TEXAS' EXPERIENCE WITH THE
BRITISH WHEEL

by

Jon Underwood

1970

Texas' Experience With the British Wheel

Our work with the British Wheel has been based on implementing the research work done by England. Our research work was directed toward obtaining the variations expected in performing the tests, variations expected in commercial aggregate sources, obtaining the polish characteristics of a sample of approximately 100 Texas sources, and studying the "rate of wear" or "rate of polish" in both the laboratory and the field. A tentative test procedure and polish value specifications were adopted, then a "Polish Value" was specified in construction contracts.

We studied the variation that could be expected in the British Portable Tester by using two operators obtaining repeat tests on the same British Wheel specimen. Each operator was required to set up and adjust the British Portable Tester and read the values from the scale. The largest range found for different operators was 2. Also a range of 2 was found for one operator when making repeat tests where the operator was required to set up the British Portable Tester between tests. We believe most of the variance can come from the adjustment of the slider length.

We varied slightly from the British test and used silicone carbide grit instead of the emory abrasive used in England because: (1) excessive cost in importing the exact British grits and (2) the hardness of the silicone carbide is very close to the hardness of the emory abrasives used by the British. England discovered in their work that the grit size used has a large effect on both the rate of polish and also on the final "polish value".

Our first testing was an attempt to duplicate the British work and polish the aggregate with different grit sizes. The results were essentially the same as those reported by the British. The specimens exhibited lower friction when a smaller grit size was used as compared to a higher friction value when a larger grit was used. Since the need in Texas was for one value; the lowest friction value which is the "Polish Value" or the point at which friction does not decrease significantly with continued traffic applications, the necessity arose to determine a suitable method of arriving at this value. It also appeared that the rate of polish could be important because many highways never receive enough traffic applications to polish to a low friction level before maintenance must be performed for structural reasons. Therefore it would be possible to specify a polish value for all highways but the polish value would be determined after a specified number of hours of polish which would vary with the expected type and amount of traffic to be carried on the subject roadway. It is believed that this will allow the use of polishable local materials for certain highways with less cost to the state. This method of study concerns a "rate of polish" which is difficult to obtain with two grit sizes because of the stair step formed in the polish rate when the grit sizes are changed. Therefore, a decision was made to polish with only one grit size. With this decision the problem of which grit size to use was encountered. Duplicate aggregate specimens were molded and each polished with a different grit size. These results were then compared with field results obtained on the same aggregate types with a locked wheel skid trailer. These results showed that no grit size used (46, 150 and 600 grit sizes) exactly duplicated the field results. The samples polished with the larger grit revealed the greatest rate of polish but the highest polish value, and the samples polished with the 600 grit had the smallest rate of polish but the lowest polish value. The results of the intermediate grit were between those obtained with the coarse and fine grit. From this the decision was made to use the 150 sized grit because (1) It appeared any of the laboratory polish rates could be correlated to the field polish rates by adapting an accelerated polish time scale corresponding to traffic applications. (2) The 150 grit gave a larger range in British Portable Numbers between initial and final polish when compared to the 46 grit test results. (3) the 600 grit was disliked because of the problems encountered with the grit feed system. In a effort to determine the effect of grit type and hardness we took four coarse aggregates and pulverized them to a maximum #100 screen size that is passing the #100 screen and retained on the #200 screen. Duplicate sets of specimens were then polished with a variety of grit types including their own grit. The usual loss of friction occured but in all cases the specimens polished to a lower level with silicone carbide. The variation in friction values which we feel can be attributed to different grit hardness (or type), was found to be approximately 5 British Portable Numbers. Due to this variation caused by grit hardness, the decision was made to use 150 silicone carbide grit for all future testing.

Next we attempted to determine the variation that can be expected for an aggregate source. This was done by obtaining a sample of aggregate from four different locations within a pit. However, no strippings or poor areas were selected. The largest range found in any one source was 7 British Portable Numbers and the smallest range was 2. So from this study one would expect some variation from within a pit. Also in an effort to determine the variation that could be expected in an aggregate sample collected from one area of a pit, 66 samples consisting of three specimens each were polished and the range in polish values for each specimen was found. The greatest range found between specimens of a sample was 9, and the average range found was 4 British Portable Numbers.

Prior to all friction testing, 4 previously polished specimens were tested. A correction for the day to day control specimen variation was obtained for the polish specimens by plotting the original values of the control specimens versus the daily value for the control specimens. A best fit line was drawn between the points and the correction was obtained from this new best fit line. Hopefully this allows all values to be representative of the British Portable Tester after it had been calibrated by the standard ASTM calibration method.

Using the above information and the British Standard as a guideline a tentative test procedure was established. Having established a tentative test procedure, we then determined the Polish Value of a sample of approximately 100 Texas sources which were located throughout the state. The lowest Polish Value was found to be 20 and the highest 58. In general, certain aggregate types have consistently higher Polish Values while others were consistenly lower, however, there is a broad range of Polish Values when considering different sources for a given aggregate type. From the above results it would appear that more consideration should be given to the aggregate source rather than the aggregate type.

Tentative tests with the British Wheel indicate a linear relationship of Polish Values exists in blended combinations of two materials. Several specimens were prepared in which the percentages were varied. The polish values of the blended materials fell on a linear line between the polish values of the two materials when polished individually. From this testing it appears that a blend of materials can be used and their blended polish value determined by measuring the polish value of each material then mathematically determining the blended value.

In summary I would like to say that the British Wheel does denote the friction characteristics of coarse aggregate. Aggregate materials can be ranked and ordered as to their friction characteristics. The British Wheel polish value of a coarse aggregate is related to the lowest friction value of the same aggregate material when polished by actual traffic. A test method and resulting specifications (as are now in experimental use in Texas) can be developed which will insure the use of a coarse aggregate with better friction characteristics when used in flexible pavements.

TEXAS HIGHWAY DEPARTMENT

SPECIAL PROVISION

TO

ITEM 6

CONTROL OF MATERIALS

For this project, Item 6, "Control of Materials", of the Standard Specifications is hereby supplemented with respect to the clauses cited below and no other clauses or requirements of this item are waived or changed hereby.

Article 6.1 Sources of Supply and Quality of Materials is supplemented by the addition of the following requirements:

Coarse aggregate furnished for use in Hot Mix Asphaltic Concrete Pavement shall have a "Polish Value" of not less than 29 when subjected to tests as specified in "Accelerated Polish Test Method for Coarse Aggregate Used in Pavement Surfaces" (attached). This is a quality test for approval of the source and not a job control test.

ACCELERATED POLISH TEST METHOD FOR COARSE AGGREGATE USED IN PAVEMENT SURFACES

Scope:

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

Definitions:

The "Polish Value" is defined as the state of polish reached by each sample when subjected to accelerated polish by means of a special machine. The test is in two parts:

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

(2) The state of polish reached by each sample is measured by a British Portable Tester and expressed as the "Polish Value".

Apparatus:

1. Accelerated Polishing Machine: A polishing device as shown in Figure 1. An accelerated polishing machine shall be mounted on a firm level and non-resiliant base of stone or concrete and shall include:

A. A wheel (referred to as the road wheel) having a flat periphery and of such size and shape as to permit 14 specimens described below to be clamped on the periphery so as to form a continuous surface of stone particles, 1-3/4 inches wide and 16 inches in diameter.

B. A means of rotating the road wheel about its own axis at a speed of 315 to 325 revolutions per minute.

C. A means of bringing the surface of a rubber tired wheel of 8 inch diameter and 2 inch width to bear on the stone surface of the road wheel with a total load of 88 ± one pound. The tire shall be an industrial 8 x 2 pneumatic 4 ply smooth hand truck tire, treated, if necessary, to obtain a true running surface. The tire shall be inflated to a pressure of 45 plus or minus 2 pounds per square inch and shall be free to rotate about its own axis, which shall be parallel to the axis of the road wheel. The plane of rotation of the tire shall be in line with that of the road wheel. Before a new tire is used on a test, it shall be given a preliminary run of 6 hours with a 150 grit silicone carbide using dummy specimens on the road wheel.

D. A means to feed the 150 grit silicone carbide at the rates shown in "Accelerated Polish Test Procedure" and in such a way that the silicone carbide grit is continuously and uniformly spread over the surface of the tire and the specimens where they are in contact. The grit shall be fed directly onto the road wheel near the point of contact with the rubber tired wheel.

E. A means to feed the water at the rate shown in "Accelerated Polish Test Procedure" in such a way that the water is continuously and uniformly spread over the surface of the road wheel near the point of contact with the rubber tired wheel.

2. Metal Molds: A number of accurately machined metal molds for preparing specimens of the dimensions specified in No. 4 - "Preparation of Test Specimen."

3. British Portable Tester: A friction measuring device. The British Portable Tester used shall conform to ASTM Designation E 303-66T with the following modifications:

A. The slider contact path shall be 3" ± 1/16 inch.

B. The slider width shall be 1-1/4 inches.

C. The rubber which is bonded to the slider shall conform to a 1/4 by 1 by 1-1/4 inch dimension.

D. The rubber shall meet the requirements as specified in ASTM Specification E 249, for Standard Tire for Pavement Tests.

E. The zero adjustment shall be checked before testing the fourteen specimens and after testing the specimens and as often as the operator deems necessary.

F. Calibration procedures of ASTM E 303-66T shall be used, however; after calibration the small slider shall be inserted.

4. A supply of disposable cups and stirring rods for use in molding the specimens.

Materials:

1. Water: A supply of tap water to be spread on the road wheel during testing.

2. Fine Sand: A supply of fine sand for sifting in the aggregate interstices prior to the placement of the polyester bonding agent.

3. Mold Release Agent: A supply of polyester mold release agent used to prevent bond between the mold and polyester.

4. Silicone Carbide Grit: A supply of silicone carbide grit (150 grit size) to be used as the polishing agent.

5. Polyester Bonding Agent: A supply of polyester resin and catalyist.

6. Coarse Aggregate: Approximately a one-half cubic-foot supply of coarse aggregate to be tested. The aggregate shall be normal plant run but laboratory crushed material may be tested.

Test Record Forms: Record test data on an appropriate work sheet (See Figure 1 in the Appendix).

Test Control: Four specially selected specimens shall be used for control and only these four specimens shall be used. The specimens shall be selected from those which have been previously polished for 10 hours conforming to the procedure herein established. The friction value (as determined from the British Portable Tester) of the specimens shall be in the following ranges:

Control Specimen #1 - 10-20	Control Specimen #3 - 30-40
Control Specimen #2 - 20-30	Control Specimen #4 - 40-55

The control specimens shall be tested with the British Portable Tester prior to measuring the "polish value" of the test specimens on any one test. Corrections to the polish value will be made on the basis of change in friction values found with the control specimens.

Preparation of Test Specimens:

1. The aggregate to be tested should pass the 1/2 inch sieve and be retained on the 3/8-inch sieve.

2. Aggregate shall be clean and free of dust.

3. The mold shall be coated with an application(s) of mold release agent.

4. Each specimen shall consist of a single layer of particles and cover an area of 3.5-inches x 1.75-inches.

5. The aggregate particles shall be placed as closely as possible in the molds with a flat surface against the bottom of the mold.

6. The interstices between the stones shall be filled with fine sand to 1/4 to 1/2 of the aggregate depth.

7. Weigh the polyester resin and catalyst into a disposable cup, add the resin to the catalyst and mix thoroughly. A mixture of 0.5 to 0.75 grams of catalyst to 50 to 57 grams of polyester resin yields sufficient material for one specimen and remains workable for 10 minutes.

8. The prepared mold is then filled to overflowing with the polyester bonding agent.

9. The consistency of the polyester should be such as to allow it to flow freely between the particles.

10. The mold is then left until the polyester has stiffened sufficiently to be struck off accurately, level with the curved sides of the mold.

11. The specimen is then left in the mold for 3-4 hours to allow sufficient hardening of the polyester in order that the specimen may be removed from the mold.

12. The excess sand is removed from the face of the specimen.

13. The specimen is then replaced in the mold for a curing period of 4 hours with a weight (conforming to the curved sides) on the mold to insure proper curvature of the specimen upon removal.

Accelerated Polish Test Procedure:

1. Determine the friction value of the control specimens for correction purposes as explained in the "Test Control" paragraph.

2. Determine the original friction number of the prepared test specimens as explained in ASTM Designation E 303-66T and modified by paragraph 3 "Apparatus."

3. Fourteen specimens shall be clamped around the periphery of the road wheel using rubber O-rings near the edges of the specimens.

4. The outer surface of the specimens shall then form a continuous strip of particles upon which the pneumatic-tired wheel shall ride freely without bumping or slipping.

5. The road wheel shall then be brought to a speed of 320 $\pm$ 5 rev/min, and the pneumatic-tired wheel shall be brought to bear on the surface of the specimen with a total load of 88 $\pm$ 1 pound.

6. No. 150 silicone carbide grit shall be continuously fed at a constant rate of approximately 25 grams per minute for the desired testing time. Water shall be fed at the same rate as the silicone carbide grit.

7. The specimens are then removed from the road wheel and washed thoroughly to remove grit.

8. Determine the friction value of the control specimens for correction purposes as explained in the "Test Control" paragraph.

9. After cleaning, the specimens shall be tested on the British Portable Tester to determine the "polish value", as explained in ASTM Designation E 303-66T and modified by paragraph 3 - "Apparatus".

POLISH VALUE TEST

District ________________	Producer ________________
Highway ________________	Pit Location ________________
Project No. ________________	Aggregate Type ________________
Date Sampled ________________	Lab Sample No. ________________
Date Tested ________________	Length of Test Period ____________

	Before Polish					Average
Specimen 1	____	____	____	____	____	____
Specimen 2	____	____	____	____	____	____
Specimen 3	____	____	____	____	____	____
Specimen 4	____	____	____	____	____	____
				Initial Value		____

	After Polish					Average
Specimen 1	____	____	____	____	____	____
Specimen 2	____	____	____	____	____	____
Specimen 3	____	____	____	____	____	____
Specimen 4	____	____	____	____	____	____
				Polish Value		____

Appendix Figure 1