EXPANSION ANCHORS FOR LANE TIES

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EXPANSION ANCHORS FOR LANE TIES

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This report covers an extension of the testing program previously carried out under the same research project, as reported in R-807 (March 1972). Three types of 7/8-in. self-drilling anchors, and one sledge drive non-drilling anchor for variable bolt size, were tested for load capacity at 1/32-in. pull-out.

Purpose

The purpose of this testing program was to determine reasonable values for capacities of expansion anchors used as lane ties. Previously reported tests on the same research project evaluated the capacities of 5/8 and 3/4-in. self-drilling, non-drilling, and torque-type anchors, set in the pavement edge. This testing program adds information on capacities and modes of failure for larger 7/8-in. self-drilling anchors marketed by three different companies, as well as an entirely different type of anchor from any previously tested.

The ultimate capacity of an expansion anchor usually is attained after considerable pull-out has occurred. If anchors are set at shallow depth, or too near a surface, concrete spalling may result during expansion of the anchor, or during pull-out. Deeper set anchors can develop greater capacity and may develop the full strength of the bolt or of a portion of the anchor itself before the concrete fails. Since the anchors in this program were tested against a slippage criterion rather than ultimate load, some of the anchors were set at mid-depth in the pavement edge, and some nearer the surface, to determine whether concrete spalling would occur during expansion or pull-out. These tests were conducted to determine the load capacity at 1/32-in. slippage.

The variables were: 1) manufacturer or supplier of the anchor, and 2) location in slab edge with respect to the slab surface.

Types of Anchors

The anchors tested were 7/8-in. self-drilling Phillips, Star, and Chicago anchors; and Williams non-drilling sledge-drive anchors that can accomodate several different bolt sizes, and require 1-5/8 in. diameter holes in the concrete. The self-drilling anchors from the three companies are nearly identical in appearance. The Williams sledge-drive anchor has an iron core with an aluminum expansion shield. Figure 1 shows the four different anchors tested.

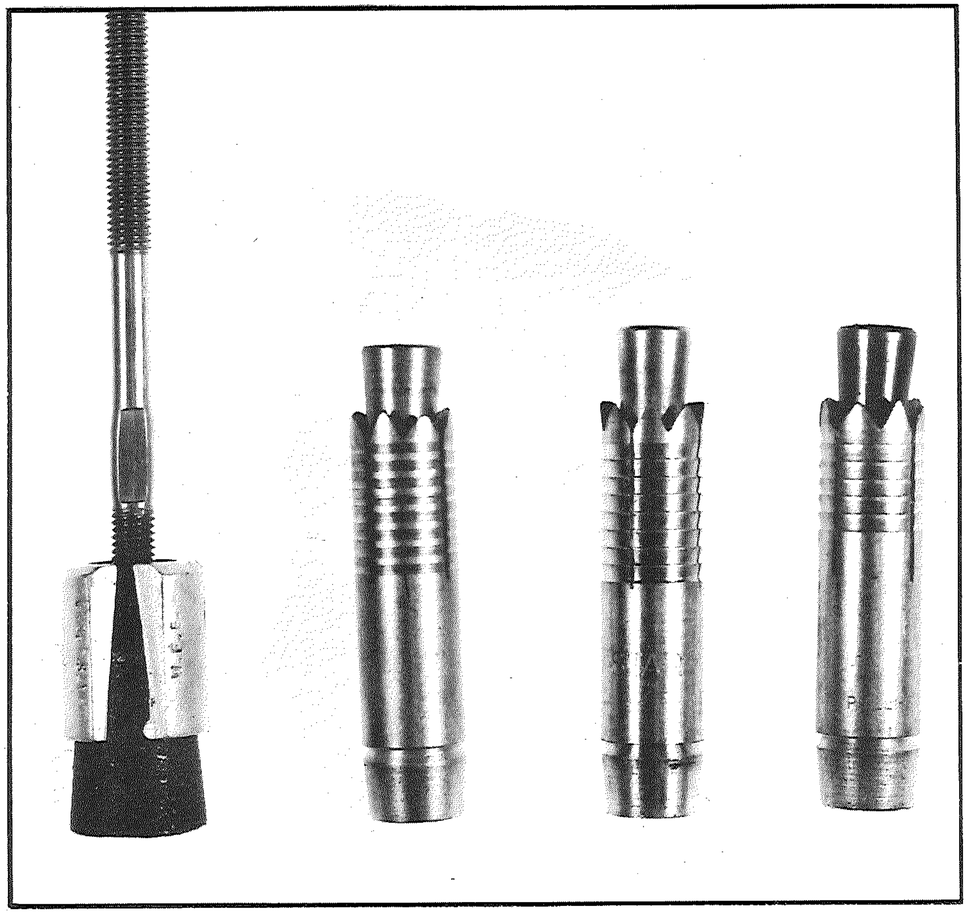

Figure 1. Types of anchors tested (left to right) Williams sledge-drive anchor for 1-5/8-in. hole; 7/8-in. self-drilling Chicago, Star, and Phillips anchors.

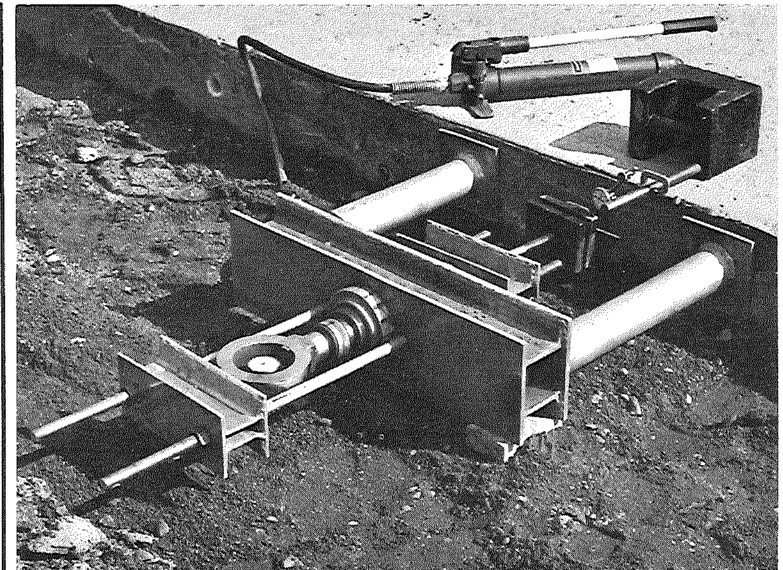

Figure 2. 20,000-lb capacity test frame used to apply load to the anchors.

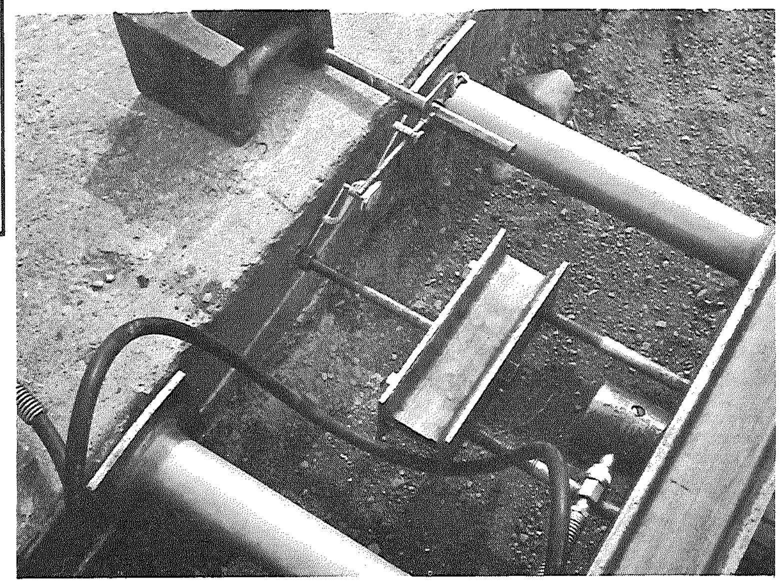

Figure 3. Drawbar and indicator arrangement used to test the anchors.

Installation

The anchors were installed in the edge of an abandoned pavement slab, on US 27 north of Lansing. The slab was 9 in. thick, built in 1947. Project records show core strengths of approximately 5,000 psi in the vicinity of the slabs used for this test.

Six samples of each type of anchor were installed in the slab edge at 3 in. and 4-1/2 in. down from the surface. Holes for the Williams anchors were made 4-1/2 in. deep, with a 1-5/8 in. diameter bit on an air hammer. Holes for the other anchors were drilled by an electric roto-hammer, using the anchors as bits. However, the anchors were expanded in place by sledge driving, since the electric hammer did not provide sufficient impact to properly seat the 7/8-in. anchors on the expanding plugs. Anchors were intermixed along the pavement edge to minimize the effect of localized concrete conditions.

Testing

Load was applied to the anchors by a hydraulic ram and pump, acting through a 20,000-lb capacity aluminum frame (Fig. 2). The load was monitored by use of a dynamometer ring and dial indicator. Pull-out or slippage was measured by a dial indicator, and load was recorded when slippage reached 1/32-in. Figure 3 shows the draw-bar and indicator arrangement.

Results

Results of the pull-out tests are shown in Table 1.

1) Anchor Location: In previous testing of smaller anchors it was found that distance from the surface did not affect the capacity of the anchors at 1/32-in. pull-out because concrete failures were not generated by the loads applied. However, the 7/8-in. anchors are capable of developing loads high enough to spall the concrete before the specified pull-out is attained when the anchors are set closer to the surface. No concrete failures were caused by expanding the anchors in place, but it was noted that the concrete at this site seemed to be in good condition and quite strong. Anchors of this size set close to a surface in weaker or new pavements might cause failures at time of installation. Therefore, it would seem reasonable to set such anchors at mid-depth, with tolerances of perhaps $\pm$ 1/2-in. to 3/4-in. for 9-in. pavements.

TABLE 1
DETAILS AND RESULTS OF PULL-OUT TESTING

Type of Anchor	Distance from Pavt. Surface, in.	Hole Diam, in.	Hole Depth, in.	Capacity at 1/32-in. Pull-out, lb	Type of Failure
Phillips 7/8	4-1/2	---	---	16,000	None
Phillips 7/8	4-1/2	---	---	16,000	None
Phillips 7/8	4-1/2	---	---	11,400	None
Phillips 7/8	4-1/2	---	---	16,000	None
Phillips 7/8	4-1/2	---	---	11,400	None
Phillips 7/8	4-1/2	---	---	10,200	None
				Avg 13,600	
Star 7/8	4-1/2	---	---	16,000	None
Star 7/8	4-1/2	---	---	16,000	None
Star 7/8	4-1/2	---	---	15,400	None
Star 7/8	4-1/2	---	---	8,600	None
Star 7/8	4-1/2	---	---	16,000	None
Star 7/8	4-1/2	---	---	15,800	None
				Avg 14,600	
Chicago 7/8	4-1/2	---	---	13,400	None
Chicago 7/8	4-1/2	---	---	13,000	None
Chicago 7/8	4-1/2	---	---	16,000	None
Chicago 7/8	4-1/2	---	---	12,400	None
Chicago 7/8	4-1/2	---	---	16,000	None
Chicago 7/8	4-1/2	---	---	16,000	None
				Avg 14,400	
Williams	4-1/2	1-5/8	4-1/2	11,600	None
Williams	4-1/2	1-5/8	4-1/2	6,800	None
Williams	4-1/2	1-5/8	4-1/2	15,600	Concrete
Williams	4-1/2	1-5/8	4-1/2	6,800	None
Williams	4-1/2	1-5/8	4-1/2	10,000	None
Williams	4-1/2	1-5/8	4-1/2	16,000	None
				Avg 11,200	
Phillips 7/8	3	---	---	13,000	None
Phillips 7/8	3	---	---	10,000	Concrete
Phillips 7/8	3	---	---	11,400	Concrete
Phillips 7/8	3	---	---	9,600	Concrete
Phillips 7/8	3	---	---	11,000	None
Phillips 7/8	3	---	---	12,000	Concrete
				Avg 11,200	
Star 7/8	3	---	---	12,200	None
Star 7/8	3	---	---	10,800	None
Star 7/8	3	---	---	7,400	None
Star 7/8	3	---	---	11,400	Concrete
Star 7/8	3	---	---	12,800	None
Star 7/8	3	---	---	11,600	None
				Avg 11,000	
Chicago 7/8	3	---	---	8,600	Concrete
Chicago 7/8	3	---	---	9,400	None
Chicago 7/8	3	---	---	6,800	Concrete
Chicago 7/8	3	---	---	10,800	None
Chicago 7/8	3	---	---	7,600	Concrete
Chicago 7/8	3	---	---	5,800	Concrete
				Avg 8,200	
Williams	3	1-5/8	4-1/2	3,400	None
Williams	3	1-5/8	4-1/2	15,000	Concrete
Williams	3	1-5/8	4-1/2	12,800	Concrete
Williams	3	1-5/8	4-1/2	12,000	None
Williams	3	1-5/8	4-1/2	10,200	None
Williams	3	1-5/8	4-1/2	5,200	None
				Avg 9,800	

2) Anchor Size: Only Phillips self-drilling anchors were evaluated in smaller sizes in the previous tests. A comparison of the average results for 3/4-in. Phillips self-drilling anchors shown in R-807, with average results for 7/8-in. self-drilling anchors from Table 1, indicates a capacity increase of more than 40 percent.

3) Anchor Type: Self-drilling vs. Non-drilling. The Williams sledge-drive anchors tested in this program provided average capacities only slightly lower than the self-drilling anchors. Results also are comparable to those obtained with the 3/4-in., non-drilling, flush type and torque-type anchors evaluated previously.

Discussion

The 7/8-in. self-drilling anchors evaluated in this program have demonstrated their ability to develop relatively high pull-out resistance at low slippage. Self-drilling anchors also have additional advantages. Since the anchor itself drills the hole, variability in capacity due to oversize holes is eliminated. This type of anchor is also more easily inspected for proper installation, because the hole is drilled by the anchor to a depth equal to the length of the anchor, and the anchor is then driven over the plug until the same penetration is obtained. Hence the finished installation, properly done, has a predetermined appearance that is more easily recognized by casual observance.

Disadvantages of the self-drilling anchors include limited penetration from the surface and a slightly more involved drilling operation for the contractor. They also are somewhat higher priced than some of the other types of anchors. Cost for self-drilling anchors of the types used in this study is in the range of $1.00 each in small quantities (excluding the hook bolt, which could add another $.50). Discounts for large quantities could be expected to reduce this cost to some extent. Anchors of this size naturally require a 7/8-in. bolt, and it would seem reasonable to specify a standard hex-head machine bolt rather than to require a special 7/8-in. hook bolt.

The Williams sledge-drive anchors have the disadvantage of invisible installation, as do all similar anchors. However, the design of the expansion shield and method of installation seem to provide some additional capability to compensate for variability in hole size, that is not found in some other non-drilling types of anchors.

Cost of this anchor reportedly is about $.60 each, with a 1/2-in. diameter "pig-tail" available at about $.25 each. Larger diameter pig-tails can be used with this anchor if desired, since the expansion cone can be furnished with the hole drilled and tapped for various size bolts, with a maximum size of 1 in. Obviously, the cost of the hook-bolt or pig-tail will increase with the diameter. However, for long-time installations in corrosive environments, some increase in bar diameter above 1/2 in., would seem to be worthwhile.

Recommendations

Based on the results and discussion listed above, the following design values are recommended for the anchors tested.

1) Self-drilling, 7/8-in. Chicago, Phillips, and Star anchors; 12,000 lb.

2) Williams sledge-drive in 1-5/8 in. drilled holes 4-1/2 in. deep; 10,000 lb.

The values given apply to use of the anchors in the edge of 9-in. concrete pavement, as lane ties for an additional pavement lane, concrete base course, or concrete shoulders. Vertical position in the pavement edge should be maintained at mid-depth, with a tolerance of not more than ± 3/4-in.