MICHIGAN
STATE HIGHWAY DEPARTMENT
Murray D. Van Wagoner
State Highway Commissioner

DOWEL BAR INVESTIGATION

PART II

STUDY OF DOWEL BAR COATINGS IN BOND STRESS

By
George A. Mansfield
Assistant Research Engineer

Research Laboratory Project 38 F-5 (2)
Research Report OR 20

Reprint of Original Report

Research and Testing Division
State Highway Laboratory
University of Michigan
Ann Arbor, Michigan
December 8, 1938

STUDY OF DOWEL BAR COATINGS IN BOND STRESS

The second section of this investigation deals with the study of various types of paints, asphalts, tars, oils and greases used as coatings on dowel bars to destroy the bond between the steel bar and concrete. The materials were rated according to effect of relieving bond stress, application of coating and thickness of film applied. To ascertain these results the following procedure was used.

Each bar was coated for 7-1/2 in. of its length at one end and a cap fitted over the painted end for 2-1/2 in. of its length. These bars were molded in 6 by 12 in. cylinders and imbedded in the center of cylinders to a depth of 7 in. After a 7-day curing period the bars were removed from the concrete cylinders by pulling on a tension machine with the head moving at the rate of 0.314 in. per min. with resultant stress required to extract dowel recorded. An average of three tests for each type of material was considered sufficient for a comparative analysis. Although the rate at which the bars were removed from concrete cylinders does not coincide with the action of dowel and pavement in slab structure, the results contained herein afford a relative comparison between various coated and uncoated bars, five tests being made on the latter. It is the assumption that the research as conducted in the laboratory is a true indication of effectiveness of coatings in field practice.

In Table I of dowel bar stresses the various types of coatings investigated are listed including results of determinations of drying time, load required to extract dowel, and bond stress. The initial load represents the total load required to break initial bond and final load represents the constant total load while removing dowel. These loads are in turn transferred to bond stress in pounds per square inch of surface area both for initial and constant strain. The bond stress was computed for a surface

area of 10.6 sq. in. which is the total area of bar in contact with the concrete as 2.5 in. is covered with the sleeve cap allowing a 4.5 in. effective length of dowel bar.

On the basis of least bond stress the material best suited for dowel bar coating is grease, both universal and cup, but the feature of application is unfavorable for use in actual construction. Next in efficiency for relieving bond is two coats of tar, TP-2, but in this case the film of tar is excessively heavy, approximately 1/16 in., defeating the purpose of the dowel bar in transferring of load.

A further study was made of materials most suitable for use by measurement of film applied to bars. Five bars were dipped in each of the following materials: Red lead, RC-1, RC-2, AE-5, and Chicago Paint Works paint. A determination of film thickness on bars coated with the above materials was made and the results are compiled in Table II. From the combined observations of method of application, effect of reducing bond stress and thickness of coating applied, the five recommended types are rated in the following descending order: RC-1, coating 0.001 in.; Chicago Paint Works, coating 0.004 in.; RC-2, coating 0.0045 in.; AE-5, coating 0.006 in.; red lead, coating 0.013 in. All of the above approved materials are easily applied without heating by one dipping with excess material permitted to drain off.

Conclusions

From the results of this investigation of typical effective coating would be a material that could be applied in a thin film and dry to touch in a few hours without acquiring the hard finish of lacquer.

Red lead, asphaltic oils RC-1, and RC-2, and a commercial product manufactured by the Chicago Paint Works are most satisfactory for combination of breaking bond, ease of application and a minimum film. Both one and two coat tests were conducted, but it was discovered that one thickness was sufficient and as effective. Linseed oil coating

over paint did not decrease the bond stress. The remaining materials listed gave bond stress results much in excess of above mentioned and are not considered efficient for the purpose intended.

TABLE I

TABULATION OF DOWEL BAR STRESSES

Specimen No.	Coating	Dry to Touch	Total Load		Bond Stress lb. per sq. in.	
			Initial	Final	Initial	Final
1	Uncoated		4650	2340	438	221
2			4940	2160	466	204
3			5190	1970	490	186
4			5350	3700	505	349
5			4560	1950	431	184
		Avg.	4938	2424	465	229
6	Universal		0	0	0	0
7	Grease		0	70	0	7
8			0	0	0	0
		Avg.	0	23	0	2
9	Cup		180	90	17	8
10	Grease		---	75	--	7
11			---	60	--	6
		Avg.	180	75	17	7
12	Red Lead	24 hr.	150	150	14	14
13	1 coat		150	150	14	14
14			280	280	26	26
		Avg.	193	193	18	18
15	Red Lead	24 hr.	280	160	26	15
16	2 coats		290	180	27	17
17			280	185	26	17
		Avg.	283	175	26	17
18	Red Lead +		490	220	46	21
19	Linseed		650	310	61	29
20	Oil		520	290	49	27
	1 coat	Avg.	553	273	52	26
21	Red Lead +		280	150	26	14
22	Linseed		270	160	25	15
23	Oil		260	170	25	16
	2 coats	Avg.	270	160	25	15

Table I - cont'd

Specimen No.	Coating	Dry to Touch	Total Load		Bond Stress lb. per sq. in.	
			Initial	Final	Initial	Final
24	RC-1	3 hr.	310	270	29	25
25	1 coat		350	270	33	25
26			320	270	30	25
27			350	270	33	25
		Avg.	333	270	31	25
28	RC-2	2 hr.	390	290	37	27
29	1 coat		280	260	26	25
30			410	320	39	30
		Avg.	360	290	34	27
31	RC-2	2 hr.	380	290	36	27
32	2 coats		360	280	34	26
33			430	270	41	25
		Avg.	390	280	37	26
34	Chicago	2 hr.	350	140	33	13
35	Paint		270	150	25	14
36	Works		280	190	26	18
37	Pent. 52		400	220	38	21
	1 coat	Avg.	325	175	31	17
38	Chicago	2 hr.	750	370	71	35
39	Paint		280	150	26	14
40	Works		290	160	27	15
	Pent. 52					
	2 coats	Avg.	440	227	42	21
41	AE-5	1 hr.	720	500	68	47
42	1 coat		620	510	59	48
43			720	580	68	55
		Avg.	687	530	65	50
44	AE-5	1 hr.	500	300	47	28
45	2 coats		380	220	36	21
46			390	260	40	25
		Avg.	423	260	37	25

Table I - Cont'd

Specimen No.	Coating	Dry to Touch	Total Load		Bond Stress lb. per sq. in.	
			Initial	Final	Initial	Final
47	Linseed		780	450	74	42
48	Oil		780	500	74	47
49			---	440	--	42
		Avg.	780	463	74	44
50	#7 Black +		780	480	74	45
51	Linseed		730	440	69	42
52	Oil		660	390	62	37
	1 coat	Avg.	723	437	68	41
53	#7 Black +		590	420	56	40
54	Linseed		490	330	46	31
55	Oil		400	300	38	28
	2 coats	Avg.	493	350	47	33
56	50/50 WOA +	1 hr.	940	560	89	53
57	Mineral		1060	680	100	64
58	Spirits		990	680	93	64
	1 coat	Avg.	997	640	94	61
59	TCP-2	30 min.	680	500	64	47
60	1 coat		860	660	81	62
61			500	370	47	35
		Avg.	680	510	64	48
62	AE-1	1 hr.	1180	780	111	74
63	1 coat		730	450	69	42
64			1030	570	96	54
		Avg.	980	600	92	57
65	SC-1		600	370	57	35
66	1 coat		1420	760	134	72
67			1450	1010	137	95
		Avg.	1157	713	109	67

Table I - Cont'd

Specimen No.	Coating	Dry to Touch	Total Load		Bond Stress lb. per sq. in.	
			Initial	Final	Initial	Final
68	MC-1	24 hr.	1120	860	106	81
69	1 coat		1440	1080	136	102
70			1280	1020	121	96
		Avg.	1280	987	121	93
71	#7 Black	1 hr.	1530	1090	144	103
72	1 coat		1260	910	119	86
73			1450	1190	137	112
		Avg.	1413	1063	133	100
74	#7 Black	1 hr.	1530	1080	144	102
75	2 coats		1310	880	124	83
76			1590	1010	150	95
		Avg.	1477	990	139	93
77	#7 Black	1 hr.	1510	1110	142	105
78	Tar Base		1520	1010	143	95
79	1 coat		1580	1040	149	98
		Avg.	1537	1053	145	99
80	Barrett	1 hr.	1840	1560	174	147
81	Black		3050	2880	288	272
82	Tar Base		3230	3120	305	294
	1 coat	Avg.	2707	2520	256	238
83	TP-2	30 min.	3420	3230	322	305
84	1 coat		2750	2430	260	229
85			4940	3890	465	367
		Avg.	3703	3183	350	300
86	TP-2	30 min.	60	40	6	4
87	2 coats		60	30	6	3
88			400	320	38	30
		Avg.	173	130	16	12

Table I - Cont'd

Specimen No.	Coating	Dry to Touch	Total Load		Bond Stress lb. per sq. in.	
			Initial	Final	Initial	Final
89	Lansing	1 hr.	5120	4000	483	378
90	Paint &		6280	6250	593	590
91	Color		5380	4950	508	467
	Pent. 4					
	1 coat	Avg.	5593	5067	527	478
92	Lansing	1 hr.	6150	6000	580	566
93	Paint &		5370	5190	507	490
94	Color		6800	6180	641	583
	Pent. 4					
	2 coats	Avg.	6107	5790	577	546
95	Pavement	5 min.	7280	7080	687	668
96	Lacquer		7580	6960	715	657
97	White		8080	7460	763	705
	1 coat	Avg.	7647	7167	720	677
98	Pavement	5 min.	7500	7310	708	690
99	Lacquer		7020	6810	662	643
100	White		7640	7000	720	660
	2 coats	Avg.	7387	7040	697	664
101	Std. Oil Co.	1 hr.	670	510	63	48
102	Black		760	630	72	59
103	Pent. 97		700	530	66	50
	1 coat	Avg.	710	557	67	52

TABLE II

DETERMINATION OF FILM THICKNESS
MEASUREMENTS IN INCHES

Coating	Diameter by Micrometer					Average Diameter	Difference Averages	Average Film Thickness
	1	2	3	4	5			
Red Lead								
Coated	0.778	0.785	0.781	0.779	0.789	0.782		
Uncoated	0.757	0.754	0.757	0.758	0.756	0.756	0.026	0.0130
RC-1								
Coated	0.758	0.757	0.759	0.760	0.761	0.759		
Uncoated	0.757	0.757	0.755	0.754	0.750	0.755	0.004	0.002
RC-2								
Coated	0.765	0.767	0.763	0.765	0.764	0.765		
Uncoated	0.756	0.755	0.758	0.754	0.756	0.756	0.009	0.0045
AE-5								
Coated	0.767	0.769	0.766	0.768	0.767	0.767		
Uncoated	0.754	0.757	0.750	0.756	0.758	0.755	0.012	0.0060
Chicago Paint Works								
Coated	0.761	0.762	0.762	0.764	0.763	0.762		
Uncoated	0.753	0.754	0.756	0.754	0.752	0.754	0.008	0.0040