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STATE HIGHWAY DEPARTMENT
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A COMPARISON OF THE BOND-REDUCING EFFECTIVENESS OF CUTBACK ASPHALT WITH THAT OF A POWDERED GRAPHITE LUBRICANT AS DOWEL BAR COATINGS

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At the request of the Construction Division, the Research Laboratory has made a special study of the bond-reducing properties of a graphite lubricant used by the Pennsylvania Highway Department for coating dowel bars. The material was compared with a cutback asphalt product similar to that commonly used in Michigan. Pennsylvania Highway Department's specifications for their graphite lubricant will be found in Appendix A.

Coatings Tested

The asphalt product consisted of SCA asphalt cut back 50 percent with gasoline.

The composition of the graphite lubricant was as follows:

Part 1

Dixon's No. 2 medium flake graphite		60%
Vehicle	linseed oil . . 65%	40
	turpentine . . 35	
		100%

Part 2

Carbon tetrachloride	60%
Naphtha	40
	100%

Parts 1 and 2 were made separately and were then mixed together in such proportions that the weight of Part 2 was 40 percent of that of Part 1. Complete instructions for preparing the graphite lubricant will be found in Appendix B.

Test Procedure

The test was divided into three groups. Group 1 consisted of three graphite-coated specimens, and three asphalt-coated specimens tested one day after the concrete was poured. Groups 2-A and 2-B each consisted of three graphite-coated specimens and three asphalt-coated specimens tested at seven days. Groups 3-A and 3-B each consisted of three graphite-coated specimens and three asphalt-coated specimens tested at the end of twenty-eight days.

All of the dowels used in this test were 1-inch diameter structural grade plain steel bars. These bars were embedded a distance of 7-1/2 inches into concrete cylinders, 6 inches in diameter and 12 inches deep. The bars were set in the forms, coated with one of the bond-reducing agents, and allowed to stand for one hour before the concrete cylinders

were poured around them. Figure 1 shows the three graphite-coated bars, and Figure 2 the three asphalt-coated bars in the forms ready for embedment into the concrete cylinders. The graphite lubricant was mixed thoroughly and a coating approximately 1/16 inch thick was applied to the dowel bar by daubing it on with a cloth. The cutback asphalt was applied to the bars in a similar manner, until the bar was thoroughly coated.

The concrete cylinders were cast, and then cured for seven days under wet burlap with the exception, of course, of the specimen tested at the end of one day. Figure 3 shows a picture of the device used for pulling the bars out of the concrete cylinders. Each bar was threaded on the protruding end and fastened to a plate as shown. This plate was pulled upward by applying a force through the dynamometer ring with a hydraulic jack. The load required to break the bond in each case was termed "Pull-Out Load" and is listed for various specimens in Table 1. After the initial bond had been broken, the average force necessary to continue to pull the bar out of the concrete was recorded. This is designated in Table 1 as "Friction Load".

Test Results

A study of Table 1 does not indicate any consistent relationship between the age of the specimens at testing and the "Pull-Out Load". Between specimens of a given group, and with a given casting, the pull-out load values are reasonably consistent. There is a great deal of variation, however, between the pull-out load values for test specimens tested at a given time with a given coating when the test specimens were cast from different batches.

The primary objective of this test program was to compare the bond-reducing properties of graphite lubricant with that of cutback asphalt. This comparison shows that the graphite lubricant has much better bond-reducing properties. In every group tested, the graphite lubricant had better bond-reducing properties, but for some groups this was much more marked than for others. For all specimens tested, regardless of age at time of test, the dowels lubricated with the graphite had a pull-out load only 19 percent of that for the dowels lubricated with the cutback asphalt. The load required to continue to pull the dowel out of the concrete after the initial bond had been broken is designated as "Friction Load". This average value for all specimens coated with graphite lubricant was only 13 percent of that for the specimens coated with cutback asphalt.

Table 1

Test Results

Group No.	Specimen No.	Time of Test - Days	Coating: Graphite Lubricant Pull-Out Load-Pounds	Graphite Lubricant Friction Load-Pounds	Cutback Asphalt Pull-Out Load-Pounds	Cutback Asphalt Friction Load-Pounds
1	1	1	288	125	1250	875
	2		238	156	1500	875
	3		250	75	1125	875
	Average		259	119	1292	875
2-A	1	7	125	63	1250	713
	2		138	63	1250	713
	3		150	56	3125	1250
	Average		138	61	1875	892
2-B	1	7	1000	625	3250	2125
	2		750	375	3625	2250
	3		500	250	2875	1875
	Average		750	418	3250	2083
3-A	1	28	1000	250	1125	875
	2		1250	625	2375	1500
	3		875	500	1750	1600
	Average		1042	458	1750	1325
3-B	1	28	188	Approx. 50*	4625	3125
	2		125	" 50*	4500	3500
	3		188	" 50*	4100	2875
	Average		167	Approx. 50	4408	3167
Average of all specimens with given coating			471	221	2515	1668

* Too small to be measured accurately with dynamometer ring.

APPENDIX A

COMMONWEALTH OF PENNSYLVANIA
Department of Highways

LOAD TRANSFER UNITS

Supplementing Section 5.1.3(11) of the
Specifications Form 408, 1950

Section 5.1.3(11) - TRANSVERSE JOINTS - is supplemented as follows -

One-half the length of each slip-dowel bar of load transfer units shall be rendered bondless with a coating of graphite lubricant consisting of flake graphite mixed with a vehicle having quick drying characteristics. The lubricant shall meet the following requirements. -

Graphite Paste -

	Percent by Weight	
	Minimum	Maximum
Flake Graphite	55	65
Vehicle	35	45

The vehicle shall contain at least sixty-five (65) percent of fixed oils, the remainder to be volatile thinners and dryers. The paste shall be thoroughly mixed.

Flake Graphite -

	Percent by Weight	
	Minimum	Maximum
Graphitic Carbon	85	- -
Graphitic Carbon passing #100 sieve. . .	84	92
Graphitic Carbon passing #325 sieve. . .	46	50

To prepare lubricant for application, approximately three (3) to four (4) pounds of the graphite paste shall be placed in a suitable container and forty (40) percent by weight of a (60/40) mixture of carbon tetrachloride and naphtha shall be added thereto. The resulting lubricant shall be thoroughly mixed.

The lubricant shall be applied to the free end of dowels by daubing, mopping or gloved hand to produce a thorough coating approximately one-sixteenth (1/16) inch thick. Brushes shall not be used for application of the lubricant.

The lubricant shall be mixed and applied, as specified, at least one (1) hour before the concrete is placed around the dowel assembly.

APPENDIX B

MIXTURE AND APPLICATION OF GRAPHITE LUBRICANT USED AS A BOND REDUCER FOR SLIP DOWELS

The graphite lubricant shall be composed of two parts. Part 1 shall consist of the following ingredients and proportions:

Part 1			Percent by Weight
Dixon's #2 Medium Flake Graphite			60
Vehicle	Linseed oil	65%	40
	Turpentine	35%	

Part 2 shall consist of the following ingredients and proportions, and shall be 40 percent by weight of Part 1.

Part 2

		Percent by Weight
Carbon tetrachloride	60%	40
Naphtha	40%	

Each part shall be mixed separately according to the above directions and placed in air tight containers. Prior to application, both parts shall be mixed together thoroughly and the resulting mixture applied to the dowel by daubing or mopping with a rag or gloved hand, to produce a uniform coating approximately 1/16 inch thick. Care should be taken to see that the graphite lubricant is thoroughly mixed at all times, since the graphite settles out of suspension quite rapidly. Brushes shall not be used for the application of the graphite lubricant.

The graphite lubricant shall be applied as specified at least one hour before the concrete is placed around the dowel assembly.

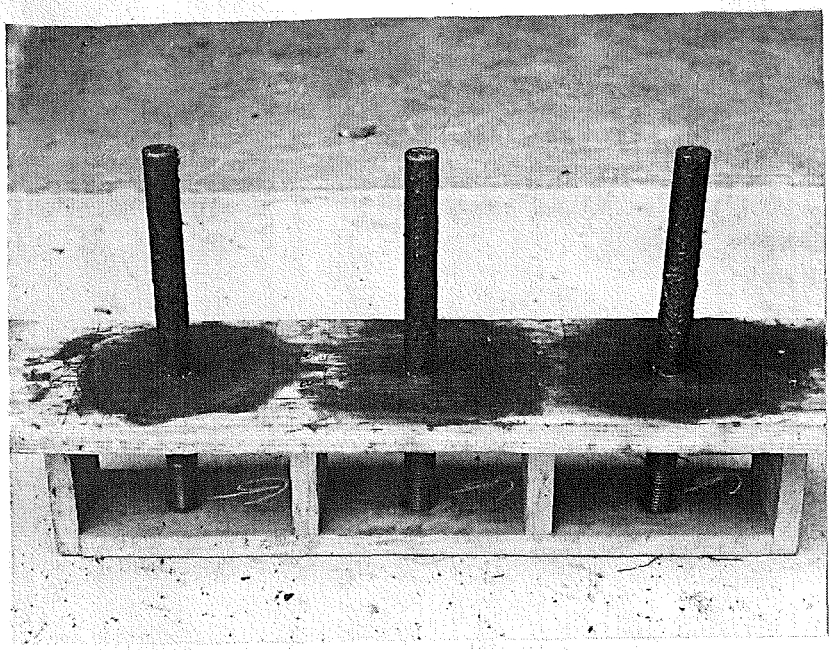

Figure 1. Dowel bars coated with graphite paste prior to being embedded in concrete cylinders.

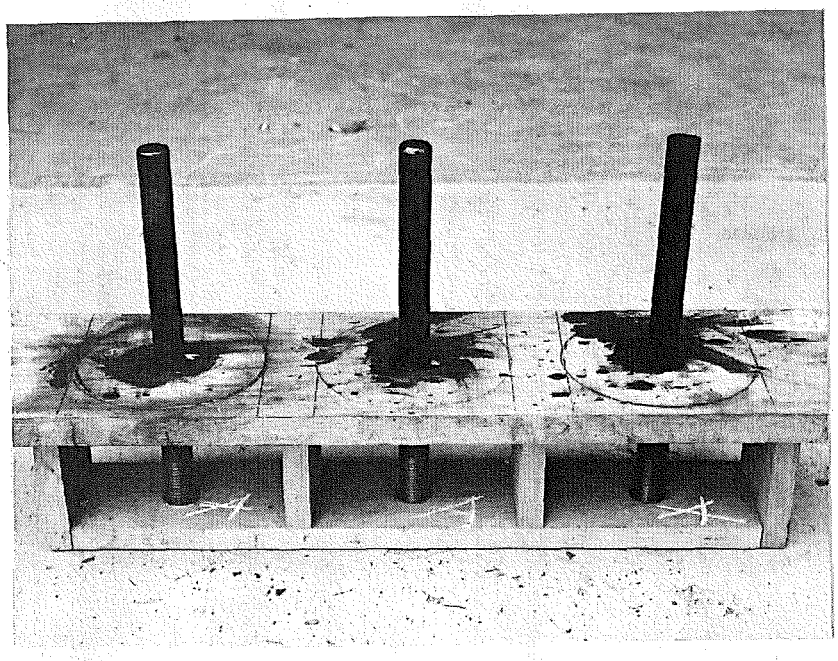

Figure 2. Dowel bars coated with a 50 percent gasoline cut-back asphalt prior to being embedded in concrete cylinders.

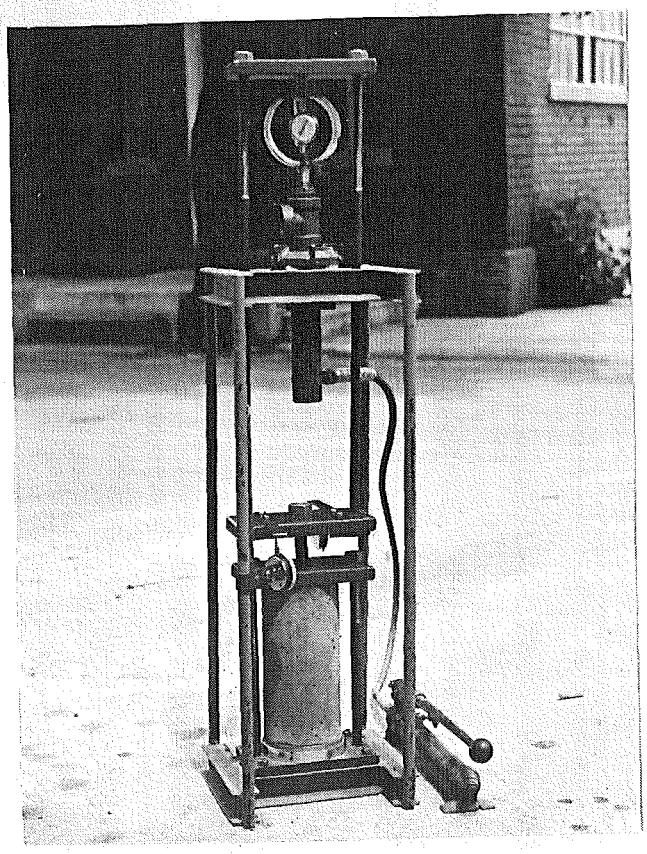

Figure 3. Specimen in pull-out testing machine ready for testing.