually work themselves to the surface. The tires cannot be burned openly because of air pollution; and, if an incinerator is used, extensive pollution controls are required to meet the pollution requirements of smoke and fumes (2).

Researchers at the Texas Transportation Institute have proposed that "highway litter should pay its own way", while the reclaimed rubber industry has expanded this idea and proposed that "the highway system should also assume some of the responsibility of absorbing litter directly generated by its own use" (3).

A considerable amount of work, using reclaimed rubber as an additive to bituminous applications, has been evaluated several times in the past. Its use in bituminous concrete was evaluated under research projects issued by various agencies (2) (4) (5) (6) (7). Its use in hot asphalts for joint sealing and binder material was also covered in several research projects (8) (9) (10) (11).

Ground vulcanized rubber, or reclaimed rubber, is a product obtained by a controlled processing (handled and sorted, with metal and fabric removed) of discarded tires. The reclaimed rubber produced by this process is uniform and contains few of undesirable contaminates (10).
Reclaimed tire rubber has been used in asphalt to create a stress-absorbing membrane interlayer (SAMI) for use between the existing pavement surface and the new overlay material. SAMI has been researched by various states and agencies. Degrees of success with this concept and opinions on the benefits of SAMI vary.

BACKGROUND

Many resurfacing programs are plagued by premature failures caused by fatigue-type cracking, thermal-induced cracking and reflective cracking. This cracking may be minimal or quite extensive and is often the reflected condition of the previous surface. The number of previous overlays, the type of pavement (flexible or rigid), the climatic location, the asphalt properties and percentage of truck traffic can each or cummulatively contribute to a decreased life of the new overlay.

Many methods and materials have been tried to correct this problem; but, to date, none have eliminated the reflective cracking problem and only a few have significantly delayed the inevitable development of cracking.

OBJECTIVE

The purpose of this research study was to evaluate, under actual field conditions, the effectiveness of a rubber-asphalt membrane interlayer (SAMI) in retarding the development of reflective-type cracking in bituminous overlays. The layer of flexible asphalt-rubber material, with a PA #1B (pea gravel) cover aggregate, was placed between the existing pavement and the surface course(s). This layer was proposed to prevent moisture infiltration through the old surface and to limit the ability of the pavement to transmit stress between the separated layers. The performance of the SAMI will be evaluated comparatively with the performance of the designated control section (without stress-absorbing membrane interlayer SAMI).
The construction and performance data from these applications are expected to provide guidance for future work. Primarily, the cost-benefit of the SAMI treatments will be considered when preparing recommendations on additional use of SAMI.

SCOPE

The experimental work consisted of 3½ inches (1½ inches of wearing course and 2 inches of binder course materials) of hot, plant-mixed ID-2 bituminous concrete over a rubber-asphalt membrane placed on a prepared bituminous concrete surface at location 1. Only the 1½ inches of wearing course was placed on the SAMI at location 2. The stress-absorbing membrane interlayer consisted of a blend of 33-1/3 percent by weight of ground reclaimed rubber in H-1 asphalt at location 1 and 25 percent by weight of ground reclaimed rubber in AC-20 at location 2. Both applications were made at the rate of 0.60 gallons per square yard and covered with PA #1B crushed limestone aggregate.

LOCATION

The experimental projects were located as follows:

Location 1 (See Figures 1 & 2)

Engineering District 2-0, Centre County
LR 307, TR 322, Stations 545+00 to 680+00
Square Yards: 35,573
Type of Work: Base repairs as required, stress-absorbing membrane interlayer, 1½ inches ID-2 wearing surface course and 23,733 square yards of ID-2 binder (2" thickness) on selected areas. Some areas with leveling course only.

Control Sections: Stations 575+00 to 570+00, WB
595+00 to 590+00, WB
660+00 to 665+00, EB

Total square yards of experimental SAMI section: 26,871
FIGURE 1: PROJECT LOCATION

FIGURE 2: PROJECT LOCATION
Location 2 (See Figures 3 & 5)

Engineering Districts 9-0 and 10-0: Cambria and Indiana Counties
LR 314, TR 22

Section 303, Indiana and Cambria Counties
Stations 188+50 to 200+44 Bk., Indiana Co.
Stations 0+00 to 49+00, Cambria Co.

Section 305, Stations 204+75 to 235+25, Cambria Co.

Square Yards: 23,886
Type of Work: Base repairs as required, leveling course, stress-absorbing membrane interlayer, and \( \frac{1}{2} \) inches of ID-2 wearing surface course

Control Sections: (See Figures 4 & 6)

Indiana County
Station 188+50 to 198+50, EB
Station 195+20 to 188+50, WB

Cambria County
Stations 3+00 to 13+00, Both lanes
Stations 47+30 to 37+30, WB
Stations 205+25 to 212+75, EB
Stations 234+75 to 227+25, WB

Total Square yards experimental SAMI section: 15,793
FIGURE 3: PROJECT LOCATION (CAMBRIA-INDIANA 303)
FIGURE 4: CONTROL SECTIONS (303)
FIGURE 5: PROJECT LOCATION (CAMBRIA 305)
NOT TO SCALE

FIGURE 6: CONTROL SECTIONS (305)

LIMIT OF WORK
Sta. 204+75 (S.L.D.)
L.R. 314, Sec. 305
Jackson Twp., Cambria Co.

LIMIT OF WORK
Sta. 235+25 (S.L.D.)
L.R. 314, Sec. 305
Jackson Twp., Cambria Co.

NOTE: DO NOT PLACE STRESS ABSORBING MEMBRANE-INTERLAYER ON THE CONTROL SECTIONS.
GENERAL INFORMATION

Both locations are Federal Aid Primary Rural routes that are two lane highways. No relocation or reconstructions have been made since the original construction in the 1930's. Subsurface soil types were not verified in the field; however, according to the geological map of Pennsylvania, both projects are basically located in weathering shales.

Various resurfacings have been made to the original reinforced concrete pavement, tapered bottom (9"-7"-9"), placed on location 1 (Centre County) project in 1932. The last resurfacing was 2½ inches of ID-2 placed in 1962.

Various resurfacings have also been made to the original 9-inch, reinforced concrete pavement placed on location 2 (Cambria County) in 1939 and 1936. The last resurfacing on Section 303, (Station 188+50, Indiana County to Station 49+0, Cambria County) was 1½ inches of ID-2 binder and 1-inch of FJ-1 wearing surface placed in 1965. The last resurfacing on Section 305, Stations 204+75 to 235+25, Cambria County, was 2½ inches of ID-2 in 1960. (See Figures 7 and 8).
TYPICAL SECTION
L.R. 314 Sec. 303 (T.R. 22)
CAMBRIA CO. & INDIANA CO.

CROWN OF EXISTING PAVEMENT OR RATE OF SUPERELEVATION

24'-0"

BIT. WEARING CRSE. ID-2

1/2" DEPTH SRL-E

BIT. LEVELING CRSE.

0.06 FT./FT.

EXIST. CONC.

EXIST. SURF. & BINDER

STRESS ABSORBING MEMBRANE INTER-LAYER

(SEE SKETCH FOR LOCATION OF CONTROL SECTION)

WHEEL RUTS

(Bit. Scratch CRSE.)

EXIST. CR.

AGGR. BASE

PAVED SHLDR. TYPE-7

(COMPOSITION-A, 2-3/4" DEPTH)

EXIST. SHLDR. & SLOPE

EXIST. CR. AGGR. BASE

Paved SHLDR. Type-7

(COMPOSITION-A, 2-3/4" DEPTH)

ACTUAL PAVING LIMITS:

(INDIANA CO.) Sta. 188+25 to Sta. 200+44 Bk.

(CAMBRIA CO.) Sta. 0+00 Ahd. to Sta. 47+55

No Scale

STA. 188+25 to STA. 188+50 See Attached Drawings

STA. 47+30 to STA. 47+55 For Paving Notch

PLACE TYPE-6 PAVED SHOULDERS (Avg. Width 7')

STA. 188+25 to STA. 200+44 Bk. (6" Depth)

NOTE: ALL STATIONS ARE S.L.D STATIONS

* SUPERELEVATION

GREATER THAN .05 FT./FT.

S.E.

.02 FT./FT.

PAVEMENT

SHOULDER

* For Super elevation under 0.05 FT./FT. Eliminate the 4' Rounding and use the 0.02 FT./FT. Slope on the Shoulder, Beginning From the edge of the Pavement.

* The Shoulder on the Low Side of a Super elevated Section should be sloped at the same Rate as the Pavement, when the Rate of Pavement Slope exceeds the Required Shoulder Slope of 0.06 ft./ft.

SHOULDER Rounding on High Side of super-elevated Curves

STA. 15+80 to STA. 18+07 (RT. Side)

STA. 16+00 to STA. 18+07 (LT. Side)

NO SCALE

FIGURE 7: TYPICAL SECTION

No Scale
TYPICAL SECTION
L.R. 314 Sec. 305 (T.R. 22)
CAMBRIA CO.

ACTUAL PAVING LIMITS: S.L.D. Sta. 205+00 to S.L.D. Sta. 235+00

STA. 205+00 to STA. 205+25 See Attached Drawings
STA. 234+75 to STA. 235+00 For Paving Notch

PLACE TYPE-6 PAVED SHOULDERS (6' to 8' Width)
STA. 226+00 to STA. 235+00 (6' Depth)

NOTE: ALL STATIONS ARE S.L.D. STATIONS

No Scale

SHOULDER Rounding ON HIGH SIDE
OF SUPERELEVATED CURVES

FIGURE 8: TYPICAL SECTION
Climatological data, as recorded by the National Atmospheric Administration (NOAA) weather station at State College, Pennsylvania is presented in Table 1 for location 1 (Centre County). The weather station at the Ebensburg Sewage Plant in Ebensburg, Pennsylvania is presented in Table 1 for location 2 (Cambria County).

The average number of annual freeze-thaw cycles through the various pavement layers for location 1 is: 59 (surface), 22 (base), 1 (sub-base), and 1 (subgrade). The actual maximum frost penetration is 60 inches below the pavement surface.

The average number of annual freeze-thaw cycles for location 2 is: 55 (surface), 18 (base), 3 (subbase), and 1 (subgrade). The actual maximum frost penetration is 54 inches below the pavement surface. Freeze-thaw data and frost penetration data were obtained for the period 1970 through 1978 and are included in the published report FHWA-PA-RD-68-30, "Frost Action Effects on Pavement - Vols. 1 and 2" - May 1979.

MATERIALS

Approximately 42,664 square yards of the stress-absorbing membrane interlayer was applied to the prepared roadway surface as specified at the two project locations. The following materials were used for the stress-absorbing membrane interlayer:

(a) **Asphalt Cement.** The asphalt cement was specified to be either Class H-1 or Class AC-5. Class H-1 was used for the Centre County location, but Class AC-20cc was used for the Cambria-Indiana Counties location. Laboratory test results are recorded in Table 2.

(b) **Granulated Rubber.** The granulated rubber for the Centre County project was supplied by the Centrex Corporation, Finlay, Ohio. The granulated rubber for the Cambria-Indiana County project was supplied by
U.S. Rubber Reclaiming Co., Inc., Vicksburg, Mississippi. Specifications and laboratory test results are recorded in Table 3.

(c) Coarse Aggregate. The specification and test results are presented in Table 4. Coarse aggregate was a PA #1B (pea gravel) gradation meeting the quality requirements for Type A. Crushed limestone aggregate was used on both projects.

CONSTRUCTION PROCEDURE

Prior to the placement of the stress-absorbing membrane interlayer (SAMI), the existing roadway was prepared as specified by the contract. This work included base replacement undercutting and/or base replacement as necessary. The base replacement undercutting involved removal of unstable subbase or subgrade areas encountered during base replacement, and the excavated areas were backfilled with coarse aggregate, PA #2A material, 2-inch top size. Subgrade drains were constructed in those areas where water conditions were encountered. The base replacement was completed using bituminous concrete base course material.

Joint or crack rehabilitation was completed as specified. The existing surface and structures were conditioned by removing all fatty and other unsuitable material from the surface and by removing excess joint sealer and crack filler materials. Open joints and cracks were sealed with Class J-1 bituminous material to within \( \frac{1}{4} \)-inch of the surface of the existing pavement and immediately covered with a light coating of approved dry sand. Open cracks of more than one inch in width were filled with a suitable fine bituminous concrete mixture. (Figure 12).
Location #1 - (CENTRE COUNTY)

Base repairs were completed as required, and all major transverse cracks were repaired by the base replacement method. Binder course (ID-2, a coarse mixture) and wearing course (FJ-1, a fine mixture) were used for a leveling course as required.

The sequence of work was leveling, placement of the SAMI, binder course and wearing course. Application of the stress-absorbing membrane interlayer (SAMI) began on July 7, 1980 at Station 613+40 and work progressed in a westbound direction to the project limit of work. One distributor load of 14.9 tons and part of the second distributor, approximately 7.5 tons, were used before mechanical problems with the hydraulic system developed and caused the operation to cease. It was raining on the following day so further applications were suspended until July 9th. The remaining stress-absorbing membrane interlayer was placed on July 9th to complete all sections of the project. The total usage on July 9th was 36.5 tons for a project total of 58.9 tons of blended asphalt and rubber. On Monday, July 7th, 5,973 gallons were used for an average coverage of 0.61 gallons per square yard; and on July 9th, 9,733 gallons were used for an average coverage of 0.57 gallons per square yard.

The blending of the asphalt and rubber was accomplished using a specially constructed small volume blender developed and fabricated by the sub-contractor. This blender was a separate piece of equipment which could produce quantities of approximately 200 gallons or work as a continuous mixing operation. The asphalt cement was pumped directly to the mixing chamber which resembled a small pugmill type mixer. A separate bin, with an auger system for charging the granulated rubber, was located...
above the mixing chamber. The asphalt cement was metered, causing the required amount of granulated rubber to be added. The blended asphalt-rubber mixture was then pumped directly to the waiting distributor where mixing and heating were continued by the distributor until the full batch was obtained. The on-site technician sampled the asphalt-rubber mixture to determine the present viscosity before adding the required diluent, AMSCO 140 solvent, supplied by Union Oil Company of California. This sampling was completed periodically until the desired viscosity (centipoises) of between 8,000 and 9,000 was obtained by using a portable viscometer. This data is shown in Table 5. The material was then transported to the project site for application.

The application of rubber-asphalt mixture was made using specially designed distributors with high pressure spray bars to obtain the specified rate of 0.60 gallons per square yard (Figure 9). A chip spreader followed immediately behind the asphalt distributor and placed the coarse aggregate (PA #1B, ½" nominal size) at a rate of 35-40 pounds per square yard. Two pneumatic-tire rollers that were capable of exerting 100 pounds per square inch were used to compact or "set" the aggregate in the hot rubber mixture. Rolling was continued until four coverages were completed (Figure 10). The completed layer was broomed the following day and again just prior to placing the hot plant mix bituminous material (binder course).

All transverse joints in the SAMI were made by placing building paper over the end of the previous application and then starting the new application on the paper covering a small portion of the exposed previous application. All longitudinal joints were lapped approximately four inches.
A two-inch layer of ID-2 binder material was placed as specified directly on the stress-absorbing membrane interlayer (SAMI) followed by the one and one-half inch thick ID-2 wearing surface course.

Location #2 (CAMBRIA-INDIANA COUNTY)

Base repairs were completed, and all major transverse cracks were repaired as required. A leveling course of ID-2 wearing was placed immediately on the old surface (see Figures 11 and 12). Application of the stress-absorbing membrane interlayer began on May 15th at Station 212+75 and progressed eastbound (Figure 13). All the programmed SAMI material was placed in Section 305, Stations 212+75 to 234+75 EB and 205+25 to 227+25 WB. The sub-contractor then moved to Section 303 and placed additional SAMI from Stations 47+30 to 28+50 EB and 37+30 to 13+00 WB. The remaining SAMI programmed for Section 303 was placed on May 16th from Stations 28+50 to 13+00 EB, 3+00 to 198+50 EB, and 3+00 to 195+20 WB. A total of 2,540 gallons of SAMI material was placed on Section 305, for a coverage of 0.64 gallons per square yard. Section 303 used a total of 7,245 gallons of SAMI material for an average coverage of 0.63 gallons per square yard. The blending of the asphalt and rubber was completed by heating the asphalt in the distributor to the required relatively high temperature of 390 F. The calculated quantity of rubber was then added slowly through the open top hatch and continuously mixed with the asphalt until the proper consistency was obtained. The heated material was then transported to the work site and applied using the specially designed distributors with high pressure spray bars to obtain the specified rate of 0.60 gallons per square yard. A chip spreader followed immediately behind the asphalt distributor and placed the coarse aggregate (PA #1B) at a rate of 35-40 pounds per square yard (Figure 14). Two pneumatic tired
rollers; one a nine-wheel exerting 5,011 pounds per wheel and the other a
seven-wheel exerting 5,714 pounds per wheel and both capable of exerting
100 pounds per square inch; were used to compact or "set" the aggregate
in the hot rubber mixture. Rolling was continued until four coverages
were completed. The compacted layer was allowed to cool before being
broomed to remove any loose material. The section was then opened
to traffic.

All transverse joints in the SAMI were made by placing building
paper over the end of the previous application and then starting the new
application on the paper covering a small portion of the exposed, previous
application. All longitudinal joints were lapped approximately four inches.
The pavement section was then completed using a one and one-half inch
thick layer of ID-2 wearing surface course material placed directly on the
SAMI.

**EVALUATION SECTIONS**

Prior to construction, three sections in the SAMI were randomly
located throughout the Centre County (location 1), and five evaluation
sections were randomly located throughout the Cambria-Indiana County pro-
ject (location 2). The condition of the old wearing surface was recorded
and photographed in each of these sections and will be used for comparative
purposes in evaluating the performance of the stress-absorbing membrane
interlayer. The limits of each section were established using permanent
markings. All sections except one were located to allow side-by-side
comparisons of treated versus untreated pavement. The control sections
(untreated) were as designated in Figures 4 and 6 and as listed in Table 6.

**COST DATA**

Both projects were completed as part of normal construction
contract bids. Project location 1 (Centre County) was constructed by
D. E. Smith, Inc., of Mifflintown, Pennsylvania, as the prime contractor and Sahuaro Petroleum and Asphalt Co., Phoenix, Arizona was the sub-contractor. Table 7 lists the construction cost data.

Project location 2 (Cambria-Indiana Counties) was constructed by Grannas Brothers Contracting Co., Inc. of Hollidaysburg, Pennsylvania, as the prime contractor and Arizona Refining Company, Phoenix, Arizona, was the sub-contractor.

**OBSERVATIONS**

**Location #1 - CENTRE COUNTY**

The blending of the asphalt and rubber was accomplished without incident. The specially designed blender made the combination of the asphalt and rubber much more efficient and required much less time to introduce the rubber. There appeared to be more control of the mixing with this method as opposed to the method used on location 2. Safety was improved significantly because this method did not require the higher blending temperatures and did not expose personnel to the "burping" or splashing of hot asphalt that existed when the rubber was blended directly in the distributor. This "burping" or splashing occurred when moisture, contained in the granulated rubber, formed steam bubbles in the hot asphalt. The application of the rubber-asphalt mixture was significantly improved over the location 2 application by this method of pre-blending and placement at a lower temperature. The "set-time" of the asphalt-rubber mixture was increased significantly because this method allowed the sprayed material to remain "tacky" longer. The cover aggregate was readily accepted into the asphalt-rubber membrane even 5 to 10 minutes after its placement. This improved ability of the membrane to accept and hold the cover aggregate was due to the use of the softer H-1 asphalt that was viscosity adjusted.
and the more homogenous rubber-asphalt mix from the portable "pug-mill" type blender. This section of SAMI was opened to traffic for a period of four days before it was covered with ID-2 binder course material. No loss of cover aggregate was noted during the period.

**Location #2 - CAMBRIA-INDIANA COUNTY**

The blending of the asphalt and rubber was completed satisfactorily, although the addition of the granulated rubber through the hatch did expose personnel to the "burping" or splashing of the hot mixture (385 F). The method was slow, but could have been made more efficient had a conveyor-auger system been used to transport the granulated rubber from ground level to the distributor hatch.

The application of the rubber-asphalt mixture was not completed in a satisfactory manner (Figure 15). Some streaking, caused by inoperative spray nozzles, (Figure 16) occurred. The "set-time" of the SAMI was very short, less than one minute, and numerous problems were encountered where the aggregate did not adhere properly to the rubber-asphalt mixture. The membrane would almost immediately form a surface layer that had little tackiness. This rapid hardening of the membrane was primarily a result of the use of the harder AC-20 asphalt without an extender oil. When the aggregate spreader followed the distributor by more than 100 feet, the aggregate could be readily brushed off the membrane before the rolling operation.

Another construction problem developed when the stress-absorbing membrane interlayer was being covered the following week. The air temperatures were in the low 90's, and the surface temperatures of the SAMI ranged to nearly 130 F. Some areas had lost much of the cover aggregate.
from the abraiding action of the traffic. Consequently, pick-up of the SAMI material on the construction equipment tires (paver and trucks) occurred. This pick-up became excessive and "globs" or large pieces of the SAMI were entrapped in the ID-2 wearing surface material. These "globs" of SAMI were pushed to the surface of the hot ID-2 wearing surface layer when it was compacted (Figure 18). These areas resembled "mushrooms" that were flattened under the roller wheels on the pavement surface. The areas where pick-up of the SAMI occurred lacked the required cover aggregate that did not properly adhere and was abraided away. It was necessary to cool the pavement surface to about 90°F with water and allow it to dry before paving could continue. Paving of the wearing course on the remainder of the SAMI was coordinated with cooler ambient temperatures.

Within a few days after the wearing course was completed, it appeared "flushed" in several areas. This "flushing" was thought to be a result of the SAMI material bleeding through the one and one-half inch thick wearing course. Skid resistance measurements were made on the project within one month after the "flushed" appearance was noted, and no significant difference in the skid measurements were noted between the "flushed" areas and the rest of the project.

**DISCUSSIONS**

Significant differences in the appearance of the SAMI material and construction performance were noted between the two projects:

1. More "smoke" was evident at the nozzles on project location 2 (Cambria-Indiana Counties) because of the required higher application temperatures. It appeared that the rubber was being "melted" in the asphalt. Possibly, some coking of the SAMI occurred at these higher temperatures.

21.
2. The "set-time" of the SAMI was too short on location 2 for practical construction operations. The use of the harder AC-20 asphalt was not acceptable for this application.

3. The cover aggregate was necessary to act as a blotter to allow construction equipment to work on the SAMI and to prevent bleeding of the SAMI into the overlying pavement layers.

4. The portable "pug-mill" type mixer used at location 1 provided better mix control and a more homogeneous mix. The membrane on this job was similar to the texture of whipped cream as opposed to the smooth, glassy surface of the membrane at location 2. Satisfactory adherence of the cover aggregate was achieved on the location 1 site. The use of this portable mixer is recommended for future work. Mixing the rubber directly on the asphalt distributor should be discouraged.

5. No remarkable differences exist to date between the treated and untreated (control) evaluation sections. No cracking has occurred in either the treated or control sections at location 1 (Centre County). A total of five cracks have reflected through the surface course in both the treated and control sections at location 2 (Cambria-Indiana Counties).

FUTURE EVALUATIONS

This project will continue to be evaluated for the three-year period of the FHWA contract. Brief letter-type progress reports will be submitted the first, second, and third years following the completion of the project to present additional information that may be noted.
ACKNOWLEDGEMENTS

This report describes the construction and initial evaluation of the special study, "Discarded Tires in Highway Construction". Financial support for this evaluation has been provided in part by the Federal Highway Administration under Demonstration Project Number 37, "Discarded Tires in Highway Construction".

Construction of the field trials were under the general supervision of the Pennsylvania Department of Transportation, Engineering District 2-0 (Centre County Project): Earnest Karns, District Construction Engineer; Ivan L. Myers, District Materials Engineer; John S. Cumo, Project Engineer; and Mike Zoltoski, Construction Inspector. The general contractor was D. E. Smith, Inc., who placed the cover aggregate and bituminous pavement and the sub-contractor, Sahuarro Petroleum and Asphalt Co., the rubber-asphalt supplier and applicator. The District 9-0 and 10-0, (Cambria and Indiana County projects): were under the general supervision of Steven Pepoy, District Construction Engineer; Charles H. Weidley, District Materials Engineer; Tom Bracken, Project Engineer; William Carter and William Pershing, Construction Inspectors. The general contractor was Grannas Brothers Contracting Company, Inc., who placed the cover aggregate and bituminous pavement and the sub-contractor Arizona Refining Company, the rubber-asphalt supplier and applicator. In addition, the following people are acknowledged for their efforts in making the field trial a successful one: Gary L. Hoffman, D.O.T., Materials Evaluation Engineer, Prithvi S. Kandhal, D.O.T., Bituminous Testing Engineer, H. Richard Basso, D.O.T., Asphalt Research Lab Supervisor; and Karen L. Ford, D.O.T., Materials Testing Division Secretary. Sahuarro Petroleum and Asphalt Co.
was represented by Jim L. Slatten and Arizona Refining Company was represented by William G. Hamlin.
REFERENCES


25.

PHOTOGRAPHS
FIGURE 9: SPECIAL ASPHALT DISTRIBUTOR

FIGURE 10: COMPLETE SAMI
FIGURE 11: BEFORE CONSTRUCTION

FIGURE 12: AFTER PREPARATION
FIGURE 13: PLACING SAMI

FIGURE 14: PLACING COVER AGGREGATE
FIGURE 15: COMPLETED SAMI
(Location #2, Cambria Co.)

FIGURE 16: STREAKING OF SAMI
(Location #2, Cambria Co.)
FIGURE 17: ADHESION VARIATIONS
(Location #2, Cambria Co.)

FIGURE 18: RUBBER-ASPHALT PENETRATING ID-2 WEARING SURFACE
(Location #2, Cambria Co.)
TABLES
### TABLE 1. ANNUAL SUMMARY OF LOCAL CLIMATOLOGICAL DATA

<table>
<thead>
<tr>
<th>YEAR</th>
<th>TEMPERATURE (F)</th>
<th>MINIMUM OF 32°F</th>
<th>PRECIPITATION (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGHEST</td>
<td>LOWEST</td>
<td>LAST SPRING</td>
</tr>
<tr>
<td>1979</td>
<td>93</td>
<td>-10</td>
<td></td>
</tr>
<tr>
<td>1978</td>
<td>92</td>
<td>-2</td>
<td>5-1</td>
</tr>
<tr>
<td>1977</td>
<td>93</td>
<td>-12</td>
<td></td>
</tr>
<tr>
<td>1976</td>
<td>94</td>
<td>-4</td>
<td>4-27</td>
</tr>
<tr>
<td>1975</td>
<td>89</td>
<td>8</td>
<td>4-22</td>
</tr>
</tbody>
</table>

**Location 1 (Centre County)**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>TEMPERATURE (F)</th>
<th>MINIMUM OF 32°F</th>
<th>PRECIPITATION (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>88</td>
<td>-22</td>
<td>6-13</td>
</tr>
<tr>
<td>1978</td>
<td>89</td>
<td>-20</td>
<td>6-14</td>
</tr>
<tr>
<td>1977</td>
<td>92</td>
<td>-20</td>
<td>6-8</td>
</tr>
<tr>
<td>1976</td>
<td>89</td>
<td>-13</td>
<td>5-23</td>
</tr>
<tr>
<td>1975</td>
<td>92</td>
<td>-16</td>
<td>4-23</td>
</tr>
</tbody>
</table>

**Location 2 (Cambria County)**

34.
TABLE 2: ASPHALT CEMENT

**Location 1: Centre County**
Asphalt Type, H-1
Asphalt Producer, Amoco Oil Co., Baltimore, MD
Laboratory No., 80-3210
Affidavit No., A16868
Date Sampled, 7-9-80

<table>
<thead>
<tr>
<th>Sample Date</th>
<th>Affidavit Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration @ 77 F</td>
<td>257</td>
</tr>
<tr>
<td>Absolute Visc., @ 140 F</td>
<td>440</td>
</tr>
<tr>
<td>Kinematic Visc., @ 275 F</td>
<td>188</td>
</tr>
</tbody>
</table>

**Location 2: Cambria-Indiana Counties**
Asphalt Type, AC-20 cc
Asphalt Producer, Ashland Petroleum Co., Floreffe, PA
Laboratory No., 80-0850
Affidavit No., 01849

<table>
<thead>
<tr>
<th>Sample Date</th>
<th>Affidavit Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration @ 77 F</td>
<td>71</td>
</tr>
<tr>
<td>Absolute Visc., @ 140 F</td>
<td>2029</td>
</tr>
<tr>
<td>Kinematic Visc., @ 275 F</td>
<td>459</td>
</tr>
</tbody>
</table>
### TABLE 3: GRANULATED RUBBER GRADATIONS (PERCENT PASSING)

<table>
<thead>
<tr>
<th>SIEVE SIZE</th>
<th>GRADATION SPECIFICATIONS</th>
<th>LOCATION 1 CENTRE COUNTY</th>
<th>LOCATION 2 CAM.-IND. COUNTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>#8</td>
<td>100</td>
<td>#8 100</td>
<td>#8 99.9</td>
</tr>
<tr>
<td>#10</td>
<td>98-100</td>
<td>#16 83</td>
<td>#10 99.2</td>
</tr>
<tr>
<td>#40</td>
<td>0-10</td>
<td>#30 11</td>
<td>#40 43.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#50 2.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>#100 1.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>#200 0.5</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 4: COARSE AGGREGATE GRADATIONS (PERCENT PASSING)

<table>
<thead>
<tr>
<th>SIEVE SIZE</th>
<th>GRADATION SPECIFICATION</th>
<th>LOCATION 1, CENTRE CO.</th>
<th>LOCATION 2, CAM-IND CO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>100</td>
<td>100 100 100 100</td>
<td>100 100</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>75-100</td>
<td>87 94 88 90</td>
<td>81 83</td>
</tr>
<tr>
<td>#4</td>
<td>10-30</td>
<td>12 38* 18 19</td>
<td>12 23</td>
</tr>
<tr>
<td>#8</td>
<td>0-10</td>
<td>2 11* 4 4</td>
<td>1 8</td>
</tr>
<tr>
<td>Loss by Wash #200 max.</td>
<td>2.0 1.8 2.9* 1.5 -1.7 0.5 1.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Excessive
<table>
<thead>
<tr>
<th>Location #1, CENTRE COUNTY</th>
<th>Location #2, CAMBRIA-INDIANA COUNTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>18,750 5,880 133 .239 325 8,500</td>
<td>20,020 5,200 - .206 380 -</td>
</tr>
<tr>
<td>21,750 7,020 310 .244 325 9,000</td>
<td>20,200 5,200 - .205 390 -</td>
</tr>
<tr>
<td>10,500 3,223 122 .235 335 8,500</td>
<td>11,400 3,000 - .208 380 395</td>
</tr>
<tr>
<td>21,750 6,840 154 .239 345 9,000</td>
<td>11,400 3,000 - .208 380 395</td>
</tr>
<tr>
<td>22,500 6,900 135 .235 340 8,000</td>
<td>11,400 3,000 - .208 380 395</td>
</tr>
</tbody>
</table>
TABLE 6: LOCATIONS AND DIMENSIONS OF EVALUATION SECTIONS

<table>
<thead>
<tr>
<th>EVALUATION SECTION</th>
<th>STATIONS</th>
<th>DIMENSIONS (FEET)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCATION #1 (CENTRE COUNTY)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TREATED</td>
<td>570+00 to 575 EB</td>
<td>12 X 500</td>
</tr>
<tr>
<td>UNTREATED</td>
<td>570+00 to 575 EB</td>
<td>12 X 500</td>
</tr>
<tr>
<td>TREATED</td>
<td>590+00 to 595 EB</td>
<td>12 X 500</td>
</tr>
<tr>
<td>UNTREATED</td>
<td>590+00 to 595 WB</td>
<td>12 X 500</td>
</tr>
<tr>
<td>TREATED</td>
<td>660+00 to 665 WB</td>
<td>12 X 500</td>
</tr>
<tr>
<td>UNTREATED</td>
<td>660+00 to 665 EB</td>
<td>12 X 500</td>
</tr>
</tbody>
</table>

<p>| LOCATION #2 (CAMBRIA-INDIANA COUNTY) |                      |                   |
| TREATED           | 195+20 to 198+50 WB | 12 X 230          |
| UNTREATED         | 195+20 to 198+50 EB | 12 X 230          |
| UNTREATED         | 3+00 to 13+00 EB &amp; WB | 24 X 1000   |
| TREATED           | 0+00 to 3+00 EB &amp; WB | 24 X 300          |
| TREATED           | 13+00 to 16+00 EB &amp; WB | 24 X 300   |
| UNTREATED         | 37+30 to 47+30 WB   | 12 X 1000         |
| TREATED           | 37+30 to 47+30 EB   | 12 X 1000         |
| UNTREATED         | 250+25 to 212+75 EB | 12 X 750          |
| TREATED           | 205+25 to 212+75 WB | 12 X 750          |
| UNTREATED         | 227+25 to 234+75 WB | 12 X 750          |
| TREATED           | 227+25 to 234+75 EB | 12 X 750          |</p>
<table>
<thead>
<tr>
<th>ITEM</th>
<th>QUANTITY (SQUARE YARDS)</th>
<th>UNIT PRICE</th>
<th>TOTAL BID PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location #1 (Centre Co.)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stress-absorbing Membrane</td>
<td>26,573</td>
<td>1.65</td>
<td>43,845.45</td>
</tr>
<tr>
<td>Interlayer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Location #2 (Cam.-Ind. Co's)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stress-absorbing Membrane</td>
<td>17,664*</td>
<td>1.95</td>
<td>34,444.80</td>
</tr>
<tr>
<td>Interlayer</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Only 15,793 s.y. completed because of insufficient quantity of granulated rubber.
APPENDIX A: Specifications for SAMI Stress-Absorbing Membrane Interlayer

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
Materials and Testing Division

Specifications for
STRESS ABSORBING MEMBRANE-INTERLAYER

DESCRIPTION

This work shall consist of constructing a stress absorbing membrane between an existing pavement surface and a new bituminous concrete overlay in accordance with these specifications and within reasonably close conformity to the lines shown on the drawings and as specified.

MATERIALS

The materials and their use shall conform to the requirements of Form 408-76, Section 470.

(a) Asphalt Cement. The asphalt cement shall be Class H-1 conforming to the requirements of Bulletin 25 or Class AC 2.5 conforming to AASHTO Designation M 226, Table 2.

(b) Granulated Rubber. The granulated rubber shall be vulcanized, reclaimed tire tread rubber which has been milled to meet the following requirements:

<table>
<thead>
<tr>
<th>Passing Sieve</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>#8</td>
<td>100</td>
</tr>
<tr>
<td>#10</td>
<td>98-100</td>
</tr>
<tr>
<td>#40</td>
<td>0-10</td>
</tr>
</tbody>
</table>

The material shall have a specific gravity of 1.15 ± 0.02 and shall be free of fabric, wire, cord or other contaminating materials except that a maximum of 4 percent of calcium carbonate may be included to prevent the particles from sticking together.

(c) Coarse Aggregate. Coarse aggregate shall be 1B meeting the requirements of 703.3, Type A.

(d) Blending Asphalt-Rubber. The method and equipment for combining the asphalt and rubber shall be so designed and accessible that the percentage, by weight, of each of the two materials can be readily determined. The asphalt and rubber shall be blended before placing in the distributor. A bituminous distributor with circulating pump and internal mixing device will be required to maintain a homogenous blend of the ingredients.
The proportions of the asphalt and the granulated rubber, by weight, shall be 75 percent ± 2 percent asphalt and 25 percent ± 2 percent granulated rubber (granulated rubber amount to equal 33-1/3 percent of asphalt weight). The materials shall be combined as rapidly as possible for such a time and at such a temperature that the consistency of the mix approaches that of a semifluid material. The temperature of the asphalt shall be between 350 and 450 degrees F.

After the mixture has become semifluid, it shall be cut back with Kerosene. The maximum amount of Kerosene used shall not exceed 7-1/2 percent, by volume, of the hot asphalt-rubber composition as required for adjusting the viscosity for spraying or better "wetting" of the cover material. The Kerosene shall have a boiling point of not less than 350 degrees F. and the temperature of the hot asphalt-rubber shall not exceed 350 degrees F. at the time of adding the Kerosene.

CONSTRUCTION REQUIREMENTS

Construction shall conform to the requirements of Form 408-76, Section 470 and the following additional provisions:

(a) Preparation. The existing pavement shall be cleaned of all loose and foreign materials. After cleaning and prior to the application of the membrane seal, the existing pavement surface shall be treated with a tack coat applied by distributor and as specified in Section 460.

(b) Asphalt-Rubber Application. The asphalt-rubber stress-absorbing membrane shall be placed only when the ambient air temperature is above 50 degrees F., the pavement is absolutely dry, and the wind conditions are such that a satisfactory membrane can be achieved.

After reaching the proper consistency, the asphalt-rubber material shall be applied immediately and in no case shall the material be held at a temperature over 330 degrees F. for more than 1-1/2 hours after reaching the proper consistency.

The hot asphalt-rubber mixture shall be applied at a minimum rate of .60 of a gallon per square yard (based on 7-1/2 pounds per hot gallon). The maximum deviation from the specified rate shall not exceed 0.06 gallon per square yard.

All transverse joints shall be made by placing building paper over the end of the previous application, and the joining application shall start on the building paper. Once the application process has progressed beyond the paper, the paper shall be disposed of.

All longitudinal joints shall be lapped approximately four inches.

(c) Cover Material. Cover material shall be clean and free of surface moisture and shall be applied at the rate of 35-40 lbs. per sq. yd. Application of the cover material shall be made as close to the distributor operation as possible to avoid excessive cooling of the asphalt-rubber membrane before the aggregate is placed.
(d) Rolling. The cover material shall be rolled with pneumatic
tired rollers carrying a maximum of 5,000 pounds on each wheel and a mini-
mum air pressure of 100 pounds per square inch in each tire.

Sufficient rollers shall be furnished to cover the width of the
spread with one pass. It is imperative that the first pass be made im-
mediately behind the spreader and if the spreading is stopped for any
reason, the spreader shall be moved ahead so that all cover material
spread may be immediately rolled. The rolling shall continue until four
complete coverages have been made. Final rolling shall be completed with-
in two hours after the application of the cover material.

(e) Removing Loose Cover Material. The power broom used in removing
loose cover material shall be a rotary sweeper type.

Sweeping shall be performed at the beginning of the day following
placement, or at any time when it is required to remove loose cover
material that is detrimental to the membrane or is an inconvenience to
traffic. Additional sweeping may be required just prior to the placement
of the bituminous concrete overlay.

If, because of temperatures or other causes, there is displacement of
the embedded cover material, sweeping shall be discontinued until such
time as there will be a satisfactory retention of cover material. Additional
final sweeping shall be done and all excess cover material removed from
the travel lanes and shoulders prior to the placement of the bituminous con-
crete overlay.

(f) Placement of Overlay. Placement of the overlying asphaltic
concrete shall be completed within 24-hours after placement of the asphalt-
rubber stress-absorbing membrane. At the contractor's option, he may
extend this period to a maximum of seven calendar days, providing he
accepts responsibility for maintaining the integrity of the membrane for
the additional time desired. Any sanding with an approved material,
flushing with water, patching with asphalt-rubber, additional sweeping,
or other means necessary and approved, shall be at the contractor's expense.

METHOD OF MEASUREMENT

This work will be measured in accordance with the method specified
in Section 401.4.

BASIS OF PAYMENT

The Stress Absorbing Membrane-Interlayer will be paid for at the con-
tact unit price per square yard or contract price per ton as specified
in Section 401.5.
APPENDIX B: Specifications for SAM Stress-Absorbing Membrane (Seal Coat Construction)

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION
Materials and Testing Division

Specification for
STRESS ABSORBING MEMBRANE
(Seal Coat Construction)

DESCRIPTION

This work shall consist of constructing a stress absorbing membrane as a seal coat in accordance with these specifications and as specified.

MATERIALS

The materials and their use shall conform to the requirements of Section 470.

(a) Asphalt Cement. The asphalt cement shall be Class H-1 conforming to the requirements of Bulletin No. 25 or Class AC-5 conforming to AASHTO Designation M 226, Table 2.

(b) Granulated Rubber. The granulated rubber shall be vulcanized, reclaimed tire tread rubber which has been milled to meet the following requirements:

<table>
<thead>
<tr>
<th>Passing Sieve</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>#8</td>
<td>100</td>
</tr>
<tr>
<td>#10</td>
<td>98-100</td>
</tr>
<tr>
<td>#40</td>
<td>0-10</td>
</tr>
</tbody>
</table>

The material shall have a specific gravity of 1.15 ± 0.02 and shall be free of fabric, wire, cord or other contaminating materials except that a maximum of 4 percent of calcium carbonate may be included to prevent the particles from sticking together.

(c) Fine Aggregate. Fine aggregate shall meet the requirements of Section 703.2 and shall conform to gradation #1 for BC Sand, Type B of Section 703.1(b).

(d) Coarse Aggregate. Coarse aggregate shall be No. 1B meeting the requirements of Section 703.3, Type A.

Aggregate shall be precoated with 0.5 to 0.75 percent paving grade asphalt.
(e) **Blending Asphalt-Rubber.** A bituminous distributor with circulating pump and internal mixing device will be required to maintain a homogeneous blend of the ingredients. The method and equipment for combining the asphalt and rubber shall be so designed and accessible that the percentage, by weight, of each of the two materials can be readily determined.

The proportions of the asphalt and the granulated rubber, by weight, shall be 75 percent ± 2 percent asphalt and 25 percent ± 2 percent granulated rubber (granulated rubber amount to equal 33-1/3 percent of asphalt weight). The materials shall be combined as rapidly as possible for such a time and at such a temperature that the consistency of the mix approaches that of a semifluid material. The temperature of the asphalt shall be between 350 and 450 degrees F.

After the mixture has become semifluid, it shall be cut back with Kerosene. The maximum amount of Kerosene used shall not exceed 7-1/2 percent, by volume, of the hot asphalt-rubber composition as required for adjusting the viscosity for spraying or better "wetting" of the cover material. The Kerosene shall have a boiling point of not less than 350 F and the temperature of the hot asphalt-rubber shall not exceed 350 F at the time of adding the Kerosene.

If a job delay occurs after the full reaction has taken place, the material may be slowly reheated to an acceptable spraying temperature, but shall not exceed 350 F.

**CONSTRUCTION REQUIREMENTS**

Construction shall conform to the requirements of Section 470 and the following additional provisions:

(a) **Preparation.** The existing pavement shall be cleaned of all loose and foreign materials. After cleaning and prior to the application of the membrane seal, the existing pavement surface shall be treated with a tack coat applied by distributor and as specified in Section 460.

(b) **Application.** The asphalt-rubber stress-absorbing membrane shall be placed only when the ambient air temperature is above 50 F, the pavement is absolutely dry, and the wind conditions are such that a satisfactory membrane can be achieved.

After reaching the proper consistency, the asphalt-rubber material shall be applied immediately and in no case shall the material be held at a temperature over 330 F for more than 1-1/2 hours after reaching the proper consistency.

The hot asphalt-rubber mixture shall be applied at a minimum rate of 0.60 of a gallon per square yard (based on 7-1/2 pounds per hot gallon). The maximum deviation from the specified rate shall not exceed 0.06 gallon per square yard.
Any distributor that produces a streaked or irregular distribution of the material shall be promptly corrected or removed from the project if not corrected.

All transverse joints shall be made by placing building paper over the end of the previous application, and the joining application shall start on the building paper. Once the application process has progressed beyond the paper, the paper shall be disposed of.

Transverse joints created by short stoppages (approximately five minutes or less) such as changing chip or distributor trucks, can be made by holding the chip application short of the end of the asphalt-rubber application approximately 1-1/2 feet. The joining application of asphalt-rubber can then proceed immediately with as little overlap of the previous application as is necessary to insure a continuous binder application.

All longitudinal joints shall be lapped approximately four inches.

(c) Cover Material. Cover material shall be free of surface moisture and shall be applied at the rate of 40 ± 5 lbs. per sq. yard.

(d) Blotter Material (Sand). The blotter material shall be free of surface moisture. Immediately after the initial pass of the rollers, blotter sand shall be uniformly applied at the rate of 5 lbs. per square yard. Additional blotter sand may be required after opening to traffic and sweeping. The additional blotter sand shall be placed at the locations and rates designated by the engineer.

(e) Rolling. The cover material shall be rolled with pneumatic tired rollers carrying a minimum of 5,000 pounds on each wheel and a minimum air pressure of 100 pounds per square inch in each tire. Sufficient rollers shall be furnished to cover the width of the spread with one pass. It is imperative that the first pass be made immediately behind the spreader and if the spreading is stopped for any reason, the spreader shall be moved ahead so that all cover material spread may be immediately rolled. The rolling shall continue until four complete coverages have been made. Final rolling shall be completed within two hours after the application of the cover material.

(f) Removing Loose Cover Material. The power broom used in removing loose cover material shall be a rotary sweeper type.

Sweeping shall be performed at the beginning of the day following placement and be completed not more than 24 hours after the application of the cover material.

If, because of temperatures or other causes, there is displacement of the embedded cover material, sweeping shall be discontinued until such time as there will be a satisfactory retention of cover material. Additional final sweeping shall be done and all excess cover material removed from 3 to 5 days after the roadway has been opened to traffic.
TRAFFIC CONTROL

Except for times when it is necessary that hauling equipment and/or pilot trucks must travel on the newly applied seal coat, traffic of all types shall be kept off the seal coat until it has had time to set properly. The speed of all hauling equipment and pilot trucks shall not exceed 15 miles per hour. The minimum traffic free period shall not be less than two hours.

METHOD OF MEASUREMENT

This work will be measured in accordance with the method specified in Section 401.4.

BASIS OF PAYMENT

The Stress Absorbing Membrane will be paid for at the contract unit price per square yard as specified in Section 401.5.