AIR FORCE TACTICS, TECHNIQUES, AND PROCEDURES 3-32.17

10 OCTOBER 2023

RAPID AIRFIELD CRATER AND SPALL REPAIR

DEPARTMENT OF THE AIR FORCE

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BY ORDER OF THE SECRETARY OF THE AIR FORCE

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Tactical Doctrine

RAPID AIRFIELD CRATER AND SPALL REPAIR

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This publication supports Air Force Instruction (AFI) 10-209, *RED HORSE Program,* AFI 10-210, *Prime Base Engineer Emergency Force (BEEF) Program*, AFPAM 10-219, Volume 4, *Airfield Damage Repair Operations*, and Air Force Doctrine Annex 3-34, *Engineer Operations*. It addresses necessary actions required to repair damage to an airfield after an attack that will establish a Minimum Airfield Operating Surface (MAOS) and will enable execution of the Air Component Commander's Air Tasking Order (ATO). Refer recommended changes and questions about this publication to the Office of Primary Responsibility using the Department of the Air Force Form 847, *Recommendation for Change of Publication*; route DAF Forms 847 from the field through the appropriate functional chain of command and Major Command publications/forms managers. Ensure all records generated as a result of processes prescribed in this publication adhere to Air Force Instruction 33-322, *Records Management and Information Governance Program*, and are disposed in accordance with the Air Force Records Disposition Schedule, which is located in the Air Force Records Information Management System. 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 Air Force.

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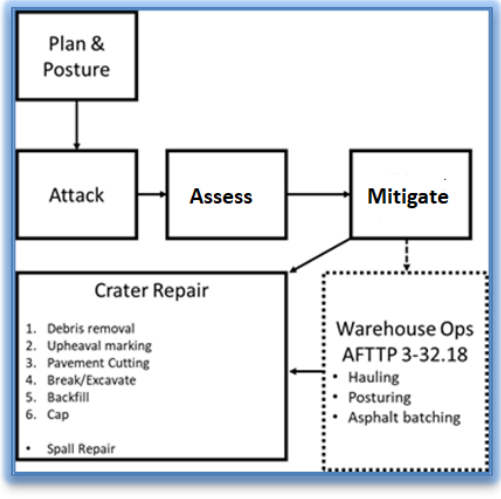
Chapter 1

INTRODUCTION

1.1. Overview. Crater repair is part of the larger process of Rapid Airfield Damage Recovery (RADR), see **Figure 1.1.** This includes planning for attack, surviving the attack, assessing the damage, mitigating hazards, warehouse operations and crater repair.

Figure 1.1. RADR Process.



1.1.1. The crater repair process is based on an assembly line concept where the assembly line moves from crater to crater. Each step in the crater repair process has a dedicated crew that performs the same repair step at each crater, one crater after another until the step has been completed on all craters in the identified repair zone. The six steps of the crater repair process are:

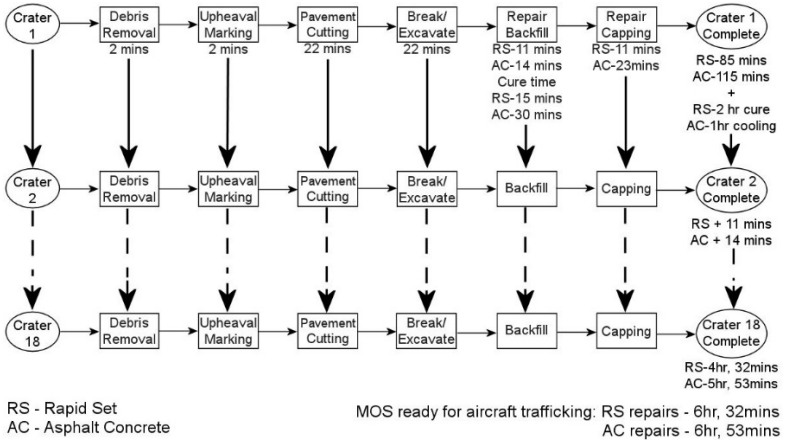
1- Debris Removal
2- Upheaval Marking

3- Pavement Cutting
4- Pavement Breaking & Excavation
5- Backfilling
6- Capping

1.1.2. The predominant expected crater size results in an 8.5-foot by 8.5-foot by 24-inch-deep repair. Repairs are based on 18-inch-thick concrete runway surfaces with no reinforcing steel, or asphalt surfaces of any thickness. Under ideal conditions, a crater repair team can complete 18 small craters or two large craters in 6.5 hours.

1.1.3. **Figure 1.2.** identifies repair processes and time to complete each process and **Table 1.1.** and **Table 1.2.** provide completion times per crater. Repair times listed include travel between repairs and setup time, but do not include airfield damage assessment, unexploded explosive ordnance (UXO) mitigation, convoy to the repair area, CBRN threat, extreme weather variances, equipment variances, team proficiencies, or personnel/equipment attrition.

Figure 1.2. Crater Repair Process.



Note: Timelines in **Table 1.1.** and **Table 1.2.** are projected under ideal repair conditions. Actual repair times may differ, depending on site condition, crater size, or equipment malfunction.

Table 1.1. Repair Times per Crater with Rapid Set Concrete Caps (minutes).

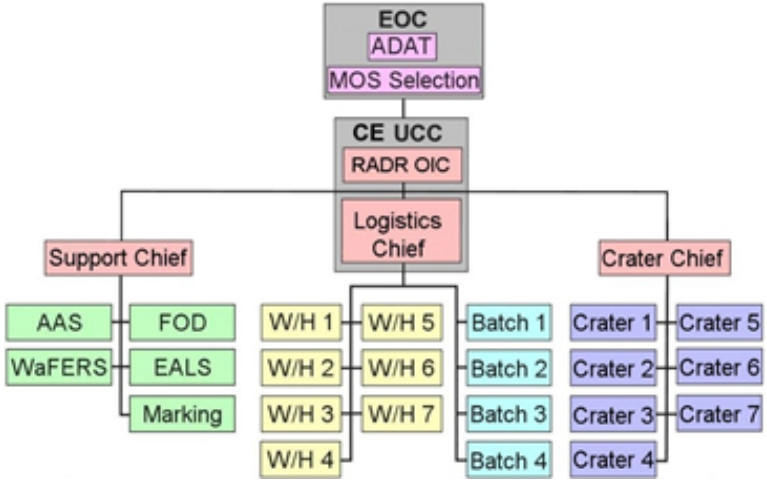
Crater	1	2	3	4	5	6	7	8	9
Completed	85	96	107	118	129	140	151	162	173
Final Cure	205	216	227	238	249	260	271	282	293
Crater	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Completed	184	195	206	217	228	239	250	261	272
Final Cure	304	315	326	337	348	359	370	381	392

Table 1.2. Repair Times per Crater with Asphalt Caps (minutes).

Crater	1	2	3	4	5	6	7	8	9
Completed	115	129	143	157	171	185	199	213	227
Cured	175	189	203	217	231	245	259	273	287
Crater	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Completed	241	255	269	283	297	311	325	339	353
Cured	301	315	329	343	357	371	385	399	413

1.2. Command and Control. Rapid Airfield Crater and Spall Repair has four levels of command: (1) Rapid Airfield Damage Recovery (RADR) Officer in Charge (OIC), (2) Crater Repair Chief, (3) Crater Repair Team Lead, and (4) Crew Leads, see **Figure 1.2.** for org chart.

Figure 1.3. RADR Command and Control Overview.



1.2.1. Rapid Airfield Damage Recovery (RADR) Officer in Charge (OIC). The RADR OIC assists the Crater Repair Chief by addressing unresolved problems. The OIC does so by requesting support from the Logistics Chief or Support Chief and their RADR teams (e.g., Warehouse Teams, Foreign Object Debris [FOD] Removal Team, and Aircraft Arresting System Team) or through the Civil Engineer (CE) Unit Control Center (UCC) Commander when support is required from sources outside of CE (e.g., vehicle maintenance, fuels). The RADR OIC works closely with Operations Management personnel (3E6X1) to track personnel, vehicles, and materials and ensure resupply actions happen in a timely manner to support future requirements.

1.2.2. Crater Repair Chief. The Crater Repair Chief actively manages multiple crater repair teams. The Chief's primary responsibility is ensuring the crater repair teams are progressing in a timely manner and addressing disruptions such as equipment breakdowns, material shortages, and personnel problems. The Chief communicates with the Logistics Chief and Support Chief when support is re-

quired from, or needed by, logistics and support teams. He or she has direct communications with the Warehouse Team Leads supporting the Crater Repair Teams. The Crater Chief contacts the RADR OIC when support may be needed from external organizations (e.g., fuels and vehicle maintenance). Also, the Crater Chief informs the RADR OIC when crews have completed their primary task and are available to assist elsewhere.

1.2.3. Crater Repair Team Leads. Team leads manage multiple crater repair crews. As with the Crater Repair Chief, team leads manage repair crews and monitor operations for impediments that may prevent crews from completing their tasks on schedule. When a crew experiences problems, the Lead assists with addressing the obstacles and reports delays to the Crater Repair Chief.

1.2.4. Crew Leads. Crew Leads manage their crew to ensure all necessary equipment, vehicles, and materials are available to complete their tasks within repair timelines. The seven crater repair crews are:

1- Debris Removal
2- Upheaval Marking
3- Pavement Cutting
4- Pavement Breaking and Excavation
5- Backfilling
6- Capping
7- Spall Repair

1.3. General Safety Considerations. In standard and nonstandard construction practices, there are multiple known risk factors in performing RADR duties. It is vital to protect workers from hazards such as high-pressure subsystems and components, harmful solvents and adhesives, and silica dust. The risks and safety factors involved with materials and operations should be identified prior and briefed to all personnel that could be involved. A key responsibility of supervisors is to ensure personnel have and wear the necessary personal protective equipment (PPE) and individual protective equipment for the working environment. Unsafe field operations while conducting RADR could cause long and short-term injuries, health issues, disable equipment, and negatively affect the mission.

1.3.1. Published Guidance. Review applicable safety standards and technical manuals for additional safety requirements before performing RADR operations. Guidance can be found in the following subparagraphs. Compliance with technical order warnings and cautions is essential.

1.3.2. DAFMAN 91-203, *Air Force Occupational Safety, Fire, and Health Standards*, lists PPE for selected CE activities. Although technical orders (T.O.) and other job-related publications address proper wear and use of PPE and individual protective equipment, workers ultimately have the responsibility to properly use, inspect, and care for protective equipment assigned.

1.3.3. Consult AFI 48-137, *Respiratory Protection Program* for training documentation procedures and inhalation guidance. Refer to 29 CFR 1910.133, *Eye and Face Protection*, and AFI 48-127, *Occupational Noise and Hearing Conservation Program*, for additional guidance and information. For end users consult 29 CFR 1910.134, *Respiratory Protection*.

1.3.4. Handlers and users of any polymeric repair material should ensure a Safety Data Sheet (SDS) from the manufacturer always accompanies the material. Before use, review and follow the SDS guidance for personal protective equipment and other safety precautions.

1.3.5. In accordance with AFMRA/SG3PB Policy Memo dated 30 Sept. 2020, "Commanders have the discretion to elect the use of the Joint Service General Purpose Mask (JSGPM) M50 series protective mask as approved by Air Force Bioenvironmental Engineer or a National Institute of Occupational Safety and Health (NIOSH) certified respirator for "Training events Only". PPE is identified in **Table 1.3.**

1.4. Personal Protective Equipment (PPE). Supervisors should coordinate with the Bioenvironmental Engineering Flight and the Wing Safety office on the PPE needed to perform RADR operations. Brief safety procedures and appropriate PPE before operations and verify that all PPE has been approved for the work to be performed. See **Table 1.3.** for a list of PPE for typical RADR operations. **Note:**

Breathing crystalline silica dust is a serious health hazard. Those performing duties where they may be exposed to silica dust should wear appropriate PPE (including respiratory and eye protection) according to Commander's guidance.

Table 1.3. Listing of Typical PPE by Operation.

Operation or Equipment	Typical PPE Required
Dump Truck	Safety-toe boots Gloves
Loader, Grader, Sweeper, Backhoe, Bulldozer, Roller, Paver	Safety-toe boots Gloves Eye protection (dust and bright sun) Hearing protection Respiratory protection (if dusty)*
Jackhammer, Pneumatic Drill	Respiratory protection* Safety-toe boots Eye protection Hearing protection Gloves
Concrete Saw	Safety-toe boots Eye protection Hearing protection Respiratory protection (if dusty)* Gloves
Concrete Mixer	Safety-toe boots Eye protection Respiratory protection* Hearing protection
Portable Power Tools	Eye protection Hearing protection Respiratory protection (if dusty)*
Paint Striping	Eye protection Respiratory protection* Gloves Coveralls
*N-95, P-95, and R-95 respirator or M50 JSGPM, as directed by Commander.	

Chapter 2

RESOURCES

2.1. Crater Repair Team Manning. No personnel UTCs are exclusively dedicated to RADR. Teams are manned from CE beddown or base operating support force Unit Type Codes (UTCs). **Table 2.1.** identifies manning requirements for the Crater Repair Team by crew (AFTTP 3-32.10, *Introduction to Rapid Airfield Damage Recovery*, provides complete airfield recovery manning requirements for various RADR capabilities).

Table 2.1. Crater Repair Team Manpower Requirements.

Crew	No.
Crater Team Lead	1
Debris Removal	2
Upheaval Marking	3
Pavement Cutting	6
Pavement Breaking & Excavation	3
Backfill	5*
Capping	8*
Spall Repair	3
Total	**29**

Note*: Two individuals from the Upheaval Marking Crew transfer to the Backfill or Capping Crew after completing marking tasks, but they are not counted twice and not dual tasked. This will typically mean that these individuals will go to whichever process requires the volumetric mixer e.g., if the operation is a rapid set concrete repair, they would be on the Capping Crew and if the operation is an asphalt repair, they would be on the Backfill Crew.

2.2. Crater and Spall Repair UTCs. Crater and spall repair UTCs equip one Crater Repair Team with tools, equipment, material, and vehicles required to complete eighteen 8.5-ft x 8.5-ft repairs or two 30-ft x 30-ft repairs, and up to 200

spalls (24 inches in diameter and 6 inches deep). These UTCs are scalable and modular to provide larger capabilities. The four crater and spall repair UTCs are:

- 4FWCR: Crater Repair Vehicles and Equipment
- 4FWCM: Concrete Cap Repair Materials
- 4FWAE: Asphalt Cap Repair Materials
- 4FWSR: Spall Repair Equipment and Materials

2.2.1. Crater Repair Vehicles and Equipment (4FWCR). This UTC provides crater repair vehicles with associated work-tool attachments, equipment, and tools as identified in **Table 2.2.** The UTC is tasked three times for a medium-, five times for a large-, and seven times for a very large-capability.

Table 2.2. Crater Repair Team Vehicles and Equipment (4FWCR).

Vehicle	Qty
Compact Track Loader	5
Hammer	2
Chisel	2
Moil	2
Broom, Hyd., Angle	3
Broom, Poly Kit	3
Saw, Wheel, 45-inch blade	4
Saw, Wheel, 60-inch blade	5
Saw Teeth Set (1K per set)	1
Compactor, Vibratory	1
Bucket-MP, 78-inch	1
Forks, 48-inch Pallet W/Carriage	2
Planer, Cold	1
Front End Loader	2
Bucket	3
Boom with Hook	3
Forks	3
Wheeled Excavator	2
Hammer, AR75B, W/Chisel PT	2

Bucket, 24-inch	2
Bucket, 48-inch	2
Telehandler Forklift, 10K, with Forks	2
Water Distributor Truck, 1.5K Gal	2
Water Distributor Tank, 2K Gal	4
Volumetric Mixer	2
Dump Truck, 10-T	1
Vibratory Roller, Dual Steel Wheel	1
Roller, Pneumatic	1
Trailer, 20T, 38-ft Flatbed (for Tool Attchs)	2
Tool Trailer	1
Light Cart	6
Water Skid, 1K Gal (For Dump Truck)	2
Inclement Weather Kit	1
See **Attachment 2** for work tool attachment pre-attack utilization and storage plan, and tool trailer inventory.	

Note: Tractor/trailer support should be requested from Logistics Readiness Squadron/Group to haul work-tool attachment trailers to the airfield.

2.2.2. Crater Repair Material (4FWCM and 4FWAE). There are two crater repair materials UTCs: 4FWCM provides repair materials for repairs with concrete caps and is managed by warehouse operations; 4FWAE provides repair materials for repairs with Asphalt Caps and materials are split to be managed by warehouse operations (flowable-fill backfill material) and the asphalt batch plant (asphalt material). **Table 2.3.** lists the repair material quantities.

Table 2.3. Crater Repair Materials (4FWCM and 4FWAE).

Material	Qty
4FWCM – Concrete Cap Materials	
Flowable-Fill Super Sacks	60
Rapid Set Concrete Super Sacks	48
4FWAE – Asphalt Cap Materials	
Flowable-Fill Super Sacks	84

Asphalt*	40 Tons
*Recommend units establish most appropriate contract vehicle for asphalt delivery.	

Note: Rapid-Set repair material provided in UTC 4FWCM is provided by a sole source vendor with proprietary rights to the design. Curing time of a locally sourced rapid-setting concrete mix most likely will not meet the required cure time. In addition, the volumetric mixer in UTC 4FWCR is designed specifically to mix rapid-set or flowable-fill materials in 4FWCM. Therefore, using locally acquired rapid-setting concrete materials in the volumetric mixer may not provide the proper water to repair material mixture.

2.2.2.1. Flowable-fill and rapid set repair materials contain concentrated amounts of crystalline silica. Over exposure to crystalline silica may cause chronic silicosis, a serious and incurable respiratory disease. The following is a rule-of-thumb regarding silica: if dust containing silica is visible in the air, it is almost always over the permissible limit.

2.2.2.2. In accordance with the Occupational Safety and Health Administration Standard 29 CFR 1910.134, individuals in RADR positions (e.g., excavation spotters, volumetric mixer loading helpers, helpers slashing flowable-fill sacks, Spall Repair Crew) exposed to respirable crystalline silica (i.e., airborne dust from the repair material) must wear a suitable National Institute of Occupation Safety and Health (NIOSH)-certified respirator. Operators of vehicles with air conditioning do not require respirators if the air conditioning is on and windows are shut.

2.2.2.3. NIOSH recommends using N95, R95, or P95 respirators to minimize inhalation of silica dust. Find NIOSH-certified N95 filtering face-piece respirators (GM 8210) in Drawer #1 of the RADR Tool Trailer. In addition, suitable dust goggles must be worn.

2.2.3. Spall Repair Equipment and Materials (4FWSR). This UTC provides equipment and materials necessary to repair up to 200 spalls. **Attachment 2** lists the UTC's equipment and materials.

Chapter 3

POST ATTACK ACTIONS

3.1. Actions. Once released under ALARM BLACK or YELLOW and directed by the CE UCC, depending on installation plans, perform the following actions to prepare for airfield recovery processes. **Note:** Long-lead, pre-threat, and pre-attack actions are listed in AFTTP 3-32.10, *Introduction to Rapid Airfield Damage Recovery*.

3.1.1. The Emergency Operations Center (EOC) distributes the selected Minimum Airfield Operating Surface (MAOS) coordinates to the Rapid Airfield Damage Recovery Officer in Charge (RADR OIC) in the Civil Engineer-Unit Control Center (CE-UCC). The OIC, with assistance from the Crater Repair Chief, verifies convoy routes and assigns repair zones to crater repair teams.

3.1.2. The RADR OIC and Crater Repair Chief receive Geospatial Expeditionary Planning Tool (GeoExPT) reports identifying repair zones and damage to repair within the repair zones. They then determine type of repairs that will be performed in each repair zone and order of repairs. **Note:** A repair zone is a grouping of damage assigned to a single repair team, performing a single repair method (e.g., for a medium capability, two teams may be assigned concrete caps and the third assigned as asphalt caps). Craters are typically within 100 feet of each other, with 18 small or 2 large craters per repair zone. Craters greater than 100 feet apart begin to introduce travel time inefficiencies.

3.1.3. Upon direction from the UCC/RADR OIC, teams receive the RADR briefing from the OIC. The briefing can be provided to the Team Leads only or, if practical, to the entire RADR work force. The briefing provides MAOS information such as minimum operating strip (MOS) coordinates, taxiways to repair, ramp areas to repair, repair zone coordinates, and the type of repairs to be performed, see **Attachment 3** for recommended briefing template. GeoExPT reports by repair zone are passed to each Crater Repair Team Lead. **Note:** While not in the briefing template, remind personnel that several repair materials (flowable fill,

rapid set cement concrete, citric acid, spall repair material, etc.) are involved in the crater and spall repair processes that may cause potential negative health effects. Stress the use of proper personal protective equipment and administering first aid measures, as described in the respective Material Safety Data Sheets, should any chemicals get in eyes, on skin, ingested, or inhaled.

3.1.4. Either after the RADR briefing or during the briefing if only team leads are briefed, teams prepare vehicles for the convoy by splitting the Foreign Object Debris (FOD) Removal vehicles at the front of the convoy to escort teams to their repair zones (FOD removal procedures can be found in **Chapter 9**). Crater Repair Team debris removal vehicles may assist the FOD Removal Team with clearing routes to the airfield. Position the remaining vehicles in order of crater repair tasks (e.g., debris removal, upheaval marking, pavement cutting, pavement breaking and excavation, backfill, and capping). The remaining Support Teams (e.g., Airfield Lighting, Airfield Marking and Striping, Aircraft Arresting Systems) are typically postured behind the Crater Repair Crews. Warehouse and Asphalt Batch Plant vehicles proceed to their designated operating locations. Once the convoy has been postured, teams await the order to mobilize to the airfield.

3.1.5. Material Shortage assessment. Warehouse Leads determine if on-hand repair material quantities are sufficient to complete required repairs and report findings to the Logistics Chief.

3.1.5.1. The initial material requirements are generated from damage inputs processed through GeoExPT. The Upheaval Marking Crew reports dimensions of surveyed repair patches to the supporting Logistics Chief (located in the CE UCC) for comparison to initial GeoExPT estimates to verify sufficient stocks of repair material are available. After excavation, the spotter reports actual repair volume (width x length x depth) to the supporting Logistic Chief to determine if sufficient repair material is on hand; material procurement, production, substitution, and delivery must be adjusted accordingly when different than the initial GeoExPT estimates.

3.1.5.1.1. When it is known repair material will run short, there are repair deviations to help overcome shortages; however, these deviations come at a cost.

3.1.5.1.2. Deviating from procedures described in the following chapters results in repairs failing with fewer aircraft passes. This requires the runway to be closed more often to repair the repairs, which may impact the air tasking order (ATO).

3.1.5.1.3. Any repair deviations should be approved through the CE-UCC and reserved, to the greatest extent possible, for repairs furthest from the MOS centerline, at the end of a unidirectional MOS, and in the middle of a bi-directional MOS.

3.1.5.1.4. All repairs within aircraft landing gear paths should be accomplished IAW prescribed procedures in **Chapters 4** and **5**.

3.1.5.1.5. Besides reducing the repair dimensions to the greatest extent possible while still ensuring all upheaval is removed, the following repair deviations may help overcome repair material shortages.

3.1.5.2. Flowable Fill Backfill Material Shortages. The following repair deviations may help extend flowable fill repair material. Recommend they be performed in the order as listed if materials are available.

3.1.5.2.1. Backfilling under a concrete cap:

- Reduce repair excavation depth from 24 inches to 20 inches and backfill with 10 inches of flowable-fill.
- Partially backfill with two compacted 3-inch lifts (6-inch for large crater) of crushed stone in the bottom of the repair and finish backfill with 8 inches of flowable-fill.
- Completely replace flowable-fill backfill with crushed stone.

3.1.5.2.2. Backfilling under an asphalt cap:

- Reduce repair excavation depth from 24 inches to 18 inches and backfill with 8 inches of flowable-fill.

- Partially backfill with two compacted 3-inch lifts (6-inch for large craters) of crushed stone in the bottom part of the repair and finish backfill with 8 inches of flowable-fill.
- Replace flowable-fill backfill with crushed stone.

3.1.5.3. Rapid Set Capping Material Shortages. The following repair deviations may help extend rapid set repair material. Recommend they be performed in the order as listed if materials are available.

- Increase backfill thickness from 14 inches to 18 inches and cap the repair with 6 inches of rapid-set.
- Use wet placed flowable-fill backfill method and cap repair with asphalt.
- Fill entire repair with flowable-fill.

3.1.5.4. Asphalt Capping Material Shortages. The following repair deviations may help extend asphalt repair material. Recommend they be performed in the order as listed if materials are available.

- Reclaim asphalt from suitable asphalt pavements on the installation such as parking lots, runway/taxiway shoulders, roads, etc.
- Use dry placement flowable-fill backfill method and cap repair with rapid-set concrete as described in **Chapter 4**.

3.1.6. Once sufficient numbers of explosive hazards have been mitigated and portions of the repair zones opened for repair, the RADR teams are directed to proceed to the airfield. The FOD Removal Team leads the convoy followed by the Upheaval Marking Crew assigned to the first repair zone encountered**.**

3.2. Mobilizing Repair Force. The EOC informs the UCC of selected MAOS details and directs commencement of RADR operations. The UCC, in turn, directs the RADR teams. Since the RADR OIC is normally in the UCC during the MAOS selection phase and can observe damage plotting, he/she should be fully aware of the overall RADR recovery picture. With this knowledge, the RADR OIC and RADR Chiefs determine the best repair methods based on time, available resources, and damage locations. Then, the volumetric mixer hoppers are loaded

with the appropriate repair materials. After routes are cleared of debris and UXO, vehicles are moved from dispersal sites to a staging area in preparation for convoying to the repair sites. The Crater Chief then takes on-scene control of the RADR operation by briefing designated travel routes of vehicles, equipment, and personnel from dispersal sites; assigning tasks to the various Crater Repair Teams; and coordinating the efforts of the support teams (see **Attachment 4** for recommended convoy brief). A last check of equipment is made, and the UCC is notified that the RADR teams are ready to proceed. If the team can follow the same routes to the MOS as the ADATs used previously, most apparent UXO hazards on such routes will have already been identified and the potential for incurring unidentified blockages of preplanned routes due to damage and/or UXO should be noticeably reduced.

Chapter 4

SMALL CRATER REPAIR PROCESS

4.1. General Information. The small repair process is performed on repairs with dimensions 11 feet or less. **Note:** See **Chapter 5** for large crater repair procedures (repairs with at least one dimension greater than 11 feet). Task completion times are based on 8.5-foot square repairs 24 inches deep. The 8.5-foot square repair is a baseline and actual repair times will be +/- depending on crater size and depth. Performance data is being collected that will assist in more accurately determine expected repair times and will be published at a later date.

4.2. Arrival at the Repair Zone. The assigned Crater Repair Team stops short of the first repair zone while the remainder of the convoy continues to subsequent repair zones.

4.2.1. The Upheaval Marking Crew places a traffic cone on each corner of the repair zone's leading edge. The Excavation, Backfill, and Capping Crews dismount and conduct a post-attack reconnaissance sweep starting at the leading edge of the repair zone and proceed to the trailing edge where a traffic cone is placed on each corner of the repair zone's trailing edge. Team members report remaining hazards (e.g., UXO, damaged utility lines, electrical circuits) to the Crater Repair Team Lead.

4.2.2. If UXO mitigation is not complete within the repair zone, the post-attack reconnaissance sweep members stop short of the UXO Mitigation Team to ensure at least 250 feet of stand-off distance and place traffic cones at that location. If UXO mitigation is complete when the Debris Removal Crew has cleared debris from all craters between the leading and trailing set of cones, they dismount and complete the PAR sweep to the repair zone's trailing edge and place trailing cones on the corners of the repair zone's trailing edge. However, if UXO mitigation is still not complete within the repair zone, stop short of the UXO Mitigation Team to ensure at least 250 feet of stand-off distance and place traffic cones at that location. Team members report any hazards to the Crater Repair Team Lead.

4.3. Debris Removal. The two crew members clear debris from the repair zone. Debris removal begins immediately after the PAR sweep has proceeded at least 250 feet beyond the first crater to be repaired. The goal is to remove debris around each crater within 1.5 minutes. Resources required for debris removal are listed in **Table 4.1.**

Table 4.1. Debris Removal Resources.

Position	Suitable AFSCs	Veh/Equip/Tools
Operator	3E2X1, 3E3X1, 3E4X1	*Compact Track Loader (CTL) w/bucket
Operator	3E0X1, 3E0X2, 3E1X1, 3E2X1, 3E3X1, 3E4X3, 3E5X1, 3E6X1	Loader w/multi-purpose bucket
*The CTL is the primary backup vehicle to support pavement cutting and can also be tasked to support spall repair with a cold planer attachment. **Note:** One Operators (usually 3E5) is identified as the Crew Lead		

4.3.1. Step 1. The crew works together to clear debris at least 15 feet from around each crater the first time through the repair zone.

4.3.2. Step 2. Return to the first crater in the repair zone to push the previously cleared debris to at least 30-feet from the edge of the minimum operating strip (MOS) closest to the damage. Pile heights should not exceed 36 inches.

4.3.3. Step 3. When the Excavation Crew begins on the first crater, debris removal operators begin pushing debris excavated from the crater to at least 30-feet from the edge of the MOS. The debris removal operators follow the Excavation Crew to each crater to remove excavated debris throughout the repair zone.

4.3.4. Step 4. After excavated debris has been removed, operators continue to clear debris throughout the repair zone.

4.3.5. Step 5. After the Capping Crew has capped the repair and achieved initial set, the Compact Track Loader (CTL) operator thoroughly cleans around the

edges of each repair (CTL with buckets and/or brooms). Pay attention to slurry buildup at edges of the repair. **Note:** If pavement breaking advances two or more craters beyond the excavation process, either the loader or CTL (depending on the crater size) begins removing broken pavement from the craters already hammered ahead of the excavator to accelerate the excavation process. **Note:** If performing a crushed stone repair, the foreign object debris (FOD) cover construction/unfolding area and temporary stockpile areas must also be cleared after debris has been cleared from around each crater. The FOD cover area should be approximately 100 feet and the fill material stockpile a minimum of 30 feet from the crater.

4.3.6. Step 6: Once all excavated debris has been removed, the Crater Repair Team Lead informs the Crater Chief that Debris Removal Crew has finished their primary task. If not needed elsewhere, the loader operator begins loading any available warehouse dump trucks with debris to be removed from the airfield and the CTL supports other crater repair activities as needed (e.g., cleaning spilled backfill and capping materials). If necessary, the work tool attachment may be changed to support other activities.

4.4. Upheaval Determination and Marking. Upheaved pavement (**Figure 4.1.**) is not always easily visible; therefore, upheaval determination is accomplished through crater profile measurements (CPM) to ensure all damaged pavement is identified and removed. Unremoved upheaval will most likely fail under traffic and create FOD hazards. Conversely, removing more pavement than necessary increases repair times and uses more repair material than necessary, possibly depleting repair material before all repairs are complete. Resources for upheaval determination are listed in **Table 4.2**.

Figure 4.1. Cross Section of Crater Illustrating Upheaved Pavement.

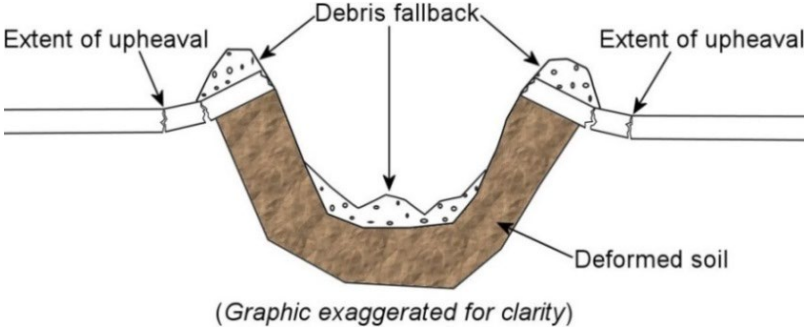


Table 4.2. Upheaval Marking Resources.

Position	Suitable AFSCs	Veh/Equip/Tools
Crew Lead	3E5X1[1]	Pickup/T-stanchion
Helper	Any[2]	T-stanchion, broom
Helper	Any[2]	Sight rod, marking material
Note 1: Supports MAOS Marking Team after upheaval marking is complete. **Note 2:** Supports capping crew (water truck operator & helper) after upheaval marking is complete.		

Note: It is imperative repair teams know the airfield's pavement construction prior to an attack. This knowledge of the construction is used to make upheaval adjustment in order to avoid the load transfer dowel bars when possible. Adjustments resulting in larger repairs require more repair materials; however, avoiding dowel bars results in faster repairs. The Crater Repair Team Lead determines whether to increase repair sizes to avoid dowels and when craters in proximity will be combined into a single repair.

Note: The Logistics Chief continually compares quantities of on-hand repair material to actual repair dimensions to project repair material shortages. As actual repair dimensions are determined by the Warehouse Leads and reported to the Crater Repair Team, the Crater Repair Team Leads may reduce repair dimensions where possible to avoid material shortages. The Logistics Chief may direct material from a warehouse(s) with excess material to a warehouse(s) experiencing shortages. If material shortages cannot be avoided, employ methods to extend or use substitute material such as crushed stone as described in the backfill process (**paragraph 4.7.**). Equipment operators and Crater Profile Measurement Crew members work in close proximity. They must exercise extreme caution during upheaval measurement or serious injury or death to personnel could result.

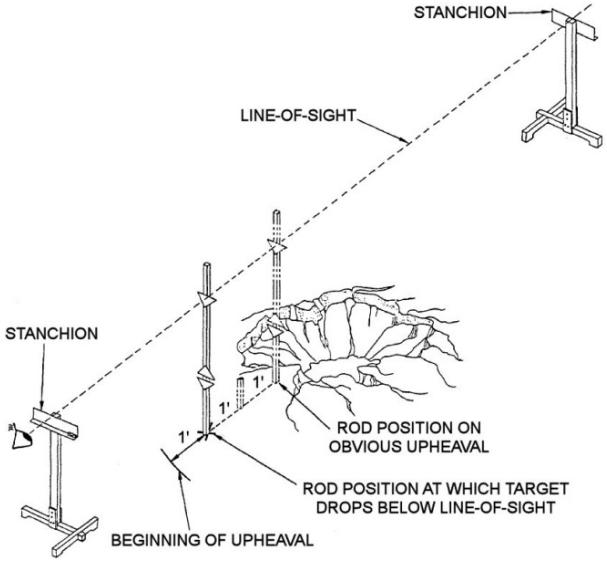
4.4.1. Use the following procedures when apparent crater size is less than 20 feet in diameter. Work from the crater centerline (oriented parallel to aircraft traffic) outward in one direction and then in the opposite direction.

4.4.1.1. Step 1. Place profile measurement stanchions at least six paces from the crater lip on opposite sides of crater. Ensure the stanchions are placed on sound pavement (no upheaval), aligned along approximate crater centerline and parallel to aircraft traffic (**Figure 4.2.**). Remove debris from under stanchion feet and level aluminum sighting planes on top of each stanchion by centering bubble in level.

4.4.1.2. Step 2. Place rod between stanchions with single target up. The Engineering technician stands approximately 2 paces behind stanchion and sights rod's single target along upper edge of both stanchion sighting planes.

4.4.1.3. Step 3. While keeping plumb, move sight rod every foot to measure upheaval along the line-of-sight between stanchions (**Figure 4.2.**). Start measurements on obvious upheaval, moving away from the crater and toward stanchion.

Figure 4.2. Performing Crater Profile Measurements.



Note: In high winds, stanchions may overturn. Place heavy objects (e.g., sand-bags) on stanchion feet.

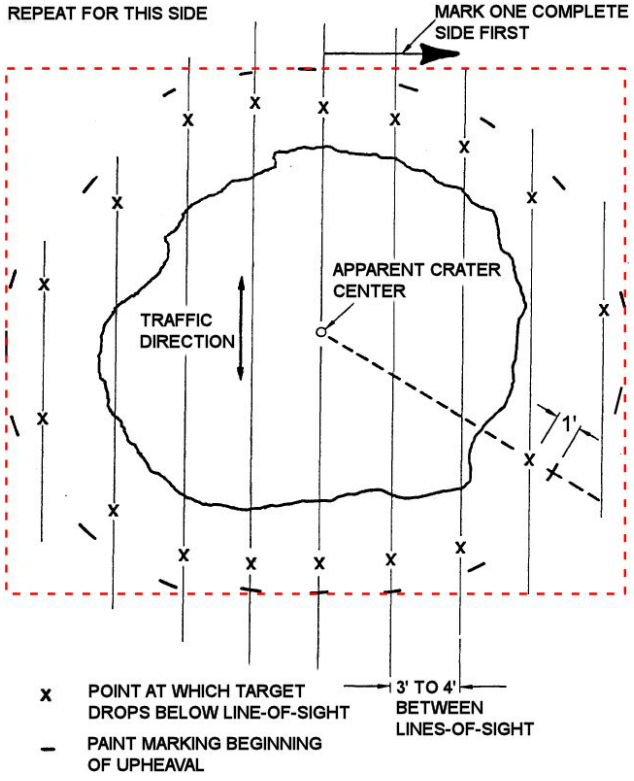
4.4.1.4. Step 4. When reaching the upheaval starting point (i.e., when the single triangular target drops below the line-of-sight across the top of the two stanchion rectangular sighting planes), clean the pavement and mark a spot 1 foot farther out from the rod with a lumber crayon from the tool trailer (**Figure 4.3.**).

4.4.1.5. Step 5. Repeat Steps 2 through 4 along same line-of-sight on opposite side of crater.

4.4.1.6. Step 6. Position both stanchions approximately 3 to 4 feet left or right of original line-of-sight and repeat Steps 2 through 5 (**Figure 4.3.**). Continue this procedure until far edge of crater upheaval on side selected has been reached.

4.4.1.7. Step 7. Repeat step 6 on opposite half of crater until all upheaval has been identified.

Figure 4.3. Marking Upheaval.



Note: If the triangle is more than two inches below the line-of-sight across the top of the two stanchions, there is a sunken slab, and the measurement continues until the triangle rises (this observation is indicative of a sloughing base material or could be caused by a camouflet).

4.4.1.8. Step 8. Using push broom, sweep area clean between upheaval marks. Rather than marking the upheaval in the shape of the crater, square pavement cut lines by using outermost extents of the upheaval markings as shown in **Figure 4.3.** Markings are placed parallel to the adjacent concrete slab joint (**Figure 4.4.**) or parallel and perpendicular to the path of traffic in asphalt (**Figure 4.5.**). Marking only the corners of the repair, in both directions, may be sufficient when using the pavement cutting alignment aids discussed in **paragraphs 4.6.3.1**. and **4.6.3.2.**

Figure 4.4. Pavement Cut Line Orientation on Concrete.

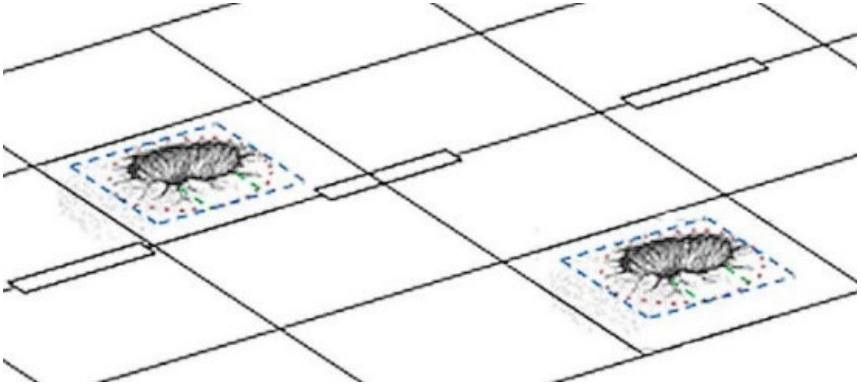
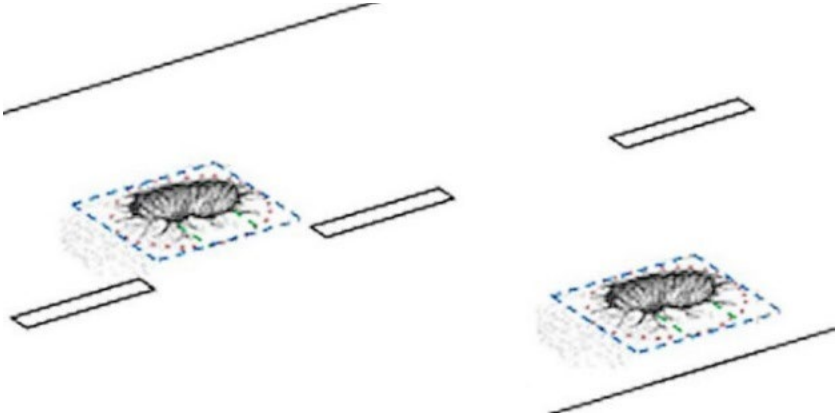


Figure 4.5. Pavement Cut Line Orientation on Asphalt.



4.4.1.9. Step 9. Use paint/crayon to identify each crater with a number starting with 1 and continuing in sequence up to 18 as each crater's cut lines are marked.

4.4.1.10. Step 10. Repeat steps 1-9 for each crater in repair zone.

4.4.2. The relative repair location drives five marking variations: 1 – crater centered on slab (**Figure 4.6.**), 2 – crater centered between two slabs on a joint (**Figure 4.7.**), 3 – slab close to a joint (**Figure 4.8.**), 4 – slabs with load transfer devices (**Figure 4.9., Figure 4.10.,** and **Figure 4.11.**), and 5 – craters in close proximity (**Figure 4.12.**).

Figure 4.6. Crater Centered on Slab.

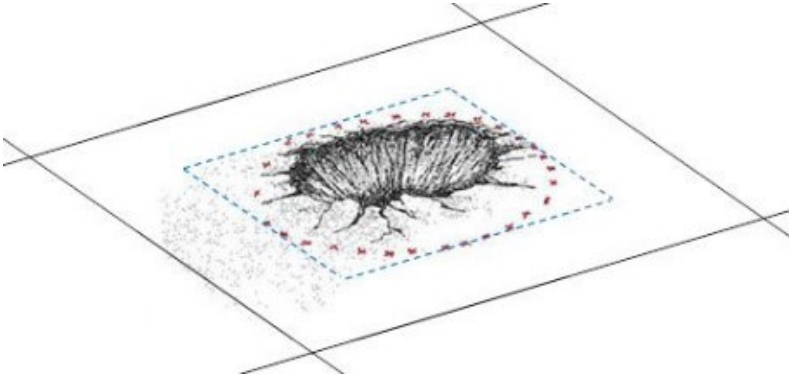
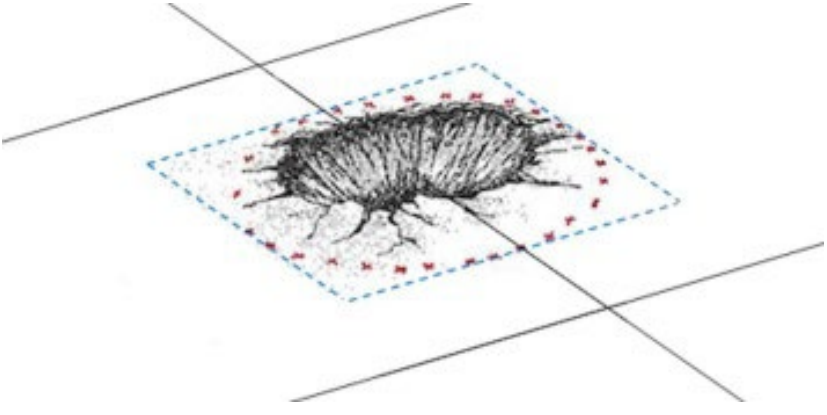
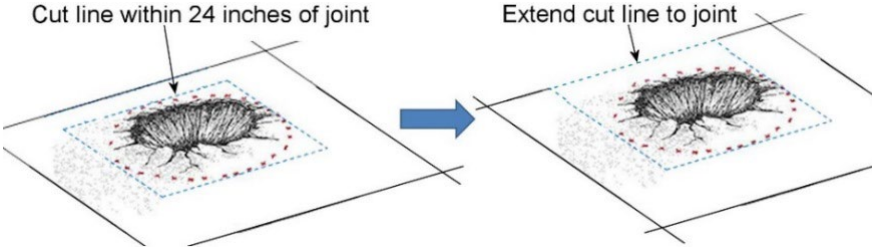


Figure 4.7. Crater Centered Between Two Slabs on a Joint.



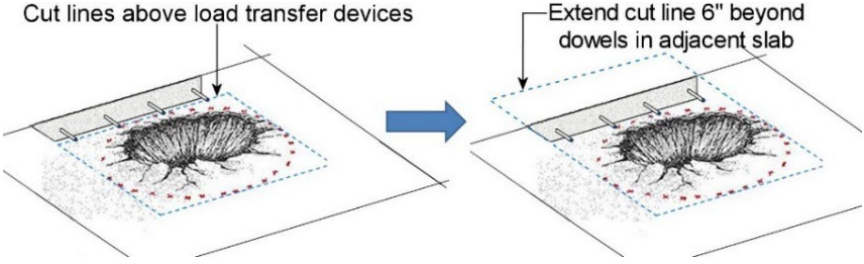
Note: Re-established joint after return of normal operations IAW UFC 3-250-08FA, *Standard Practice for Sealing Joints and Cracks in Rigid and Flexible Pavements*.

Figure 4.8. Cut Lines <24 Inches of a Joint (No Material Shortage or Dowels).



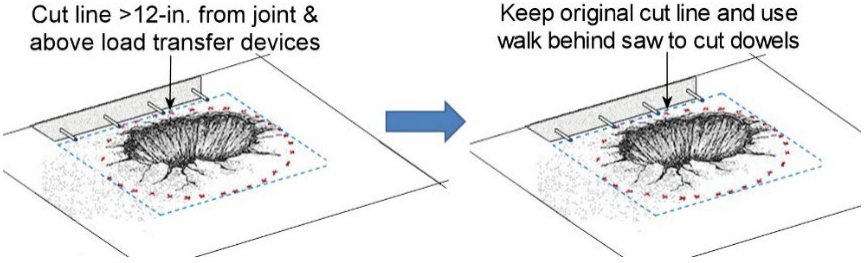
Note: When repair material is not limited, extend cut lines to joint when no load transfer devices are present.

Figure 4.9. Cut Lines Above Load Transfer Devices (No Material Shortage).



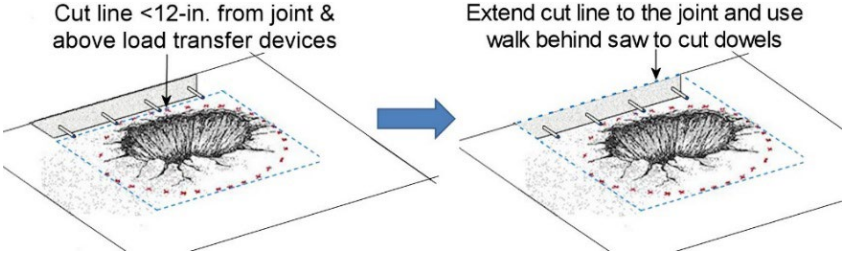
Note: When repair material quantity is not limited (or when a walk-behind saw is not available) move cut lines 6 inches beyond dowels in the adjacent slab to expedite the process. Use CTL with wheel saws to perform cuts.

Figure 4.10. Cut Line >12 Inches from Joint (Material Shortage).



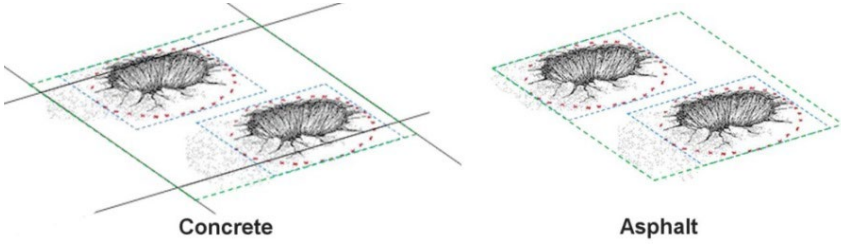
Note: When cut lines are greater than 12 inches from the joint and repair material quantity is limited, use a walk-behind saw to cut the line across dowels and use the CTL and wheel saws to perform remaining cuts. Place cones at craters containing dowels to notify the walk-behind saw operators that dowels are present.

Figure 4.11. Cut Line <12 Inches from Joint (Material Shortage).



Note: If cut line is less than 12 inches from the joint, move cut line to the joint and use the walk-behind saw to cut across the dowels; use the CTL and wheel saws to perform remaining cuts. After marking cut lines measure length and width of cut lines and report results to the supporting Warehouse Lead. Place cones at craters containing dowels to notify the walk-behind saw operators that dowels are present. The joints are reestablished during the capping process.

Figure 4.12. Multiple Craters in Close Proximity.



Note: If distance between craters in close proximity prevents cutting with CTL and saw attachment, use walk-behind saw to cut two closest parallel sides of craters. When walk-behind saw cannot safely fit between two craters, create a single large repair.

4.4.3. Once all upheaval has been determined and marked within the repair zone, the Crater Repair Team Lead informs the Crater Chief that Upheaval Marking Crew has finished their primary task.

4.5. Pavement Cutting. Pavement cutting is the most critical step in the repair process regarding time. Proper pavement cutting creates efficiencies in the excavation and capping processes. Removing more pavement than necessary may increase time to complete the repair and may enlarge repairs to the extent to exhaust repair materials. **Table 4.3.** lists pavement-cutting resources.

Table 4.3. Pavement Cutting Resources.

Position	Suitable AFSCs	Veh/Equip/Tools
Operator	3E2X1, 3E4X1	CTL w/wheel saw
Operator	3E2X1, 3E4X1	CTL w/wheel saw
Operator	3E2X1, 3E4X1	CTL w/wheel saw
Operator	3E2X1, 3E4X1	CTL w/wheel saw
Spotter	Any	Shovel, pavement cutting alignment aid, and dust mask

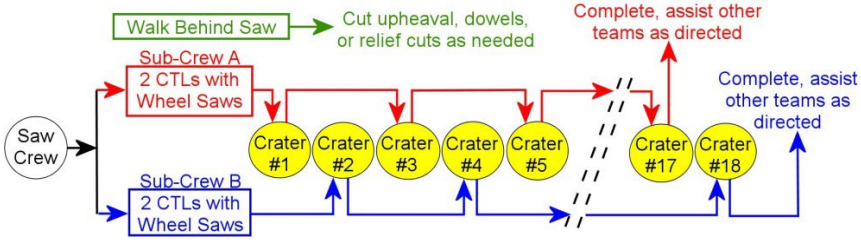
Spotter	Any	Shovel, pavement cutting alignment aid, and dust mask
		*Walk-behind saw w/water source
*Spall Crew member is tasked to operate walk-behind saw if needed. Warehouse Team dump truck with water trailer supports walk-behind saw.		

4.5.1. Saw Attachment Descriptions. The CTL saw attachments come in 45-inch (SW345) and 60-inch (SW360) diameter blades. The 45-inch blade has a maximum cutting depth of 17 inches and the 60-inch blade cuts to a depth of 23 inches; the kerf of each blade is 3 inches wide. If pavement thickness is 17 inches or less, it is recommended to use the 45-inch blade for ease of operation. The wheel saw blade may be shifted side-to-side for alignment purposes. If the blade is shifted to either side to the extent that debris from the sawing process is in line with the CTL tracks, the spotter must remove the debris with a shovel before the CTL tracks reach the debris.

Note: If CTL is not fully enclosed and air-conditioned, the CLT operator is exposed to silica dust and must wear a respirator found in drawer #1 in the RADR Tool Trailer.

4.5.3. Process. The cutting speed of the wheel saw attachment in 18-inch-thick Portland Cement Concrete is approximately one foot per minute (time may be affected by concrete strength, aggregate hardness, or pavement thickness). Accordingly, the goal is to complete the pavement cutting process on an 8.5-ft x 8.5-ft crater within 22 minutes in ideal conditions. The six-member crew is evenly divided into two sub crews (A and B) composed of two CTL operators and one spotter. The two sub crews work on separate craters simultaneously, finishing two repairs within 22 minutes, resulting in an overall average pavement cutting time of 11 minutes per repair (**Figure 4.13.**). The pavement cutting sub-crews start with CTLs facing each other on parallel sides of a marked repair. The pavement cutting steps are as follows:

Figure 4.13. Pavement Cutting Process.



4.5.3.1. Step 1: The spotter positions the ground-target stand 16 inches beyond the end of the cut line when using the 45-inch blade, or 14 inches for the 60-inch blade, with flat end of the base towards the cut (**Figure 4.14.**). These measurements result in an approximate 4-inch overcut when the front of the saw shroud contacts the ground-target.

Figure 4.14. Pavement Cutting Alignment Aids.

Note: The alignment guides attached to the top of the saw attachment are mounted using magnetic bases and may move during sawing operations. Periodically, ensure the alignment aids have not moved, and if so, realign them to ensure a straight line is cut. If alignment aids continually move and become unaligned, use alternate methods to securely attach them to the saw attachments.

Note: It is imperative overcuts be kept to approximately four inches, anything less potentially adds time to break pavement from the repair corners. Conversely, overcuts longer than four inches add precious time to the cutting process, consume large quantities of rapid-set material to repair the overcuts, have the potential to cause FOD after repairing the overcut, and reduce the number of repairs that can be sawed before the conical cutting bits require replacement.

4.5.3.2. Step 2: The CTL operator aligns the alignment guides, connected to the top of the saw attachment, with the ground-target stand (**Figure 4.14.**) and lowers the cutting blade so it is level and approximately one inch above the pavement.

Note: The pavement cutting spotter is exposed to silica dust and must wear a respirator, found in drawer #1 in the RADR Tool Trailer, and suitable dust goggles.

4.5.3.3. Step 3: The spotter guides the CTL operator to position the cutting wheel above the cut line to where an overcut of approximately four inches will occur. This best-practice is accomplished for the 45-inch wheel saw by aligning a mark placed 12 inches (14 inches for the 60-inch wheel saw) from the rear plate of the shroud with the start of the pavement cut line. The blade will travel slightly rearward when lowering and should provide the four to five inch overcut at the start of each cut line.

4.5.3.4. Step 4: Set the cutting depth at the minimum position (the blade between 6 and 8 inches below the skids). Lower the saw close to the ground so the full skid length is parallel to the ground surface. Do not try to lower the skids to the ground at this stage.

4.5.3.5. Step 5: At low idle, activate the control for the drum rotation and continuous flow. Gradually increase the engine speed to high idle.

4.5.3.6. Step 6: Slowly adjust the depth setting of the wheel saw to full depth. When full cutting depth is reached, move forward at a SLOW speed. Increase the forward speed until an optimum working speed is reached. The wheel may stall if traveling too fast.

Note: Keep the shroud in contact with the pavement while cutting. Failure to do so could cause debris (e.g., chunks of concrete) to be discharged from underneath the shroud causing injury to personnel. In addition, if the shroud is kept raised above the surface, any object unintentionally entering the shroud (e.g., shovel) may be launched by the rotating saw blade, which may cause injury to personnel.

4.5.3.7. Step 7: The operators cut in opposite directions on parallel cut lines (**Figure 4.15.**). On smaller craters the operator may need to side shift the cutting wheel towards the repair to create the necessary clearance for two CTLs to cut simultaneously. Spotters remove cutting debris that piles in front of the shrouds and CTL tracks.

Figure 4.15. Cutting Parallel Lines Simultaneously.

Note: The spotter must remove debris from the CTL's shroud and track path. If the shroud and/or tracks of the CTL travel over debris the blade will rise and decrease the cutting depth and may cause a curved cut, which may cause the blade to bind.

4.5.3.8. Step 8: The CTL operators stop the cutting process when the saw shroud contacts the alignment aids, which results in an overcut of approximately 4 inches.

4.5.3.9. Step 9: The CTL operators then reposition on the two remaining cut lines and make cuts in the same manner as described above.

4.5.3.10. Step 10: Upon completion of the final cuts, the CTL operators move (leapfrog) past the other pavement cutting crew to the next crater and wait to be lined up by the spotter as described above.

4.5.3.11. Step 11: After cuts are complete, the spotter measures the length and width of the repair and reports the measurements to the Crater Repair Team Lead who then reports the measurements to the Warehouse Lead (see AFTTP 3-32.18, *Rapid Airfield Damage Repair-Warehouse Operations* for information on RADR Warehouse Teams).

4.5.3.12. Step 12: This process continues until all craters (up to 18 feet) have been cut in the team's repair zone.

4.5.3.13. Step 13: The Crater Repair Team Lead informs the Crater Chief when the Pavement Cutting Crew has finished its primary tasks so its members may be loaned to other crews/teams as necessary.

4.5.3.14. If an edge is damaged during the cutting process, cut out additional damage when greater than 24-inches or more than half the length of the slab. Otherwise, complete the repair and treat the additional damage as a spall.

4.5.3.15. When available, the Spall Repair Team should repair any overcuts. The capping material is removed from the overcut(s) and then repaired in the same manner as spalls described in **Chapter 7**.

4.5.3.16. Spotters inspect the saw bits and saw wearing shoes after each side of a repair is cut to determine if the bits and/or shoes need replacing. If the CTL operators experience a decrease in cutting times, or if the blade begins to spark excessively during the cutting process, the most likely cause is worn saw bits. At this

point the spotter inspects the bits and, if necessary, directs the CTL operator to exchange the saw attachment with a spare from the attachment trailer. If saw attachment replacement bits are needed, designated individuals should replace saw blade bits. Wing mobile vehicle maintenance personnel may assist as available.

4.5.3.17. When cut lines fall within areas containing load transfer devices (i.e., dowels), use the walk-behind saw (**Figure 4.16.**) to cut the dowels. Task one member of the Spall Repair Crew to operate saw and, through the Crater Chief to the Logistics Chief, request one Warehouse dump truck operator to tow a water source for the saw. Walk-behind saw cutting speed will be significantly reduced when cutting through high strength concrete and alignment dowels.

Note: Longitudinal joints on Runways and taxi ways usually contain dowels. The last three transverse joints on taxiways and aprons usually contain dowels.

Figure 4.16. Walk-behind Saw.

4.6. Pavement Breaking and Excavation. This crew is responsible for breaking the damaged pavement within the cut lines and removing the disturbed subsurface material.

4.6.1. Resources. **Table 4.4.** identifies resources required for the pavement breaking and excavation process.

Table 4.4. Pavement Breaking and Excavation Resources.

Position	Suitable AFSCs	Veh/Equip/Tools
Operator	3E2X1	Wheeled excavator with hammer attachment
Operator	3E2X1	Wheeled excavator with bucket
Spotter	Any	Shovel, tape measure, and marking paint
Note: Pavement breaking with hammer attachments may not be necessary in asphaltic materials. After pavement cutting, an excavator with bucket or loader may be sufficient to excavate repair without breaking operations.		

4.6.2. Pavement Breaking. Pavement breaking (**Figure 4.17.**) can begin as soon as pavement cutting is complete on the first repair. The goal is to complete pavement breaking within 10 minutes per crater. **Note:** If the repair will have an asphalt cap, the Crater Repair Team Lead informs the Warehouse 1 Lead that pavement breaking is about to commence. The Warehouse 1 Lead directs the supporting batch plant to begin batching operations to ensure asphalt is ready and available on the airfield when needed.

Figure 4.17. Excavator Performing Pavement Breaking.

4.6.2.1. Step 1: Break pavement into pieces suitable for buckets on excavating equipment. **Note:** Depending on the length of the saw overcuts, the slab may not be free floating, and special attention should be paid to breaking the corners.

4.6.2.2. Step 2: When pavement has been suitably broken, the operator moves to the next available crater location to begin pavement breaking. Before moving to the next crater, use the breaker to remove at least two large pieces of debris out of the crater to ensure the excavator bucket can reach down in the crater to remove debris. **Note:** When the operator excavating the repair is not keeping up, use the breaker attachment to flip-out as much of the broken material as possible until the operator excavating the repairs catches up.

4.6.2.3. Step 3: Crater Repair Team Lead informs the Crater Chief when pavement breaking has been completed on all repairs so personnel/vehicles may be loaned to other crews as necessary.

4.6.3. Excavation. As soon as the pavement breaking is complete on the first repair, the excavation team begins excavating the repair. The goal is to excavate each repair within 11 minutes. To aid the excavation process, lines are marked 24 inches up the sides of the bucket when the bucket is sitting flat on the ground. The lines provide a visual reference for the spotter to guide the excavator operator (**Figure 4.18.**). The excavation sub-crew begins at the first crater where pavement breaking has been completed. **Note:** The excavator spotter is exposed to silica dust and must wear a respirator found in drawer #1 in the RADR Tool Trailer.

Figure 4.18. Excavator Bucket with 24-inch Reference Marks.

4.6.3.1. Step 1: Excavate repair with spotter guidance filling the bucket as much as possible to prevent delays in excavation. Attempt to make repair walls as vertical as possible with bucket. Be careful not to damage pavement edges, especially asphalt surfaces. **Note:** If base materials are sloughing to the point the adjacent slab is undercut, additional pavement may need to be removed.

4.6.3.2. Step 2: Place removed debris adjacent to the crater where it can be removed by the debris removal crew.

4.6.3.3. Step 3: Excavation is complete when reaching 24 inches (+/- 2 inches) in depth (even with the line on the bucket). The operator then proceeds to the next crater ready for excavation.

4.6.3.4. Step 4: The spotter cleans corners and vertical faces as necessary and levels the bottom of the excavation with a shovel. The spotter measures the dimensions of the excavation, including depth of the repair, and reports the measurement to the Warehouse Lead. Finally, the spotter marks the backfill depth on the walls of the excavated repair with marking spray paint obtained during pre-attack action and moves to the next crater. **Note:** Proper backfill depth for a concrete cap is 10 inches below the surrounding pavement and 4 inches below the surrounding pavement for an asphalt cap.

4.6.3.5. Step 5: The Crater Repair Team Lead informs the Crater Chief when personnel have finished their tasks and may be loaned to other crews as necessary.

4.7. Backfill. The RADR backfill process utilizes a flowable-fill product in place of traditional crushed stone. The flowable-fill is a medium strength, high viscosity, excavatable, rapid-setting, cementitious backfill material. The material is packaged in 3,000-pound (approximately 1 cubic yard [CY]) super sacks and used beneath rapid-setting concrete or asphalt. **Note:** Warehouse Leads report material quantities, usage, and shortages to the Logistics Chief to determine if materiel should be shared between warehouses or modify repair methods to extend flowable-fill usage.

4.7.1. Backfill under Rapid-Set Concrete Cap. When the repair is capped with rapid-setting concrete, flowable-fill is placed using the dry placement technique commonly known as “slash and splash”. A 3,000-pound super sack of flowable-fill is suspended over the excavated area, the bag is “slashed” releasing the material into the repair and manually hand spread/leveled, then “splashed” with 50 gallons of water before adding the next super sack. The goal to complete the “slash and splash” backfill method is no more than 11 minutes per crater. **Table 4.5.** identifies resources required for the backfill process under a rapid-set concrete cap.

Table 4.5. Resources for Backfill under Rapid-Set Concrete.

Position	Suitable AFSCs	Veh/Equip/Mat/Tools
Lead	3E2X1	
Operator	3E2X1, 3E4X1, 3E4X3	Water truck, water flow meter*
Operator	3E1X1, 3E6X1	Telehandler
Spotter	Any	Utility knife, rake
Spotter	Any	Utility knife, rake
*If a flow meter is not available, time how long it takes to fill a 55-gallon drum (from 4FWSR UTC) with water truck. Add water at same rate per super sack. **Note:** When necessary, use crushed stone backfill IAW Tri-Service Pavement Working Group (TSPWG) Manual 3-270-01.3-270-07, *O&M: Airfield Damage Repair*.		

Note: Supply of flowable-fill repair material provided with each ADR capability is based upon a pre-determined number of craters plus 10 percent. The excavation depth of each crater is calculated at 24 inches. Repeated over-excavation may rapidly lead to a flowable-fill shortage.

4.7.1.1. The supporting warehouse determines and delivers the required repair material to the repair zone (see AFTTP 3-32.18). The warehouse telehandler operator at the repair zone unloads super sacks from warehouse trailers at a location identified by the Crater Repair Team Lead. If the next loaded trailer has not arrived at the repair zone by the time the previous trailer is unloaded, the warehouse telehandler operator may assist the repair team by placing the appropriate number of super sacks, identified by the Crater Repair Team Lead, diagonally from a repair corner approximately 15 feet away (**Figure 4.19.**). This leaves room for pavement cutting, breaking, and excavating processes if not already complete. Align super sack handles so the backfill crew telehandler forks can slide through both sacks without readjusting position. **Figure 4.20.** displays expected consumption of flowable-fill when used under a rapid-set concrete cap (14 inches of flowable-fill). The table assumes the excavation depth is 2 feet (all dimensions are in feet).

Figure 4.19. Backfill Super Sack Placement.

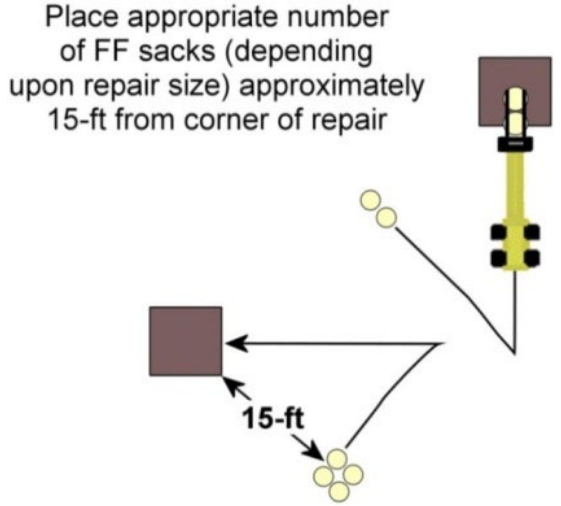


Figure 4.20. Flowable-Fill Sack Consumption Rate under Concrete Cap.

L x W	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
8	2.49	2.64	2.80	2.96	3.11	3.27	3.42	3.58	3.73	3.89	4.04	4.20	4.36	4.51	4.67
8.5	2.64	2.81	2.98	3.14	3.31	3.47	3.64	3.80	3.97	4.13	4.30	4.46	4.63	4.79	4.96
9	2.80	2.98	3.15	3.33	3.50	3.68	3.85	4.03	4.20	4.38	4.55	4.73	4.90	5.08	5.25
9.5	2.96	3.14	3.33	3.51	3.69	3.88	4.06	4.25	4.43	4.62	4.80	4.99	5.17	5.36	5.54
10	3.11	3.31	3.50	3.69	3.89	4.08	4.28	4.47	4.67	4.86	5.06	5.25	5.44	5.64	5.83
10.5	3.27	3.47	3.68	3.88	4.08	4.29	4.49	4.70	4.90	5.10	5.31	5.51	5.72	5.92	6.13
11	3.42	3.64	3.85	4.06	4.28	4.49	4.71	4.92	5.13	5.35	5.56	5.78	5.99	6.20	6.42
11.5	3.58	3.80	4.03	4.25	4.47	4.70	4.92	5.14	5.37	5.59	5.81	6.04	6.26	6.48	6.71
12	3.73	3.97	4.20	4.43	4.67	4.90	5.13	5.37	5.60	5.83	6.07	6.30	6.53	6.77	7.00
12.5	3.89	4.13	4.38	4.62	4.86	5.10	5.35	5.59	5.83	6.08	6.32	6.56	6.81	7.05	7.29
13	4.04	4.30	4.55	4.80	5.06	5.31	5.56	5.81	6.07	6.32	6.57	6.83	7.08	7.33	7.58
13.5	4.20	4.46	4.73	4.99	5.25	5.51	5.78	6.04	6.30	6.56	6.83	7.09	7.35	7.61	7.88
14	4.36	4.63	4.90	5.17	5.44	5.72	5.99	6.26	6.53	6.81	7.08	7.35	7.62	7.89	8.17
14.5	4.51	4.79	5.08	5.36	5.64	5.92	6.20	6.48	6.77	7.05	7.33	7.61	7.89	8.18	8.46
15	4.67	4.96	5.25	5.54	5.83	6.13	6.42	6.71	7.00	7.29	7.58	7.88	8.17	8.46	8.75

4.7.1.2. Step 1: Position the water truck at the repair area so it is out of the way of any repair operations. Connect a 1.5-inch by 50-foot hose with flow meter to the water truck (utilizing the flow meter ensures the proper amount of water is added for each super sack of material). **Note:** Recommend water truck driver operate the water pump and monitor the flow meter to know when to stop adding water to the repair. **Note:** If a flow meter is not available, time how long it takes for the water truck to fill a 55-gallon drum (from 4FWSR UTC). Add water at the same rate per super sack.

4.7.1.3. Step 2: The telehandler is guided to lift super sacks by the spotter. The operator lifts the super sack(s) (10K telehandlers are capable of lifting two bags simultaneously, but only empty one sack at a time) from near side of the repair and suspends it just inside the repair edge to allow the spotter to “slash” the super

sack on the two sides parallel to the forks to help spread the material (**Figure 4.21.**). Remove any sack remnants that may fall into the repair. **Note:** Individuals slashing the flowable-fill bags, and anyone in close vicinity to the airborne dust, must wear a respirator from Drawer #1 in the RADR Tool Trailer, and eye protection.

Figure 4.21. Spotter "Slashing" Super Sack.

4.7.1.4. Step 3: When the super sack is slashed, the spotter directs the forklift operator to repeatedly boom in and out to provide an even placement of material. Spotters assist with spreading and leveling the material.

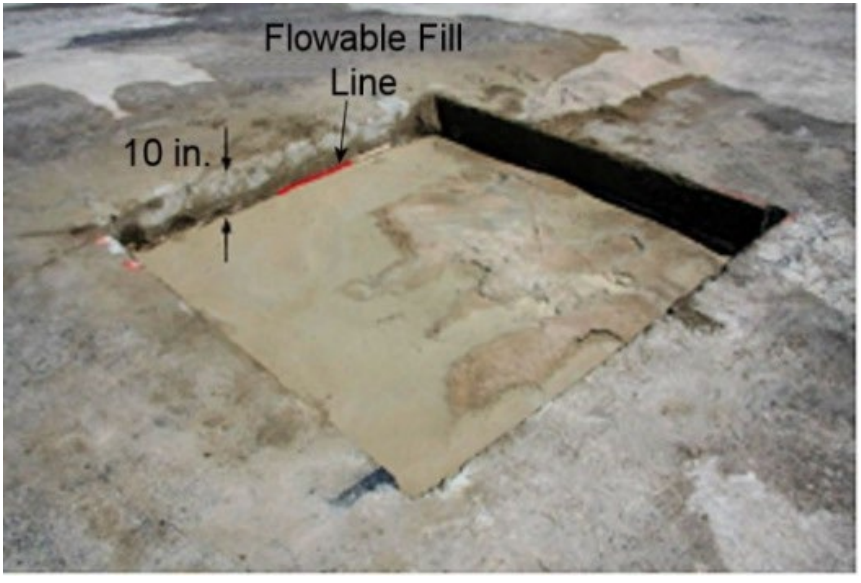
4.7.1.5. Step 4: While the first super sack is emptied, the water truck operator dispenses (splashes) 50 gallons of water in the repair as the super sack is being emptied (**Figure 4.22.**). Spray water into the flowable-fill in a manner to fully hydrate the flowable-fill while it is being added. Use the spray from the hose to level the backfill as much as possible to reduce the amount of manual effort required to level the backfill. Allow water to percolate through the dry material layer until little surface water is apparent.

Figure 4.22. Adding Water to Flowable-Fill.

4.7.1.6. Step 5: Once the proper amount of water has been added, the spotters immediately level the surface of the backfill with rakes/shovels.

4.7.1.7. Step 6: Repeat this process as each super sack is added until reaching the backfill mark (**Figure 4.23.**) made by the excavation team (10 inches from the surrounding pavement surface).

Figure 4.23. Backfill Complete.



Note: As each sack is emptied, the spotter pushes the empty bag to the rear of the forks. The forklift operator places empty bags in a designated trash collection area on the way to retrieving super sacks for the next repair.

Note: Each super sack will raise the level of fill in an 8.5' x 8.5' repair by approximately 5 inches. If the repair does not require a full super sack of material before reaching the proper backfill height, slash the bag at approximately one quarter from the top of the sack to control the amount of material dispensed. If more material is still required, slash the sack again halfway down. When the backfill, material reaches its proper height, adjust the water being added according to

the estimated amount of material added from the partial sack (e.g., only add 25 gallons if only half of a sack was used). Use remaining super sack material in the next repair.

4.7.1.8. Step 7: Crater Repair Team Lead informs the Crater Chief when personnel have finished their primary tasks so that they may be loaned to other crews as necessary.

4.7.2. Backfill under Asphalt Cap. The process for backfilling beneath an asphalt cap is accomplished with a wet placement technique utilizing the volumetric mixer (**Figure 4.24.**). The goal to complete the wet placed backfill method is expected to be no more than 14 minutes per repair. The process uses 70 gallons of water per flowable-fill super sack. **Table 4.6.** identifies the Volumetric Mixer Crew resources required for backfilling a repair capped with asphalt.

Figure 4.24. Volumetric Mixer.

Table 4.6. Backfill under Asphalt Resources.

Position	Suitable AFSCs	Veh/Equip/Mat/Tools
Operator	3E0X2, 3E2X1, 3E3X1, 3E4X1, 3E4X3	Dump truck w/water skid
Operator	3E1X1, 3E6X1	Telehandler
Operator	3E2X1	Volumetric mixer
Operator	3E2X1, 3E4X1, 3E4X3	Water truck
Helper	3EXXX	Shovels, rakes, etc.

4.7.2.1. Process. **Figure 4.25.** shows the expected consumption of flowable-fill when used under an asphalt cap (20 inches of flowable-fill). The table assumes the excavation depth is 2 feet (all dimensions are in feet).

4.7.2.1.1. Step 1: Position the water truck and volumetric mixer (pulled by dump truck w/water skid) at repair area without interfering with repair operations. **Note:** Stop dump truck and volumetric mixer parallel to the MOS centerline to prevent the need to back the volumetric mixer and/or clog traffic lanes.

Figure 4.25. Flowable-Fill Sack Consumption Rate under Asphalt Cap.

L x W	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
8	3.56	3.78	4.00	4.22	4.44	4.67	4.89	5.11	5.33	5.56	5.78	6.00	6.22	6.44	6.67
8.5	3.78	4.01	4.25	4.49	4.72	4.96	5.19	5.43	5.67	5.90	6.14	6.38	6.61	6.85	7.08
9	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75	6.00	6.25	6.50	6.75	7.00	7.25	7.50
9.5	4.22	4.49	4.75	5.01	5.28	5.54	5.81	6.07	6.33	6.60	6.86	7.13	7.39	7.65	7.92
10	4.44	4.72	5.00	5.28	5.56	5.83	6.11	6.39	6.67	6.94	7.22	7.50	7.78	8.06	8.33
10.5	4.67	4.96	5.25	5.54	5.83	6.13	6.42	6.71	7.00	7.29	7.58	7.88	8.17	8.46	8.75
11	4.89	5.19	5.50	5.81	6.11	6.42	6.72	7.03	7.33	7.64	7.94	8.25	8.56	8.86	9.17
11.5	5.11	5.43	5.75	6.07	6.39	6.71	7.03	7.35	7.67	7.99	8.31	8.63	8.94	9.26	9.58
12	5.33	5.67	6.00	6.33	6.67	7.00	7.33	7.67	8.00	8.33	8.67	9.00	9.33	9.67	10.00
12.5	5.56	5.90	6.25	6.60	6.94	7.29	7.64	7.99	8.33	8.68	9.03	9.38	9.72	10.07	10.42
13	5.78	6.14	6.50	6.86	7.22	7.58	7.94	8.31	8.67	9.03	9.39	9.75	10.11	10.47	10.83
13.5	6.00	6.38	6.75	7.13	7.50	7.88	8.25	8.63	9.00	9.38	9.75	10.13	10.50	10.88	11.25
14	6.22	6.61	7.00	7.39	7.78	8.17	8.56	8.94	9.33	9.72	10.11	10.50	10.89	11.28	11.67
14.5	6.44	6.85	7.25	7.65	8.06	8.46	8.86	9.26	9.67	10.07	10.47	10.88	11.28	11.68	12.08
15	6.67	7.08	7.50	7.92	8.33	8.75	9.17	9.58	10.00	10.42	10.83	11.25	11.67	12.08	12.50

Note: The warehouse telehandler operator at the repair zone unloads super sacks from warehouse trailers and places them in a designated location identified by the Crater Repair Team Lead. If the next loaded trailer has not arrived at the repair zone by the time the previous trailer is unloaded, the warehouse telehandler operator may assist the telehandler that loads the volumetric mixer by placing the appropriate number of super sacks, identified by the Crater Repair Team Lead, near the volumetric mixer.

Note: Some super sacks are lined with foil. To prevent foil liners from tearing and dropping into the mixer, gently lower sack straight down onto the mixer's bag breakers to make a small cut in the sack. Raise the sack straight up until sack is clear of the spike and shake the sack (with the forklift controls) until sack is emptied. Remove any pieces of foil liner that may fall into the mixer.

4.7.2.1.2. Step 2: When the required backfill level is reached (4 inches from the top of the surrounding pavement, as marked by the excavation team) the volumetric mixer operator and any available labor use rakes as necessary to make the

flowable-fill surface parallel to the parent surface to keep a consistent depth throughout the repair (**Figure 4.26.**).

Figure 4.26. Backfill Nearing Completion.

4.7.2.1.3. Step 3: Crater Repair Team Lead informs the Crater Chief when personnel have finished their tasks so they may assist others as necessary. **Note:** The volumetric mixer requires periodic cleaning during operation. Failure to perform periodic cleaning will result in operational failure. The volumetric mixer has an onboard pressure washing system. Citric acid may be added to the washout tank in case of mixer malfunction. For example, if the water pump malfunctions there will be dry material to remove from the auger. Adding citric acid to the water in the washout tank will allow more time for cleanup when using water from the washout tank to remove the dry material.

4.8. Capping Repair. Capping is accomplished with either asphalt or rapid-set concrete. Capping material should match the in-situ material, but when material

is short, mix-matching capping material and in situ material is allowable (e.g., rapid-set concrete may be used to cap a repair on an asphalt surface and vice-versa; however, life of the repairs may be diminished). Capping begins once the backfill material (using the "slash and splash" method) achieves an initial set of 15 minutes when capping with concrete and 30 minutes when capping with asphalt (wet flowable-fill placement). Ensure no water sheen is on the backfill surface and it has set enough to support foot traffic (leaves no footprints).

4.8.1. Rapid-Set Concrete Cap. A rapid-set concrete cap is placed using the volumetric mixer and a rapid-setting concrete mix. The rapid-setting concrete is packaged in 3,000-pound (approximately 1 CY) super sacks. The water to rapid-set material ratio is approximately 50 gallons of water to one (1) super sack. The rapid-setting concrete material has an initial set time of 45 minutes (at which time will support a 2.5-ton vehicle) and a fully operational cure time of two hours. **Table 4.7.** identifies resources required to place a rapid-set concrete cap.

Table 4.7. Rapid-Set Concrete Capping Resources.

Position	Suitable AFSCs	Veh/Equip/Mat/Tools
Operator	3E0X2, 3E2X1, 3E3X1, 3E4X1, 3E4X3	Dump truck w/water skid
Operator	3E1X1, 3E6X1	Telehandler
Operator	3E2X1	Volumetric mixer
Operator[1]	3E2X1, 3E4X1, 3E4X3	Water truck
Helper[1]	Any	[2]Screed, bucket and hand trowels
Helper	Any	[2]Concrete rake and square shovel
Helper	Any	[2]Concrete rake and square shovel
Helper	Any	[2]Rake, shovels, etc.

[1]Transferred from Upheaval Marking Crew
[2]An inventory of the RADR tool trailer is listed in **Attachment 2**

4.8.1.1. Before placing rapid-setting concrete, the flowable-fill backfill "slash and splash" method requires 15 minutes to achieve initial set. The goal to place the rapid-set concrete is expected to be no more than 11 minutes per repair (**Figure 4.27.**). **Figure 4.28.** shows the expected consumption of rapid-set when placing a 10-inch thick cap. The table assumes the excavation depth is two feet (all dimensions are in feet).

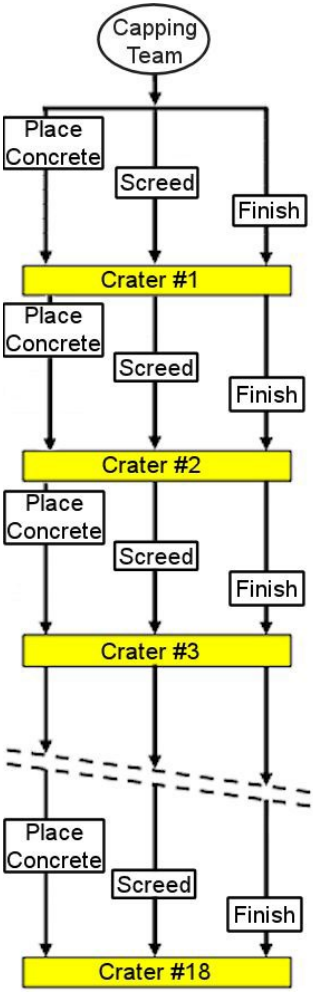
Note: Stop dump truck and volumetric mixer parallel to the MOS centerline to prevent the need to back the volumetric mixer and/or clog traffic lanes.

Note: After positioning the volumetric mixer, the helper and water truck operators keep the mixer stocked with dry material, water, and admixtures.

Note: Individuals on the mixer catwalk assisting with loading the volumetric mixer, and anyone in close vicinity to the airborne dust, must wear a respirator from Drawer #1 in the RADR Tool Trailer, and eye protection.

Note: Some super sacks are lined with foil. To prevent foil liners from tearing and dropping into the mixer, gently lower sack straight down onto the mixer's bag breakers to make a small cut in the sack. Raise the sack straight up until sack is clear of the spike and shake the sack (with the forklift controls) until sack is emptied. Remove any pieces of foil liner that may fall into the mixer.

Figure 4.27. Rapid-Set Concrete Capping Process.



Loading Volumetric Mixer

Finishing Cap with Power Screed

Touching-up Imperfections

Figure 4.28. Rapid-Set Sack Consumption Rate for 10-Inch Cap.

L x W	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
8	2.13	2.27	2.40	2.53	2.67	2.80	2.93	3.07	3.20	3.33	3.47	3.60	3.73	3.87	4.00
8.5	2.27	2.41	2.55	2.69	2.83	2.98	3.12	3.26	3.40	3.54	3.68	3.83	3.97	4.11	4.25
9	2.40	2.55	2.70	2.85	3.00	3.15	3.30	3.45	3.60	3.75	3.90	4.05	4.20	4.35	4.50
9.5	2.53	2.69	2.85	3.01	3.17	3.33	3.48	3.64	3.80	3.96	4.12	4.28	4.43	4.59	4.75
10	2.67	2.83	3.00	3.17	3.33	3.50	3.67	3.83	4.00	4.17	4.33	4.50	4.67	4.83	5.00
10.5	2.80	2.98	3.15	3.33	3.50	3.68	3.85	4.03	4.20	4.38	4.55	4.73	4.90	5.08	5.25
11	2.93	3.12	3.30	3.48	3.67	3.85	4.03	4.22	4.40	4.58	4.77	4.95	5.13	5.32	5.50
11.5	3.07	3.26	3.45	3.64	3.83	4.03	4.22	4.41	4.60	4.79	4.98	5.18	5.37	5.56	5.75
12	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60	4.80	5.00	5.20	5.40	5.60	5.80	6.00
12.5	3.33	3.54	3.75	3.96	4.17	4.38	4.58	4.79	5.00	5.21	5.42	5.63	5.83	6.04	6.25
13	3.47	3.68	3.90	4.12	4.33	4.55	4.77	4.98	5.20	5.42	5.63	5.85	6.07	6.28	6.50
13.5	3.60	3.83	4.05	4.28	4.50	4.73	4.95	5.18	5.40	5.63	5.85	6.08	6.30	6.53	6.75
14	3.73	3.97	4.20	4.43	4.67	4.90	5.13	5.37	5.60	5.83	6.07	6.30	6.53	6.77	7.00
14.5	3.87	4.11	4.35	4.59	4.83	5.08	5.32	5.56	5.80	6.04	6.28	6.53	6.77	7.01	7.25
15	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75	6.00	6.25	6.50	6.75	7.00	7.25	7.50

Note: Begin placing concrete on low end of each paving lane.

4.8.1.2. Step 1: Position the water truck and dump truck/volumetric mixer at a convenient location near the repair area, but not in the way of repair activities.

Note: The warehouse telehandler operator at the repair zone unloads super sacks from warehouse trailers and places them in a designated location identified by the Crater Repair Team Lead. If the next loaded trailer has not arrived at the repair zone by the time the previous trailer is unloaded, the warehouse telehandler operator may assist the repair team by placing the appropriate number of super sacks, identified by the Crater Repair Team Lead, near the volumetric mixer.

4.8.1.3. Step 2: The mixer operator ensures controls are set to rapid-set concrete and required admixtures are on-board (see **paragraph 7.2.1.** for suggested admixture dosage). The mixer operator directs placement of the rapid-set by swinging

the mixer chute and by having the dump truck operator pull forward or backward as needed. The mix has a very high slump (very fluid) compared to the typical four or five slump used for most slabs. The mix consistency will appear to be similar to a slurry, but not quite as fluid as the wet flowable fill mix (**Figure 4.26.**).

Note: The volumetric mixer requires periodic cleaning. Failure to periodically clean the mixer will result in operational failure. Citric acid may be added to the washout tank in case of mixer malfunction. For example, if the water pump malfunctions there will be dry material to remove from the auger. Adding citric acid to the water in the washout tank allows more time for cleanup when using water from the washout tank to remove the dry material. Cleaning details are provided in the operator's manual.
Note: If temperature is 75°F or above, retardant admixture is required to extend material working time (see **Table 7.1.)**. Mix citric acid with a small amount of water until it becomes a slurry before adding to the mix water tanks.

Note: The quality of material placed in overcuts is very important. Ensure overcuts are filled while the cap is placed. A strong FOD potential exists if slurry fills overcuts before being packed with rapid-set.

Note: When a repair crosses a runway crown, a joint must be established at the peak of the crown to achieve the proper slope on each side of the crown.

Note: Perform steps in **Attachment 4** if rapid-set concrete sets-up on the auger and requires emergency swap out (wear proper personal protective equipment and be aware of pinch points around locking pins/plates near mixing well).

4.8.1.4. Step 3: The volumetric mixer/dump truck, water truck, and telehandler forklift move to the next crater as soon as the repair is filled with capping material.

4.8.1.5. Step 4: Three remaining personnel finish the crater with the power screed (**Figure 4.29.**). Ensure screed does not ride on excess material at the repair edges.

Figure 4.29. Finishing Cap with Power Screed.

Note: Do not perform wet finishing, as described in the CTS Rapid Set specification sheet, during rapid crater repair. Small unfinished areas after screeding may be expeditiously touched up by hand.

4.8.1.6. Step 5: The Debris Removal Crew thoroughly cleans around repairs after the initial set (CTL with buckets and/or brooms). Pay particular attention to slurry buildup at edges of the repair.

4.8.1.7. Step 6: Perform Repair Quality Criteria checks by conducting line-of-sight profile measurements as described in T.O. 35E2-5-1, *Crushed-Stone Crater Repair and Line-Of-Sight Profile Measurement for Rapid Runway Repair,* and report results up the chain to the Civil Engineer Unit Control Center (CE-UCC). In addition to taking measurements in the center of the repair, also take measurements at the joints.

4.8.1.8. Step 7: Crater Repair Team Lead records completion time of each cap.

Note: A rapid-set concrete repair has an initial set time of 45 minutes in fair weather (i.e., ambient temperature above 45ºF and not raining) and is capable of supporting a 2.5-ton vehicle for paint striping and FOD removal operations. As the caps reach the initial set time, the Crater Repair Team Lead directs one of the team members to move the repair zone marking cones. This signals the Striping Crew and FOD Removal Team the work area is open for striping and sweeping. Full cure time for aircraft traffic is two (2) hours.

Note: Pavement must be dry before pavement striping begins.

4.8.1.9. Step 8: Crater Repair Team Lead informs the Crater Chief when personnel have finished their tasks so they may be loaned to other crews as necessary.

4.8.2. Asphalt Cap. The asphalt cap is placed at a compacted thickness of four (4) inches with asphalt produced by the asphalt recyclers. The wet placed flowable-fill backfill method requires 30 minutes to achieve initial set before the asphalt is placed. The goal to place asphalt is expected to be no more than 11 minutes and 30 seconds, with an additional 11 minutes and 30 seconds for compaction. **Table 4.8.** identifies resources required for the asphalt cap. **Table 4.9.** shows the expected consumption rate of asphalt when placing a 4-inch-thick cap. The table assumes the excavation depth is two feet (all dimensions are in feet).

Table 4.8. Asphalt Cap Resources.

Position	Suitable AFSCs	Veh/Equip
Lead	3E2X1	
Operator	3E0X1, 3E0X2, 3E1X1, 3E2X1, 3E3X1, 3E4X3, 3E5X1, 3E6X1	Front End Loader
Operator	3E0X1, 3E2X1	Steel wheel roller
Operator	3E0X1, 3E2X1	Pneumatic wheel roller
Operator	3E2X1, 3E4X1, 3E4X3	Water truck

Helper (x3)	Any	Lute, square shovel

Note: Recycled asphalt from suitable asphalt pavements such as parking lots, runway/taxiway shoulders, roads, etc., may be used as substitute material.

Note: As soon as the first repair has been backfilled, the Crater Repair Team Lead requests the Warehouse 1 Lead to send the first load of asphalt. At this time the warehouse dispatches a loaded dump truck to the supported repair team's location. The Crater Repair Team Lead communicates with the Warehouse 1 Lead to schedule future asphalt deliveries.

Table 4.9. Asphalt Consumption Rate for 4-Inch Cap (Tons).

L x W	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
8	1.58	1.68	1.78	1.88	1.98	2.08	2.18	2.28	2.38	2.48	2.58	2.68	2.78	2.88	2.98
8.5	1.68	1.79	1.89	2.00	2.10	2.21	2.31	2.42	2.52	2.63	2.73	2.84	2.95	3.05	3.16
9	1.78	1.89	2.00	2.12	2.23	2.34	2.45	2.56	2.67	2.78	2.90	3.01	3.12	3.23	3.34
9.5	1.88	2.00	2.12	2.23	2.35	2.47	2.59	2.70	2.82	2.94	3.06	3.17	3.29	3.41	3.53
10	1.98	2.10	2.23	2.35	2.48	2.60	2.72	2.85	2.97	3.09	3.22	3.34	3.47	3.59	3.71
10.5	2.08	2.21	2.34	2.47	2.60	2.73	2.86	2.99	3.12	3.25	3.38	3.51	3.64	3.77	3.90
11	2.18	2.31	2.45	2.59	2.72	2.86	2.99	3.13	3.27	3.40	3.54	3.68	3.81	3.95	4.08
11.5	2.28	2.42	2.56	2.70	2.85	2.99	3.13	3.27	3.42	3.56	3.70	3.84	3.98	4.13	4.27
12	2.38	2.52	2.67	2.82	2.97	3.12	3.27	3.42	3.56	3.71	3.86	4.01	4.16	4.31	4.46
12.5	2.48	2.63	2.78	2.94	3.09	3.25	3.40	3.56	3.71	3.87	4.02	4.18	4.33	4.49	4.64
13	2.57	2.73	2.90	3.06	3.22	3.38	3.54	3.70	3.86	4.02	4.18	4.34	4.50	4.67	4.83
13.5	2.67	2.84	3.01	3.17	3.34	3.51	3.68	3.84	4.01	4.18	4.34	4.51	4.68	4.84	5.01
14	2.77	2.95	3.12	3.29	3.47	3.64	3.81	3.98	4.16	4.33	4.50	4.68	4.85	5.02	5.20
14.5	2.87	3.05	3.23	3.41	3.59	3.77	3.95	4.13	4.31	4.49	4.67	4.84	5.02	5.20	5.38
15	2.97	3.16	3.34	3.53	3.71	3.90	4.08	4.27	4.46	4.64	4.83	5.01	5.20	5.38	5.57

4.8.2.1. Step 1: When asphalt arrives at the repair location, a helper checks the asphalt temperature with the temperature gun located in drawer 3 of the component trailer, to ensure it is 280°F or greater as required for break-down rolling. If below 280°F return the load for reprocessing and call for another load. The driver should be directed where to dump asphalt by the Crater Repair Team Lead.

4.8.2.2. Step 2: The front-end loader operator places the proper amount of asphalt in the repair under the direction of a spotter (**Figure 4.30.**). The loader operator then screeds the un-compacted material leaving approximately 1.5-inch, ± 0.25-inch of asphalt above surrounding pavement.

Figure 4.30. Loader Screeding Asphalt Cap.

Note: The front-end loader screeds the crater cap as long as the wheels of the loader are not placed on the un-compacted asphalt. If the repair is too wide for the loader, the asphalt is placed and rough leveled with the front-end loader and finished with a CTL and bucket and/or by hand with lutes.

4.8.2.3. Step 3: During placement and screeding of the asphalt, helpers assist with placing, cleaning, and preparing edges using lutes and/or square shovels.

4.8.2.4. Step 4: The cap is rolled with the steel-wheel roller parallel to the crown of the runway, assisted by a spotter who monitors asphalt temperature and cleans the edges. Conduct rolling as follows:

a. 0.5 pass (longitudinal with crown of runway) with steel-wheel roller, no vibration (asphalt temperature should be 280°F or greater).

b. 2.5 passes (longitudinal with crown of runway) with steel-wheel roller, vibration on (asphalt temperature should be 150°F or greater).

c. 2 passes (longitudinal with crown of runway) with pneumatic roller.

d. 3 passes with steel-wheel roller, no vibration.

e. Between passes, the helper trims any excess asphalt from edges with a square head shovel. This process is repeated until all caps are complete.

Note: A pass is equal to traveling across the repair and then returning to the original starting position. Perform each pass across entire width of the repair by overlapping the previous pass by approximately 12 inches until the entire repair cap has received the pass.

Note: If check cracking is noted in the mat or if there is evidence of chipping of concrete edges, grooves, or joints, turn off vibration and add an additional half pass for step “a” and decrease step “b” to 2 passes.

Note: The asphalt cap should be no hotter than 150°F before receiving vehicle traffic (2.5-ton vehicle for FOD removal or striping), and no hotter than 125°F (or no hotter than the surrounding pavement when it is 125°F or hotter) before receiving aircraft traffic. The average time for asphalt to cool to 150°F is two (2) hours, but times vary depending on environmental conditions.

Note: Experiments have shown smaller asphalt repairs (8.5-foot square to 12-foot square) do not necessarily require the pneumatic roller passes to achieve satisfactory asphalt density. If time is an issue, the pneumatic roller passes may be skipped.

4.8.2.5. Step 5: Thoroughly clean around edges of repair to remove excess asphalt and debris.

4.8.2.6. Step 6: The natural cooling process takes approximately 2 hours to bring asphalt temperature to 150°F (depending on environmental conditions). To reduce cooling time, the water truck operator may flood the last 5 repairs with water. The repairs are repeatedly flooded whenever the asphalt begins to develop dry areas. The water truck operator should flood a repair briefly and move to the next repair alternating between repairs as required. The repairs are ready for vehicle traffic when asphalt temperature reaches 150°F, or less. At this time the water truck operator removes the cones identifying the repair zone, which signals the Striping Crew and FOD Team the work area is open. The repair is ready to receive aircraft traffic when the asphalt temperature falls to 125°F, or is no hotter than the surrounding pavement when it is 125°F or hotter.

Note: The pavement must be dry before pavement striping begins.

4.8.2.7. Step 7: Perform RQC checks as described in T.O. 35E2-5-1, *Crushed-Stone Crater Repair and Line-Of-Sight Profile Measurement for Rapid Runway Repair,* and report results up the chain to the CE-UCC.

4.8.2.8. The Crater Repair Team Lead informs the Crater Chief when personnel have finished their tasks so they may be loaned to other crews as necessary.

Chapter 5

LARGE REPAIR PROCESS

5.1. Introduction. When any transverse side (perpendicular to the centerline) of a repair is longer than 11-feet, the large repair process described in this chapter is used. These procedures are predicated on tools and equipment in the Rapid Airfield Damage Repair (RADR) tool trailer (**Table A2.2.**). Paving lane widths should not exceed 11 feet to keep the repair manageable when using rapid-setting concrete, and because the screed in the tool trailer is only 12 feet long. Identify extent of upheaval as described in T.O. 35E2-5-1, *Crushed-Stone Crater Repair and Line-Of-Sight Profile Measurement for Rapid Runway Repair*, for craters with an apparent size of 20 feet in diameter or larger. The debris removal and upheaval marking processes are performed in the same manner as the small repair; the modifications to the remaining processes (e.g., pavement cutting, excavation, backfill, and capping) are explained below. After debris is removed and upheaval marked, perform the following processes.

Note: Be familiar with small crater repair processes as described in **Chapter 4** before beginning large crater repair.

Note: Large repair processes may result in some crater repair team members being idle for long periods of time. In these instances, the team lead should direct those individuals to assist with other tasks.

5.2. Pavement Cutting. The pavement cutting process is modified when the repair is large enough to safely use four Compact Track Loaders (CTL) simultaneously to cut pavement around a single large repair (approximately 15-ft x 15-ft or larger). In other words, each CTL cuts one of the four repair sides simultaneously (**Figure 5.1.**).

Figure 5.1. Pavement Cutting Four Sides of Large Repair Simultaneously.

5.3. Breaking and Excavation. There are two modifications when excavating a large repair: (1) Breaking and excavating may take place simultaneously when the repair is approximately 10-ft x 10-ft or larger. (2) Depth of excavation depends on the depth of disturbed subgrade material. The spotter informs the excavator operator when proper depth has been reached. **Figure 5.2.** shows pavement breaking and excavating taking place simultaneously; the Debris Removal Crew (CTL and loader) is clearing excavated material away from the repair.

Figure 5.2. Breaking and Excavating Large Repair Simultaneously.

5.4. Backfill. Backfill may be accomplished with flowable-fill and/or crushed stone material.

5.4.1. Flowable Fill. The Backfill Crew may add one individual (forklift operator) when repairs are 15-ft x 15-ft or larger for a total of six members (**Table 5.1.**). If one of the RADR warehouses is located on semi-improved surfaces, its warehouse forklift may be transferred to the repair team, or when a capping team is not placing an asphalt cap its loader may be used with a fork attachment.

Table 5.1. Recommended Flowable-Fill Backfill Resources.

Position	Suitable AFSCs	Veh/Equip/Mat/Tools
Lead	3E2X1	
Operator	3E2X1, 3E4X1, 3E4X3	Water truck, water flow meter
Operator	3E1X1, 3E2X1, 3E6X1	Telehandler
Operator	3E1X1, 3E2X1, 3E6X1	Telehandler/Forklift
Helper	Any	Rake, shovel, etc.
Helper	Any	Utility knife, rake

Note: Individuals slashing flowable-fill bags, and those in close proximity to the airborne dust, must wear a respirator found in drawer #1 in the RADR Tool Trailer.

5.4.1.1. Step 1: Using a telehandler (an additional forklift when the repair is 15-ft by 15-ft or larger), dispense dry flowable fill using the "slash and splash" method, as described in **paragraph 7.1.2.1.2.** directly into the excavation in 4-to-6-inch lifts (**Figure 5.3.**). Extend and retract the boom to help evenly spread material throughout the repair.

Figure 5.3. Dry Flowable Fill Placement.

5.4.1.2. Step 2: Two helpers (or three when repair is 15-ft x 15-ft or larger) use hand tools to evenly spread/level backfill material as it is placed in the repair.

5.4.1.3. Step 3: The water truck operator adds 50 gallons of water per sack as the sacks are emptied and allows it to percolate through the dry material layer until little surface water is apparent (**Figure 5.4.**). The stream of water may be directed to assist with distributing repair material within the repair.

5.4.1.4. Step 4: Repeat process until backfill is 10 inches below parent slab.

5.4.2. Crushed Stone. See **Table 5.2.** for crushed stone backfill resources. One Operator compacts the crushed stone backfill. In addition, the backfill crew may use a loader, operated by the other helper, to assist with leveling the crushed stone backfill.

Table 5.2. Recommended Crushed Stone Backfill Resources.

Position	Suitable AFSCs	Veh/Equip/Mat/Tools
Lead	3E2X1	
Operator	3E2X1, 3E3X1, 3E4X1	CTL with compactor (possibly from Debris Removal Crew)
Operator	3E0X1, 3E0X2, 3E1X1, 3E2X1, 3E3X1, 3E4X1	Front end loader (From Capping Crew or Debris Removal Crew)
Helper	Any	Hand tools
Helper	Any	Plate compactor, hand tools

Note: When using the CTL's roller attachment for compacting crushed stone, lifts should be no thicker than 3 inches. Lifts may be 4 to 6 inches if an excavator with a compactor plate attachment is used.

5.4.2.1. If flowable fill material is close to being exhausted, crushed stone may be used to extend the flowable fill by using three to six inches of crushed stone in the bottom of the repair and the remaining eight to 11 inches backfilled with flowable fill or use the remaining flowable fill to backfill repairs in the aircraft's wheel path and crushed stone to backfill repairs under the wings. If all flowable fill is exhausted before completing all repairs, use crushed stone to backfill the entire 14 inches in accordance with T.O. 35E2-5-1, *Crushed-Stone Crater Repair and Line-Of-Sight Profile Measurement for Rapid Runway Repair,* and the following guidance.

5.4.2.2. Step 1: After the repair has been excavated, The Backfill Crew helpers assist with leveling the subgrade (soil) using rakes and shovels. If the repair is 15-ft x 15-ft or larger, a loader or CTL may be required to assist with leveling the subgrade material.

5.4.2.3. Step 2: Geotextile fabric (stored in tool trailer) is placed in the bottom of the repair to separate the underlying soil from the crushed stone backfill (**Figure 5.5.**). If one sheet does not cover the entire excavated area, use two sheets, and

overlap the first sheet by one foot. Remove excess fabric or fold over into the repair.

Figure 5.4. Placing Geotextile Fabric.

5.4.2.4. Step 3: Warehouse dump trucks begin dumping crushed stone into the excavation. When the repair is 15-ft x 15-ft or larger, dump trucks distribute material around the repair as much as possible by dumping a partial load in one location, lowering the bed, and then moving to another location to dump more material until the proper lift thickness is obtained for compaction.

5.4.2.5. Step 4: The Backfill Crew helpers assist with leveling the backfill to the appropriate lift thickness using rakes and shovels. If the repair is 15-ft x 15-ft or larger, a loader or CTL may be required to assist with leveling the backfill material.

5.4.2.6. Step 5: Once the backfill lift is somewhat level and of the proper thickness for the compaction method, begin compaction with either a CTL with roller attachment (**Figure 5.6.**) or excavator with plate compactor attachment (**Figure 5.7.**). A helper uses the walk-behind plate compactor (**Figure 5.7.**) from the tool trailer to compact the subgrade around the walls and corners of the excavation.

Make several passes with compactor until no loose pockets of material are apparent. Continue placing and compacting material in 3-inch lifts until reaching 10 inches below parent slab (**Figure 5.9.**).

Figure 5.5. CTL with Roller Attachment.

Figure 5.6. Excavator with Plate Compactor Attachment.

Figure 5.7. Plate Compactor.

Figure 5.8. Completed Crushed Stone Backfill.

5.5. Capping.

5.5.1. Concrete Cap Repair. Two capping crew helpers prepare plastic forms after the paving lanes' sizes have been determined. The remaining crew responsibilities are described in **Table 5.3.**

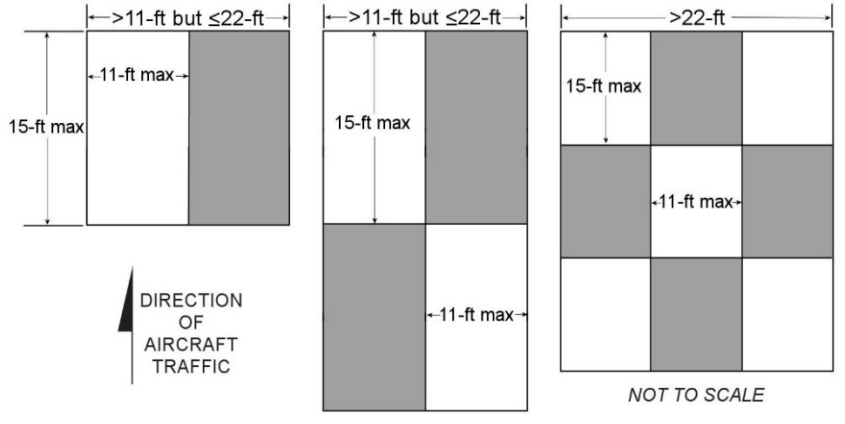
Table 5.3. Large Repair Concrete Capping Resources.

Position	Suitable AFSCs	Veh/Equip/Mat/Tools
Operator	3E0X2, 3E2X1, 3E3X1, 3E4X1, 3E4X3	Dump truck w/water skid; tows volumetric mixer
Operator	3E1X1, 3E6X1	Telehandler forklift
Operator	3E2X1	Volumetric mixer

Operator	3E2X1, 3E4X1, 3E4X3	Water truck
Helper	Any	Hand tools
Helper	Any	Plastic forms, finishing tools
Helper	Any	Plastic forms, finishing tools
Helper	Any	Hand tools

5.5.1.1. Due to the nature of rapid-setting concrete, two helpers install plastic concrete forms to divide the repair into manageable sections before the concrete begins to setup. Repairs should be divided similar to those illustrated in **Figure 5.9.** when the only screed available is the 12-ft screed from the RADR Tool Trailer. Regardless of screed length, the largest dimension of a formed section should be no greater than 15 feet to prevent the rapid-set concrete from prematurely curing before finishing the placement of concrete. In addition, a 15-ft x 15-ft repair or smaller should reach its goal of 3,000 passes.

Figure 5.9. Dividing Large Repairs for Multiple Pours with 12-ft Screed.



Note: When a repair crosses a runway crown, a joint must be established at the peak of the crown to achieve the proper slope on each side of the crown.

Note: Begin placing concrete on low end of each paving lane.

5.5.1.2. Place concrete in either all shaded or all unshaded sections in **Figure 5.9.** first. After curing enough to walk on without leaving footprints, remove forms and place concrete in the remaining sections (the sections of the opposite shading convention).

5.5.1.3. Step 1: Once the excavation is complete (before backfilling begins) helpers begin cutting the plastic concrete forms to proper length using a reciprocating saw (**Figure 5.10.**). Use stacking accessory (**Figure 5.11.**) to stack two 4-inch-tall forms.

Note: An 8-inch-tall form is desired for the 10-inch concrete cap to prevent the form from protruding above the surrounding parent slab if the backfill was placed too high.

5.5.1.4. Step 2: Place stacked forms on top of the backfill after the 15-minute initial set of flowable-fill. Hammer form pins (**Figure 5.12.**) through stacking pockets.

Figure 5.10. Cutting Forms to Proper Length.

Figure 5.11. Stacking Pocket Accessory for Plastic Concrete Forms.

Figure 5.12. Installing Form Pins.

Figure 5.13. Checking Form Height with String Line.

5.5.1.6. Step 4: If temperature is 75°F or higher, add citric acid, in anhydrous powder form, to the volumetric mixer's mix water tanks as identified in **Table**

7.1. to increase the working time of the Rapid Set concrete. See **paragraph 7.2.** for citric acid mixing.

Note: Mix citric acid with a small amount of water until it becomes a slurry before adding to the mix water tanks.

5.5.1.7. Step 5: Forms may need to be reused; therefore, spray release agent on form faces and bottom grooves on backside of the forms. Release agent can be found in the RADR tool trailer.

Note: Stop dump truck and volumetric mixer parallel to the minimum operating strip (MOS) centerline to prevent the need to back the volumetric mixer and/or clog traffic lanes.

5.5.1.8. Step 6: Fill the first formed section with Rapid Set concrete (**Figure 5.14.**). Finish the rapid-setting concrete cap with a screed bar and hand tools (**Figure 5.15.**). Only minimal finishing of the repair using hand tools is required.

Figure 5.14. Placing Rapid-Setting Concrete Cap with Volumetric Mixer.

Figure 5.15. First Quadrant Poured within Framework.

Note: Do not perform wet finishing, as described in the CTS Rapid Set specification sheet, during rapid crater repair. Small, unfinished areas after screeding may be expeditiously touched up by hand.

5.5.1.9. Step 7: Fill the quadrant diagonally across from the quadrant just placed (labeled "Fill this quadrant next" in **Figure 5.15.**) and minimally finish with screed and hand tools.

5.5.1.10. Step 8: Once the first two quadrants have cured enough to walk on without leaving footprints, remove plastic forms and attach expansion board material to the side of concrete slabs to create a joint between all four of the slabs.

5.5.1.11. Step 9: Fill the remaining two quadrants with Rapid Set concrete and minimally finish with hand tools.

Note: Individuals on the mixer catwalk assisting with loading the volumetric mixer, and anyone in close vicinity to the airborne dust, should wear a respirator from Drawer #1 in the RADR Tool Trailer, and eye protection.

Note: Perform steps in **Attachment 4** if rapid-set concrete sets-up on the auger and requires emergency swap out (wear proper personal protective equipment and be aware of pinch points around locking pins/plates near mixing well).

5.5.2. Asphalt Cap Repair. Research, development, test, and evaluation for large crater repair with asphalt caps were still underway at the time of this writing. Procedures will be added to this AFTTP when finalized.

Chapter 6

LEGACY CRATER REPAIRS

6.1. Crushed Stone Crater Repair. When flowable-fill and/or rapid-set concrete materials are depleted or in short supply, crushed-stone repairs may be required. Perform crushed-stone repairs IAW T.O. 35E2-5-1. **Table 6.1.** shows crushed stone crater repair steps performed by RADR crews.

Table 6.1. Crushed-Stone Crater Repair Steps and Responsible Crews.

Crushed Stone Repair Steps	Responsible Crew
1. Clearing Crater Site	Debris Removal
2. Initial Upheaval Identification	Upheaval Determination and Marking
3. Removing Upheaval and Excavating	Pavement Breaking and Excavation
4. Intermediate Crater Profile Check	N/A (not accomplished)
5. Filling Crater	Backfill
6. Crater Edge Cleaning	Backfill
7. Leveling Fill Material	Backfill
8. Overfilling Crater	Capping
9. Final Grade and Compaction	Capping (screed and finish cap)
10. Check crater repair quality	Capping
11. Install FOD cover	Spall

6.2. FOD Cover Construction and Installation. Refer to T.O. 35E2-2-7, *AM-2 Airfield Landing Mat and Accessories*, when covering crushed-stone repairs with AM-2 matting. Refer to T.O. 35E2-3-1, *Folded Fiberglass Mats for Rapid Runway Repair*, when covering crushed-stone repairs with Folded Fiberglass matting.

Chapter 7

CRATER REPAIR IN EXTREME CONDITIONS

7.1. Rainy or Humid Conditions.

7.1.1. Rapid-Set Concrete Cap Repair. Perform the rapid-set concrete repair from debris removal through the excavation process in the same manner as described in **Chapters 4** and **5**.

Note: Lumber crayons (in place of paint or other marking media) in the RADR trailer should be used when marking upheaval to prevent the marks from being washed away by the wet conditions.

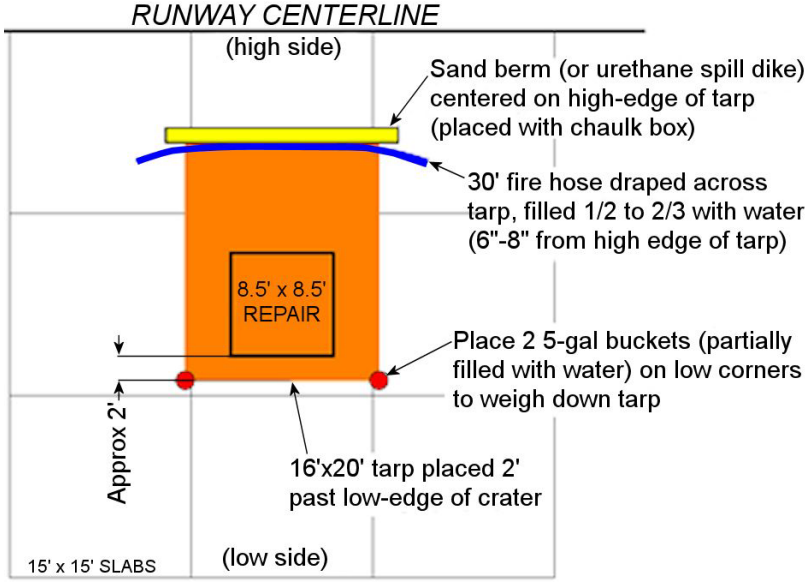
7.1.1.1. Backfill. Attempt to remove as much water as possible from the repair before backfilling. This can be accomplished during the excavation process by scooping as much water out of the repair with the excavator bucket and then removing as much of the remaining water with the water pump from the RADR Tool Trailer. If the bottom of the repair still has standing water, or the soil is saturated, place just enough dry flowable-fill in the bottom of the repair to soak up the remaining moisture. Then, backfill the repair in the same manner as described in **paragraph 4.7.** After the repair has been backfilled to the proper depth (i.e., 10 inches below the surrounding pavement) perform the water mitigation procedures.

7.1.1.2. Water Mitigation Procedures. Once each repair has been backfilled to proper height, the Spall Repair Crew employs the Inclement Weather Kit components (**Table A2.3.**) to keep water out of each repair during the 15 minute backfill cure time (after all repairs have been capped, the Spall Repair Crew begins spall repair process with help from other repair crews). **Figure 7.1.** illustrates component of water mitigation to include optional urethane spill dikes that may be used to robust the configuration.

Note: Place cone under the center of the tarp to prevent water pooling on the tarp.

Note: Use dry sand in the chalk-box to place the sand berm. When dry sand is not available use alternate methods (e.g., water hose, pigs, urethane spill dikes).

Figure 7.1. Water Mitigation Kit Components Employed.



7.1.1.3. Capping the Repair. The volumetric mixer must be loaded under cover and then covered during transport to prevent rain from entering the hopper. Travel time from the covered area to the airfield will most likely require the spare volumetric mixer to be put into a rotational delivery of capping material along with the primary mixer to reduce time between deliveries. Perform the following steps to cap the repair in wet weather:

7.1.1.3.1. Step 1: While under cover, load the volumetric mixers with 6 supersacks of rapid-set material and cover the hoppers with the onboard tarps or aluminum covers. Secure the tarps so they do not blow off during transport.

7.1.1.3.2. Step 2: When the first volumetric mixer arrives at the first repair (and after the 15 minutes backfill material cure time has elapsed), use blowers from the RADR Tool Trailer to remove water from the tarp and then remove the tarp by folding the tarp from the low side of the repair towards the high side without disturbing the sand berm and water hose.

7.1.1.3.3. Step 3: Use blowers to blow any water from the repair before placing capping material. Fuel cans may be obtained from the RADR Tool Trailer to store fuel for the blowers. Two-cycle oil should be acquired during pre-attack actions.

7.1.1.3.4. Step 4: Start the volumetric mixer and begin placing capping material in the repair as described in **Chapter 4**. When material has been exhausted, the volumetric mixer is returned to the covered area to be reloaded with repair material. The second loaded volumetric mixer should be at the repair site when the first volumetric mixer departs to the covered area for replenishment. Continue placing capping material from the second volumetric mixer for the remaining repairs and repeat this process until all repairs have been capped.

7.1.1.3.5. Step 5: After using the screed on the cap, cover the repair with the tarp throughout the 45-minute initial cap cure time.

7.1.1.3.6. Step 6: Repeat the process for the remaining repairs and remove the tarps from each repair after the initial 45-minute cure time.

Note: Perform steps in **Attachment 4** if rapid-set concrete sets-up on the auger and requires emergency swap out (wear proper personal protective equipment and be aware of pinch points around locking pins/plates near mixing well).

7.1.2. Asphalt Cap Repair. Wet-weather conditions may have a negative impact when placing a hot-mix asphalt (HMA) cap. Water mitigation measures must be employed to keep as much water as possible off the repair after backfilling is complete. In addition, HMA storage and transport methods must be altered to prevent the HMA cooling below minimum placement temperatures. Repair procedures are the same as during fair-weather conditions until the repair has been excavated; however, lumber crayons (in place of paint or other marking media) in

the RADR trailer must be used when marking upheaval to prevent the marks from being washed away by the wet conditions. Perform the following procedures when an HMA cap is placed in wet weather.

7.1.2.1. Backfill. Attempt to remove as much water as possible from the repair before backfilling. This can be accomplished during the excavation process by scooping as much water out of the repair with the excavator bucket and then removing as much of the remaining water with the water pump from the RADR Tool Trailer. If the bottom of the repair still has standing water, or the soil is saturated, place just enough dry flowable-fill in the bottom of the repair to soak up the remaining moisture. Two options exist to place backfill in wet weather: volumetric mixers with covers installed, or the "slash and splash" method as described in the fair-weather backfill procedures under a rapid-set concrete cap.

7.1.2.1.1. Volumetric Mixer Backfill Method. Fill hoppers under cover and then extend the on-board cover over hoppers before leaving overhead cover. Load mixers on a rotational basis using the spare volumetric mixer per team. Then, follow procedures described in **Chapter 4**. After backfilling the repair, immediately begin water mitigation procedures described in **paragraph 7.1.1.2**.

7.1.2.1.2. "Slash and Splash" Backfill Method. This is a stop-gap measure only to be used during wet weather; repairs will not be of the same quality and are not likely to last as long as when using the volumetric mixer during backfill. Follow procedures described in **paragraph 4.7.1.** when using this method. The only deviation is to backfill the repair until backfill reaches 4 inches below parent slab surface. When complete, immediately begin water mitigation procedures described in **paragraph 7.1.1.2**.

7.1.2.2. Capping the Repair.

7.1.2.2.1. Step 1: After the 30-minute initial backfill cure time, use blowers from the RADR Tool Trailer to remove water from the tarp and then remove the tarp by folding the tarp from the low side of the repair towards the high side without disturbing the sand berm and water hose. Ensure there is enough room between

the edge of the repair and the folded back tarp to allow a frontend loader to travel between the repair and tarp.

7.1.2.2.2. Step 2: Use blowers to blow any water from the repair before placing HMA capping material.

7.1.2.2.3. Step 3: Dump trucks with bed covers should be at the repair ready to dump HMA as the repair's water mitigation tarp is being removed. Before dumping, the spotter checks the HMA temperature with a digital infrared thermometer to verify it is 280°F or hotter as required for break down rolling. If the HMA is equal to or greater than the minimum required temperature, carefully dump the proper amount of HMA directly into the repair. Use blowers to divert water from the repair during the placement of the HMA.

7.1.2.2.4. Step 4: The front-end loader should be prepositioned on opposite sides of the repair as HMA is dumped into the repair. After the dump truck has finished dumping HMA and moved out of the way, the front-end loader evenly spreads the HMA across the entire repair until the cap is approximately 1.5 inches, ±0.25 inches, higher than the runway surface.

Note: Adjust overfill height if the cap thickness is not exactly 4 inches deep.

7.1.2.2.5. Step 5: During asphalt placement and spreading, helpers assist with placing, cleaning, and preparing the edges using lutes and/or square shovels.

7.1.2.2.6. Step 6: When repair is overfilled to the appropriate height, the mat is ready for rolling; place the tarp over the cap and conduct rolling as follows:

a. 0.5 pass (parallel to center line) with steel-wheel roller, no vibration

b. 2.5 passes (parallel to center line) with steel-wheel roller, vibration on

c. 2 passes (parallel to center line) with pneumatic roller

d. 1 pass with steel-wheel roller, no vibration

e. Remove tarp and complete 2 passes (longitudinal with crown of runway) with steel-wheel roller, no vibration

Note: If check cracking is noted in the mat or if there is evidence of chipping of concrete edges, grooves, or joints, turn off vibration and add an additional half pass for step "a" and decrease step "b" to 2 passes.

Note: It is necessary for the asphalt cap to be 150°F or less before receiving initial vehicle traffic (2.5-ton vehicle for FOD prevention or paint striping), and 125°F or less before receiving aircraft traffic.

7.1.2.2.7. Step 7: The natural cooling process takes approximately 2 hours to reduce asphalt temperature to 150°F (depending on environmental conditions). Rain will help reduce cooling time; however, if rain is very light or intermittent, the water truck operator will flood repairs with water. Repairs are flooded as asphalt begins to develop a dry area. The operator should flood a repair briefly and move to the next repair alternating between repairs as required. When repairs reach 150°F the water truck operator removes cones identifying the repair zone, signaling to the Striping Crew and FOD Team that the work area is open.

7.2. Heat Above 74°F. In warmer climates, an additive with the ability to extend set time of rapid setting concrete is required. If rapid setting concrete sets too quickly, the concrete could cause malfunction of the volumetric mixer or not allow sufficient finish time for the crater repair. This same additive is not required for flowable fill but can be used to slow flowable fill set time in case of an emergency. The additive used for slowing set time is citric acid (anhydrous) in powder form. The material is typically purchased in 50 lb. bags and stored in 50 lb. buckets inside RADR material containers for both flowable fill and rapid setting concrete.

7.2.1. The manufacturer's recommendations and field experience were used to develop the recommended dosage rate for citric acid (**Table 7.1.**) when placing rapid setting concrete at various temperatures. The citric acid should be added to an empty five-gallon bucket along with one to two gallons of water and stirred

briefly before adding to the volumetric mixer water tanks. In emergency situations, where rapid setting concrete or flowable fill is beginning to setup (particularly on the auger), it is recommended that 2 to 3 pounds of citric acid be mixed with one to two gallons of water and applied to the setting up repair material. This action will slow the set time to help aid in the cleanup process.

Table 7.1. Citric Acid Dosage Recommendations for Rapid Set Concrete.

Ambient Temperature (°F)	Citric Acid Dosage (lbs. per 50 gallons of water)
Below 75	0
75-79.9	1
80-84.9	2
85 and above	3

7.2.2. To reduce logistics of measuring citric acid during repairs, citric acid is packaged as shown in **Figure 7.2**. Fifty pounds of citric acid are stored in six-gallon buckets with screw-on lids. A plastic scoop that holds approximately one pound of citric acid is stored inside the bucket so the citric acid can be measured easily before adding to the mix water tanks. Instructions are displayed on the outside of the bucket as a quick reference.

Figure 7.2. Citric Acid Stored in Bucket.

7.2.3. In hot climates, draw water early in the morning and if not used immediately, place water vessel under cover to shield from the sun. If necessary, ice may be added to the water to cool below 70°F.

7.3. Cold Weather Below 50°F. In colder climates, an additive with the ability to reduce set time of rapid setting concrete may be required. If the rapid setting concrete sets too slowly, the concrete may not cure within the 2-hour requirement to support aircraft traffic. Use aluminum sulfate additive to meet the curing time. This additive is not in the crater repair UTC and must be sourced, purchased, and stocked in locations where climates fall below 50°F.

7.3.1. The aluminum sulfate in powder form should be added to approximately 5 gallons of water to form slurry before being added to the volumetric mixer water tanks.

7.3.2. **Table 7.2.** displays the recommended dosage rates for aluminum sulfate per super sack of dry concrete material based on the ambient temperature. If the ambient temperature is between the temperatures listed, the lower temperature should be used to maintain conservatism. The RADR rapid setting concrete mix is not recommended for use below 15˚F.

Table 7.2. Recommended Dosage Rates for Aluminum Sulfate.

Ambient Temperature (°F)	*Dosage Rate (lb./super sack)
50 and above	None
45	9
40	12
35	15
30	18
25	24
20	29
15	35
*Recommend dosage rate per 3,000-lb super sack of dry concrete material	

7.4. Nighttime Operations. Six light carts are included with each 4FWCR UTC. Four are designated for lighting the airfield repair zone and should be towed to the airfield if repairs are expected to be performed during darkness. The remaining two are designated for warehouse and batch plant operations.

7.5. Camouflet Repair. Explosive Ordnance Disposal (EOD) teams should investigate and mitigate any UXO within the camouflet. Afterwards, pavement will be cut just beyond the void to ensure a sound base exists under the edge of the parent pavement and the camouflet will then be repaired as a crater.

Chapter 8

RAPID SPALL REPAIR

8.1. Introduction. Aircraft cannot land or takeoff until spalls have been repaired. Spall repair must be completed within the same 6.5 hours as crater repair, Emergency Airfield Lighting System (EALS) installation, aircraft arresting system (AAS) installation, and Minimum Airfield Operating Surface (MAOS) marking and striping. Spalls are defined as pavement damage that does not penetrate the full pavement thickness to the underlying soil layers, is not larger than five feet in diameter, or no upheaval in surrounding pavements (**Figure 8.1.**). Thousands of spalls will be expected after an attack, possibly hundreds will require repair.

Figure 8.1. Spall and Crater Profiles.

8.2. Resources. Table 8.1. identifies the Expeditious Spall Repair resources (UTC 4FWSR) and required crew personnel. The smallest operational capability fielded is a Medium Capability, which has 3 spall crews (9 personnel). Large Capabilities have 15 spall repair personnel and the Very Large Capability have 21 spall repair personnel. Therefore, teams have the flexibility to configure their crews to best meet their situation.

Note: Small capabilities are located at Air Force Civil Engineer Center sponsored training sites.

Table 8.1. Spall Crew Required Resources per Small Capability.

Position	Suitable AFSCs	Veh/Equip/Tools
Lead	3E1X1, 3E3X1, 3E2X1	P/U with utility trailer or 1.5 Ton Stake bed
Operator	3E1X1, 3E3X1, 3E2X1	
Operator	3E1X1, 3E3X1, 3E2X1	

8.2.1. Crew Size Recommendations. The scope of spall damage will most likely govern crew size. Experimentation has shown a 4-person spall repair crew is the optimal crew size for spall repair operations. However, there are instances when a 3-person and/or 5-person crew may be more appropriate; fatigue plays a large roll when determining crew sizes.

Note: Crew performance may differ from the following examples due to personnel experience, personnel skills, equipment condition, etc.

8.2.1.1. Through testing it has been determined a 3-person crew can repair an average of 40 spalls per hour. Therefore, it appears this crew can repair up to 260 spalls within the 6.5-hour recovery time if they had enough repair material; however, this would only be the case in ideal conditions without factoring in personnel fatigue and cure time.

8.2.1.2. Factoring in fatigue, environmental conditions (e.g., extreme heat), and threat conditions requiring personal protective gear (e.g., battle rattle, chemical ensembles, etc.), it is a given the crews' production rate will decrease over time. In addition, cure time for the last spall repair before aircraft trafficking is 2-hours. **Table 8.2.** shows testing results for production rates of three spall repair crew sizes over a 4.5-hour period.

Table 8.2. Production Rates.

Crew	Hour 1	Hour 2	Hour 3	Hour 4	Final 30 mins	Total
3-Person	40	39	38	34	13	164
4-Person	50	49	47	40	16	202
5-Person	65	65	63	58	26	277

8.2.1.3. As mentioned earlier, a Medium Capability has 9 spall repair personnel. This provides the flexibility of having multiple crew sizes to meet the scope of damage. The Crater Repair Chief may choose to have three 3-person crews; two 4-person crews; one 4-person crew and one 5-person crew; one 3-person crew and one 4-person crew; one 3-person crew and one 5-person crew; or only one of either of the three crews. If the spall repair personnel are left over after selecting crew sizes, the extra people may be used for resupplying the spall repair crews (see **paragraph 8.4.**).

8.2.1.4. The Crater Repair Chief has even more flexibility with Large (15 spall repair personnel) and Very Large Capabilities (21 spall repair personnel). The possible crew sizes and numbers increase exponentially. **Table 8.3.** provides a simplified example of determining numbers of spall repair crews related to workload. For example: if there were 450 spalls and the installation had a Medium Capability, assemble one 4-person crew and one 5-person crew.

Table 8.3. Examples of Spall Repair Crews to Assemble per Workload.

Spall Qty	Very Large Capability (21 persons)	Large Capability (15 persons)	Medium Capability (9 persons)	Small Capability (3 persons)
	Crew Sizes	Crew Sizes	Crew Sizes	Crew Sizes

	3	4	5	3	4	5	3	4	5	3	4	5
150	1			1			1			1		
200		1			1			1		1		
250			1			1			1			
300	2			2			2					
350	1	1		1	1		1	1				
400		2			2			2				
450		1	1		1	1		1	1			
500	2	1		2	1		3					
550			2			2	3					
600		3			3		3					
650		2	1		2	1						
700	1		2	1		2						
750		1	2		1	2						
800			3	2	1	1						
850	2		2			3						
900	1	1	2			3						
950		2	2			3						
1000		5				3						
1050	2	1	2									
1100			4									
1150	2		3									
1200	2		3									
1250	2		3									
1300	2		3									
1350	2		3									

1400	2		3	

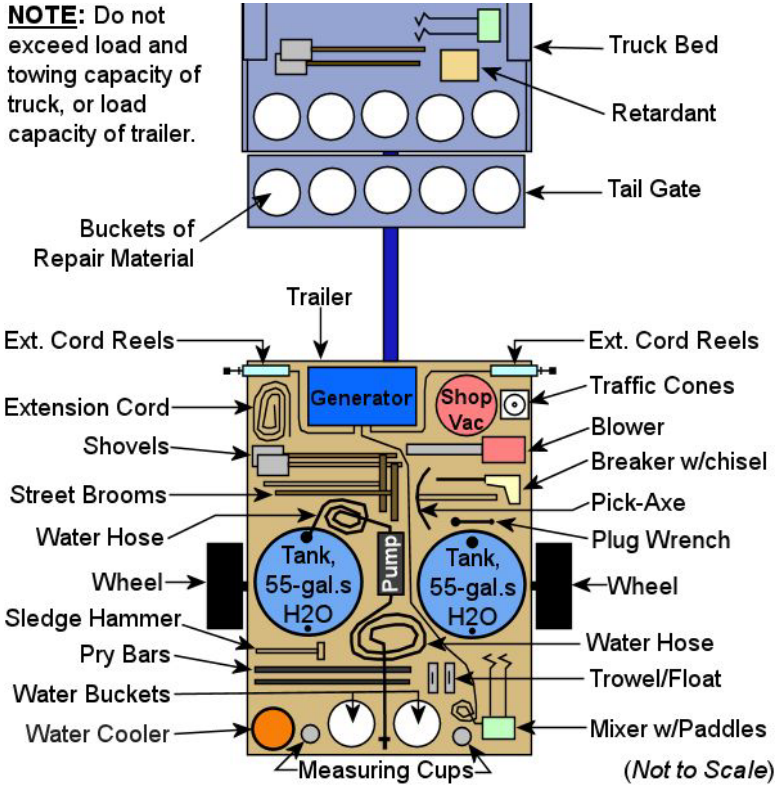
8.2.2. Equipment and Tools. The 4FWSR UTC inventory, for a 3-person crew, is found in **Table A2.4**. A Medium Repair Capability has three UTCs with equipment and tools for 9 persons, a Large Repair Capability has enough equipment and tools for 15 persons, and a Very Large Capability supports 21 persons.

8.2.3. Vehicle Configuration Recommendations. Ideally, the vehicle configuration should be capable of carrying all consumables and equipment necessary to complete repairs for assigned spall field(s) without having to restock. However, spall repair vehicles used for airfield recovery will be shop and/or Basic Expeditionary Airfield Resources (BEAR) vehicles and there is no way of knowing what vehicles will be available. When work is expected during darkness, ensure wobble lights, head-mounted lamps, and trouble-lights are loaded on vehicles. Whatever configuration is used, the vehicle load and towing capacities should not be exceeded. Recommended vehicle configurations follow:

8.2.3.1. Six-Pack Pickup with Utility Trailer. This is the preferred vehicle configuration (**Figure 8.2.**). The trailer eliminates the need to unload mixing material/equipment at each stop; thereby, increasing speed of repairs and lessening fatigue of crew members. Without the trailer, this vehicle does not have enough capacity or cargo space to be useful for the spall repair mission. The trailer provides load capacity to complete large numbers of repairs without continuously restocking consumables (i.e., water and repair material). The truck must have an appropriate hitch for the trailer connection. **Figure 8.3.** provides stocking recommendation for the truck and trailer.

Figure 8.2. Six-pack Pickup with Utility Trailer.

Figure 8.3. Recommended Pickup and Trailer Stocking Configuration.

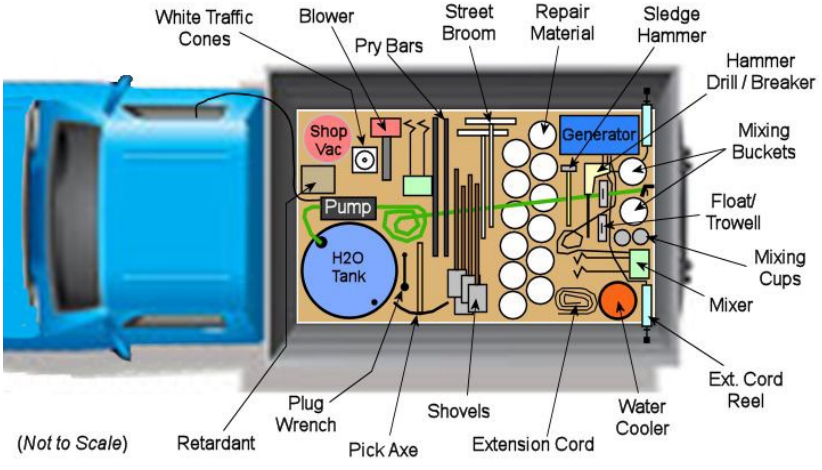


8.2.3.2. 1-Ton Stake-bed Truck**.** Other than the six-pack, the 1-ton stake-bed truck (**Figure 8.4.**) is the most likely vehicle available to perform expeditious spall repair after an attack. Its advantage is twice the load capacity of the six-pack (when there is no utility trailer available). However, its load capacity is still limited and must be restocked often with consumables. A 1.5- or 2-ton stake-bed truck is preferable to reduce the need of restocking. If available, an electric lift-gate would

ease the process by keeping the lift-gate 12 to 18-inches above the pavement surface and use it as the mixing station surface. This eliminates the need to unload and load the mixing buckets, cups, and mixer at every stop. Removing the side rails may improve access to cargo. See **Figure 8.5.** for the recommended load configuration for the equipment and materials.

Figure 8.4. 1-ton Stake-bed Truck.

Figure 8.5. 1-ton Stake-bed Truck Recommended Load Configuration.



8.2.4. Repair Material. The spall repair UTC materials are on the Approved Spall Repair Products List found on the Tri-Service Transportation website at https://transportation.erdc.dren.mil/cacsites/TriService/pavement_repair.aspx. The kit contains enough material to repair approximately 200 spalls with an average size of 24-inches in diameter and 6-inches deep. When replenishing the kit, ensure only items on the approved list are ordered. Follow manufacturers' instructions for mixing and placing material. Some approved material is self-leveling after mixing while some require finishing with a steel trowel or magnesium float. Mixing repair material is best performed by adding the material to water rather than adding water to the material. When possible, add proper amount of water to an empty five-gallon bucket and then add repair material to better achieve thorough mixing.

Note: Individuals mixing repair material should wear a respirator from drawer #1 of the RADR Tool Trailer.

8.2.5. Water Supply Set Up. Arrange water supply assets as shown in **Figure 8.6**. Use item 7 when a power-port is available inside the cab; otherwise, use item 8 to connect the pump to the vehicle battery. The on-demand pump starts and stops automatically as the spray nozzle is opened and closed.

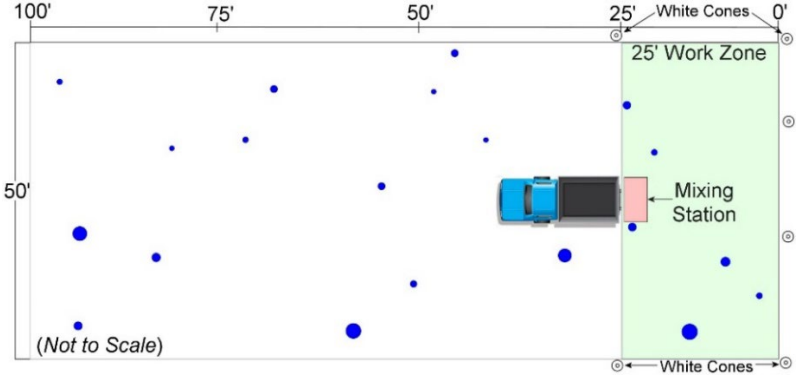
Figure 8.6. Water Supply Set Up.

ITEM	DESCRIPTION	QTY
1	Drum, poly, open head, 55 gal.	2
2	Wrench, drum bung, 10” lg	1
3	Hose, garden, 50’	3
4	Connector, brass, double male	4
5	Pump, 12V, on-demand	2
6	Cable, 12.5’ power ext., 2-pin	1
7	Adapter, power port, 2-pin	1
8	Adapter, battery clips, 2-pin	1
9	Nozzle, garden hose	2
10	Bucket, 5 gal. w/lids	2

8.3. Repair Process. After vehicles/trailers have been loaded, perform expeditious spall repairs as follows:

8.3.1. Identify Repair Zone. The repair zone is the area of a spall field where repairs occur each time the vehicle stops. The recommended repair zone is 50-ft wide by 25-ft long (**Figure 8.7.**). If the minimum operating strip (MOS) is wider than 50 feet, consider making additional passes with the same crew or additional crews.

Figure 8.7. Repair Zone.



8.3.1.1. When using one crew for a full width runway, first repair spalls down the center of the MOS at the width of the aircraft wheel path so they cure within the established deadline. Then, while going in the opposite direction, repair spalls down one side of the runway. Finally, reverse direction and complete the spalls on the opposite/final side of the runway. Otherwise, three crews may work to cover the full MOS width simultaneously.

8.3.1.2. Mark spall fields with white cones (located within the spall repair kit) to prevent vehicle traffic over repairs while curing. Repairs may be trafficked by vehicles after 45 minutes of curing time and aircraft after 2 hours of curing time.

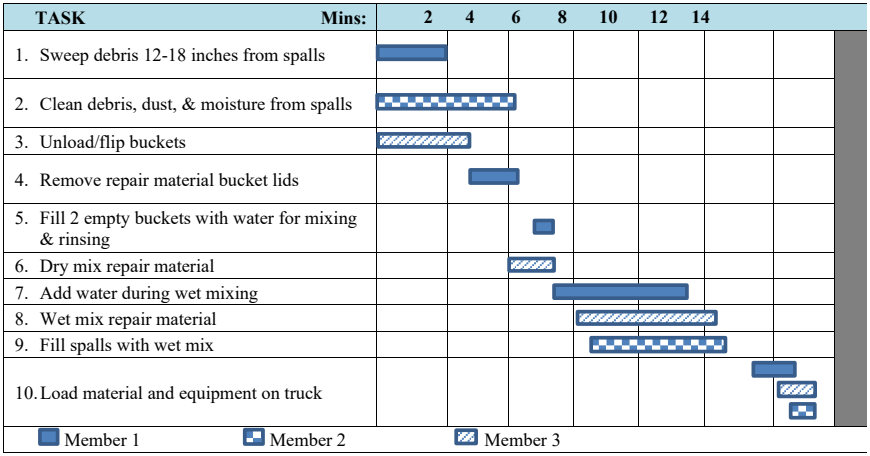
8.3.1.3. Damage penetrating the full pavement depth must be repaired by the crater repair crews. Notify Crater Repair Team Lead of the damage and mark the

damage within spall fields by laying a white cone on its side to notify the crater repair team.

8.3.2. Concrete Spall Repairs. Spall repairs during airfield recovery will be expeditious temporary repairs. Table 8.4 lists the steps, personnel that perform each step, and time associated with each step. Consider rotating responsibilities at each repair zone to limit fatigue to any one individual. Adjust responsibilities when increasing crew size.

Note: When time permits after initial recovery, repairs will be re-accomplished with permanent repairs IAW AFTTP 3-32.16, *Sustaining Airfield Pavement at Contingency Locations*.

Table 8.4. Three-Person Crew Process at Each Repair Zone.



8.3.2.1. Repair Preparation. To help ensure a suitable bond, the spall must be cleaned and standing water removed before placing repair material in the spall.

8.3.2.1.1. If upheaval is apparent, or damage has penetrated completely through the pavement to underlying soil structures (**Figure 8.8.**), mark the spall with a white cone on its side, inform the Crater Repair Team Lead of the situation and move on to the next repair.

Note: When upheaval is apparent, it must be removed either manually with a jackhammer, saw, or compact track loader with a planer attachment (all available on the ADR work-tool attachment trailer).

Figure 8.8. Spall Prepared for Expeditious Repair.

8.3.2.1.2. Using a push broom, one crew member sweeps large debris at least one foot around the entire perimeter of the spall.

8.3.2.1.3. Another crew member starts the generator and using the electric blower or shop vacuum completely removes large chunks of debris, dust, and standing water from the spall. Keep the one-foot clean space around the spall. If loose pieces of debris cannot be removed by hand, remove them with a pickaxe, pry bar, sledgehammer, or impact hammer/breaker. **Figure 8.8.** shows a properly prepped spall ready for repair.

8.3.2.2. Repair Material Preparation. A third crew member estimates amount of spall repair materials required to perform repairs in the repair zone and unloads this amount from the truck and places buckets at the mixing station.

Note: One bucket on average can repair a 16-inch diameter spall, two inches deep.

8.3.2.2.1. The repair material consolidates during storage; therefore, tumble the buckets end-over-end six to eight times in order to break apart the solid chunks of condensed dry mix into smaller, more manageable pieces when dry mixing with the power mixer.

Note: This step may be conducted during pre-attack actions to save time during recovery.

8.3.2.2.2. By this time the first member should be finished clearing debris from the spalls. He/she removes bucket lids and fills two 5-gallon buckets with water from the water tank and places them at the mixing location.

Note: The water buckets require constant filling for mixing as well as for cleaning the mixer paddles and floats/trowels to prevent repair material buildup.

Note: Individuals mixing repair material should wear a respirator from drawer #1 of the RADR Tool Trailer.

8.3.2.2.3. Plug the power mixer (**Figure 8.9.**) into the generator and plunge the paddles into the dry mix with a continuous and rapid rotation of the mixer head until all material is disturbed and has a “fluffy” appearance (approximately 30 seconds).

Note: This step may be conducted during pre-attack actions to save time during recovery.

Figure 8.9. Power Mixer.

8.3.2.2.4. Once material has been thoroughly dry-mixed and spalls within the repair zone have been prepared (i.e., debris, dust, and water removed) slowly add the manufacturers recommended amount of water to the repair material bucket while mixing (**Figure 8.10.**). Mix material until all dry spots have disappeared and a consistency of pancake batter is achieved (approximately 1.5 to 2 minutes).

Note: Rinse paddles in water bucket after mixing each bucket.

Figure 8.10. Adding Water While Mixing Repair Material.

Note: All rapid-setting concretes react differently in various environmental/ climatic conditions. Therefore, the mixer operator must pay particular attention to how quickly the material appears to be setting up. The mixer operator determines how long each mix will be mixed and when the mix is considered unsuitable for repairs and should be discarded.

Note: When temperatures are greater than 90° Fahrenheit the material is likely to start setting either before mixing is complete, while carrying the material to the spall, and/or while filling the spall. Conversely, when temperatures are less than 40° Fahrenheit, or where humidity is excessive, the same mix may not set for hours. Admixtures (retarders/accelerators) are utilized to mitigate these conditions (**Figure 8.11.**).

Figure 8.11. Retardant Admixture.

8.3.2.3. Placing Repair Material. Once a uniform wet-mix has been achieved, the member finished cleaning the spalls now quickly carries and places wet mixed material in the clean spalls.

8.3.2.3.1. Depending upon the type of repair material and environmental conditions, it may readily flow (**Figure 8.12.**) into all exposed voids/cracks until reaching the surrounding pavement surface, or may require floating and/or troweling (**Figure 8.13.**) to ensure material fills all exposed voids/cracks and to achieve a smooth and flush finish. Avoid feathering material beyond perimeter of the repair; material on the parent surface may become a FOD potential.

Note: When troweling is required, do not spend excessive time attempting to achieve a perfectly smooth and flush surface.

Figure 8.12. Self-Leveling Mix.

Figure 8.13. Mix Requiring Floating/Troweling.

8.3.2.3.2. Slightly overfill the repair, not greater than 0.25-inch (**Figure 8.14.**), to compensate for settlement during hydration.

Note: A magnesium float or steel trowel should be readily available in the event of overspill or when the material sets up too quickly leaving a rough surface texture that may cause aircraft tire damage if not smoothed (**Figure 8.15.**). Excess material must quickly be removed before it sets and placed back in the bucket to prevent a FOD potential.

Figure 8.14. Correctly Filled Repair.

Figure 8.15. Smoothing Repair with Trowel.

8.3.2.4. Transport to Next Repair Zone. Once repairs in the repair zone have been accomplished, all tools, materials, and trash are placed in the transport vehicle and the team moves to the next 25-foot by 50-foot repair zone (**Figure 8.7.**).

8.4. Asphalt Spall Repairs. Perform expeditious asphalt spall repairs in the same manner as described for expeditious concrete spall repairs in **paragraph 8.3.2**. These repairs are not likely to last 100 passes; therefore, they must be constantly monitored and repaired immediately when signs of failure appear. Replace the expeditious repairs with a permanent repair as soon as repair crews are granted time on the MOS.

8.4.1. If upheaval is apparent, place a white cone on its side on the spall, inform the Crater Repair Team Lead of the situation and move to the next repair. Crater Repair Team personnel repair these spalls after all craters in the repair zone have been repaired during crater repair cure time.

8.4.2. The Crater Repair Team should attempt to roll the asphalt upheaval if it appears it can be rolled into place. If unable to roll the upheaval back in place, remove upheaval with a jackhammer, saw, or compact track loader with a planer attachment (all-available on the RADR tool trailer). After airfield recovery, replace the repair with an asphalt patch when time permits.

8.5. Restocking Vehicle(s) with Consumables. Vehicle configuration will determine how often consumables (i.e., water and repair material) are restocked. When comparing **Figure 8.3.** and **Figure 8.5.** it is readily apparent more consumables can be loaded on the truck and utility trailer configuration; therefore, this configuration does not require restocking as often as the 1-ton vehicle configuration. Likewise, 1.5- and 2-ton cargo trucks require less restocking than the 1-ton truck.

Note: The more spall repair crews there are, the more personnel will be required to help keep the crews supplied with consumables. Therefore, any spall repair personnel not tasked may help the warehouse keep the crews stocked.

8.5.1. Using the spall baseline (24-inch diameter by 6-inch deep), the amount of repair material and water (about 1 gallon of water per bucket) the vehicle can

carry, and the number of spalls a crew can repair per-hour, it can be estimated how often each vehicle configuration must be restocked before resources are depleted. See **Table 8.5.** for restocking requirements.

Table 8.5. Spall Repair Consumables Restocking Requirements (mins).

Vehicle Configuration	Repair Material	Water
1-Ton Stake Bed Truck	20	80
6-Pack Truck w/trailer	30	160
1.5-Ton Stake Bed Truck	60	160
2-Ton Stake Bed Truck	80	160

8.5.1.1. Six-Pack Truck and Utility Trailer Configuration. A significant advantage with this configuration is 110 gallons (approximately 8-lbs per gal) of water can be stocked on the trailer along with tools and equipment and the half-ton truck's cargo capacity can be reserved for buckets of repair material, which equates to 20 buckets (approximately 50-lbs per bucket). This configuration can repair approximately 20 spalls before repair material runs out and approximately 110 spalls before the water runs out. According to **Table 8.2.**, it takes approximately 30 minutes for a 3-person crew to repair 20 spalls. Therefore, the warehouse team must restock the truck with repair material every 30 minutes and the water must be restocked every 2 hours and 40 minutes with a water truck from the backfill or capping crew. Restocking intervals are adjusted as fatigue affects production rates.

8.5.1.2. 1-Ton Stake Bed Truck. A significant disadvantage with this configuration is the load capacity of the truck limits the water load to only 55 gallons and the repair material to 15 buckets. Unfortunately, this is the most common vehicle available for spall repair. This configuration requires restocking repair material approximately every 20 minutes and refilling the water tank approximately every 80 minutes initially.

8.5.1.3. 1.5-Ton Stake Bed Truck. This vehicle increases the time between restocking requirements compared to the 1-ton truck. Two 55-gallon water tanks

can be loaded on this truck along with 36 buckets of repair material. This configuration requires restocking repair material approximately every 60 minutes and the water tank refilled approximately every 160 minutes initially.

8.5.1.4. 2-Ton Stake Bed Truck. This vehicle may be loaded with 110 gallons of water and 56 buckets of repair material. This configuration provides the greatest intervals between restocking. Water must be restocked every 160 minutes and repair material is restocked every 80 minutes.

8.6. Spall Repair in Rain. A roll of plastic sheeting is included in the Spall Repair UTC. Load this roll on the vehicle when loading equipment and material. During pre-attack actions, fill several buckets with sand to use for damming around repairs to keep rain from flowing in repairs. Load buckets of sand on the vehicle when rain is expected during repair operations.

8.6.1. Follow procedures from **paragraphs 8.3.2.1** thru **8.3.2.4** above.

8.6.2. If pavement is sloped towards repairs causing water intrusion, use sand to dam around the high side of the repairs to keep water out.

8.6.3. With a wet-mixed bucket of repair material ready, vacuum or blow standing water out of the spall and immediately pour repair material in the spall.

8.6.4. As material is placed in the spall, cut a piece of plastic large enough to overlap the surrounding parent pavement by at least four inches. Immediately after repair material is placed, cover the repair with plastic and anchor plastic sheet edges with debris to resist wind from blowing plastic off the repair.

Note: This action slows repair set time.

8.6.5. Once all spalls have been repaired, return to original starting point and remove plastic covers from repairs and place plastic in an empty bucket to be discarded later.

8.7. Spall Repair Complete. The Spall Crew informs the Crater Team Lead when spall repair is complete to receive their next assignment.

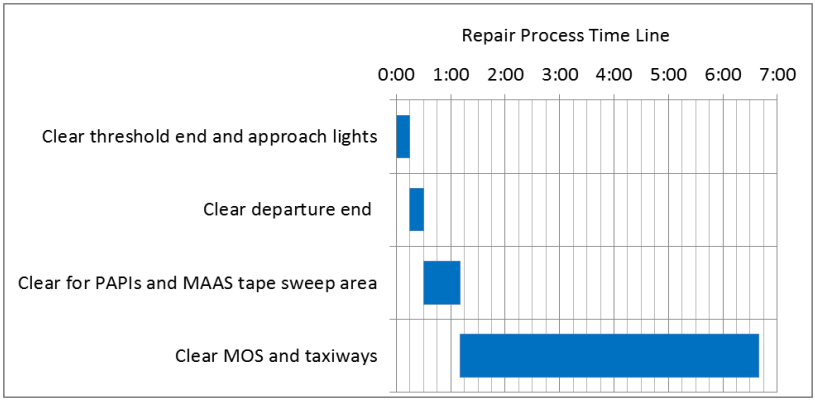
8.8. Permanent Spall Repair. When conditions return to normal operations, upgrade expeditious repairs with permanent repairs as described in UFC 3-270-01, *O&M Manual Asphalt and Concrete Pavement Maintenance and Repair.*

Chapter 9

FOREIGN OBJECT DEBRIS REMOVAL

9.1. Overview. This team provides the capability to remove large and small debris from the convoy routes, crater repair areas, perform initial and simultaneous sweeping operations on the airfield and around the crater repair areas, and perform final sweeping operations before aircraft trafficking can begin. One foreign object debris (FOD) Removal Team supports all Rapid Airfield Damage Recovery (RADR) capabilities (i.e., small, medium, large, and very large). For example, if the installation has a Medium RADR Capability, only one FOD Removal Team is postured to support the three repair teams. It may be augmented with debris removal equipment and compact track loaders (CTL) from the crater repair teams with broom attachments. See **Figure 9.1.** for recommended order of operations after clearing the convoy routes and material delivery paths on the runway.

Figure 9.1. Recommended Order of Operations.



Note: The following debris removal data was collected during a RADR exercise at Kadena AB and may be useful for planning purposes:

- Time to remove and broom 3’ x 10’ x 100’ debris berm from side of runway: 55 minutes

- Time to remove 1” minus debris, no higher than 3’, from a 75’ x 300’ area: 1.5 hours

- Time to sweep and vacuum 75’ x 300’: 1.75 hours

9.2. Runway Cleanliness Standards. The peacetime standard of cleanliness for runways and taxiways requires that they be kept free of any debris that could cause damage to aircraft. In wartime, the runway surfaces will be extensively covered with debris after an attack; no equipment available can rapidly clear the surface to peacetime standards. In any case, the risk to aircraft being launched from a “dirty” runway is much less than if during an attack aircraft were caught sitting on the ramp waiting for sweeping operations to be completed.

9.2.1. Different standards of cleanliness can be achieved by using various combinations of equipment in the RADR equipment sets. Tests have shown that very little benefit is achieved by making more equipment coverages than the following recommendations:

9.2.1.1. The cleanest surface is achieved by making one fast (4 to 5 mph) sweep of the area with a grader, followed by two coverages with a vacuum sweeper traveling at 3.5 to 4 mph.

9.2.1.2. Achieve a clean surface by conducting one fast (4 to 5 mph) grader coverage followed by one coverage with a kick-broom traveling approximately 5.5 mph. These speeds are effective only if debris is mostly dry. If debris is wet and sticky, a broom cannot produce a good clean surface.

9.2.1.3. A slow (2 to 3 mph) grader coverage followed by a second, faster (3 to 5 mph) coverage will leave a “dirty” surface, because more large stones are left on it.

9.2.1.4. The “dirtiest” surface, but fastest operation, is left by conducting one “fast” (4 to 5 mph) coverage with a grader only.

9.3. Resources. Table 9.1. identifies the resources required for the FOD removal process.

9.3.1. **Vehicles.** Vehicles for the FOD Removal Team are provided by UTC 4FWFD, usually during airfield recovery operations at main operating bases (MOB) when time is of the essence. See **Table 9.1.** for a complete list of the FOD Removal Vehicle Set.

9.3.2. **Personnel.** Personnel on the FOD Removal Team are sourced from permanently assigned personnel at a MOB and/or beddown forces at a contingency location. When forces are sourced specifically for FOD removal duties task two Pavements/Construction Teams (4FPAS).

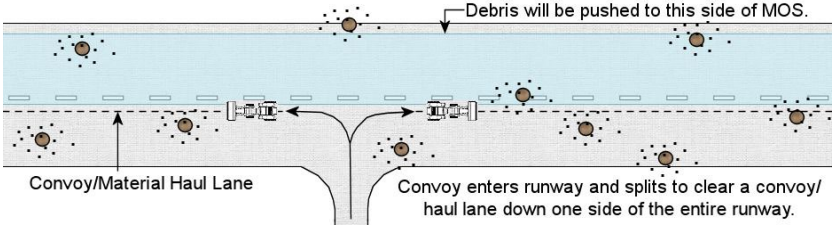
Table 9.1. FOD Removal Resources.

Position	Suitable AFSCs	Veh/Equip/Tools
Team Lead	3E2X1	Grader, tractor-trailer, dozer
Operator	3E2X1	Grader
Operator	3E0X1, 3E0X2, 3E1X1, 3E2X1, 3E3X1, 3E4X3, 3E5X1, 3E6X1	Front-End Loader
Operator	3E2X1, 3E4X3	Ind. Tractor w/kick broom
Operator	3E2X1, 3E4X3	Ind. Tractor w/kick broom
Operator	3E0X1, 3E2X1	Vacuum sweeper
Operator	3E0X1, 3E2X1	Vacuum sweeper
Operator	3E0X1, 3E2X1	Vacuum sweeper
Note: The Lead's primary vehicle is the grader; if the dozer is required to remove damaged aircraft from the Minimum Airfield Operating Surface (MAOS), the lead will haul the dozer to the airfield with the tractor-trailer first and then return to retrieve the grader.		

9.4. Process. Sweep all areas to be trafficked by aircraft even if debris appears minimal. It is essential to remove as much shrapnel as possible since even small pieces of sharp metal can damage tires. The following steps are recommended in the FOD removal process.

9.4.1. Step 1: The FOD Team leads the convoy to the runway. Upon arrival, the FOD Removal Team should split into two crews (augmented by one loader from each crater repair team) and each crew clears a 25 feet wide convoy/material haul lane down the entire minimum operating strip (MOS) (**Figure 9.2.**). The Rapid Airfield Damage Recovery Officer in Charge (RADR OIC)/Crater Chief should direct which side of the minimum operating strip (MOS) the haul lane will be cleared. Debris will be moved to the opposite side.

Figure 9.2. FOD Team Clearing Haul/Material Lane.



9.4.2. Step 2: After clearing the haul lane, the FOD Removal Team clears the threshold and departure ends. After the ends of the runway have been cleared, the crater repair team loaders return to their respective teams.

9.4.3. Step 3: Make a single coverage about 15 feet wide with the grader 1,400 feet down the centerline of what will be the overruns of the MOS to provide open access for approach lighting placement.

9.4.4. Step 4: Clear a path about 15 feet wide from the MOS to the Precision Approach Path Indicator installation location.

9.4.5. Step 5: Clear a path about 25 feet wide from the MOS to the aircraft arresting system (AAS) installation locations.

9.4.6. Step 6: Clear parking aprons and taxiways. A better standard of sweeping is required on parking aprons and uphill sections of the taxiway where the aircraft needs to use more power and is therefore likely to ingest more debris. Use a kick broom sweeper or second grader coverage at these locations.

9.4.7. Step 7: Clear the MOS as follows:

9.4.7.1. Clear the first 300 feet (the most critical area) with a vacuum sweeper.

9.4.7.2. Clear the next 800 feet with a vacuum sweeper, if possible.

9.4.7.3. Clear remainder of MOS with kick broom sweeper or by two passes with the grader.

9.4.8. As time and vehicles permit, remove as much FOD as possible from all airfield pavements to be used for launch and recovery purposes. Sweeper support will be in high demand and plan to make frequent trips to the MOS for FOD clean up—aircraft activity and winds will continually blow additional debris across the airstrip. Once airfield pavement debris clearance is under control, you can expect demands from wing leadership to clean base thoroughfares leading to the flightline from maintenance facilities, munitions storage areas, and petroleum oil and lubricant storage sites.

Note: The FOD Removal Team will most likely operate as a distributed team to adequately support all recovery teams. As such, it is critical for the Command and Control (C2) element to be kept informed of clearing operations and upcoming requirements. The FOD Removal Team departs the MAOS after the Airfield Management Team has accepted the MAOS for operations.

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DCS/Logistics, Engineering & Force Protection

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References

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Prescribed Forms

None

Adopted Forms

DAF Form 847, *Recommendation for Change of Publication*, 15 Apr 2022

Abbreviations and Acronyms

AFTTP—Air Force Tactics, Techniques, and Procedures
ATO—Air Tasking Order
CE—Civil Engineer
CFR—Code of Federal Regulations
CPM—crater profile measurements
CTL—compact track loader
CY—cubic yard
EOC—Emergency Operations Center
FOD—foreign object debris
HMA—hot mix asphalt
MAOS—Minimum Airfield Operating Surface
MOS—Minimum Operating Strip
NIOSH—National Institute of Occupational Safety and Health
OIC—Officer in Charge

PPE—Personal Protective Equipment

OPR—office of primary responsibility

RADR—Rapid Airfield Damage Recovery

T.O.—technical order

UTC—Unit Type Code

UXO—unexploded explosive ordnance

Terms

Airfield—An area prepared for the accommodation (including any buildings, installations, and equipment), landing, and takeoff of aircraft.

Air Tasking Order (ATO)—A method used to task and disseminate to components, subordinate units, and command and control agencies projected sorties, capabilities and/or forces to targets and specific missions. Normally provides specific instructions to include call signs, targets, controlling agencies, etc., as well as general instructions.

Airfield Damage Assessment—Locating, classifying, and measuring the damage (camouflet, crater, spall, and UXO) on the airfield operating surfaces.

Alarm Black—An alert condition signifying the attack is over, but chemical agent contamination is possible. Personnel are cleared to leave shelters but must wear chemical protective ensembles.

Alarm Yellow—An alert condition generally established when an attack is expected within 30 minutes or less. This allows forces to take protective actions.

Apron—A defined area on an airfield intended to accommodate aircraft for the purposes of loading or unloading passengers or cargo, refueling, parking, or maintenance.

Contingency—A situation requiring military operations in response to natural disasters, terrorists, subversives, or as otherwise directed by appropriate authority to protect US interests.

Camouflet—Craters with relatively small apparent diameters, but deep penetration and subsurface voids created by the munition puncturing through the pavement surface and exploding in the underlying material. **Note:** Munitions that penetrate the surface but do not explode are also treated as a camouflets.

Command and Control (C2)—The exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission. C2 functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.

Contingency—An emergency involving military forces caused by natural disasters, terrorists, subversives, or by required military operations. Due to the uncertainty of the situation, contingencies require plans, rapid response and special procedures to ensure the safety and readiness of personnel, installations, and equipment.

Crater—The pit, depression, or cavity formed in the surface of the earth by an explosion. It may range from saucer-shaped to conical, depending largely on the depth of burst.

Crater Field—A cluster of small craters (less than two feet apart) where their upheaval joins the neighboring crater within a defined area.

Damage Assessment—The process of identifying and locating damage and unexploded ordnance following an attack. Damage assessment activities generally are separated into two categories: airfield pavements and facility/utility.

Debris—Material ejected from the crater including broken pavement and soil. Debris is some-times usable as backfill material particularly for large crater repair, but for small crater or spall repair it is generally not advisable.

Dispersal—Relocation of forces for the purpose of increasing survivability.

Emergency Operations Center (EOC)—A temporary or permanent facility where the coordination of information and resources to support domestic incident management activities normally takes place.

Explosive Ordnance—All munitions containing explosives, nuclear fission or fusion materials, and biological and chemical agents.

Explosive Ordnance Disposal (EOD)—The detection, identification, on-site evaluation, rendering safe, recovery, and final disposal of unexploded explosive ordnance. It may also include explosive ordnance which has become hazardous by damage or deterioration.

MAOS Selection—The process of plotting damage and UXO locations on an air-base runway map and using this information to select a portion of the damaged runway which can be repaired most quickly to support aircraft operations.

Minimum Airfield Operating Surface (MAOS)—The combined requirement for airfield surfaces for both runway, access routes and aircraft parking areas. The MOS is part of the MAOS.

Minimum Operating Strip (MOS)—1. A runway which meets the minimum requirements for operating assigned and/or allocated aircraft types on a particular airfield at maximum or combat gross weight. 2. The MOS is the smallest area to be repaired to launch and/or recover aircraft after an attack. Selection depends upon mission requirements, taxi access, resources available, and estimated time to repair. For fighter aircraft, the typically accepted dimensions are 5,000 feet long by 50 feet wide.

Ordnance—Explosives, chemicals, pyrotechnics, and similar stores, e.g., bombs, guns and ammunition, flares, smoke, or napalm.

Pavement Upheaval—The vertical displacement of the airfield pavement around the edge of an explosion-produced crater. The pavement upheaval is within the crater damage diameter but is outside the apparent crater diameter. In other words, it is that part of the pavement out of "flush" tolerance which is elevated above the adjacent undamaged surface.

Recovery—The development, coordination, and execution of service- and site-restoration plans for impacted communities and the reconstitution of government operations and services through individual, private-sector, nongovernmental, and public assistance programs that: identify needs and define resources; implement additional measures for community restoration; incorporate mitigation measures

and techniques, as feasible; evaluate the incident to identify lessons learned; and develop initiatives to mitigate the effects of future incidents.

Response—Activities that address the short-term, direct effects of an incident. Response includes immediate actions to save lives, protect property, and meet basic human needs. Response also includes the execution of emergency operations plans and of incident mitigation activities designed to limit the loss of life, personal injury, property damage, and other unfavorable outcomes.

Runway—A defined rectangular area of an airfield, prepared for the landing and takeoff of aircraft along its length. A runway is measured from the outer edge of the thresholds from one end of the runway to the others. The width of the runway is typically measured from the outer edge of the load-bearing pavement on one side to the outer edge of the load-bearing pavement on the other side. In some cases, the runway may be measured from the outside edge of the runway marking line on one side to the outside edge of the marking line on the other side and any remaining load bearing pavement is considered shoulder.

Safety Data Sheet—Safety Data Sheets includes information such as the properties of each chemical; the physical, health, and environmental health hazards; protective measures; and safety precautions for handling, storing, and transporting the chemical.

Spall—Pavement damage that does not penetrate through the pavement surface to the underlying soil layers. A spall damage area could be up to 1.5 meters (5 feet) in diameter.

Spall Field—A cluster of spalls within a defined area.

Taxiway—A specially-prepared or designated path on an airfield or heliport, other than apron areas, on which aircraft move under their own power to and from landing, takeoff, service, and parking areas.

Threat—An indication of possible violence, harm, or danger.

Unexploded Explosive Ordnance (UXO)—Explosive ordnance which has been primed, fused, armed, or otherwise prepared for action, and which has been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard

to operations, installations, personnel, or material, and remains unexploded either by malfunction or design.

Attachment 2

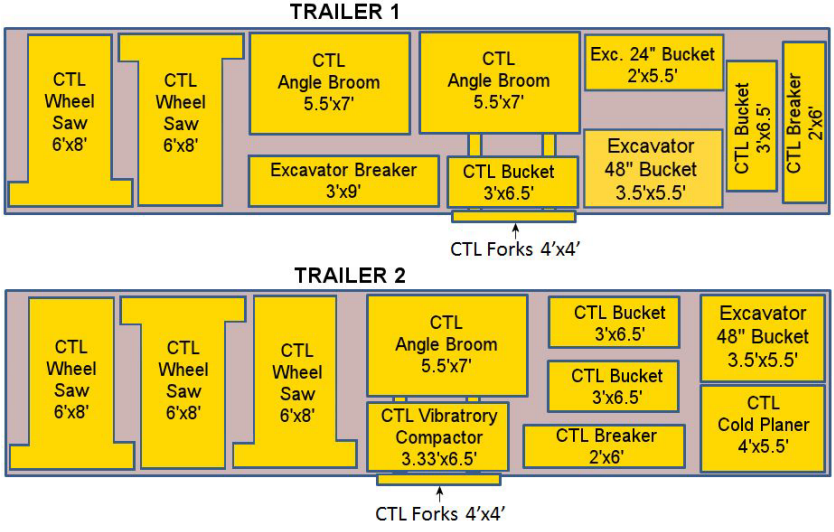
WORK ATTACHMENTS AND TOOL TRAILER COMPONENTS

Table A2.1. Vehicle Work Tool Attachments Utilization and Storage Plan.

CTL Attachments (5 CTLs per capability)	Qty. Per Capability	On Trailers	Attached to Vehicle	Storage Area
SW360 Wheel Saw	5	5*	4*	0
SW345 Wheel Saw	4			0
Bucket-MP, 78", .52 CY	5	4	1	0
Angle broom, BA18	3	3	0	0
Breaker H65D (w/chisel & moil)	2	2	0	0
Vibratory Compactor, CV18B	1	1	0	0
Forks, 48" Pallet with Carriage	2	2	0	0
CTL Cold Planer Attachment	1	1	0	0
Excavator Attachments (2 Excavators per capability)				
Plate Compactor	2	0	0	2
Concrete Breaker	2	1	1	0
Bucket, 24-inch	2	1	1	0
Bucket, 48-inch	2	2	0	0
Front-End Loader Attachments (4 Front-end loaders per capability)				

Bucket	4	0	4	0
Boom with Hook	4	0	0	4
Forks	4	0	0	4
*Pavement thickness (determined from pre-attack airfield survey) will determine wheel-saw size attached to CTLs				

Figure A2.1. Work Tool Attachment 40-foot Flatbed Trailer Load Plan.



Note: Divide like items and attachments between trailers for survivability (dimensions may change without notice).

Table A2.2. ADR Tool / Component Trailer.

Item	Qty	U/I	Description
1	1	EA	Dynamic Cone Penetrometer Kit, K-100 Airfield Deluxe
2	1	EA	Saw, walk-behind, 42” (Model: FS 7000 D 3-SP)
3	6	EA	Blade, saw, walk-behind, 24”
4	3	EA	Blade, saw, walk-behind, 36”
5	3	EA	Blade, saw, walk-behind, 42”
6	20	BX	Teeth, wheel saw, concrete (50 per box)
7	1	EA	Generator, diesel, 6000W
8	1	EA	Compactor, rammer, 4-stroke
9	1	EA	Compactor, plate, 4-stroke
10	1	EA	Power unit, MBW, screed, Honda engine
11	2	EA	Board, screed, MBW 12’
12	1	EA	Saw, cut-off, K-12 (K760)
13	6	EA	Blade, cut-off saw, K-12, 12”
14	1	EA	Pump, water (MUD HOG)
15	1	EA	Hose, suction 3”x20’
16	1	EA	Compressor, portable
17A	2	EA	Hammer, demolition, electric 40 lb.
17B	2	EA	Moil, hammer, demolition
17C	2	EA	Chisel, hammer, demolition
17D	1	EA	Chisel, bull point
18A	2	EA	Drill, hammer, electric, SDS Max
18B	2	EA	Chisel, pointed 19”
18C	2	EA	Bit, drill, 3/4”x21”
18D	2	EA	Bit, drill, 3/4”x13”
18E	2	EA	Pointed chisel (Hilti 282264)
18F	2	EA	Grease
19	3	EA	Light, wobble
20	3	EA	Shield, reflector, wobble light
21	2	PK	Vibrator, concrete, electric
22A	1	EA	Saw, reciprocating

Item	Qty	U/I	Description
22B	10	EA	Blade, super reciprocating saw
27	12	EA	Shovel, square head
28	10	EA	Shovel, round head
29	2	EA	Plastic, sheeting, roll, 20'x100' (10Mil)
30	6	EA	Rakes, garden/bow
31	6	EA	Handle, broom, street, wood 54"
32	6	EA	Broom, street
33	4	EA	Axe, pick
34	4	EA	Maddox
35	2	EA	Hoe, mortar
36	1	EA	Wheelbarrow
37	4	EA	Hammer, sledge, 10 lb.
39	2	EA	Measuring wheel
40	1	EA	Level 4"
41	4	EA	Bar, pinch, digging
42A	1	EA	Bag, stake, 24"
42B	120	EA	Stakes, nail 24"x3/4"
43	1	EA	Bag, tool, canvas 24"
	2	EA	Jerrican, gas, 5-gal
44	2	EA	Jerrican, diesel, 5-gal
45	4	EA	Spout, jerrican, flex 16"
46	2	PR	Chocks, wheel (roped pair)
47	1	EA	Bit, spade (YAN 254-1461)
48	1	EA	Cutter, asphalt, crosscut
50	1	EA	Moil (conical) point
	1	EA	Chisel point (YAN 254-1455)
52	2	EA	Float, magnesium bull w/mount bracket
53	6	EA	Handle, bull float
54	10	EA	Come-a-long, concrete
55	6	EA	Bucket, 5-gal w/lid
56	4	EA	Shovel, asphalt (scoop type)
57	6	EA	Rake, asphalt
58	6	EA	Lute, asphalt, telescoping handle

Item	Qty	U/I	Description
59	1	EA	First aid kit, large
60	2	BX	Towels, shop (box of 200)
61	50	EA	Cones, traffic, orange, all-weather 18”
62	2	EA	Puller, stake
63	12	EA	Form, concrete, 2”x4”x12’ (plastic)
64	12	EA	Form, concrete, 2”x6”x12’ (plastic)
65	3	BK	Pocket, stacking (5 per bucket)
66	2	BK	Pocket, slide (15 per bucket)
67	18	EA	Form board, exp. joint, 1/2”x4”x10’
68	18	EA	Form board, exp. joint, 1/2”x6”x10’
69	18	EA	Cap, plastic, for form board 1/2”
70	2	EA	Release agent, all purpose (asphalt)
71	2	EA	Release agent, all purpose (concrete) 5-gal
72	2	EA	Sprayer, liquid, 2-gal hand pump
73	1	EA	Geotextile, (12.5’W x 360’L roll) (cut to 10’ lg)
74	1	EA	Gas can, spill proof, 1 gal
	4	EA	Bolted target stands
	4	EA	3/4” Pipe 50”
	4	EA	Magnetic saw targets
	4	EA	Non-magnetic saw targets
	4	EA	Threaded target stands
	4	EA	CPM Stanchion
	2	EA	Upheaval rod
Cabinet 1 Contents			
1	2	EA	Gun, caulk
2	1	EA	Mixer, dual paddle, concrete
3	4	EA	Shield, face
4	1	EA	Funnel
5	3	EA	Paddles, mixer
Cabinet 2 Contents			
1	1	EA	Hose, discharge, 3”x25’
2	2	EA	Hose, fire, 2”X50’
3	4	EA	Meter, flow

Item	Qty	U/I	Description
4	8	EA	Coupling, brass
Cabinet 3 Contents			
1	1	EA	Grinder, angle
2	1	EA	Saw, circular 7-1/4
3	6	EA	Blade, circular saw
4	1	EA	Drill, electric, 1/2” chuck
5	1	EA	Wrench, impact, electric, 1/2”
6	10	EA	Wheels, grinder, cut-off
Cabinet 4 Contents			
1	2	EA	Wand, air compressor
2	4	EA	Hose, garden, 50’
3	2	EA	Hose, rubber, red, 3/8”x50’
4	2	EA	Aluminum 2” male camlock to 1.5” female
5	2	EA	Aluminum 2” female camlock to 1.5” male
6	2	EA	Aluminum 2” NPT to 1.5” NH double female
7	2	EA	2” Camlock fog nozzle
8	2	EA	Aluminum 2” male camlock x 2” female NPT
9	1	EA	Aluminum 3” male camlock to 2” male camlock
10	2	EA	3” Female camlock to 2” male camlock
11	2	EA	Aluminum 2” Female camlock to 1.5” female
12	2	EA	2” camlock fog nozzle
Cabinet 5 Contents			
1	6	EA	Cord, extension, 15A twist lock, 50 ft.
2	1	EA	Level, 2 ft.
3	2	EA	Square, speed, combination
4	8	EA	Knee pads, neoprene, Velcro strap
Cabinet 6 Contents			
1	200	EA	Glow stick, chem-light, green, 6”
2	4	EA	Measure set, liquid, nesting
3	4	EA	Broom, concrete, hand 12”
4	6	EA	Brush, scratch, heavy-duty with scraper
Cabinet 7 Contents			
1	14	EA	Binder, load (5/16” – 3/8” 7,300LB)

Item	Qty	U/I	Description
2	10	EA	Chain, grade 100 w/twist, 3/8” link; 20’ length
3	1	EA	Cables, jumper, 20 ft.
Cabinet 8 Contents			
1	1	EA	Cutter, bolt, 3 in 1, 24”
2	2	EA	Chain, grade 70 w/twist lock, (1/4” link; 20’ long)
3	4	EA	Bar, crow, wrecking, 3/4x30
4	1	EA	Box, tool, mechanics
5	2	EA	Wrench, pipe, 18”
6	2	EA	Wrench, pipe, 36”
7	2	EA	Pliers, wire twist, 12”
8	2	EA	Pliers, wire twist, 9”
9	2	EA	Bag, tool, large
10	2	EA	Strap, tow, 20 ft.
11	2	EA	Bag, trash, 50 gallon
12	2	EA	Hammer, claw
13	4	EA	Hammer, sledge, 3 lb.
Drawer 1 Contents			
1	120	EA	Mask, dust
2	30	EA	Glasses, safety
Drawer 2 Contents			
1	6	EA	Brush, utility, nylon, 8” OAL
2	2	EA	Gloves, disposable, (box 100)
3	200	EA	Plug, ear, pair (33 nrr)
4	96	EA	Crayon, florescent red
Drawer 3 Contents			
1	1	EA	Set, drill bit and driver
2	12	EA	Scrapers, hand, 4”
3	6	EA	Thermometer, infrared / IR-100
4	8	EA	Level, line
5	20	EA	Knife, utility
6	20	PK	Blade, knife, utility (20 per pack)
7	4	EA	Opener, bucket
8	1	KT	Wrenches/plugs/Allen wrenches/handles

Item	Qty	U/I	Description
9	1	EA	Wrench, oil plug
10	2	EA	Wrench, spark plug
11	3	EA	Handles
12	2	KT	Wrenches, Allen
Drawer 4 Contents			
1	2	RL	Wire, bailing, 25 ft.
2	4	EA	Nozzle, hose, garden
3	4	RL	String, nylon, 500’ roll
4	2	EA	Tape, measure, 100 ft.
5	20	EA	Tape, measure, 25 ft.
6	1	RL	Tape, Teflon, thread sealant
7	4	RL	String, nylon (500’)
Drawer 5 Contents			
1	4	EA	Edger, concrete, brass
2	4	EA	Jointer, concrete, brass
3	6	EA	Float, hand, magnesium, 18”
4	6	EA	Trowel, finishing, steel, 16”

Table A2.3. Inclement Weather Kit (Two Quadcon Shipping Containers).

Item	Description	Qty	Cont.	Location
1	Complex Dry-Line Marker	1	1	Floor
2	Fire Hose, Custom, 30-ft Long	18	2	Basket 2
3	2.5-in Dust Cap	18	2	Basket 2
4	2.5-in Dust Plug	18	2	Basket 2
5	Containment Dike, 10-ft Long	36	2	Basket 1
6	No. 10 Sieve	4	2	Basket 2
7	Plastic Sheeting, 20-ft x 100-ft	2	2	Basket 1
8a	Tarpaulin	10	2	Basket 1
8b	Tarpaulin	14	2	Basket 2
9	Vacuum	1	1	Wall
10	Backpack Blower	3	1	Wall
11	5-gal Bucket	36	1	Floor

Item	Description	Qty	Cont.	Location
12	Bucket Lid	36	1	Tote
13	Pop-up Tents	10	2	Basket 3
14	Paint, Crayon, Red, 12 Ct	5	1	Tote
15	Pipe Heater Cable, 30-ft Long	2	1	Tote
16	Automatic Heat Cable, Electric, 18-ft	2	1	Tote
17	Tent Anchor Bags	44	2	Basket 1
18	Inline Water Heater	1	1	Floor
19	Water Pump	1	1	Wall
20	Suction Hose, 20-ft Long	1	1	Wall
21	Discharge Hose, 50-ft Long	1	1	Wall
22	Ramp, 36-in Wide x 18-in Long	1	1	Door
23	Tote, 50-gal	1	1	Floor
24	Blower Extensions	3	1	Tote
25	Shop Vac Hose	1	1	Tote
26	Shop Vac Accessories Kit	1	1	Tote
27	Suction Hose Strainer, Metal	1	1	Tote
28	Shovel, Charcoal/Ash	1	1	Tote
29	Tie Down, Cargo, Aircraft	22	1	Misc.
29a	Tie Down, Cargo, Aircraft	6	2	Basket 1
30	Ratchet Strap	3	1	Misc.

Figure A2.4. Spall Repair Kit (3 Quadruple Containers).

Item	Description	Qty	Cont.	Location
1a	Rapid Set Mortar Mix, Bucket	96	2	Baskets
1b	Rapid Set Mortar Mix, Bucket	96	3	Baskets
2	Dual Paddle Mixer, XO 55	2	1	BB-T3
3	Mixing Paddles	8	1	BB
4	Extension Cord, 50-ft Long	2	1	TB
5	Extension Cord, Spring Return	2	1	TB-T4
6	Shop Vacuum	1	1	BB
7a	Blower/Vac, Elec	1	1	BB-T2
7b	Blower/Vac, Elec	1	1	BB-T4
8	Generator	1	1	Floor
9	Hammer Drill/Breaker	1	1	BB
10	Wobble Light	2	1	TB
11	Incandescent Hand Lamp, 25-ft Long	2	1	TB-T2
12	Shovel, Square Head	4	1	Wall
13	Shovel, Round Head	2	1	Wall
14	Pickaxe	1	1	Wall
15	Sledgehammer, 8-lb	1	1	Wall
16	Sledgehammer, 3-lb	1	1	TB-T1
17	Garden Hose Nozzle	2	1	TB-T2
18a	Garden Hose, 25-ft Long	2	1	TB-T2
18b	Garden Hose, 25-ft Long	2	1	TB-T4
Legend: BB = Bottom Basket, TB = Top Basket, T1, 2, 3 = Tote 1, 2, 3				
19	Drum, 55-gal, Open Head	2	1	Floor
20	Drum Bung Wrench	2	1	TB-T2
21	Pump, 12-Volt, 4 GPM @ 60 PSI	2	1	TB-T1
22	3/4” NH x 1/2” NPT, Dbl Male Connector	4	1	TB-T1
23	Cable, 12-1/2-ft with 2-pin Disconnect	2	1	TB-T2
24	Adapter With 2-pin Disconnect	2	1	TB-T2
25	Cable, 18-in Long, Alligator Clips	2	1	TB-T2
26	Utility Knife	4	1	TB-T2

Item	Description	Qty	Cont.	Location
27	Utility Knife Blade, 5 Piece	4	1	TB-T2
28	Fuel Can, 5-Gal, With Spout	1	1	BB
29	Pliers, 9-in	2	1	TB-T2
30	Snips, Duckbill, 13-in	2	1	TB-T1
31	Bucket Opener	2	1	TB-T2
32	Broom, Concrete Finishing	2	1	TB-T3
33	Broom, Concrete Hand	2	1	TB-T2
34	Float, Hand, Magnesium	4	1	TB-T2
35	Trowel, Finishing	2	1	TB-T2
36	5-Gal Bucket	2	1	BB
37	Bucket Lid	2	1	BB
38	Knee Pad	3	1	TB-T1
39	Measuring Cup, 1-qt	4	1	BB-T1
40	Measuring Cup, 2-qt	4	1	BB-T1
41	Measuring Cup, 4-qt	4	1	BB-T1
42	Water Cooler, 5-gal	1	1	TB
43	Safety Glasses, Tinted	3	1	TB-T1
44	Ear Plug, Box, 100 CT	1	1	TB-T1
45	Dust Mask, Box, 20 CT	1	1	TB-T1
46	Face Shield	3	1	TB-T1
47	Head Lamp	3	1	TB-T3
48	First Aid Kit	1	1	TB-T1
49	Shop Towels, Bucket	2	1	TB-T1
50	Traffic Cone, 18” White	20	1	BB
51	Glow Stick, 10 Pk, 12 Hour	3	1	TB-T1
52	Trash Bag, 50-gal, 100 Pk	1	1	TB
53	Safety Belt, High Visibility	3	1	TB-T1
Legend: BB = Bottom Basket, TB = Top Basket, T1, 2, 3 = Tote 1, 2, 3				
54	Plastic Sheeting, 20-ft x 100-ft	1	1	TB
55	Tie Down, Cargo, Aircraft	5	1	BB-T3
55a	Tie Down, Cargo, Aircraft	9	1	Misc.
55b	Tie Down, Cargo, Aircraft	6	2	Misc.
55c	Tie Down, Cargo, Aircraft	6	3	Misc.

Item	Description	Qty	Cont.	Location
56	Ramp, 36-in W x 18-in L	1	1	Floor
57	Zip Tie, 18-in Long, 15 CT	1	1	TB-T3
58a	Cable Wrap	5	1	TB-T3
59b	Cable Wrap	4	1	BB-T3
59a	Tote	4	1	TB
59b	Tote	4	1	BB
60	Broom Handle	2	1	Wall
61	Crowbar, Straight, 71-in Long	2	1	Wall
62	Extension Cord, 25-ft Long	2	1	BB-T3
63	Safety Glasses, Clear	3	1	TB-T3
Legend: BB = Bottom Basket, TB = Top Basket, T1, 2, 3 = Tote 1, 2, 3				

Attachment 3

RADR PRE-CONVOY BRIEFING TEMPLATE

Figure A3.1. RADR Pre-Convoy Brief Template.

ADR PRE-CONVOY BRIEF								
1. Briefing Location:								
2. Threat								
a. FPCON	Alpha	Bravo	Charlie	Delta				
b. Threat Level	Low	Moderate	Significant	High				
c. Work Party Security	Yes	No						
3. Environmental conditions								
a. Expected Weather	Fair	Rain	Snow					
b. Heat Category	1	2	3	4	5			
c. (Heavy) Work/Rest Cycle	40/20	30/30	30/30	20/40	10/50			
d. Water intake (quart/hour)	3/4	1/1	1/1	1/1	1/1			
e. Chemicals present	Yes	No						
f. MOPP level	MOPP 0	MOPP 1	MOPP 2	MOPP 3	MOPP 4	Variations:		
g. Performance Period	Day	Night						
4. UXOs Present	Yes	No	Required Clear zone around UXO (feet):					
Camouflets Present	Yes	No	Required Clear zone around camouflet (feet):					
5. MAOS details								
a. MOS coordinates	Coord string:	T/H:	Departure:	Width:	Length:	C/L offset:		
b. MOS configuration	Unidirectional	Bidirectional	Runway ID:					
c. Taxiway(s) reqd. to repair								
d. Taxiway pavement depth	inches							
e. Arresting system(s)	1. Coordinates:	Conc.	Asph.	Soil	2. Coordinates:	Conc.	Asph.	Soil
Set-back installation(s)	No	Yes	Setback distance from centerline:					
f. Lighting	PAPIs	DTG	Approach	AAS Markers	Edge	Taxiway		
g. Striping	Approach	Departure	Centerline	Taxiway	Blackout			
h. MOS pavement depth	Approach:	Departure:	Center:					
i. Dowels Present	Yes	No						
6. Crater Repair Teams	1	2	3	4	5	6	7	
a. Number of craters								
b. Repair zone coordinates								
c. Capping Material	RS A FC	RS A FC	RS A FC	RS A FC	RS A FC	RS A FC	RS A FC	
d. Camouflets	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	
e. Push debris	Left	Right						
f. Place repair material	Left	Right						
7. Spall Field Coordinates								
8. Warehouse Teams	1	2	3	4	5	6	7	
Material to Haul	RS FF	RS FF	RS FF	RS FF	RS FF	RS FF	RS FF	
9. Asphalt Batch Plants	1	2	3	4				
Supports Repair Team(s)	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7				
10. Utility Locations	Fuel:	Water:	Electric:	Drains:	Comm:			
Required Utility Repairs	Fuel:	Water:	Electric:	Drains:	Comm:			
11. Convoy Route(s)	Primary:	Alternate:						
Special Instructions								
12. Status/DIME Reporting	Authentication required:	Yes	No					

Attachment 4

EMERGENCY AUGER SWAP OUT PROCEDURES

A4.1. ProAll Mixer:

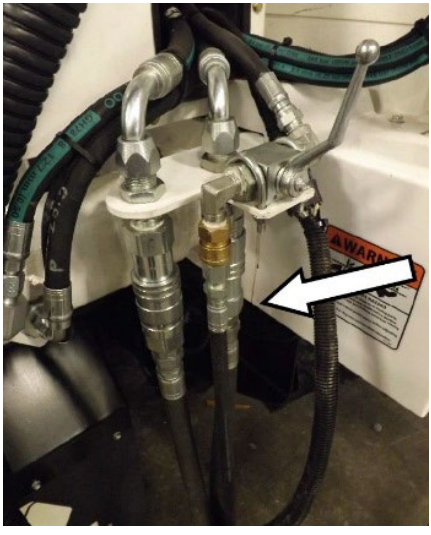
- Swap-out is performed by a 3-man team: Member 1, Member 2, and Member 3.

- Member 1 removes tie-down straps and lifting clamps (fork pockets) from spare auger (**Figure A4.1**) stored on a single pivoting tube.

Figure A4.1. Spare Auger Tie-Down Straps and Lifting Clamps.

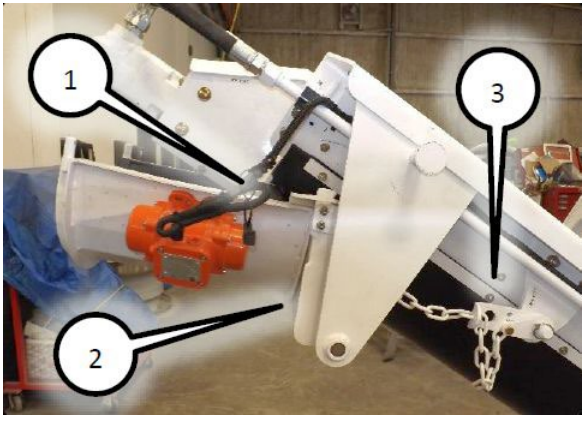
- Members 2 and 3 lower auger chute to a horizontal position and disconnect hydraulic lines and electrical connectors from the hydraulic control system (**Figure A4.2**).

Figure A4.2. Hydraulic Line Quick Disconnects and Electrical Connector.



- Members 2 and 3 remove transition chute, by (1) disconnecting the electrical connector from the chute vibrator, (2) pulling the release pin, (3) removing the adjusting chains on both sides of the auger, and (4) rotating the transition chute off its mount (**Figure A4.3**).

Figure A4.3. Transition Chute.



- Members 2 and 3 disconnect water hoses and remove the rapid release ears near mixing well by removing the pin and rotating the cam lever up and off the ear (**Figure A4.4**). A hammer and tapered punch (located in the RADR Tool Trailer) is recommended to remove and install auger attachment pins.

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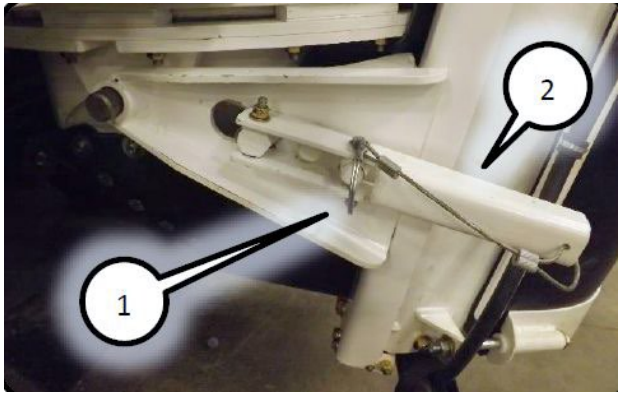
Figure A4.4. Mix Auger Ears. (1) Pin, (2) Cam Lever.



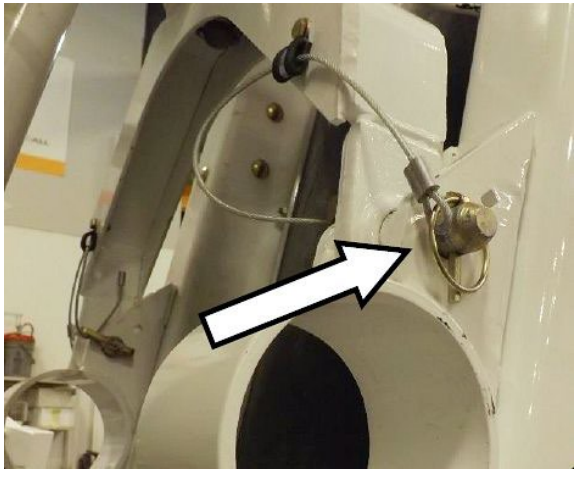
- Member 1 installs lifting clamps on the damaged auger and then positions the forklift to assist in removal of damaged auger.

- When Members 2 and 3 release the auger chute from the mixing well and hoses are disconnected, they swing the auger chute 90 degrees.

- Member 1 inserts the forks into the lifting clamps to support the auger.

- Members 2 and 3 remove pins connecting auger chute to the link arm (**Figure A4.5**).

Figure A4.5. Link Arm Pin Location.



- Member 1 sets damaged auger aside to be repaired

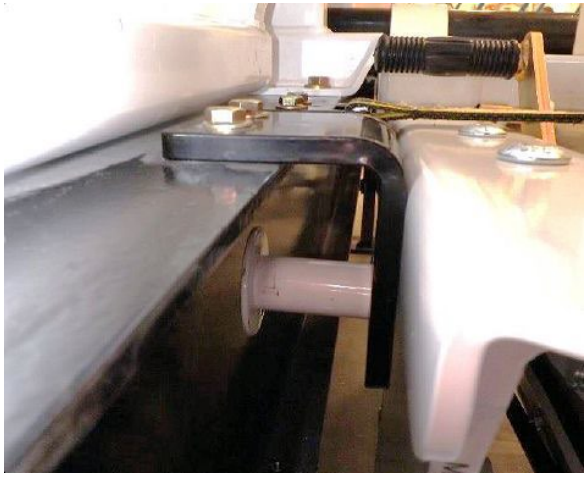
- Members 2 and 3 reinstall the lifting clamps on spare auger and Member 1, using the forklift, removes spare auger from the stowage location with assistance from other two members.

    - Pull the auger out from the machine until the pin clears the rear holding bracket (**Figure A4.6**).

Figure A4.6. Rear Auger Holding Bracket.

- Rotate the auger on the pivot tube so the motor lowers towards the ground and the lock pin on the auger clears the front holding bracket (**Figure A4.7**).

Figure A4.7. Front Auger Holding Bracket.



- Lift the auger with a forklift to clear the lip on the pivot tube.
- Remove the auger straight from the machine to clear the pivot tube.

- Member 1 positions the spare auger for installation in reverse order of removal.

A4.2. Cementech Mixer:

- Completely lower the mixer assembly.
- Place a lifting strap through the D-rings on the mixer and slide the strap loops over the tine of a forklift. Lift the tine just enough to remove pressure from the hydraulic cylinder (**Figure A4.9**).

Figure A4.9. Lifting Mixer to Relieve Pressure on Cylinder.

- Remove pins that hold the cylinder and first chute from the mixer assembly. Make sure to uncouple the chute vibrator wiring harness connector (**Figure A4.10**).

Figure A4.10. Pins Holding Cylinder and First Chute from Mixer Assembly.

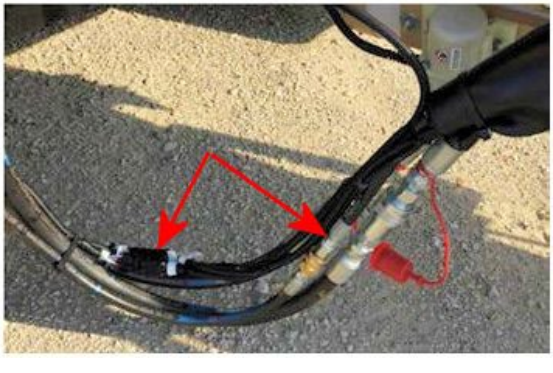
- Completely retract the cylinder and gently lower it until it rests on the conveyor cover.

- Remove the cotter pin and washer from the hanger pins on both sides of the hopper (**Figure A4.11**).

Figure A4.11. Cotter Pins and Washers Location.

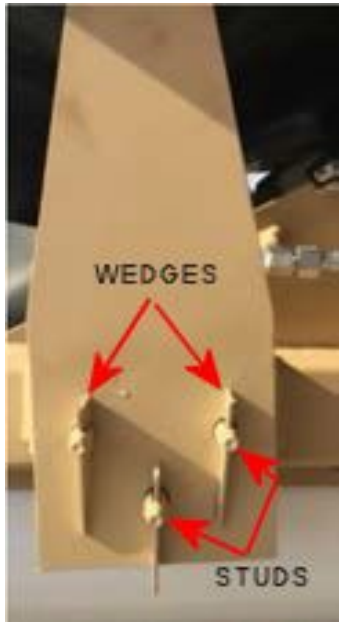
- Uncouple mixer hydraulic hoses and wire loom connectors (**Figure A4.12**).

Figure A4.12. Mixer Hydraulic Hoses and Wire Loom Connectors.



- Knock the retaining wedges out the **right** mixer arm (**Figure A4.13**). Pull the hanger bracket off the hanger pin and three arm studs and push the mixer assembly to the left. BE CAREFUL! Even though the mixer assembly is balanced it can drop on one end or swing without warning.

Figure A4.13. Retaining Wedges and Arm Studs.



- Carefully maneuver the mixer away from the unit and set it in a safe location where it can be stored without damage until it is worked on or stowed back on the trailer.

- Remove the lifting strap from the mixer assembly and install it on the spare mixer located on the front right side of unit. Carefully place the forklift in the proper position to lift the spare mixer off the frame (**Figure**

A4.14). DO NOT HIT THE OIL COOLER WITH THE FORKLIFT TINES!

Figure A4.14. Lifting Spare Mixer Assembly from Storage Location.

- Drive the locking wedges out of the retaining pins (**Figure A4.15**).

Figure A4.15. Locking Wedge and Retaining Pin.

- Raise the forklift boom to put a little tension on the lifting strap and remove the pins from the chute hanger brackets (**Figure A4.16**).

Figure A4.16. Chute Hanger Bracket Pins.

- Slowly lift the spare mixer off of the unit and maneuver it to the rear of the unit to be mounted.
- Remove the right-side hanger ear from the mix auger.
- Slide the left hanger ear onto the pin and install the flat washer and the cotter pin (**Figure A4.11**).
- Align the three pin holes in the right hanger ear and slide the ear over the mixer pins and hanger pin at the same time. It may be necessary to wiggle the discharge end or the mixer assembly to assist the hanger ear going onto the pins.
- Once the ear is in place, install the flat washer, cotter pin, and the three wedges (**Figure A4.13**).
- Raise the mixer assembly with the forklift so the mixer is at 10 degrees. Extend the hoist cylinder, align the mounting holes, and install the pin (**Figure A4.17**). Use the hoist lever to make adjusts to slide the pin in.

Figure A4.17. Hoist Cylinder Pinned to Mounting Holes.

- Install the first chute.
- Connect the hydraulic lines and wire looms (**Figure A4.12**).
- Grease the lower seal system on the mix auger with the grease gun mounted on the fender. Place the grease gun on the grease zerk located on the bottom end of the mixer (**Figure A4.18**). Pump the gun until grease is coming out between the hub on the mixer shaft and the outer ring (**Figure A4.19**).

Figure A4.18. Grease Zerk Location.

Figure A4.19. Area Where Grease Will Exit the Seal.