

**SPECIAL PROVISION 960
GROUND TIRE RUBBER MODIFIED ASPHALT
CONCRETE FRICTION COURSES**

960-1 DESCRIPTION

This work shall consist of designing and constructing a Surface Asphalt Rubber (AR) Hot Mix Asphalt (HMA) surface mixture of the type specified in the Contract. Mix types are generally referred to as Open Graded Friction Course (OGFC), Superpave Dense Graded (SDG) or Marshall Dense-Graded (MDG), and Gap-Graded (GG) Marshall Designed (MD) and Gap-Graded (GG) Superpave Designed (SD). The liquid asphalt to be used during production shall be blended with a Ground Tire Rubber Modifier (GTRM) to produce a homogenous asphalt rubber blend. This Section specifies mixes designated as:

- OGFC AR 38 and OGFC AR 12
- SDG AR 38 and SDG AR 12
- MDG AR 38 and AR 12
- GG MD AR 38, GG MD AR 12 or GG MD AR 34
- GG SD AR 38, GG SD AR 12 or GG SD AR 34

Meet the plant and equipment requirements as well as Construction Requirements of Supplemental Specification 401 or Special Provision 959 as applicable, except as modified herein. Superpave laboratory specimens shall be compacted as specified in Special Provision 959 and in accordance with AASHTO T 312. The design number of gyrations (N_{design}) shall be as specified in AASHTO R 35 for the Traffic Level specified in the contract documents. OGFC specimens shall be compacted to 50 gyrations in accordance with AASHTO T 312. GG specimens shall be compacted to the Superpave N_{design} level specified in Section 959-2.01 and AASHTO R-35 (GG SD), or to the Marshall criteria specified in Section 401-2.02 and in the contract documents (GGSD), as applicable.

960-2 MATERIALS

960-2.1 Ground Tire Rubber Modifier - The GTRM shall consist of automobile and truck tires processed by ambient or cryogenic grinding. Heavy equipment tires, uncured, or devulcanized rubber shall not be used in the production of GTRM. GTRM must be free from contaminants including fabric, metal, mineral, and other non-rubber substances, and must be free-flowing. Up to 4% talc (by weight of rubber), or other inert dusting agent, may be added to prevent sticking and caking of the rubber particles.

- a. Physical Properties - The physical properties of the ground tire rubber shall meet the following requirements:

**SPECIAL PROVISION 960
GROUND TIRE RUBBER MODIFIED ASPHALT
CONCRETE FRICTION COURSES**

Specific Gravity.....1.10 ± 0.06
 Moisture Content.....Maximum 0.75%
 Metal Contaminants.....Maximum 0.01%
 Gradation - The gradation shall meet the limits shown in Table 960-1 when tested by AASHTO T 27 using dry sieving only.

Table 960-1 Gradation of Ground Tire Rubber

Sieve Size	% Passing
No. 16	100
No. 30	70-100
No. 50	20-40

Chemical Requirements - The chemical composition of the ground tire rubber shall be determined in accordance with ASTM D 297 and shall meet the following requirements:

Acetone Extract.....Maximum 25%
 Rubber Hydrocarbon Content.....40 to 55%
 Ash Content.....Maximum 8%
 Carbon Black Content.....20 to 40%
 Natural Rubber.....16 to 45%

- b. Packaging and Identification Requirements - The ground tire rubber shall be supplied in moisture resistant packaging such as either plastic disposable bags or other appropriate bulk containers. Each container or bag of ground tire rubber shall be labeled with the manufacturer’s designation for the rubber and the specific type, maximum nominal size, weight and manufacturer’s batch or LOT designation.
- c. Certification Requirements - The Contractor shall provide the Engineer a certification from the manufacturer confirming that the ground tire rubber meets the requirements of this Section.

960-2.2 Asphalt Binder - The virgin binder shall be PG 64-22 or PG 67-22 and shall meet requirements for the Superpave performance grade in Supplemental Specification 702.

960-2.3 Asphalt Rubber Binder - Thoroughly mix and react the asphalt binder and ground tire rubber for a minimum of 45 minutes at a temperature of 325°F to

**SPECIAL PROVISION 960
GROUND TIRE RUBBER MODIFIED ASPHALT
CONCRETE FRICTION COURSES**

375°F using a “wet process.” Rubber particles shall be dissolved into the asphalt binder so that no undissolved rubber particles are larger than No. 60 mesh. The GTRM asphalt binder blend shall be produced to meet the requirements of Table 960-2. Accomplish blending of the asphalt binder and ground tire rubber at the supplier’s terminal or at the contractor’s plant site.

- a. Equipment - Use blending equipment that is designed for asphalt rubber binder and capable of producing a homogeneous mixture of ground tire rubber and asphalt binder meeting the requirements of Table 960-2. Use a batch type or continuous type blending unit that provides for sampling of the blended and reacted asphalt rubber binder material during normal production and provides for accurate proportioning of the asphalt binder and ground tire rubber either by weight or volume.

In order to meet specification requirements, keep the asphalt rubber uniformly blended while in storage. Storage tanks shall provide continuous agitation with both vertical and horizontal recirculation. Store the GTRM binder blend at 300°F to 350°F. If approved Warm Mix additives are introduced into the reacted GTRM binder blend, the storage temperature may be reduced by 25°F. Equip storage tanks with an external sampling device. The maximum storage time of the GTRM asphalt binder at the plant site shall be 3 days, unless approved by the Engineer.

TABLE 960-2 Asphalt Rubber Binder Requirements

Test	Requirement	Test Method
Virgin Binder Grade	PG 64-22 or PG 67-22	AASHTO M 320
Flash Point (C.O.C.), °F, Min.	450	AASHTO T 48
Rotational Viscosity, 275°F, Pa·s, max.	3	AASHTO T 316
Softening Point, °F, min.	135	AASHTO T 53

- a. Testing and Certification Requirements –
1. Blending at Project Site: Monitor the ground tire rubber content in the asphalt rubber binder daily based on the weight of the ground tire rubber used and the weight of virgin asphalt binder used.
 2. Blending at Supplier’s Terminal - Where blending the asphalt rubber binder at the supplier’s terminal, the supplier shall furnish certification on the bill of lading for each load delivered to the project site that includes:

**SPECIAL PROVISION 960
GROUND TIRE RUBBER MODIFIED ASPHALT
CONCRETE FRICTION COURSES**

the quantity, the customer name, the delivery location, and a statement that the asphalt-rubber binder was produced in accordance with and meets the requirements of Section 960. Include with the certification, copies of the certifications for the ground tire rubber and asphalt binder, as specified in 960-2.1 and 960-2.2, respectively.

- b. Asphalt Rubber Binder Blending Quality Control Records - Maintain adequate Quality Control records for the Engineer's review of all blending activities. The Quality Control records shall include at a minimum the following information (for each batch of asphalt rubber binder produced): project number, shipping date, customer name and delivery location, asphalt binder supplier, asphalt binder quantity in gallons and by weight, ground tire rubber supplier, ground tire rubber quantity in pounds, and viscosity results.

960-2.4 Coarse Aggregate - Meet the requirements of Sections 959-3.02.b and 959-3.02.c and any additional requirements or modifications specified herein for the various mixtures.

960-2.5 Fine Aggregate - Meet the requirements of Section 959-3.02.d and any additional requirements or modifications specified herein for the various mixtures.

960-2.6 Anti-Stripping Agents - Furnish hydrated lime, or a liquid heat stable additive, as specified in Section 959-3.02 for all mixtures using asphalt rubber binder.

960-3 GENERAL COMPOSITION OF MIXES

960-3.1 General - Use a bituminous mixture composed of aggregate (coarse, fine, or a mixture thereof), asphalt rubber binder, and in some cases, anti-stripping agent. Size, uniformly grade and combine the aggregate fractions in such proportions that the resulting mix meets the requirements of this Section.

960-3.2 Grading Requirements – SDG AR38 and SDG AR 12 mixtures shall have a gradation at design within the ranges shown in AASHTO M-323 for Nominal Maximum Aggregate Size 3/8-inch and ½-inch mixtures, respectively. MDG AR 38 and MDG AR 12 mixtures shall meet grading requirements of 3/8-inch and ½-inch Nominal Maximum Aggregate Size mixtures, respectively, as specified in Supplemental Specification 401-2.03. OGFC and Gap-graded mixtures shall meet gradation requirements of Table 960-3.

TABLE 960-3 OGFC and GAP-GRADED GRADATIONS (Percent Passing)

**SPECIAL PROVISION 960
GROUND TIRE RUBBER MODIFIED ASPHALT
CONCRETE FRICTION COURSES**

Sieve Size	OGFC Mixtures		Gap-Graded Mixtures		
	OGFC AR 38	OGFC AR 12	GG AR 38	GG AR 12	GG AR 34
1 inch	---	---	---	---	100
3/4 inch	---	100	---	100	90-100
1/2 inch	100	85-100	100	90-100	65-85
3/8 inch	85-100	55-75	75-95	70-90	50-70
No. 4	25-55	15-25	28-42	24-42	22-42
No. 8	5-15	5-10	15-25	15-25	15-25
No. 200	0-4	0-4	3-7	3-7	3-7

960-4 MIX DESIGN

Both OGFC and GG mixtures shall have GTRM added to the virgin binder at the rate of 15-20 percent by weight of the total binder content. SDG and MDG mixtures shall have GTRM added to the virgin binder at the rate of 5 percent of the total binder weight.

960-4.1 OGFC Mixtures - The contractor will design the OGFC mixtures and PRHTA will verify the mixture designs. Furnish the materials and all appropriate information (source, gradation, etc.) as specified in Section 959-3.03.d. The Department will have two weeks to verify the mix design. The mixture shall meet requirements for the National Center for Asphalt Technology (NCAT) OGFC mix design procedure. The optimum asphalt content of OGFC mixtures shall be a minimum of 5.5%.

960-4.2 GG AR 38, GG AR 12 and GG AR 34 Mixtures - Provide a mix design conforming to the Superpave requirements of Section 959-3.03 (GG SD AR) or the Marshall requirements of Section 401-3.06 (GG MD AR).

960-4.3 Marshall Stability and Flow - GTRM HMA mixtures produced using Marshall procedures of Section 401 shall have a minimum stability of 1,250 pounds when tested according to AASHTO T 245. The flow shall range between 0.08 to 0.18 inches.

960-4.4 Moisture Susceptibility - GTRM HMA mixtures shall meet the moisture susceptibility requirements of Special Provision 959-3.03.c.8 except that a minimum retained tensile strength of 70 percent may be acceptable if the average dry tensile strength is greater than 100 pounds per square inch.

**SPECIAL PROVISION 960
GROUND TIRE RUBBER MODIFIED ASPHALT
CONCRETE FRICTION COURSES**

960-5 ACCEPTANCE OF THE MIXTURE

960-5.1 Quality Control Requirements for Testing Asphalt Rubber Binder - Test the asphalt rubber binder for the viscosity requirement of Table 960-2 at the following frequencies and situations:

1. One per batch (for batch blending) or two per day (for continuous blending) during blending at the project site or supplier's terminal.
2. Each load delivered to the project site when blended at the supplier's terminal.
3. At the beginning of each day from the storage tank when storing the asphalt rubber binder at the project site, obtain the sample for testing from the discharge piping exiting the storage tank.

The viscosity shall be determined by one of two methods:

- (a) Use a portable rotational viscometer according to AASHTO T 316. Obtain the viscosity testing equipment specified and make it available to the Engineer for verification purposes.
- (b) In lieu of a portable rotational viscometer, the contractor may install an in-line viscometer to verify the viscosity is at least 2,500 centipoises at 350°F, unless otherwise approved.

If the asphalt rubber binder does not meet the minimum viscosity requirement, make the appropriate adjustments in order to (1) correct the viscosity of the blended material, and (2) correct the blending operation. These corrective actions shall result in an asphalt rubber blend that is within the requirements of Table 960-2, and may include increasing the ground tire rubber content, lowering the blending temperature, changing the supply of ground tire rubber or increasing the reaction time. In the event that the corrective actions taken fail to correct the problem, or the material consistently fails to meet the minimum viscosity requirement, stop all asphalt rubber production operations and solve the problem. In the event that the viscosity of the asphalt rubber binder increases to the extent that plant production or paving operations of the mixture are adversely affected (i.e. density or texture problems occur), stop plant operations and resolve the problem.

**SPECIAL PROVISION 960
GROUND TIRE RUBBER MODIFIED ASPHALT
CONCRETE FRICTION COURSES**

Do not resume production operations until the Engineer grants approval. The Engineer may require that any mix placed with low viscosity asphalt rubber binder be removed and replaced. Upon approval of the Engineer, the contractor may obtain an engineering analysis of the deficient material by an independent laboratory (approved by the Engineer) to determine disposition of the material. Any material allowed to remain in place shall be accepted with a composite pay factor for the Lot as determined in Special Provision 959-6.

- 960-5.2 Verification Requirements** - The Engineer will test the asphalt rubber randomly on an as-needed basis to ensure conformance with the minimum viscosity requirement specified in Table 960-2. Testing will be performed with a portable rotational viscometer provided by the contractor, or by monitoring results of in-line viscometer provided by the contractor.
- 960-5.3 Use of Excess Asphalt Rubber** - The Contractor may use excess asphalt rubber in other asphalt concrete mixes requiring the use of a PG 64-22 or PG 67-22 binder by blending with virgin PG 64-22 or PG 67-22 binder so that the total amount of ground tire rubber in the blended binder is less than 2.0%.
- 960-5.4 AR 38 and AR 12 mixtures** – SDG AR 38 and SDG AR 12 mixtures shall meet Mixture Acceptance requirements of Special Provision Section 959-6. MDG AR 38 and MDG AR 12 mixtures shall meet Mixture Acceptance requirements of Supplemental Specification Section 401-7.02.
- 960-5.5 OGFC** - OGFC mixtures shall meet the acceptance requirements described as follows:
1. The mixture will be accepted with respect to gradation (P-3/8, P-4, and P-8), asphalt binder content (Pb) only.
 2. The standard LOT size will be the same as specified for Superpave mixtures in Section 959-4.01.e.
 3. Master Production Range is shown in Table 960-4.
 4. The mixture will be accepted on the roadway with respect to surface tolerance in accordance with Section 410.
 5. No density testing will be required for OGFC mixtures.

TABLE 960-4

**SPECIAL PROVISION 960
GROUND TIRE RUBBER MODIFIED ASPHALT
CONCRETE FRICTION COURSES**

OGFC and GG Mixtures Master Production Range	
Characteristic	Tolerance from Job Mix Formula
Asphalt Binder Content (%)	Target ± 0.60
Passing 3/8 inch Sieve (%)	Target ± 7.00
Passing No. 4 Sieve (%)	Target ± 6.00
Passing No. 8 Sieve (%)	Target ± 5.00

960-5.5.1 Individual Test Tolerances for OGFC Production: Terminate the LOT if any of the following Quality Control failures occur:

- 1) An individual test result of a subplot for asphalt binder content does not meet the requirements of Table 960-4,
- 2) Two consecutive test results for gradation on any of the following sieve sizes (3/8 inch, No. 4, and No. 8) do not meet the requirements of Table 960-4,

When a LOT is terminated due to a QC failure, stop production of the mixture until the problem is resolved to the satisfaction of the contractor’s Paving Quality Assurance Manager(s) responsible for the decision to resume production after a quality control failure. In the event that it can be demonstrated that the problem can immediately be or already has been resolved, it will not be necessary to stop production. When a LOT is terminated, make all necessary changes to correct the problem. Do not resume production until appropriate corrections have been made. Inform the Engineer of the problem and changes made to correct the problem. After resuming production, sample and test the material to verify that the changes have corrected the problem. Summarize this information and provide it to the Engineer prior to the end of the work shift when production resumes. In the event that a Quality Control failure is not addressed as defined above, the Engineer’s approval will be required prior to resuming production after any future Quality Control failures.

Address any material represented by a failing test result in accordance with Section 960-3.1. Any LOT terminated under this Subarticle will be limited to a maximum Pay Factor of 1.00 (as defined in Section 959-6) for each quality characteristic.

960-6 SPECIAL CONSTRUCTION REQUIREMENTS

**SPECIAL PROVISION 960
GROUND TIRE RUBBER MODIFIED ASPHALT
CONCRETE FRICTION COURSES**

960-6.1 Hot Storage of OGFC and GG Mixtures - When using surge bins in the normal production of OGFC, do not leave the mixture in the surge bin for more than one hour. Silo storage of OGFC and GG GTRM HMA mixtures shall not exceed 4 hours.

960-6.2 Temperature requirements for AR 38 and AR12 - Ambient temperature and mix temperature shall be according to requirements for Superpave mixtures in Section 959-5.07.

960-6.3 Temperature Requirements for OGFC and GG Mixtures:

960-6.3.1 Air Temperature at Laydown - Spread the mixture only when the air temperature in the shade away from artificial heat is at or above 60°F.

960-6.3.2 Temperature of the Mix - Heat and combine the asphalt rubber binder and aggregate in a manner to produce a mix having a temperature, when being shipped from the plant site, that is $\pm 25^\circ\text{F}$ within the target mixing temperature of 325°F . If approved Warm Mix additives or technologies are used, the mixing temperature may be reduced by 25°F .

$$\text{PLI} = \frac{\text{Total Weight of Roller (pounds)}}{\text{Total Width of Drums (inches)}}$$

960-6.4 Compaction - Pneumatic-tired rollers shall not be permitted. Provide a minimum of two rollers which may be either vibratory, or static steel-wheeled rollers. Vibratory rollers shall be operated in static mode when compacting OGFC mixtures. Rollers used for OGFC compaction shall have an effective compactive weight in the range of 135 to 200 Pounds per Linear Inch (PLI), determined as follows:

Any variation of this equipment requirement, and the rolling pattern to be used, must be approved by the Engineer. Establish an appropriate rolling pattern for the pavement in order to effectively seat the mixture without crushing the aggregate. In the event that the roller begins to crush the aggregate, reduce the number of coverages or the PLI of the rollers. If the rollers continue to crush the aggregate, use a tandem steel-wheel roller weighing not more than 135 lb/in (PLI) of drum width. Complete finish rolling before the mat reaches a temperature of 240°F .

To minimize adhesion to the drum during the rolling operations, the Contractor may add liquid detergent to the water in the roller.

**SPECIAL PROVISION 960
GROUND TIRE RUBBER MODIFIED ASPHALT
CONCRETE FRICTION COURSES**

Compact GG MD AR mixtures according to Section 401-4.12 and meet acceptance requirements of Section 401-7.02 Compact GG SD AR mixtures according to Section 959-5.12 and meet acceptance requirements of Section 959-6.01.

960-6.5 Opening to Traffic - At intersections and in other areas where the pavement may be subjected to cross-traffic before it has cooled, spray the approaches with water to wet the tires of the approaching vehicles before they cross the pavement. Traffic shall not be allowed on the finished mat until the pavement layer has cooled to 140°F unless approved by the Engineer.

960-7 THICKNESS CONTROL

The Engineer will monitor the spread rate periodically, based on Equation 1, to ensure uniform thickness. The calculated spread rate is based on the bulk specific gravity of the asphalt mix at the Job Mix Formula asphalt content. If the spread rate varies by more than 5% of the spread rate set by the Engineer or specified in the plans, immediately make all corrections necessary to bring the spread rate into the acceptable range. The total thickness of the layer will be the plan thickness as shown in the Contract Documents.

Spread rate (lbs/yd²) = t x Gmb x 46.8 **(Equation 1)**

Where:

- t = Thickness (in.) (Plan thickness)
- Gmb = Bulk specific gravity of the mixture at the specified asphalt content (from the verified mix design)

Layer thickness of Open and Gap-Graded mixtures shall be within the ranges specified in Table 960-5.

TABLE 960-5 Mixture Thickness

Layer Thickness	OGFC Mixtures		Gap-Graded Mixtures		
	OGFC AR 38	OGFC AR 12	GG AR 38	GG AR 12	GG AR 34
Minimum	3/4 inch	1 inch	1 inch	1.25 inches	1.75 inches

**SPECIAL PROVISION 960
GROUND TIRE RUBBER MODIFIED ASPHALT
CONCRETE FRICTION COURSES**

Maximum	1 inch	1.5 inches	1.5 inches	2 inches	2.5 inches
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960-8 METHOD OF MEASUREMENT

For the work specified under this Section, the quantity to be paid for will be the weight of the mixture in tons. The bid price for the asphalt mix shall include the cost of the virgin asphalt binder, GTRM, anti-stripping agent, as well as blending and handling. There will be no separate payment or unit price adjustment for the GTRM material in the asphalt mix.

960-9 BASIS OF PAYMENT

960-9.1 General - Price and payment will be full compensation for all the work specified under this Section. Based on the quality of the material, a pay adjustment will be applied to the bid price of the material as determined on a LOT by LOT basis. The pay adjustment will be assessed by calculating a Pay Factor for individual quality characteristics. The pay adjustment will be computed by multiplying a Composite Pay Factor for the LOT by the bid price per ton.

960-9.2 AR 38, AR 12, and GG Mixtures - Material Acceptance and payment for mixtures designed and produced using Superpave criteria will be based on the requirements of Section 959-6. Acceptance and payment for mixtures designed with Marshall procedures will be based on Section 401-7.02.

960-9.3 OGFC - Acceptance and payment for OGFC mixtures shall be according to the requirements of Section 959-6 with the following exceptions:

1. Pay factors will be calculated for asphalt binder content and the percent passing the 3/8 inch, the No. 4, and the No. 8 sieves only. The composite pay factor (CPF) shall be calculated as follows:

$$CPF = [(0.20 \times PF \text{ 3/8 inch}) + (0.30 \times PF \text{ No. 4}) + (0.10 \times PF \text{ No. 8}) + (0.40 \times PF \text{ AC})]$$

2. Table 960-6 replaces Table 959-11. In the event that two or less subplot test results are available for a LOT, Pay Factors will be determined based on Table 960-5 using the average of the accumulated absolute deviations from the target value. (Deviations are absolute values with no plus or minus signs.) Use the 1-Test column when there is only one subplot test result and use the 2-Tests column when there are two sublots.

**SPECIAL PROVISION 960
GROUND TIRE RUBBER MODIFIED ASPHALT
CONCRETE FRICTION COURSES**

TABLE 960-6 OGFC Pay Factors for Test Results Involving Small Quantities

Pay Factor	1-Test Deviation	2-Test Average Deviation
Asphalt Binder Content (%)		
1.00	0.00-0.50	0.00-0.35
0.90	0.51-0.60	0.36-0.42
0.80	>0.60	>0.42
3/8 inch Sieve (%)		
1.00	0.00-6.50	0.00-4.60
0.90	6.51-7.50	4.61-5.30
0.80	>7.50	>5.30
No. 4 Sieve (%)		
Pay Factor	1-Test Deviation	2-Test Average Deviation
1.00	0.00-5.00	0.00-3.54
0.90	5.01-6.00	3.55-4.24
0.80	>6.00	>4.24
No. 8 Sieve (%)		
1.00	0.00-3.00	0.00-2.12
0.90	3.01-3.50	2.13-2.47
0.80	>3.50	>2.47

960-9.4 Control Strip Section – Control Strip Section will be paid at the contract unit price per unit of measurement. Such price and payment shall constitute full compensation for the cost of cold milling, if required, preparation of the surface to be paved; the furnishing and placing of any required prime and tack coat; and the furnishing, placing, compacting and finishing of all required materials for the control strip section; and for all labor equipment, tools and incidentals necessary to complete said work.

960-10 Payment: Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
OGFC AR, Type (38 or 12) ¹	Ton
GG AR, Type (MD (50 or 75)) ² (38, 12 or 34) ¹	Ton
GG AR, Type (SD (TL)) ³ (38, 12 or 34) ¹	Ton
SDG AR, Type (TL) ⁴ (38 or 12) ¹	Ton
MDG AR, Type (50 or 75) ⁵ (38 or 12) ¹	Ton
Control Strip Section	Ton

**SPECIAL PROVISION 960
GROUND TIRE RUBBER MODIFIED ASPHALT
CONCRETE FRICTION COURSES**

Important Notes:

¹ Indicate the applicable Nominal Maximum Aggregate Size (NMAS) of Mix as follows:

38 = Mix NMAS of 3/8-inch

12 = Mix NMAS of 1/2-inch

34 = Mix NMAS of 3/4-inch

² Indicates that the GG AR mixture will be designed using Marshall procedure and the number in the parenthesis indicates the number of applicable hammer blows (AASHTO T 245).

³ Indicates that the GG AR mixture will be designed using Superpave procedure and the number in the parenthesis is the traffic level indicated in contract.

⁴ The number in the parenthesis is the traffic level indicated in contract.

⁵ The number in the parenthesis indicates the number of applicable hammer blows (AASHTO T 245).