

OFFICE MEMORANDUM

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MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

November 18, 1968

To: C. J. Arnold, Supervisor
Structures Unit

From: M. A. Chiunti

Subject: Anchorage Resistance of Standard Hook-Bolts. Research Project
54 F-35. Research Report R-688.

Per your request, pull-out tests were performed to determine the anchorage resistance of standard hook-bolts. All tests were performed in the Laboratory with the cooperation of the Concrete and Surface Treatments Unit, which was responsible for casting the test blocks and testing the compression cylinders.

A total of 20 hook-bolts were tested, using five concrete test blocks. Test block Nos. 1 and 2 each contained two male and two female hook-bolts of 1/2 in. diam with 9/16-12UNC rolled threads. Test block Nos. 3, 4, and 5 each contained two male and two female hook-bolts of 9/16 in. diam with 5/8-11 UNC rolled threads. The minimum tensile strength requirement for each size assembly as given in the current Standard Specifications is 16,000 lb and 20,000 lb for the 1/2- and 9/16-in. diam bolts, respectively.

All of the test block dimensions were 36 by 36 by 9 in. deep. Block Nos. 1, 2, and 3 were cast from a 6 sack, Type III cement mix and blocks 4 and 5 were made from a 5.7 sack, Type I cement mix. The results of the compression cylinder tests for each block are given in Table 2. The reinforcement for the first three blocks consisted of two No. 5 bars, 28 in. long, laid just above the bolts and spaced 4 in. from the edge and 4 in. apart along each side. Blocks 4 and 5 contained the same size and length reinforcement bars at the same spacing along two opposite sides only. A hook-bolt was placed in the center of each side with a male opposing a female and in all cases the right angle bend was positioned horizontally so as not to engage the reinforcement at the time of pull-out.

Load was applied to the hook-bolts by the test frame shown in Figure 1. The ultimate load and a description of the type of failure for each hook-bolt were recorded after each test. These results are summarized in Table 1. Photographs of typical failures of each type of hook-bolt are shown in Figure 2. In all cases the 1/2-in. diam hook-bolts failed in tension at the bend under a load ranging from 14,100 pounds to 16,100 pounds and produced only small surface spalls. Of the twelve 9/16-in. diam hook-bolts tested, three failed by straightening and pulling out of the block, five cracked the test block, and the remaining four failed in tension at the bend. The load at which the 9/16-in. diam bolts failed ranged from 16,000 pounds to 22,000 pounds. The average failure load for each case was as follows:

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1/2 in. male, with reinforcement	- 14,475 lbs.
1/2 in. female, with reinforcement	- 15,850 lbs.
9/16 in. male, with reinforcement	- 17,750 lbs.
9/16 in. female, with reinforcement	- 20,650 lbs.
9/16 in. male, without reinforcement	- 19,200 lbs.
9/16 in. female, without reinforcement	- 19,900 lbs.

As can be seen, the female type hook-bolts failed at a higher load than the male. It is possible that the extra bond strength contributed by the larger exposed area of the female bolts, which use a sleeve, is the reason for this. No explanation can be offered for the lower load failure of the male bolts with reinforcement as compared to the male bolts without reinforcement. It should also be noted that load frame reactions near the corners may have helped initiate block failures.

Since the testing program was quite limited, no definite conclusions can be drawn. However, the following facts seem to be indicated:

1. Anchorage is sufficient to develop the strength of the 1/2-in diam bolts.
2. The 9/16-in diam bolt anchorage is quite well balanced, since three bolts straightened and pulled out, four bolts failed in tension and five bolts caused block failures.
3. Although the average capacities for the 9/16-in diam bolts are slightly below the minimum specified, the results seem reasonable in light of the methods used in the tests.

TESTING AND RESEARCH DIVISION

Manuel A. Chivato

Highway Laboratory Technician
Structures Unit
Research Laboratory Section

MAC:slt

TABLE 1
HOOK-BOLT PULL OUT TEST RESULTS

Test Block No.	Bolt Size	Bolt No.	Bolt Type	Ultimate Load, lbs	Remarks
1	1/2"	1	Female	16,100	Bolts failed in tension at the bend
		2	Male	14,700	
		3	Male	14,700	
		4	Female	16,100	
2	1/2"	1	Male	14,400	Bolts failed in tension at the bend
		2	Male	14,100	
		3	Female	15,600	
		4	Female	15,600	
3	9/16"	1	Male	16,400	Cracked the test block Hook-bolt straightened and pulled out Hook-bolt straightened and pulled out Cracked the test block
		2	Female	20,200	
		3	Female	22,000	
		4	Male	16,000	
4	9/16"	1	Male	18,800	Cracked the test block Hook-bolt straightened and pulled out Bolt failed in tension at the bend Bolt failed in tension at the bend
		2*	Female	20,400	
		3	Female	21,400	
		4*	Male	19,400	
5	9/16"	1*	Female	19,400	Cracked the test block Cracked the test block Bolt failed in tension at the bend Bolt failed in tension at the bend
		2	Female	19,000	
		3*	Male	19,000	
		4	Male	19,800	

* No reinforcement

TABLE 2
COMPRESSION CYLINDER TEST RESULTS

Test Block No.	Pour Date	Hook-Bolt Pull-Out Date	Cylinder No.	Compression Test Date	Slump	Compressive Strength, psi
1	7-10-67	7-18-67	1	7-17-67	2-1/4"	4,639
			2	7-18-67		4,809
			3	7-18-67		4,841
			4	8-7-67		6,666
2	7-11-67	7-19-67	1	7-18-67	2-1/2"	5,032
			2	7-19-67		5,159
			3	7-19-67		5,278
			4	8-8-67		5,595
3	9-14-67	9-22-67	1	9-21-67	2-1/4"	4,705
			2	9-21-67		4,330
			3	10-12-67		5,502
			4	10-12-67		5,892
4	12-12-67	12-20-67	---	12-19-67	3"	3,270*
			---	1-9-67		4,080*
5	12-19-67	12-28-67	---	12-20-67	3-1/4"	1,400*
			---	12-22-67		2,270*
			---	12-26-67		2,740*
			---	1-16-68		3,450*

* Average of two cylinders

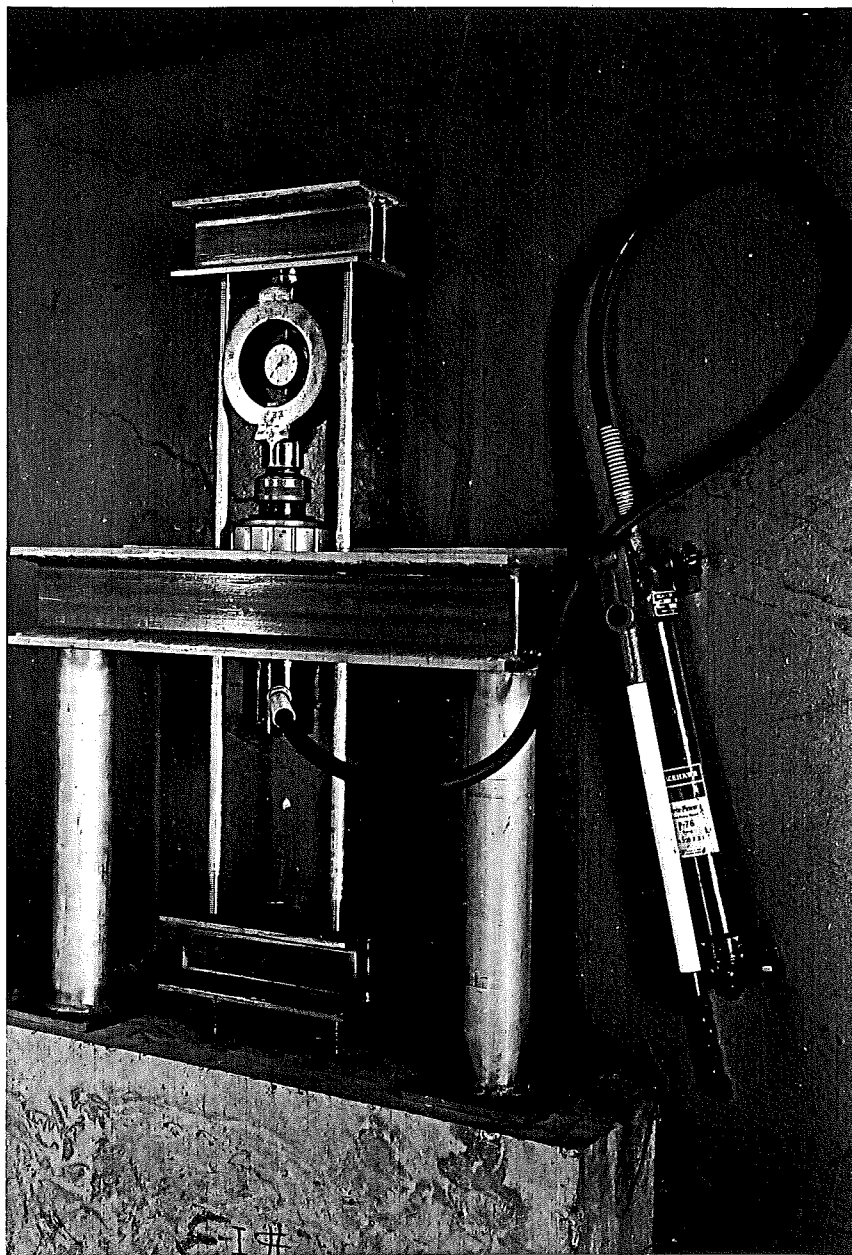
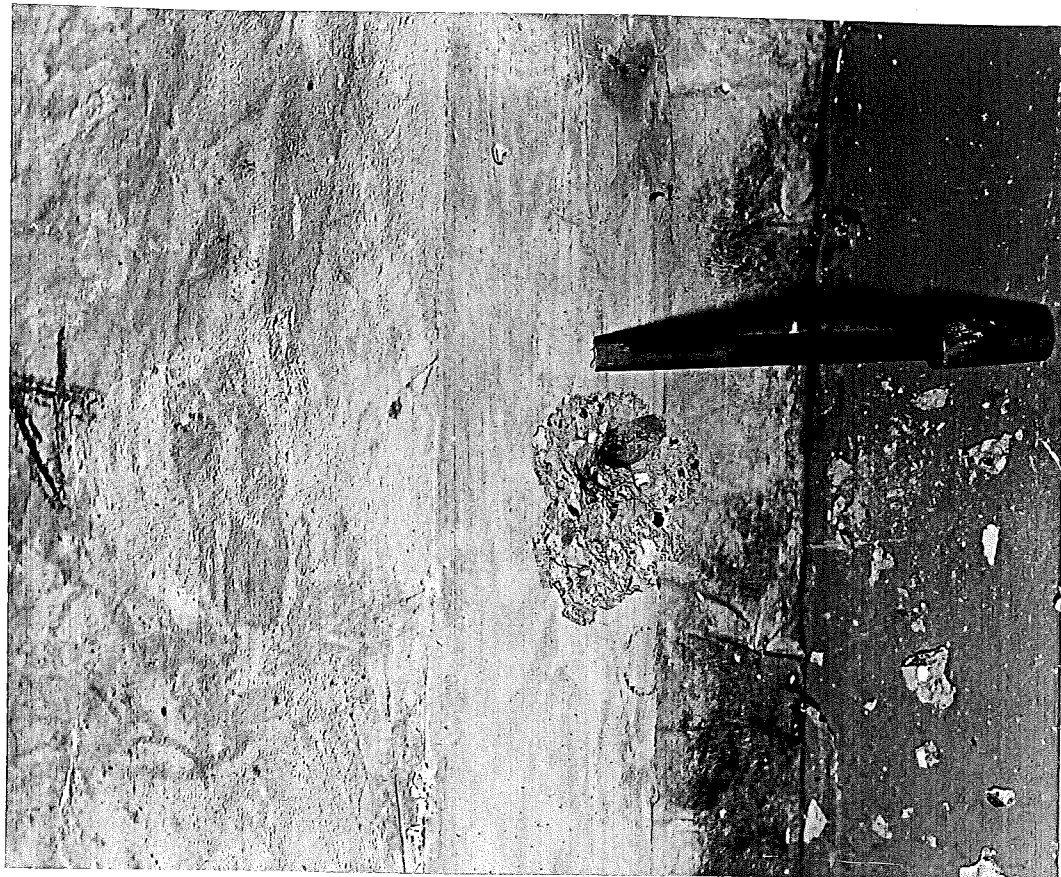


Figure 1. Hook-bolt pull out test frame.

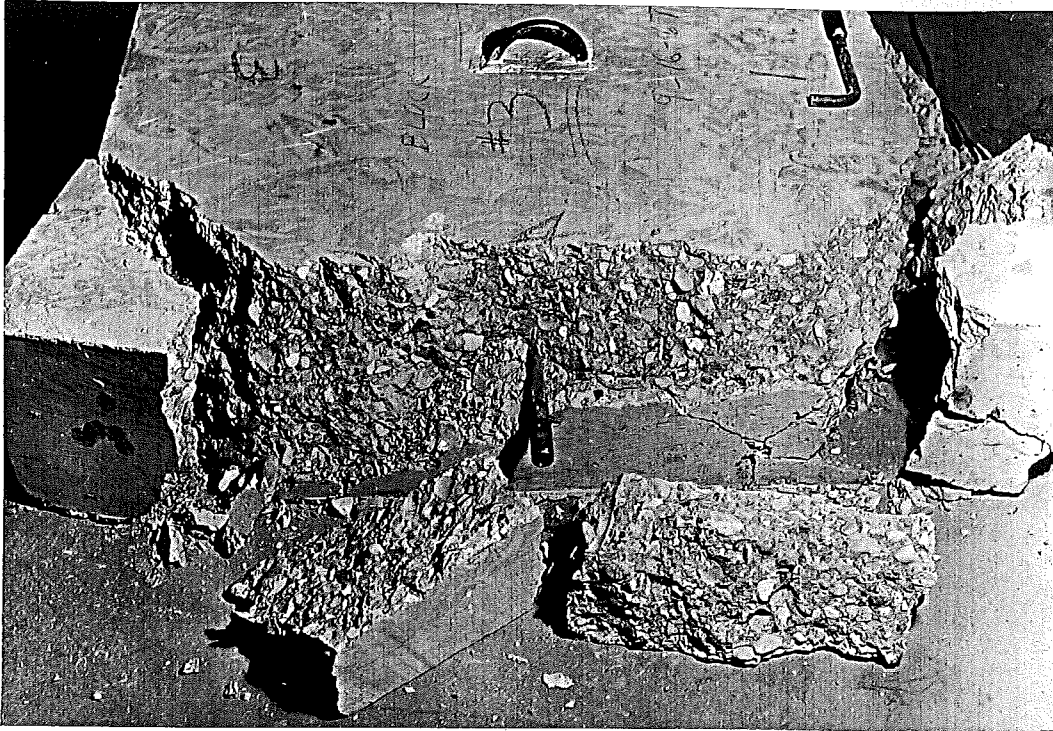


Block no. 1, bolt no. 3, 1/2" dia., male

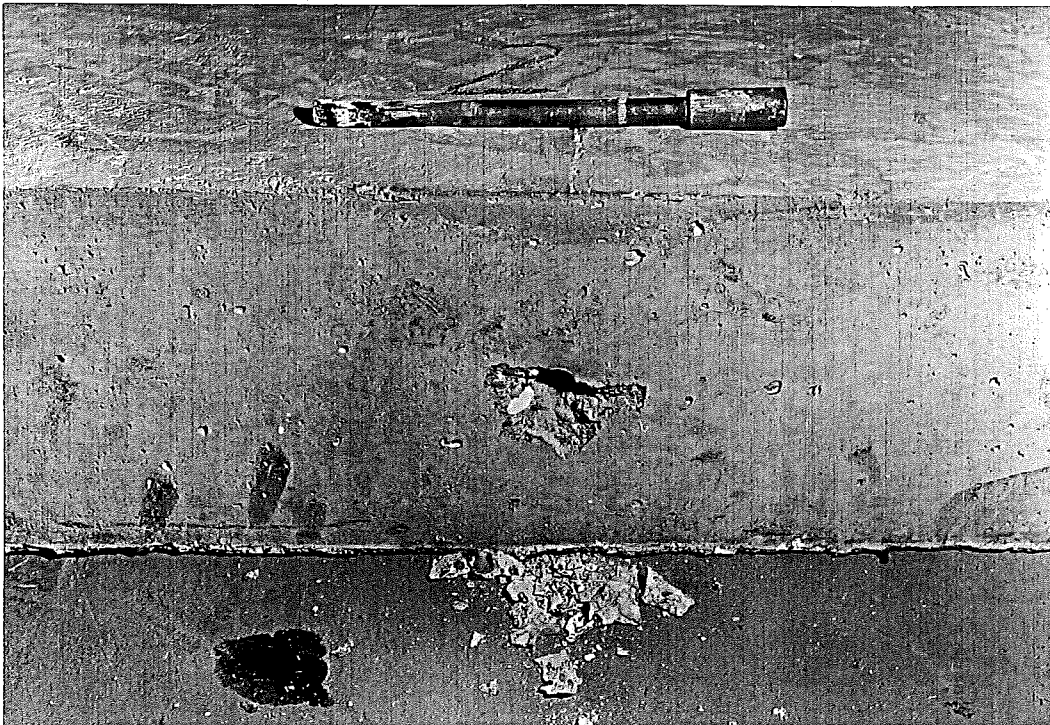


Block no. 1, bolt no. 4, 1/2" dia., female

Figure 2. Typical failure of each type bolt.

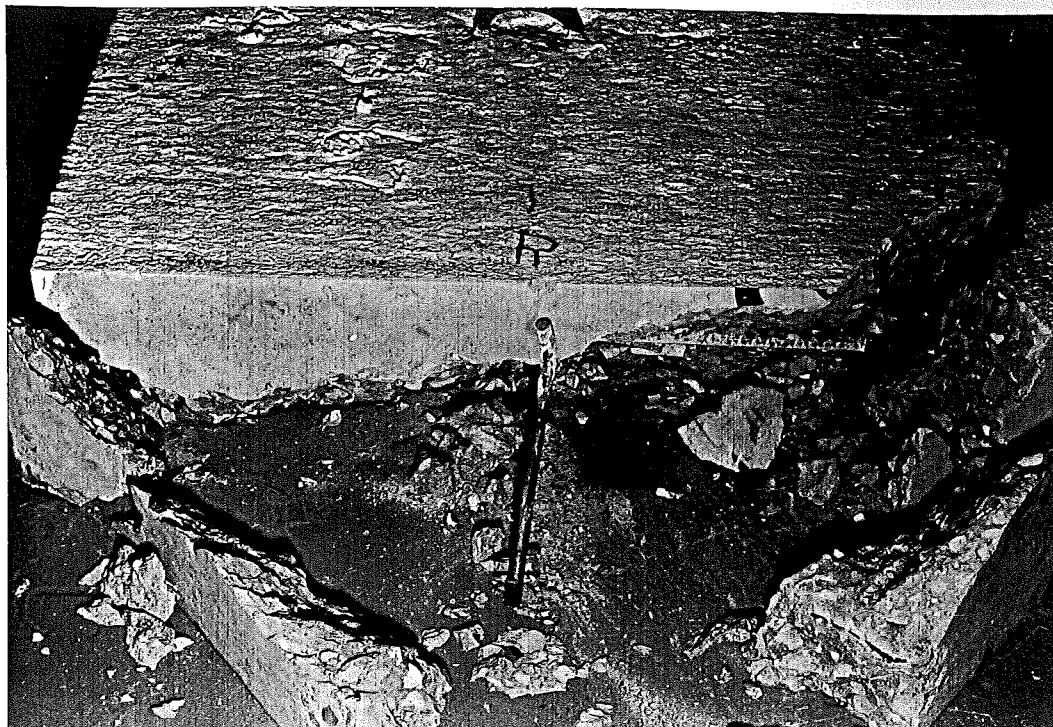


Block no. 3, bolt no. 4, 9/16" dia., male

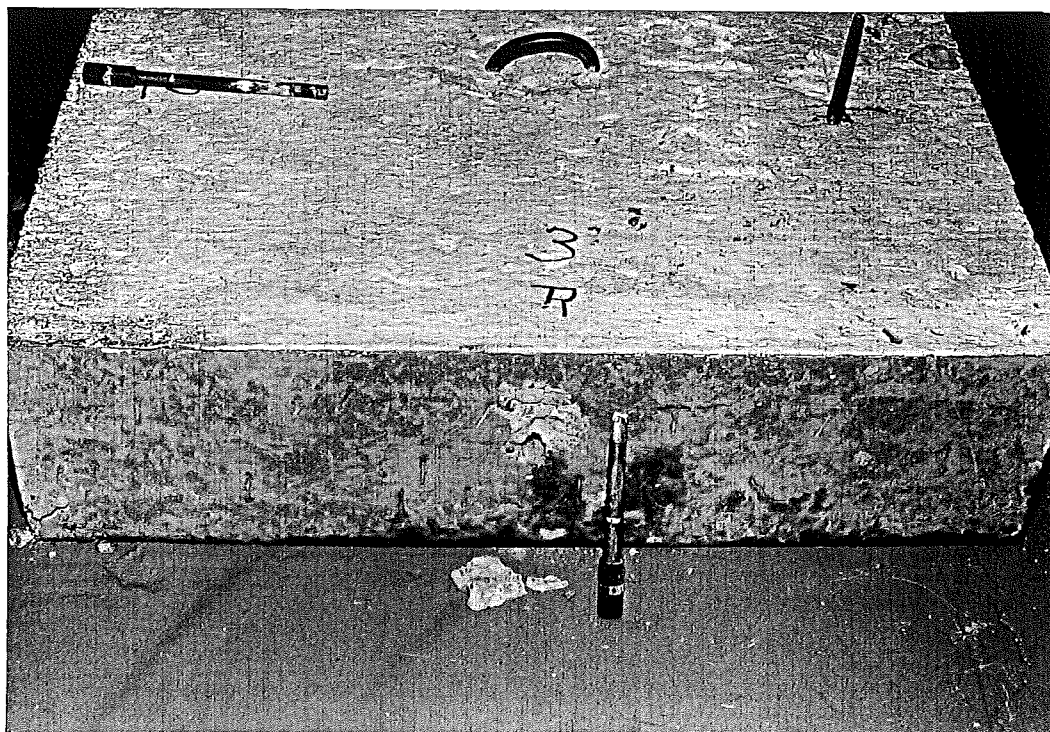


Block no. 3, bolt no. 2, 9/16" dia., female

Figure 2 (con't). Typical failure of each type bolt.



Block no. 4, bolt no. 1, 9/16" dia., male



Block no. 4, bolt no. 3, 9/16" dia., female

Figure 2 (con't). Typical failure of each type bolt.