EVALUATION OF "WEJ-IT," AND "TAPER-BOLT" EXPANSION ANCHORS

MICHIGAN DEPARTMENT OF
STATE HIGHWAYS AND TRANSPORTATION

EVALUATION OF "WEJ-IT," AND "TAPER-BOLT" EXPANSION ANCHORS

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This report covers the results of an evaluation requested by the Committee for the Investigation of New Materials. Tests were conducted to evaluate the load capacity of various expansion anchors at not more than 1/32 in. slippage. The types of anchors and manufacturers were as follows:

1) "WEJ-IT" - WEJ-IT Corporation, Broomfield, Colorado
2) "Taper-Bolt" - U. S. Expansion Bolt Co., York, Pennsylvania.

Purpose

The purpose of this evaluation was to determine the suitability of the subject anchors for use as lane ties on highway projects. It has been determined from previous testing programs that the ultimate pull-out load that an expansion type anchor can sustain usually occurs after considerable slippage has taken place. Since the primary application of expansion anchors in highway construction is for use as lane ties, it is imperative that any given anchor be able to sustain maximum loads with minimal slippage. Also, if an anchor is installed too near a surface or in relatively new concrete, the possibility exists that the concrete may spall if excessive force is generated during expansion of the anchor. These tests were conducted to determine the load capacity at 1/32 in. slippage.

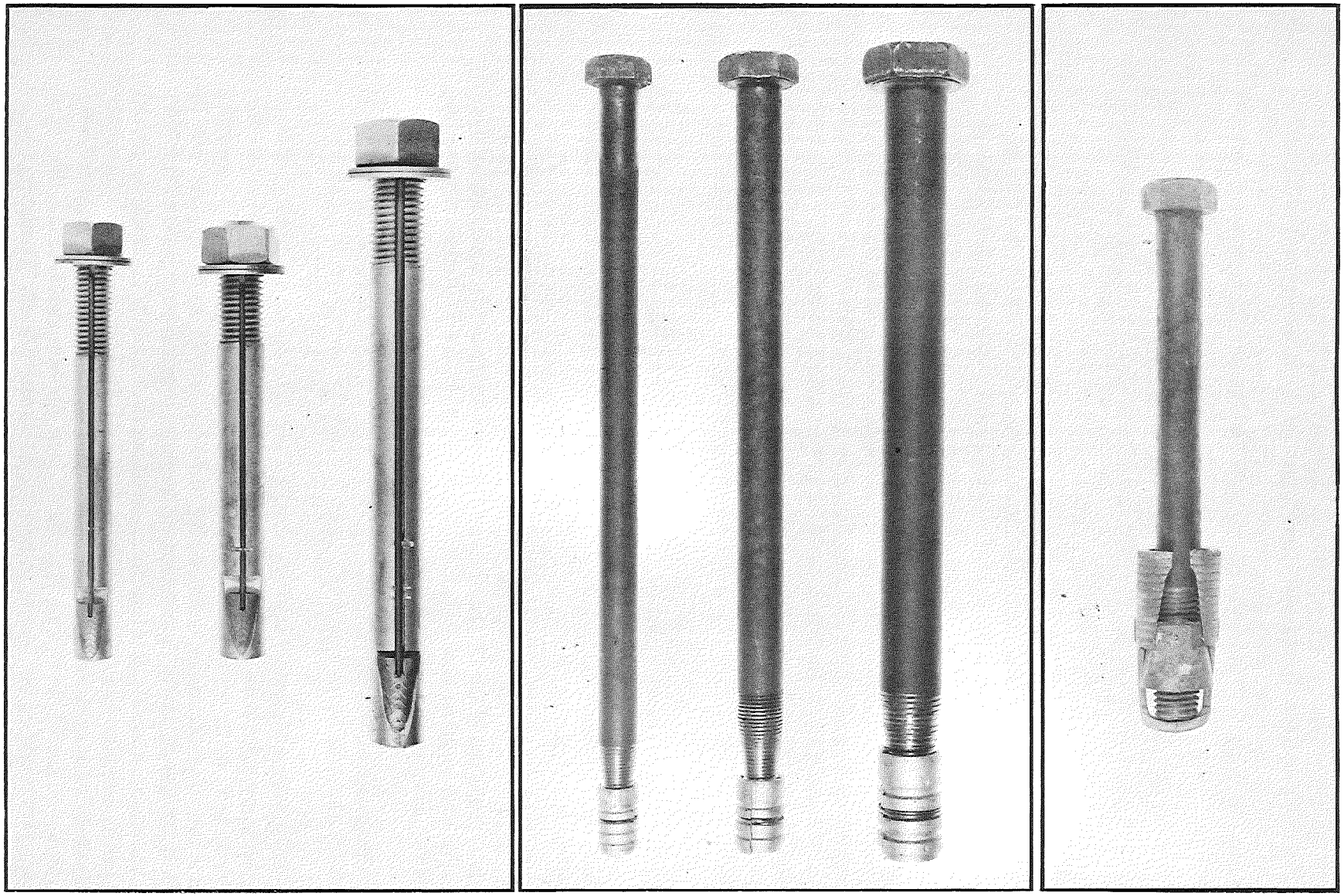
Test Samples

The types of anchors evaluated were WEJ-IT, and Taper-Bolt. In addition, six 3/4-in. Bethlehem K-1 shields were installed under similar conditions for comparison.

The anchors were supplied by the manufacturers or their representatives. Both the WEJ-IT and Taper-Bolt are available in a variety of diameters and lengths; however, only those sizes which are primarily used on highway construction projects were supplied, at our request.

Figure 1 shows the different types of anchors evaluated. A description of each type follows:

WEJ-IT - This type of anchor utilizes a hole of the same diameter as the bolt being installed. The assembly consists of a nut, washers, anchor wedges with attached wire connections, and the bolt proper with two wire slots 180 degrees apart. Anchoring of the assembly in the drilled hole is accomplished by the wedges being held in place against the wall of the hole by the steel wire connections and keyed washers while the stud is pulled into the wedges as the nut is torqued. WEJ-IT anchors are most commonly provided from cold rolled steel with zinc plating; however, they are also available in stainless steel, aluminum, and hot-dip galvanized. The size of WEJ-IT anchors evaluated were 5/8, 3/4, and 7/8-in. diameters.



5/8, 3/4, and 7/8 in. WEJ-IT anchors.

5/8, 3/4, and 1 in. U. S. Expansion Bolt Co. Taper-Bolts.

3/4-in. Bethlehem K-1 Shield.

Figure 1. Types of anchors tested.

Taper-Bolts - Taper-Bolts are also a type of anchor utilizing a hole of the same diameter as the bolt. The assembly consists of a high strength bolt with machined tapered threads which engage a zinc alloy nut with matching internally tapered threads. Anchoring of the device is achieved by expansion of the nut as the bolt is torqued. One advantage of Taper-Bolts, is the ability to pre-expand the nut to fit over-sized holes. Taper-Bolts are supplied in SAE Grade 5 heat-treated steel, other materials or protective coatings are available on request. The sizes of Taper-Bolts evaluated were 5/8, 3/4, and 1-in. diameters.

Bethlehem K-1 Shields - As previously mentioned, these anchors were installed and tested to provide a comparison under similar conditions. These anchor types have been evaluated previously for pull-out load at 1/32 in. slippage, the results of the evaluation were published in Research Report R-807 (March 1972).

Installation

The anchors were installed in the edge of an unused ramp at the Grass Lake truck weighing scales located on westbound I 94 east of Jackson (Fig. 2). The slab is 9 in. thick, built in 1962. Project records show core compressive strengths of approximately 6,000 psi in the vicinity of the area used for the tests.

Six samples of each size and type were installed approximately midway down the slab edge. In order to minimize the effect of localized concrete conditions, the anchors were divided into six sets of seven anchors each, and each set was randomized using a table of random digits.

The holes were drilled with an electric roto-hammer mounted in the fixture shown in Figure 3. Carbide tipped drill bits of the sizes recommended by the manufacturer were used. After drilling, all holes were cleaned with compressed air.

All holes were drilled to a nominal 4-in. depth except where the manufacturer's minimum embedment recommendations required deeper holes, such as was the case with the 7/8-in. WEJ-IT and 1-in. Taper-Bolts. Manufacturers minimum embedment requirements for 7/8-in. WEJ-IT's and 1-in. Taper Bolts are 5-1/2 in. and 4-5/8 in., respectively.

Expansion of the anchors in the holes was performed as per manufacturer's recommendations.

WEJ-IT anchors require one to two turns of the nut when used in concrete of 6,000 to 7,000 psi compressive strength.

The torque recommended for the Taper-Bolts varies over a considerable range depending on the strength of the concrete in which the anchors

Figure 2. Installation site. Note randomly drilled holes for different size and type anchors.

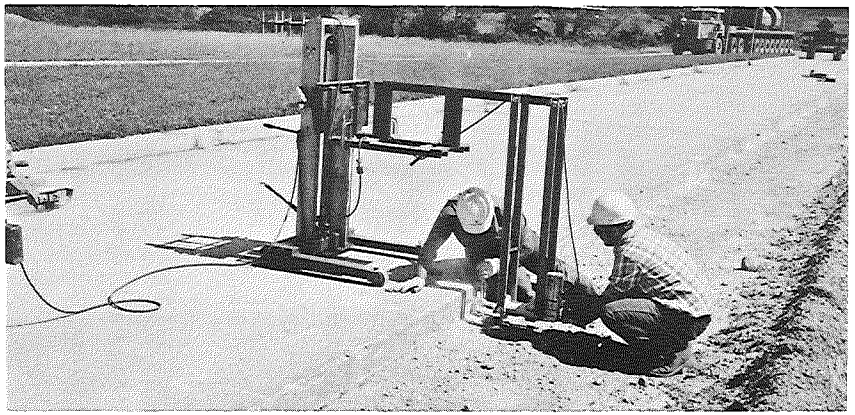


Figure 3. Fixture used to hold roto-hammer in correct alignment while drilling holes.

Figure 4. Aluminum frame used to apply load to the anchors.

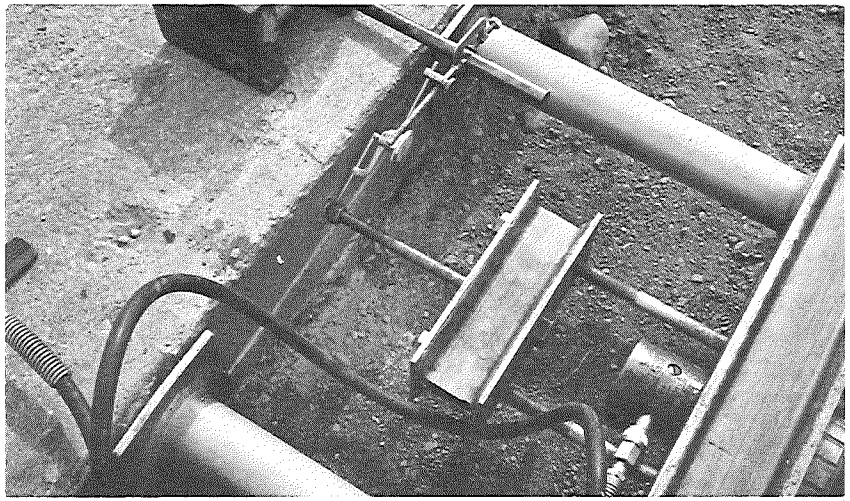
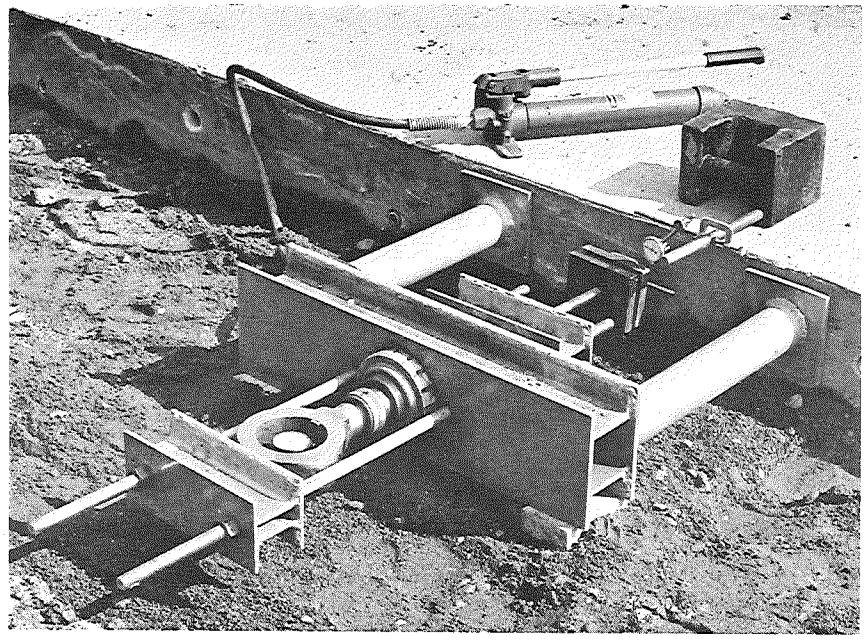


Figure 5. Indicator arrangement used to measure anchor extrusion.



are being installed. The torque values used in this evaluation are given in Table 1. The low torque values for each size are those recommended for use in concrete of 2,500 psi strength. The high torque values correspond to approximately 4,000 psi concrete except for the 500 lb-ft torque applied to the 1-in. Taper-Bolts. This high torque value was applied to determine if it would cause damage to the concrete. Previous experience has shown that some torque-type anchors will spall the pavement at higher torque values. Taper-Bolts did not.

Testing

Load to the anchors was applied by using an aluminum test frame (Fig. 4). 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 on the anchors was recorded when the anchor slippage reached 1/32 (0.031) in. as measured by a dial indicator. Figure 5 shows the indicator arrangement used to measure anchor extrusion.

Results

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

1) WEJ-IT: The 5/8, 3/4, and 7/8-in. diameter WEJ-IT anchors developed average pull-out loads, at 1/32 in. slippage, of 6,000 lb, 6,000 lb, and 7,000 lb, respectively. In comparison, the average pull-out load at 1/32 in. slippage of the 3/4-in. WEJ-IT is less than 60 percent of the average load developed by the 3/4-in. Bethlehem anchor. However, there was no consistency in the amount of pull-out load the WEJ-IT anchors would sustain at these relatively small extrusions. Pull-out loads for 3/4-in. diameter anchors ranged from 1,600 to 10,000 lb.

Although 1/32 in. slippage of the anchors sometimes occurred at relatively small loads, it was noticed that the WEJ-IT anchors would sustain considerably larger loads than those shown; however, this occurred at extrusions of 1/8 to 3/8 in.

2) Taper-Bolts: Results of tests show that a 3/4-in. diameter Taper-Bolt torqued to 200 lb-ft would meet the Department's specified load requirement of 3,000 lb per lineal ft of joint (10,000 lb at 40-in. spacing), with 1/32 in. or less slippage.

The 5/8-in. Taper-Bolts are also capable of meeting specified load requirements; however, in order to obtain adequate pull-out loads, torque values near the limits of the assembly are required.

The 1-in. Taper-Bolts in all cases sustained 16,000 lb with very small extrusions. The load required to extrude the assembly 1/32 in. was not obtained since the capacity of the testing device was being approached.

TABLE 1
RESULTS OF PULL-OUT TESTING

Anchor Type	Bolt Diameter, in.	Concrete Hole Diameter, in.	Nominal Bolt Torque, lb-ft	Load At 1/32-in. Pull-Out, lb						Average Load, lb
				Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	
WEJ-IT	5/8	5/8	---	5,400	6,200	7,700	3,400	6,000	7,400	6,000
	3/4	3/4	---	10,000	1,600	7,400	8,000	5,700	3,400	6,000
	7/8	7/8	---	3,200	5,200	10,000	12,300	[1]	4,300	7,000
Taper Bolt	5/8	5/8	100	6,800	4,300	4,800				5,300
	3/4	3/4	200	10,300[2]	10,600	12,000				11,000
	1	1	250	16,000[2]	16,000[2]	16,000[2]				16,000[3]
	5/8	5/8	[4]				6,300	16,000[2]	10,600[2]	
	3/4	3/4	250				10,600	[5]	10,000	10,300
	1	1	500				16,000[2]	16,000[2]	16,000[2]	16,000[3]
K-1	3/4	1-1/4	90	11,200	7,700	11,400				10,100
	3/4	1-1/4	120				15,500	8,800	9,200	11,200

[1] Stripped threads on bolt at two turns of nut.
[2] Load at less than 1/32-in. pull-out.
[3] 16,000 lb load not a maximum, but near calibrated capacity of the testing equipment.
[4] Varied torque, 125, 150, and 200 lb-ft. Average load not computed due to various torque values.
[5] Bolt failure while attempting to obtain seven turns of bolt, approximately 400 lb-ft torque.

Discussion

Communications with field construction personnel has indicated that occasionally torques of 60 lb-ft on expansion shields (Bethlehem or FJ-1) have caused damage to "green" concrete, even when the anchors were installed at mid-slab depth. Consequently, in many instances this type of anchor is not being torqued sufficiently when used with new pavements, to attain required pull-out resistance.

The Taper-Bolts evaluated in this testing program have demonstrated the ability to develop relatively high pull-out resistance at low slippage. However, the expansion-nut portion of the anchor is zinc alloy, which should cause it to sacrifice itself to steel in a galvanic cell. Therefore, we hesitate to recommend use of this type of anchor for lane ties, since moisture and salt solution are plentiful, and the installation is intended to last for many years. No information on long term performance under such a severe environment was submitted by the producer. It does seem reasonable, however, to allow use of the Taper-Bolt anchors for attachment of guardrail end-shoes to existing concrete parapet bridge railing. In this case the installation is well drained, generally under no pull-out load, and is expected to function in shear if and when a car impacts the railing. The anchor has only the bolt head exposed, which is desirable, and the bolt most likely would be removable if required for maintenance. Hot dip galvanizing should be specified for installations of this type if approved. Since this type of anchor is not available in 7/8-in. diameter, and 3/4-in. is too small for use with the 4-hole end-shoe, the 1-in. size would be required, and end-shoes would have to be drilled oversize.

As part of this evaluation, a 3/4-in. Taper-Bolt was installed 1 in. from the slab surface and torqued to approximately 350 lb-ft with no visible damage to the concrete. This indicates that the expansion force is distributed well enough so that this type anchor may be used in lower strength concrete, or nearer to surfaces, without causing the damage sometimes associated with torque-type anchors.

As was previously mentioned, the WEJ-IT anchor will develop ultimate pull-out loads greater than those shown in Table 1; however, this does not occur until considerable slippage has taken place, and the greater slippage is not allowable for lane ties. End-shoes for guardrail should be attached with headed bolts and therefore this stud-type anchor is not recommended for such use. Sign mountings on structures are normally over traffic, and would require more dependable capacity than demonstrated by WEJ-IT anchors. Since there has been a recent design change, requiring lane ties to be 5/8-in. minimum diameter, the 5/8-in. anchors tested will not be considered acceptable for use as lane ties. (Threading the rod would reduce the minimum diameter below the allowable size.)

Recommendations

Based on the discussion and results of tests, and discussions with construction personnel, the following recommendations are made:

1) Do not approve Taper-Bolts or WEJ-IT anchors for use as lane ties.

2) Consider the possibility of using 1-in. Taper-Bolts for attachment of guardrail end-shoes to concrete parapet bridge-rail on existing structures. (New structures should have embedded anchorage devices.)

3) Due to the large variation in load capacity of the WEJ-IT anchors, they are not recommended for sign mounting on structures, and stud-type anchors such as these are not recommended for end-shoe attachment to concrete parapet bridge-rail.