EXPANSION ANCHORS FOR USE AS LANE TIES

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

EXPANSION ANCHORS FOR USE AS LANE TIES

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This report covers the results of a testing program conducted to evaluate the load capacity of various expansion anchors at 1/32-in. slippage. The tests were initiated as a result of a meeting held May 5, 1971 with representatives of the Construction, Design, and Testing and Research Divisions.

Purpose

The purpose of this testing program was to determine reasonable values for capacities of expansion anchors used as lane ties. Previous tests on expansion anchors have been conducted to determine their ultimate load capacities. The ultimate load of an expansion anchor usually occurs after considerable slippage has taken place. If the anchor is set at a shallow depth, or too near a surface, concrete spalling may result during expansion or testing. 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.

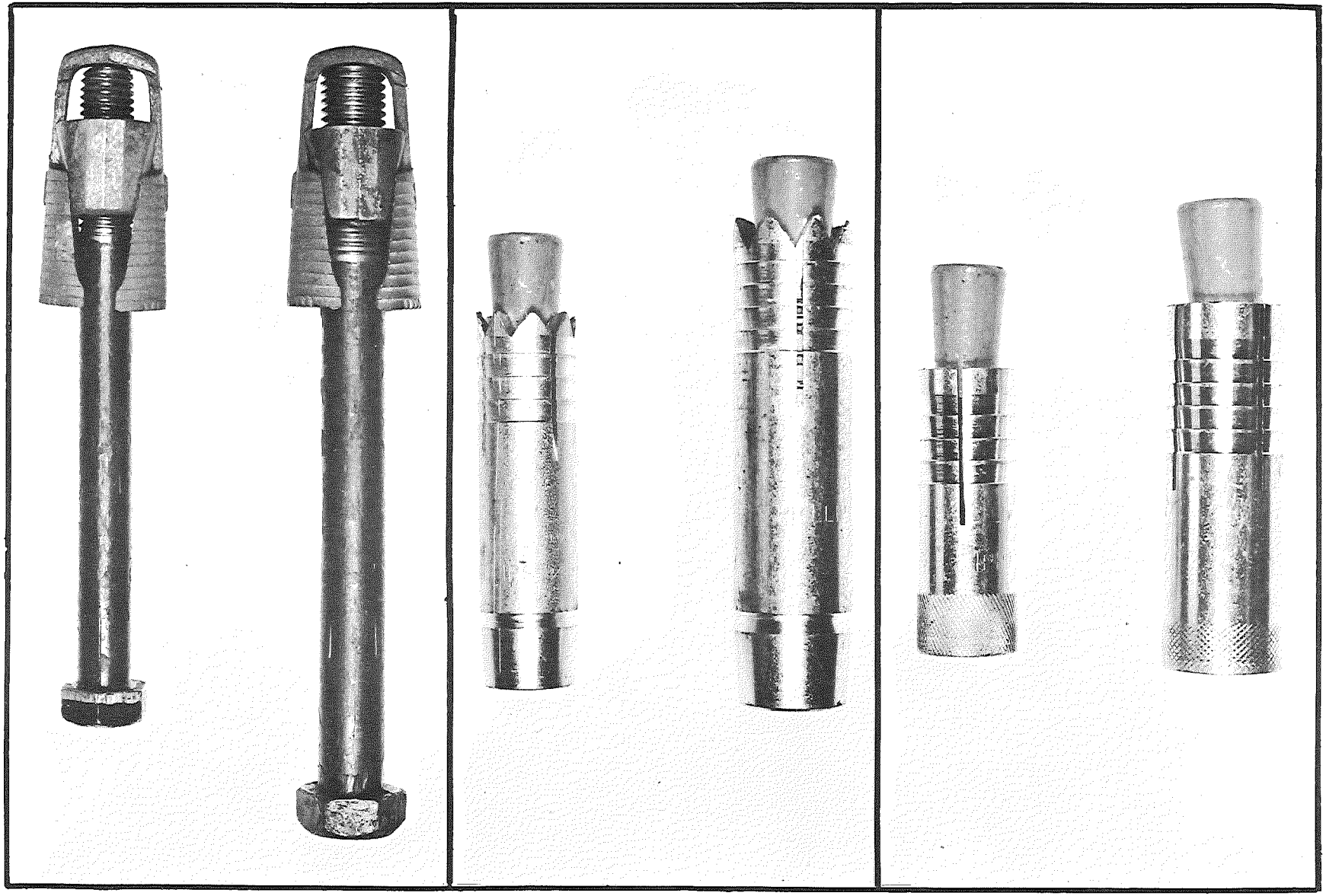
Since the anchors in this program were tested against a slippage criterion rather than ultimate load, various depths and surface clearances were included to determine whether spall type failures would occur during expansion or loading of the anchors. These tests were conducted to determine the load capcity at 1/32-in. slippage.

Variables for the tests were as follows:

1) Location of the anchors in the slab edge with respect to the slab surface
2) Size of the expansion anchors
3) Depth of the hole into which the anchors were inserted
4) Amount of torque applied to shell type anchors prior to pull-out.

Test Samples

The types of anchors tested were K-1 expansion shells, self-drilling redheads, and flush or non-drilling type redheads. Anchors of each type were included for both 5/8 and 3/4 in. diameter bolts. However, the K-1 shells for both size bolts were identical except that the cast iron cone was threaded to accommodate whichever size bolt was required. The RS-9 expansion anchor currently specified is no longer manufactured by Republic Steel Corp. Other anchors similar to the RS-9 anchor are available, but could not be obtained in time to be included in the tests. Figure 1 shows the types of anchors tested.



K-1 Expansion Shell | Self-drilling Redheads | Flush or non-drilling Redheads

Figure 1. Types of anchors tested. 5/8 in. (left); 3/4 in. (right).

Installation

The anchors were installed in the edge of the concrete parking area of the M 78 weigh station west of the City of Lansing. The slab is 9 in. thick and was constructed in 1952. The concrete was designed for a 28 day compressive strength of 3,500 psi.

Three samples of each type and size were installed in the slab edge 3, 4-1/2, and 6 in. down from the surface. In addition, three sets of three K-1 shells of each size were installed at the mid-depth slab edge location for the purpose of hole depth and torque evaluations. The hole depths and diameters, and bolt torque values are given in Table 1.

The torque values of 90 and 160 lb-ft for the 5/8 and 3/4 in. K-1 shells were suggested by the manufacturer. The 90 lb-ft value for the 5/8 in. anchor was used for a standard and 100 lb-ft torque was used to determine the effect of torque on load capacity. In the case of the 3/4 in. anchor the suggested value of 160 lb-ft was used as maximum, and a value of 100 lb-ft was used as a standard. These values were selected because it was found that 160 lb-ft torque in some cases would damage the anchors or the concrete would fail before the required torque was obtained. Holes for the flush and self-drilling type anchors were drilled by an electric roto-hammer. Holes for the torque-type anchors were drilled with an air hammer. Drill sizes were as recommended by the manufacturer of the anchors. The flush and self-drilling anchors were installed by the driver and hammer method and to obtain uniformity the anchors were driven to refusal. The torque applied to the K-1 anchors was measured with a 600 lb-ft capacity torque wrench.

Testing

Load to the anchors was applied by using a 20,000 lb capacity aluminum test frame (Fig. 2). The load was applied at a uniform rate by the hydraulic pump and cylinder and monitored by the use of a dynamometer ring and dial indicator. The pull-out load placed on the anchors was recorded when the anchor slippage reached 1/32 (0.031) in. as measured by means of a dial indicator. Figure 3 shows the drawbar and indicator arrangement used when testing the flush and self-drilling type anchors and the set-up used to test the K-1 shells is shown in Figure 4.

Results

The results of the pull-out tests are shown for anchors installed 3, 4-1/2, and 6 in. from the top surface of the slab in Table 1. A brief discussion of the results follows:

TABLE 1
INSTALLATION DETAILS AND RESULTS
OF TORQUE AND PULL-OUT TESTING

Distance from top of slab, in.	Anchor Type	Bolt Diam, in.	Concrete Hole Diam, in.	Concrete Hole Depth, in.	Bolt Torque, lb-ft	Load at 1/32-in. Pull-out			Average Load, lb
						Sample 1	Sample 2	Sample 3	
3	Flush	5/8	27/32	2-9/16	---	5,000	8,500	(1)	6,700
	Self-drilling	5/8	---	---	---	7,000	9,600	5,600	7,400
	K-1 Shell	5/8	1-1/4	4	90	10,600	12,000	10,600	11,100
	Flush	3/4	1	3-3/16	---	12,800	9,000	8,000	9,900
	Self-drilling	3/4	---	---	---	5,200	8,200	10,800	8,100
	K-1 Shell	3/4	1-1/4	4	100	13,800	10,000	11,600	11,800
4-1/2	Flush	5/8	27/32	2-9/16	---	6,600	4,000	8,500	6,400
	Self-drilling	5/8	---	---	---	5,600	5,600	6,600	5,900
	K-1 Shell	5/8	1-1/4	4	90	8,600	11,000	7,400	9,000
	K-1 Shell	5/8	1-1/4	4	100	14,200	9,600	11,400	11,700
	K-1 Shell	5/8	1-1/4	6	90	12,600	11,000	10,000	11,200
	K-1 Shell	5/8	1-1/4	6	100	12,600	12,800	8,400	11,300
	Flush	3/4	1	3-3/16	---	10,800	13,400	11,400	11,900
	Self-drilling	3/4	---	---	---	8,600	7,800	9,600	8,700
	K-1 Shell	3/4	1-1/4	4	100	10,600	12,200	11,600	11,500
	K-1 Shell	3/4	1-1/4	4	160	10,800	14,800	(2)	12,800
	K-1 Shell	3/4	1-1/4	6	100	12,000	10,800	10,000	10,900
	K-1 Shell	3/4	1-1/4	6	160	14,800	10,600	(3)	12,700
6	Flush	5/8	27/32	2-9/16	---	7,400	6,000	(1)	6,700
	Self-drilling	5/8	---	---	---	5,600	8,600	9,600	7,900
	K-1 Shell	5/8	1-1/4	4	90	9,600	5,600	12,800	9,300
	Flush	3/4	1	3-3/16	---	8,800	10,200	8,600	8,700
	Self-drilling	3/4	---	---	---	8,200	9,600	7,400	8,400
	K-1 Shell	3/4	1-1/4	4	100	12,200	9,000	(4)	10,600

(1) Only two anchors of this type were set.
(2) Sample damaged; not tested.
(3) Concrete failed at 150 lb-ft torque during installation.
(4) Concrete failed at 85 lb-ft torque during installation.

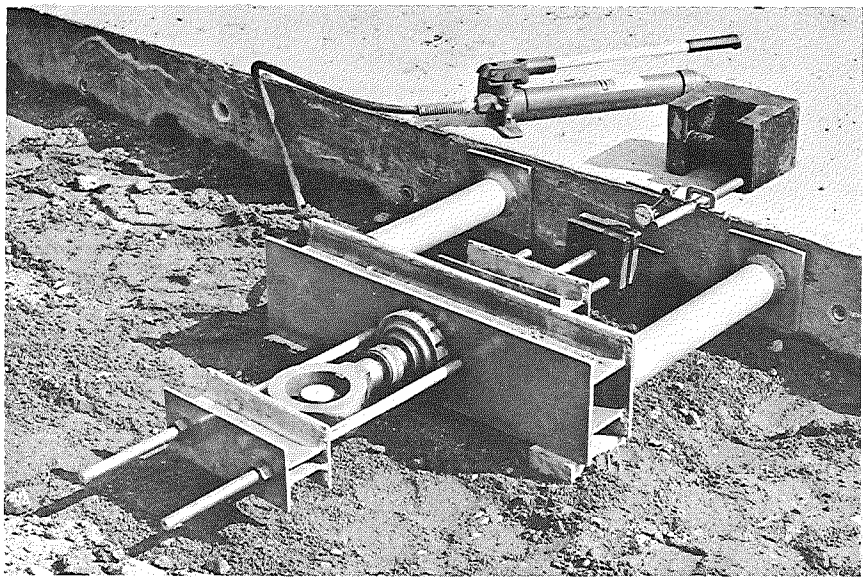


Figure 2. 20,000-lb capacity test frame used to apply load to the anchors.

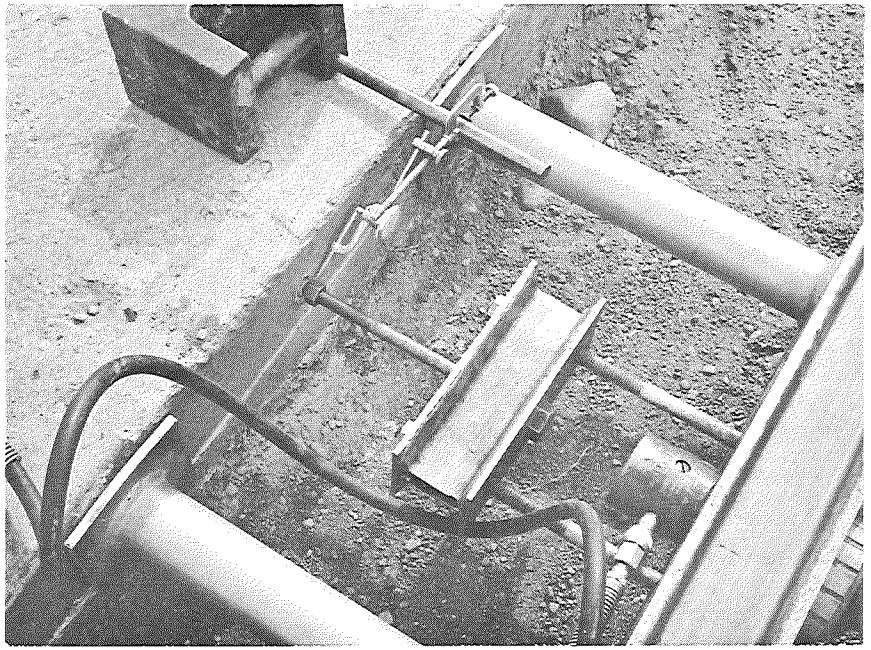


Figure 3. Drawbar and indicator arrangement used to test the flush and self-drilling type anchors.

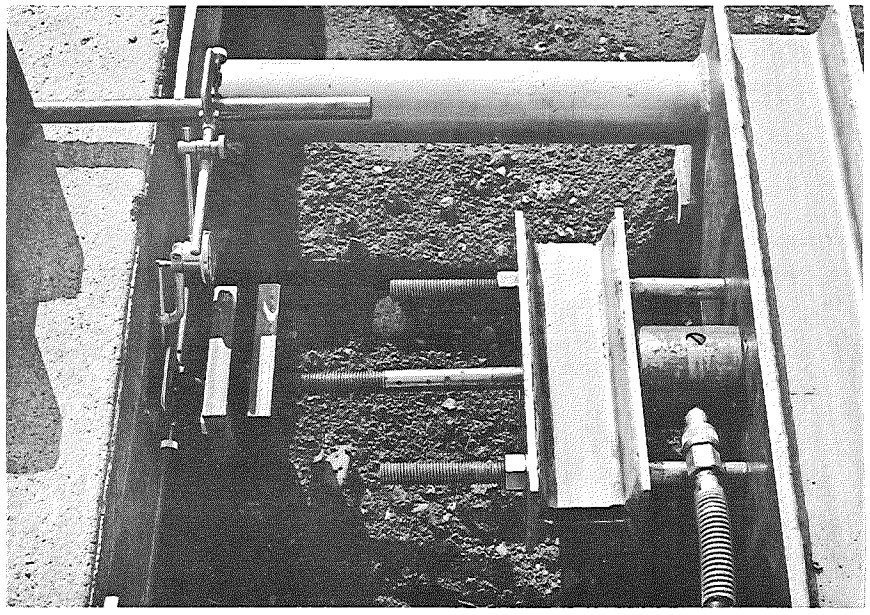


Figure 4. Drawbar and indicator arrangement used to test the K-1 shells.

1. Anchor Location -- The location of the anchors with respect to slab surface apparently does not affect the load capacity at 1/32-in. slippage. In all cases where the anchors were expanded without failure of the concrete, they were able to withstand sufficient load to reach the selected slippage value without damage to the concrete. None of the flush or self-drilling anchors caused concrete failures during expansion. One 3/4 in. K-1 anchor, located at mid-depth of the slab, fractured the concrete during bolt torque application. Of the six K-1 shells installed 6 in. below the surface, only one fractured the concrete during bolt torquing.

2. Anchor Size -- The increase in anchor size appears to increase load capacity. The load capacity of the flush or non-drilling and self-drilling anchors increased 55 percent and 18 percent, respectively, by increasing the anchor size from 5/8 to 3/4 in. diameter. The size of the K-1 shells was the same for both 5/8 and 3/4 in. diameter bolts, and when the same torque was applied to both sizes, capacities were approximately equal. Higher torque applied to the larger bolts increased the average capacity by about 15 percent.

3. Anchor Hole Depth -- The hole depth for the self-drilling anchors cannot be changed because these anchors are designed to be installed flush with the surface. The non-drilling type can be installed flush, or deeper if desired. For the K-1 shells the hole depth can be varied from a recommended minimum of 4 in. to any depth desired. In these tests the K-1 anchors were set at 4 and 6 in. depths. Since there were no concrete failures during pull-out testing, it is assumed that variations in capacity with hole depth are due to other factors.

4. Anchor Torque -- The pull-out resistance of the K-1 shell type anchor at limited slippage can be increased by increasing the amount of torque applied to the anchor bolt. For the 5/8 in. shell an average increase of about 15 percent in load capacity resulted by increasing the torque from 90 to 100 lb-ft. A torque increase from 100 lb-ft to 160 lb-ft resulted in an increase in load capacity of about 15 percent for 3/4 in. anchors. However, this high torque could cause concrete failures in weaker concrete or new pavements. The capacity at 1/32-in. slippage of all anchors tested is given in Table 1. As can be seen, load capacity of anchors within each group varies considerably. This variation is due to many factors and can be expected to be present in all installations.

Recommendations

On the basis of these tests, design values indicated in Table 2 are recommended, provided that proper drill sizes are used and the same installation techniques are employed as in this experiment. The values given apply to expansion anchors used for lane ties in concrete pavements, concrete base course, and concrete shoulders.

TABLE 2
RECOMMENDED DESIGN VALUES FOR EXPANSION ANCHORS

Anchor Type	Bolt Diam, in.	Concrete Hole Diam, in.	Concrete Hole Depth, in.	Bolt Torque, lb-ft	Allowable Design Load, lb
Flush	5/8	27/32	2-9/16	---	6,000
	3/4	1	3-3/16	---	8,000
Self drilling	5/8	---	---	---	6,000
	3/4	---	---	---	8,000
K-1 Shell	5/8	1-1/4	4	100	10,000
	3/4	1-1/4	4	100	10,000