

PULL-OUT TESTS ON FOUR TYPES
OF EXPANSION SLEEVE TIE BAR DEVICES

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Research Laboratory Division
Office of Testing and Research
Report No. 315
Research Project 59 F-52

Michigan State Highway Department
John C. Mackie, Commissioner
Lansing, September 1959

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PULL-OUT TESTS ON FOUR TYPES OF EXPANSION SLEEVE TIE BAR DEVICES

At the request of Mr. R. Durfee, Assistant to the Road Construction Engineer, the Research Laboratory Division conducted a series of pull-out tests on four types of expansion sleeve tie bar devices. Previously, a similar set of tests, utilizing 9-in. by 9-in. by 12-in. concrete blocks, were made on five samples of expansion hook bolts manufactured by the Chicago Expansion Hook Bolt Company. The results of these tests were reported in a letter to Mr. C. A. Lundberg, Road Construction Engineer, dated January 14, 1959.

In order to better simulate actual conditions under which these devices would be used, and precluding any premature concrete failure with the use of small blocks, all of the specimens were installed along the center of the 9-in. face of an unreinforced concrete slab 3 ft. wide, 9-in. thick, and 30 ft. long. This slab was poured in 1954, in conjunction with a dowel bar design study, and had a 28-day compressive strength of 4200 psi.

Description of Samples

A description of each of the four types of expansion sleeve tie bar devices subjected to pull-out tests are as follows:

1. Expansion Hook Bolt - This device consists of a 5/8-in. diameter bolt with a flared end, a cylindrical lead sleeve, and a tapered cast-iron cone insert.

2. Threaded Anchoring Unit - This device consists of a 5/8-in. diameter bolt with a standard threaded end, a threaded cast iron cone, a plain cast iron cone, and two tapered lead sleeves.

Each of the above two types of devices is manufactured by the Chicago Expansion Bolt Company. A photograph of these two units is shown in Figure 1.

3. Expansion Sleeve - This device consists of a 5/8-in. diameter bolt with a rolled threaded end, a cast iron cone, and a serrated expanding sleeve.

4. Expansion Sleeve - This device is identical to the one described in "No. 3" above except for the bolt diameter, which is 3/4-in. instead of 5/8-in.

Each of these two types of devices is manufactured by Bethlehem Steel Company. A photograph of these two units is shown in Figure 2.

Test Procedure

The installation of each of the four types of devices along the center of the 9-in. face of the concrete slab was as follows:

1. Expansion Hook Bolt: This type of device was inserted into a 1-in. diameter hole, 2-1/2 in. deep. The cast iron cone was then driven under the lead sleeve by means of a slotted tube until no further deformation of the sleeve took place.

2. Threaded Anchoring Unit: This type of device was inserted into a 1-1/8-in. diameter hole, 2-in. deep and was driven in the same manner as described above until no further deformation of the sleeves took place.

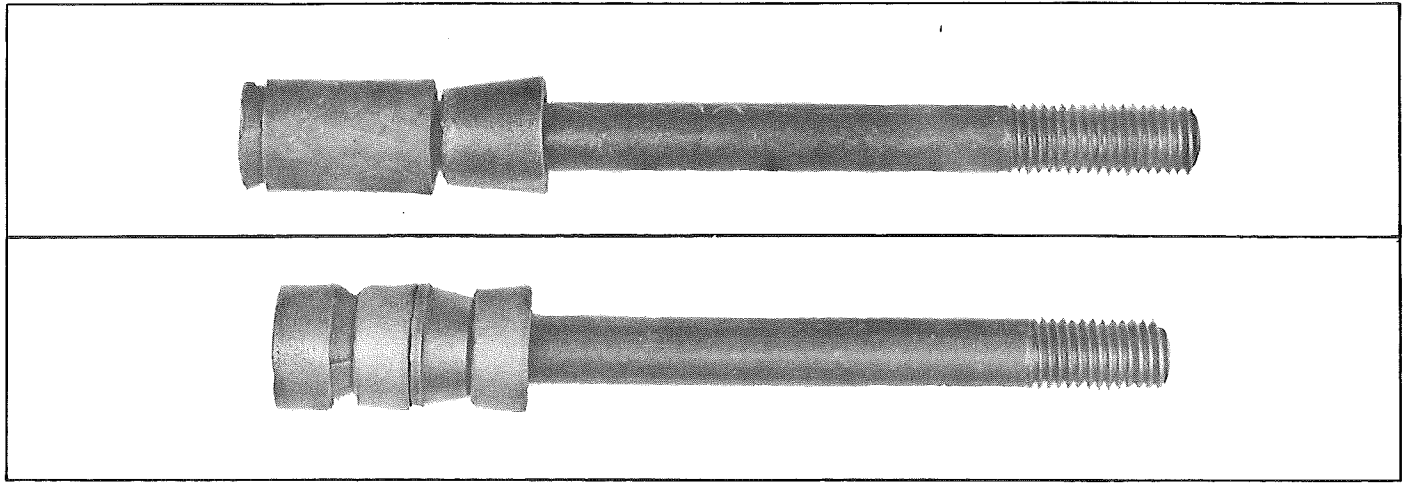
3. Expansion Sleeve: Both the 5/8-in. diameter and 3/4-in. diameter expansion sleeve units were inserted into a 1-1/4-in. diameter hole 4-in. deep. The bolt was then tightened with a torque wrench to a value of 60 foot-pounds.

The installation of each type of device was in accordance with the recommended procedure as prescribed by the manufacturer of the particular units. All holes were drilled with a rotary air drill, using detachable steel rock bits. A picture of this drill is shown in Figure 3.

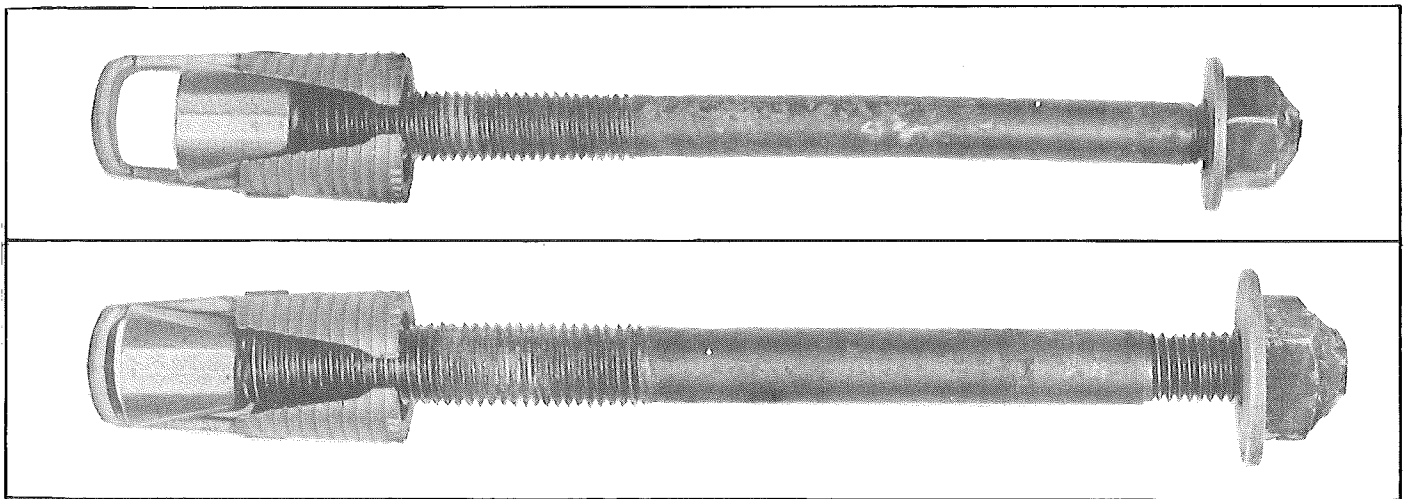
The tie bar devices were pulled from the concrete slab by means of a hydraulically-operated jack and a pre-calibrated dynamometer ring mounted in a steel testing frame. A typical test set-up showing the testing frame in position for pulling one of the tie bar devices is shown in Figure 4.

Results

The results of the pull-out tests, including ultimate loads, and the nature of failure are compiled in Table 1. Photographs showing the condition of each type of unit and the condition of the concrete at failure are shown in Figures 5 through 11.

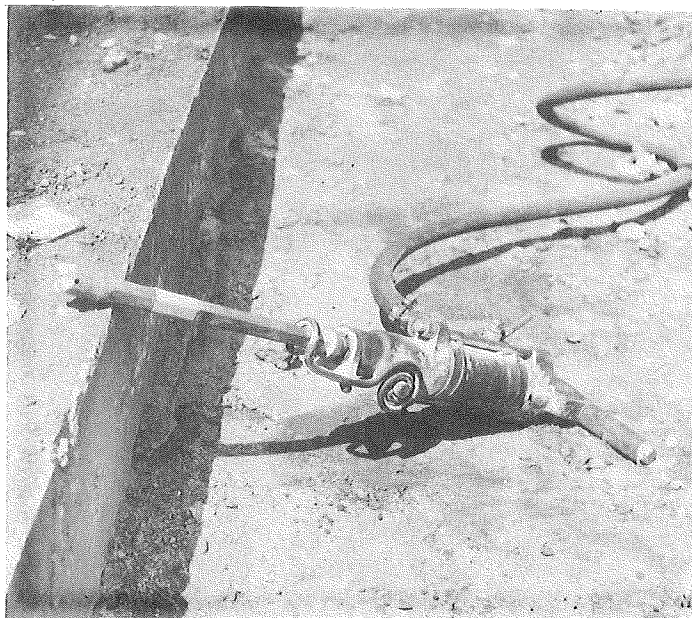


▲ Figure 1 Top: Chicago expansion hook bolt. Bottom: Chicago threaded anchoring unit.



▲ Figure 2 Top: Bethlehem steel expansion sleeve, 5/8-in. diameter. Bottom: Bethlehem steel expansion sleeve, 3/4-in. diameter.

▼ Figure 3 Rotary air drill for drilling holes in concrete slab.



▼ Figure 4 Typical test set-up.

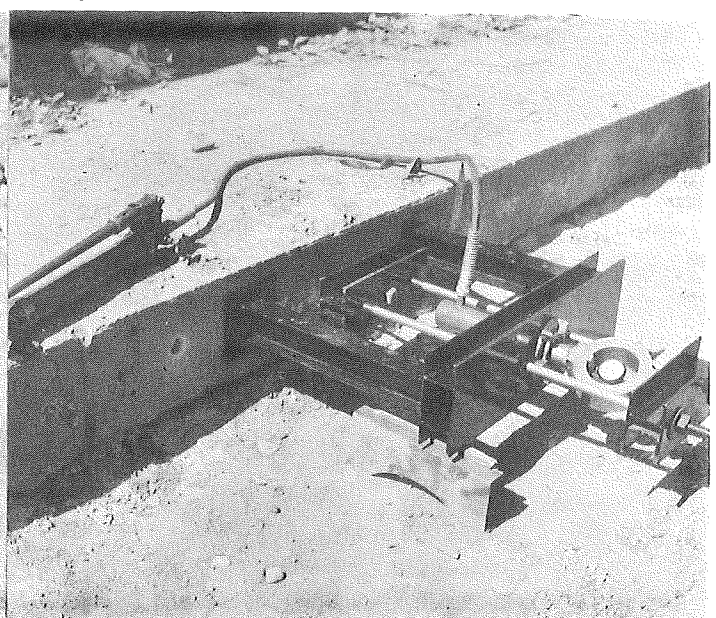


Figure 5. Typical failure of Chicago expansion hook bolt units shown by three specimens on left. Original condition shown by specimen on right.

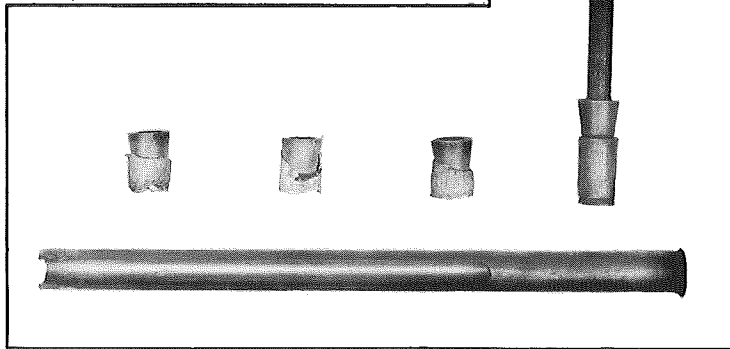


Figure 6. Typical failure of Chicago threaded anchoring units shown by three specimens on left. Original condition shown by specimen on right.

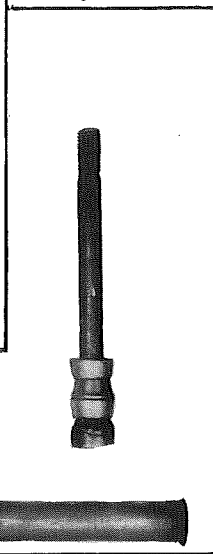


Figure 7. Condition of 5/8-in. diameter Bethlehem steel expansion sleeve units after failure of concrete slab shown by three specimens on left. Original condition of devices shown on right.

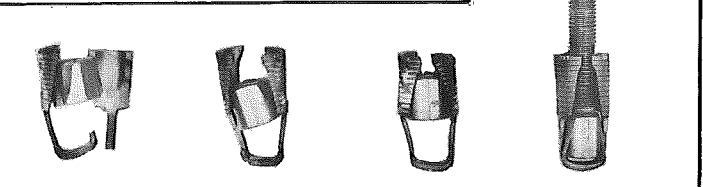
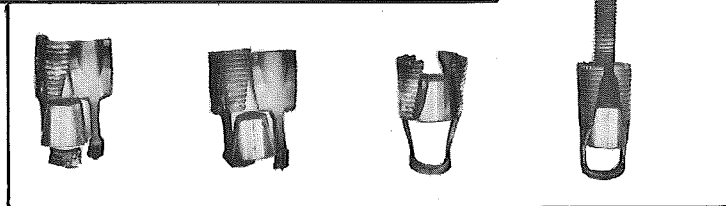
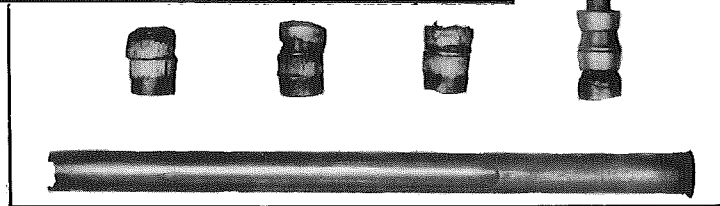


Figure 8. Condition of 3/4-in. diameter Bethlehem steel expansion sleeve units after failure of concrete slab shown by three specimens on left. Original condition of devices shown on right.

Figure 9. Condition of concrete after failure of Chicago expansion hook bolt device.

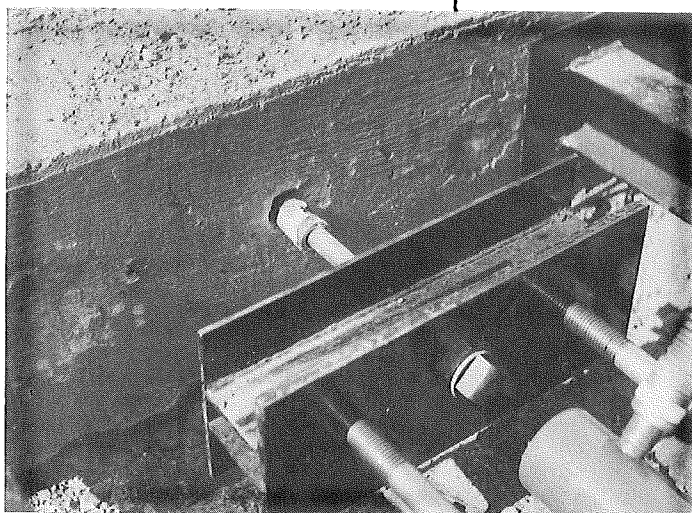


Figure 10. Condition of concrete after failure of Chicago threaded anchoring units.

Figure 11. Typical condition of concrete slab after failure using 5/8-in. diameter or 3/4-in. diameter Bethlehem steel expansion sleeve devices.

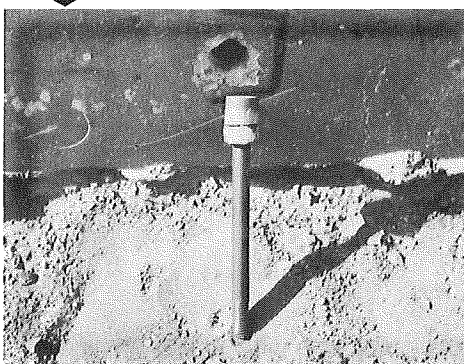


Table 1

ULTIMATE PULL-OUT LOAD VALUES*

Manufacturer	Type	Bolt Diam.	Concrete Hole Diam.	Concrete Hole Depth	Ultimate Load (lbs.)			Failure
					High	Mean	Low	
Chicago Expansion Bolt Co.	Expansion Hook Bolt	5/8"	1"	2-1/2"	9,125	6,720	4,800	Loss of anchorage Failure of lead sleeve
Chicago Expansion Bolt Co.	Threaded Anchoring Units	5/8"	1-1/8"	2"	7,700	5,174	2,900	Loss of anchorage Failure of lead sleeves
Bethlehem Steel Co.	Expansion Sleeve	5/8"	1-1/4"	4"	15,180	14,020	13,150	Loss of anchorage Concrete slab fracture
Bethlehem Steel Co.	Expansion Sleeve	3/4"	1-1/4"	4"	15,500	13,890	12,300	Loss of anchorage Concrete slab fracture

* Results of four samples for each type of anchoring device.

In the case of either the expansion hook bolt or threaded anchoring unit devices, all of the specimens failed by loss of anchorage with no damage to the concrete slab. All of the expansion sleeve devices failed by loss of anchorage accompanied by a fracture of the concrete slab.

Summary

The ultimate pull-out loads for the 5/8-inch diameter and the 3/4-in. diameter expansion sleeve devices, manufactured by the Bethlehem Steel Company, were reasonably consistent for the four samples of each type tested. By using the installation procedure described for these devices, the tests would indicate a fairly uniform load capacity could be obtained.

Both types of expansion sleeve devices have an average pull-out load capacity in excess of 13,000 lbs. which is the minimum tensile strength requirement for standard joint hook bolts. The expansion hook bolt and threaded anchoring unit devices have average pull-out capacities of approximately 0.5 and 0.4, respectively, of this 13,000-lb. tensile strength value.

In comparing the tensile load resistance of these anchoring devices to the standard joint hook bolt, tests indicate that the Bethlehem expansion sleeve units would be equivalent, while the Chicago Bolt Company devices would not.

The required tensile capacity of a longitudinal pavement joint tie bar device depends upon the spacing of the device, the friction developed by

the subgrade, and the volume of concrete between the joint and the nearest free edge of the slab. Based on the test results and equivalent design considerations, it could be generalized that approximately twice as many expansion hook bolt devices and 2.7 times as many threaded anchoring units as the expansion sleeve type devices, would be required to achieve the same joint strength.