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MICHIGAN
STATE HIGHWAY DEPARTMENT
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AN INVESTIGATION OF RIGID FORM LINING

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Highway Research Project 48 G-42

Research Laboratory
Testing and Research Division
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HYDRON FORM LINING

Research Project AE 6-42

Subject

An investigation of Hydron Form Lining.

Purpose

To compare the surface texture and hardness of concrete cast in contact with Hydron form lining and oiled plywood respectively.

Origin of Investigation

Request by Bridge Division.

Scope

Concrete blocks 12 - by 12 - by 6 inches containing about 4.5 percent entrained air were molded in forms with the two square faces in contact with Hydron form lining and oiled plywood respectively. Hydron form lining was used in both the dry and wet conditions. The specimens were inspected for texture and subjected to a wear test at 8 days to determine surface hardness.

Summary

1. The average depth of penetration of plywood-formed surfaces was 60 percent greater than that of Hydron-formed surfaces in the 10-minute wear test.

2. Hydron liner used in the dry condition reduced but did not entirely prevent formation of air pockets on the concrete surface. Wet Hydron liner was not efficient in reducing the number of surface voids.

3. There was little difference in the surface hardness of concrete cast against Hydron in the wet and dry conditions. However, pre-wetting should be avoided on account of the warping of the lining which occurs and the greater number of surface voids formed when the lining is saturated before placing the concrete.

4. The wear was proportional to the slump of the concrete regardless of the forming material.

Conclusions

1. In these tests the Hydron-formed surfaces were superior to the plywood-formed surfaces with regard to both texture and hardness.

2. Hydron-formed surfaces should require less rubbing than plywood-formed surfaces on concrete structures.

Recommendations

The results of this investigation appear to justify a full-scale field trial on a suitable structure in order to determine the practicability and efficiency of the material in actual construction.

Materials

1. Forms:

   (a) Hydron Form Liner.
      (1) Manufacturer - United States Rubber Co.
      (2) Description and Specifications:
         a. Muslin membrane cemented to a pasteboard back.
         b. Length: 48 in., 60 in., and 72 in.
         c. Width: 48 in.
         d. Thickness: 0.08 in.
         e. Weight: 0.2 lb. per sq. ft.
         f. Packages: 25 sheets

   (b) Oiled Plywood.

2. Concrete Materials

   (a) Cement: Peerless, Detroit Air Entraining.

   (b) Fine Aggregate: Bolchot S. and Gr. Co., Lansing, MS.

   (c) Coarse Aggregate: American Aggregates Corp., Green Oak, MI.

Proportions

1. Constants

   (a) Cement content: 5.5 sacks per cubic yd. of concrete.

   (b) $^{b}/_{bo}$: 0.70

   (c) S.W.C. : 1.20

   (d) Weight per cubic foot of dry loose coarse aggregate: 100 lbs.

2. Quantities per sack of cement (Grade A Concrete)

   (a) Cement: 94 lbs.

   (b) Fine Aggregate: 227 lbs.

(c) Coarse Aggregate: 344 lbs.

(d) Water: 59.5 lbs.

3. Quantities per sack of cement (Mortar).

(a) Cement: 94 lbs.

(b) Fine Aggregate: 227 lbs.

(c) Water: 45.1 lbs.

Procedure

1. Preparation of Test Specimen.

(a) Forms were made of a 3/4 in. plywood in such a manner as to form a 12 in. by 12 in. by 6 in. block molded on end.

(b) The Hydron liner was stapled by Scotch or by carpet tacks to one 12 in by 12 in. surface. The opposite side was oiled to provide the oiled plywood surface.

(c) The concrete blocks were molded by filling in two layers, each consolidated by an electric vibrator.

(d) The mortar blocks were molded by filling in several layers but one block was vibrated and the other was hand rodded and spaded with no vibration. These blocks were made for long period wear tests so as not to be affected by any coarse aggregate that might be on the surface of concrete.

(e) The blocks were cured overnight with a damp covering, then 6 days in a moist room. They were then air-dried one day before the test.

2. Wear Test Apparatus and Procedure.

(a) Description: The wear test device consisted of a star grinding wheel assembly mounted in a drill press. It was weighted in such a manner as to apply 18 pounds of pressure on the grinding wheels. See Figure 1.

(b) Method of Measurement: The penetration of the grinding assembly was measured by means of a Federal Dial Indicator mounted as shown in Figure 1. Readings were taken with the assembly in four positions each at 90° to the preceeding in a clockwise direction.

(c) On concrete blocks readings were taken at zero, 3 and 10 minute intervals of grinding.

(d) On mortar blocks readings were taken at zero, 3, 6, and 10 minutes and at 5 minute intervals thereafter until the grinding wheel assembly had reached its maximum possible penetration.

Results

1. Surface Texture

(a) Hydron lining imparts a smooth surface showing the weave of the muslin membrane (Figure 2). The irregularity at the top was due to mortar clinging to the muslin when it was pulled loose. This happened on several blocks. The surface is dense and would require very little rubbing for final treatment.

(b) The plywood also imparted a smooth surface to the concrete (Figure 3) but began to exhibit signs of deterioration by the 7th block (Figure 4).

(c) The concrete blocks were vibrated without hand spading or puddling and a considerable number of air pockets developed in all surfaces. This is believed due to the vibrator which was a 2 inch high frequency electric type and the relatively narrow section of concrete. Areas of the least number of air pockets were selected for grinding.

(d) One mortar block was vibrated, the other hand-spaded, but both showed excessive air pockets.

(e) Wetted liners did very little to reduce air pockets as shown by Figure 5 as compared with the plywood formed surface in Figure 6, both of which were from the same block.

(f) In general there were fewer air pockets in the Hydron lined surface than in the plywood lined surface regardless of the slump, but are in no wise eliminated. The liner must be kept dry as recommended in the company's literature to eliminate warping and to act as an absorbent surface.

2. Surface Hardness.

(a) In all but one case the wear on the plywood formed surface was greater than the wear on the Hydron lined surface. The one exception was the 3 minute test on block No. 5. The Hydron liner in this case was kept continuously soaked for

2-1/2 hours prior to molding and therefore did not absorb water from the concrete. Table I gives the test results. Figure 10 shows graphically the comparison between wear on the plywood formed surface and the wear on the wet and dry Hydron lining formed surfaces.

(b) Wear was proportional to the slump of concrete as shown in Figure 11. The slump values were grouped because of the relatively few number of tests.

(c) The wear test brought out the evidence of air pockets underneath the surface as shown by Figure 7 as compared with Figure 2 which are photographs of the same surface. The unevenness of the ground surface is due to grinders of varying diameter which were replaced after the first four blocks were tested.

(d) Typical examples of wear are shown in the photographs of Figures 5 and 9, which are the two opposite surfaces of the same block. Figure 5 shows the Hydron-formed surface, and Figure 9 of the plywood formed surface after grinding. It is noticeable that greater wear is shown on the plywood-formed surface than the Hydron-formed surface.

7. Surface hardness of Mortar Blocks

These blocks were tested to the extent of the grinding wheels which was about 1/4 inch. Table 2 and Figure 12 show the comparison between vibrated and non-vibrated blocks and between the Hydron-lined and plywood lined surface. No great difference exists between the two blocks as far as method of consolidation is concerned. The greatest difference presents itself between the Hydron-lined and the plywood-lined surface. The former requires approximately 3 times as long as the latter to produce equal wear.

It is evident that the effect of the Hydron liner reaches deeper than the depth penetrated, but the testing device was not capable of grinding further. A very slight increase of slope of the curves to the right in Figure 12 indicates a gradually weaker structure as the machine ground deeper.

TABLE 1

Summary of Test Data on Concrete Blocks

Specimen Number	Age	Slump	W/c	Type of Lining	Condition of Lining	Depth of Penetration		Remarks
						5 minutes	10 minutes	
	Days	In.	g.p.g.			Inches	Inches	
1	9	5-1/2	5.14	Plywood	Oiled	.038	.044	2 tests
				Hydrex	Dry	.034	.041	2 tests
2	9	3-1/2	5.54	Plywood	Oiled	.023	.044	3 tests
				Hydrex	Wet	.018	.029	3 tests
3	9	3	5.54	Plywood	Oiled	.018	.031	3 tests
				Hydrex	Dry	.009	.020	3 tests
4	8	3-3/4	5.54	Plywood	Oiled	.032	.045	4 tests
				Hydrex	Dry	.013	.021	4 tests
5	8	3-7/8	5.54	Plywood	Oiled	.012	.046	4 tests
				Hydrex	Wet	.013	.029	4 tests
6	8	5	5.54	Plywood	Oiled	.026	.070	4 tests
				Hydrex	Wet	.017	.038	4 tests
7	8	3-1/2	5.44	Plywood	Oiled	.024	.072	4 tests
				Hydrex	Dry	.016	.037	4 tests
8	8	3	5.21	Plywood	Oiled	.029	.071	4 tests
				Hydrex	Dry	.011	.027	4 tests

TABLE 2

Summary of Wear Data on Mortar Blocks

Time	Plywood Surface				Mortar Surface			
	No. 9		No. 10		No. 9		No. 10	
Min.	Wear in.	Cum Wear in.	Wear in.	Cum. Wear in.	Wear in.	Cum Wear in.	Wear in.	Cum Wear in.
0	0	0	0	0	0	0	0	0
3	.025	.025	.031	.031	.019	.019	.021	.021
6	.018	.043	.017	.048	.002	.021	.008	.029
10	.021	.064	.021	.069	.006	.027	.005	.034
15	.034	.098	.031	.099	.011	.038	.010	.044
20	.060	.158	.040	.139	.008	.046	.007	.051
25	.072	.230	.045	.184	.012	.058	.005	.056
30			.052	.236	.008	.066	.008	.064
35					.009	.075	.011	.075
40					.010	.085	.008	.083
45					.009	.094	.014	.097
50					.009	.103	.014	.111
55					.014	.117	.015	.126
60					.007	.124	.014	.140
65					.007	.131	.017	.157
70					.016	.147	.016	.173
75					.013	.160	.020	.193
80					.013	.173	.019	.212
85					.028	.201		
90					.019	.220		

Mix No. 9: Slump 2-1/2 in., vibrated.

Mix No. 10: Slump 4 in., hand spaded.

Hydron used in dry condition, both mixes.

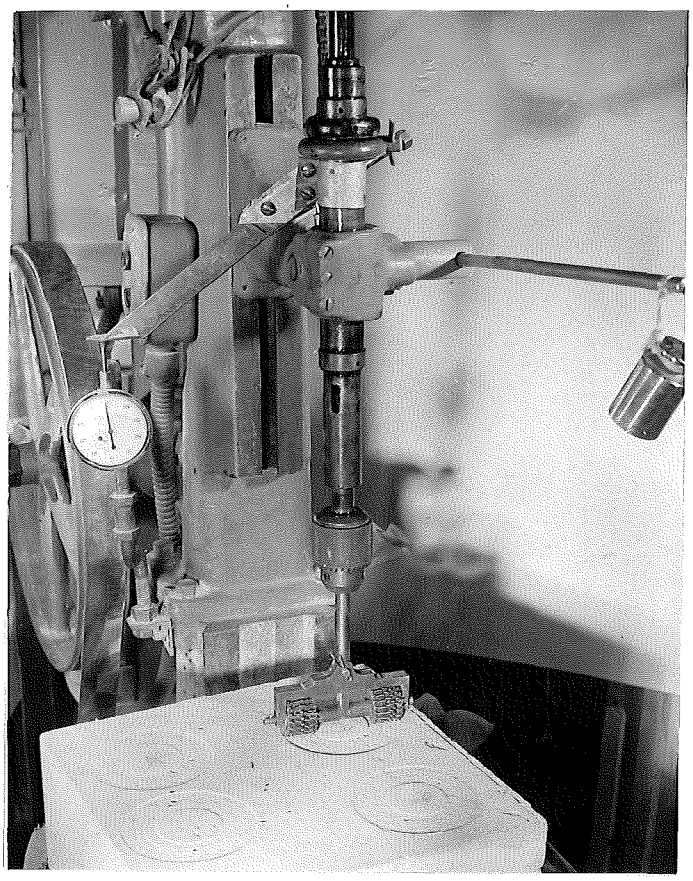


Figure 1. Apparatus used in wear test for surface hardness.

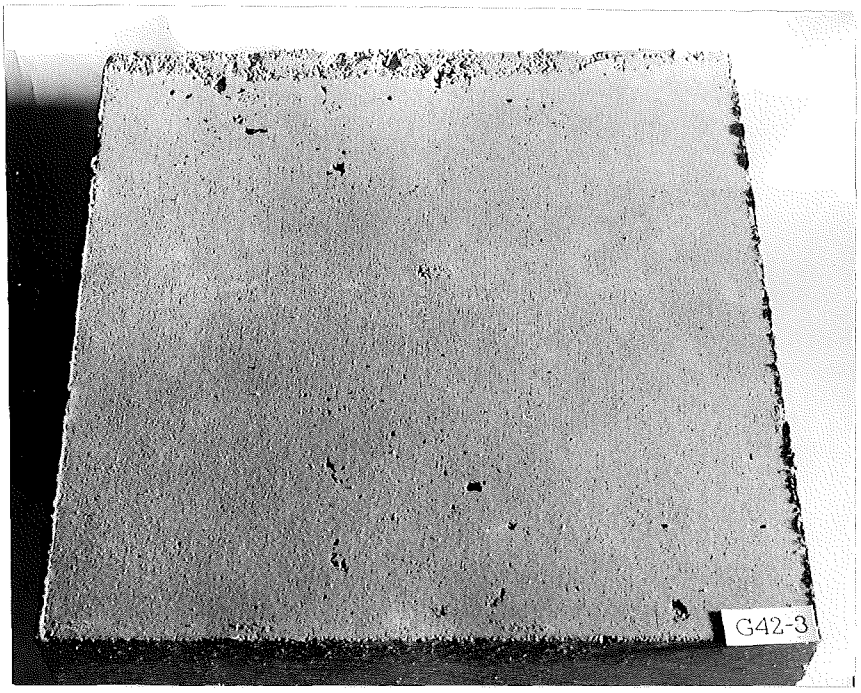


Figure 2. Texture of dry Hydron-formed concrete surface.

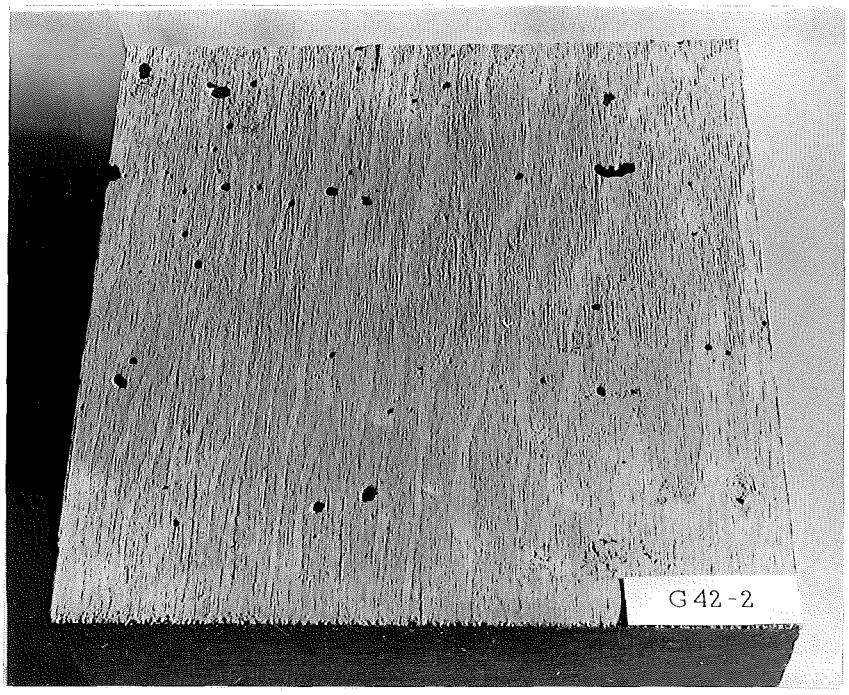


Figure 3. Texture of oiled plywood-formed concrete surface.

Figure 4. Surface showing effect of warping and cracking of plywood after being used six times.

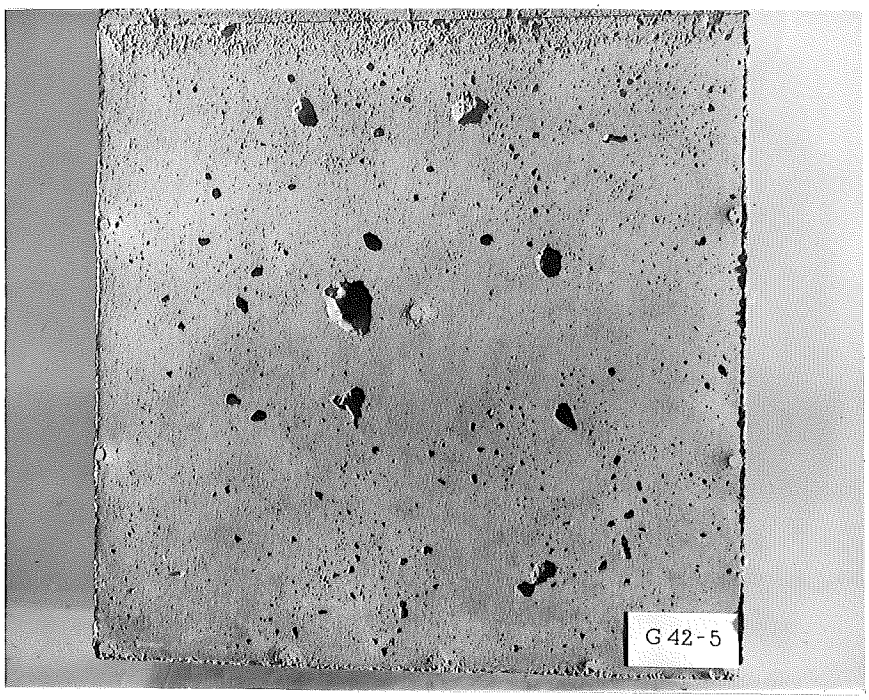


Figure 5. Surface formed with wet Hydron lining

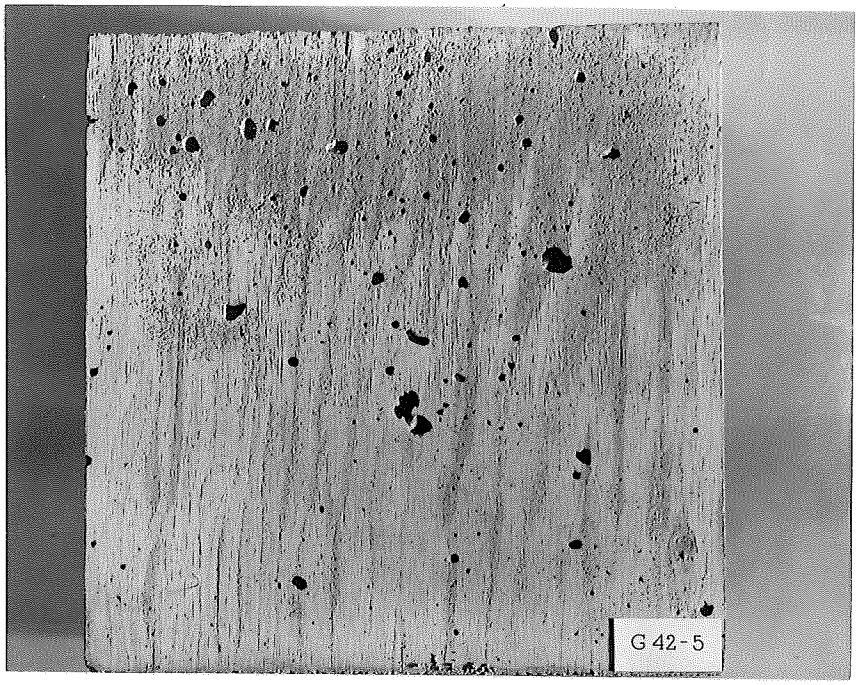


Figure 6. Plywood-formed surface of same block shown in Figure 5.

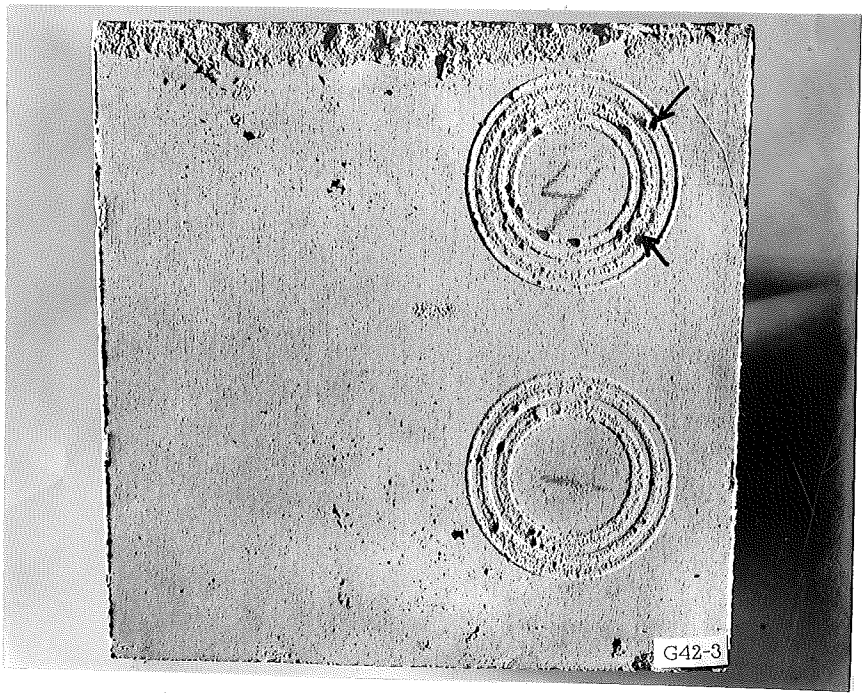


Figure 7. Air pockets uncovered in wear test. This is the same surface shown in Figure 2.

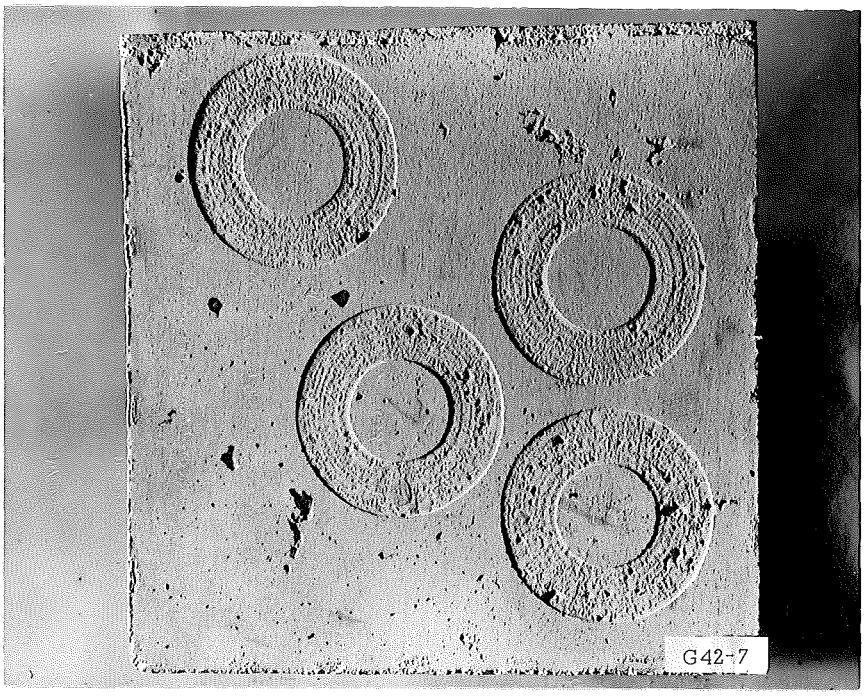


Figure 8. Depth of penetration of Hydron-formed surface in wear test.

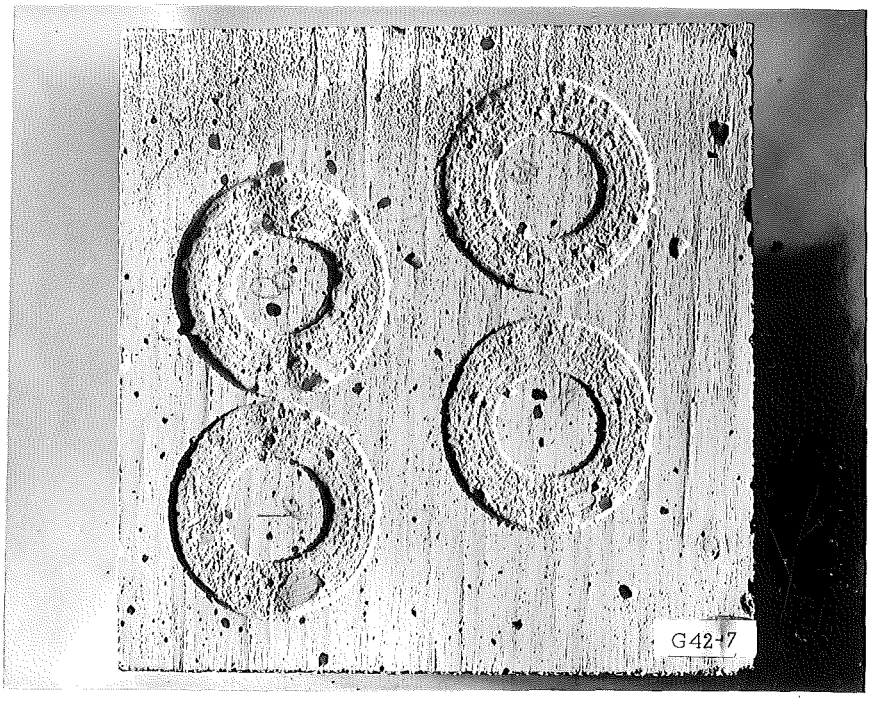
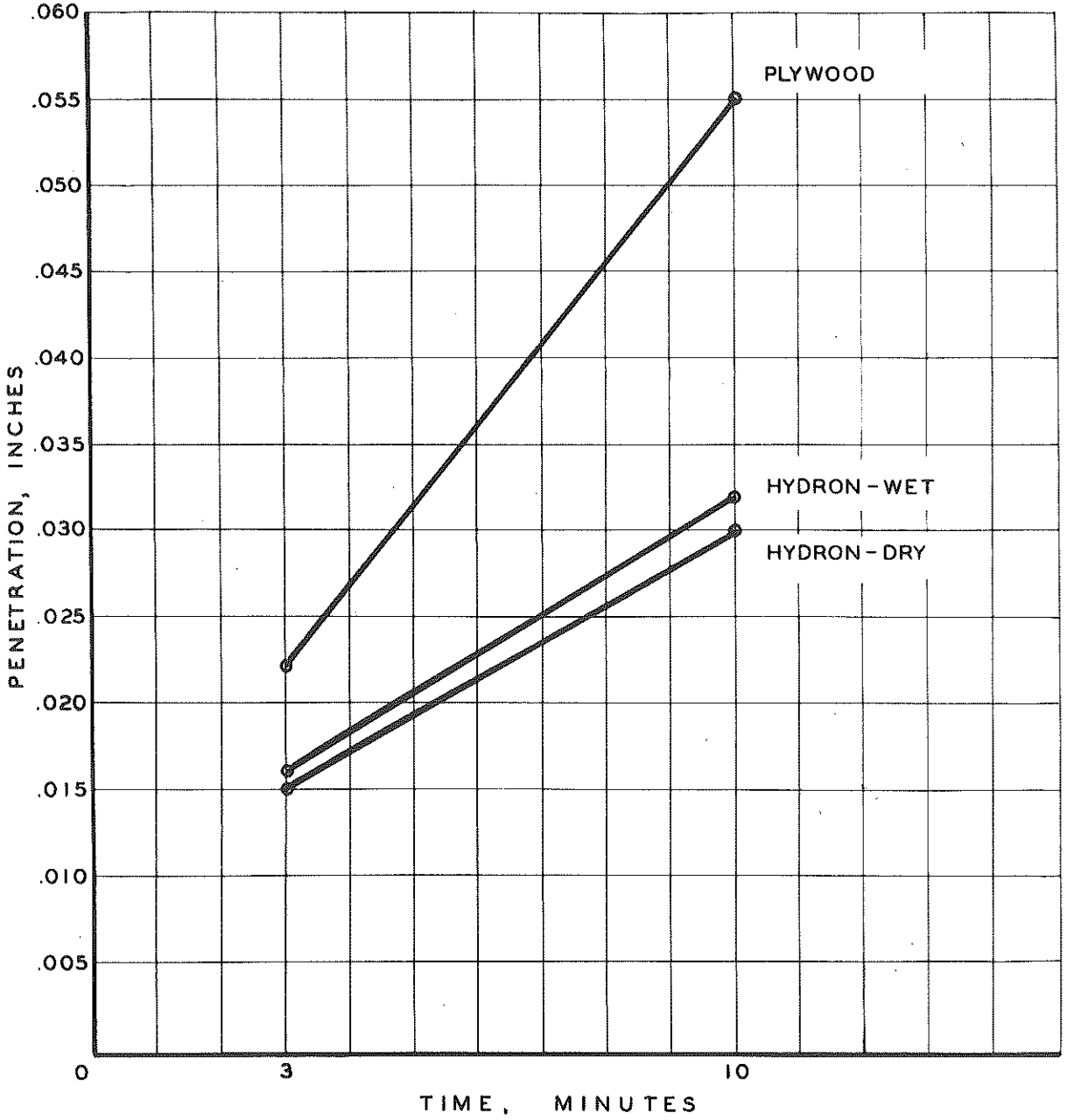


Figure 9. Depth of penetration of plywood-formed surface on opposite side of same block shown in Figure 8.



EFFECT of FORM LINING on SURFACE HARDNESS of CONCRETE

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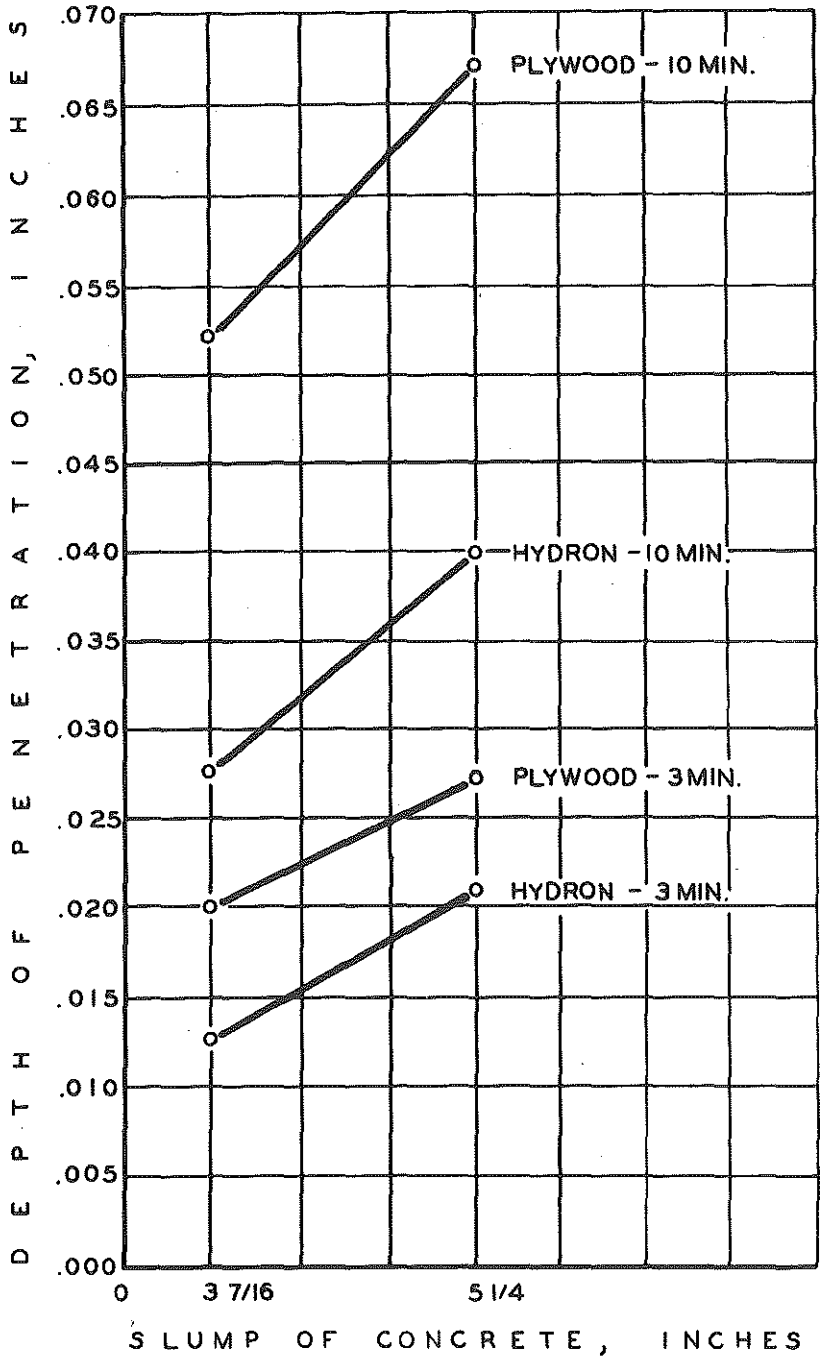
Figure 10



RELATION *between* SLUMP *and* SURFACE HARDNESS *of* CONCRETE

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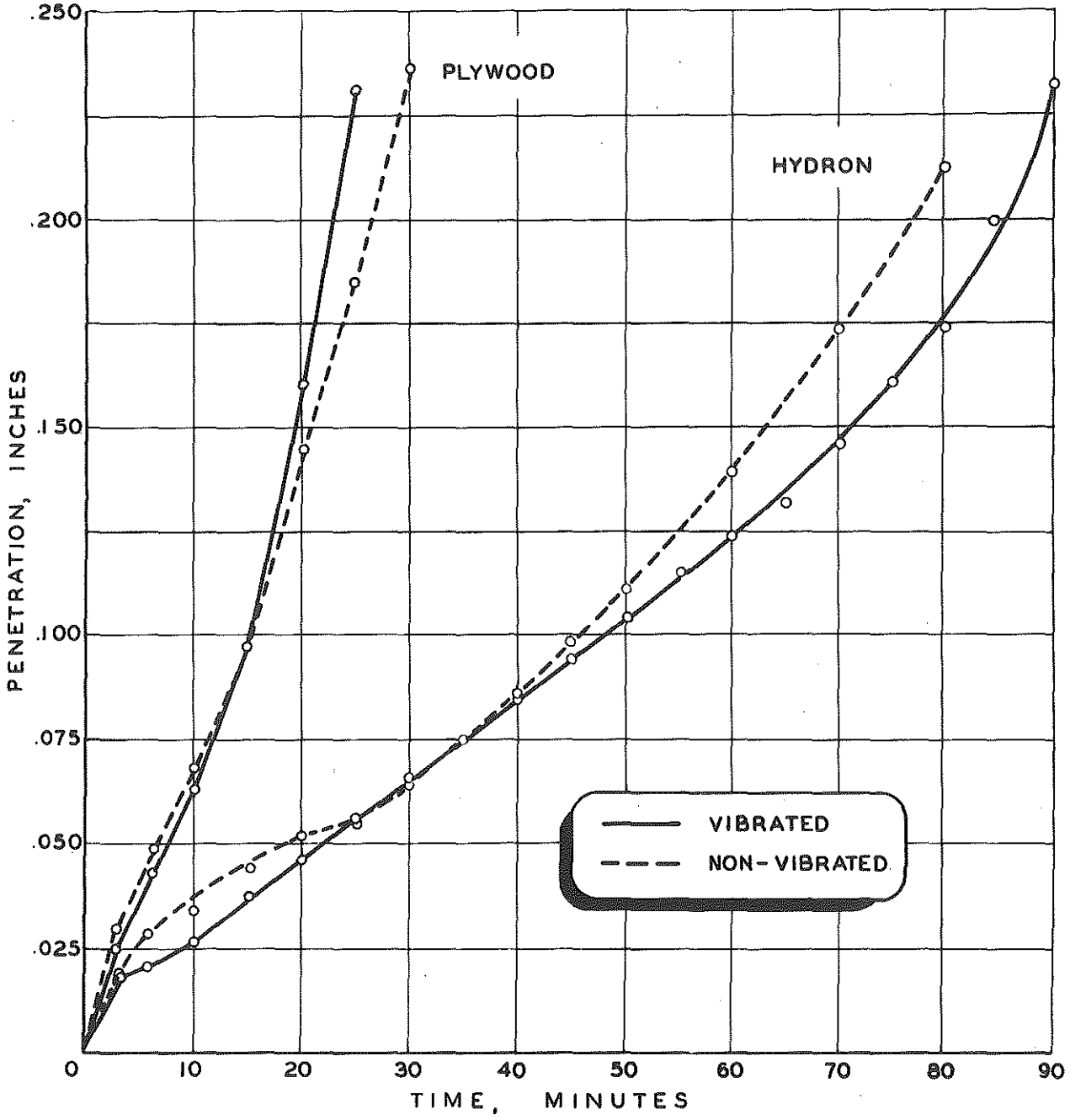
Figure 11



EFFECT of FORM LINING on SURFACE HARDNESS of MORTAR

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Figure 12