TRI-SERVICE PAVMENTS WORKING GROUP (TSPWG)

POCKET MANUAL (PM) 3-270-01.20-02

O&M: Airfield Damage Repair

5 MAY 2022

RAPID SETTING CONCRETE REPAIR CAPPING USING TYPE I AND TYPE III CEMENT

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RAPID SETTING CONCRETE REPAIR CAPS USING TYPE I AND TYPE III CEMENT

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

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FOREWORD

This Tri-Service Pavements Working Group Pocket 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 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 Pocket Manual, the SOFA, the HNFA, and the BIA, as applicable. This pocket manual provides guidance for rapid-setting concrete repair capping using Type I and Type III cements. The information in this pocket 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 (TOs), field manuals, technical manuals, handbooks, Tactics, Techniques or 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 PAVEMENT WORKING GROUP (TSPWG)

NEW SUMMARY SHEET

Document: TSPWG Pocket Manual 3-272-01.20-02, *Rapid Setting Concrete Caps using Type I and Type III Cement*

Superseding: None

Application: This document is authoritative but not directive. The information in this publication takes precedence over conflicting information found in other nondirective publications.

Description: This publication describes the use of rapid-setting concrete capping materials used to repair damaged airfield pavements using Type I and Type III portland cements with locally available materials.

Reasons for Document: Provide guidance to engineer repair teams for producing a rapid-setting concrete using Type I and Type III cements for airfield pavement repairs.

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).

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CHAPTER 1 INTRODUCTION

1-1 OVERVIEW.

The process of airfield damage repair is composed of four phases. After an attack, the first phase consists of identifying & repairing a minimum aircraft operating strip (MAOS). The second phase sustains the MAOS by monitoring and repairing initial crater repairs. The third phase expands the MAOS to accommodate higher sortie rates or other aircraft. Materials and equipment to support these three phases can be found in Air Force UTCs: 4FWCR, *Crater Repair Vehicles, Tools, and Equipment*; 4FWSP, *Sustainment Pavement Repair (SuPR) Kit*; 4FWCM, *Concrete Cap Materials*; 4FWAB, *Asphalt Cap Materials*; and 4FWSR, *Spall Repair Equipment and Materials*. The final phase is reconstitution of the installation.

In some cases, rapid-setting concrete capping materials are limited in stock, not available, or being conserved. However, in most locations, Type I or Type III cement is available. This manual outlines methods using Type I or Type III cement to mix capping materials. The mixes presented are effective alternatives for fast-setting concrete capping as opposed to using rapid-set concrete. The mix designs can support up to 3000 sorties after six hours of curing. In addition, concrete using Type III cement can support up to 500 passes if trafficked after four hours. Comparatively, concrete using Type I cement can support up to 500 passes if trafficked after five hours.

1-2 PURPOSE AND SCOPE.

This manual describes using locally available Type I or Type III cement for mix design and processes for capping crater-damaged runways. This manual supplements UFC 3-270-01, *O&M Manual: Asphalt and Concrete Pavement Maintenance and Repair*, and *Interim Process for Rapid Airfield Damage Recovery (RADR)*, or AFTTP 3-32.17, *Rapid Airfield Crater and Spall Repair*, whichever is published and current.

1-3 APPLICABILITY.

The information in this publication takes precedence over conflicting information in other nondirective publications.

1-4 GENERAL BUILDING REQUIREMENTS.

Comply with UFC 1-200-01, DoD Building Code outlining applicability of model building codes and government-unique criteria. Use this manual in addition to UFC 1-200-01.

1-5 GLOSSARY.

Appendix A contains acronyms, abbreviations, and terms.

1-6 REFERENCES.

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

CHAPTER 2 CRATER CAPPING

2-1 OVERVIEW.

This chapter describes mix designs that produce a fast-setting concrete mix using Type I and Type III cement. Additionally, the chapter outlines accelerant additives used to decrease cure time and allow air traffic operations onto the pavement in a more expedient timeframe. This research ignores typical concerns, such as long-term durability, aesthetics, and corrosive soil reactions, that are of minimal importance in an expedient field application. Horizontal surface repairs identified in this manual are not expected to last more than two to five years.

Note: Read this entire chapter before beginning the concrete mixing process.

2-2 GENERAL LIMITATIONS.

The following paragraphs contain cautionary information pertaining to mix designs for rapid-setting concrete crater capping using Type I and Type III cement.

2-2.1 Use the mix designs in this manual for temporary crater repairs only.

2-2.2 The potential for alkali-silica reaction (ASR), sulfate attack, scaling, D-cracking, or sliver spalling is significantly high with these mixes. If the aggregates in your area are ASR susceptible or you suspect that they are then do not leave the mix in place for more than 12 months. If the existing pavement in your area has or shows signs of ASR, assume the aggregates are ASR susceptible unless tested. If you typically add Class F fly ash to the concrete mix in the area, assume the aggregates are ASR susceptible. Local aggregates can be tested for ASR susceptibility using ASTM C1260, *Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)*; however, test for 28 days versus the recommended 14 and assume they are susceptible if the expansion is 0.08 percent or higher as opposed to the usual 0.1 percent limit.

2-2.3 The identified mix designs are not designed to combat freeze-thaw or ASR. In addition, air contents are not prescribed or tested.

2-2.4 Performance of these mixes depends on and is sensitive to the materials used and environmental conditions. All concrete mixes are unique and impacted by slight differences in gradation, angularity, moisture content, capacity and absorption rates of aggregates, dissolved minerals in the water, alkali content, and fineness of the cements. Therefore, it is recommended that each installation test annually and adjust mixes based on the proportioning provided in the mix designs. Gathering this information will ensure each installation understands and documents the time required before sorties can be generated. Having accurate material test data ensures the mix is easily placed into the repair and engineers are prepared and familiar with the placement and finishing properties of the mix. The mix can be adjusted to increase flow, decrease segregation, and speed consolidation, screed, and finishing requirements. Actual set times will vary based on local materials used.

2-2.5 If necessary, use plasticizer versus adding more water to the mix. Do not use standard airfield water reducers (lignosulfonates) with these mixes as they retard the set and curing time. Plasticizers are not recommended but, if necessary, only use a super plasticizer or a high range water reducer (not normally allowed on airfield paving). Test any plasticizer before using in emergency repairs. Use one-half the manufacturer's recommended dose to start.

2-2.6 The mixes are more sensitive to changes in the water/cement ratio than CTS Rapid Set or Buzzi Unicem products described in AFTTP 3-32.16, *Sustaining Airfield Pavement at Enduring Contingency Locations*. Tight control of the water/cement ratio is required.

2-3 MIX DESIGNS.

2-3.1 If a local batch plant has the ability to provide a suitable mix, evaluate the strength of the resulting concrete before accepting the mix. Determine if the concrete can achieve 2000 psi compressive strength within six hours for pass levels above 500 and 1500 psi in four hours for pass levels between 100 and 500.

2-3.1.1 If conducting repairs within the U.S., the state DOT may have an approved rapid-setting high-early-strength concrete available for bridge deck repairs.

2-3.1.2 If the temperatures are 40 °F (4.4 °C) and dropping, heat the water to

50 °F (10 °C) or higher before adding. Cover the repair with plastic or insulated tarp or straw. If available, apply heat or steam under the plastic or tarp covering.

2-3.2 As a baseline for developing mix proportions in the field, use the following criteria for Type I and Type III Portland cements:

- Minimum Type I or III cement content: 752 lbs. per cubic yard
- Accelerator: Dosage rate of 2 percent by weight of portland cement
- Water/cement ratio: 0.35 to 0.38 for Type I cement mixtures; 0.43 to 0.45 for Type III cement mixtures
- Coarse aggregates: #67 stone (¾-in. maximum aggregate size) or local equivalent meeting ASTM C33, Standard Specification for Concrete Aggregates
- Fine aggregates: Locally available natural sand meeting ASTM C33 requirements
- Target slump: 4 to 8 inches

Note: Check the slump of the material onsite before adding any accelerant to determine if additional water is required to produce a slump of 4 to 8 inches. If the slump is too low, slowly add water. After the accelerant is added, check the slump as quickly as possible to ensure the batch is within slump range and prevent the rapid-setting material from hardening in the mixer.

2-3.3 Use Tables 2-1 and 2-2 for mix designs using Type I & Type III cement.

Table 2-1 Type I Cement Mix

Material	Lbs. per Cubic Yard
Cement (Type I)	752 lbs.
Fine Aggregate	1386 to 1455 lbs.
Coarse Aggregate	1610 lbs.
Water	265 to 288 lbs.

*Water/cement ratio: 0.35 to 0.38 percent

*Accelerant and high range water reducer as needed

Table 2-2 Type III Cement Mix

Material	Lbs. per Cubic Yard
Cement	752 lbs.
Fine aggregate	1255 to 1299 lbs.
Coarse aggregate	1610 lbs.
Water	313 to 327 lbs.

*Water/cement ratio: 0.43 to 0.45 percent

* Accelerant and high range water reducer as needed

2-4 ADDING RETARDER.

2-4.1 Although this manual primarily covers fast-setting concrete required for crater repair concrete capping, there are instances when environmental conditions require extending set times, such as hot weather conditions (temperatures at or above 80 °F [26.7 °C]). Adding 0.2 percent of citric acid by weight of cement will extend set times and maintain concrete strength requirements. Dissolve the acid in water before adding.

2-5 ADDING ACCELERATORS.

2-5.1 Typically, accelerants are used for cold weather concrete operations (temperatures below 50 °F [10 °C] and dropping). However, rapid airfield damage recovery (RADR) requires the use of fast-setting concrete in a wide range of weather conditions. Temperatures above 50 °F (10 °C) drastically decrease set time when accelerants are added and can become unworkable when temperatures are 68 °F (20 °C) and warmer if not tested prior to application. Accelerating additive options identified in this manual are aluminum sulfate $(Al_2(SO_4)^3)$, calcium chloride $(CaCl_{2)}$, calcium nitrate $(Ca(NO_3)^2)$ and calcium formate (Ca$(HCOO)_2$). As a starting baseline, use a dosage rate of 2 percent by weight of cement during the test batch and make adjustments based on results. Using a higher percentage of accelerator by weight of cement significantly decreases the set time. Conduct a test mix before a large placement to ensure the teams have sufficient working time to place and finish the concrete cap.

Note: These rates are based on a CTS Rapid Set concrete mix and may need to be adjusted slightly when used with Type I or Type III cement to produce the required results.

2-5.1.1 Calcium Chloride ($CaCl_2$).

Use 2 percent calcium chloride by weight of cement. For example, an eight-bag mix (752 pounds) of cement requires 15 pounds dry weight of calcium chloride. Do not add the accelerant to the truck at the batch plant. Dissolve calcium chloride in water before adding to the concrete. Be advised, added water increases the water/cement ratio. Also, be aware that the process of dissolving calcium chloride is exothermic and can generate a significant amount of heat. Ensure workers wear manufacturer's recommended personal protective equipment (PPE) when handling calcium chloride. Add the accelerant to the concrete mixer at the crater site. After adding to the truck, mix for only three minutes. Discharge concrete from the truck immediately after mixing time is complete.

2-5.1.2 Calcium Nitrate, Calcium Nitrite, Calcium Formate.

Calcium nitrate, ($Ca(NO_3)^2$), calcium nitrite ($Ca(NO_2)^2$), and calcium formate, ($Ca(HCOO)_2$)can also be used in lieu of calcium chloride but cure times may need to be extended one to two hours. Use the same dosage rate as calcium chloride (2 percent) on the test batch then make adjustments to the accelerant.

2-5.1.3 Aluminum Sulfate ($Al_2(so_4)_3$).

Aluminum sulfate acts as a flocculent or coagulant when added to water and waste water treatment facilities. Aluminum sulfate may be readily available if a water or waste water treatment plant is located on the installation, in grounds maintenance shops, and in agricultural nurseries. Aluminum sulfate can be used in lieu of calcium chloride. The recommended dosage rates by weight of cement are 2 percent to 3 percent. For example, 1 cubic yard of Type I cement weighs 752 pounds so the amount of aluminum sulfate required to produce fast-setting concrete at 50 °F (10 °C) would range from 15 to 22.5 pounds. The recommendation is to start with the lower dose rate and tailor the additive according to required workability time.

2-5.2 Add accelerant in powder form to approximately 5 gallons of water to form a slurry before adding to the volumetric mixer water tanks or transit mixer drums. Mix for three minutes after adding the accelerant. Discharge the concrete from the transit mixer immediately after mixing is complete. The slump (workability) of the mix changes significantly with small changes in the water/cement ratio and it reduces rapidly following mixing with the accelerant (aluminum sulfate or calcium chloride).

2-5.3 When using the Type I and Type III cement-based mixes in a volumetric mixer or transporting it to the site in a transit mixer, ship the mix dry and do not rotate the transit mixer drum except to dispense into the volumetric mixer or front-end loader for placement into the volumetric mixer.

2-6 PLACEMENT.

Use the following recommendations to prepare and place the Type I or Type III cement mix.

2-6.1 Install a subbase 6 to 12 inches thick compacted in lifts using a plate compactor. For the base course, use 6 to 12 inches compacted, crushed stone. Use sand compacted in 6-inch lifts with a plate compactor if crushed stone is not available.

2-6.2 The recommended thickness of the concrete cap is 12 to 14 inches as opposed to the 10 inches recommended for CTS Rapid Set.

2-6.3 Use backpack vibrators to consolidate the concrete in the crater. Recommend at least two for small craters and for repairs larger than 10 feet wide.

2-6.4 The surface of the repairs will begin to degrade, generating some cracking and FOD after 500 passes if cured six hours or 75 passes if cured four to five hours. Inspect and sweep repair areas every 10 to 25 passes after these levels or at least three times daily, whichever is more frequent.

2-6.5 Empty and clean mixers as close to the site as possible.

2-6.6 When using a transit mixer, after the concrete is discharged, add 25 to 50 pounds of food-grade citric acid and 50 gallons of water to each mixer to reduce material buildup in the mixers (regardless of ambient temperature). Mix for a minimum of two minutes. Empty and clean each mixer drum and chute as close to the job site as possible.

2-6.7 Test the placed concrete using a Windsor Probe or Schmidt hammer. The target strength is 2000 psi compressive strength for 500 or more passes or 1500 psi for only 100 passes. If neither are available, use a loaded dump truck or equivalent to check if the repair has sufficiently cured for traffic after four hours of set time for Type III or five hours for Type I mixes. Once the truck has driven over the patch, to validate for air traffic, the criteria is that only small cracking appears along the edges or a single crack in the crater's center. If multiple cracks occur in the test patch or actual repair after cure time, wait another 30 minutes before traffic is allowed then repeat the test. If more than 500 sorties are needed, wait an additional two hours after a successful test before aircraft use.

2-7 SPALL (PARTIAL DEPTH REPAIRS).

When conducting spall repairs using Type I or Type III cement with accelerants, mix smaller portions to allow adequate placement time. Tailor the cubic yard mix design identified in Tables 2-1 and 2-2. Ensure the coarse aggregate does not exceed #67 stone (¾-inch). For proper preparation and placement of spall repairs, refer to UFC 3-270-01.

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APPENDIX A GLOSSARY

°C	Degrees Celsius
°F	Degrees Fahrenheit
AFTTP	Air Force Tactics, Techniques, and Procedures
ASR	Alkali-Silica Reaction
ERDC	Engineer Research and Development Center
FOD	Foreign Object Damage
psi	Pound per Square Inch
TSPWG	Tri-Service Pavements Working Group
UFC	Unified Facilities Criteria
UTC	Unit Type Code

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APPENDIX B REFERENCES

JOINT

Pavements Transportation Community of Practice (CoP), https://transportation.erdc.dren.mil/cacsites/TriService/qpl_rscrcm.aspx

TSPWG PM 3-270-01.21-05, *Rapid Airfield Damage Repair in Cold Weather*, https://www.wbdg.org/ffc/dod/supplemental-technical-criteria

UFC 3-270-01, *O&M Manual: Asphalt and Concrete Pavement Maintenance and Repair*, https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc

ARMY

https://www.dtic.mil/

ERDC GSL TR-12-11, *Field Prepared Rapid-Setting Concretes: Phase II, Field Testing*

ERDC GSL TR 13-32, *Cold Weather Crater Repair Testing at Malmstrom AFB, MT*.

ERDC TR-14-10, *Laboratory Evaluation of Expedient Low-Temperature Admixtures for Runway Craters in Cold Weather*

AIR FORCE

https://www.e-publishing.af.mil/

AFTTP 3-32.10, *Introduction to Rapid Airfield Damage Recovery (RADR)*

AFTTP 3-32.16, *Sustaining Airfield Pavement at Enduring Contingency Locations*

AFTTP 3-32.17, *Rapid Airfield Crater and Spall Repair*

Interim Process for Rapid Airfield Damage Recovery (RADR), 30 Nov 2018, Rev 12.0, https://usaf.dps.mil/:b:/r/teams/CEDASH/_layouts/15/WopiFrame.aspx?sourcedoc={63a1067d-6ca8-4e20-bb27-ad5df45afe3b}&action=interactivepreview

UTC 4FWAB, *Asphalt Cap Materials*

UTC 4FWCR, *Crater Repair Vehicles, Tools, and Equipment*

UTC 4FWCM, *Concrete Cap Materials*

UTC 4FWSP, *Sustainment Pavement Repair (SuPR) Kit*

UTC 4FWSR, *Spall Repair Equipment and Materials*

ASTM

https://www.astm.org/

ASTM C33, *Standard Specification for Concrete Aggregates*

ASTM C1260, *Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)*