EXPANSION ANCHOR EVALUATION
HILTI HDI ANCHORS

MICHIGAN DEPARTMENT OF
STATE HIGHWAYS AND TRANSPORTATION

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This report covers experimental pull-out tests to evaluate the capacity of 3/4-in. Hilti "HDI" Expansion Anchors, at 1/32-in. maximum allowable slippage. Phillips 3/4-in. non-drilling or flush-type anchors were included for comparison. The experiment was requested by the Department's Committee for the Investigation of New Materials, as an evaluation of Hilti HDI anchors for use as lane ties.

Procedure

The Hilti anchors were supplied by the manufacturer, along with an electric hammer-drill and a carbide tipped drill bit of the proper size. Figure 1 shows the Hilti HDI and Phillips flush-type anchors that were evaluated, along with the setting tools.

Dimensionally, the anchors are quite similar. The Phillips anchors have circumferential grooves, while the Hilti anchor is smooth on the outside surface. Phillips anchors are expanded in place by driving the anchors over the tapered conical plug, which contacts the bottom of the hole. Hilti HDI anchors are expanded by driving home an expander plug from the open end of the anchor. The Hilti setting tool is designed so that the shoulder "bottoms out" on the face of the anchor when the expander plug is properly seated.

The anchors were set in the edge of an unused ramp at the Grass Lake truck weighing station on westbound I 94 east of Jackson. Project records show core compressive strengths of approximately 6,000 psi in the vicinity of the area used for the experiment.

Holes were drilled in the slab edge so that the anchors would be flush with the edge of the pavement when set. Anchors were intermixed along the pavement edge, to average out any localized differences in the concrete.

Since previous experience has shown that setting expansion anchors in a pavement edge may cause spall-type failures in the concrete, a few of the anchors were set closer to the bottom of the slab, while the majority of the anchors were set at the usual mid-depth location.

The manufacturer's (Hilti) specified carbide tipped drill-bit was used for drilling the holes for all anchors. The bit diameter was measured at 1.016-in. when new, and again at 1.014-in. after drilling 27 holes.

The anchors were expanded by driving with a 4-lb sledge.

Testing

Load was applied to the anchors by a hydraulic pump and cylinder in a 20,000-lb capacity frame (Fig. 2) and was monitored by the calibrated dyna-

mometer ring and dial indicator. Slippage was recorded by another dial indicator as shown in Figure 3.

Results

Results of the pull-out tests are shown in Tables 1 and 2. The average capacity of the Phillips anchors averaged approximately 7,000 lb at 1/32-in. slippage. Even though most of the Hilti anchors were unloaded long before they pulled out 1/32-in., the average load applied to the anchors placed at mid-slab depth exceeded 14,000 lb. These results are very high when compared to the Phillips anchors evaluated here, and also with respect to self-drilling anchors previously tested and approved for use as lane ties (MDSHT Research Reports R-688, R-690, R-807, R-825, R-867, R-981, and R-987). Therefore, it is evident that if the Hilti HDI anchors were set in properly sized holes, in concrete of sufficient strength, they would provide adequate anchorage for hook-bolt lane ties.

Discussion

Several problems exist in the specification and use of expansion anchors for lane ties.

1) Many anchors require some pull-out or slippage to develop resistance, but slippage of a lane tie allows the joint to open.

2) Some anchors generate large lateral pressures when expanded, and may fracture the pavement if set in green concrete, or too close to an edge.

3) Torque-type anchors must have adequate torque applied before their pull-out resistance develops to the required level. However, overtorque may ruin the anchor, break the bolt, or spall the concrete.

4) Non-drilling anchors require drilled holes of precise diameter, in order to develop proper pull-out resistance. Oversize holes can reduce capacity considerably, while undersize holes prevent insertion.

5) It is very difficult to perform meaningful inspection to determine whether anchors have been properly installed.

The Hilti HDI anchors evaluated in this program develop high pull-out resistance, but also generate considerable lateral force. The test site was in old concrete that is very strong, but the anchors caused spall failures when set 3 in. or less from the bottom of the slab. Previous evaluations have shown that anchors causing spall failures of this type when set nearer the top or bottom of an old slab, may cause concrete failures when set at mid-slab depth in new construction. Therefore, we have previously issued

recommendations that Bethlehem K-1 shells (torque type), and similar anchors not be used in widening pavements unless the full 28-day concrete strength has been attained. This same reasoning applies to the Hilti HDI anchors.

Much of the past discussion concerning expansion anchored lane ties has dealt with the difficulties of inspection at the construction site. Non-drilling anchors have not been allowed because of problems in determining whether drilled holes were of the proper size. Holes drilled oversize can reduce the capacity of such anchors. The hammer size and pressure used on air hammers also can have an effect on the shape and size of the holes.

Therefore, if the Hilti anchor were to be accepted for use on construction jobs, it would seem that the size of the drill and hammer used for making the holes would have to be controlled, if consistent results are to be expected.

It is obvious that the Hilti HDI anchors are capable of producing high holding power, if properly installed. Like many other items, however, the extent to which this capability is exhibited on the job depends on quality control in the construction process. If an inspector first established that a plug had been installed in the anchor, he could determine whether it was properly seated by inserting the setting tool. The other important steps would be to see that proper sized drills were used for making the holes, and that the hammers were not overpowered.

The manufacturer-recommended equipment used in this experimental work produced excellent results, was easy to operate, and quite speedy. On the other hand, heavy contractors equipment used on past construction projects to speed up the operation, sometimes has given poor results. We believe that the manufacturer's equipment and recommended procedures are reasonable and effective. However, it is obvious here, as with previously evaluated anchors, that care and vigilance will be required in the selection, installation, and inspection of the anchors, if adequate results are to be obtained.

Caution

Faulty installation of expansion anchored lane ties can result in early failure of the joint, with no reasonable means of repair available. One localized installation made last year resulted in a 1-1/2 in. joint opening in less than six months.

Conclusions and Recommendations

1) Hilti HDI anchors that were evaluated, installed as per the manufacturer's recommendation, produced very good results; adequate for lane

tie applications. They are recommended for consideration as lane tie anchors in widening full-strength concrete.

2) Phillips non-drilling anchors installed in the same manner as the Hilti anchors produced about 50 percent as much holding power. Since capacity is quite low, close spacing would be necessary to develop the required 3,000 lb/ft of joint, and there also would be special inspection problems. This anchor is not recommended.

3) Hilti anchors should not be used for widening concrete with less than 28-day strength.

4) Each type of anchor presents special problems with respect to installation and inspection. Non-drilling flush type anchors have not been allowed to date. Construction staff will have to decide whether the Hilti system can be handled by inspectors and contractors to give a reasonably dependable anchorage system.

5) Recommended spacings and capacities for the various types of expansion anchors are shown in Table 3.

TABLE 1
HILTI HDI EXPANSION ANCHORS, 3/4-in.

Sample Number	Distance From Bottom of 9-in. Slab, in.	Approximate Load at Initial Slippage, lb	Slippage at 10,000 lb Load, in.	Load at 1/32-in. Slippage, lb	Maximum Load Applied, lb	Maximum Slippage, in.	Comments
1	4-1/2	1,000	0.014	More than 16,000[1]	16,000[1]	Less than 0.031	
2	2-1/2	4,500	---	7,500	7,500	---	Concrete spall to bottom of slab
3	2-1/2	--	---	--	--	---	Concrete fractured when anchor was set
4	4-1/2	Not determined	0.031	10,000	13,500	0.050[2]	
5	4-1/2	6,500	0.012	11,000	11,500	0.050[2]	
6	4-1/2	10,000	0.003	More than 15,000[1]	15,000[1]	0.025	
7	4-1/2	16,000	0.000	More than 16,000[1]	16,000[1]	0.002	
8	4-1/2	10,000	0.001	More than 16,000[1]	16,000[1]	0.014	
9	4-1/2	8,500	0.008	More than 16,000[1]	16,000[1]	0.025	
10	4-1/2	More than 16,000	0.000	More than 16,000[1]	16,000[1]	0.000	
11	4-1/2	16,000	0.000	More than 16,000[1]	16,000[1]	0.002	
12	4	10,000	0.005	More than 16,000[1]	16,000[1]	0.011	
13	3	--	---	--	--	---	Concrete fractured when anchor was set
14	3	--	---	--	--	---	Concrete fractured when anchor was set

[1] Test terminated, due to high load.
[2] Test terminated, due to slippage.

TABLE 2
PHILLIPS "RED HEAD" NON-DRILLING EXPANSION ANCHORS
(3/4-in.)

Sample Number	Load at Initial Slippage, lb	Load at 1/32-in. Slippage, lb	Maximum Applied Load, lb	Slippage at Maximum Load, in.
1	6,500	8,500	9,500	1/8
2	4,000	4,500	7,000	1/2
3	6,000	6,000	6,000	1/8
4	4,000	6,500	7,000	1/8
5	6,000	9,000	10,000	1/8
6	5,500	7,500	8,000	1/8
7	7,000	7,500	7,500	1/8
8	5,000	7,500	7,500	1/8
9	6,500	8,500	13,000	3/8
10	5,500	7,000	9,500	1/8

TABLE 3
RECOMMENDED USAGE AND DESIGN VALUES

New Concrete Widening

Anchor Type	Diameter, in.	Allowable Design Load, lb	Maximum Anchor Spacing, in.
Self-Drilling[1]	3/4	7,500	30
	7/8	12,000	48

Old Concrete Widening

Anchor Type	Diameter, in.	Torque, lb-ft	Allowable Design Load, lb	Maximum Anchor Spacing, in.
Self-Drilling[1]	3/4	---	7,500	30
	7/8	---	12,000	48
Bethlehem K-1 (torque type)	3/4	100	10,000	40
Hilti HDI[2]	3/4	---	10,000	40

[1] Acceptable self-drilling type anchors are: Phillips, Star, or Chicago.

[2] If accepted by the Department, with appropriate requirements for installation and inspection.

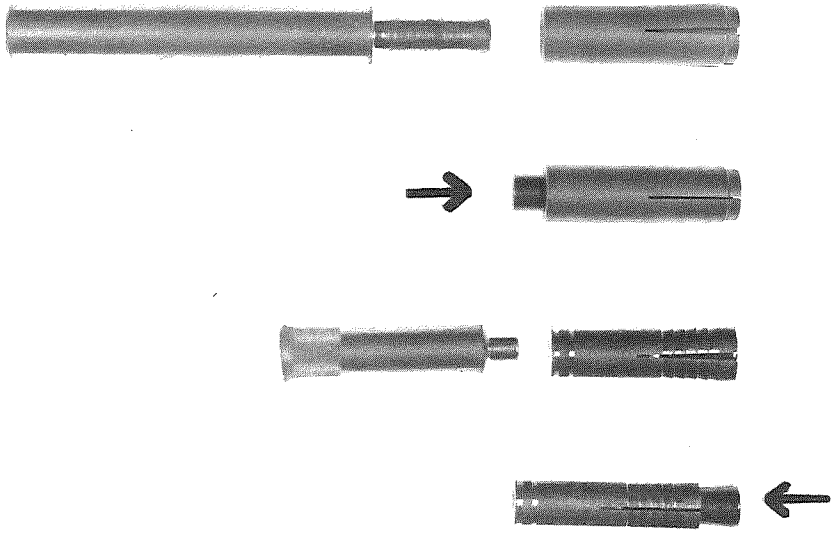

Figure 1. Hilti 3/4-in. HDI anchor and setting tool (top) and Phillips non-drilling flush-type anchor and setting tool (below). Arrows indicate the direction of movement of the expansion plug.

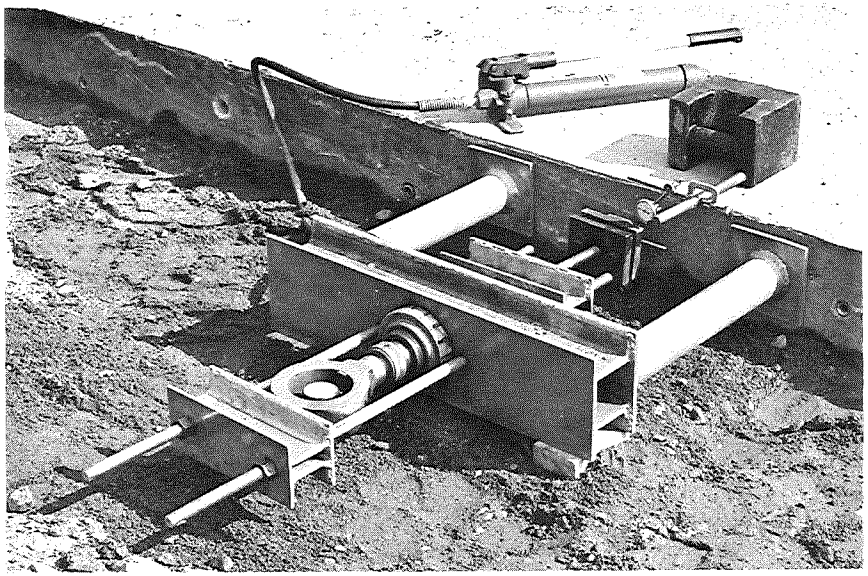

Figure 2. 20,000-lb capacity test frame used to apply load to the anchors.

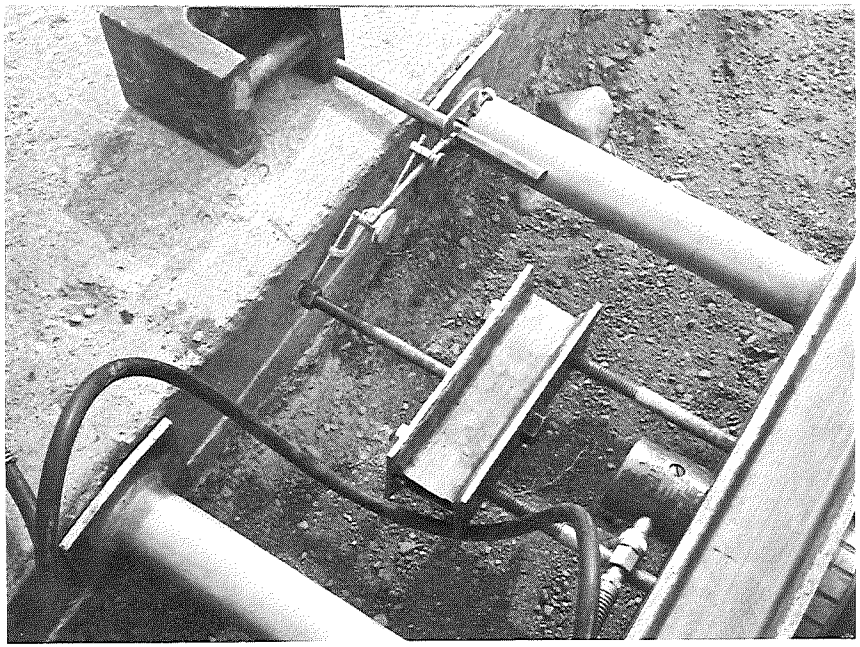

Figure 3. Drawbar and indicator arrangement used to test the flush and self-drilling type anchors.