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Installation and Use of Concrete Anchors

Mechanical Expansion Anchors and Adhesive Anchors

Motorists seem to be divided on their opinions of road signs: some view them as invaluable tools for navigating today's complex road and highway systems, others see them as eyesores, or feel that there are too many. Regardless of opinions, signs provide important information to motorists, especially those who aren't familiar with a particular area. Most people don't realize the design considerations that go into safely mounting these signs and other items, such as protective fencing for pedestrians, to the hardened concrete of bridge beams or traffic barriers. Since the signs and fencing are often directly above or adjacent to locations where people walk or drive their vehicles, the means of attaching these items must be secure. Currently, these attachments are secured to hardened concrete using concrete anchors. There are two types of concrete anchors in use: mechanical expansion anchors and adhesive anchors.

Anchor Definitions and Installation Procedures

Mechanical Expansion Anchors - Mechanical expansion anchors work by applying frictional force to the sides of a predrilled hole. There are three types of mechanical expansion anchors used by MDOT: stud, drop-in, and self-drilling.

Stud Anchors: The stud mechanical anchor consists of a threaded rod with an expansive device at one end and a threaded portion with a nut on the other end (see Figure 1). This anchor is installed by sliding the expansive end of the anchor into a predrilled hole. It is set by tightening the nut to the recommended torque. Stud anchors protrude above the surface of the concrete after installation and should be used when the object being attached requires a washer and nut of a specified size or diameter.

Drop-in Anchors: The drop-in anchor consists of an anchor body and either an internal or external expansion plug (see Figure 2). A drop-in anchor manufactured with an internal plug is installed by placing it into a predrilled hole and it is set by driving the plug to the required depth using a setting tool and a hammer. Once set, a bolt or rod can be threaded into the anchor body. The drop-in anchor with an external plug is installed in similar fashion.

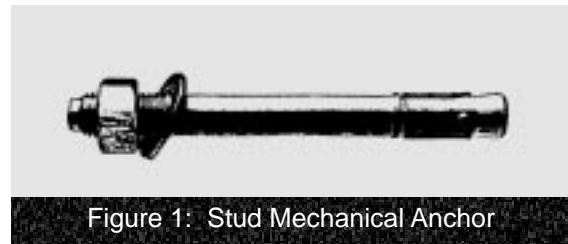


Figure 1: Stud Mechanical Anchor

The external plug is inserted into the expanding end of the anchor, and the entire assembly is inserted into a predrilled hole. It is set by forcing the anchor body around the external plug using a hammer and setting tool. Once set, a bolt or rod can be threaded into the anchor body. Unlike stud anchors, drop-in anchors do not protrude above the concrete surface after installation.

Self-drilling Anchors: The self-drilling anchor is similar to the drop-in anchor; however, since it has a cutting tip, a predrilled hole is not required (see Figure 3). Installation of the self-drilling anchor requires a roto-hammer and a special chuck which grips the upper cone of the anchor body (see Figure 4). In order to avoid the possibility of the anchor becoming lodged in the hole, the hole should be blown out with compressed air repetitively during the drilling process. After the hole is drilled and blown out, the anchor is removed and the external plug is inserted in the expansive end of the anchor. The anchor is then reinserted into the hole and is set

by using a hammer and setting tool. Once set, the upper cone can be knocked off and a bolt or rod can be threaded into the anchor body.

An important point to note is that anchor-type selection and installation are critical when vibratory loads will be present.



Figure 2: Drop-in Mechanical Expansion Anchor

Installation Considerations for Mechanical Expansion Anchors

When installing mechanical expansion anchors, it is important that the installer follows the installation procedures provided by the manufacturers. In addition, the guidelines specified in the MDOT 1996 *Standard Specifications for Construction* should be followed. There are three common installation problems associated with mechanical expansion anchors: improper hole preparation, not applying adequate torque, and drilling oblong holes.

Proper hole preparation enables mechanical expansion anchors to develop the frictional force required for proper holding strength. The expansive end of mechanical expansion anchors must have complete contact with the sides of the hole. According to the MDOT 1996 *Standard Specifications for Construction*, “The hole shall be blown out with oil-free compressed air, brushed, and blown out again.” (p. 7.131) This is done to remove any dust and debris created during drilling, which can interfere with the contact of the mechanical expansion anchor and the sides of the hole.

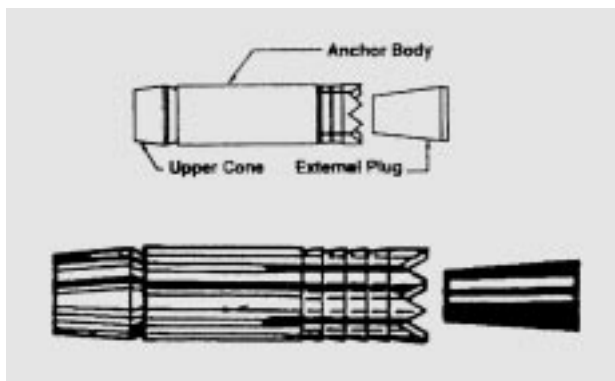


Figure 3: Self-Drilling Mechanical Expansion Anchor



Figure 4: Self-drilling Mechanical Expansion Anchor with Roto-Hammer Socket

The second problem typically involves tightening mechanical expansion anchors with a wrench. Mechanical expansion anchors should be set by applying the manufacturer’s recommended torque, as the “turn of nut” method is not acceptable.

The third problem occurs most often when reinforcing steel is hit during drilling. In an attempt to salvage the hole, the installer will drill an oblong hole to avoid the rebar. Since mechanical expansion anchors rely on contact with the sides of the hole to develop frictional resistance, the oblong-shaped hole reduces the capacity of the anchor. According to the MDOT 1996 *Standard Specifications for Construction*, “The Contractor shall accurately locate the steel reinforcement by the use of a pachometer or other approved means prior to drilling the hole.” (p. 7.131) If reinforcing steel is encountered when drilling holes for mechanical expansion anchors, the hole should be abandoned and a new hole should be drilled.

Adhesive Anchors

Adhesive Anchors - Adhesive anchors work through a chemical bond between the adhesive, anchor, and concrete. MDOT has approved two types of adhesive anchor systems: a two-part system and a glass capsule.

Two-part Adhesive System: The two-part system consists of resin and hardener which are combined through a mixing nozzle. The nozzle and delivery gun resemble a caulking gun. The adhesive should not be used until a uniform resin/hardener mixture exits the nozzle. This may mean that the first few pumps of the mixture are discarded.

Glass Capsule: The second type of adhesive anchor is the glass capsule. This is also a two-part system, but both the resin and hardener are contained within a glass tube that has separate compartments for each component. The glass capsule can be installed more quickly and easily when using rebar or threaded rod. The resin and hardener is mixed in the hole by using a roto-hammer with a threaded rod or rebar. The spinning rod or rebar is inserted into the hole and is used to break the glass capsule. Once the glass breaks, the rod is inserted to the

desired depth and is turned for the manufacturer's recommended time, which ensures the proper mixture of the resin and hardener. Once the adhesive is fully mixed, disconnect the rod or rebar from the roto-hammer, being careful not to disrupt the anchor placement.

An important point to note is that adhesive selection and installation are critical when sustained loads on the anchor will be present.

Installation Considerations for Adhesive Anchors

One important factor to consider when working with adhesive anchors is the fact that there is gel time and cure time. Gel time refers to the time the adhesive takes to initially set. Depending on the temperature and the type of adhesive used, this gel time can range from 20 minutes to 1 hour. To ensure that the threaded rod or rebar will penetrate the adhesive to the required depth, the anchor must be installed into the adhesive before the gel time expires. Cure time refers to the time the product takes to fully harden. The cure time can range from 1 hour to 24 hours, depending on conditions. The anchor can withstand the desired loading after the adhesive has fully cured.

The problems typically encountered with the installation of adhesive anchoring systems include improper mixing and hole preparation. It is vital that manufacturer's recommendations are followed during installation. One of the most common problems is the improper mixing of the hardener and the resin. When the components are not fully mixed, pockets of uncured adhesive result, which reduce the capacity of the anchor. When using the two-part system, it is important that the installer discards the initial adhesive that exits the nozzle until a uniform mixture is present. When using the glass capsules, the installer must continue to spin the rod for the manufacturer's recommended time.

As with mechanical expansion anchors, proper hole preparation is also a critical step in the installation of adhesive anchors. According to the MDOT *1996 Standard Specifications for Construction*, "All loose concrete, dust, dirt, and oil shall be removed from the holes by washing with water under pressure and mechanical agitation. The holes shall be blown out with oil-free compressed air and shall be dry before installation of the adhesive." (p. 7.131)

A limitation encountered with the installation of some adhesive anchors involves trying to install them when the conditions are not favorable. If the installer tries to install an adhesive anchor when the temperature is below 4° C, the adhesive will either not cure, or will take a very long time to cure. If an installation must be made during cold weather, the concrete must be heated prior to installation. Due to the fact that concrete is a poor con-

ductor of heat, it requires a considerable amount of energy to bring it up to the required temperature.

Advantages of Each Anchor Type

Mechanical Expansion Anchors: The biggest advantage that mechanical expansion anchors have over adhesive anchors is immediate loading. Mechanical expansion anchors can accept the designed load as soon as they are installed. This may be advantageous for applications that require traffic control or have a limited installation time. Adhesive anchors differ in that the adhesive must be fully cured before a load can be applied to the anchor.

Adhesive Anchors: Adhesive anchors have several advantages over mechanical expansion anchors. One advantage is that adhesive anchors can operate properly if adjacent to rebar. The expansive end of mechanical expansion anchors must have complete contact with the sides of the hole to operate as expected. If rebar is encountered while drilling a hole for mechanical expansion anchors, the hole must be abandoned and an alternate hole must be drilled. Another advantage that adhesive anchors have is that either threaded rods or rebar (either black bar or epoxy coated) can be inserted into hardened concrete using adhesive anchors. Mechanical expansion anchors only permit a threaded rod or bolt.

Testing Procedures

Proper installation techniques are needed for concrete anchors to perform as expected. To help ensure correct installation, separate proof load and field testing procedures for each type of concrete anchor are specified in the MDOT *1996 Standard Specifications for Construction*.

Mechanical Expansion Anchors:

"Prior to use, the proposed anchor shall be proof tested by the Engineer. The proof test shall be prepared by the Contractor on a separate concrete block or shall be prepared on the structure by the Contractor in a location approved by the Engineer." (p. 7.131)

The proof load test is used to not only demonstrate the contractor's installation procedures, but the anchor's ability to develop specified pull-out loads, based on its diameter.

"The Contractor shall conduct field testing, at three locations specified by, and in the presence of, the Engineer, during the first day of production. The field test shall demonstrate that the anchor will provide a minimum pull-out resistance of 50 percent of the proof tensile load at 2 mm slippage. The Engineer may conduct random pullout tests, at 50 percent of the proof tensile load, for acceptance." (p. 7.132)

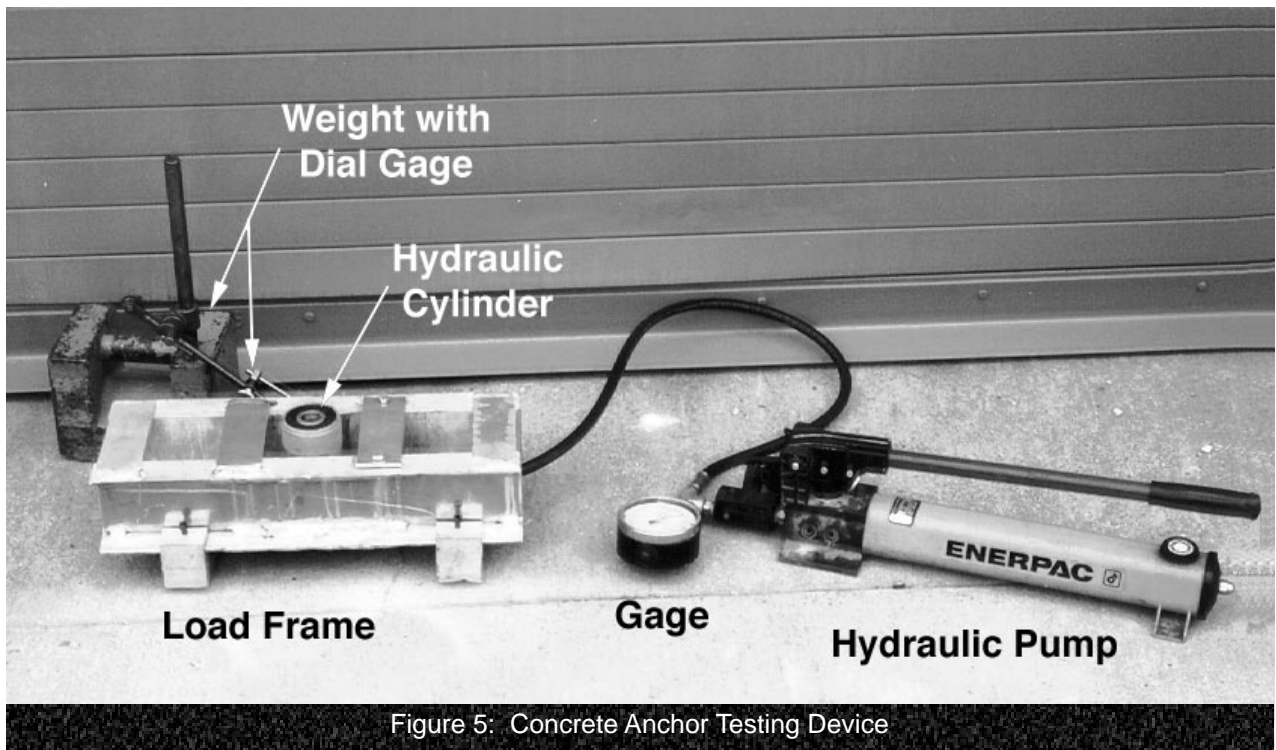


Figure 5: Concrete Anchor Testing Device

Adhesive Anchors:

“Prior to use, the proposed systems shall be proof tested by the Engineer. A minimum of three proof test anchors shall be prepared by the Contractor in the position to be used, on a separate concrete block, and in the presence of the Engineer. The tests of the proposed systems shall consistently demonstrate that the yield strength of the anchored bars can be developed in pull-out tests and that the bars shall be bonded to the concrete a minimum of 90 percent of the bar length and area. Bar slippage at yield strength shall not average more than 2 mm.” (p. 7.130)

“The Contractor shall conduct field testing, at three locations specified by, and in the presence of, the Engineer, during the first day’s production. The pull-out test shall demonstrate that 90 percent of the bar’s yield strength develops with less than 2 mm slip. The Engineer may conduct random pull-out tests for acceptance. Acceptance tests must equal 90 percent of the

bar’s yield strength with less than 2 mm slip. The Contractor shall repair damage to epoxy coating.” (p. 7.131)

One important point to note is that in the past, MDOT was responsible for the quality control testing of concrete anchors and provided the testing devices and personnel needed. This is no longer the case. Although MDOT still retains the ability to conduct random quality assurance testing, it is now the contractor’s responsibility to provide concrete anchor testing devices (see Figure 5) and personnel for testing. Details for the testing devices are available from MDOT’s Materials & Technology Structural Research Unit and ASTM E 488. Each contractor must have their testing device calibrated and certified on an annual basis.

For additional information regarding the design and/or use of concrete anchoring systems, contact Dave Juntunen at (517) 322-5707 or Doug Needham at (517) 322-1979. Additional information can also be obtained by contacting LTAP at (906) 487-2102.

Reference Material for Concrete Anchoring Systems

1996 Standard Specifications for Construction
Michigan Department of Transportation, 1996.

Design Procedures for Concrete Anchors
(*Mechanical Expansion Anchors and Adhesive Anchors*)

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