"Spraygrip"

Epoxy Non-Skid Seal

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

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STATE HIGHWAYS AND TRANSPORTATION

"Spraygrip"
Epoxy Non-Skid Seal

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Bituminous Unit

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Introduction

"Spraygrip is a proprietary product of Prismo Universal Corporation. It is used as a skid resistant treatment over old pavements. Spraygrip is composed of an asphalt extended two-component epoxy binder and calcined bauxite aggregate. The bauxite is sized such that 100 percent will pass a 1/4-inch square opening sieve. The cost, $10.00 per square yard, is expensive but for special applications where thickness is a serious problem, this material may prove to be valuable. Prismo provided the MDSH&T a three year warranty which states that the material will be replaced if it fails.

History

In the fall of 1972, on Project MS 63031/04705A, Spraygrip skid proofing was applied to an old concrete pavement on southbound Telegraph Road at the intersection of 10 Mile Road and also, to an old bituminous pavement on 10 Mile Road where it intersects with the west side of Telegraph Road. The two component resin was applied at a rate of approximately 2.5 lbs per square yard and the bauxite was applied at an excess rate of approximately 12.5 lbs per square yard. The bituminous pavement was not cleaned but the concrete pavement was cleaned lightly with a Tennant grinder before the Spraygrip was applied.

Within one month of the application, the Spraygrip began peeling from the concrete in small areas and larger areas were loose. (December 5, 1972 letter from Mr. Paul J. Serafin to Mr. Max R. Hoffman, Subject: "Spraygrip" Two Month Evaluation; Project MS 63031/04705A.)

By April 27, 1973 large areas had peeled from the old concrete with the rate of peeling increasing sharply. Mr. D. E. Orne recommended to Mr. Max N. Clyde, in his letter on "Spraygrip" repair, dated May 10, 1973, that all Spraygrip be removed from the old concrete. The Spraygrip treated area on the old bituminous pavement showed no peeling at this time.

The Oakland County Road Commission removed the remaining Spraygrip from the old concrete with a motor grader without problem in June 1973.

Prismo Univeral Corporation reapplied the Spraygrip to the old concrete in the fall of 1973. They tried several methods of treating the old concrete before reapplication of the Spraygrip.

Specifications

Technical specifications from the project proposal are attached. They include all specifications for the aggregate and two component asphalt modified binder except the proportions of A and B which were to be mixed together.

Construction

Spraygrip was applied to approximately 3,700 sq yd of all concrete pavement on the Telegraph Road and 10 Mile Road intersection between 9/27/73 and 10/11/73. (See Figure 1) Prismo Universal Corporation experimented with several variations of surface preparation and treatment before the Spraygrip was applied. These are as follows (See Figure 1):

1. Prismo Prime only
2. Sand blast with Prismo Prime
3. Sand blast without Prismo Prime
4. Ground with Tennant grinder with Prismo Prime
5. Ground with Tennant grinder without Prismo Prime

The air temperature varied from 46F to a high of 78F during the six day construction period.

Materials used on the job were:

Bauxite Aggregate - Gugann, Brazil, South America
Epoxy - Prismo Universal Corp.
Prismo Prime - Adhesive Products Co., Bronx, N.Y.

The area to be primed was sprayed with two parts resin No. T-243 and one part hardner, No. T-166. The prime was allowed to dry before application of Spraygrip.

Spraygrip was applied by mixing the Epoxy proportions, 1 part component A No. V8849 and 1 part component B No. V8849 and spraying simultaneously on the pavement with a distributor at a rate of approximately 2.5 lbs per square yard. This was followed immediately with an excessive amount of bauxite chips applied at a rate of approximately 12.5 lbs per square yard was applied with a 4 ft wide chip spreader.

Testing

The contractor sampled the epoxy from the spray bar after completion of a section pavement, poured the material into the appropriate pan, allowed the epoxy to harden, and turned the samples over to the MDSH&T. The Research Laboratory conducted tests on these samples and the test results are as follows:

Date Sampled	Tensile Strength (psi)	Elongation Percent	Thickness Average inches	Absorption Percent 24 hrs/water
Specifications	1500-2500	30-70	0.1 to 0.2	
9/30/73	610	72±	0.106	0.37
10/4/73	2410	22.4	0.082	0.23
10/8/73	260	90±	0.085	0.87
10/11/73 (am)	3060	11.2	0.078	0.19
10/11/73 (pm)	3520	5.0	0.058	0.22

"The above material was cured at room temperature and was tested on 11/19/73." "The results indicate considerable variability, possibly in the 1:1 ratio of the two liquid components in the field application." as per the Research Laboratory.

Skid tests were taken on the cured Spraygrip by the Research Laboratory on 10/29/73 with the results as follows:

Test Location	Lane	Coefficient of WSF		
		Low	High	Avg.
Telegraph Rd. Imm	SBRT	0.77	0.81	0.79
N of 10 Mile Road	SBOL	0.82	0.87	0.85
	SB#3	0.77	0.79	0.78
	SB#2	0.85	0.86	0.85
	SB1L	0.82	0.83	0.83
10 Mile Rd. Imm	EB	0.73	0.78	0.75
W of Telegraph Rd.	EBRT	0.69	0.74	0.72
	EB	0.65*	0.66*	0.66*
	EBRT	0.67*	0.70*	0.68*

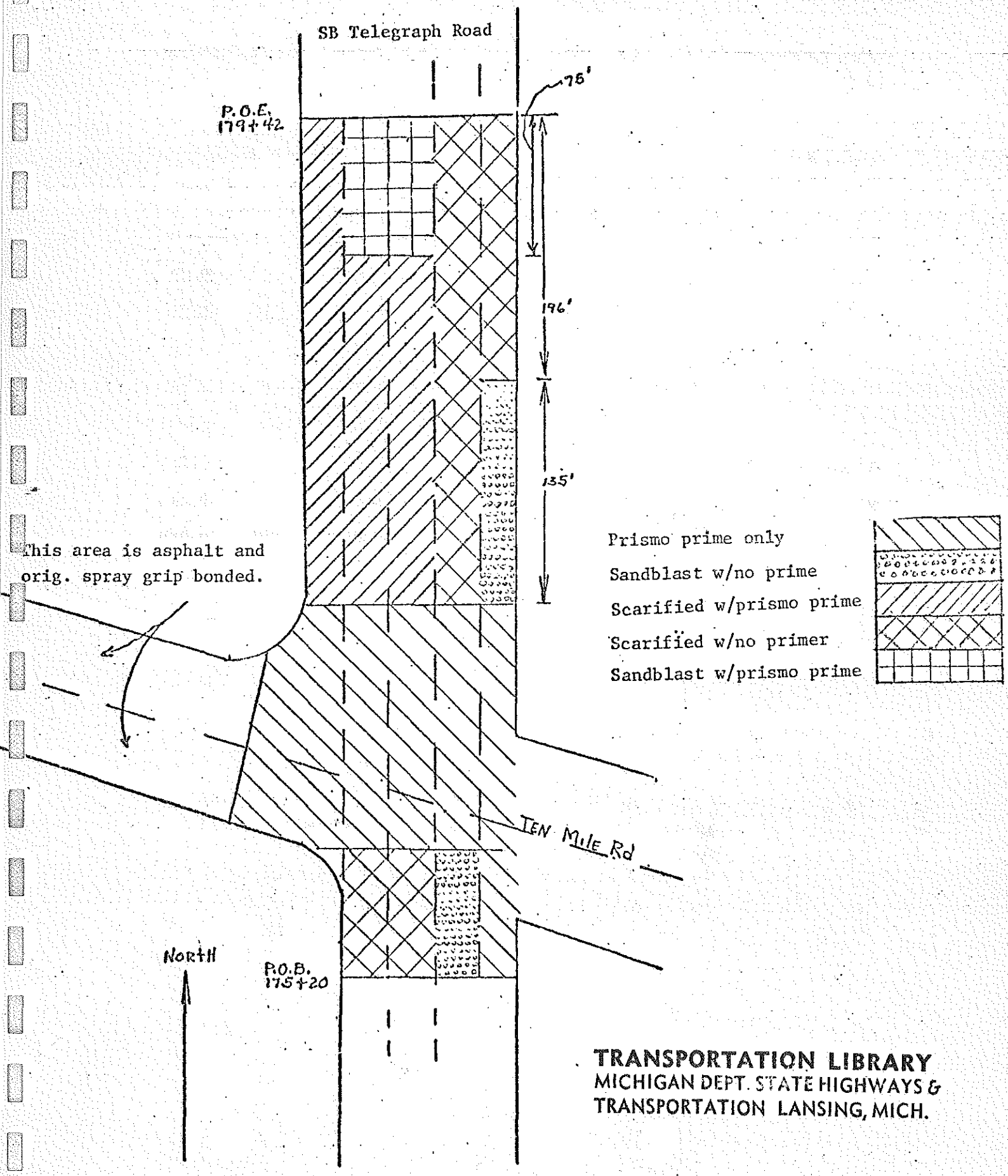
*Skid test results conducted on Spraygrip applied fall of 1972.

Conclusion

The Spraygrip applied to the old bituminous pavement in the fall of 1972 still has good skid resistance and shows no signs of peeling.

The Spraygrip application on old concrete placed in the fall of 1972 peeled off completely within 6 months. Therefore, it is felt that the second Spraygrip application (fall 1973) should be observed for at least 1-1/2 years before any decision is made for further use. The different types of preparation of old concrete surfaces should also be evaluated at this time.

Figure 1



TECHNICAL SPECIFICATION

ANTI-SKID PAVEMENT TREATMENT

1. SCOPE

This specification covers an anti-skid treatment applied to highway pavements using specialized equipment and a trained team of technicians. The treatment consists of a two-component resin applied uniformly over the pavement and which is flooded with a polish resistant aggregate.

2. MATERIALS

2.1 Binder

The binder shall be a chemically curing two-component compound, the two components to be metered in proper proporations and homogenized immediately prior to application to the pavement. This material shall provide a good adhesion to clean asphalt and concrete pavements and shall bind a properly applied skid-resistant aggregate.

2.1.1 Cure Time of the Binder

The cure time shall be the period of time after application of binder during which the pavement must be closed to traffic. This critical period of time is temperature dependent according to the following tabulation:

Surface Temperature	Cure Time (Maximum)
60°F	5 hours
75°F	3 hours
95°F	1½ hours
110°F	1 hour

2.1.2 Tensile Strength of the Binder

The tensile strength of the cured resin binder without aggregate shall be between 1500 and 2500 pounds per square inch, determined

according to ASTM Method of Test D638-64T (Test Speed B). The test specimen shall conform to ASTM Method D412-66 (Die C). The specimen shall be between 0.1" and 0.2" in thickness and shall be cured at a temperature between 50°F and 90°F for 5 to 8 days, and the test shall be performed at a temperature of 75°F ± 4°F. The cured sample shall be sufficiently large that 6 specimens may be cut from it. The percent elongation at rupture shall be between 30% and 70%.

2.2 Aggregate

The aggregate shall be calcined bauxite (RASC Grade) calcined at a temperature no less than 1600°C (2912°F).

2.2.1 Aggregate Gradation

Sample conformity to this specification shall be determined using ASTM Method of Test C136-67. Sampling of the bulk material, which shall be supplied in 50-lb bags, shall be accomplished according to ASTM Recommended Practice E105-58. The product gradation shall be within the following limits:

U.S. Standard Sieve Size		Percentage	
Passing	Retained	Minimum	Maximum
-	6	0	3
6	7	5	15
7	16	80	95
16	30	0	2
30	-	Trace	

2.2.2 Chemical Analysis

The aggregate shall conform to the following chemical analysis:

Aluminum Oxide	Al_2O_3	86%
Iron Oxide	Fe_2O_3	2.5%
Silica	SiO_2	7.5%
Titanium Dioxide	TiO_2	4%

The above percentages may vary ±10% of the value indicated.

2.2.3 Physical Characteristics

Hardness: The material shall possess a Mohs hardness value no less than 8.

Crushing Value: The aggregate shall have an aggregate crushing value of no more than 30, as determined by the method described in Appendix A.

Aggregate Abrasion Value: The aggregate abrasion value shall be no more than 4, as determined by the method of test described in Appendix B.

Polish Resistance: The polished stone value for the aggregate shall be no less than 70, as determined by the method of test described in Appendix C.

3. PREPARATORY TREATMENT OF THE PAVEMENT

The pavement surface shall be thoroughly swept clean of dust and loose foreign bodies, using a stiff broom or a street-sweeping machine. Any oil visible on the surface shall be removed by washing and scrubbing with a weak solution of detergent followed by a clean water flush.

The pavement shall be allowed to dry of free water, subsequent to the cleaning operation.

Permanent fixtures, manhole covers and other street furniture shall be masked where required.

4. APPLICATION EQUIPMENT

The resin shall be applied onto the pavement by a mechanical sprayer. This unit shall be capable of accurage and continuous combination of the two components of the resin system, mixing them thoroughly into a homogeneous state prior to uniformly spraying the mixture onto the pavement. In order that the mixture be reproducible regardless of ambient temperature variations, the two components shall be heated to predetermined temperatures controlled to assure that the sprayed mixture is proportioned to within two (2%) percent by weight of the nominal specified proportions. Volume flowmeters for each component shall be calibrated to the precision required to assure this accuracy in proportioning.

The application equipment shall be capable of spraying the resin binder onto the pavement with a uniformity such that the thickness of binder collected on any strip two inches (2") wide, anywhere within

the width of the spray bar, shall not vary by more than ten percent (10%). Furthermore, the mean amount of binder collected on any four adjacent strips shall not differ from the amount collected on any one of the strips by more than five percent (5%). The contractor shall provide a certificate of compliance to the requirements of this paragraph before work commences.

The equipment for applying the aggregate shall be capable of saturating the binder. A means to remove excess aggregate after complete curing of the binder shall be provided.

5. METHOD OF APPLICATION

The mixed resin system shall be sprayed onto the pavement at a rate not less than 2½ pounds per square yard. After the resin system achieves the road surface temperature and prior to gelling, it shall be saturated with aggregate at a rate of approximately 12.5 pounds per square yard. The aggregate shall be dispensed in such a manner that it does not roll and cause the exposed surface of the particles to be wet with the binder. The masking material used to prevent undesirable coverage of permanent fixtures shall be removed before the binder achieves its cure. The road shall be maintained free of traffic until the binder is cured. Immediately prior to opening the pavement to normal traffic, the excess aggregate shall be removed.

Hand application of the mixed resin system to areas inaccessible to the application equipment shall be permitted, but materials shall be mixed by weight in quantities not exceeding 20 pounds and stirred by mechanical means and spread with a serrated rubber squeegee.

6. CONTROL TESTING DURING APPLICATION

A check shall be made at the completion of each application to determine the quantities of each binder component which have been used. The volume quantities shall be converted to weights to estimate the accuracy of proportioning and the average rate of spread over the measured area of the treated pavement.

The contractor shall sample the mixed resin system from the spray bar not less frequently than one sample for each 1,000 square yards completed or for each application area, whichever is the more frequent. These samples shall be poured into a shallow tray and allowed to cure undisturbed. From these samples, tensile strength tests specimens shall be prepared and tested according to Paragraph 2.1.2 above.

7. LIMITATIONS

7.1 Weather: Since the cure time of the resin increases with decreasing temperature, the contractor must satisfy himself that adequate time is available after the end of the spraying operation and the time when the road must be opened to traffic. It is imperative that the binder be undisturbed by traffic until it achieves a full cure, requiring that the road be closed for a period of time consistent with the cure times specified in Section 2.1.1 above.

While the treatment can be applied to a damp pavement, work shall not proceed when there is free water on the surface.

7.2 Site Condition: All sites for application of the anti-skid treatment shall be inspected by qualified technical personnel prior to acceptance of the award by the contractor. Not all pavement conditions are suitable for the treatment and sites being unsatisfactory shall be specified and eliminated from the award.

8. WARRANTY

The contractor shall guarantee the application of Spray Grip anti-skid treatment against failure attributable to wear or poor adhesion to the pavement and shall replace, without cost, all portions of the treatment which fail to provide satisfactory service for a period of three years but shall not be liable under this guarantee to replace portions of the treatment removed by others. Damage to the treatment caused by failure of the underlying pavement or caused by outside influences such as traffic accidents, shall not be considered failure of the treatment under the terms of this paragraph.

Method of Measurement and Basis of Payment: "Spraygrip" will be measured by area in square yards and the contract unit price per square yard shall be payment in full for all material, labor and equipment to prepare the surface and place the skidproofing complete including Maintaining Traffic.

APPENDICES

TO THE

TECHNICAL SPECIFICATION

APPENDIX A - Determination of Aggregate Crushing Value

APPENDIX B - Determination of Aggregate Abrasion Value

APPENDIX C - Determination of Aggregate Polish Stone Value

APPENDIX A

DETERMINATION OF AGGREGATE CRUSHING VALUE

A.1 GENERAL:

The aggregate crushing value gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load.

The aggregate crushing test shall be made as described in subparagraphs A.2 to A.6, on aggregate passing a 1/2" and retained on a 3/8" U.S. Standard test sieve.

A.2 APPARATUS

The following apparatus is required for the standard test:

(i) An open-ended steel cylinder of nominal 6" internal diameter, with plunger and baseplate, of the general form and dimensions shown in Figure A.1. The surfaces in contact with the aggregate shall be machined and case-hardened, or otherwise treated, so as to have a diamond piramid hardness value of not less than 650, in accordance with ASTM Method of Test E92-57, and shall be maintained in a smooth condition.

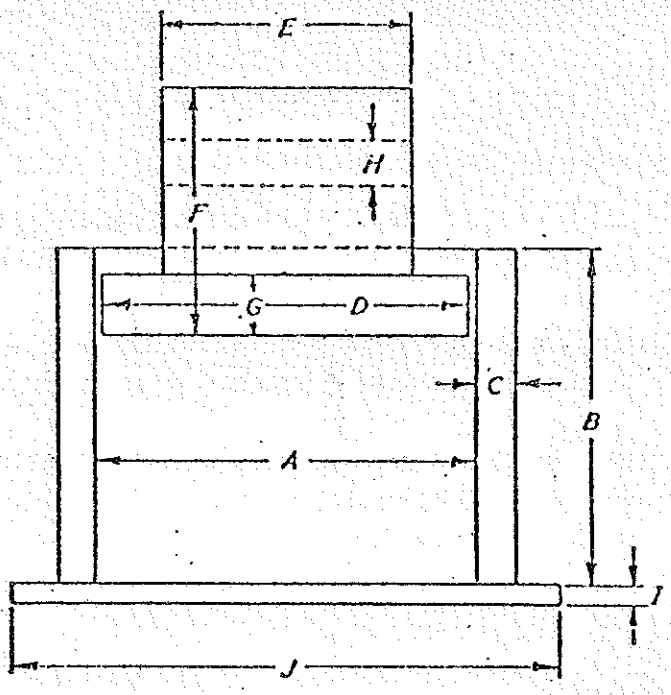
(ii) A straight metal tamping rod of circular cross section 5/8" diameter and 18" to 24" long. One end shall be rounded.

(iii) A balance of 3 kg capacity and accurate to 1 g.

(iv) U.S. Standard test sieves of sizes 1/2", 3/8", and No. 8.

(v) A compression testing machine capable of applying a load of 40 tons and which can be operated to give a uniform rate of loading so that this load is reached in ten minutes. The machine may be used with or without a spherical seating.

(vi) For measuring the sample, a cylindrical metal measure of sufficient rigidity to retain its form under rough usage and having an internal diameter of 4-1/2" and an internal depth of 7".



KEY TO DIMENSIONS

Letter	Diemnsions for	Nominal 6 Inch Internal Diameter Cylinder
	Cylinder	Inches
A	Internal diameter	6-1/16 ± 1/64
B	Internal depth	5 to 5-1/2
C	Wall thickness	5/8
	Plunger	
D	Diameter of Piston	6 ± 1/64
E	Diameter of Stem	3-3/4 to 6
F	Overall length of piston plus stem	4 to 4-1/2
G	Depth of Piston	1
H	Diameter (nominal) of hole	3/4
	Baseplate	
I	Thickness (nominal)	1/4
J	Length of each side of square	8 to 9

Figure A.1 Outline form and principal dimensions of cylinder and plunger apparatus for aggregate crushing test

A.3 PREPARATION OF TEST SAMPLE

The material for the standard test shall consist of aggregate passing a ½" and retained on a 3/8" U.S. Standard test sieve and shall be thoroughly separated on these sieves before testing. The aggregate shall be tested in a surface-dry condition.

The quantity of the aggregate shall be such that the depth of the material in the cylinder shall, after tamping as described in subparagraph A.4, be 4".

The appropriate quantity may be found conveniently by filling the cylindrical measure in three layers or approximately equal depth, each layer being tamped 25 times with the rounded end of the tamping rod and finally levelled off, using the tamping rod as a straightedge.

The weight of material comprising the test sample shall be determined (weight A) and the same weight of sample shall be taken for the repeat test.

A.4 TEST PROCEDURE:

The cylinder of the test apparatus shall be put in position on the baseplate, and the test sample added in thirds, each third being subjected to 25 strokes from the tamping rod. The surface of the aggregate shall be carefully levelled and the plunger inserted so that it rests horizontally on this surface, care being taken to ensure that the plunger does not jam in the cylinder.

The apparatus, with the test sample and plunger in position, shall then be placed between the platens of the testing machine and loaded at as uniform a rate as possible, so that the total load is reached in ten minutes. The total load shall be 40 tons.

The load shall be released and the whole of the material removed from the cylinder without further breaking of the sample and sieved on the No. 8 U.S. Standard test sieve, until no further significant amount passes in one minute. The fraction passing the sieve shall be weighed (weight B).

In all of these operations care shall be taken to avoid loss of the fines. Two tests shall be made.

A.5 CALCULATIONS:

The ratio of the weight of fines formed to the total sample weight in each test shall be expressed as a percentage, the result being recorded to the first decimal place:

$$\text{Aggregate crushing value} = \frac{B}{A} \times 100$$

where A - weight in grams of surface-dry sample,
B = weight in grams of the fraction passing the No. 8 U.S. Standard test sieve.

A.6 REPORTING OF RESULTS:

The mean of the two results shall be reported to the nearest whole number as the aggregate crushing value.

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APPENDIX B

DETERMINATION OF AGGREGATE ABRASION VALUE

B.1 GENERAL:

This test gives a measure of the resistance of aggregates to surface water by abrasion.

B.2 APPARATUS:

(i) An abrasion machine consisting essentially of a flat circular cast iron or steel grinding lap not less than 2 ft in diameter, which can be rotated in a horizontal plane at a speed of 28 or 30 rev/min and which is provided with the following accessories:

At least two trays for holding the test samples made from 1/8" mild steel plate and of internal dimensions 3-3/4 x 2-1/4 x 5/16 in. (referred to below as the "larger trays").

Means for locating two of the larger trays with their center points 10-1/4" from the center of the lap, diametrically opposite to each other and with their longer sides lying in the direction of rotation of the lap. The trays must be free to move in a vertical direction, but restrained from moving in the horizontal plane.

A weight with a rounded base for pressing the test samples against the surface of the lap, having means for adjusting the weight to 2kg $\pm$ 10g.

Means for feeding sand continuously on the lap in front of each test sample at the rate of 1-1/2 to 2 lbs per min, and for removing and recovering the sand after it has passed under the test samples.

(ii) U.S. Standard test sieves 1/2", 3/8", and Nos. 20, 30, 40, 50, and 100.

(iii) A hotplate not less than 5" square, giving a surface temperature of about 100^{o}C.

(iv) The trays made from 3/16" mild steel plate and of internal dimensions 3-5/8 x 2-1/8 x 5/16" (referred to below as the smaller trays), having the same external dimensions as the larger trays.

(v) A fine camel-hair brush (about 1/8").

(vi) A balance of capacity not less than 1 kg, accurate to 0-1 g.

(vii) A well-ventilated oven, thermostatically controlled at a temperature of 105 $\pm$ 5°C.

B.3 MATERIALS:

(i) Compound for setting the samples in the trays. (A mixture of equal quantities by weight of brown Swedish pitch and plaster of Paris has been found suitable.)

(ii) An abrasive consisting of Leighton Buzzard silica sand, at least 75% of which shall pass the No. 30 and be retained on the No. 40 U.S. Standard sieve, and all of which shall pass the No. 30 and be retained on the No. 50 sieve. It shall be dry and shall not have been previously used. About 7 lbs of sand shall be used for each sample.

(iii) Fine sand, substantially passing a No. 100 sieve, to prevent the setting compound from squeezing up between the individual pieces of aggregate.

B.4 SAMPLE FOR TEST:

The test sample shall consist of aggregate passing the 1/2" and retained on the 3/8" sieve and shall be washed to remove surface dust. The pieces selected for the test sample shall not be flaky and shall be of such a size that when placed in one of the smaller trays they form a single layer projecting above the upper edge of the tray by 3/16" to 1/4". Each test sample shall consist of 33 cm^3 of aggregate and may be obtained either by taking a weight in grams equal to 33 times the specific gravity on an oven-dried basis of the aggregate, or by taking sufficient saturated and surface-dry aggregate to displace 33 ml of water in a 100 ml measuring cylinder.

NOTE: The cylinder should be tapped lightly on a bench to remove bubbles of air trapped by the aggregate.

B.5 PREPARATION OF TEST SAMPLE

The aggregate shall be tested in a surface-dry condition. If dried by heating, the period of drying shall not exceed four hours, and the temperature shall not exceed 110°C, and the sample shall be cooled to room temperature before testing. It shall then be weighed to the nearest 0·1 g (weight A).

The test sample shall be placed in one of the smaller trays, and the interstices between the pieces of aggregate shall be filled up to the level of the top of the tray by running in the fine sand through a funnel drawn to a fine point (a suitable funnel can be improvised from stout paper). Surplus sand shall be removed by means of the camel-hair brush. The tray, aggregate and sand, shall then be placed on the hotplate or in the oven until they reach a temperature not less than about 80°C.

One of the larger trays shall be placed on the hotplate and filled with molten setting compound, which shall then be allowed to cool until it is of such a viscosity that the tray and setting compound can be inverted, and pressed down onto the hot aggregate in the smaller tray.

NOTE: This operation can be facilitated by the use of a clamp for holding the tray. A suitable clamp can be made in two halves from 3/8" x 1/8" strip metal in the form of a frame to fit around the outer edges of the tray, provided with handles and so constructed as to facilitate the rapid location of the tray.

The larger tray shall be so placed that it is as nearly as possible in register with the smaller. The two trays shall be pressed together until their edges are in contact, left to cool, and then pried apart and the sand and all surplus setting compound removed.

The resulting test sample should have a reasonably flat upper surface, and should consist of a single layer of aggregate held firmly by the setting compound, but projecting about 3/4" above its upper surface, which should be approximately level with the top edge of the tray; the setting compound should not have been squeezed up between the pieces of aggregate.

The sample tray with aggregate and compound shall be weighed to the nearest 0·1 g (weight B).

B.6 TEST PROCEDURE:

The sample tray shall be placed in the abrasion machine and loaded so that it rests upon the lap with a total load (including the weight of the tray, compound and aggregate) of 2 kg $\pm$ 10 g. The lap shall then be turned through 500 revolutions at a speed of 28-30 rev/min, the Leighton Buzzard sand specified above being fed continuously onto it immediately in front of each test sample at a rate of 1-1/2-2 lbs per minute, and being removed from the lap after it has passed under the test sample. The sand shall be reused as many times as is necessary to complete the test (usually about four times) and shall then be discarded. Two samples of each material shall be tested.

On completion of the 500 revolutions, the test samples shall be removed from the machine and weighed (weight C).

B.7 CALCULATIONS:

The percentage loss in weight by abrasion of each test sample shall be calculated from the formula:

$$\frac{100\ (B-C)}{A}$$

where A = weight of surface-dry aggregate (g)
B = weight of tray with aggregate and setting compound before abrasion (g)
C = weight of tray with aggregate and setting compound after abrasion (g).

B.8 REPORTING THE RESULTS:

The mean of the two results shall be reported to the first decimal place as the aggregate abrasion value.

APPENDIX C

DETERMINATION OF THE LABORATORY DETERMINED POLISHED-STONE VALUE

C.1 GENERAL:

The object of this test is to give a relative measure of the extent to which different types of roadstone in the wearing surface will polish under traffic. The results of this test should be used for comparative purposes only. Limits cannot at present be specified for the polished-stone value in any particular set of circumstances. Where the wearing surface of a road consists largely of stone, the state of polish of the stone will be the dominant factor, but other factors also affect the resistance of the surface to skidding. The test is in two parts:

(i) Samples of stone are subjected to an accelerated polishing action in a special machine.

(ii) The state of polish reached by each sample is measured by means of a suitable friction test and is expressed as a laboratory determined polished-stone value.

C.2 APPARATUS:

(i) An accelerated polishing machine which shall be rigidly mounted on a firm, level and nonresilient base of stone or concrete and shall include:

A wheel (referred to below as the "road wheel") having a flat periphery, and of such a size and shape as to permit fourteen of the specimens described below to be clamped on the periphery so as to form a continuous surface of stone particles 1-3/4" wide and 16" in diameter.

Means of rotating the road wheel about its own axis at a speed of 315-325 rev/min.

Means of bringing the surface of a rubber-tired wheel of 8" in diameter and 2" breadth to bear on the stone surface of the road wheel with a total load of 88 $\pm$ 1 lb. The tire shall be an

industrial 8 x 2 pneumatic 4-ply rating smooth hand-truck tire, specially selected and if necessary treated to obtain a true running surface. The tire shall have a hardness of 55 ± 5 International Rubber Hardness degrees as determined by ASTM Method of Test D1415-68, and shall be inflated to a pressure of 45 ± 2 lbf/in.^{2}; it shall be free to rotate about its own axis, which shall be parallel with the axis of the road wheel, and the plane of rotation of the tire shall be in line with that of the road wheel.

It is important that the machine shall be accurately aligned and that both wheels shall be free to rotate without play in the bearings. The following limits shall be applied:

The planes of rotation of the two wheels shall be not more than 20 min of arc out of parallel (1/32" in 6 inches).

The center planes of the two wheels shall not be more than 1/32" apart.

Before a new tire is used on a test, it shall be given a preliminary run of three hours with No. 36 corn emery and three hours with emery flour, as in an actual test, but using spare specimens. The tire shall be discarded after ten test runs have been made with it, or sooner if it shows signs of irregular wear or hardening.

Means to feed the No. 36 corn emery specified in subparagraph C.3 (i) and water at the rates shown in C.5 and in such a way that emergy and water are continuously and uniformly spread over the surface of the tire and the specimens where they are in contact. The emergy and water shall be fed directly onto the road wheel near the point of contact with the rubber-tired wheel.

Means to feed the emery flour specified in subparagraph C.3(ii) and water at the rates shown in C.5 and in such a way that the emergy flour and water are continuously and uniformly spread over the surface of the tire and the specimens where they are in contact.

(ii) A number of accurately machined metal moulds for preparing specimens of the dimensions specified in subparagraph C.4.

(iii) A friction tester complying with the requirements set out in ASTM Method of Test E303-69.

(iv) U.S. Standard test sieves of the following sizes: 3/8", 5/16" (both perforated plate), Nos. 30, 35, 40, 45, 50, 100, and 270 (fine mesh).

C.3 MATERIALS:

(i) A supply of No. 36 corn emery complying with the following grading requirements:

U.S. Std. Sieve No.	Nominal Width of Aperture (microns)	Total Percentage Passing
30	590	98-100
35	500	70-100
40	420	30-90
45	350	0-30
50	297	0-5

(ii) A supply of air-floated emergy flour the whole of which shall pass a No. 270 U.S. Standard sieve.

C.4 PREPARATION OF SPECIMENS:

At least 7 lbs of 3/8" particles shall be available for each sample to be tested. The particles actually used in the preparation of the test specimens shall all pass the 3/8" U.S. Standard sieve and be retained on the 5/16" sieve. They shall be neither flaky nor elongated and shall be clean and free from dust.

The sample shall be obtained from the normal run of production from the plant, since chippings that have been freshly crushed in the laboratory may give misleadingly high results. The surface texture of the particles which is to be exposed to the polishing action of the tire, shall be representative of the average surface texture of the stone. A few particles having a very smooth or a very rough surface texture may occur in almost any sample, but these shall not be used in preparing the test specimen.

Each specimen shall consist of a single layer of 40-60 of the particles, placed as closely as possible and covering an area of 3.57 x 1.75 inches

set in a sand-cement mortar with their exposed surfaces protruding from the mortar. The surface of the specimen shall be flat across the shorter dimension, but shall be curved in the arc of a circle of 16" diameter along the longer dimension.

The finished specimen shall present the natural surface of the stone chippings with no sharp projecting edges to the polishing tire, and shall be not less than 1/2" thick, and the undersurface shall be the arc of a circle of exactly the same diameter as the periphery of the road wheel of the polishing machine. Four specimens shall be made from each material to be tested.

The specimen is prepared by carefully placing 40-60 selected particles in a single layer with their flattest surfaces lying on the bottom of the mold. The interstices between the stones are then filled to 1/4 to 1/2 their depth with fine sand (all passing a No. 100 U.S. Standard sieve), the sand is wetted thoroughly with a fine spray of water, three pieces of 0.05" (18-gauge) iron wire are laid along the longer dimension to act as reinforcement* and the mold is filled to overflowing with a mortar made from equal portions by weight of sand passing a No. 100 U.S. Standard sieve and high alumina cement. The consistency of the mortar shall be such as to permit it to flow freely between the particles. The mold is then left until the mortar has stiffened sufficiently to be struck off accurately level with the curved sides of the mold (usually between 3 and 6 hours). The specimen is then left in the mold, covered by a water-saturated cloth, for a further 24 hours, after which it is removed from the mold and stored under water with the stone surface downwards for 7-14 days and shall be tested immediately on removal from the water.

C.5 ACCELERATED POLISHING OF SPECIMENS:

The temperature of the room in which the accelerated polishing is carried out shall lie within the limits 20 $\pm$ 5°C. Fourteen specimens shall be clamped round the periphery of the road wheel of the polishing machine, strips of polythene 0.01" thick being inserted between adjacent specimens

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*The reinforcement may be inserted after the mortar has been placed, but if this is done great care will be necessary to avoid disturbance of the chippings.

and between the underside of the specimens and the periphery of the wheel. The outer surface of the specimens shall then form a continuous strip of particles with a periphery of 16" diameter, upon which the pneumatic-tired wheel shall ride freely without bumping or slipping.

The road wheel shall then be brought to a speed of 315-325 rev/min and the pneumatic-tired wheel shall be brought to bear on the surface of the specimens with a total load of 88 lbs. Water and the No. 36 corn emery specified in C.3(i) shall be fed continuously onto the road wheel at rates within the following limits for a period of 3 hours ±5 minutes.

Rate of feed

No. 36 corn emery - 20-35 g/min
Water - The water shall be fed at the same rate as the corn emery.

The run shall be interrupted after 2 hours and the used corn emery removed from the base.

On completion, i.e. after 3 hours, the machine and specimens shall be thoroughly cleaned by washing, so that all trace of the corn emery is removed. The machine shall then be operated for a further 3 hours ±5 minutes as described in the preceding paragraph, except that in place of the corn emery the air-floated emery flour specified in C.3(ii) shall be fed continuously with water at rates within the fllowing limits:

Rate of feed

Air-floated emery flour - 2-4 g/min
Water - The rate of feed of the water shall be twice that of the emery flour.

The specimens shall then be removed from the machine and shall be thoroughly washed in running water to remove all trace of the emery flour. Emery flour which almost invariably packs in the interstices between the stone particles shall be removed by scrubbing with a stiff bristle brush. The slightest trace of emery flour on or between the stone particles will cause a lowering of the result of the friction test.

After washing, the specimens shall be stored face downwards under water at a temperature of 18-22°C for a period of between 1/2 and 2 hours and

immediately on removal from the water, shall be tested on the friction tester as described below. At no time prior to this testing shall the specimens be allowed to dry out.

C.6 FRICTION TESTING

The British Portable Number for a minimum of four samples of each material shall be determined according to ASTM Standard Method of Test E303-69. Two of the specimens shall be tested with one slider edge and two with another edge. It is preferable to use two edges from different sliders rather than two from the same slider.

Reporting of Results: The value obtained for each of the four specimens shall be reported to the nearest whole number and the mean of these four values shall be reported as the "laboratory determined polished stone value."

Although it is desirable to report the value to the nearest whole number, in comparing the results of tests a difference of less than 5 units cannot be regarded as significant.