TSPWG 3-32.17.07-2
6 June 2019

TRI-SERVICE PAVEMENTS WORKING GROUP (TSPWG) MANUAL

ANCHORING A FIBERGLASS MAT ASSEMBLY IN ASPHALT CONCRETE PAVEMENT

TRI-SERVICE PAVEMENTS WORKING GROUP MANUAL (TSPWG M)

ANCHORING A FIBERGLASS MAT ASSEMBLY IN ASPHALT CONCRETE PAVEMENT

Indicate the preparing activity beside the Service responsible for preparing the document.

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER CENTER (Preparing Activity)

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	**Date**	**Location**

This TSPWG Manual supersedes Air Force ETL 07-2, *Anchoring a Fiberglass Mat Assembly in Asphalt Concrete (AC) Pavement*, dated 19 December 2007.

FOREWORD

This Tri-Service Pavements Working Group (TSPWG) Manual supplements guidance found in other Unified Facilities Criteria, Unified Facilities Guide Specifications, Defense Logistics Agency Specifications, and Service-specific publications. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and, in some instances, Bilateral Infrastructure Agreements (BIA). Therefore, the acquisition team must ensure compliance with the most stringent of the TSPWG Manual, the SOFA, the HNFA, and the BIA, as applicable. This manual provides guidance on anchoring a folded fiberglass mat assembly in asphalt concrete pavement. The information in this TSPWG Manual is referenced in technical publications found on the Whole Building Design Guide. It is not intended to take the place of Service-specific doctrine, technical orders (T.O.), field manuals, technical manuals, handbooks, Tactics, Techniques, and Procedures (TTPs), or contract specifications but should be used along with these to help ensure pavements meet mission requirements.

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TRI-SERVICE PAVEMENTS WORKING GROUP MANUAL (TSPWG M)
NEW SUMMARY SHEET

Document: TSPWG Manual 3-32.17.07-2, *Anchoring a Fiberglass Mat Assembly in Asphalt Concrete Pavement*

Superseding: Air Force ETL 07-2, *Anchoring a Fiberglass Mat Assembly in Asphalt Concrete (AC) Pavement*

Description: This Tri-Service Pavements Working Group (TSPWG) Manual provides an alternate method of installing a Type 3 polymer plug anchor to anchor fiberglass mats in AC pavements.

Reasons for Document: This manual provides an alternate method of installing anchors to folded fiberglass mats (FFM) in AC pavements as defined in Technical Order (T.O.) 35E2-3-1, *Folded Fiberglass Mats for Rapid Runway Repair.* Specifically, this manual revises paragraph 7.6 of T.O. 35E2-3-1 and provides a method to reconfigure or modify the anchor bolt and a choice of anchor-setting materials, thereby providing performance that is equal or superior to previous methods for anchoring in AC pavements.

Impact: There is no cost impact. The following benefits should be realized:

- Supplemental information on the operation, maintenance, and repair of pavements as well as airfield damage repair will be available to all Services.

- Maintenance and/or upgrading of this supplemental information will include inputs from all Services.

Unification Issues: None

Note: The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Department of Defense (DOD).

CHAPTER 1 INTRODUCTION

1-1 BACKGROUND.

The US Air Force has developed a folded fiberglass mat (FFM) as part of a rapid runway repair (RRR) system to cover craters repaired with a well-compacted granular base material for fighter aircraft operations and as an expedient airfield runway repair that functions as a foreign object debris (FOD) cover for expedient bomb crater repairs.

Technical Order (T.O.) 35E2-3-1, *Folded Fiberglass Mats for Rapid Runway Repair*, describes the use of part number R-256 NSN 8030-01-376-7248, a two-part polymer kit that is no longer available from the manufacturer. Furthermore, T.O. 35E2-3-1 provides instruction on anchoring mats to asphalt concrete (AC) and portland cement concrete (PCC) pavements thicker than 10 inches (254 mm); however, there is a need to anchor mats to AC pavements that are significantly thinner than this. Testing by the Air Force Research Laboratory (AFRL) at Tyndall AFB, Florida, and the U.S. Army Engineer Research and Development Center (ERDC) at Vicksburg, Mississippi, has resulted in a suitable replacement for the polymer kit recommended in T.O. 35E2-3-1 and a method has been developed to anchor the mats to thinner AC pavements.

1-2 PURPOSE AND SCOPE.

This Tri-Service Pavements Working Group (TSPWG) Manual provides an alternate method of installing a Type 3 polymer plug anchor to anchor fiberglass mats in AC pavements as defined in T.O. 35E2-3-1. Specifically, this manual revises paragraph 7.6 of T.O. 35E2-3-1 and provides a method to reconfigure/modify the anchor bolt and a choice of anchor-setting materials, thereby providing performance that is equal or superior to previous methods for anchoring in AC pavements.

1-3 APPLICABILITY.

This manual is applicable to the following:

- All pavement engineers
- Air Force, U.S. Army Corps of Engineers (USACE), and Navy offices responsible for design and construction
- All designers and construction contractors building airfield pavements

1-4 GLOSSARY.

Appendix B contains acronyms, abbreviations, and terms.

1-5 REFERENCES

Appendix C contains a list of references used in this manual. The publication date of the code or standard is not included in this manual. Unless otherwise specified, the most recent edition of the referenced publication applies.

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CHAPTER 2 RECOMMENDED PROCEDURES TO INSTALL FFM ANCHORS IN THIN ASPHALT

2-1 MODIFY CONCRETE WEDGE ANCHORS.

The standard concrete wedge anchors (type that is standard with the FFM kit) may need to be modified. Use anchors that are approximately 9.5 inches (241.3 millimeters [mm]) long and 0.5 inch (12.7 mm) in diameter (measured across the threads).

- Modify each anchor by removing the nylon collar section, expansion sleeve, and cone at the bottom of the bolt and replacing them with three 1.375-inch (35-mm) outside diameter (OD) washers with a spacer 0.5 inch (12.7 mm) tall between them and one threaded coupling nut with a hexagonal outer shape and a piece of tape on the end of the coupling. Ensure the coupling is long enough (about 1.5 inch [38.1 mm] long) where the end of the bolt does not extend below the bottom of the coupling. Oversized nuts can be used as spacers.
- Before final assembly, place each bolt in an FFM bushing then add the washers, spacers, and coupling nut.
- Ensure the junction of all parts (sleeve, washer, spacer, and coupling) are tight and the threads of the bolt cannot be seen along the length of the modified bolt. This is important to ensure the bolts can be removed and reinserted after the anchors have been in service.

1. Place the FFM on the ground in the desired location.
2. Use a hammer drill to drill a 1.5- to 2-inch (38.1- to 50.8-mm) - diameter hole to a depth of 10 to 11 inches (254 to 279.4 mm).
3. Use a shop vacuum to remove loose material from the hole.
4. Wash the asphalt portion of the shaft with a small amount of water.
5. Ensure the bolt is in the FFM bushing.
6. Ensure the bolt and bushing fit properly in the mat and the hole by placing it in the hole and then removing it.
7. Keep the bushing on the bolt.
8. Place Liquid Roc 500+ in the hole to a level approximately 0.5 inch (12.7 mm) from the pavement surface.

   Note: At high temperatures (above 90 degrees Fahrenheit [°F] [32.2 degrees Celsius [°C]), the epoxy can set in two to three minutes so have all materials ready and available. Have an extra tube of epoxy available at all times.

- This product is best when used for temperatures between 60 °F (16.6 °C) and 95 °F (35 °C).
- If temperatures are below 60 °F (16.6 °C), use AC100+ Gold or HIT-ICE.
- If temperatures are above 95 °F (35 °C), use Liquid Roc 500+.

9. Insert the bolt into the hole. Ensure the adhesive flows around the washers and avoid creating air pockets.

10. Seat the bushing in the transition and ensure the bolt is flush with the bushing.

11. Open to traffic after one hour of cure time above 70 °F (21.1 °C) (using Liquid Roc 500+); two hours if 40 to 70 °F (4.4 to 21.1 °C) (using AC100+ Gold or HIT-ICE).

2-2 TESTING PROCEDURES.

2-2.1 This section describes the sample preparation, testing, and best practices performed on this anchoring system in the past.

2-2.2 Anchors were placed by drilling a 1.5-inch (38.1-mm) -diameter hole approximately 10 inches (254 mm) deep. The hole was cleared of debris and filled with epoxy. The modified bolt was inserted into the hole. After allowing the epoxy to cure, the bolts were loosened and retightened to ensure the repair is maintainable, if needed. The bolts were then pull-tested to determine the pull-out strength.

2-2.3 AFRL obtained the best results using a water-insensitive two-part structural epoxy. A double-tube container containing a total of 22 ounces (650.6 milliliters [ml]) of epoxy will fill a single hole. Adhesives packaged this way can be applied manually, pneumatically, or with a power-operated injection tool. The epoxy is proportionally mixed through a static element mixing nozzle.

2-2.4 Additionally, if drills, mixing paddles, and potable water are available, fast-setting grouts using 2-inch (50.8-mm) -diameter holes can also be employed. Fast-setting grouts behave similarly to the epoxies, with faster cure times in hot weather and longer set times in colder climates. Using heated water improves cure times in cold conditions. The grout is typically packaged in dry form in a 5-gallon (18.9-liter [L]) bucket. The materials examined herein required 1 gallon (3.8 L) of water to produce approximately 2 gallons (7.6 L) of grout. This volume of grout is used to install approximately five to seven anchor bolts. Once poured, screed the material and finish in a manner similar to concrete. Adding slightly more or less water (only a few ounces [mL] or as recommended by the manufacturer) will produce a thinner or thicker grout, respectively, but should not affect the finished strength.

2-3 MODIFIED ANCHOR SYSTEM.

2-3.1 Epoxy.

2-3.1.1 Characteristics.

2-3.1.1.1 Required.

Required characteristics include a working time of three to five minutes at 75 °F (23.9 °C); cure time less than 120 minutes at 75 °F (23.9 °C); water-insensitive; temperature range will differ depending on the climate where the mat is applied. The usual range is from 40 to 95 °F (4.4 to 35 °C). Some are designed for high temperatures up to 140 °F (60.0 °C) and some are designed for temperatures as low as -10 °F (-23.3 °C); however, none have been found to be effective over the full temperature range from -10 to 140 °F (-23.3 to 60 °C). Many epoxies will not set in temperatures below 40 °F (4.4 °C).

2-3.1.1.2 Desired.

The epoxy should be formulated for underwater applications.

2-3.1.1.3 Selecting Epoxy for Cold Weather Applications.

When selecting an epoxy for cold weather applications, consider the cure time and viscosity (pumpability) characteristics. AC100+ Gold and HIT-ICE performed well in all tests.

2-3.1.2 Specific Epoxies Tested.

2-3.1.2.1 590 Hi-Mod Gel Superstick (E-Bond Epoxies, Inc.).

This product was extremely sensitive to moisture. Any moisture in the subgrade will affect the materials even when the pavement surface is dry. This product had a long cure time (8 to 24 hours), even at room temperature, which is unacceptable for most RRR applications.

2-3.1.2.2 Concrete Welder (PERCOL Polymerics, Inc.).

This product was extremely sensitive to moisture. Any moisture in the subgrade will adversely affect the materials even when the pavement surface is dry, which is unacceptable for most RRR applications.

2-3.1.2.3 Liquid Roc 500+ (MKT Fastening Corp.).

This product provided satisfactory performance. This product can be placed or cured underwater. (http://www.mktfastening.com/)

2-3.1.2.4 Epcon A7+ (Quick-Cure Adhesive) (Red Head).

This product provided satisfactory performance. (https://www.itwredhead.com/products/adhesive-anchors/a7)

2-3.1.2.5 AC100+ Gold (Powers Fasteners).

This product provided satisfactory performance at low temperatures (35 °F [1.7 °C]). This product can be placed or cured underwater. (http://www.powers.com/adhesive_anchors.php)

2-3.1.2.6 HIT-ICE (Hilti).

This product provided satisfactory performance at low temperatures (35 °F [1.7°C]). This product can be placed or cured underwater. (http://www.hilti.com)

2-3.2 Fast-Setting Water-Based Grouts.

2-3.2.1 Required Characteristics.

Required characteristics include a working time of 10 to 15 minutes at 75 °F (23.9 °C); cure time less than 60 minutes at 75 °F (23.9 °C); water-insensitive and can be used in a submerged condition similar to concrete; temperature range will differ depending on the climate where the mat will be applied. The usual range is from 40 to 95 °F (4.4 to 35 °C) but temperatures above 95 °F (35 °C) will shorten work and cure times, while in the lower temperature range (approximately 50°F [10.0°C] and below) work and cure times will increase. Anchor holes require minimal preparation and grout is insensitive to dust or moisture in the hole; ensure the grout is a non-shrink, non-metallic type material.

2-3.2.2 Specific Grout Tested.

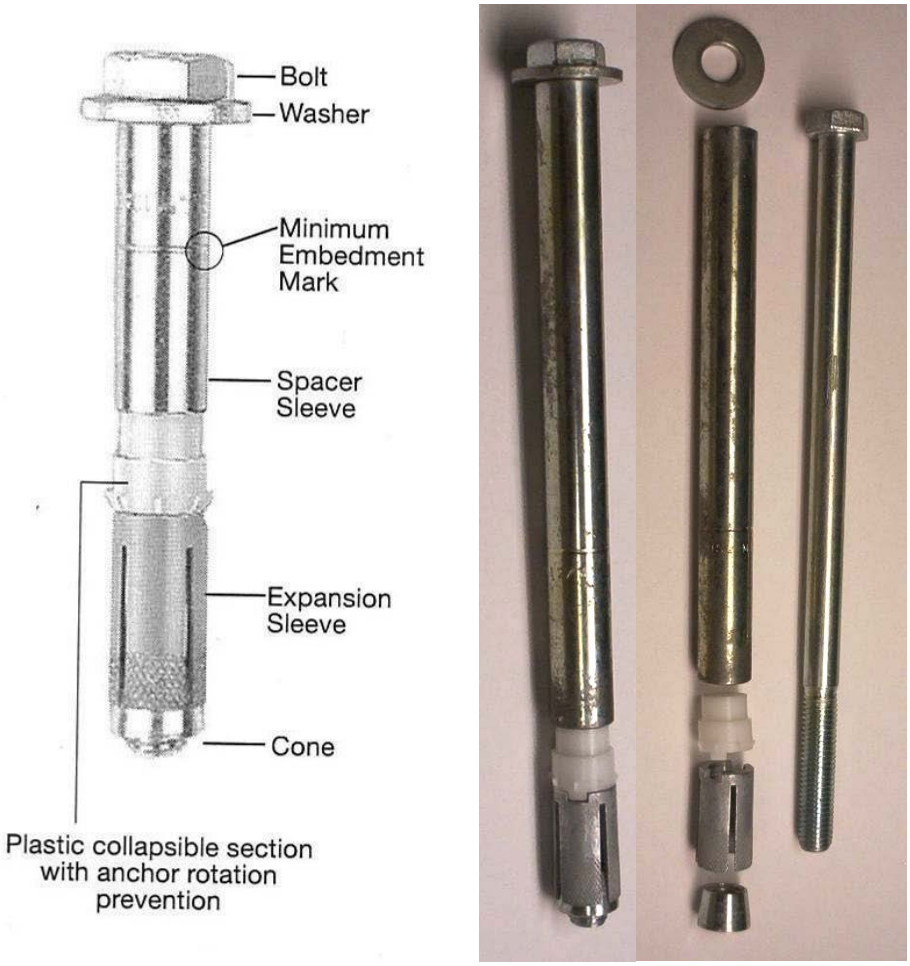
Hard-Rok™ Anchoring Cement (Adhesives Technology Corp.) provided satisfactory performance. (http://atcepoxy.com/products/anchoring/)

2-3.3 Modified Anchor Bolt.

2-3.3.1 Existing Anchor Bolts.

The anchors are Hilti HSL-3 M12/50 expansion anchors (Hilti Corp.). Hilti HSL-3 bolts are similar and a suitable substitute. The anchors are approximately 9.5 inches (241 mm) long and 0.5 inch (13 mm) in diameter. The sleeve has a 0.75-inch (19-mm) OD. They are designed for use in cracked concrete. Figure 2-1 shows the anchor and its components. The anchor comes with a shoulder bolt, a washer, a steel sleeve, a nylon collar section, an expansion sleeve, and a cone.

Figure 2-1 M12/50 Expansion Anchor



2-3.3.2 Modifications.

The standard anchor was modified by removing the nylon collar section, expansion sleeve, and cone and replacing them with three 1.375-inch (34.9-mm) -OD washers, two 0.5-inch (12.7-mm) spacers, one threaded coupling nut with a hexagonal outer shape, and a piece of tape on the end of the coupling. The coupling was a metric class 5.8 zinc-plated steel coupling nut M12 screw, 1.5 inches (38.1 mm) in length, 0.625 inch (15.9 mm) in width, with a 0.069-inch (1.75-mm) pitch. The tape on the end of the coupling is needed to ensure epoxy does not enter the coupling and precludes the bolt from being removed and reinserted after the epoxy has cured. The spacers consisted of two 0.625-inch (15.9 mm) -inside diameter (ID) nuts, which allowed the threaded portion of the 0.5-inch (12.7-mm) bolt to easily pass through. The nuts were approximately 0.5 inch (12.7 mm) tall. Spacers made from sections cut from the sleeve were also tried; however, epoxy was able to pass between the spacers and the washers due to the clearance between the bolt and the washer relative to the thickness of the spacer wall.

Figure 2-2 shows the anchor components and Figure 2-3 shows the assembled components.

Figure 2-2 Modified Anchor Components

Figure 2-3 Assembled Modified Anchor

2-3.4 Test Setup and Procedures.

The tests were conducted on asphalt pavement that was 4.75 inches (121 mm) to 5.75 inches (146 mm) thick. The asphalt was placed over a crushed stone base that was approximately 9 inches (229 mm) thick. The temperature ranged from 75 to 100 °F (23.8 to 37.8 °C). A 1.5-inch (38-mm) -diameter hole was drilled 10 to 11 inches (254 to 280 mm) deep. Excess debris at the bottom of the hole was removed using a standard shop vacuum cleaner. The adhesives were tested in both wet and dry environments. The holes were cleaned with a variety of methods, including washing the surfaces with water, while several holes were tested without any cleaning. The epoxy was injected in each hole and an anchor with a loading plate was placed in and over the hole.

The anchors were tested at one hour, six hours, and 24 hours after placement. The anchors were pulled vertically using a forklift and a front-end loader. The maximum pulling force was recorded using a Dillon 100,000 pounds force (444.8 kilonewton [kN]) load cell.

Three tests were also conducted on pavements and subgrades at 35 to 39 °F (1.7 to 3.9 °C). The temperature of the pavement and subgrades was monitored using thermal couples. The anchors were tested at 45 minutes and 6 hours.

2-3.5 Test Results.

Tests on anchors placed in temperatures above 75 °F (23.9 °C) resulted in strengths in excess of 5,000 pounds (22.2 kN) of force. A total of twenty-seven tests using Liquid Roc 500+ resulted in a minimum pull strength of 5,000 pounds (22.2 kN) of force, a maximum of 15,000 pounds (66.7 kN) of force, and an average of 10,000 pounds (44.5 kN) of force. The pull test strengths appeared to be insensitive to moisture, cure times over one hour in length, and surface preparation. Note that the ultimate pullout force is a function of the pavement structure and material characteristics in which the anchor is

embedded. Less competent pavement structures are expected to provide lower ultimate pullout strengths, approaching the lower end of the range tested or 5,000 pounds (22.2 kN) of force. For example, tests completed at the ERDC site using the recommended system with a 4.5- to 6-inch (114.3- to 152.4-mm) -thick AC surface but a poor-quality base produced an average pullout strength of 6,500 pounds (28.9 kN) of force. In contrast, more competent pavements, which include increased asphalt thicknesses or higher-strength materials, provides anchor pullout strengths near the maximum values reported. Thus, in extremely thin or weak asphalt pavements, additional anchors are required to provide the same pullout resistance for the FOD cover.

Some epoxies such as AC100+ Gold and HIT-ICE are designed to be placed at low temperatures. These products set within several minutes and cured sufficiently within 45 minutes to attain pull strengths of 15,000 pounds (66.7 kN) of force when placed and cured at 35 °F (1.7 °C). Note that the lower temperatures significantly increased the stiffness of the pavement, which caused a significant increase in the strength of the anchor system.

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APPENDIX A BEST PRACTICES

[RESERVED]

APPENDIX B GLOSSARY

B-1 ACRONYMS

°C	Degrees Celsius
°F	Degrees Fahrenheit
AC	Asphalt Concrete
AFRL	Air Force Research Lab
ERDC	U.S. Army Research and Development Center
ETL	Engineering Technical Letter
FFM	Folded Fiberglass Mat
FOD	Foreign Object Debris
kN	Kilonewton
ml	Milliliter
mm	Millimeter
OD	Outside Diameter
RRR	Rapid Runway Repair
T.O.	Technical Order
TSPWG M	Tri-Service Pavements Working Group Manual
USACE	U.S. Army Corps of Engineers

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APPENDIX C REFERENCES

AIR FORCE

T.O. 35E2-3-1, *Folded Fiberglass Mats for Rapid Runway Repair*