EXECUTIVE SUMMARY OF INFORMATION COMPILED FROM
INVESTIGATIONS AND DEMONSTRATION PROJECTS PERTAINING TO
THE USE OF GROUND TIRE RUBBER IN HIGHWAY CONSTRUCTION

Submitted to

Florida Department of Transportation

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Engineering & Industrial Experiment Station
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>DOCUMENTATION OF INFORMATION AND DEMONSTRATION PROJECTS</td>
<td>1</td>
</tr>
<tr>
<td>TYPE AND AMOUNT OF GTR IN FRICTION COURSE MIXTURES</td>
<td>6</td>
</tr>
<tr>
<td>BLENDING REQUIREMENTS</td>
<td>7</td>
</tr>
<tr>
<td>EFFECTS ON CONSTRUCTION AND PAVEMENT PERFORMANCE</td>
<td>8</td>
</tr>
<tr>
<td>ESTIMATED GROUND TIRE RUBBER USAGE AND COST IN HIGHWAY APPLICATIONS</td>
<td>8</td>
</tr>
<tr>
<td>DEVELOPMENTAL SPECIFICATIONS FOR ASPHALT-RUBBER HIGHWAY CONSTRUCTION APPLICATIONS</td>
<td>10</td>
</tr>
<tr>
<td>OTHER METHODS FOR USED TIRE RECYCLING</td>
<td>11</td>
</tr>
<tr>
<td>LISTING OF REPORTS PERTAINING TO FDOT ASPHALT-RUBBER INVESTIGATIONS</td>
<td>15</td>
</tr>
<tr>
<td>LISTING OF SELECTED REFERENCES ON OTHER USES OF WASTE TIRES</td>
<td>15</td>
</tr>
<tr>
<td>APPENDIX A</td>
<td>17</td>
</tr>
<tr>
<td>APPENDIX B</td>
<td>20</td>
</tr>
<tr>
<td>APPENDIX C</td>
<td>22</td>
</tr>
<tr>
<td>APPENDIX D</td>
<td>25</td>
</tr>
</tbody>
</table>
INTRODUCTION

The provisions of Section 336.044(3) of the Florida Statutes created by Senate Bill 1192 in 1988 directed the Florida Department of Transportation (FDOT) to expand, where feasible, its use of recovered (waste) materials for highway construction. Specifically, the bill directed that an investigation be conducted to determine how ground tire rubber (GTR) from recycled waste tires could be used in quality asphalt concrete mixtures for highway construction by undertaking demonstration projects as part of currently scheduled construction projects. It further stipulated that within one year after the conclusion of the demonstration projects the FDOT shall report to the Governor and the Legislature on the maximum percentage of ground tire rubber that can be effectively utilized in road construction projects. Concurrent with the submission of the report the FDOT shall review and modify its standard road and bridge construction specifications to allow and encourage the use of ground tire rubber consistent with the findings of the demonstration projects.

The purpose of this Executive Summary is to provide a concise overview of all FDOT and University of Florida activities pertaining to the development of the use of ground tire rubber in asphalt-rubber binders for specific asphalt concrete mixtures and other highway construction applications and to document the steps taken by the FDOT to facilitate the use and quality control of this material. The term asphalt-rubber in this report is defined as a blend of GTR with a paving grade asphalt cement.

DOCUMENTATION OF INFORMATION AND DEMONSTRATION PROJECTS

The following information in this section is presented in chronological order. The first investigation conducted by the FDOT in the use of asphalt-rubber for highway construction was performed nearly 10 years before the passage
of Senate Bill 1192. That project was to evaluate asphalt-rubber as a stress absorbing interlayer and a binder for seal coat construction. A demonstration project constructed on SR 60, Hillsborough County, was used to evaluate the performance of asphalt-rubber in these applications. The results of this study are documented in an August 1980 report prepared by the FDOT for the U.S. Department of Transportation (1). As a result of this demonstration project, the FDOT has permitted the use of GTR in selected surface treatment and interlayer construction. In addition, FDOT currently permits the use of GTR in certain joint sealers and in railroad crossing pads.

Upon passage of Senate Bill 1192 by the 1988 Florida Legislature, FDOT personnel in cooperation with University of Florida researchers established and implemented a detailed plan to address this legislative mandate. The relatively short time period allocated for this investigation required the concurrent activities. One primary activity was to document pertinent information from technical literature on asphalt-rubber and its applications. The National Center for Asphalt Technology (NCAT) at Auburn University was selected to conduct this investigation because of their knowledge and experience with asphalt-rubber, paving mixtures, and construction processes. Their report, dated August 1989, provided a comprehensive documentation of material properties, benefits, limitations and recommendations for utilization of ground tire rubber and asphalt-rubber binders (2). This state-of-the-art overview of asphalt-rubber in an asphalt concrete application confirmed and validated the direction for FDOT in the development of the subsequently constructed demonstration projects.

From 1989 through 1990, three demonstration projects were constructed to evaluate the use of GTR in asphalt concrete friction course mixtures. A summary of key information for the three demonstration projects is presented in Table 1. Each project required a substantial preliminary effort to assure the best possi-
### TABLE 1

**SUMMARY OF ASPHALT-RUBBER FRICTION COURSE DEMONSTRATION PROJECTS**

<table>
<thead>
<tr>
<th>Date Constructed:</th>
<th>Location:</th>
<th>Type of Mix:</th>
<th>Ground Tire Rubber</th>
<th>Test Sections</th>
<th>Total Binder Content</th>
<th>Length of Test Section - ft.</th>
<th>Comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Demonstration Project</td>
<td>March 1989</td>
<td>N.E. 23rd Avenue Gainesville, FL</td>
<td>Dense-Graded Friction Course (FC-4)</td>
<td>(1) 80 mesh/3%</td>
<td>(1) 7.1%</td>
<td>(1) 3520</td>
<td>5% GTR of 80 mesh GTR produced the best results during construction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2) 80 mesh/5%</td>
<td>(2) 7.3%</td>
<td>(2) 3656</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(3) 40 mesh/10% (b)</td>
<td>(3) 8.2% (b)</td>
<td>(3) 2460</td>
<td>10 to 15% GTR appears satisfactory. Either 80 or 24 mesh GTR could probably be used.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(4) control/0%</td>
<td>(4) 7.0%</td>
<td>(4) 2532</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(5) 1818</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(4) 2880</td>
<td>Blending temp. too low (275°F). Increased blending time to 45 min. Both asphalt-rubber and conventional mix were placed with equal ease.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(5) 1761</td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>(6) 263</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(a) By weight of total binder</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(b) Also included 5.0% extender oil</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(c) Not preblended - mixed in pugmill</td>
</tr>
</tbody>
</table>

| 2nd Demonstration Project | June 1989 | State Road 16 Starke, FL | Open-Graded Friction Course (FC-2) | (1) 80 mesh/5% | (1) 8.0% | (1) 2100 |
|                          |           |                           |                                 | (2) 80 mesh/10% | (2) 8.4% | (2) 5655 |
|                          |           |                           |                                 | (3) 80 mesh/15% | (3) 11.4% | (3) 5513 |
|                          |           |                           |                                 | (4) 24 mesh/17% | (4) 10.3% | (4) 5937 |
|                          |           |                           |                                 | (5) control/0% | (5) 6.3% | |
|                          |           |                           |                                 | (6) 80 mesh/10% (c) | (6) 6.9% | (6) 263 |

| 3rd Demonstration Project | September 1990 | Interstate 95 St. Johns County | Open-Graded Friction Course (FC-2) | (1) 80 mesh/10% |
|                          |           |                               |                                 | (2) 80 mesh/10% |
|                          |           |                               |                                 | (3) 80 mesh/10% |
|                          |           |                               |                                 | (4) 80 mesh/10% |

(a) By weight of total binder
(b) Also included 5.0% extender oil
(c) Not preblended - mixed in pugmill
ble operational conditions for production, construction, and testing for materials evaluation. This involved development of work plans, special provisions, mix designs, and considerable interaction with the prime asphalt contractor and the subcontractor providing the blending of GTR with the asphalt cement. During construction, extra sampling and specialized tests were performed in addition to the standard quality control and quality assurance tests. This required a concentrated effort to furnish a sufficient number of qualified personnel to conduct these tests and to observe construction procedures for assessment of any problems or deficiencies.

The first demonstration project (3) was constructed in Gainesville during March 1989 using a dense-graded friction course (FC-4) containing 3, 5, and 10 percent GTR (by weight of total binder). Dense-graded friction course mixtures are generally more susceptible to changes in binder content and particle size of GTR than open-graded mixtures. Tests conducted on the hot-mix samples with different levels of GTR indicated that the mix from test section 2 with 5.0 percent GTR appeared to be the best mix. Although all of the asphalt-rubber mixtures exhibited some degree of sticking to the pavers screed, it was only considered excessive during paving of Test Section 3 which had 10 percent GTR. Otherwise, no major problems were encountered during construction of these asphalt-rubber friction courses.

The second demonstration project (4) was constructed on SR 16 near Starke in June 1989 using 5 to 17 percent GTR (by weight of total binder) in an open-graded friction course (FC-2). Construction was accomplished without any significant difficulty or observable problems. Test Sections 3 and 4 with 15 and 17 percent GTR, respectively, had high total binder contents which could exhibit long term performance and hydroplaning problems. However, the results obtained from construction of this demonstration project indicated that 10 to 15 percent
GTR can effectively be used in open-graded friction course mixtures, but the total binder content should probably be less than used in these mixtures on this project.

The University of Florida provided technical assistance and documentation of these projects (3,4). A report prepared by the FDOT Materials Office (5) also provides a general overview and summary of FDOT involvement through September 1989. Of primary importance is the preliminary laboratory investigations conducted by the FDOT to establish asphalt-rubber blends and mix designs for the first two demonstration projects. Other special studies were conducted to evaluate asphalt-rubber blending requirements and the effectiveness of extraction testing (6).

The third and last demonstration project was constructed on Interstate 95 during September 1990 using 10% GTR (by weight of asphalt cement). The purpose of this project was to determine whether or not asphalt-rubber could be blended and incorporated into an open-graded friction course mixture using a prototype production blending unit on a conventional construction project without encountering any problems which would contribute to construction defects or delays. The information collected on this demonstration project is documented in a technical report from the University of Florida (7). This demonstration project was constructed without any major technical problems. However, the blending time required to provide adequate reaction of GTR with the asphalt cement had to be increased to 45 minutes with this prototype blending unit because of the lower than anticipated temperature (275°F instead of 310°F) of the asphalt cement. This indicated the need to either increase the blending unit capacity or provide additional heating for the unit to assure adequate blending to maintain hot mix production rate at the desired 100 tons/hour.
The constructability and short term performance of these asphalt-rubber test pavements indicate that it is feasible to use GTR for friction course construction without any major change in construction operations. Although the long term performance of these pavements cannot be evaluated until sometime in the future, there is sufficient test data and corroborating information that suggests asphalt-rubber friction courses, particularly open-graded, have improved durability over conventional friction course mixtures. This improvement is related to 1) reduced age hardening because of anti-oxidants in the rubber and increased film thickness, and 2) improved retention of aggregate because of increased film thicknesses and greater resiliency. Greater binder contents and the retention of thicker binder films on the aggregate are possible because of the increase in viscosity and shear susceptibility produced by the addition of GTR.

TYPE AND AMOUNT OF GTR IN FRICTION COURSE MIXTURES

The type of rubber currently deemed satisfactory for use in asphalt-rubber friction course mixtures is that produced by ambiently grinding tires to a suitable fineness (2). Cryogenically produced rubber is not presently acceptable because the effect of its smooth faced particulates on reaction time and material properties has not been evaluated.

The amount and fineness (gradation) of the GTR to be used in asphalt-rubber blends depends on the application. In dense-graded friction course mixtures, 5.0 percent (by weight of asphalt cement) of GTR passing the No. 50 sieve (e.g., a nominal maximum 80 mesh) can be used. In open-graded friction courses, 15.0 percent (by weight of asphalt cement) of GTR passing the No. 30 sieve (e.g., a nominal maximum 40 mesh) can be blended with the asphalt cement. Open-graded mixtures are more tolerant to larger rubber particulate size and greater GTR contents.
Another application of GTR is in the asphalt-rubber binder for an asphalt-rubber membrane interlayer. In this case about 0.6 gal/sq.yd of asphalt-rubber is sprayed over the prepared pavement surface and uniformly sized aggregates are spread and rolled into the membrane prior to placement of the asphalt concrete structural layers. This asphalt-rubber blend uses 25 percent (by weight of asphalt cement) of GTR passing the No. 10 sieve (e.g., a nominal maximum 20 mesh). This provides a membrane that will seal the pavement from intrusion of moisture and retard reflective cracks. Exact requirements are presented in a subsequent section on developmental specifications and Appendices A, B and C.

BLENDING REQUIREMENTS

GTR is to be blended with asphalt cement for a sufficient period of time to achieve a uniform product with fairly stable consistency (viscosity). This reaction time is reduced when using finer ground tire rubber, softer asphalt cements, and higher blending temperatures. This was identified in FDOT laboratory studies as part of the demonstration projects. Another advantage of fine GTR is that the resulting asphalt-rubber blend is more homogeneous and is better suited for viscosity testing and other quality control tests than blends containing coarse GTR (particle sizes retained on the No. 30 sieve). Although reaction time is reduced at higher blending temperatures, excessive temperature and holding at elevated temperatures for long periods will degrade the quality of asphalt-rubber binder because of volatile loss and accelerated hardening.

Conventionally, GTR is packaged in plastic bags which are opened and dumped into the hopper of a feeding unit. The feed of GTR and asphalt cement into the blending unit are adjusted to achieve the desired percent GTR in the asphalt-rubber binder. The size and operation of the blending unit may differ according to approach selected by the asphalt-rubber blending contractor. The blending
temperature and reaction time requirements are given in the development specification for asphalt-rubber binder presented in Table B1 (Appendix B).

EFFECTS ON CONSTRUCTION AND PAVEMENT PERFORMANCE

Properly proportioned asphalt-rubber binders can be used in dense or open-graded friction course mixtures without any significant effect upon conventional mix production operations. However, standard asphalt metering pumps on asphalt hot-mix plants may not be adequate to handle the higher viscosity binder, particularly when using higher percentages of coarse GTR. Plants with asphalt weigh buckets will generally operate without any problems provided the spray bar orifices do not restrict flow.

Conventional paving operations for friction course mixtures can be used for paving of asphalt-rubber mixtures. Dense-graded friction course mixtures with asphalt-rubber should tend to reduce pavement distortions at intersections in urban areas due to improved resilient properties of the asphalt-rubber. Open-graded friction course mixtures with asphalt-rubber will tend to eliminate binder drainage from the aggregate and allow for increased binder contents which in combination with the improved resilient properties of asphalt-rubber should provide improved aggregate retention and improved durability.

The recycling of asphalt concrete pavements with asphalt-rubber friction course surfaces is not anticipated to be a problem because of the low rubber content present in the total amount of reclaimed asphalt pavement (RAP) for normal milling depths (2).

ESTIMATED GROUND TIRE RUBBER USAGE AND COST IN HIGHWAY APPLICATIONS

The estimated annual use of GTR is based upon the total tonnage of open and dense-graded friction course mixtures normally used during one construction year. In addition, the asphalt-rubber membrane interlayer is included in the GTR use
calculations, based on estimated number of lane miles per year. These calculations and the yearly GTR usage projections are:

<table>
<thead>
<tr>
<th>Friction Course</th>
<th>Tons Rubber/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Open-Graded Friction Course (FC-2):</strong></td>
<td></td>
</tr>
<tr>
<td>640,000 Tons x 8.2% Binder = 52,480 Tons Binder per Year</td>
<td></td>
</tr>
<tr>
<td>52,480 Tons Binder x 15% Rubber = 7,872 Tons Rubber per Year</td>
<td></td>
</tr>
<tr>
<td><strong>Dense-Graded Friction Course (FC-1 &amp; 4):</strong></td>
<td></td>
</tr>
<tr>
<td>160,000 Tons x 7.4% Binder = 11,840 Tons Binder per Year</td>
<td></td>
</tr>
<tr>
<td>11,840 Tons Binder x 5% Rubber = 592 Tons Rubber per Year</td>
<td></td>
</tr>
<tr>
<td><strong>Asphalt-Rubber Membrane Interlayer:</strong></td>
<td></td>
</tr>
<tr>
<td>7040 S.Y. x 0.6 Gal x 25% Rubber = 4.5 Tons Rubber per Lane Mile</td>
<td></td>
</tr>
<tr>
<td>4.5 Tons Rubber x -600 Lane Miles = 2,700 Tons Rubber per Year</td>
<td></td>
</tr>
<tr>
<td><strong>Pavement Marker Adhesive, Joint Filler, Railroad Crossing Pads, Guardrail Spacers:</strong></td>
<td></td>
</tr>
<tr>
<td>Total Estimated FDOT Usage Per Year = 12,154</td>
<td></td>
</tr>
</tbody>
</table>

The total yearly generation of waste tires was estimated based upon 0.75 tire/year/capita and the 1990 population in Florida of 13,000,000. Approximately 10 lbs. of ground tire rubber is recovered from each tire which computes to be 48,750 tons of rubber per year.

On this basis, the FDOT can consume 25 percent of the generated waste tire rubber. Since the amount of asphalt concrete used by cities, counties and developers exceeds that used by FDOT on an annual basis, it is assumed that their use of GTR would equal or exceed that of the FDOT. Therefore, the projected highway usage of GTR from waste tires in Florida is 50 percent of the total generated.
However, this figure is questionable because at the present time two major national suppliers of ground tire rubber already obtain some of their waste tire supply from Florida. Also, the roofing and tire manufacturing industry incorporate GTR in some of their products. Consequently, the exact status of usage cannot be determined unless a very detailed and comprehensive study is undertaken.

Cost estimates performed by the FDOT State Materials Office indicate that a reasonable increase in cost of $3.20 per ton of mix or about a 10 percent increase in cost would occur when using GTR in the binder (assuming $32.00 per ton of conventional hot-mix). This additional cost translates to an increase in binder cost of about 46 percent. How, or if, this increase in cost is funded is beyond the scope of this engineering investigation.

DEVELOPMENTAL SPECIFICATIONS FOR ASPHALT-RUBBER HIGHWAY CONSTRUCTION APPLICATIONS

It was necessary to develop new specifications and to revise existing specifications before attempting to use asphalt-rubber friction course mixtures in construction on a conventional production basis. Therefore, the FDOT State Materials Office has prepared tentative or developmental specifications for use on new construction projects. These specifications were prepared using the compilation of information generated during the asphalt-rubber investigation and the experience obtained from construction of the asphalt-rubber friction course demonstration projects.

The developmental specifications are presented in Appendix A, B, and C. Appendix A is the specification for ground tire rubber for use in asphalt-rubber binders. This includes physical, chemical, packaging, and certification requirements for GTR use in dense-graded and open-graded friction courses, and for asphalt-rubber membrane interlayers. Appendix B gives the specification for the
asphalt-rubber binder materials, blending requirements (temperature and time),
and the method of measurement for the GTR and the asphalt-rubber blend. Appendix C presents the asphalt-rubber membrane specification which covers the requirements for the binder, cover material, construction equipment and procedures, special blending requirements, and method of payment.

Section 337 of the Florida Department of Transportation Standard Specifications for Road and Bridge Construction which pertains to Asphalitic Concrete Friction Courses is revised to require the use of asphalt-rubber binders in friction course construction (see Appendix D).

It should be recognized that these developmental specifications may be revised prior to actual implementation when a more thorough review has been accomplished. Furthermore, as experience is gained on asphalt-rubber construction projects, it is probable that some modifications of the specifications will be needed to improve their effectiveness.

OTHER METHODS FOR USED TIRE RECYCLING

A variety of products exist that can be constructed from whole tires. The U.S. Forest Service has used tire-faced retaining walls for construction of narrow mountain roads (8). However, this is not practical for major highway construction because of aesthetics and safety for off-road vehicular accidents. Tires have been used to control erosion along drainage channels and to stabilize highway slopes (9). Malaysia is currently seeking 35 million tires to use as a barrier reef (10). Other products such as crash barriers, playground equipment, breakwaters, and installations to control soil and beach erosion can be constructed from whole, used, tires.

Research being conducted by the University of Wisconsin is directed toward the utilization of shredded tires to replace sand and gravel fills (11). Poten-
tial benefits include reduced weight of fill constructed with rubber chips and soil, conservation of mineral aggregates, and elimination of some of the 20 million discarded tires in the State of Wisconsin. Small quantities of metals in the leachate from these fills apparently are too small to affect the groundwater.

Table 2 presents a flow chart prepared by the Oxford Energy Company to illustrate a waste tire management program. This approach emphasizes the use of whole tires for fuel in industrial uses and power plants and does not indicate the use of crumb rubber (GTR) in a blend with asphalt cement for use in roofing and paving applications.

Crumb rubber can be mixed with other materials and processed to make mud guards, floor mats, carpet padding, adhesives, new tires, or other rubber products (10). However, a Minnesota company established recently to produce rubber products from crumb rubber could not achieve the quality desired by its customers. Their inability to meet the purchaser's specifications apparently lead to bankruptcy.

Shredded tires have been successfully burned as a fuel in power plants, in cement kilns, in pulp and paper production, and by tire manufacturing facilities (10). Generally a "fluidized bed" burning system is required to achieve sufficiently high temperatures for combustion of the rubber. Often a combination of fuels are used which promotes efficient burning and reduced emissions. Although this is technically feasible, modern scrubber systems are necessary to remove particulate and undesirable emissions such as sulfur dioxides and nitrous oxides.

One example of a whole tire burning power plant is in Modesto, California (12). Tires are burned at a rate of 700/hr or about 4.5 million tires per year to produce electrical energy. Table 3 presents some of the key characteristics of the power plant.
### MODESTO ENERGY PROJECT

#### PLANT DESCRIPTION

- Permit to Operate was granted on March 5, 1988 by the Stanislaus County Air Pollution Control District after determination that the plant meets or exceeds all federal emissions standards.
- The Plant has a 14.4 megawatt generation capacity (meets the energy needs of 15,000 homes).
- Tires contain approximately 14,500 BTUs per pound, more than high-grade coal.
- Steam is produced through the complete incineration of up to 700 whole tires per hour, or 4.5 to 5 million tires per year.
- Specially-designed furnaces operating at over 2000°F, coupled with state-of-the-art air quality controls, cleanly and efficiently turn a waste product into energy and recyclable by-products.
- Generated power will be sold to Pacific Gas & Electric under a long-term contract.
- Equipment includes:
  - Two 60,000 lb./hour, 900 psig, 928°F steam generators
  - 14.4 megawatt steam turbine-generator
  - Waste tire handling/conveyor system
  - Exxon Thermal De-NOx air quality control (nitrous oxide)
  - General Electric air quality control system (sulfur and particulate removal)
- Dioxins, furans and other organic emissions are virtually non-existent, tens to hundreds of times lower than the levels projected for garbage-burners. Trace metal emissions are all well below estimates made prior to plant construction.
- The baghouse has an efficiency of better than 99% in removing particulate matter, zinc oxides and trace amounts of cadmium and lead are captured in the baghouse to be recovered and recycled.
- Independent emission studies conducted by Radian Corporation of Sacramento, and Engineering Science of Pasadena. All data and test procedures were reviewed by the Stanislaus County Air Pollution Control District.
- Turnkey construction was by General Electric Company of Schenectady, New York.
- Engineering consultant was Fichtner Consulting Engineers of Stuttgart, West Germany and Atlanta, Georgia.
LISTING OF REPORTS PERTAINING TO FDOT ASPHALT-RUBBER INVESTIGATIONS


LISTING OF SELECTED REFERENCES ON OTHER USES OF WASTE TIRES


Aggregate and Rubber Gradation

The aggregate gradations for the six test sections and the Job Mix Formulas (JMF) are given in Table 6. The gradations were determined from extraction tests performed at the central lab and district lab. The gradations conform closely to the JMF except that the percent passing the 3/8 inch sieve was consistently 4 to 5 percent greater than the JMF. However, the mix did conform to the specification requirements. The uniformity of aggregate gradations between test sections indicates good production control.

The gradations for the two different ground tire rubber (GTR) sizes for both manufacturer and FDOT test results are given in Table 7. In general the test results indicate that 90 to 100 percent of the GTR passed their designated mesh size (i.e., 80 or 24). The manufacturer's product certifications are presented in Appendix E.

Analysis of Binder Contents

The binder content for each test section was analyzed and the results summarized in Table 8. The plant binder content, computed on the basis of tons of binder and tons of hot-mix produced, were close to the design except for Sections 1 and 3. Section 1 exceeded the design binder content by 0.82 percent and Section 3 was 2.27 percent over design. Similarly, the extracted binder contents from central and district labs were comparable except for the 2.19 percent difference in values for Section 3. It was obvious that the test results for Section 3 were either partially in error or tests had been conducted on samples with greatly different binder contents.

The extracted binder contents and the acetone extractable oils (Appendix E) from the GTR were used to compute the asphalt (AC) contents (item 6) for the asphalt-rubber test sections. Comparison of these values with the design A.C. contents (item 2) indicated that the maximum difference was about 0.6
APPENDIX A

DEVELOPMENT SPECIFICATION

for

GROUND TIRE RUBBER FOR USE IN ASPHALT-RUBBER BINDER

AAA-1 SCOPE

1.1 This specification controls ground tire rubber for use in asphalt-rubber binders for use in a variety of road and paving applications.

1.2 This standard does not address any safety or environmental concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health and environmental practices and determine the applicability of regulatory limitations prior to use.

AAA-2 GENERAL REQUIREMENTS

2.1 The ground tire rubber shall be produced by ambient grinding methods. The rubber shall be sufficiently dry so as to be free flowing and to prevent foaming when mixed with asphalt cement. The rubber shall be substantially free from contaminants including fabric, metal, mineral, and other non-rubber substances. Up to 4 percent (by wt. of rubber) of talc (such as magnesium silicate or calcium carbonate) may be added to prevent sticking and caking of the particles.

AAA-3 PHYSICAL REQUIREMENTS

3.1 Gradation - when tested in accordance with FM 1-T 027 using a 50 g sample, the resulting rubber gradation shall meet the gradation limits shown in Table A1 for the type of rubber specified.

3.2 Specific gravity of the rubber as determined from ASTM D-297, pycnometer method, shall be 1.15 ± 0.05.

3.3 Moisture Content - Maximum 0.75% by weight as measured by heating to 230°F to a constant weight.

3.4 Mineral Contaminants - Maximum 0.25% by weight (FM to be developed).

3.5 Metal Contaminants - None (FM to be developed).

AAA-4 CHEMICAL REQUIREMENTS

4.1 Acetone Extract - Maximum 25 percent

4.2 Rubber Hydrocarbon Content - 40 to 55 percent
4.3 Ash Content - Maximum 10 percent

4.4 Carbon Black Content - 20 to 40 percent

AAA-5 PACKAGING AND IDENTIFICATION REQUIREMENTS

5.1 The ground tire rubber shall be supplied in moisture resistant packaging such as either disposable bags or other appropriate containers. Each container or bag of ground tire rubber shall be labeled with the manufacturer designation for the rubber and the specific type, maximum nominal size, weight and manufacturer batch or lot designation.

AAA-6 CERTIFICATION REQUIREMENTS

6.1 The manufacturer of the ground rubber shall furnish the Engineer certified test results covering each shipment of material to each project. These reports shall indicate the results of tests required by this specification. They shall include a certification that the material conforms with this specification, and shall be identified by project number, and manufacturer's batch or lot number.

6.2 The manufacturer shall also certify that the ground tire rubber was produced from waste tires from the State of Florida, or that an amount of waste tires equal to or greater than that necessary to produce the ground tire rubber was obtained from the State of Florida. Records of amounts of waste tires from Florida, and amounts of ground tire rubber shipments to Florida shall be available for review as requested by the Department.
TABLE A-1

GRADATIONS OF GROUND TIRE RUBBER

<table>
<thead>
<tr>
<th>SIEVE SIZE % PASSING</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>--</td>
<td>--</td>
<td>100</td>
</tr>
<tr>
<td>20</td>
<td>--</td>
<td>100</td>
<td>85-100</td>
</tr>
<tr>
<td>30</td>
<td>--</td>
<td>95-100</td>
<td>40-65</td>
</tr>
<tr>
<td>40</td>
<td>100</td>
<td>85-100</td>
<td>20-45</td>
</tr>
<tr>
<td>60</td>
<td>98-100</td>
<td>30-60</td>
<td>--</td>
</tr>
<tr>
<td>80</td>
<td>90-100</td>
<td>15-40</td>
<td>5-20</td>
</tr>
<tr>
<td>100</td>
<td>70-90</td>
<td>5-25</td>
<td>--</td>
</tr>
<tr>
<td>200</td>
<td>35-60</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
APPENDIX B

DEVELOPMENTAL SPECIFICATION

for

ASPHALT-RUBBER BINDER

BBB-1 SCOPE

1.1 This specification controls the production of asphalt-rubber binder for use in asphaltic concrete friction courses and asphalt-rubber membrane interlayers.

1.2 This standard does not address any safety or environmental concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health and environmental practices and determine the applicability of regulatory limitations prior to use.

BBB-2 MATERIALS

2.1 Asphalt Cement - The particular grade of asphalt cement as specified in Table BBB-1 for the respective uses shall meet the requirements of Section 916. The asphalt cement shall be fully compatible with the proposed ground tire rubber as determined by the State Materials Office.

2.2 Ground Tire Rubber - The type of ground tire rubber as specified in Table AAA-1 shall meet the requirements of Section AAA.

2.3 Asphalt-Rubber Binder - The asphalt cement and ground tire rubber shall be thoroughly mixed and reacted in accordance with the requirements of Table BBB-1. The rubber type shall be in accordance with the approved job mix formula. The blending unit may be a batch type or continuous type and shall be capable of sampling the blended and reacted asphalt-rubber binder material during normal production.

BBB-3 EQUIPMENT

The meter for the asphalt rubber binder shall meet the requirements for accuracy, condition, etc. of the Bureau of Weights and Measures of the Florida Department of Agriculture and such fact shall be recertified every 6 months either by the Bureau of Weights and Measures or by a registered scale technician.

BBB-4 METHOD OF MEASUREMENT

The ground tire rubber content in the asphalt-rubber binder shall be monitored based on the weight of ground rubber used vs. the gallons of asphalt-rubber binder used. The weight per gallon for the various types of asphalt-rubber binders included in Table BBB-1 are to be used for these calculations.

The quantity of asphalt-rubber binder material used shall be determined by a certified meter meeting requirements of BBB-3.
## TABLE BBB-1

### ASPHALT-RUBBER BINDER

<table>
<thead>
<tr>
<th>USES</th>
<th>Dense-graded FC</th>
<th>Open-graded FC</th>
<th>Asphalt-Rubber Membrane Interlayer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubber Type</td>
<td>TYPE I</td>
<td>TYPE II (or I)</td>
<td>TYPE III (or II or I) <em>(a)</em></td>
</tr>
<tr>
<td>% Gr. Tire Rubber (by wt. of asphalt cement)</td>
<td>5</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>AC Grade</td>
<td>AC-30</td>
<td>AC-30</td>
<td>AC-20</td>
</tr>
<tr>
<td>Minimum Blending Temp., °F</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Maximum Blending Temp., °F</td>
<td>335</td>
<td>350</td>
<td>375</td>
</tr>
<tr>
<td>Min. Reaction Time</td>
<td>10 min.</td>
<td>15 min. (for Type II)</td>
<td>30 min. (for Type III)</td>
</tr>
<tr>
<td>wt/gal. <em>(b)</em></td>
<td>8.6 lbs</td>
<td>8.7 lbs</td>
<td>8.8 lbs</td>
</tr>
</tbody>
</table>

*(a)* Use of finer rubber could result in the reduction of the minimum reaction time.

*(b)* Conversions to standard 60°F are not necessary.

**Note:** The minimum reaction time may be adjusted if approved by the State Materials Office depending upon the blending temperature, size of the ground tire rubber and viscosity measurement determined from the asphalt-rubber binder material prior to or during production. The addition of diluents or modifiers to obtain the desired viscosity shall be approved by the State Materials Office. Hold-over time of the asphalt-rubber binder material in excess of six hours will not be allowed without corrective action approved by the State Materials Office.
APPENDIX C
DEVELOPMENTAL SPECIFICATION
for
ASPHALT-RUBBER MEMBRANE INTERLAYER

CCC-1 GENERAL

The work specified in this section consists of the construction of an asphalt-rubber membrane interlayer composed of a separate application of asphalt-rubber binder material covered with a single application of aggregate.

CCC-2 MATERIALS

2.1 Asphalt-Rubber Binder - the asphalt-rubber binder material shall conform to the requirements of Section BBB (Type III).

2.2 Cover Material - The cover aggregate shall be a size No. 6 (modified to provide that 100 percent of the material shall pass the 3/4-inch sieve) stone, slag or gravel meeting the requirements of Section 901.

CCC-3 EQUIPMENT

The power broom for cleaning the existing pavement shall be capable of removing all loose material from the surface. The power broom for cleaning loose aggregate from the finished surface shall be a rotary sweeper type.

The aggregate spreader shall be a self-propelled unit that can be adjusted to accurately apply the cover material at the specified rate and will spread the material uniformly.

The rollers used for this surfacing shall be self-propelled, pneumatic-tired traffic type rollers equipped with at least seven smooth-tread, low-pressure tires and capable of carrying a gross load of at least eight tons. The inflation of the tires shall be maintained such that in no two tires shall the air pressure vary more than five pounds per square inch. The traffic roller shall be loaded as directed by the Engineer.

The mixing equipment for asphalt-rubber shall be designed for that purpose and shall be capable of producing and maintaining a homogeneous mixture of rubber and asphalt at the specified temperature.

The distributor used to apply asphalt-rubber shall be a pressure type capable of maintaining a homogeneous mixture of rubber and asphalt at the specified temperature and consistently applying the material in a uniform manner.
The materials shall be combined as rapidly as possible for such a time and at such a temperature that the consistency of the binder approaches that of a semi-fluid material. The time and temperature for blending of the asphalt-rubber binder shall be as specified in Table BBB-1. The Engineer shall be the sole judge of when the material has reached application consistency. After reaching the proper consistency, application shall proceed immediately; and in no case shall the mixture be held at temperatures over 325°F for more than one hour after reaching that point.

The proportions of the two materials shall be as specified in Table BBB-1. After the full reaction described above has occurred, the mix shall be diluted with kerosene type diluent. The amount of diluent used shall be 5.5 percent to 7.5 percent, by volume, of the hot asphalt-rubber binder as required for adjusting viscosity for spraying or better "wetting" of the cover aggregate. The kerosene type diluent shall have a boiling point of not less than 350°F, and the temperature of the hot composition shall not exceed this temperature at the time of adding the diluent.

5.1 Preparation of Surface - Prior to application of the asphalt-rubber, the existing pavement shall be cleaned as specified in Section 300-4.

5.2 Application of Asphalt-Rubber Binder - The asphalt-rubber binder shall be applied only under the following conditions:
   a) The air temperature is above 40°F and rising.
   b) The pavement is absolutely dry.
   c) The wind conditions are such that cooling of the asphalt-rubber binder will not be so rapid as to prevent good bonding of the aggregate.

The asphalt-rubber binder shall be uniformly applied, using a pressure distributor meeting the requirements of this specification, at the rate of 0.6 gallon per square yard. The Engineer may vary the rate of application. The application rate is based on 7.5 pounds per hot gallon. Conversions to standard 60°F are not necessary.

5.3 Application of Cover Material - Immediately after application of the asphalt-rubber, cover material meeting the requirements set out herein shall be uniformly spread at a rate of between 0.26 and 0.33 cubic feet per square yard. The exact rate will be set by the Engineer.

The application of the asphalt-rubber binder and the application of the cover material shall not be separated by more than 150 feet.

5.4 Rolling - In order to ensure maximum embedment of the aggregate, it is imperative that the entire width of the mat be covered immediately by traffic rollers meeting the requirements of this specification. For the first coverage a minimum of three traffic rollers shall be provided in order to accomplish simultaneous rolling in echelon of the entire width.
of the spread. When spreading is stopped the spreader shall be moved ahead to allow immediate rolling of all cover material.

Following the first coverage a minimum of four coverages shall be made with additional traffic rollers.

5.5 Traffic Control - The normal sequence of construction operations shall require the first pass of asphalt concrete overlay to be placed over the membrane prior to opening to traffic. When this is found not to be possible due to circumstances outside the Contractor's control, he shall terminate placement of the membrane as soon as possible to minimize the amount of the layer that will be exposed to traffic. In no case shall traffic be permitted on the membrane layer for a period of at least two hours. Any exposed membrane layer that is left open to traffic shall be covered immediately when the Contractor resumes his normal paving operation. The intent of this specification is to minimize the amount of membrane interlayer material directly exposed to traffic.

CCC-6 UNACCEPTABLE ASPHALT RUBBER MEMBRANE INTERLAYER

If the asphalt-rubber membrane interlayer should be unacceptable due to incorrect blending application rate or not meeting the requirements of this section or become damaged prior to placement of the asphaltic concrete layer, it shall be removed and replaced as directed by the Engineer. In no case shall excessive amounts of asphalt-rubber binder be allowed.

CCC-7 METHOD OF MEASUREMENT

The area of asphalt-rubber membrane interlayer shall be determined as provided in Section 9-1.3.

CCC-8 BASIS OF PAYMENT

The quantity of asphalt-rubber membrane interlayer shall be paid at the contract unit price for this item. Such price and payment shall constitute full compensation for all work specified in this section including furnishing cover material, asphalt cement, ground tire rubber, diluent, and all processing, mixing, handling, spreading, rolling, and other incidental work necessary to complete this item.

Payment shall be made under: Item No. — Asphalt-Rubber Interlayer - per sq yd.
337-1 Description

This section specifies the materials, composition, job mix formula and compensation for Asphaltic Concrete Friction Courses. The requirements for plant and equipment for this pavement are specified in Section 320. General construction requirements for all asphaltic concrete pavements as specified in Section 330 are applicable to this section subject to any exceptions contained herein.

The work will be accepted on a LOT by LOT basis in accordance with the applicable requirements of Sections 5, 6 and 9. The size of the LOT for the bituminous mix accepted at the plant will be as specified in 331-5 and for the material accepted on the roadway as stipulated in 330-10 and 330-12.

The mixes covered by this Section are designated as Friction Course 1 (FC-1), Friction Course 2 (FC-2), and Friction Course 4 (FC-4).

337-2 Materials

337-2.1 General: The materials used shall conform with the requirements specified in Division III as modified herein.

337-2.2 Asphalt-Rubber Binder Material: The asphalt-rubber binder material for all friction course mixes shall meet the requirements of Section B8. In addition, the bituminous material shall contain 0.5 percent heat stable anti-stripping additive from an approved source. This amount may be varied based on tests performed by the State Materials Office. When the amount is varied in excess of the 0.5 percent, the Contractor will be compensated at the invoice price for the additive. When the amount is varied less than 0.5 percent, the Department shall be reimbursed at the invoice price of the additive.

The heat stable anti-stripping additive shall be introduced and mixed into the asphalt cement at the asphalt terminal during loading or by the Contractor at the asphalt plant in a manner satisfactory to the Engineer. Addition of the additive at the asphalt terminal shall be certified by the supplier.

337-2.3 Course Aggregate:

337-2.3.1 General: Except as modified, herein, all coarse aggregate shall meet the requirements of Section 901.

337-2.4 Fine Aggregate:

337-2.4.1 General: Fine aggregates shall meet all applicable requirements of Section 902.

337-2.4.2 Special Requirements for FC-1:

(a) Local Materials: If clay is present in the fine aggregate, the quantity shall not exceed seven percent and it shall be of a type which will not produce clay balls in the mixture. The sand shall...
be nonplastic and shall be suitable for use in bituminous mixtures as determined by laboratory tests. If the sand deposits consist of stratified layers of varying characteristics and gradation, the Contractor shall employ such means as necessary to secure uniform material. The fine aggregate will be sampled at the asphalt plant.

(b) Screenings: Slag, granite, gravel, or any combination of these materials shall be crushed and meet the following gradation requirements in addition to the requirements in 902-5.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 10</td>
<td>40-75</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-13</td>
</tr>
</tbody>
</table>

337-2.4.3 Special Requirements for FC-4: Fine aggregate shall be composed of quartz grains and shall be reasonably free from lumps, clay, soft or flaky particles, salt, alkali, organic matter, loam or other extraneous substances. Only approved fine aggregate sources located above parallel 27 degrees, 30 minutes, in the State of Florida will be acceptable for use in FC-4 mixes. The weight of extraneous substances shall not exceed the following percentages.

<table>
<thead>
<tr>
<th>Material passing No. 200 sieve</th>
<th>4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shale</td>
<td>1.0</td>
</tr>
<tr>
<td>Coal and Lignite</td>
<td>1.0</td>
</tr>
<tr>
<td>Clay Lumps</td>
<td>1.0</td>
</tr>
<tr>
<td>Cinders and Clinkers</td>
<td>0.5</td>
</tr>
</tbody>
</table>

In addition, the total amount of the above materials in the fine aggregate shall not exceed five percent.

Fine aggregate, excluding crushed stone screenings, shall be subjected to the colorimetric test for organic impurities, and if the color produced is darker than the standard solution, the aggregate shall be rejected unless it can be shown by appropriate tests that the impurities causing the color are not of a type that would be detrimental to the pavement. Such tests shall be in accordance with FM 1-T 071 and AASHTO M-6.

Fine aggregate shall be reasonably well-graded, from coarse to fine and when tested by means of laboratory sieves, it shall meet the following requirements, in percent of total weight passing:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 4</td>
<td>95-100</td>
</tr>
<tr>
<td>No. 10</td>
<td>80-100</td>
</tr>
<tr>
<td>No. 40</td>
<td>10-40</td>
</tr>
<tr>
<td>No. 80</td>
<td>0-10</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-4</td>
</tr>
</tbody>
</table>

The above gradation for fine aggregate represents extreme limits which will be used in determining the suitability for use of sand from all sources of supply. The gradation of fine aggregate from any one source shall be reasonably uniform and not subject to the extreme range specified above. For the purpose of determining the
degree of uniformity of fine aggregate, fineness modulus determinations shall be made upon representative samples of fine aggregate submitted by the Contractor from such sources as they propose to use. Fine aggregate from any one source having a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the representative sample submitted by Contractor may be rejected.

337-2.5 Crushed Stone Screenings: Any screenings used in the combination of aggregates shall contain not more than 15 percent of material passing the No. 200 sieve. When two screenings are blended to produce the screenings component of the aggregate, one screening may contain up to 18 percent of material passing the No. 200 sieve as long as the combination of the two does not contain over 15 percent material passing the No. 200 sieve. Screenings may be washed to meet these requirements. Crushed stone screenings used in Friction Mixes shall meet the requirements of Section 902.

337-3 General Composition of Mixes.

337-3.1 General: The bituminous mix shall be composed of a combination of aggregate (coarse, fine, or a mixture thereof), mineral filler if required, and asphalt-rubber binder material. The several aggregate fractions shall be sized, uniformly graded and combined in such proportions that the resulting mix will meet the grading and physical properties of the approved job mix formula.

337-3.2 Aggregate Components: The aggregate components of the various mixes set out in this Section shall be as follows:

FC-1 Either crushed slag, crushed gravel or crushed granite, any combination of these aggregates or a combination of one or more of these aggregates with fine aggregate. The coarse aggregate component (crushed slag, crushed gravel or crushed granite) shall comprise at least 60 percent of the aggregate combination.

FC-2 Either crushed granite, crushed slag, crushed gravel or a combination of these. Crushed limestone from the Oolitic formation will also be permitted if the coarse aggregate contains a minimum of twelve percent non-carbonate material as determined by FM 5-510 and approval of the source is granted by the State Materials Office prior to its use. In addition, use of aggregates other than those listed above may be permitted if approved by the State Material Office.

FC-4 Based on a blend of fine aggregate and crushed stone screenings, with the fine aggregate comprising 50 to 70 percent of the total aggregate in the mix. The combined aggregates in the mix shall contain a minimum of 50 percent acid insoluble materials as determined by FM 5-510. All aggregate materials shall be furnished from FDOT approved sources.

Continuing approval of all sources of material for use in FC-1, FC-2 and FC-4 will be based on field performance.

337-3.3 Grading Requirements: The job mix formula, as established by the Contractor and approved by the Department, shall be within the design range specified in Table 331-1 for all friction courses.
337-3.4 Stability for FC-1 and FC-4: The constituents for FC-1 and FC-4 shall be combined in such proportions as to produce a mix having Marshall properties within the limits shown in Table 331-2.

337-4 Job Mix Formula.

The job mix formula shall conform to the requirements of 331-4.3 of these specifications except that Item No. 7 in 331-4.3.1 shall not apply to FC-2. In addition to these requirements, the job mix formula shall include test data showing that the material as produced will meet the requirements of Table 331-2.

337-5 Contractor’s Quality Control.

The Contractor shall provide the necessary quality control of the friction course mix and construction in accordance with the applicable provisions of 6-8.4 and 331-4.4. After the job mix formula has been approved, the Contractor shall furnish the material, to meet the approved job mix formula within the acceptance range as shown on the approved design mix. The extraction gradation analysis shall comply with provisions of 331-4.4.2 and Table 331-3. Plant calibration shall comply with the provisions of 331-4.4.3 and Table 331-3.

337-6 Acceptance of Mix.

337-6.1 Acceptance at the Plant: The bituminous mix shall be accepted at the plant with respect to gradation in accordance with the applicable requirements of 331-5. The asphalt-rubber binder content shall be accepted based on a calculated binder content. These calculations are based on a reading from the certified meter and quantity of mix produced.

337-6.2 Acceptance on Roadway: The bituminous mix will be accepted on the roadway with respect to density and surface tolerance in accordance with the applicable provisions of 330-10 and 330-12. There will be no density requirements for FC-2.

337-6.3 Additional Tests: The provisions of 331-5.5 shall apply to the friction courses - FC-1, FC-2 and FC-4.

337-7 Special Construction Requirements.

337-7.1 Temperature Requirements for FC-2:

337-7.1.1 Air Temperature at Laydown: The mixture shall be spread only when the air temperature (the temperature in the shade, away from artificial heat) is at or above 60°F.

337-7.1.2 Temperature of the Mix: The asphalt-rubber binder and aggregates shall be heated and combined in such a manner as to produce a mix having a temperature, when discharged from the pugmill, within the range of 265 – 300°F. The State Materials Office will set the established temperature for each project. All other requirements of 330-6.3 shall apply to FC-2.

337-7.2 Compaction of FC-2: Only seal rolling will be required and this rolling will be accomplished using a tandem steel-wheel roller. The weight of the steel-wheel roller shall not exceed 135 pounds per lineal inch (PLI) of drum width.
Rolling shall be accomplished with a single coverage and with a nominal amount of overlap.

Where the lane being placed is adjacent to a previously laid mat, the longitudinal joint will not be pinched in a manner with the roller on the cold mat. The longitudinal joint will be pinched with the roller on the mat being rolled, overlapping onto the cold mat by no more than three inches.

In no case shall a roller be allowed on the mat after the seal rolling has been completed.

337-7.3 Thickness of Friction Courses: The thickness of the friction course shall be designated in the plans. This is the minimum desirable thickness for FC-1 and FC-4, and the maximum desirable thickness for FC-2. The minimum spread rate for FC-2 shall be 25 pounds per square yard when lightweight aggregates are used, and 40 pounds per square yard when conventional aggregates are used.

337-7.3.1 Thickness Requirements - Tonnage Payment: For FC-2 mixes where payment is on a tonnage basis, the rate of application shown on the plans shall be considered approximate. The intent is to achieve the maximum thickness of the friction course shown in the plans. Particular care must be exercised to avoid exceeding the established rate of application for FC-2 mixes.

337-7.3.2 Thickness Requirements - Square Yard Payment: The thickness shall be determined in accordance with 330-15.1 except that the average thickness will not be calculated. Cores will not be taken in areas where the friction course is being transitioned in thickness to tie into an existing surface. The maximum allowable deficiency from the thickness specified in the plans shall be 1/4 inch. If any area is deficient in thickness by more than the allowable tolerance, the Contractor shall correct the deficiency by removing and replacing the friction course at the proper thickness or by overlaying with additional friction course mix. The overlay shall extend 50 feet either side of the deficient area and shall extend across the full width of the roadway.

As an exception to the foregoing, if the Engineer determines that the friction course will satisfactorily perform its intended function without corrective work, the friction course may be left in place without compensation. The area for which no payment will be made shall be the product of the total distance between cores indicating thickness within tolerances and the width of the lane which was laid in the particular pass in which the deficient thickness occurred. Additional cores will be taken as necessary to define the limits of a deficiency. Open-graded friction courses will not be cored for thickness determinations.

337-7.4 Hot Storage of FC-2 Mixes: When surge or storage bins are used in the normal production of FC-2, as with the drum mixer plants, the maximum time the mix is allowed to remain in the surge or storage bin shall not exceed one hour.

337-7.5 Longitudinal Grade Controls for Open-Graded Friction Courses: On open-graded friction courses, the use of the longitudinal grade control (skid, ski, or traveling stringline) is prohibited. The use of the joint matcher is required.
337-8 Method of Measurement.

337-8.1 Payment Based on Area: When the plans indicate that the friction course is to be paid for on an area basis, the area to be paid for shall be plan quantity subject to 9-3.2. The pay area shall include entire areas of transitions to tie into existing pavement, but excluding areas for which no payment is to be made due to deficient thickness as defined in 337-7.3. No adjustment to the area to be paid for will be made for extra thickness or deficient thickness.

337-8.2 Payment Based on Weight: When the plans indicate that the friction course is to be paid for by weight, the weight shall be determined as provided in 320-2 (including provisions for the automatic recordation system).

For FC-2 mixes, in the event the actual rate of application exceeds the rate established by the FDOT Lab (as provided in 337-7.3.1) by in excess of ten pounds per square yard, the weight to be paid for shall be reduced to a theoretical quantity computed as the product of the actual area covered by the friction course and the established rate of application plus ten pounds per square yard.

337-8.3 Asphalt-Rubber Binder Material: The provisions of 331-6.4 apply to binder materials used in friction course mixes.

337-9 Basis of Payment.

The contract unit price per square yard or per ton, as applicable, shall be full compensation for all the work specified under this section.

Payment shall be made under:

Item No. 337-1 - Asphalitic Concrete Friction Course - per square yard.

Item No. 337-2 - Asphalitic Concrete Friction Course - per ton.