PRELIMINARY STUDY IN THE DEVELOPMENT OF A METHOD FOR EVALUATING THE RELATIVE POLISHING CHARACTERISTICS OF BITUMINOUS PAVING MIXTURES

by

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I. INTRODUCTION

Research on pavement skid resistance has been conducted by the Texas Highway Department since the early 1960's. This has included the use of the skid trailer for pavement evaluations and the accelerated polish test for predicting the service of paving aggregates.

The proposed tentative procedure described within this report is the first attempt to provide an accelerated method for characterizing the relative polishing behavior of bituminous mixes.

II. MATERIALS AND METHODS

Samples of laboratory molded bituminous mixes used in this study were obtained from routinely submitted HMAC Hveem specimens received from field projects by the Materials and Tests Division. Prior to use in this study the Hveem samples had been tested for stability in accordance with Test Method Tex-208-F. Information as to asphalt type and percentage along with aggregate type and gradation accompanied each Hveem specimen.

After selection, the Hveem specimens are cut with a diamond-bladed rock saw into slabs approximately 3-1/2" x 1-5/8" x 1/4" (Figures 1 and 2). Tap water is used as coolant and cutting lubricant in the diamond saw.(1)

(1) Note: Friction of cutting the Hveem specimens into proper sized slabs will cause the temperature of the tap water to rise about 20 F in 15 minutes (58 F to 78 F). After cutting several specimens it may be desirable to change the water in the saw or circulate cool tap water.

The cuts are made such that the surfaces to be evaluated are from the top and bottom of the molded specimens. The slabs are placed into steel molds with the test surface inverted next to the mold face and cast into position with a polyester bonding agent (Figures 3 and 4). Before casting, the molds along with the specimen slabs are placed in an oven with sufficient heat to allow the slab to conform to the curved shape of the molds.(2) The steel molds, polyester and casting procedures are described in Test Method Tex-438-A. After the polyester has hardened completely (2-3 hours), the molds are disassembled and the test coupons removed (Figure 5).

When properly labeled for identification, each test coupon is tested for its initial frictional value by means of a British Portable Tester (BPT) in accordance with the method outlined in ASTM E 303 (Figure 6). The coupons are then placed on the British Accelerated Polishing Machine (Figure 7). The description of the polishing machine along with the amounts of water and silicon-carbide grit which are applied during the test are also noted in Test Method Tex-438-A. The polishing machine wheel on which the test coupons are clamped is capable of accommodating 14 test specimens.

The machine may be stopped at any time during the test cycle, the specimens removed from the wheel and tested with the BPT at any specified time interval. The frictional readings are recorded together with the length of time tested.

(2) Note: For most HMAC slabs cut to about 1/4" thick, oven temperatures of about 150 F were found to be adequate to allow the slab to conform to the mold in about 8 minutes. For samples 3/8" thick, 10-12 minutes is required, and slightly higher temperature (180 F) is necessary for limestone rock asphalt pre-mix.

During the test the specimens are subjected to centrifugal forces capable of disrupting bituminous material if poorly densified or cracked.

III. RESULTS AND DISCUSSION

During the developmental phase of this study six major aggregate types were examined and tested according to the outline described herein. These types included a synthetic lightweight aggregate from Eastland County, a synthetic "burned clay" from Beaumont, a sandstone from McMullen County, a crushed limestone from Wise County, a siliceous river gravel from Brazos County and limestone rock asphalt from Uvalde County.

The polishing-rate "curves" for the six sources are plotted on a graph illustrated as Figure 8. In general, the rate of polishing matches the polishing characteristics exhibited by material of each of the types as shown in previous tests by the standard accelerated polish test. The data for the lightweight aggregate and the siliceous gravel include readings only up to 9 hours. Readings for the other four sources are shown up to 13 hours. As shown in Figure 8, the graph for the lightweight aggregate indicates only a slight drop in readings from initial to final readings. Also the sandstone shows about the same from initial to final readings; however, both the limestone and gravel samples showed a significant drop in frictional properties during the test.

The various fluctuations reflected by the curves are probably the result of more than a single factor. The texture of the HMAC Hveem specimens, asphalt type and content, density of the specimens and the ratio of fine to coarse aggregate exposed as well as the composition of both the fine and coarse aggregate affect the frictional properties.

Figures 9 and 10 show close-up views of the polished test surface of coupons containing sandstone and limestone. Note the ratio of matrix to aggregate exposed in the test surfaces. The limestone sample shows considerable polishing and felt smooth to the touch, whereas, the sandstone specimen still felt gritty.

Failure by disruption and raveling of individual test specimens has been a problem during this developmental study. A number of possible conditions may result in sample failure including cutting the material too thin with the rock saw, casting with polyester while the material is too wet, inadequate compaction of the mix and transverse cracking of the sample when shaping to the mold. The speed (325 rpm) of the specimen wheel produces centrifugal forces which often cause break-up of the test coupons as early as 30 minutes, yet some have been tested in excess of 10 hours without failure.

Figure 11 shows test coupons which failed by disruption and raveling (Coupons S, T and O) as compared to one that tested for 13 hours without any signs of failure (Coupon P).

As a result of this pilot study, research efforts are underway to correlate laboratory polishing rates with in-service polishing rates on identical bituminous mixes. Pavements with known traffic density and skid resistance (as measured by the skid trailer) will be selected. It is hoped that this investigation will provide suggestions for improved mix designs with assurance of better skid resistance.

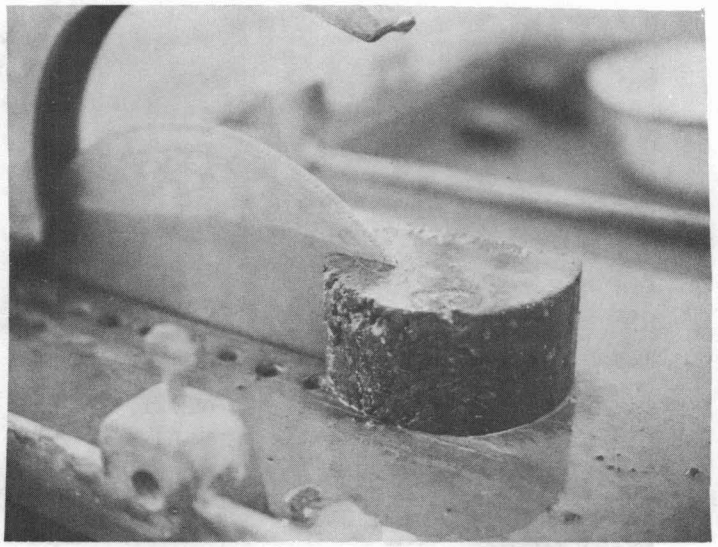

Fig. 1 A 4" diameter HMAC Hveem specimen is cut with a diamond-bladed rock saw.

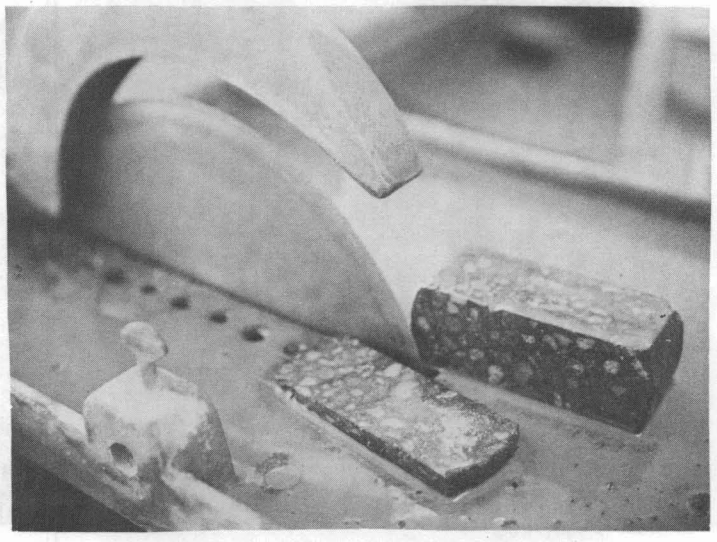

Fig. 2 Thin slabs 3-1/2" x 1-5/8" are sawed from the bituminous specimens. Slices from the top and bottom surfaces are used for testing.

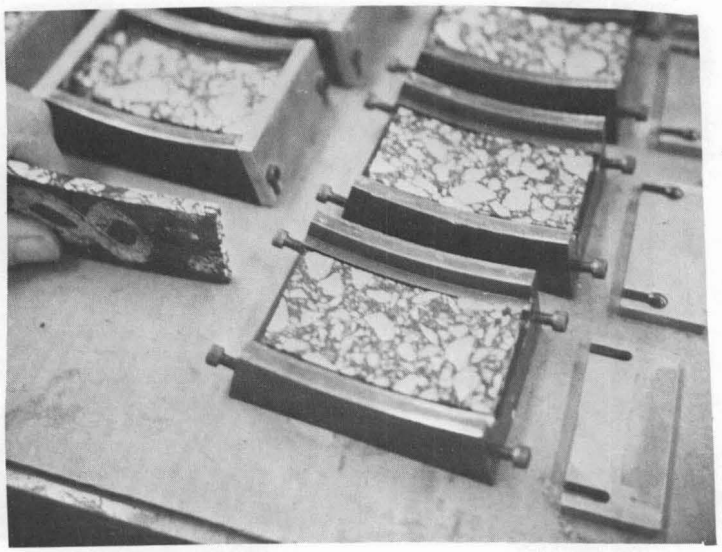

Fig. 3 The thin slabs are placed into steel molds for casting. The test surface is placed face down and the sawed surface up as shown.

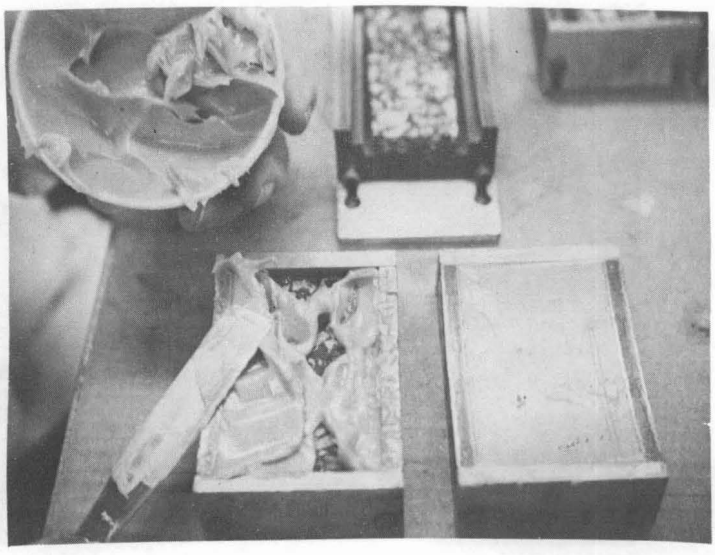

Fig. 4 A polyester bonding material is used to cast the test coupon. After 2-3 hours the polyester hardens sufficiently for the coupon to be removed.

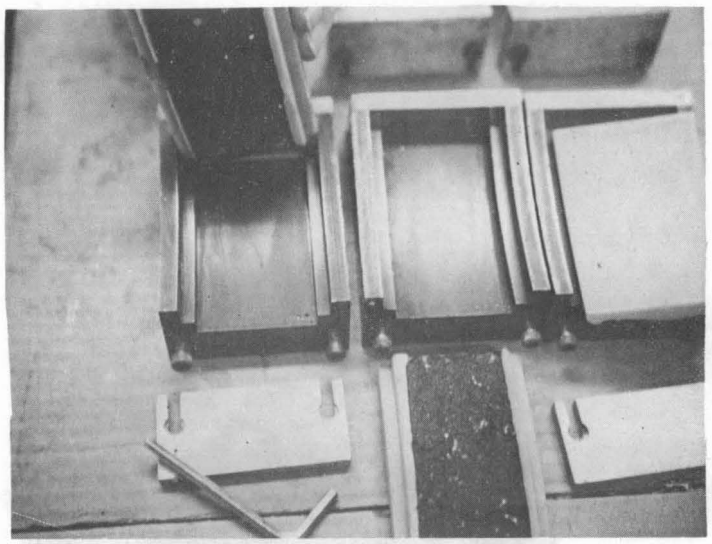

Fig. 5 Test coupons being removed from the steel molds.

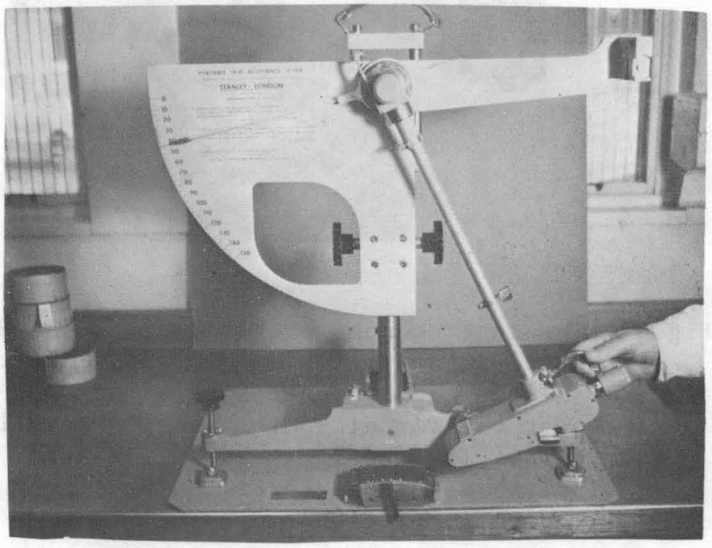

Fig. 6 Test coupons being tested for relative frictional property with a British Portable Tester.

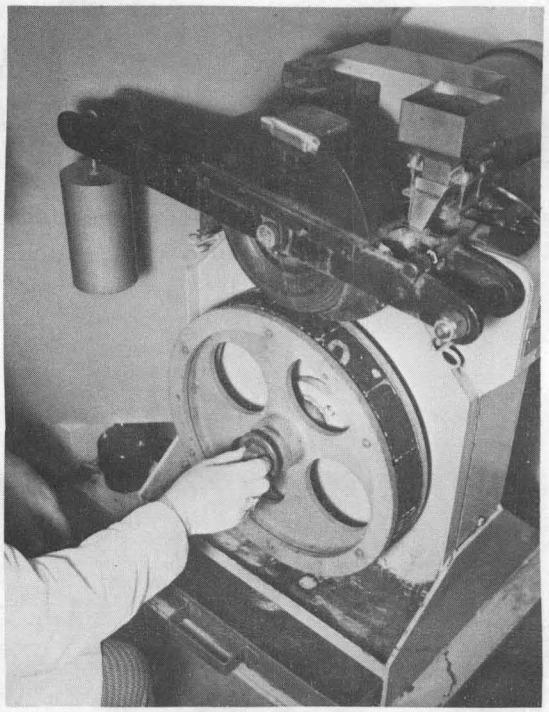

Fig. 7 The test coupons are clamped to the British Accelerated Polishing Machine. Water and silicon carbide grit are fed onto the wheel near the contact point with the small rubber tire. The wheel rotates at 325 rpm. A splash shield encloses the specimen wheel when in operation.

POLISHING CHARACTERISTICS OF HMAC LABORATORY MOLDED SPECIMENS

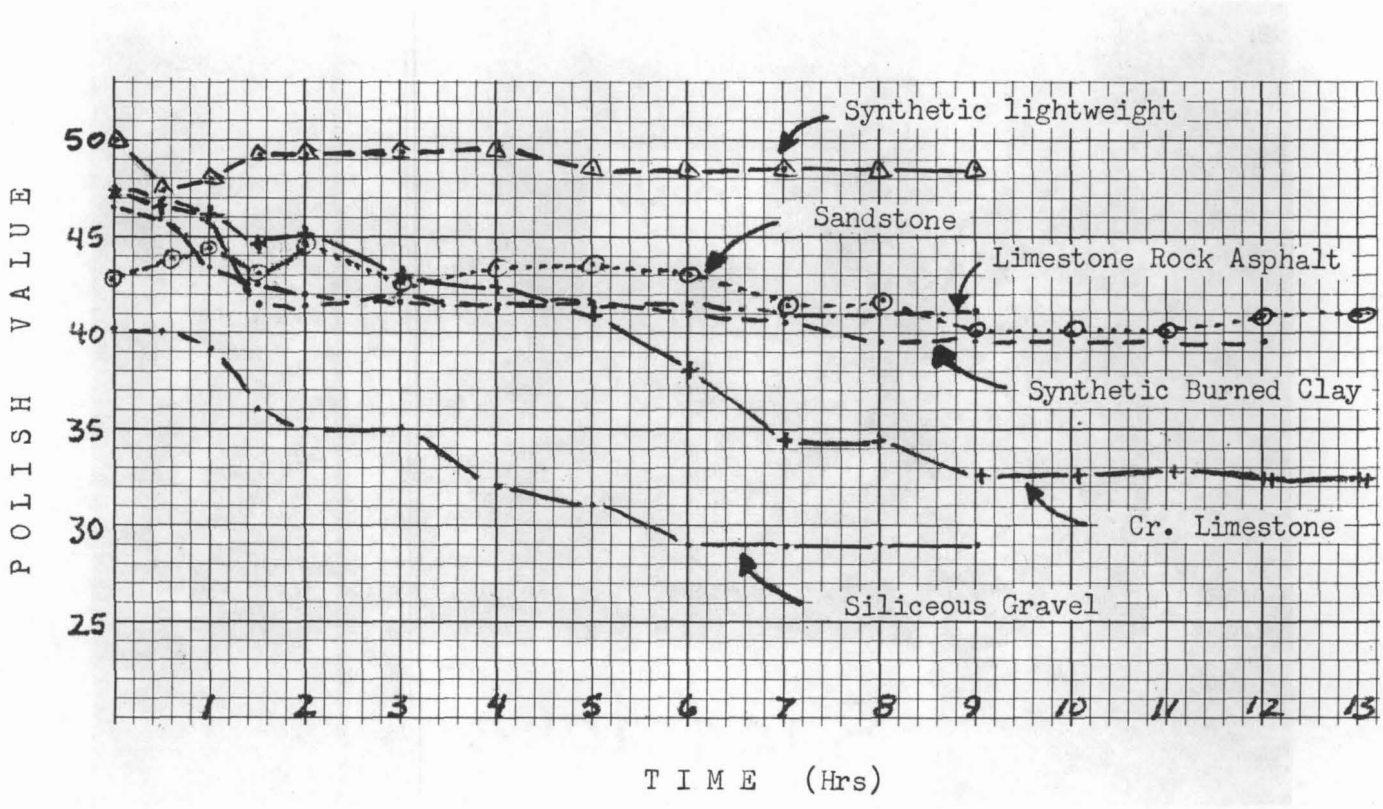

Figure 8

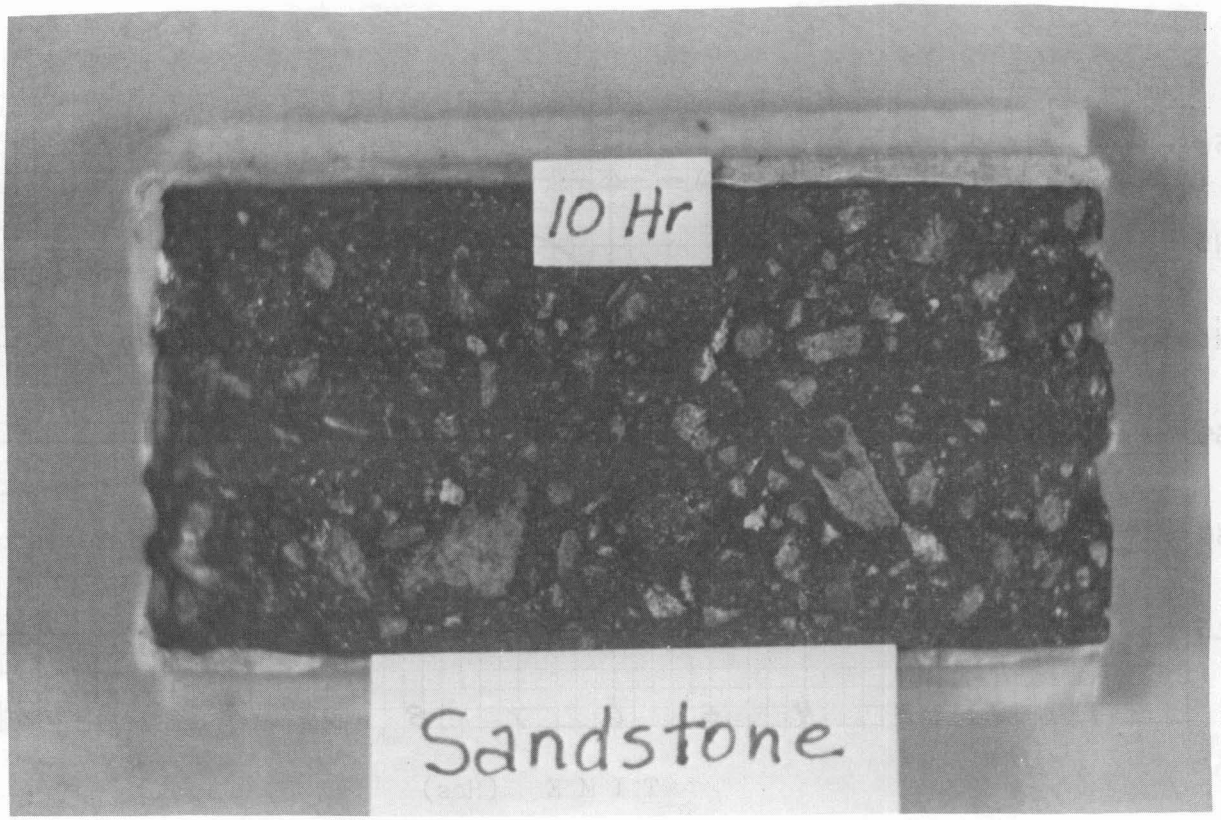

Fig. 9 Polish test coupon composed of sandstone aggregate from McMullen County shown at the completion of 10 hours of accelerated polishing. At the end of 13 hours, the polish value measured a 41. (Mag. 1.5X)

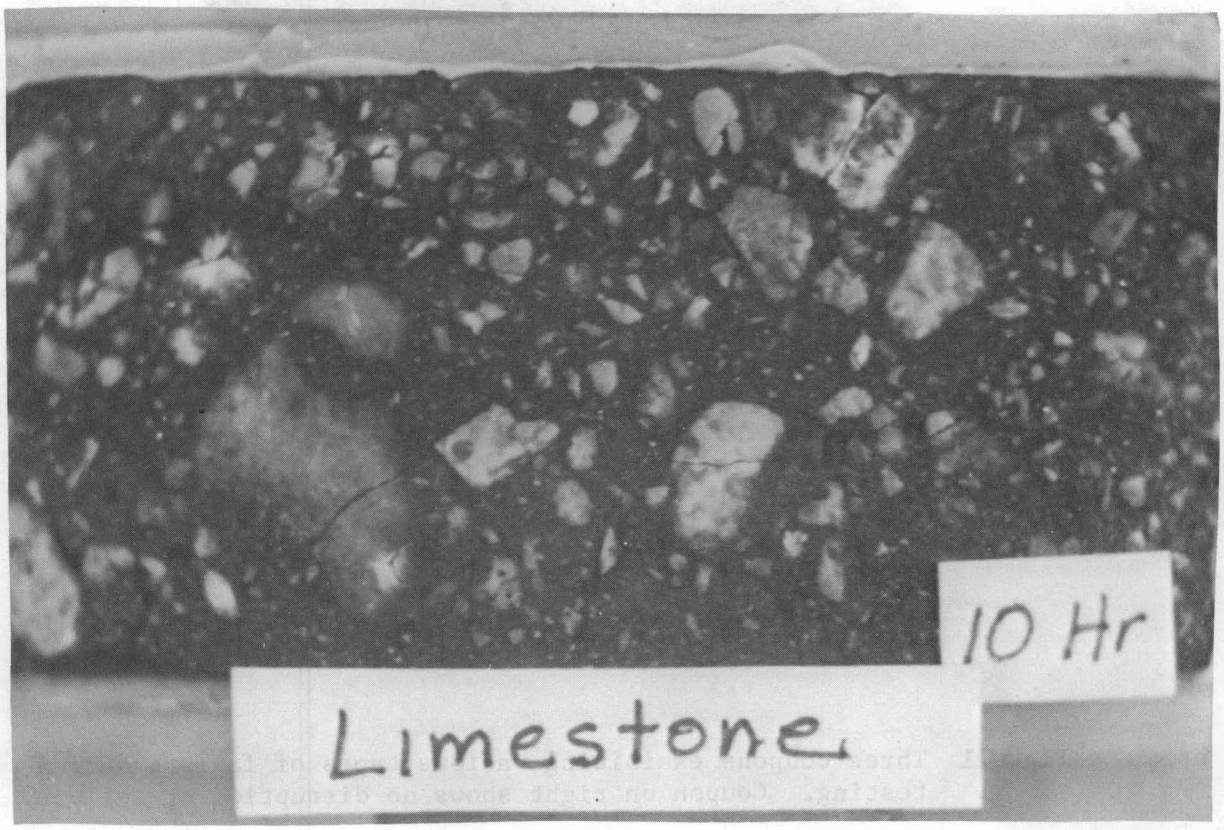

Fig. 10 Polish test coupon composed of limestone from Wise County as shown after 10 hours of accumulated polishing. The initial frictional reading as measured by the British Portable Tester was 47 compared to a final reading of 32 after 13 hours.

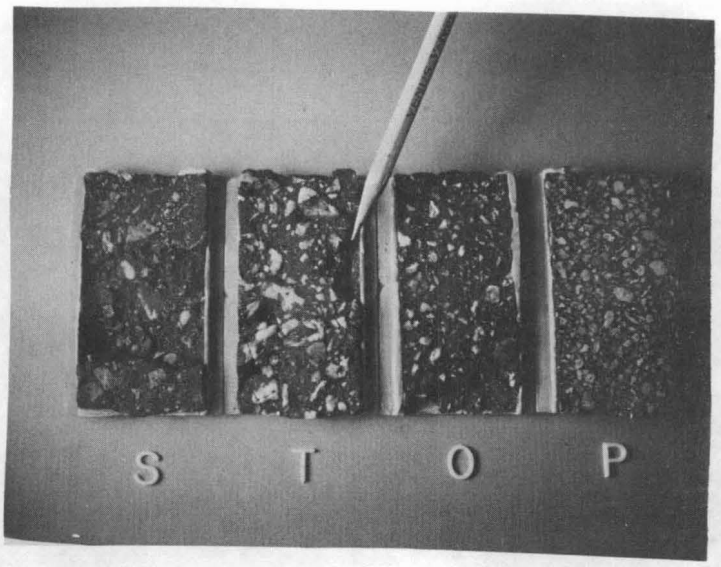

Fig. 11 Three coupons exhibiting various types of failure during testing. Coupon on right shows no disruption or failure.

APPENDIX

Test Method Tex-438-A
Rev: January 1, 1974

Texas Highway Department

Materials and Tests Division

ACCELERATED POLISH TEST FOR COARSE AGGREGATE

Scope

This test method describes a procedure for determining a relative measure of the extent to which aggregate in the wearing surface of the roadway will polish under traffic.

The aggregate samples under test are mounted on a specimen wheel to form a test strip 16 inches in diameter and subjected to the rolling action of a rubber tire. Size 150 silicon carbide grit and water are used to speed up the rate of wear.

The Polish Value is determined using a modified form of ASTM Designation: E 303.

Definitions

Friction Value: The average of a set of initial readings on the test specimen before being polished in the accelerated polish machine.

Polish Value: The average of a set of readings on the test specimens after nine hours of polishing in the accelerated polishing machine.

Sampling

A 30 pound sample representing production designated for highway use shall be submitted by a representative of the Texas Highway Department. The sample shall be properly identified on Form 202 and the name of the pit or quarry and its exact location shall be explicit.

Apparatus

1. A Wessex Accelerated Polishing Machine based on a design of the Research Laboratory of Great Britain.

2. Metal Molds to form a test specimen 3.50 inches long by 1.75 inches wide by 0.63 inches deep.

3. A British Portable Tester to measure the Friction Value and the Polish Value of the test specimens in accordance with ASTM Designation: E 303 modified as follows:

A. The slider contact path shall be $3 \pm 1/16$ inches.

B. The slider width shall be $1\text{-}1/4 \pm 1/16$ inches.

C. The rubber which is bonded to the slider shall conform to a 1 x 1-1/4 x 1/4 inch dimension ($\pm$ 1/16 inch tolerance).

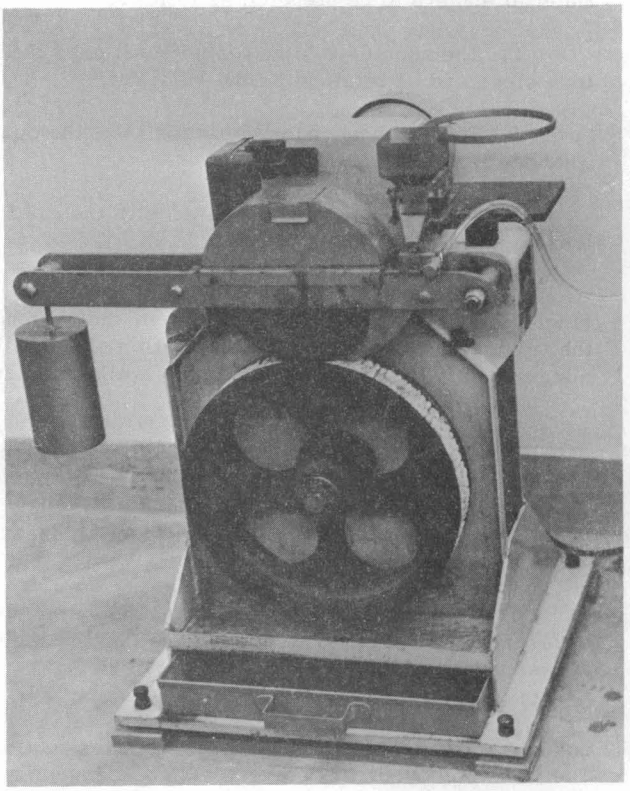

Figure 1

Wessex Accelerated Polishing Machine Showing Test Specimens Mounted on Specimen Wheel

Materials

1. Tap water.

2. Ottawa sand, Grade 20-30 meeting ASTM Designation: C 190.

3. Polyester Resin and catalyst for bonding agent with a pot life of about 20-30 minutes and a curing time of 3-6 hours.

4. Mold Release Agent for use with polyester bonding agent.

5. Silicon Carbide Grit (150 size).

6. A supply of disposable cups and stirring rods for use in mixing the bonding agent.

Preparation of Test Specimens

At least seven specimens are required for each material and are to be prepared as follows:

1. The aggregate to be tested shall pass the 1/2 inch sieve and be retained on the #4 sieve.

2. The screened aggregate shall be thoroughly washed clean and dried.

3. The molds shall be coated with the mold release agent.

4. The aggregate particles shall be placed in a single layer as closely as possible in the bottom of the molds. Aggregate particle orientation should allow adequate surface area for polishing as well as bonding.

Note: Flat, elongated, or unusually shaped particles may cause some difficulty in placement. If used, these should be placed to ensure adequate bonding, but misleading Polish Values may result from inadequate surface area for polishing.

5. The interstices between the aggregate particles shall be filled with the Ottawa sand to a depth between 1/4 to 1/2 the particle height.

6. Prepare the polyester resin and catalyst for bonding agent according to manufacturer's instructions. The consistency of the polyester shall be such as to allow it to flow freely between the particles, but not so thin as to flow into the Ottawa sand.

7. Fill prepared mold to capacity with the polyester bonding agent.

8. When the bonding agent has stiffened sufficiently, strike off the bonding agent level with the curved sides of the mold.

9. Leave specimen in the mold for a sufficient length of time (3-6 hours) to allow the bonding agent to cure properly.

10. Remove specimen from the mold and brush any excess sand from the specimen face.

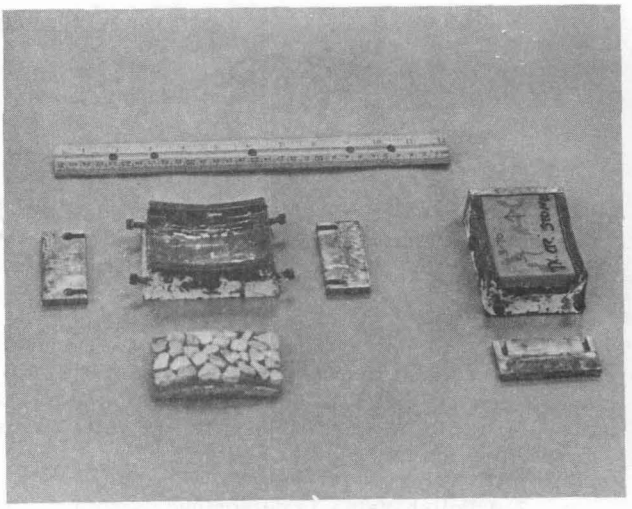

Figure 2

Metal Molds With Test Specimens

Procedure

1. Calibrate the British Portable Tester in accordance with ASTM Designation: E 303 as modified in "Apparatus", part 3.

2. Determine the Friction Value of the prepared test specimens in accordance with ASTM Designation: E 303, as modified in "Apparatus", part 3. The Friction Value is used for reference purposes.

3. A total of fourteen specimens shall be clamped around the periphery of the specimen wheel of the Wessex Accelerated Polishing machine. A rubber O-ring is placed on both edges of the test specimens to hold them against the specimen wheel. The wheel flanges are then bolted into place pressing down upon the O-rings and edges of the specimen firmly holding them in place.

A minimum of at least seven specimens of each material shall be tested to allow statistical accuracy. Dummy specimens may be used to completely fill the wheel if only one material is to be tested. The outer surface of the specimens shall then form a continuous strip of particles upon which the rubber tire shall ride freely without bumping or slipping.

4. The specimen wheel shall be brought to a speed of 320 $\pm$ 5 rpm. The rubber tire wearing wheel, inflated to 45 $\pm$ 2 psi, shall be brought to bear against the specimen wheel and loaded to 88 $\pm$ 1 pounds.

5. Silicon carbide grit (size 150) shall be continuously fed to the specimen wheel near the tire contact point at a constant rate of approximately 6±2 grams per minute along with water fed at the rate of about 50 to 75 milliliters per minute.

6. The polishing action shall be continued for a total period of nine hours.

7. The samples shall be removed from the specimen wheel and washed thoroughly to remove grit.

8. After cleaning, the samples shall be tested for Polish Value with the British Portable Tester as specified in ASTM Designation: E 303 and modified above.

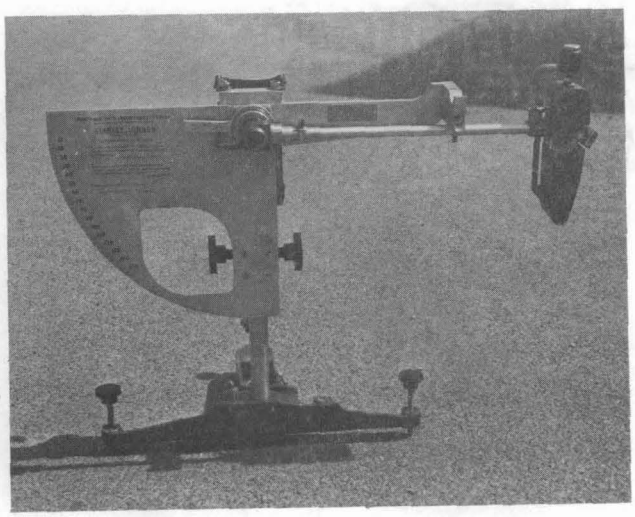

Figure 3

British Portable Tester

Report

The final report shall include the following information:

1. Information from Form 202.

2. Initial Friction Values and their average for each specimen tested.

3. Final Polish Values and their averages for each specimen tested.