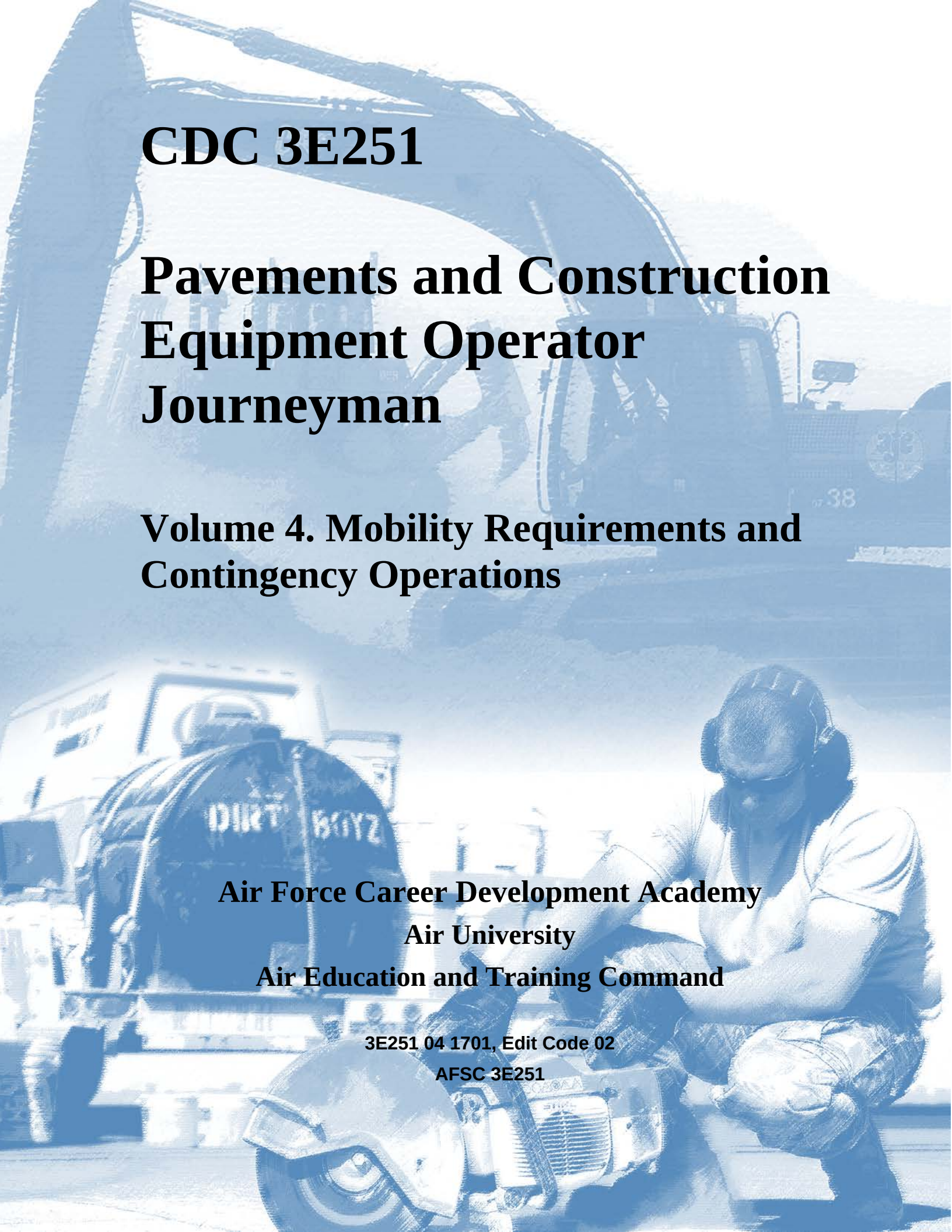

CDC 3E251

Pavements and Construction Equipment Operator Journeyman

Volume 4. Mobility Requirements and Contingency Operations

Air Force Career Development Academy

Air University

Air Education and Training Command

3E251 04 1701, Edit Code 02

AFSC 3E251

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Material in this volume is reviewed annually for technical accuracy, adequacy, and currency. For SKT purposes the examinee should check the *Weighted Airman Promotion System Catalog* to determine the correct references to study.

THIS VOLUME of CDC 3E251, *Pavements and Construction Equipment Operator Journeyman,* deals with AFSC specific contingency responsibilities and mobility requirements.

Unit 1 covers our legacy Airfield Damage Repair (ADR) procedures regarding Rapid Runway Repair (RRR) teams to repairing large/small craters and spalls and Rapid Airfield Damage Repair (RADR) which includes techniques used to repair flexible or rigid pavement craters; and the improved spall repair procedures. The unit ends with the completely new Sustainment Pavement Repair (SuPR) kit a "shop in a box" base pavements beddown repair kit.

Unit 2 provides information on prefabricated surface mats or FOD covers used in runway repair during contingencies (wartime scenarios). To include the new Fiber Reinforced Polymer (PRF) panels. The unit also covers expedient repair and construction, highlighting some of our specific wartime tasks that we may have to accomplish during contingency operations.

When you complete the four volumes of this course, you'll have gained the knowledge needed to perform duties as a pavements and construction equipment operator journeyman. When you master the contents of this course and combine this knowledge with the practical experience you get from working on your job, you can earn success, prestige, and promotions.

A glossary is included for your use.

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This volume is valued at 12 hours and 4 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Page

Unit 1. Airfield Damage Repair

TO FLY, to fight, and to win is the Air Force mission. If our aircraft are unable to fly because of enemy damage on our airfields, the potential for great loss of equipment and personnel increases. For decades, Civil Engineers have developed fast and efficient methods to get aircraft back in the air after an attack. Rapid Runway Repair (RRR) was the gold-standard for a long time. But the rest of the airfield can be damaged so the process changed to Airfield Damage Repair (ADR). As new satellite technologies develop, there have been increased capabilities. The latest system utilizing Global Positioning System (GPS) is called Rapid Airfield Damage Repair (RADR). It will reduce repair times even further than the previous two systems. This unit covers the conventional, or *legacy* ADR, as well as RADR. By reading and understanding the material in this unit, you'll be better prepared to do your part in repairing damaged runways and taxiways.

1–1. Legacy Airfield Damage repair

Implementing new technologies across the Air Force takes time. When you get to your first duty station you will probably see parts of both the old and new systems of airfield damage repair. If you deploy or are in an exercise you may have to use one or the other or a combination of the two. Either way, the RADR system applies advanced technology to the ADR system which works very well. In order to fully understand the RADR system, you'll need a foundational knowledge of ADR.

601. Basics of crater and spall repair

Any ADR operation can be a complex procedure composed of many individual but interrelated steps. While you (or another part of the ADR team) are accomplishing one step, other team members are simultaneously doing other steps. ADR is a team effort. Like most team activities, each individual must do his or her part at the appropriate place and time if optimum results are to be attained. To be a productive team member, you need to be sure you know and thoroughly understand your responsibilities. Never forget that each individual is essential to the success of the total effort. In this section we look at the following subject areas: ADR philosophy, definitions, pre-attack and preparatory actions, and how to make crater repairs and spall repairs.

ADR philosophy and definitions

ADR capabilities cover a wide range of functional actions to establish, sustain, and recovery airbase operations. In a scenario where an enemy airbase has been seized, ADR assets and capability may be limited until minimum airfield repairs are completed to enable cargo aircraft to bring in additional resources. Special capability units, such as airborne Rapid Engineer Deployable Heavy Operational Repair Squadron Engineer (RED HORSE) and contingency response groups (CRG), will likely do airfield repairs when opening the airbase. Afterwards, operations will be handed off to follow-on Prime Base Engineering Emergency Force (BEEF) units to continue airfield repairs. After establishing an airbase and beginning sustainment of operations, the potential enemy threat must be assessed and resources acquired in anticipation to counter those potential threats.

Philosophy

ADR is an essential element in the rapid projection and application of Joint US Military power to ensure the United States can establish airbase operations anywhere on the globe in minimal time. ADR used to be simply called Rapid Runway Repair (RRR). But because repairs can be done to much more than just the runway, the procedures and name were changed to *Airfield* Damage Repair. This concept of operations (CONOPS) addresses Prime BEEF, RED HORSE and ADR capabilities to support the installation's flying mission. ADR capability includes tasks such as damage assessment, explosive ordnance reconnaissance, Minimum Operating Strip (MOS) selection, Repair Quality Criteria (RQC) determination, airfield surface repair, minimum airfield operating surface (MAOS) marking and striping, aircraft arresting system installation, and airfield lighting system repair and installation.

Definitions

When ADR was still RRR, the Air Force developed sets of equipment and personnel to do the job. These sets are called *R-1*, *R-2*, and *R-3* and were sometimes called the "*R*" or "*Triple R*" sets. Even though some of the procedures changed, the R-sets remained fundamentally the same. Understanding how the R-sets work with each other to do ADR helps make sense of your responsibilities in repairing an airfield.

Rapid runway repair

Rapid runway repair is the process of using construction equipment, tools, portable equipment, expendable supplies, and temporary surfacing materials to provide a minimum operating surface through expedient repair methods in the shortest possible time. The procedures to accomplish this must be well planned, realistic, and workable.

Rapid runway repair equipment sets

An Air Force RRR equipment set is a standardized set of equipment and vehicles that enables Air Force Civil Engineers to conduct ADR. There are three fielded RRR sets. The sets are graduated in a building-block manner to provide a designated crater repair capability. For a detailed listing of equipment and vehicles contained in each kit, see Air Force Pamphlet (AFPAM) 10–219, Volume 4, *Airfield Damage Repair Operations* and Unified Facilities Criteria (UFC) 3–270–07.

Basic (R–1) RRR set

This set supports the repair of up to three large bomb craters—up to 50 feet—with foreign object damage (FOD) cover in four hours. Basic sets are currently in place at most theater locations and contain approximately 59 items of vehicles/construction equipment (e.g., front-end loaders, dump trucks, and excavators) and additional supplemental items (flood lights, spall repair material, AM–2, and fiberglass mats).

Supplemental (R–2) RRR set

This set contains additional vehicles and equipment which complements the R–1 set; it gives the capability of repairing six craters in four hours. The R–2 set contains 26 items of vehicles/construction equipment and supplemental items.

Supplemental (R–3) RRR set

This set contains additional vehicles and equipment that, when combined with the R–1 and R–2 sets, enable six repair teams to complete 12 crater repairs in four hours. Only a few main operating bases have the R–3 package in place. The R–3 set contains 18 pieces of vehicles/construction equipment and supplemental items.

Pavement damage categories

There are generally three pavement damage categories and sizes:

1. Spall.
2. Small crater.
3. Large crater.

Figure 1–1 illustrates the characteristics of each. As you can see, the categories also correspond with the type ordnance most commonly used.

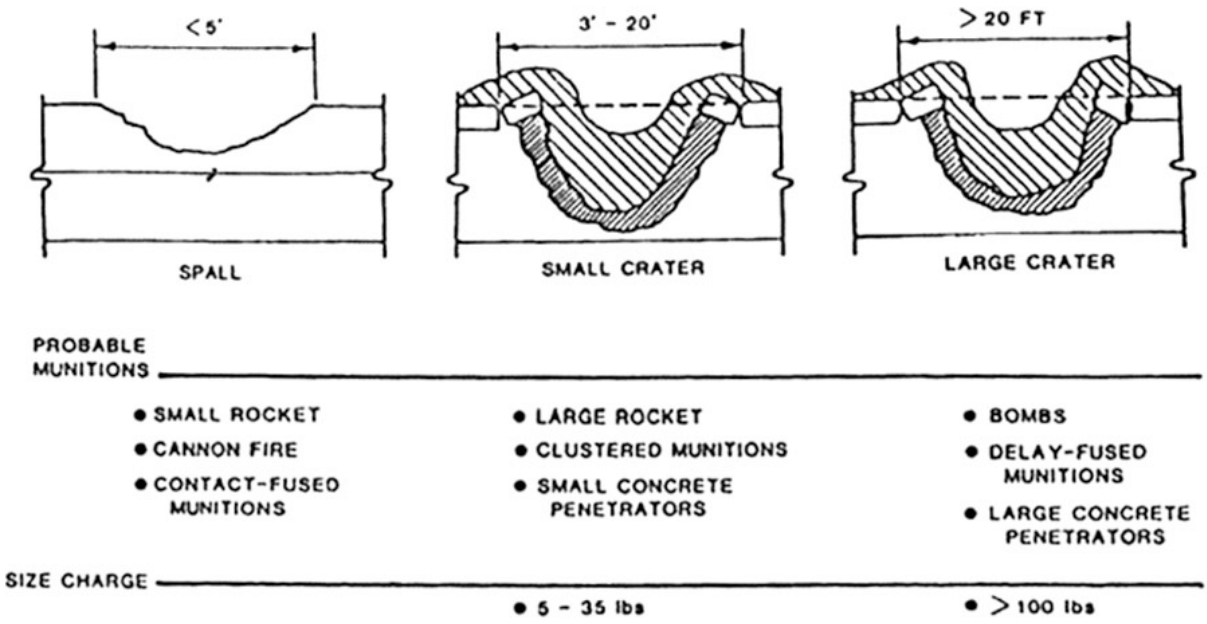


Figure 1–1. Pavement damage categories.

Spall

A spall is defined as pavement surface damage that doesn't penetrate the pavement base course but results in a pavement damage area less than five feet in diameter. Spall damage is most likely to occur from the following:

1. Small rockets.
2. Aircraft cannon fire.
3. Contact-fused munitions.

Small craters

Small craters are defined as pavement damage from conventional weapons that penetrate or disturb the subgrade and result in the following two conditions:

1. Possible pavement upheaval around the crater edge.
2. A pavement damage area up to 20 feet in diameter.

Small craters are typical of the damage that results from weapons having five to 35 pounds of charge. These include the following:

1. Large rockets.
2. Small concrete penetrators.
3. Clustered penetrator munitions.

Large craters

Large craters also must penetrate or disturb the subgrade, but the damage pavement damage **exceeds** 20 feet in diameter. Large craters would generally result from weapons in the 100-pound class (or larger) category.

These include the following:

1. General-purpose bombs.
2. Delay-fused munitions.
3. Large concrete penetrators.

The depth of the burst is important in determining the principal crater types and penetration. We show examples of the surface-burst, optimum-burst, deep-burst, and the penetration capabilities of each in figure 1–2.

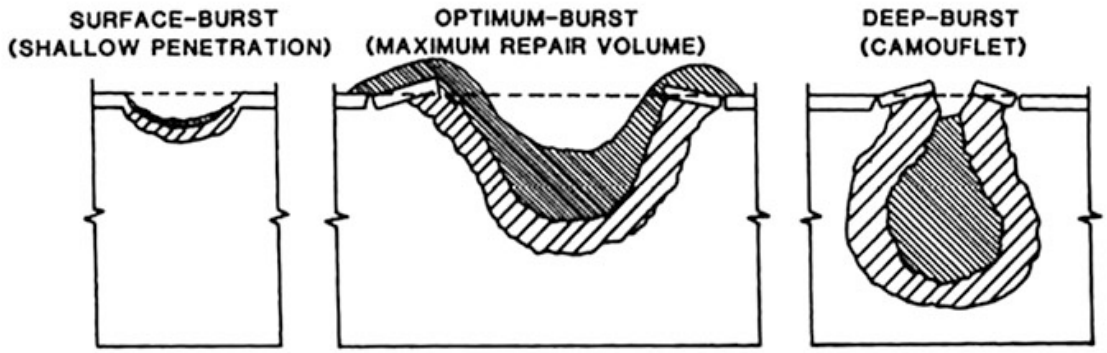


Figure 1–2. Principle crater types.

Minimum operating strip

A minimum operating strip (MOS) is the smallest amount of area that must be repaired to launch and recover aircraft safely. Selection of the MOS depends upon mission requirements, taxi access, resources available, and estimated time to repair. The MOS length depends on the greater of the take-off or landing distance of the mission aircraft. For fighter aircraft, the typically accepted dimensions are 50 feet wide by 5,000 feet long. For the C–130 Hercules, the dimensions are 3,500 feet long by 60 feet wide. For the C–17 Globe master III, the dimensions are at least 3,500 feet long with 300 feet overruns (so, 4,100 total) and 90 feet wide, but may be longer depending upon altitude, surface type, weather conditions and runway condition rating of the airfield (Engineering Technical Letter [ETL] 97–9). Don't be surprised if the installation commander wants a larger (longer and wider) MOS due to proposed aircraft usage and safety.

Expedient repair

We define expedient repairs as airfield pavement repairs that create an operationally capable MOS/MAOS, based on assigned mission aircraft requirements, in the most expeditious manner. CE planners can assume that under ideal circumstances where equipment and materials are available, just like it would be at your main operating locations, each crater can be repaired in four hours. More austere bases where heavy equipment or required materials are not readily available require additional time. Criteria have been established for expedient repairs that provide accessible and functional MOS/MAOS for 100 C–17 passes, 100 C–130 passes, or 100 passes of a particular aircraft other than the C–17 or C–130 at its projected mission weight, or the number of passes required to support the initial surge mission aircraft.

Sustainment repair

Repair efforts designed to upgrade expedient repairs for increased aircraft traffic we know as sustainment repairs. Sustainment repairs should be initiated as soon as the operational tempo permits considering that expedient repairs are only designed to support 100 aircraft sorties. Sustainment repairs to a MOS/MAOS are expected to support the operation of 5,000 C–17 passes, 5,000 C–130 passes or the number of passes required to support mission aircraft other than the C–17 or C–130 at the projected mission weights throughout the anticipated operation. “Expected to support...” means that these numbers of passes can be conducted before additional maintenance is required. While construction time is important for conducting sustainment repairs, quality control is even more important so that further maintenance will be minimized.

Permanent repair

Once the conflict is over, permanent repairs return the air base to its original condition. Permanent repairs are designed to sustain 50,000 or more C–17 passes, 50,000 C–130 passes, or to support a service defined airfield design type depending upon mission aircraft.

Repair quality criteria

Runway repair teams attempt to make repairs flush with the original pavement surface; however, flush repairs are difficult to achieve in the required time. Repair quality criteria (RQC) provides guidance for determining whether non-flush repairs are usable. RQC also provides limits to indicate when repair maintenance is required.

Pre-attack and post-attack actions

With modern technology and intelligence, a base normally receives an advanced warning if an enemy attack becomes eminent. When this happens, the RRR assets must be equally divided and dispersed to three separate and pre-designated locations. These three locations need to be as far away from the threat (airfield) area as practical. Each dispersal location should be divided equally with (but isn’t limited to) the R1 set equipment. Similarly, during the post attack actions it is important to know your role and what steps must be taken immediately to ensure an expedient recovery of the airfield.

Pre-attack actions

If the advanced notification is sufficient, the materials and equipment needed for ADR operations should be loaded onto the designated vehicles before they’re dispersed.

Also, at this time the equipment and vehicles should receive a final operator inspection and service. After all vehicles and equipment are dispersed, suitable camouflage, concealment, and deception measures must then be initiated. Without dispersing and camouflaging, the equipment could become a profitable target for an offensive air operation. If the equipment gets destroyed, the ability to recover the airfield in such a manner as to present a speedy air interdiction is jeopardized. After all, repairing damaged airfield surfaces is your primary wartime mission. During a conflict, the most capable pilots and best aircraft are worth nothing if we, pavement and construction equipment specialists, don’t provide the necessary airfield from which to function.

Post-attack actions

After the attack is over, an “all clear” will be given. At this time, all three dispersed groups move to their designated staging areas, which are situated near the runway, and wait for final directions from the civil engineering damage control center (CEDCC). Extreme care must be taken during this move. It’s best to assemble and move the equipment in a convoy with the front-end loaders leading the way. Disperse vehicles (increase interval distances) within the convoy so as not to create yet another target for enemy fire. Following the front-end loaders should be graders, which assist in clearing and widening the path for the remaining vehicles. The reason you want front-end loaders leading the way is so they can clear debris off the convoy route.

After the team reaches the staging area, they'll most likely be placed in a holding mode. During this time a number of other critical activities are in operation. These include the following:

1. Strategy planning by the ADR officer in charge (OIC) and noncommissioned officer in charge (NCOIC) team members.
2. Explosive ordinance removal (EOR).
3. MOS teams.
4. Damage assessment.

The length of time to complete these tasks is dependent upon a number of factors, not the least of which are weather conditions, types of munitions used, and the extent of damage inflicted. Patience is the best policy, even if the wait is long. It's to your benefit that each of these functions be accomplished correctly. Any errors in this early phase, such as overlooking unexploded ordnance (UXO), can be very costly.

Now, let's say the MOS has been established and the EOD team members have cleared a sufficient area of the MOS from UXO's. The ADR team is now ready to begin ADR operations. Keep in mind that not all repair activities can commence at the same time because of ordnance clearing delays. At times equipment may have to be shifted between teams as well as tasking changes in order to complete the mission. Flexibility and creativity are important and pay dividends in the long run.

602. Legacy crater repair

Modern aircraft are marvels of technology; however, they require strong, smooth runway surfaces for takeoff and landing. After an air attack, runways and taxiways may suffer damage. If this happens, those runways must be repaired to a standard that allows operations to be resumed with minimal risk to the aircraft. This means the pavement surface doesn't have to be as smooth as was originally achieved when it was constructed, but the surface roughness must not be beyond the tolerance permitted for the particular aircraft or combinations of aircraft that use the MOS. This type of action is called *expedient crater repairs.*

Expedient crater repairs

As discussed earlier, there are other methods being tested and implemented, so be ready for whatever method is used in your area of responsibility (AOR). There are currently seven methods used, the three listed below as well as "choked ballast repair" used for wet craters "stone and grout repair" (above and below freezing), "concrete cap repair" and "asphalt repair" (ref: UFC 3-270-07, pg. 2-2, table 2-1 and paras 2-2.41.1 – 2-2.45.13). The three methods we will be discussing are ***debris, backfill, choke ballast over debris, and sand-grid*** methods. Each repair method requires basically the same crater preparation before installing a foreign object damage (FOD) cover. The preparation steps include:

1. Making a simple survey to determine the extent of upheaval.
2. Removal of unsound pavement and upheaval.
3. Backfilling with debris and select fill.
4. Leveling and compacting to meet repair quality criteria (RQC) before placement of the FOD cover.

Since the fiberglass mat method can be accomplished in a flush manner, this method is the primary repair method for MOS repairs. In contrast, AM–2 matting repairs are normally used on taxiways where aircraft speeds are much slower and where less aircraft damage is likely to result.

Arriving at the crater

Upon their arrival from the dispersal site, all front-end loaders and graders should be traveling with their blades and buckets down. This aids in establishing a haul route for equipment operations. The haul route should be wide enough for two trucks or other heavy equipment to pass one another. The

haul route can also serve vehicles and equipment that are not needed on the MOS. In this way, unnecessary vehicles won't hinder UXO clearance and sweeping operations on the MOS.

Once the ADR team arrives, they use the front-end loader to immediately start to clear the debris around the crater. This clearing operation provides a path at least two front-end loader buckets wide with the debris being pushed completely out of the way. It's best to use the front-end loader because it can move heavier material and work quicker than the grader. Work the front-end loader on the side of the crater in which the select fill is to be dumped. If time won't be lost, the crater crew chief may have all four sides of the crater cleared.

Use the front-mounted broom in conjunction with a grader to clear an area where the prefabricated surface mats are to be assembled. Also, sweep areas that will be highly trafficked. It's essential to remove as much shrapnel and debris as possible because even small pieces of sharp metal can cause tires to be severely damaged.

As the area around the crater is being cleared, the graders can be clearing the MOS and adjoining taxiways. At the same time the grader and front-end loader operations are ongoing, the load and haul crew can deliver the prefabricated surface mats to the crater site. Also, haul crews bringing select fill *must* start at the same time the grader and front-end loaders are in operation; this helps meet the time constraints on the delivery of materials to repair areas. Delivering material must continue until the crater NCOIC determines that sufficient quantities are at the crater sites. Not all of the fill material needs to be stockpiled at the crater edge; instead, some can be dumped directly into the crater void. This depends on the type of crater repair. If too much fill material is brought in, it can quickly be pushed off the MOS and out of the way. It's better to bring too much than not enough and delay the repair process.

A spotter at the crater site releases the dump truck tailgate latch as the truck backs up to deliver the load. After the load is dumped, the truck immediately returns to be loaded again. After arriving at the loading site, the dump truck operator then secures the tailgate for the next load.

Unload dozers as quickly as possible to reduce traffic congestion. Unload the dozer on the side of the crater closest to the edge of the MOS. This reduces any unnecessary damage to the pavement surface caused by the dozer tracks.

Pipes and cables in the bomb crater

On some airfields, pipes and cables run alongside or under the runways and taxiways. Because of this, it's very possible to have a broken pipe or cable in a crater located on the MOS. There's also the high risk of the pipe or cable being damaged again while teams are dumping fill or compacting stone. It won't always be possible to make pipe or cable repairs in the crater without seriously delaying the crater repair operation. If it becomes necessary for you to repair the broken pipe or cable in a crater located on the MOS, you must use a bypass technique. We illustrate this concept in figure 1–3. Your first action must be to isolate the damaged utility by opening switches or closing valves. This eliminates the possibility of electrocution or of flooding the crater with water, aviation fuel, or sewage. Next, follow the utility line in both directions from the crater for a safe suitable distance, then uncover the existing line. You must go a suitable distance out of the way in order to not hinder other operations taking place; also, you don't want to get hit or run over by another piece of ADR equipment. Once the utility line is uncovered, you can connect a new pipe or cable to the existing line and bypass the crater.

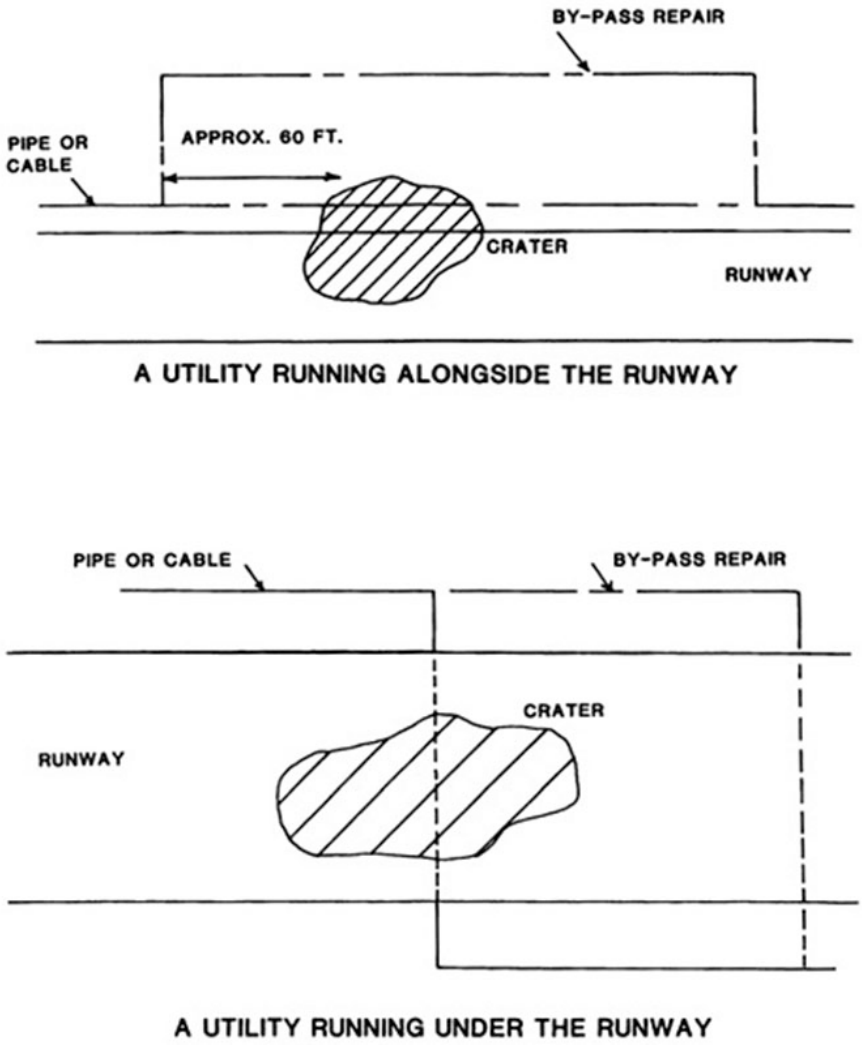


Figure 1–3. Utility bypass technique.

Removing crater upheaval

After the front-end loaders clear around the crater, assess the area of the upheaval (heaved lip) to determine what you must remove. Use a cutting torch or K–12 saw to cut any reinforcing steel projecting out of the upheaved lip.

Since there's no specific pattern required to remove the upheaval, you can move the excavator around the crater to break the pavement. You can then use the front-end loader or dozer to push the pieces off the edge of the MOS. If the crater is large, use a dozer inside the crater to break the upheaval from below and push it up and out to the edge of the crater. Use the dozer to enter the crater as soon as enough debris is pushed in to allow for a safe entry. This can best be done when the crater is 3/4 full. This also minimizes damage to the pavement surface. The dozer should remain in the crater during backfilling to help level and compact the fill material.

You can use the excavator to assist in the upheaval removal. When the jack hammering action is no longer necessary or is completed, quickly replace the excavator impactor attachment with a bucket attachment. Use the front-end loader to pick up or push the removed crater pieces at least 30 feet off the MOS, and pile them not any higher than three feet (minimum height for aircraft wing clearance).

Since the crater edge needs to be as vertical as possible, use a front-end loader to perform an edge cut 18 to 24-inches deep. Do final dressing and cleaning up with shovels and brooms as necessary.

Filling the crater

Now that the crater upheaval is removed, the crater must be filled to prepare it for placement of a final repair cover. The method you use to fill the crater depends on ground conditions and the availability of repair materials. The most common methods used to fill a crater are debris backfill, choke ballast over debris, and chocked ballast repair (for wet craters). The sand grid repair method is seldom used, but will be discussed. Due to similarities between choke ballast over debris and choke ballast repairs (for wet craters), we will discuss the process for choke ballast over debris. Let's take a look at the debris backfill, chock ballast over debris, and sand grid methods.

Debris backfill

This method allows the use of debris up to one foot in diameter to be pushed back into the crater. Fill the crater to within 18-to-24 inches of the existing surface with debris. Place crushed stone in six-to seven-inch lifts. Compact each lift of crushed stone using a minimum of four passes of a five-ton single-drum vibratory roller or two passes of a 10-ton vibratory roller. One pass of the roller means traveling across and back in the same lane. Then, overfill the crater with three inches of crushed stone and compact it with a vibratory roller. Grade the compacted crushed stone to approximately 1 inch above the pavement surface. Compact the crushed stone using an additional two passes of a five-ton single-drum vibratory roller or one pass with a 10-ton vibratory roller.

The last step for repair is profile measurements. The repaired crater must not exceed the maximum RQC of ±0.75 inch (¾ of an inch). A repair outside this tolerance may still be useable, depending on its location but will have a much shorter life before it requires additional maintenance to bring it back within this limitation and may result in aircraft damage. Although not normally required, additional cuts and compaction may be needed to achieve a flush surface repair.

Choke ballast over debris

There may be circumstances when debris won't be suitable as crater subgrade fill material. This can be caused from a number of reasons including a high water table, broken water lines, or a heavy rain during ADR. When any of these circumstances occur, use single sized (normally one and one-half to two and one-half inches [per T.O. 35E2–5–1] diameter) choked ballast rock to fill the crater. Choked ballast rock settles naturally into a mass without the need for mechanical compaction.

If a crater is more than half full of water, pump out the water. You can do this by using a diaphragm pump, a water truck's pump, or by dipping the water out with the excavator bucket. Once you remove the water, prepare the crater for repair in the normal manner, except you must clear all loose debris from the inside and outside of the crater.

If geotextile is available, cut and place a sheet in the bottom of the crater. Once the geotextile layer is in position, the dump trucks can start filling the crater with ballast rock. When the level of ballast rock is within 18-to-24 inches of the existing surface, use the dozer and front-end loaders to level the surface as much as possible. Placing the geotextile into the bottom of the crater is designed to separate unlike soils and fill material, and to reduce the chances of the material mixing. By using the geotextile, you can greatly reduce materials settling within the crater. Then, overfill the crater with three-inches of crushed stone. The remaining repair procedures remain unchanged. However, if a sheet of geotextile is unavailable, you can use the same crater repair methods. To complete the repair, follow the directions to use crushed stone to cap the crater.

Sand grid repair

There are only a few differences between this type of repair and those you have already learned. Filling and compacting the crater is the same up to the last 16 inches or the cap of the repair. This measurement is critical to make sure the repair is flush. Once you reach that level, compact and line the crater with a geotextile membrane.

Next, place the first layer of sand-grid *parallel* to the centerline of the runway and backfill with a cohesionless material (sand). Overfill the grid by approximately two inches. Compact the first layer

by making two passes with a vibratory roller. After compaction, strike all excess material off level with the top of the sand-grid. This is critical to ensure that the flush repair meets the RQC. Place a membrane over the first layer of sand-grid.

Lay the second layer of sand-grid *perpendicular* to the first layer and the runway centerline. Backfill and overfill the sand-grid using cohesionless material, if possible. Compact this layer of backfill. If the two sand-grids are installed and compacted properly, the sand grid should not protrude above the pavement surface. Grade any excess materials from the surface so the repair is flush with the original pavement. Install and anchor the mat cover. The sand-grid repair must have a FOD cover installed to be operational.

Sweeping operations

When the craters are filled and covered with the appropriate covering, sweep the entire area. To do this, move all equipment and excess materials out of the immediate MOS area. The final cleaning and sweeping of the surrounding repair area should be quick and complete. Use all available equipment such as shovels, hand brooms, front-end loaders, towed, and all-purpose sweepers for the sweeping operation.

The last step is to make sure that all debris from the initial bombing attack and that generated from the preparation process is totally removed from the MOS. This prevents any hazards to flying operations or the aircraft arresting barriers and airfield lighting systems from functioning.

603. Legacy spall repair

Earlier we discussed and defined spalls as pavement surface damage that does not penetrate the pavement base course and can reach diameters of up to five feet. We will discuss spalls and their repair types in greater depth.

Spall repair methods

Just like crater repairs, we must repair these smaller types to ensure the MOS can be used. There are several repair methods available; the following are just a few of them:

1. Cold-mix asphalt.
2. Fast-setting Portland cement.
3. Magnesium phosphate cement.

NOTE: Cleaning spalls requires you to remove loose debris and unsound pavement. If any water is in the hole, remove it and dry the hole using wind, heat, or compressed air. Once you do this, fill the hole with the repair material.

Cold-mix asphalt

This is the quickest method, but it has had limited success. We use a conventional cold-mix for spalls that are up to two feet in diameter. Place the asphalt in two-inch layers and compact it to a tight mass with a small tamper or plate compactor. Once the spall is completely filled, top the layer with one to one and one-half more inches of asphalt and compact that flush with the surrounding surface with a vibratory roller.

Fast-setting Portland cement

Although we mentioned three repair methods, the two most commonly used quick-set repair systems are Portland cement and magnesium phosphate cement.

Portland cement is usually a self-contained system composed of rapid setting cement, pea gravel, sand, and sometimes a five-pound container of water. You can use a portable concrete mixer to mix the components. Mix the ingredients for a minimum of four minutes, but don’t exceed seven minutes. Be sure not to place more material in the mixer than you can place in 20 minutes. This is the approximate curing time. For this reason, you’ll need to clean the mixer and tools frequently to prevent the material from adhering to them. After you mix the material, place it in the spall and

scrape the excess material off. When you use this method in low temperatures, the curing time can be extended to as much as two hours.

Magnesium phosphate cement

This is an inorganic compound which we use in a manner similar to Portland cements. The curing time varies based on the temperature. You can use this material over a temperature range of about 35 to 75° F. Mix magnesium phosphate in small concrete mixers for one to two minutes and then place it into the spalls quickly because it sets fast. Mix only the quantity you need.

There are numerous commercial-off-the-shelf materials available for spall repair. Some of these materials have been tested and approved for DOD use while others have not. Before you can use any material on DOD airfields, make sure it is certified for use. Contact your service technical representative for the appropriate material and installation procedures for your particular application.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

601. Basic of crater and spall repair

1. Match the items listed in column B with the definitions in column A. Each item in column B may be used only once.

Column A

____ (1) Repairs three 50-foot craters within a four-hour period.
____ (2) Pavement damage from conventional weapons that's up to 20 feet in diameter.
____ (3) Pavement surface damage that doesn't penetrate the pavement's base course.
____ (4) Total assets capable of repairing six craters in four hours.
____ (5) Pavement damage that disturbs the subgrade and is larger than 20 feet in diameter.

Column B

a. R–2
b. R–1.
c. Spalls.
d. Small crater.
e. Large crater.

2. What are the three types of repairs we make to a runway?

3. What type of guidance does RQC provide?

4. When are ADR assets dispersed?

5. What actions do you take after all the equipment is dispersed?

6. What's your primary wartime mission?

7. Why is the loader the best option to lead the convoy to the repair?

8. What team is responsible for removing UXOs?

602. Legacy crater repair

1. List the basic preparation methods we use in all crater repairs before placement of FOD cover.

2. How wide do you construct the haul route? Explain.

3. What equipment do you use to clear the mat assembly area?

4. Who determines the amount of select fill needed for the crater?

5. Why is repairing broken pipes or cables in a crater a high risk?

6. How do you remove reinforcing steel from the crater heave?

7. What determines the methods you use in filling the crater?

8. What do you do after the crater is covered with the appropriate FOD covering?

603. Legacy spall repair

1. What are the types of spall repair methods?

2. How do we clean spalls?

3. What's the maximum time you can mix Portland cement in the portable mixer?

4. Over what temperature range is magnesium phosphate effective?

1–2. Rapid Airfield Damage Repair

Rapid Airfield Damage Repair (RADR) operations were born out of the ever-changing environment we live in. Although our legacy operations are still very much a part of our way of life, they were

created based off the Cold War threat at that time. The emerging threat and continuous updates in weapons technology required us to adapt and modernize our way of doing business. RADR concept is still very much like our legacy operations, it is still a series of interrelated steps all working in concert together to return our airfield to a useable and maintainable state. The legacy ops however, even when done properly still appeared to be what could only be defined as “controlled chaos”. RADR is meant to work more like an assembly line in which individual teams are assigned specific tasks and once those tasks are completed they will move on to the next crater allowing the next team to follow behind them and complete their assigned task and so on.

Since expedient runway technology repair has improved vastly in recent decades, Air Force Civil Engineering Center (AFCEC) modernized its performance stages. These stages are the foundation of an assembly line approach to crater repair. Being familiar with and well trained in these stages is essential to decreasing the time it takes to repair the runway. More than that, it minimizes the number of personnel required to be in harms way.

604. Rapid rigid and flexible crater repair

AFCEC divided the crater repair process into 8 stages. Stages 1-3 have undergone the most significant changes during this modernization process. Stages 4-8 as you will see finish the process with the proven legacy methods. With this new approach we will now be able to repair 120 smaller craters in a 6 ½ hour time period versus our legacy ADR sets completing 12 large craters within 4-8 hours. This also returns to operation an MOS of 150’ x 10,000’ compared to the legacies 50’ x 5000’. In this lesson you will cover the new ADR upgrades, rigid and flexible crater repair methods, and spall repair. By working smarter and not harder you will find out how all of this will become possible despite how difficult it may seem.

Upgrades

Stage 1: Rapid Airfield Damage Assessment System (RADAS): is a family of sensors and data processors affixed to localized towers or onto remotely piloted aircraft to locate, measure and classify all airfield damage. Next the information is shared into the Geospatial Expeditionary Planning Tool (GeoExPT) which analyzes the data, selects the most efficient MOS and assists in managing the repair effort.

Stage 2: Multiple UXO Removal System (MURS): consists of aerial and ground robotic vehicles anchored by the Recovery of Airfield Denied by Ordinance (RADBO) platform. This platform is located on a Mine-Resistant Ambush Protected (MRAP) vehicle with a Zeus 3 laser system capable of neutralizing UXO’s in place. With this system, Explosive ordinance disposal (EOD) personnel are now capable of mitigating thousands of UXO threats in a shorter period of time, allowing damage repair to begin in as early as 60 minutes.

Stage 3: Damage Repair: or crater repair consists of 6 steps, 1) debris removal, 2) upheaval marking, 3) pavement cutting, 4) pavement breaking and excavation, 5) backfill and 6) capping. These steps will also be covered more in depth in the next section as this is the 3E2’s primary task.

Stages 4-8: Are listed as our legacy capabilities covering FOD removal, emergency airfield lighting, Mobile Aircraft Arresting System (MAAS) installation, MOS marking and Paint striping.

Due to manning AF wide, AFSC’s may be called upon to perform a task that is outside of their typical duties. You will see HVAC technicians performing FOD removal, or a structures troop performing pavement breaking, and this is simply that there aren’t enough 3E2’s to accomplish every task required. We will concentrate solely on Stage 3 “Damage Repair” since this is where 3E2’s get to showcase their talents.

Damage repair

The crater repair process is based on an assembly line concept where teams assigned specific tasks move from crater to crater. Each step in the crater repair process has a dedicated crew that performs

the same step at each crater, one crater after another until the step has been completed on all craters in the identified repair zone.

Each repair team is provided a GeoExPT generated map identifying their repair zone. This report includes general MAOS information, corner locations of the repair zone, and coordinates and prioritizes all repairs. The final two repairs will not be completely cured, or cooled for asphalt caps, within the 6.5-hour repair time. Therefore, these repairs will be the repairs farthest from the MOS centerline, and outside the widest aircraft wheel paths expected to use the MOS. Within 2 hours after the last rapid-set repair has been capped, or 1 hour after the last asphalt repair has been capped. Keeping these two repairs on the same side of the MOS will decrease travel time between repairs. Figure 1–4 shows you what a repair priorities map will look like provided from the GeoExPT and from this priority map each repair team will be led to their respective repair zones as directed by the ADR OIC/Crater Chief.

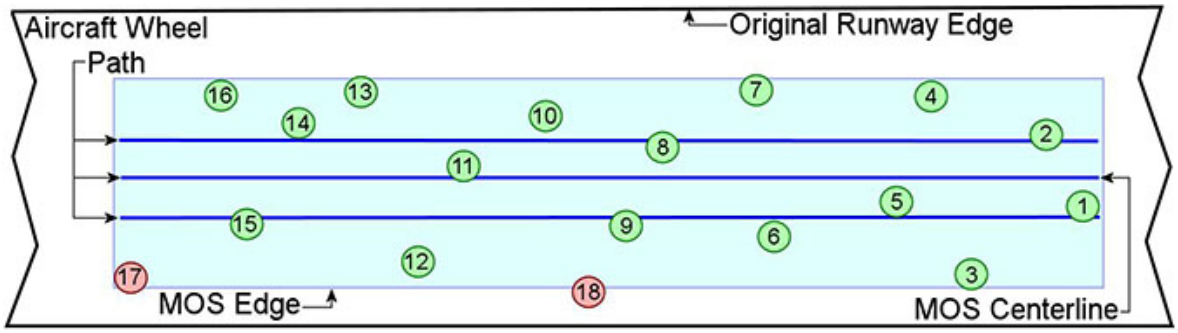


Figure 1–4. Repair zone showing repair priorities.

Debris removal

Debris removal is the first of the six step process and begins immediately after the leading edge of the repair zone is identified and a post-attack reconnaissance (PAR) sweep has been conducted. Debris is removed within 1.5 minutes per crater in the priority order, as identified by GeoExPT. Figure 1–5 describes the required resources to accomplish this task.

Position	Suitable AFSCs	Veh./Equip./Tools	Equip. Subs
Operator	3E2X1, 3E4X1	[1]CTL w/bucket	[2]Equipment with a bucket or a blade
Operator	3E0X1, 3E0X2, 3E1X1, 3E2X1, 3E3X1, 3E4X1	Loader w/multi-purpose bucket	[2]Equipment with a bucket or a blade
Note 1: The CTL is the primary backup to support pavement cutting and can be tasked to support spall repair with a cold planner attachment. **Note 2**: Any equipment with a bucket/blade (i.e., loader, skid steer, backhoe, grader, dozer, or an excavator with a blade). Depending on size and volume of debris, it may be possible to use a kick broom. Use smaller and highly maneuverable equipment capable of moving debris as quickly as possible.			

Figure 1–5. Debris removal resources.

Compact-track loader (CTL) operators will begin the debris removal around each crater, again in priority order, past apparent upheaval; this allows the upheaval marking team to begin as soon as possible. Debris will be removed at least 15 feet from the crater to allow your loader operator to push the debris to a designated location at least 30 feet from the MOS edge (stockpiled no higher than 36-inches). If the material is too heavy for the CTL then the loader operator will assist, also if the crater is small enough to allow the loader to straddle then he may make the first pass clearing enough space for the marking team to begin.

Once all debris has been removed from around the craters in the repair zone the operators will then begin removing debris from the entire repair zone, paying close attention to the progress made in

pavement cutting/breaking and excavation. It is also the CTL operator's responsibility job to go back and assist with opening up that same 15 foot perimeter around each crater. Conversely if pavement breaking has moved two or more craters beyond excavation CTL operators or loaders (depending on crater size) will begin removing broken pavement from the craters already hammered ahead of the excavator to accelerate the excavation process.

After all excavated debris has been removed, the loader operator begins loading stockpiled debris into dump trucks to be removed from the airfield and the CTL operators will support other repair activities as needed (ie, cleaning spilled backfill and capping materials, rubbish removal, etc.). As with all tasks, once complete the Crater repair team lead will inform the Crater Chief when personnel have finished their tasks and are idle so that they may be loaned to other crews as necessary.

Upheaval marking

Unless all unsound pavements are identified and removed, it is likely the unsound pavement will break apart under traffic and create a FOD problem. Upheaved pavement cannot always be identified visually (fig. 1–6); therefore, upheaval determination is accomplished by performing crater profile measurements (CPM) to ensure all damaged pavement is identified and removed. Conversely, removing more pavement than necessary will increase repair times and use more repair material than necessary, which could eventually cause the repair material to be depleted before all repairs are complete. Upheaval marking begins immediately after debris has been removed from around the first repair (fig. 1–7).

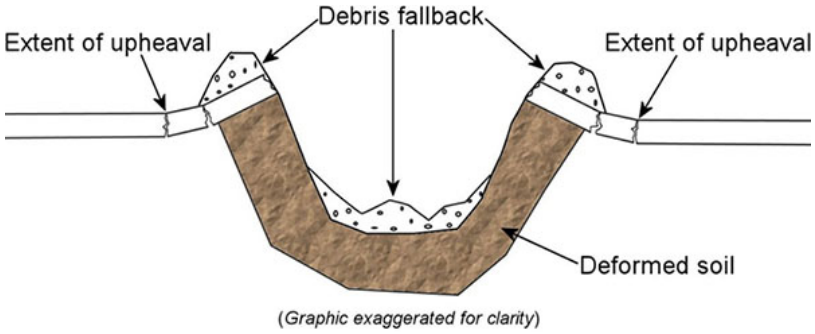


Figure 1–6. Cross section of crater illustrating upheaved pavement.

Position	Suitable AFSCs	Veh./Equip./Tools	Equip. Subs
Crew Lead	[1]3E5X1	Pickup/[3]T-stanchion	Any vehicle
Helper	[2]Any	[3]T-stanchion, broom	
Helper	[2]Any	[3]Sight rod, marking material	
Note 1: Supports MAOS marking after upheaval marking is complete. **Note 2**: Individuals receive just-in-time CPM training upon assignment to the crew. Supports capping (water truck operator & helper) crew after upheaval marking is complete. **Note 3**: Locally manufacture line-of-sight profile measurement devices IAW TO 35E2-5-1.			

Figure 1–7. Upheaval marking crew resources.

The average upheaval marking time per crater is 1.5 minutes. The following procedures deviate from the TO process and are to be used for craters with an apparent size of 10 feet in diameter or smaller.

- Rather than moving the sight rod every 2 feet along the line-of-sight between the stanchions, move the sight rod 1 foot between measurements (fig. 1–8). Doing so will keep the repair as small as possible to prevent premature depletion of repair material.
- 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 rectangular sighting planes on the stanchions) clean the pavement and mark a spot 1 foot farther out from the rod with a lumber crayon from the ADR trailer. This procedure also saves repair material.

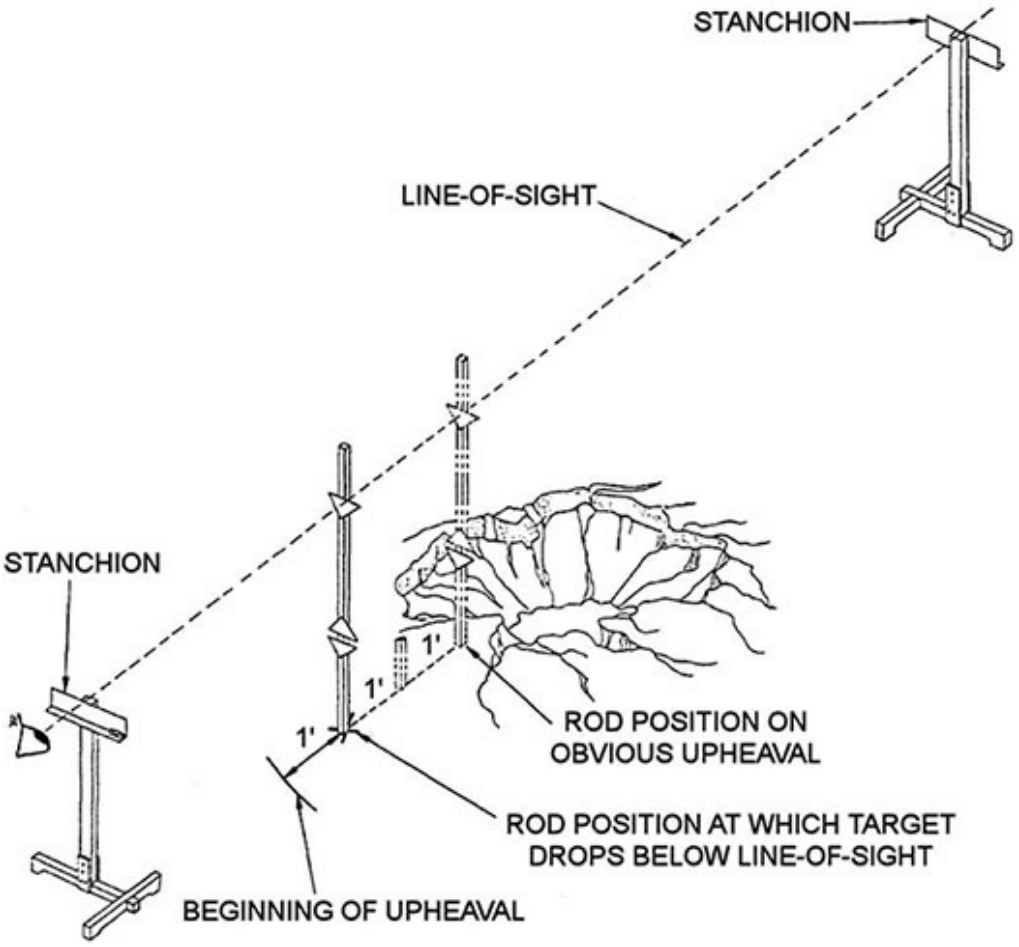


Figure 1–8. Performing crater profile measurements.

- Rather than marking the upheaval in the shape of the crater, square the pavement cut lines by using the outermost extents of the upheaval markings as shown in figure 1–9. Markings are placed parallel to the adjacent concrete slab joint (fig. 1–10) or parallel and perpendicular to the path of traffic in asphalt (fig. 1–11). It is important to understand that crater location plays an important role in how the repair is made. They can be across a joint (with or without load transfer devices), within 24 inches of a joint or even across multiple joints. Regardless of repair type to be made, it is important to know the basics. Below are your standard repairs within a slab or simply on asphalt.
- Crater Repair Team Lead informs the Crater Chief when personnel have finished their tasks and are idle so that they may be loaned to other crews as necessary.

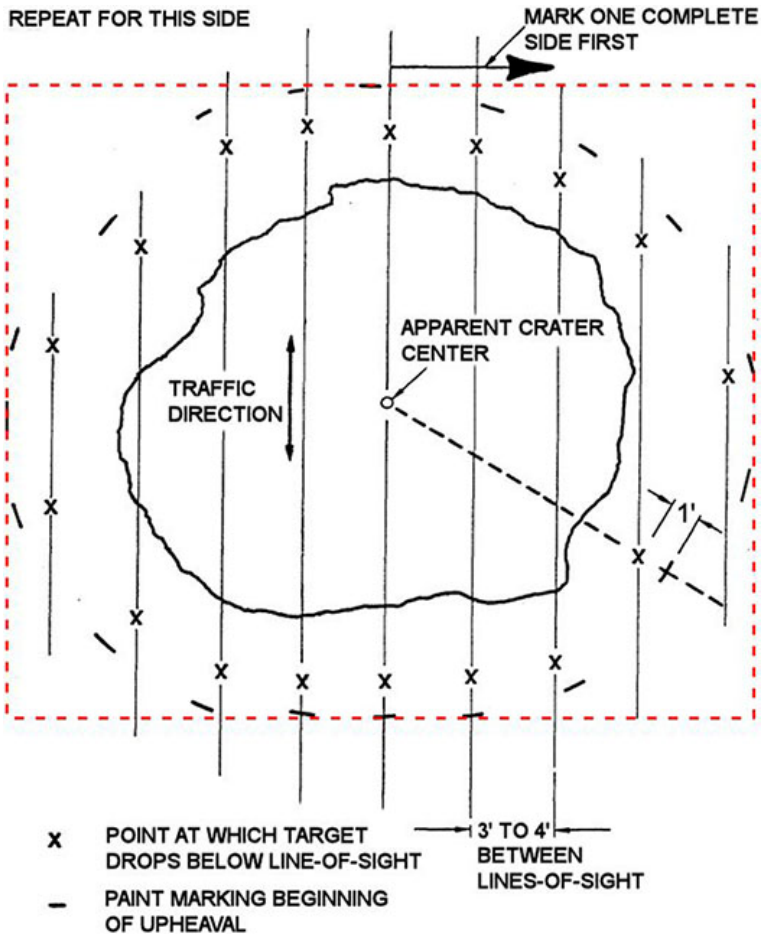


Figure 1–9. Marking upheaval.

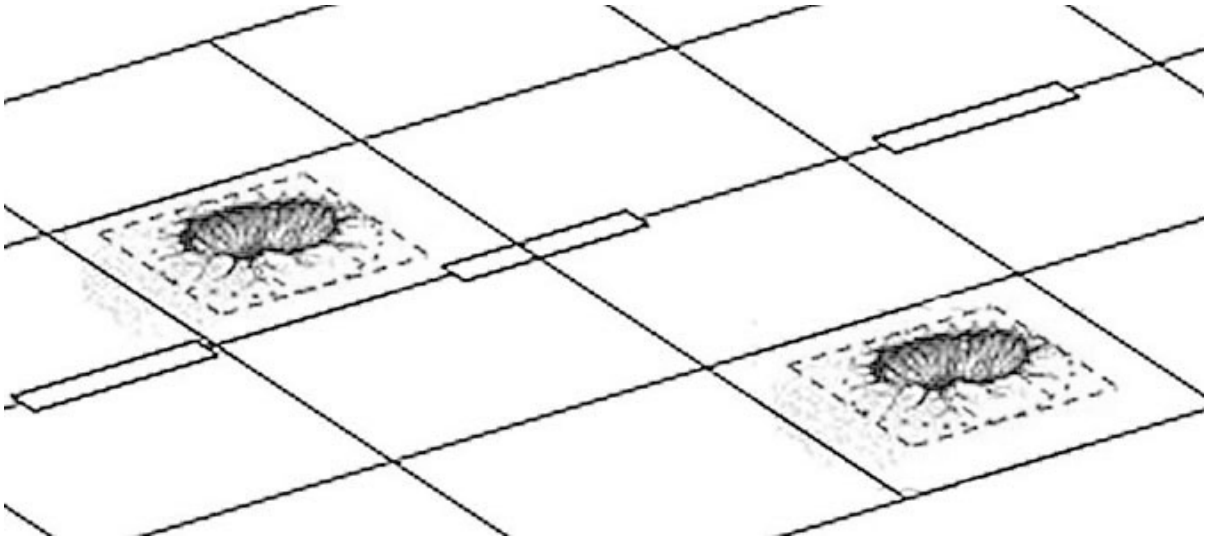


Figure 1–10. Pavement cut line orientation on concrete.

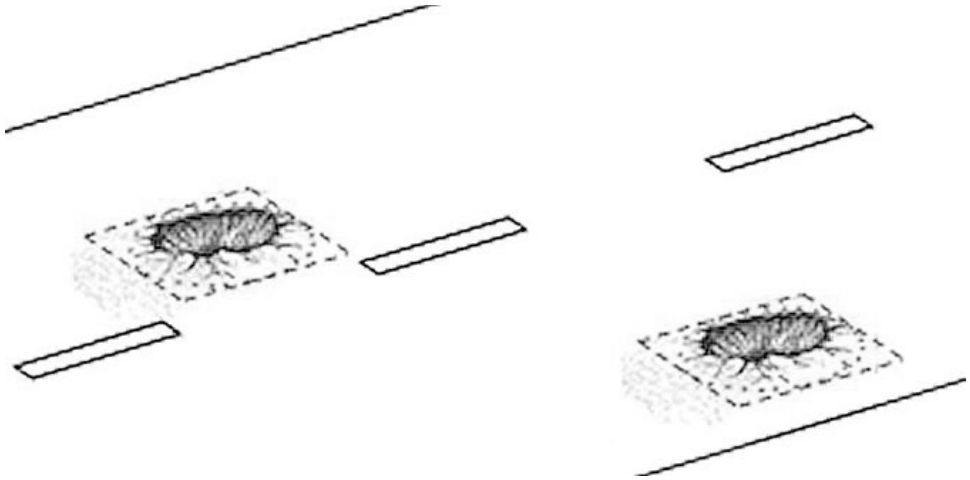


Figure 1–11. Pavement cut line orientation on asphalt.

Pavement cutting

Pavement cutting is the most critical step in the repair process in regards to meeting the required repair timeline. Proper pavement cutting impacts the efficiency of the excavation and capping processes. Figure 1–12 lists the resources required for pavement cutting.

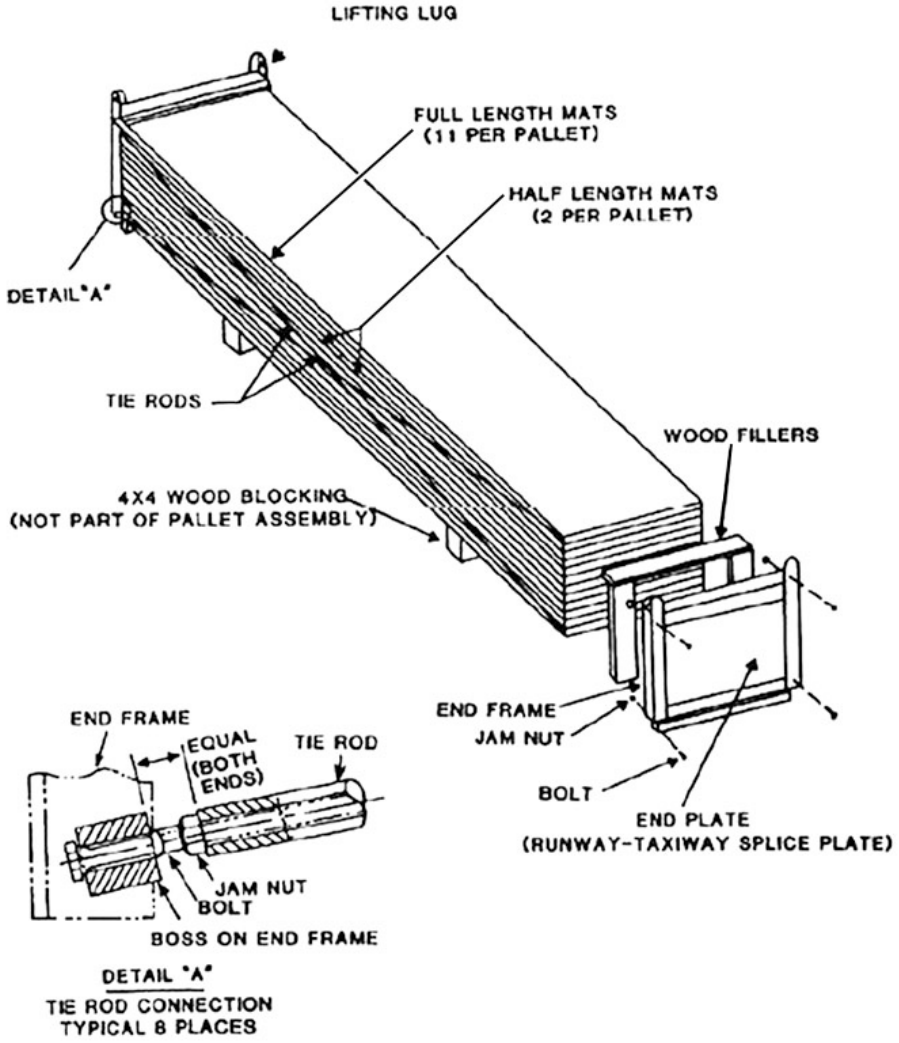


Figure 1–12. Pavement cutting resources.

Saw attachment descriptions

The CTL wheel saw attachment comes with a 45 inch and 60 inch 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 less than 18 inches 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 travel over the debris.

Walk-behind saw

The walk behind saw requires a dedicated water source. Although the saw has been retrofitted with an internal water pump it does not provide sufficient water for larger blades (36 inch and 42 inch); therefore the water source should have its own water pump capable of providing sufficient pressure.

Process

The cutting speed of the wheel saw attachment in 18 inch thick PCC is approximately one foot per minute. The six member crew is evenly divided into two sub crews (A and B) composed of two CTLs with wheel saw attachments and one spotter. The two sub crews work on separate craters simultaneously as shown in figure 1–13. If a crater repair team completes their cutting process on all of their craters before another team, the ADR OIC/Crater Chief will direct the respective Crater Repair Team Lead on what task their CTL operators will do next (e.g., assist other crater repair teams to cut repairs, exchange wheel saw attachment with broom attachment and assist FOD Team, etc.).

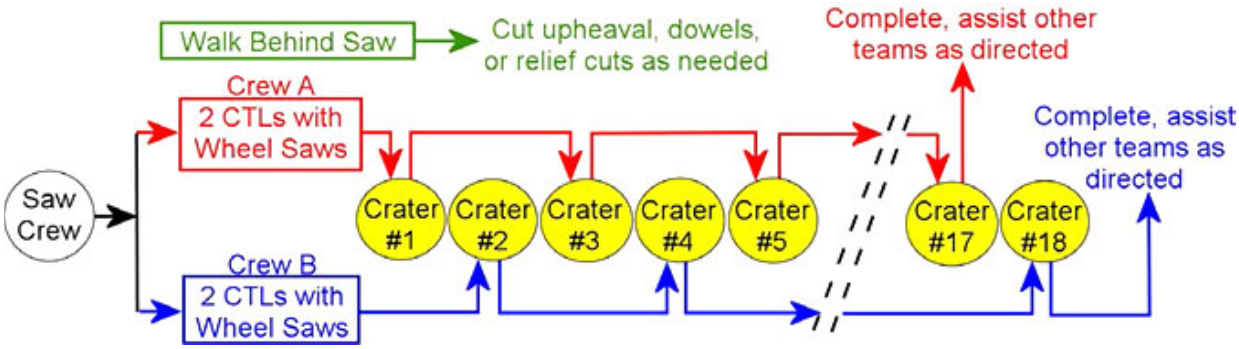


Figure 1–13. Pavement cutting process.

The pavement cutting sub-crews start with the CTLs facing each other on parallel sides of a marked repair. The spotter will position the ground-target alignment aid 13 inches beyond the end of the cut line when using the 45 inch blade, or 11 inches when using the 60 inch blade, ensuring the flat end of the base is facing the cut (fig. 1–14).

The CTL operator aligns the ground-target alignment aid with the cutting aid connected to the top of the wheel saw (fig. 1–14). The operator will then raise the shroud of the saw to its highest extent, align the back edge of the blade with the beginning of the cut line, once aligned the operator will engage the saw blade and lower to full depth. Keep in mind due to the mechanics of the CTL, the blade will move slightly rearward as the blade is lowered.

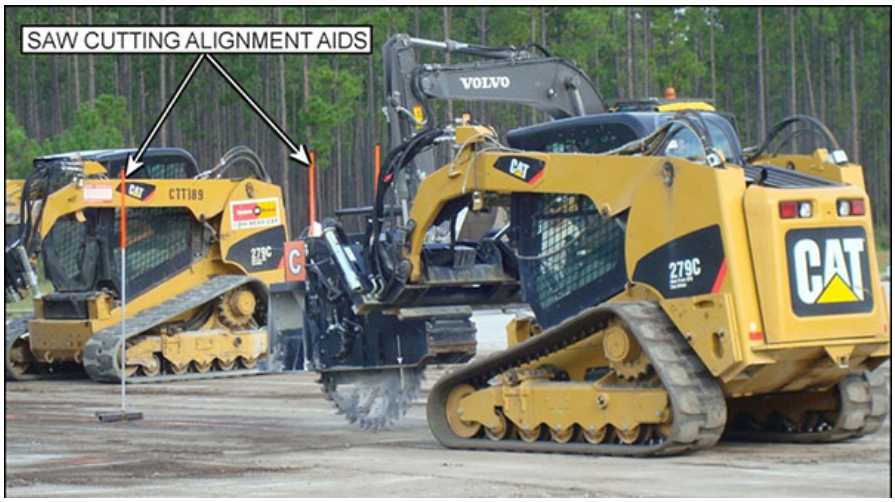


Figure 1–14. Pavement cutting alignment aids.

The operators cut in opposite directions on parallel cut lines while the spotters shovel excess cutting debris that piles in front of the shrouds (fig. 1–15). This prevents the shroud from traveling over the debris, which causes the blade to rise and consequently decreases the depth of cut.

Figure 1–15. Cutting parallel lines simultaneously.

During the cutting process, the CTL operators will stop the cutting when the front of the shroud comes into contact with the alignment aids. The CTL operators then reposition on the two remaining parallel cut lines and make cuts in the same manner as described above. Upon completion of the final cuts, the CTL operators move (leap frog) past the other pavement cutting crew to the next priority crater (previously shown in fig. 1–13) and wait to be lined up by the spotter as described above.

While the CTL operators are setting up for the next crater the spotter is measuring 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.

This process will continue until all crater (up to 18) have been cut within the teams repair zone, and as always, the Crater Repair Team Lead will inform the Crater Chief when task is complete so that members may be loaned to other crews as necessary.

NOTE: It is imperative that overcuts be kept to a minimum. Overcutting adds precious time to the cutting process, consumes large quantities of rapid-set material to repair the overcuts. It also has the potential to cause FOD after repairing the overcut, and reduces the number of repairs that can be sawed before the conical cutting bits require replacement. Also, when cut lines fall within areas containing load transfer devices (i.e., dowels), use the walk behind saw (fig. 1–16) to cut the dowels. Task one member of the Spall Repair Crew to operate saw and task one dump truck operator to tow water source for saw.

Figure 1–16. Walk behind saw.

Pavement breaking and excavation

Breaking and excavation can be another make or break point in the repair process. If care is not taken in regards to the edges/corners during the breaking stage you may chip or crack the pavement further and may require an additional cut. Likewise, it is important to regulate the depth of the excavation to prevent using more capping material than necessary. In order to prevent this from happening it is going to take teamwork and disciplined operators.

Pavement breaking

The pavement breaking will begin as soon as the pavement cutting step is complete on the first crater. Pavement breaking resources are listed on figure 1–17.

Position	Suitable AFSCs	Veh.s/Equip./Tools	Equipment Sub
Operator	3E2X1	Wheeled excavator with hammer attachment	Tracked excavator, backhoe, or CTL with hammer attachment
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.			

Figure 1–17. Pavement breaking resources.

NOTE: If the repair will have an asphalt cap, inform the Warehouse 1 Lead that pavement breaking is about to commence so that he/she may direct the supporting batch plant can begin batching operations to ensure asphalt is ready and available on the airfield when needed to cap the repair.

Pavement should be broken into manageable sized pieces for equipment with buckets during the excavation. Be sure to pay special attention to the saw overcuts, the pavement may not be a free floating pad due to the cuts not meeting up at full depth at the corners. After the pavement has been suitably broken, the operator moves onto the next crater allowing the excavation to begin. Excavation may take longer than breaking, if this happens during the breaking process use the breaker to flip out as much material as possible to help speed things up.

Excavation

Similar to all other steps, as soon as the first crater is available, the next crew begins their task. In this case the excavation team begins excavating the repair area. Excavation resources are listed in figure 1–18.

Position	Suitable AFSCs	Veh./Equip./Tools	Equipment Sub
Operator	3E2X1	Wheeled excavator with bucket	Tracked excavator, backhoe, CTL, or loader
Spotter	Any	Shovel, tape measure, and marking paint	
Note: On larger craters, frontend loaders and CTLs may operate from within the crater to speed excavation.			

Figure 1–18. Excavation resources.

To aid in this process lines are marked 24 inches up the side of the bucket when the bucket is sitting flat on the ground. The lines provide a visual reference for the spotter to guide the operator ensuring proper depth (fig. 1–19).

Figure 1–19. Excavator bucket with 24 inch reference marks.

After all material has been excavated to a depth of 24 inches the spotter will clean the corners and vertical faces as necessary and level the bottom of the excavation with a shovel. The spotter will then take an accurate measurement and report it to the Crater Repair Team Lead who requests the necessary materials from the Warehouse Lead. Before moving to the next crater the spotter will finally mark the backfill depth on the sides of the excavation (10 inches below surrounding pavement for a concrete cap and 4 inches below surrounding pavement for asphalt cap). Once the excavation team has completed all craters the Crater Repair Team Lead will inform the Crater Chief that they are idle so that they may be loaned out to other crews as necessary.

Backfill

The ADR backfill process utilizes a flowable-fill product in place of traditional crushed stone. The flowable-fill is a high strength, low viscosity, excavatable, rapid-setting, cementitious backfill material. The material is packaged in 3,000 pound, 30 cubic foot, super sacks and used beneath rapid-setting concrete or asphalt.

The foil-lined super sacks are delivered and stored in 20-foot by 8-foot sealed shipping containers with desiccant, or drying agent, to keep moisture to a minimum within the containers. Shelf-life when stored in this manner is 5 years, if sacks are removed or stored in any other manner an accurate shelf-life cannot be determined.

Backfill under rapid-set concrete.

When the repair is capped with rapid-setting concrete, flowable-fill is placed using the dry placement technique commonly known as “slash and splash”. Put simply, 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 Warehouse telehandler operator, that unloads super sacks from the trailers on the airfield, places super sacks diagonally from a corner of the repair approximately 15 feet away (fig. 1–20). This leaves enough room for equipment to perform pavement cutting, breaking, and excavating of the repair if not already completed. Align the handles on top of the sacks so that the telehandler forks can slide through both sacks without readjusting position. Figure 1–21 identifies resources required for the backfill process under rapid-set concrete.

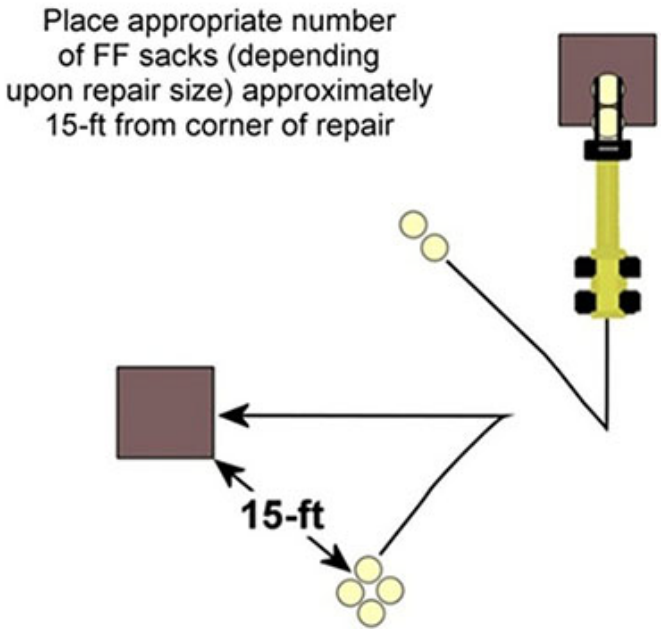


Figure 1–20. Backfill super sack placement.

Position	Suitable AFSCs	Veh./Equip./Mat./Tools	Equip./Mat. Subs
[1]Operator	3E2X1, 3E4X1, 3E4X3	Water truck[2], water flow meter	Any portable water source
Operator	3E1X1, 3E2X1, 3E3X1, 3E4X1	Telehandler	Any forklift
Spotter	Any	Utility knife, rake	
Spotter	Any	Utility knife, rake	
		Flowable-fill	[3]Crushed stone
Note 1: Airman reassigned from upheaval marking team. **Note 2**: If a flow meter is not available, a 55 gallon drum can be used instead. The "slash and splash" method requires 50 gallons of water per sack. **Note 3**: Use the crushed stone backfill method IAW UFC 3-270-07.			

Figure 1–21. Backfill under rapid-set concrete resources.

Figure 1–22 displays the expected consumption of flowable-fill when used under a rapid-set concrete cap (14 inches of flowable-fill). The table assumes that the excavation depth is 2 feet (all dimensions are in feet).

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

Figure 1–22. Flowable-fill consumption rate under rapid-set concrete cap.

The spotter will direct the telehandler operator to continue bringing super sacks, "splashing" 50 gallons of water from the water truck for each sack using a flow meter attached to the hose. This will continue until the repair is filled up to the reference mark (10 inches from surrounding pavement), as shown in figure 1–23.

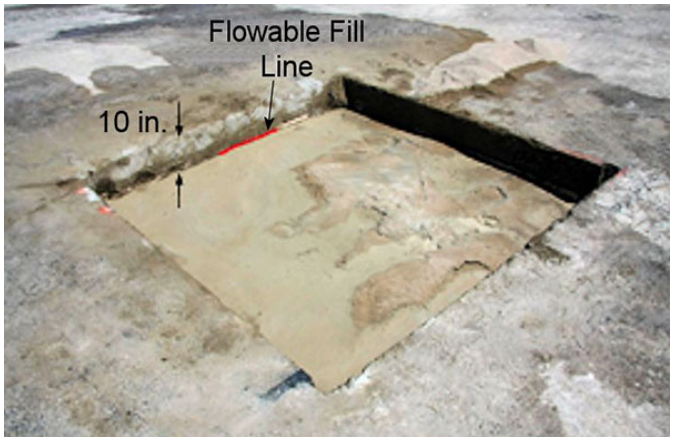


Figure 1–23. Backfill under concrete cap complete.

NOTE: If the repair does not require a full super sack and more material is still required, make an educated guess on the location of your "slash" and adjust the water being added accordingly (e.g., only add 25 gallons if only half of a sack was used). The remaining material in the super sack will be used in the next repair.

It is the responsibility of the telehandler operator to dispose of (at a designated trash collection point) the empty sacks upon completion of each repair or when retrieving additional sacks. Also once all super sacks (flowable-fill and rapid-set capping material) have been delivered and unloaded, the Warehouse telehandler operator begins reloading the attachment and tool trailers.

As always, once tasks are complete, the word is passed to the Crater Chief in case any other crews are in need of assistance.

Backfill under asphalt

The process for backfilling beneath an asphalt cap is accomplished with a wet placement technique utilizing the volumetric mixer (fig. 1–24). The process uses 70 gallons of water per super sack of flowable-fill. Resources required for backfilling under asphalt are identified on figure 1–25.

Figure 1–24. Volumetric mixer.

Position	Suitable AFSCs	Veh./Equip./Mat./Tools	Equip. Subs
Operator	3E0X1, 3E0X2, 3E2X1, 3E3X1, 3E4X1, 3E4X3	Dump truck w/water skid	Any equip. capable of towing volumetric mixer
Operator	3E1X1, 3E2X1, 3E3X1, 3E4X1	Telehandler forklift	Any forklift capable of raising a super sack over the volumetric mixer edge**
Operator	3E2X1	Volumetric mixer, rake	Transit mixer*
Operator	3E2X1, 3E4X1, 3E4X3	Water truck, rake	Any portable water source
		Flowable-fill	Crushed stone
*To prevent the flowable-fill from setting up while using a transit mixer, mixing must be performed with an extreme sense of urgency once water is added. **The telehandler forklift is able to raise super sacks high enough for cutting spikes on the volumetric mixer to puncture the super sack. However, any forklift capable of raising super sacks over the mixer edge will allow the sack to be cut open by hand.			

Figure 1–25. Backfill under asphalt resources.

During alarm black, run a minimum of one yard of material through the volumetric mixer to ensure proper operation and correct settings. Also, stock the mixer catwalk with any required admixtures. Figure 1–26 shows the expected consumption of flowable-fill when used under a 4 inch asphalt cap (20 inches of flowable-fill). The table assumes that the excavation depth is 2 feet (all dimensions are in feet).

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

Figure 1–26. Flowable-fill consumption rate under asphalt cap.

Backfilling using a volumetric mixer takes a combination of support equipment/operators. Using the backfill under asphalt method requires the volumetric mixer, a dump truck (w/water skid), water truck, and the telehandler. Working together the volumetric mixer, being towed by the dump truck will position the chute over the center of the repair, ensuring the controls are set to “flowable-fill”. As the flowable-fill is consumed, the telehandler operator restocks the hopper with super sacks as needed and disposing of the sacks at the predetermined trash collection point. Figure 1–27 shows a backfill under asphalt cap nearing completion.

NOTE: The water truck operator maintains water supply and admixtures in the volumetric mixer saddle tanks. When the water truck is empty, it is replaced with a water trailer. If the volumetric mixer is towed by a dump truck with a water skid in the bed, save the water in the skid to use when the water truck leaves to be refilled or swap the empty water trailer for a full one.

It is also important to note that the volumetric mixer will require periodic cleaning during the operation. Failure to perform periodic cleaning could result in an operational failure.

Figure 1–27. Backfill under asphalt cap nearing completion.

Once all super sacks (flowable-fill backfill and rapid-set capping material) have been delivered and unloaded, the telehandler operator will begin reloading the attachment and tool trailers. As always once the task is complete the Team Lead will inform the Crater Chief and loan out crews as necessary.

Capping

The capping process is accomplished with either asphalt or rapid-set concrete. The capping material does not necessarily need to match the surrounding pavement (rapid-set concrete can be used to cap a repair in asphalt and vice-versa). Capping begins once the backfill achieves initial set of 15 minutes for rapid-set concrete ("slash and splash") and 30 minutes for asphalt (wet flowable-fill placement). Ensure there is no water sheen on the backfill surface and the backfill can support foot traffic (leaves no foot prints). Shown below in figure 1–28 the list of required resources is identified for rapid-set concrete cap.

Position	Suitable AFSCs	Veh./Equip./Mat./Tools	Equipment Subs
Operator	3E0X1, 3E0X2, 3E2X1, 3E3X1, 3E4X1, 3E4X3	Dump truck w/water skid	Any vehicle able to tow the volumetric mixer
Operator	3E1X1, 3E2X1, 3E3X1, 3E4X1	Telehandler	*Any forklift able to raise a super sack over the edge of the volumetric mixer
Operator	3E2X1	Volumetric mixer	**Transit mixer
Operator	3E2X1, 3E4X1, 3E4X3	Water truck	Any portable water source
Helper	Any	***Screed, bucket and hand trowels	
Helper	Any	***Concrete rake and square shovel	
Helper	Any	***Concrete rake and square shovel	
		Rapid-set concrete	
		Admixtures	TBD

*Telehandler forklift is able to raise super sacks high enough to reach the puncture spikes on the volumetric mixer. However, any forklift able to raise super sacks over the mixer's edge allows the sacks to be cut open by hand.
**To prevent the rapid-set from setting up while using a transit mixer, mixing must be performed with an extreme sense of urgency once water is added.
***An inventory of the ADR tool trailer is listed in **Appendix C**.

Figure 1–28. Rapid-set concrete cap resources.

Rapid-set 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, 25 cubic foot, super sacks and has a water to rapid-set material ratio of approximately 50 gallons of water for each super-sac. 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.

NOTE: The shipping and storage requirements are the same for the rapid-set concrete as is if for the flowable-fill.

Before placing rapid-setting concrete, the flowable-fill backfill "slash and splash" method requires 15 minutes to achieve initial set. Once you have achieved initial set-time the volumetric mixer (towed by the dump truck) and water truck arrive at the repair. The mixer operator must ensure the controls are set to "rapid-setting concrete" and required admixtures are on board and adjusts the placement of the chute over the center of the repair with help from the tow vehicle. The completion time per crater for placing the rapid-set concrete is expected to be no more than 11 minutes. Figure 1–29 explains the process for capping with rapid-set concrete.

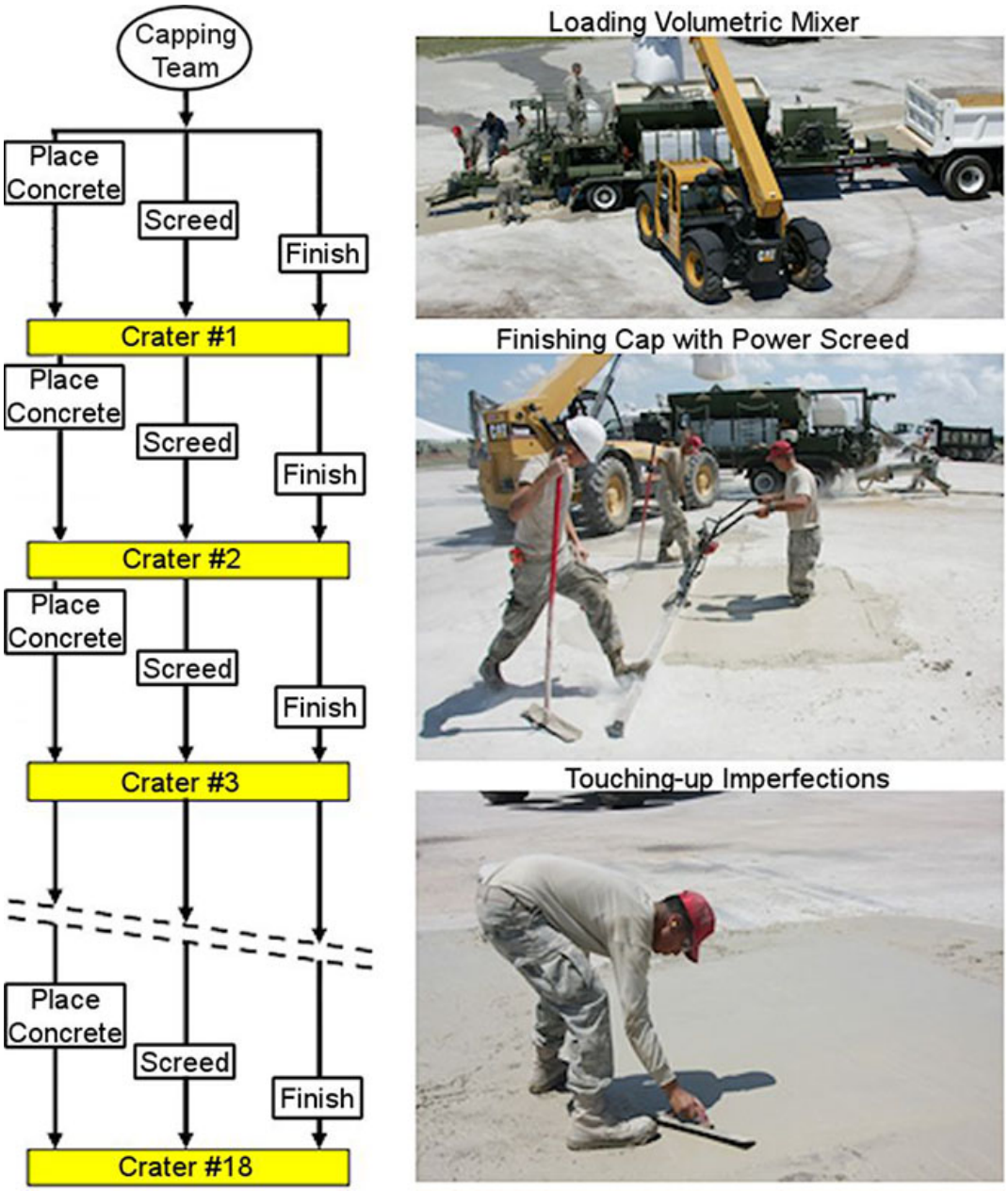


Figure 1–29. Rapid-set concrete capping process.

NOTE: If the outside temperature is above 75°F, retardant admixture is required to extend working time of the material. If the rapid setting concrete sets too quickly, the concrete could cause a malfunction of the volumetric concrete 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-pound (lb.) bags, but will be stored in 50 lb. buckets inside ADR material containers for both flowable fill and rapid setting concrete.

The recommended dosage rates are shown in the table below. The citric acid should be added to an empty five gallon bucket along with one to two gallons of water and stirred briefly before being added to the volumetric mixer mix water tanks. Citric acid must be added to both water tanks since the mixer draws water from both tanks during placement of rapid setting concrete. In emergency situations where rapid setting concrete or flowable fill is beginning to setup while adhered to tools or

equipment (particularly the volumetric mixer auger), it is recommended that 2-3 lbs. of citric acid be mixed with one to two gallons of water and applied to the rapid setting concrete or flowable fill. This action will slow the set time down to help aid in the cleanup process (see fig. 1–30).

Figure 1–30. Citric acid bucket kit/dosage.

NOTE: The volumetric mixer requires cleaning after completing three repairs. Failure to perform periodic cleaning will result in operational failure.

NOTE: Ensure overcuts are filled while the cap is placed. If slurry (flowable-fill) fills overcuts before being packed with rapid-set, a strong FOD potential exists after capping.

When the repair has been capped, the mixer crew will proceed to the next repair while the finishing crew will stay back to screed/touch up imperfections before moving onto the next priority. The Debris Removal crew thoroughly cleans around repairs when capping is finished (CTL with buckets and/or brooms) and the Crater Repair Team Lead records completion time for each cap.

NOTE: A rapid-set concrete repair has an initial set time of 45 minutes in fair weather and is capable of supporting a 2.5 ton vehicle. 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 Prevention Team that the work area is open for striping and sweeping. Full cure time for any aircraft trafficking is two hours.

Asphalt cap

The asphalt cap is placed at a compacted thickness of four 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 completion time per crater to place the asphalt is expected to be no more than 11 minutes, 30 seconds, with an additional 11 minutes, 30 seconds for compaction. The resources required (based upon ambient temperature) for the asphalt cap are identified on figure 1–31.

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

Figure 1–31. Asphalt cap resources.

NOTE: Once the first repair has been backfilled the Team Lead requests the first load of asphalt and a schedule of future asphalt deliveries from the Warehouse Lead.

When the asphalt arrives at the repair location the driver will be directed where to dump by the Crater Repair Team Lead. At this time the temperature range of the asphalt should be 280 degrees Fahrenheit or greater as required for breakdown rolling. Under the direction of a spotter, the loader operator will place and screed the asphalt to the proper level ensuring his wheels are not placed on the uncompacted asphalt as identified in figure 1–32. If the repair is too wide for the loader, the asphalt is placed and rough leveled by the loader and finished by hand or by CTL's w/bucket.

Figure 1–32. Loader screeding asphalt cap.

NOTE: For a 4-inch thick repair the un-compacted asphalt should be 1.5 inches above the surrounding pavement, 1.375 inches of un-compacted material for every 1 inch of compacted repair thickness.

NOTE: Asphalt screed attachments are currently being tested for the CTLs and/or telehandler forklifts.

During the placement and screeding of the asphalt, the designated crew members assist with monitoring asphalt temps, placing, cleaning and tucking the edges using lutes and/or square shovels. This preps the repair to be rolled with the steel-wheel roller longitudinal to the crown of the runway, the asphalt at this time should be 280 degrees Fahrenheit or greater. The roller operator first completes a 0.5 static pass followed by 2.5 vibratory passes with the steel wheel roller. Next, make 2 passes with the pneumatic tire roller (smaller craters may not require use of a pneumatic tire roller) and finish with 3 static passes with steel wheel roller. Between passes, the helper will trim any excess asphalt from the edges with a square head shovel. This process is repeated until all caps are complete.

The natural cooling process takes approximately 2 hours to bring the asphalt down to 150°F (depending on environmental conditions), which is the required temperature to receive vehicle traffic. To reduce the cooling time, the water truck operator will flood the last 5 repairs with water. The repairs are repeatedly flooded whenever the asphalt begins to develop a dry area. The operator will flood a repair briefly and move to the next repair alternating between repairs as required. At this time the water truck operator moves the cones that identify the repair zone, signaling the Striping Crew and FOD Team that the work area is open. The repair is ready to receive aircraft trafficking until the asphalt temperature reaches 125°F or less. The final step as with all other tasks, the Crater Chief is informed the task is complete so crews may be loaned out as necessary.

605. Rapid spall repair procedures

Spall repair is as important as crater repair; aircraft cannot land or takeoff until spalls have been repaired, especially those within 25 feet of the MOS centerline. Therefore, spall repair must be completed within the same 6.5 hours as does crater repair, EALS installation, MAAS installation, and 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 foot in diameter, or no

upheaval in surrounding pavements (fig. 1–33). It is expected hundreds, possibly thousands, of spalls will require repair after an attack.

Position	Suitable AFSCs	Veh./Equip./Mat.	Equip. Subs
Operator	3E0X1, 3E0X2, 3E1X1, 3E2X1, 3E3X1, 3E4X1	Loader	*CTL w/bucket
Operator	3E2X1, 3E5X1	Steel wheel roller	Roller attachment for the CTL
Operator	3E2X1, 3E5X1	Pneumatic roller	**Dump truck with bed loaded
Operator	3E2X1, 3E4X1, 3E4X3	Water truck	Any portable water source
Helper	Any	Lute, square shovel	
Helper	Any	Lute, square shovel	
Helper	Any	Lute, square shovel	
		Asphalt	

*The track impressions left behind by the CTL roll out as long as the CTL drives directly on and off of the un-compacted repair and does not turn.
**Testing has shown that a vibratory roller alone is capable of achieving density on a smaller, confined asphalt repair area. Testing continues to determine whether a pneumatic roller is required for a large crater.

Figure 1–33. Spall and crater profiles.

Crew size and production rate

Crew size plays a large role when determining how many spalls will be able to be repaired in the same 6.5 hours required for crater repair. Similarly, the scope of the spall damage will likely govern the recommended crew size. Repair teams can range from a 3-person crew (small capability) up to a 21-person crew (very large capability) giving flexibility to configure crew sizes to best fit the needs of the local situation.

Experimentation has shown that a 4-person spall repair crew is the ideal size to repair approximately 200 spalls (24 inches diam. And 6 inches deep) within the 6.5 hour window. However, there may be instances where a 3 or 5-person crew may be more appropriate. (**NOTE**: Crew performance may differ due to numerous conditions. Fatigue, experience, skills, equipment/environmental conditions, threat conditions, and so forth, and should always be taken into account when determining crew size.)

NOTE: Preparation and planning is always the key to mission success. In this case having the tools and equipment ready for execution is pivotal to completing the task of re-opening the runway. Figure 1–34 shows a likely combination of pickup truck and trailer stocking configuration to ensure you are carrying a one-stop shop to spall repair. Keep in mind there are many configurations dependent on vehicle/trailer availability, but this breakdown of required items should give you an idea of the tools necessary to get the job done.

Figure 1–34. Recommended pickup and trailer stocking configuration.

Production rates will undoubtedly decrease over time due to fatigue, figure 1–35 gives estimated production rates over the 4.5 hour period keeping in mind the final 2 hours include cure time before aircraft is allowed to traffic over the repair.

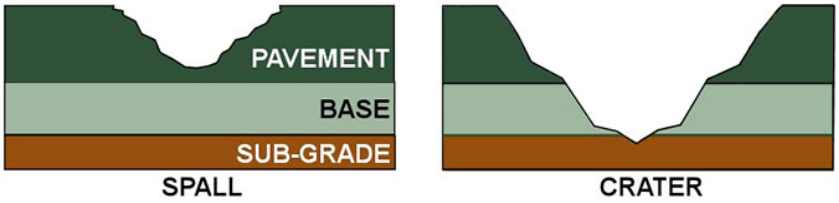


Figure 1–35. Production rates.

Although the number of personnel within the crews will stay within the 3 to 5 person range, the number of crews can multiply until reaching the very large capability requirement of 21 total personnel. With the very large capability crew size the number of spalls that can be repaired can reach approximately 1150 spalls.

Area prep and spall repair

Repair zones should be identified prior to recovery after attack so crews may know where they will begin there repairs. The recommended repair zone is 50-ft wide by 25-ft long. If the MOS is wider than 50-ft, consider (if using a single crew for the full width) making your first pass down the center of the MOS at the width of the expected aircraft wheel path so they may cure within the established deadline. Then make a return pass to repair spalls down one remaining edge of the runway, finishing off with another full pass down the unfinished edge. If more crews are available they may work to cover the full MOS width simultaneously.

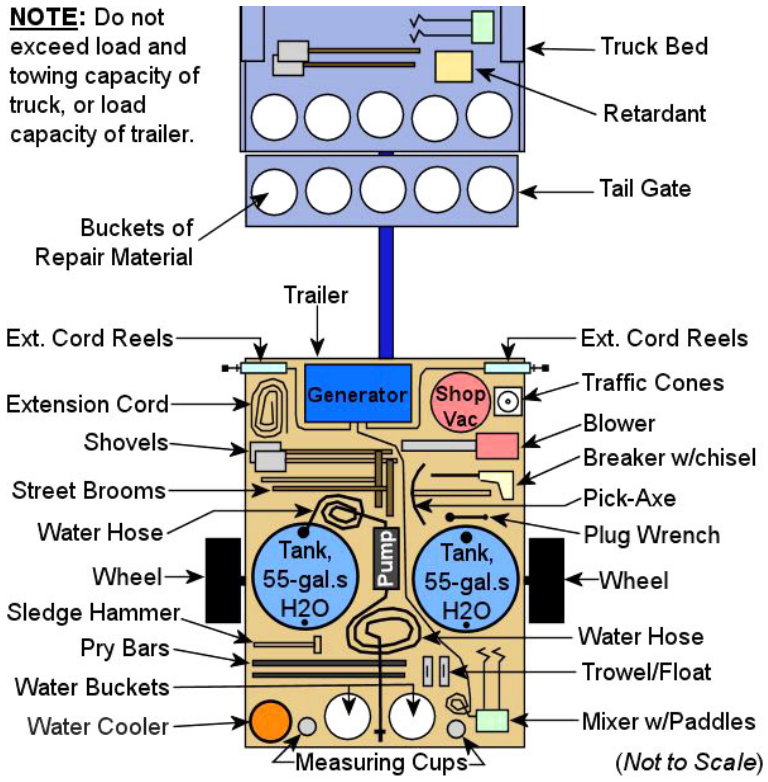


Figure 1–36. Spall prepared for expeditious repair.

Area preparation is vital to establishing a solid bond to the existing pavement. All spalls must be cleaned and all standing water must be removed prior to placing repair material into the spall. Using the established crews each member is assigned tasks which should be rotated frequently to avoid early fatigue. (**NOTE:** If upheaval is apparent or the damage has penetrated completely through the pavement, mark the spall with a white cone to inform the Crater Repair Team Lead of the situation and move on to the next spall.)

Using a push broom, one member sweeps the larger debris a minimum of 12 inches away from the spall. Another member will (by using a generator, electric blower or shop vacuum) clear the spall of smaller debris, dust and any standing water all while

keeping the one foot diameter around the spall clear. If debris is noticeably loosened but cannot be removed by hand, they must be removed by using a pick axe, pry bar, sledge hammer or impact hammer. Figure 1–36 shows a properly prepared spall ready for repair.

Spall repairs during "recovery after attack" will be expeditious temporary repairs. Figure 1–37 lists the steps, personnel that perform each step, and time associated with each step. Adjust responsibilities when increasing crew size. (**NOTE:** When time permits after initial recovery, repairs will be reaccomplished with permanent repairs in accordance engineering technical letter (IAW ETL) 07-8, *Spall Repair of Portland Cement Concrete (PCC) Airfield Pavements in Expeditionary Environments*.)

Crew Size	1st Hour	2nd Hour	3rd Hour	4th Hour	Final 30 min.s (4.5 hrs)	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

Figure 1–37. Three person crew process at each repair zone.

Spall repair material is a cementitious, rapid setting, self-leveling repair mortar. The most common type of repair material used has a working time of 7–9 minutes and will reach compressive strengths of >2500 psi within 2 hours and more than 6000 psi at the 28 day mark. The material comes pre-packaged and stored in its own 5 gallon mixing bucket (just add water). The repair material will consolidate with prolonged storage and needs to be tumbled end over end (6 to 8 times) and dry mixed with the power mixer (approximately 30 seconds or until material appears "fluffy") prior the actual repair effort. These steps may be conducted during attack-preparation actions to save time during recovery.

Once the crew arrives at the first repair zone one member begins setting out the repair material to be mixed while the others start clearing the debris, dust and water. When enough of the area is ready to begin, simply open the buckets and add the manufacturers recommended amount of water to the dry-mix while the material is being mixed using the power mixer. The mix material should be mixed until all the dry spots have disappeared and it has reached a pancake batter consistency (approximately 1.5 to 2 min). (**NOTE:** Be sure to keep a bucket full of water nearby to rinse off concrete tools and the paddles after mixing each bucket to prevent build up.)

Figure 1–38. Retardant admixture.

NOTE: All rapid setting concretes react differently in various environmental/climate 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 should be discarded (i.e., considered unsuitable for repairs).

NOTE: When temperatures are greater than 90°F the material is likely to start setting before mixing is complete, while carrying the material to the spall, and/or while filling the spall. Conversely, when temperatures are less than 40°F or where humidity is excessive, the same mix may not set for hours. Admixtures (retarders/accelerators) are utilized to mitigate these conditions (fig. 1–38).

Once a uniform wet-mix has been achieved, the member that was blowing out the spalls now quickly carries and places the wet mixed material in the clean spalls. Depending upon the type of repair material and environmental conditions, it may readily flow into all exposed voids/cracks until reaching the surrounding pavement surface (fig. 1–39) or may require floating and/or troweling to ensure the 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.)

(Member 1) (Member 2) (Member 3)

TASK Min.s:	2	4	6	8	10	12	14
1. Sweep debris 12-18 inches from spalls							
2. Clean debris, dust, & moisture from spalls							
3. Unload/flip buckets							
4. Remove repair material bucket lids							
5. Fill 2 empty buckets with water for mixing & rinsing							
5. Dry mix repair material							
6. Add water during wet mixing							
7. Wet mix repair material							
8. Fill spalls with wet mix							
9. Load material & equipment on truck							

Figure 1–39. Self-leveling mix.

Slightly overfill the repair, not greater than 0.25-inch (fig. 1–40), 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 (fig. 1–41). Excess material must quickly be removed before it sets and placed back in the bucket to prevent a FOD potential.)

Figure 1–40. Repair slightly overfilled.

Figure 1–41. Smoothing repair with trowel.

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. Vehicle configuration will determine how often consumables (i.e., water and repair material) are restocked. When comparing pickup with trailer configuration or simply a 1-ton pickup it is readily apparent that 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. (**NOTE:** The more spall repair crews, 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.)

Asphalt spall repair

Perform expeditious asphalt spall repairs in the same manner as described for expeditious concrete spall repairs. 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.

If upheaval is apparent, place a white cone 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.

The Crater Repair Team will 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 ADR tool trailer). After airfield recovery, replace the repair with an asphalt patch when time permits.

As with all steps of ADR recovery once a task is complete the Crater Chief is informed so crews may receive their next assignment.

NOTE: When conditions return to normal operations, re-accomplish the expeditious repairs with permanent repairs as described in UFC 3-270-03, *Concrete Crack and Partial-Depth Spall Repair*.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

604. Rapid rigid and flexible crater repair

1. How many craters will we be able to repair using the new ADR process and in what time frame?

2. What are the 3 stages (names) that have made the most significant changes?

3. How does the crater repair assembly line process work?

4. Which step is accomplished by performing crater profile measurement?

5. Why is it important to keep overcuts to a minimum?

6. During backfill under rapid-set concrete, how much water is used for each super-sac and how is it measured?

7. What equipment is needed when using the volumetric mixer for backfill under asphalt?

8. Explain whether or not it is acceptable to clean out the volumetric mixer after all spalls are repaired.

9. Who is contacted at the end of each step throughout the entire process? Why?

605. Rapid spall repair procedures

1. What is the ideal spall crew size and how many spalls can be repaired in 6.5 hours?

2. Using a 5 person crew, how many spalls can be repaired in 4 hours?

3. Spall repair material can be described as?

4. Why should you slightly overfill a spall repair during concrete spall repair?

5. What should you do when operational conditions return to normal?

1–3. Sustainment Pavement Repair Kit

The sustainment pavement repair (SuPR) kit project is the culmination of research that began in 2005. This research effort was initiated by the then Air Force Central (AFCENT) commander to determine why airfield repairs were failing prematurely. It became imperative to develop and or identify products, equipment, and procedures for field engineers to make fast, durable repairs working around aircraft missions in high tempo environments. What was needed were materials that could gain strength rapidly but were less sensitive to mixing proportions, as well as equipment that was small, air transportable, and multi-purpose, yet powerful enough to do the job quickly and effectively. After reading this section, you may wonder how we went as long as we did without a SuPR Kit in the past. Civil engineers now have a superior capability for contingency repair and sustainment with this “shop-in-a-box”.

606. SuPR kit concept of operations

The SuPR kit gives civil engineers the ability to perform high quality repairs and return an airfield to service within 2-hours (versus days) while supporting a high aircraft sortie rate. It focuses on sustainment but may be used for spall repair during any phase of airfield operations.

SuPR kit capabilities

The kit will allow engineers in the field to get away from "repairing the repairs" and to place high quality durable repairs with minimal impact on flight operations. More efficient repair techniques reduce the required manpower and, because most of the kit's items are widely used in the field, training will be easier and more efficient. Plans are for the SuPR kit to be treated as war readiness material, or WRM assets.

When deploying to an airfield, pavement may need significant repairs before receiving mission aircraft (e.g., fighters), beddown forces, or materiel. In this instance, either a RED HORSE (RH) advanced echelon repair team or a RH small horizontal construction team, depending upon airbase accessibility, deploys with their appropriate equipment unit type codes (UTC), alongside contingency response forces, in an "open the airbase" scenario. They perform a minimum number of expedient airfield surface repairs to establish limited aircraft operations.

Cargo aircraft then deliver equipment, personnel and materials necessary for Prime BEEF or RH engineers to establish the airbase. In this phase, engineers make the previous expedient repairs more permanent and extend the airfield to achieve initial operating capability (IOC) allowing limited mission aircraft operations. Subsequently, airfield sustainment capabilities must exist until Basic Expeditionary Airfield Resources (BEAR) equipment and materials arrive and a supply chain established. The SuPR kit provides this interim maintenance capability.

The SuPR Kit may be used to complete some major repairs when augmented with additional materials and transport capabilities. It also may be augmented with other ADR kits in order to enhance its effectiveness and reduce lifecycle logistics associated with ADR, and in particular sustainment repair capabilities. These augmentation kits are tailored to the particular types of pavement, distress, and local materials at the airfield.

Once the full allotment of BEAR vehicles and equipment arrive, Prime BEEF forces work to bring the airfield to full operational capability and transition into operate and sustain-the-airbase missions. The SuPR kit should remain in place until all equipment essential to the timely repair of airfield pavements has been replaced with BEAR, leased or other suitable assets, or the mission is closed or redeployed.

In addition, engineers may be tasked to temporarily deploy to forward operating locations (FOLs), without a permanent engineer capability, to perform minor airfield repairs. Because of its small footprint, the SuPR kit is ideally outfitted to provide this capability.

SuPR kit description

This kit is a specialized equipment-and-materials-only UTC that provides Prime BEEF and RH teams the capability to perform durable asphalt and concrete pavement maintenance and repair (typically spall, joint/crack, small patch or single slab repairs).

The kit consists of five 20-ft by 8-ft freight containers with multi-use equipment deployable via air, sea or land. The kit includes two vehicles (compact track loader (CTL) and compact vibratory roller) that will require fuel and periodic maintenance. The following major equipment is provided in the kit:

- 279C compact track loader with seven attachments.
  - Cold planer.
  - Concrete breaker.
  - Drum compactor.
  - Forks.
  - Multi-purpose bucket.
  - Rotary broom.
  - Turbine heated asphalt mixer.
- Vibratory compact roller, self-propelled, dual drum, 3-ton.
- Concrete and asphalt hand tools.

- Concrete mixer.
- Tow-behind air compressor.
- Two 6-kilowatts (kW) generators.
- Walk behind saw (60 hp), 18-42-inch blades.
- Walk behind saw (18 hp), 18-inch blade.

There are three equipment containers (1–3) and two repair material containers (4 & 5). The containers are labeled in the top left corner on both long ends of each container for ease of identification (fig. 1–42). The containers have been certified air transportable on C–130s, C–17s, and C-5s. The individual empty and gross container weights are listed in figure 1–43. Figure 1–44 lists the kit's basic repair material and coverage.

Figure 1–42. Container identification label.

Figure 1–43. Shipping container weights.

Figure 1–44. SuPR kit repair material quantity and coverage.

607. SuPR kit operation

Many deployed locations have limited space for setting the containers up for use; therefore, site them according to the desired layout and available square footage. Figure 1–45 shows the clearances required for unloading each container.

Container	Empty Weight (lbs)	Gross Weight (lbs)
Container 1	5,050	23,000
Container 2	5,050	18,000
Container 3	5,050	15,500
Container 4	5,050	28,750
Container 5	5,050	28,750

Figure 1–45. Clearances required for unloading containers.

Siting and layout

Place containers on improved or semi-improved surfaces capable of supporting the weight of containers (i.e., up to 29k lbs.). The layout area should be in a location with adequate draining and is not prone to standing water or flooding. It is recommended that 20-foot of clear space for material handling equipment be available on both ends of equipment containers (1, 2, & 3) and 20-foot of clear space be available on both ends and both sides of material containers (4 & 5), which open on all four sides. Below are a couple configurations examples (figs. 1–46 & 1–47) that are ideal, but of course not always feasible; available space will always dictate the layout configuration. If space is limited, remember that you can site the containers near roads or parking lots. A road or parking lot can temporarily allow extra clearance around the containers for loading and unloading.

NOTE: There are six 10'x 20' tarps located in container 4 that may be temporarily used to provide covered storage areas until more durable tarps/covers can be obtained. Ideally, find a pole locally, like a camouflage netting pole with spreader, at least 9-foot tall. Place the pole in the center of the tarps to shed rain.

Figure 1–46 demonstrates a 7,500 sq. ft. layout area. Tarps may be stretched between containers 1 and 2 and between containers 2 and 3 to provide two 11-ft. by 20-ft. covered storage and work areas.

Repair Material	Cont. #4	Cont. #5	Coverage (ft^3) per Bucket	Total Coverage (ft^3)
Rapid Set (Bucket)	100	100	0.4	80
Flowable Fill (Bucket)	50	50	0.4	40
Asphalt (Bucket)	100	100	0.3	60
Cold Patch (Bucket)	22	22	0.7	30.8
Repair Material	**Cont #4**	**Cont #5**	**Coverage (ft)**	**Total (ft)**
Expansion Board (6"x1/2")	32	32	10	640
Expansion Board (4"x1/2")	32	32	10	640
3/4" Backer Rod	2	0	200	200
Joint Sealant (1/2" joint)	6	6	12	144
Notes: - Waste not included in calculations. - 100 each load-transfer dowels, w/chairs, are stored in container 2.				

Figure 1–46. Container layout example 1 (7,500 sq. ft.).

Container #	Ends	Sides
1	20-feet	*5-feet
2	20-feet	*5-feet
3	20-feet	*5-feet
4	20-feet	20-feet
5	20-feet	20-feet
*Required to fully open end doors (270°) and secure them to the side walls; may not be required in all instances.		

Figure 1–47. Container layout example 2 (4,760 sq. ft.).

Layout configuration in figure 1–47 demonstrates stacking containers 4 and 5 which provides a layout footprint of 4,760 sq. ft. Covered storage may be constructed by attaching tarps on the outer-side of container 2 and support the other end with locally obtained poles/posts.

Kit setup

SuPR kits are packed and ready for shipping (accounting for total weight of each box and weight distribution throughout each box), however they are not necessarily ready for use the second they are put in place. It is the team's responsibility to make use of the specific configuration and organize the contents of the container within that space to make use of the equipment more effectively.

NOTE: Check all fluid levels and fill as necessary before operating any equipment/vehicles. All items included in the containers are listed on a shipping list known as the Bill of Materials Placard as shown in figure 1–48.

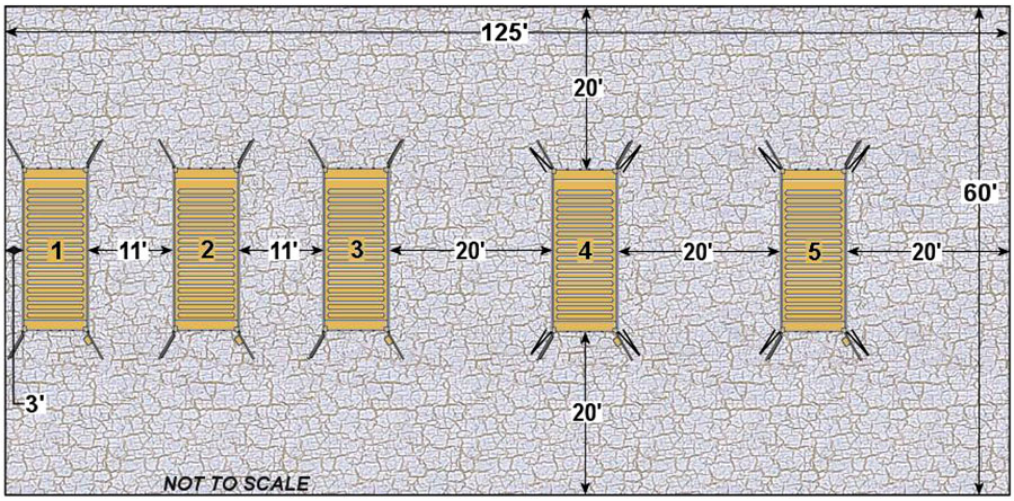


Figure 1–48. Example bill of materials placard.

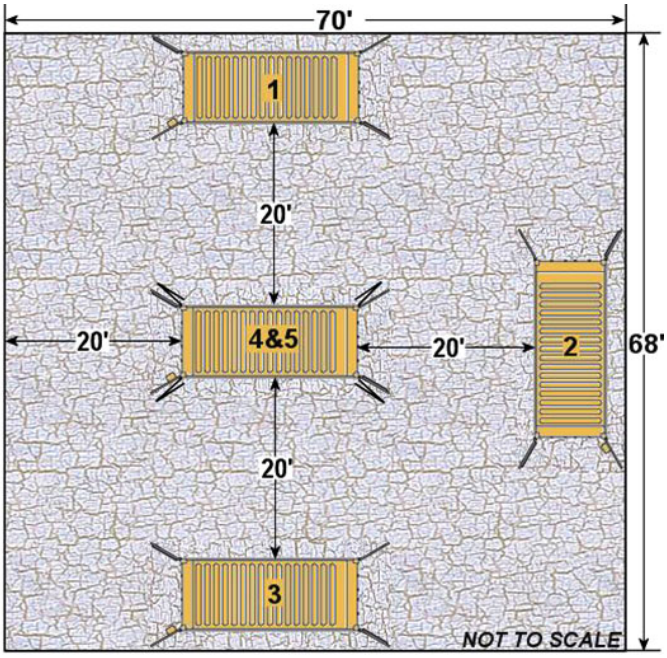


Figure 1–49. Container power components.

The containers are pre-wired with four lights (one in each corner), a light switch on each end, and one convenience outlet next to a breaker panel. Power is provided by plugging a 25-foot twist lock extension cord in container 2 to the receptacle on the side of the equipment containers, or on an end door of the material containers, and plugging the other end into a power source. Four extension cords are provided that may be connected together to extend the reach of the cords. When a commercial or BEAR electrical source is not available, the two 6-kW generators in containers 2 and 3 may be used as a power source for the containers. The generators have only one 30 amp, 120 volts, and alternating current receptacle; therefore, if more than one container requires power simultaneously, both generators will be required. Move extension cords between the containers as needed. Figure 1–49 shows the containers electrical components, the external connection point and a typical 6-kW generator.

It is important to remember to ground the generator prior to connecting power to the containers. A grounding rod kit (driver, grounding rod, connector, and ground wire) is located with each generator (in containers 2 and 3). Test the grounding system to ensure the earth grounding resistance is less than 25 ohms and all containers are bonded to the ground source with less than one ohm of resistance. Figure 1–50 shows a typical grounding scheme for a standard container setup.

STSTAINMENT PAVEMENT REPAIR (SuPR) KIT - CONTAINER 1 BILL OF MATERIAL			
ITEM	PART NUMBER	QTY	NOMENCLATURE
1	BCI-20-20	1	CONTAINER ONE
2	404-206577-45	1	ELECTRICAL ASSEMBLY
3	FAC-90-02	2	HANGAR BRACKET STRAPS
4	FAC-91-01	1	PALLET, ANGLE BROOM/HYDR HAMMER
5	FAC-91-02	2	PALLET, BUCKET/COMPACTOR
6	FAC-92-06	2	BRACKET, SPREADER BAR
7	FAC-93-07	1	BRACKET, MSDS STOWAGE
8	FAC-94-06	1	PINTLE HOOCK ASSEMBLY
9	GBE-91-10L04	19	STRAP, RATCHET
10	GBE-91-10L16	2	HOOK AND LOOP STRAP 1" WIDE
11	GBE-91-10L17	5	MINI FOLDING STEP
12	GBE-91-10L18	1	MULTI TERRAIN LOADER 279C
13	GBE-91-10L19	1	BRACKET MOUNTING
14	GBE-91-10L20	1	HOSE ASSEMBLY CONNECTING LINES
15	GBE-91-10L21	1	BROOM ATACHMENT
16	GBE-91-10L22	2	POLY BRUSH KIT
17	GBE-91-10L23	1	DRUM, COMPACTOR CB18B
18	GBE-91-10L24	1	HAMMER H650 S, PIN ON
19	GBE-91-10L25	1	CHISEL TOOL
20	GBE-91-10L26	1	MOIL TOOL
21	GBE-91-10L27	1	BUCKET, CLAMSHELL
22	GBE-91-10L28	1	FORK ATTACHMENT, 48" PALLET W/ CAP
23	GBE-91-10L30	1	SPREADER BAR LIFTING BEAM KIT
24	GBE-91-10L31	1	KIT, EMERGENCY MEDICAL, LG
25	GBE-91-10L62	1	CAUTION LABEL
26	GBE-91-10L63	1	DANGER LABEL
27	ILS-90-04	2	SIGN, WARNING
28	ILS-90-05	2	DANGER SIGN NO SMOKING
29	ILS-90-06	1	PLACARD, LH & CG
30	ILS-90-07	1	PLACARD, BOM
31	ILS-90-08	1	PLACARD, STRAPPING DIAGRAM
32	IHA-90-03	2	WHEEL, CHOCK
33	SST-91-02	4	CHAIN, BINDER
34	GBE-93-10L153	4	D-RING, SMALL

Figure 1–50. Container and generator grounding scheme.

Unpacking/reorganizing

While grounding is being accomplished, unpacking/re-organizing the containers should begin. Organize the equipment/vehicles removed from containers under covered storage in a manner that best suits local needs either between containers 1, 2, and/or 3 (by using the tarps provided) or in a pre-existing covered storage area on the installation. Organizing in this manner assists with providing a working space as well as storage within the containers. Be sure to use ramps mounted to the inside of the doors when removing any wheeled vehicles and equipment from containers. Ramp pins should be placed in the matching holes on the floor of the container to prevent them from slipping away from the container floor during equipment removal.

NOTE: When removing pallets from upper level wheel chocks (located in container 1) MUST be placed against the container as shown in figure 1–51. Otherwise, damage may occur to the hydraulic connection block on the CTL's lift arm if it contacts the top of the container. DO NOT attempt to unload or load upper level pallets without using the wheel chocks.

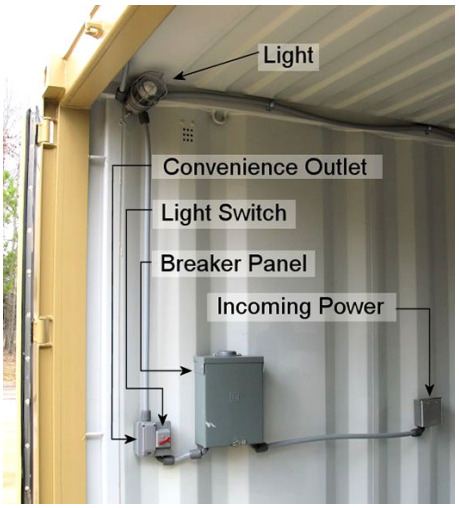


Figure 1–51. Using wheel chock to prevent connection block damage.

When re-organizing is complete, the contents of containers 1–3 will resemble figure 1–52, while containers 4 & 5 are not reconfigured, and a wide view of all 5 containers in a standard setup is shown in figure 1–53.

Figure 1–52. Interior view of containers 1–3.

Figure 1–53. Container layout after setup.

Unique items

A few CTL attachments contained may not be prevalent throughout the career field and may require some additional training.

Vibratory drum compactor

Experience has shown this roller attachment performs best when compacting crushed stone at lifts no higher than 3-inches (see fig. 1–54).

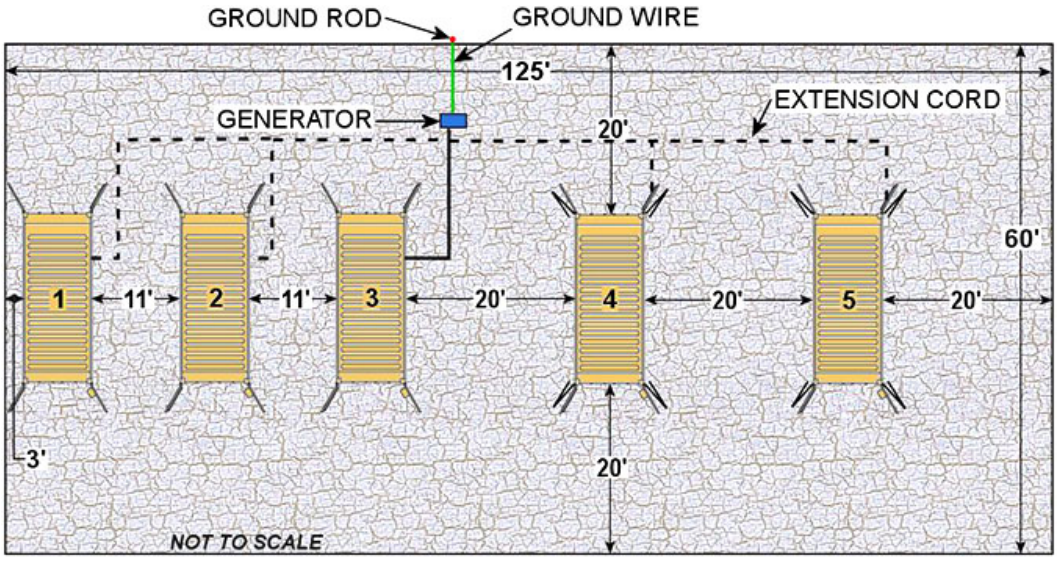


Figure 1–54. Vibratory drum compactor.

Asphalt mixer/burner

Heats up to 400 lbs. of mix to roughly 340°F in just 8 minutes. Before using, inspect the drum for warpage, cracked drum welds, leaking fuel, damaged or frayed control wiring and any other obvious discrepancies.

NOTE: Wipe off any fuel spillage prior to starting the heater. Always fuel, or refuel, the heater when item is detached. Never operate without a spotter. Ensure the drum is rotating before igniting to prevent drum warpage (fig. 1–55).

Figure 1–55. Asphalt mixer/burner.

For safety purposes there is a remote on/off switch that can be wired and run through the CTL door opening allowing the operator to turn off the heater in case of an emergency as shown in figure 1–56.

Figure 1–56. Asphalt heater remote switch.

Hand-held concrete chainsaw

These chain saws are typically used to square corners of the repairs after the repairs are sawed and excavated (fig.1–57).

Figure 1–57. Hand-held concrete chain saw.

Safety procedures

Follow these safety procedures when operating the hand-held concrete chainsaw.

1. Only operate as described by the manufacturer’s manual when pertaining to safety.
2. Do NOT operate the concrete chainsaw when fatigued.
3. Use safety-toed footwear, snug fitting clothing, protective gloves and eye, hearing and head protection devices, respiratory protection, and legging while operating the chain saw.
4. Attach the saw to a water source with a pressure not less than 20 (pounds per square inch) psi.
5. Read and heed manufacturer’s break in procedures as described in the manual to prevent piston seizure.
6. Hold chain saw firmly with both hands, do not overreach, and cut at high engine speeds.
7. Adjust chain tension per manufacturer’s suggestion, especially for the first cut. Over-tensioning of the chain and bar could result in severe loss of power output.
8. Perform system clean-up and maintenance guidelines after each use as described in the manufacturer’s manual.

CTL mounted cold planer

The cold planer may be used to rapidly remove unsound material and prepare the area for placing the repair material (fig. 1–58).

Figure 1–58. Cold planer tool attachment.

Scarifier (planer)

The scarifier is ideal to level repairs with the surrounding surface to bring the repairs within smoothness criteria. It is especially useful to make repairs flush within 200 feet of an aircraft arresting system. It is also ideal for trip hazard repair, concrete and coatings removal, creating non-slip surfaces, and paint line and markings removal (fig. 1–59).

Figure 1–59. Scarifier (planer).

Repacking containers

Reconfigure the containers in reverse order of unpacking procedures. Each container has a packing scheme placard on the inside of the end doors. They illustrate component location and tie down procedures using straps or chains and binders. There is also a bill of materials placard placed on the inside of each container door that lists contents, part numbers, and their quantities to assist (fig. 1–60).

Figure 1–60. Example packing scheme placard and bill of materials placard.

NOTE: Ensure all items are secured properly using straps, D-rings, chains and or binders prior to prevent shifting during transport.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

606. SuPR kit concept of operations

1. What does the SuPR kit prevent engineers from having do?

2. Why is training on the SuPR kit easier and more efficient?

3. Who performs a minimum number of expedient airfield surface repairs to establish limited aircraft operations?

4. How long should the sustainment kit stay in place for?

5. How many/what size containers make up the SuPR kit and which two vehicles come with it?

6. What repair type material is included in containers 4 & 5?

607. SuPR kit operation

1. What is the desired location for siting the containers?

2. What are the 10’ x 20’ tarps suggested use and which container are they located?

3. When a commercial or BEAR power source is not available how are the containers powered?

4. What are the unique CTL attachments contained within the kit?

5. Which CTL attachment is best used to make repairs flush within 200 feet of arresting systems?

Answers to Self-Test Questions

601

1. (1) b.
   (2) d.
   (3) c.
   (4) a.
   (5) e.
2. (1) Expedient, (2) sustainment, and (3) permanent.
3. RQC provides guidance for determining whether non-flush repairs are usable.
4. When an enemy attack becomes eminent.
5. Initiate suitable camouflage, concealment, and deception measures.
6. Repairing damaged airfield surfaces.
7. To clear and push any debris off the convoy route.
8. EOD.

602

1. (1) Survey to determine upheave.
   (2) Removal of unsound pavement and upheave.
   (3) Backfill with debris and select fill.
   (4) Level and compacting to meet RQC.
2. Two trucks wide. So other pieces of heavy equipment can pass one another.
3. Front-mounted broom and grader.
4. Crater NCOIC.
5. New damage may reoccur while dumping fill or compacting stone.
6. Use a cutting torch or K-12 to cut any reinforcing steel.
7. Ground conditions and the availability of stone.
8. Sweep the entire area.

603

1. (1) Magnesium phosphate cement.
   (2) Cold-mix asphalt.
   (3) Portland cement.
2. Remove loose debris and unsound pavement; and if it contains water, remove the water and dry by using wind, heat, or compressed air.
3. Seven minutes.
4. 35° to 75°F.

604

1. 120 smaller craters in a 6.5 hour time period.
2. Stage 1–Rapid Airfield Damage Assessment System (RADAS).
   Stage 2–Multiple UXO Removal System (MURS).
   Stage 3–Damage Repair.
3. Dedicated crews that performs the same step at each crater, one crater after another until the step has been completed on all craters.
4. Upheaval marking.
5. Adds time to the cuts, consumes large quantities of rapid-set, reducing the number of repairs that can be accomplished.
6. 50 gallons of water measured using a flow meter attached to the hose.
7. Dump truck (w/water skid), water truck, and the telehandler

8. The volumetric mixer must be cleaned after 3 spall repairs in order to prevent operational failure.
9. Crater Chief, so they can be loaned out to assist other crews as necessary.

605

1. 4 person spall crew to repair approximately 200 spalls in 6.5 hours.
2. 58 (See fig. 1–35).
3. Cementitious, rapid-setting, self-leveling repair mortar.
4. To compensate for settlement during hydration.
5. Re-accomplish the expeditious repairs with permanent repairs.

606

1. Repairing the repairs.
2. Most of the items in the kit are widely used in the field.
3. RED HORSE advanced echelon team, or a RH small horizontal construction team.
4. Until all equipment has been replaced with BEAR, leased or other suitable assets, or mission is closed.
5. Five 20 x 8 ft. containers, and includes a Compact Track Loader (CTL) and a vibratory roller.
6. Rapid set, flowable fill, asphalt, cold patch, expansion board, backer rod, and joint sealant.

607

1. Area with adequate draining and is not prone to standing water or flooding.
2. May be temporarily used for covered storage until more durable tarps/covers can be obtained; container 4.
3. Two 6 kW generators.
4. (1) Vibratory drum compactor; (2) Asphalt mixer/burner; (3) Hand-held concrete chainsaw; (4) CTL mounted cold planer; and (5) Scarifier (planer).
5. Scarifier (planer).

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (601) Which special capes team(s) concentrate on doing airfield repairs when opening the airbase?
   a. Sustainment Pavement Repair (SuPR).
   b. Contingency Response Group (CRG) and RED HORSE.
   c. Prime BEEF only.
   d. CRG.

2. (601) After airfield repairs and opening the base for operations, which unit will take over to continue airfield repairs?
   a. Contingency Response Group.
   b. Contractor personnel.
   c. Prime BEEF.
   d. RED HORSE.

3. (601) Which rapid runway repair (RRR) equipment set enables the completion of at *least* 6 craters within 4-hours?
   a. R–1.
   b. R–2.
   c. R–3.
   d. R–4.

4. (601) Of the rapid runway repair (RRR) equipment sets, which one is a supplemental kit capable of repairing 12 craters in 4 hours?
   a. R–1.
   b. R–2.
   c. R–3.
   d. R–1 and R–2 combined.

5. (601) Which pavement damage is caused by general-purpose bombs in the 100-pound class and delay-fused munitions?
   a. Spall.
   b. Small crater.
   c. Large crater.
   d. Small and large craters.

6. (601) What are the typical dimensions for the minimum operating strip (MOS) for tactical aircraft (fighters)?
   a. 50 x 5,000 feet.
   b. 60 x 6,000 feet.
   c. 90 x 8,000 feet.
   d. 100 x 10,000 feet.

7. (601) What type of crater repair do we make to upgrade expedient repairs?
   a. Sand-grid.
   b. Permanent.
   c. Crush stone.
   d. Sustainment.

8. (601) Airfield sustainment repairs are an upgrade to the expedient repairs and are designed to support how many passes as compared to the expedient's 100 passes.
   a. 1,000.
   b. 5,000.
   c. 10,000.
   d. 50,000.

9. (601) After a conflict is over, what type of repairs are designed to turn the airbase to its original condition?
   a. Expedient.
   b. Sustainment.
   c. Permanent.
   d. Engineered.

10. (601) When an enemy attack becomes eminent, the rapid runway repair (RRR) assets *must* be
   a. relocated to a central location.
   b. mobilized to the flight line area.
   c. kept in the equipment yard for easy access.
   d. equally divided and dispersed to pre-designated areas.

11. (601) Which piece of heavy equipment should lead the way in order to clear debris from the convoy route?
   a. Grader.
   b. Loader.
   c. Kickbroom.
   d. Dump truck.

12. (602) How many expedient crater repair methods are used by the Air Force?
   a. One.
   b. Two.
   c. Three.
   d. Seven.

13. (602) Which equipment do we use in conjunction with a front-mounted broom to clear an area where prefabricated surface mats are to be assembled?
   a. Angle dozer.
   b. Excavator.
   c. Scraper.
   d. Grader.

14. (602) Which task must start the same time the loader is clearing the crater and the grader is clearing the minimum operating strip (MOS) and taxiway locations?
   a. Sweeper team.
   b. Load and haul teams.
   c. Upheaval marking team
   d. Pavement breaking team

15. (602) Who determines how much fill material is needed at the crater repair sites?
   a. Crater OIC.
   b. Crater NCOIC.
   c. Dozer operator.
   d. Dump truck operator.

16. (602) Where is the ideal place for the dozers to be downloaded?
    a. As close to the crater edge as possible.
    b. Side of the crater furthest from the MOS edge.
    c. Side of the crater closest to the minimum operating strip (MOS) edge.
    d. Just far enough away to avoid congestion around the crater.

17. (602) What is the *first* action you take if it becomes necessary to repair a broken pipe or cable located in a crater?
    a. Isolate the damaged utility.
    b. Begin excavating on both sides of the utility.
    c. Cushion the damaged utility with a load of sand.
    d. Disregard the utility as backfilling the crater is priority.

18. (602) During upheaval removal the craters edge needs to be as vertical as possible and how many inches deep.
    a. 18 to 24.
    b. 12 to 18.
    c. 12 to 24.
    d. 24 to 36.

19. (602) During the debris backfill method of crater repair, how many inches in diameter will the debris be allowed to be pushed back into the crater?
    a. 36.
    b. 24.
    c. 12.
    d. 6.

20. (602) What is the *last* step in the airfield damage repair (ADR) process before flying operations can begin?
    a. Convoy operations.
    b. Grading operations.
    c. Sweeping operations.
    d. Foreign object damage (FOD) cover operations.

21. (603) During legacy spall repair, which method has a cure time of 20 minutes requiring frequent cleaning of the mixer and hand tools?
    a. Cold mix asphalt.
    b. Type III high early cement.
    c. Fast-setting Portland cement.
    d. Magnesium phosphate cement.

22. (603) Fast-setting Portland cement has an approximate cure time of twenty minutes, what can this cure time be extended to during colder temperatures?
    a. 1 hour.
    b. 2 hours.
    c. 4 hours.
    d. 45 minutes.

23. (603) Before you can use any material on Department of Defense (DOD) airfields, you *must* make sure it
    a. is certified for use.
    b. meets the temperature ranges.
    c. can meet PSI requirements for airfield pavements
    d. produces a clean, flexible patch of the runway surface.

24. (604) Using the new rapid airfield damage repair (RADR) techniques, how many small craters are able to be repaired within a 6 ½ hour time period?
    a. 100.
    b. 120.
    c. 140.
    d. 150.

25. (604) Which stage is considered the 3E2's primary tasking during advanced crater repair?
    a. Damage Repair.
    b. Multiple UXO Removal System (MURS).
    c. Geospatial Expeditionary Planning Tool (GeoExPT)
    d. Rapid Airfield Damage Assessment System (RADAS).

26. (604) During debris removal, debris must be pushed to a designated location at least how many feet from the MOS edge and no higher than who many feet/inches?
    a. 15ft : 3ft.
    b. 3ft : 15ft.
    c. 30ft : 36 inches.
    d. 36ft : 30 inches.

27. (604) What is accomplished to ensure all upheaval is identified and removed?
    a. Repair quality criteria (RQC).
    b. Crater profile measurement (CPM).
    c. Post-attack reconnaissance (PAR).
    d. Foreign object & debris (FOD) inspection.

28. (604) During upheaval marking what is the distance between each measurement to keep repairs as small as possible?
    a. 1 foot.
    b. 2 feet.
    c. 1 pace.
    d. 3 feet.

29. (604) Which of the damage repair steps is the *most critical* in regards to timelines?
    a. Capping.
    b. Pavement cutting.
    c. Upheaval marking.
    d. Pavement breaking and excavation.

30. (604) What are the two blade diameter sizes used on the wheel saw during pavement cutting?
    a. 17" : 23".
    b. 36" : 50".
    c. 45" : 60".
    d. 45" : 55"

31. (604) During the excavation process what is provided to the operator to ensure proper depth is met?
    a. Spotter.
    b. Tape measure.
    c. Lines marked on the bucket.
    d. Airfield Damage Repair (ADR) 24-inch bucket.

32. (604) To what depth during the excavation process does the operator clean out the crater?
    a. 12 inches.
    b. 30 inches.
    c. 36 inches.
    d. 24 inches.

33. (604) Utilizing the “slash and splash” method during backfilling, how many gallons of water is used per 3,000 lb. super sac?
    a. 55.
    b. 25
    c. 70.
    d. 50.

34. (604) Which backfill process utilizes the volumetric mixer?
    a. Flowable fill.
    b. “Slash and splash”.
    c. Backfill under asphalt.
    d. Backfill under rapid-set concrete.

35. (604) With a rapid-set cap, how long before the repair is fully operational?
    a. 45 minutes.
    b. 1 hour.
    c. 1.5 hours.
    d. 2 hours.

36. (604) Above what outside temperature is a retardant admixture required to extend the working time of the rapid set cap?
    a. 75° F.
    b. 85° F.
    c. 90° F.
    d. 100° F.

37. (604) What temperature *must* the asphalt cap reach before it is ready to receive aircraft traffic?
    a. 115° F.
    b. 125° F.
    c. 150° F.
    d. 225° F.

38. (605) What is the approximate number of spalls that can be repaired with a large capability crew of 21 personnel?
    a. 1050.
    b. 1300.
    c. 1100.
    d. 1150.

39. (605) Repair zones are identified and prioritized prior to recovery after attack, what is the recommended size of each crews repair zone?
    a. 50-ft long by 50-ft wide.
    b. 25-ft long by 50-ft wide.
    c. 25-ft long by 25-ft wide.
    d. 50-ft long by 100-ft wide.

40. (605) What must be done if during spall repair it is noticed that the damage had penetrated through to the base course?
    a. Place a white cone to inform the crater repair team lead.
    b. Place a blue cone and inform the crater repair team lead.
    c. Repair the small crater with available spall material.
    d. Place a blue cone and proceed to the next spall.

41. (605) During spall repair, what is the working temperature range for the rapid setting concrete?
    a. 40° F – 90° F.
    b. 35° F – 85°F.
    c. 45° F – 90° F.
    d. 50° F – 100° F.

42. (605) Expeditious asphalt spall repairs are not expected to last 100 passes, therefore if signs of failure appear, the repairs must be constantly
    a. removed and replaced within 3 days.
    b. monitored and repaired immediately.
    c. replaced with permanent repairs.
    d. re-rolled daily.

43. (606) What type of repairs does the Sustainment Pavement Repair (SuPR) kit allow engineers to perform?
    a. Temporary.
    b. High quality.
    c. Permanent.
    d. Expedient.

44. (606) Which team transitions the airfield into operate and sustain-the-airbase missions?
    a. Host nation.
    b. Prime BEEF.
    c. RED HORSE.
    d. Contingency action team (CAT).

45. (606) Sustainment Pavement Repair (SuPR) kits provide the capability to perform durable
    a. small crater and spall repair.
    b. asphalt or concrete pavement maintenance and repair.
    c. asphalt and concrete pavement maintenance and repair.
    d. small crater and any surface repairs (spall, joint/crack etc.).

46. (606) How many freight containers are included in one Sustainment Pavement Repair (SuPR) kit?
    a. 1.
    b. 4.
    c. 5.
    d. 8.

47. (606) How many compact track loader (CTL) attachments accompany the CTL within the kit?
    a. 5.
    b. 6.
    c. 7.
    d. 8.

48. (607) Why is 20 feet of clearance required on all fours sides of containers 4 & 5?
    a. Equipment storage.
    b. Covered work area (w/tarps).
    c. Containers open on all 4 sides.
    d. Used as expandable shelter systems.

49. (607) How many tarps are located in container 4?
    a. 4.
    b. 5.
    c. 6.
    d. 0.

50. (607) All items located within each container are labeled on which shipping lists?
    a. Packing lists.
    b. Bill of Materials placard.
    c. Material Safety Data Sheets.
    d. Shipping Container Inventory list.

51. (607) Which item *MUST* be used when removing items from the upper level of the containers?
    a. Ramps.
    b. Forks.
    c. Chocks.
    d. Spotter.

52. (607) Which compact track loader (CTL) attachment may be used to level repairs with the surrounding surface to bring the repairs within smoothness criteria?
    a. Scarifier.
    b. CTL mounted cold-planer.
    c. Vibratory drum compactor.
    d. Hand held concrete chainsaw.

Please read the unit menu for unit 2 and continue ➔

Student Notes

Unit 2. Prefabricated Surface Mats and Shelter Systems

AT SOME POINT in your career, you may be called upon to assist in the construction or repair of an airfield to support the US Armed Forces anywhere in the world. From a pavements and equipment (P&E) perspective, this involves three general subjects: surface mats, shelter systems, and expedient field construction. Surface mats are a critical part of crater repair when recovering an airfield. Shelter systems are the tents and other temporary shelters needed to house all the people and their equipment. Expedient field construction is the group of basic engineered features necessary to operate a small airbase. As a Dirtboy, you'll play a pivotal role making these essential systems operate flawlessly.

2–1. Surface Mats

In wartime, airfields sometimes get bombed. It could be that an enemy attacked a United States airbase and civil engineering (CE) needs to quickly repair it. It might be the case that US forces bombed an airfield then took it over for our operations. Either way, runways are no good with craters in them. Ideally, engineers would take their time to design the perfect crater repair. But during war or emergencies, planes need to get in the air and there's no time to wait. Surface mats are a temporary dirt cover for crater repairs instead of replacing the asphalt or concrete. They allow civil engineers to make hasty, but effective crater repairs, without the dirt damaging aircraft landing gear or engines.

There are two primary types of surface mat systems. The most common is the folded fiberglass mat (FFM). FFM's benefit is that it is light weight and can cover a large area very quickly. The other type is AM-2. These are much more durable, but far more difficult to install. Most of the AM-2 matting you'll use will be for helicopter pads or temporary aircraft parking areas.

608. Folded fiberglass mats

This FFM crater repair method was designed specifically to support tactical aircraft operations conducted over a crushed-stone repair. Cargo aircraft can also use this system on a very limited basis. A distinct advantage with this system is its deployability. Not only is this system air transportable, it can be moved easily by vehicle and positioned at greater distances from the airfield.

Folded fiberglass mat specifications

A single standard FFM weighs about 3,000 pounds and consists of nine fiberglass panels that are six-feet wide, 30-feet long and one-half inch thick. The panels are connected by elastomeric hinges,

which are approximately three-inches wide. When folded, the mats are six-feet wide, 30-feet long, and eight to 10-inches thick. See figure 2–1 for illustrations of a folded and an unfolded mat. Besides the FFM, this ADR system also includes joining panels and support kits “A” and “B”. The joining panels come in 24- and 30-foot lengths. One of each size is needed to connect two 30-by 54-foot mats together. The resulting 54-foot long by 60-foot wide mat is the normal size suitable for most crater repairs. If you’d like more information and images of the FFM system, you can visit the manufacturer’s website at http://www.rapidrunwayrepair.com/index.html.

If larger foreign object debris (FOD) covers are required, we can splice additional mats together to form almost any size. Mat kit “A” contains all the necessary tools and hardware required to assemble, install, and maintain the system. Mat kit “B” contains the anchoring systems required to attach the mat to a range of airfield pavement surfaces.

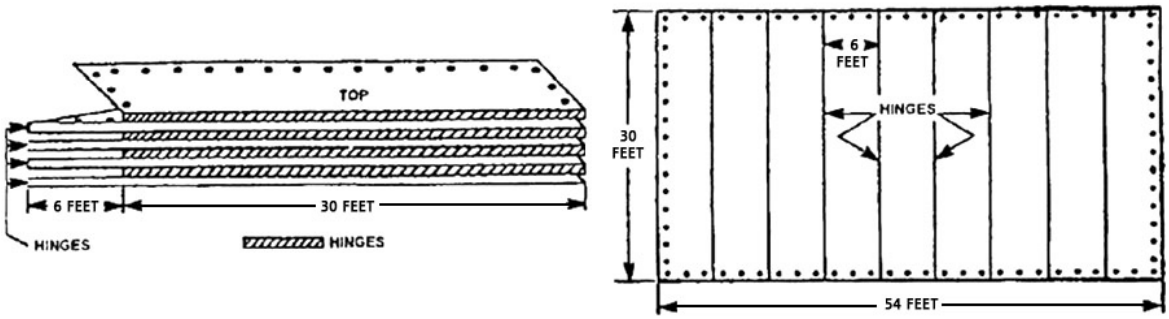


Figure 2–1. FFM configuration.

Mat unloading procedures

Before unloading begins, the ADR crater team chief selects a mat assembly area near the crater location and makes sure the area is cleared of debris and well swept. This area must be large enough to accommodate at least two unfolded mats and for equipment to work around the mats.

Unloading can be done with either two forklifts, or a front-end loader with a nylon strap sling. If you use a front-end loader, lift the mat slightly off the trailer and have the tractor-trailer drive slowly out from underneath the mat. If you use forklifts to unload the mat, take care to ensure the forks don’t damage the mat.

If two or more mats are to be joined, place them end-to-end, approximately four feet apart and position them so that both mats unfold in the same direction (toward the center of the minimum operating strip (MOS). The mats are stenciled “TOP” and “BOTTOM.” A good way to be sure of the top or bottom is to look for the five-inch countersunk area around the holes; this area is always on the “TOP.”

Mat unfolding procedures

The area used for unfolding mats must be clear of debris and firm enough to support vehicles. Select a location that’s as close as possible to the crater but out of the way of other repair activities. You can use a front-end loader and forklift to unfold the mats. First attach the nylon straps to the sixth hole located on either end of the mat. Then use a chain to connect the straps to the front-end loader. Working from the opposite side of the nylon straps, carefully lift the first panel with a forklift. You’ll find shovels useful for separating the mat panels when you are to insert the forks. As a panel is raised, the front-end loader pulls the mat out until the panel is unfolded. This process is repeated for each panel until the entire mat is unfurled. Again, take extreme care when using the forklift to ensure the forks don’t damage the mat. If it’s necessary to unfold the mat manually, use a minimum of four people.

Mat joining and positioning

Perform the joining operation at the same time the crater crew is repairing the crater. In this way, you can pull, place, and anchor the mat immediately after the crater is repaired.

Initial positioning

To accomplish the initial positioning, attach the nylon straps and chains to the mat and tow the vehicle in the same fashion you used to unfold the mat. Now, tow one mat until the 30 foot edges of both mats are even with each other. To make the work easier, keep a four-foot section between the mats. With the mats in this position, the holes on the joining seam should now be basically aligned. You can do any further alignment after the installation of the joining panels on one of the mats.

Joining panel concept

Joining two mats requires a two-foot, 1¼-inch-wide, 30-feet long two-ply panel that we mount beneath the seams of the adjoining mats. Secure the joining panels to each mat by using two-part bushings which you then screw together.

Joining panel installation

Use a forklift to raise the mat one or two feet above the pavement. The next step is to slide the first joining panel into place. Now align the holes with those in the mat. After you align the holes, lower the mat to install and hand-tighten the joining bushings. Repeat the process for the second joining panel. If needed, you can shift the joining panels slightly by tapping them with a four by eight inch wood block and sledgehammer. Be sure to always attach both joining panels to one mat before attempting to attach the second mat.

Positioning the second mat

The second mat is aligned and placed on the joining panel. The next step is to install a top flush mount bushing with a one by five-eighths inch thread through mats one and two. Place these into the short bushings in the joining panel and tighten them. This allows the two joined mats to be installed as a single unit.

Towing and positioning the mat

Before towing the mat over the crater, be sure the area over which you are to tow the mat is clean and free of debris. If towing carries loose rocks into the repaired crater surface, those rocks may later puncture the mat because of the aircraft traffic.

Towing requisites

When the width of the MOS permits, pull the mat parallel to and along the side of the crater. Be sure to align the joining panel with the center of the crater. Remember if two mats are joined together; always pull the mat perpendicular to the hinges in order to eliminate scooping up debris with the joining panel.

Towing

Transport the full-sized rigid mat by evenly spacing four nylon straps evenly along the edge. Once these are secured, use a towing chain to pull the mat. A forklift, front-end loader, or other piece of construction equipment is most suitable for this task. Make sure the fiberglass mat is towed with equal weight distribution.

Once the mat is in position over the crater, make sure the following criteria are met:

1. When the crater’s entire area is located on the MOS, both the center of mat and crater should match closely.
2. Center the mat over the crater if it’s partially on the MOS and it’s completely surrounded by sound pavement.
3. When the crater is half or partially off the MOS, align the mat with the pavement edge rather than centering the mat over the crater.
4. Before you unhook the towing gear, be sure the area is sound for anchoring purposes. Move the mat, as necessary, to obtain sound pavement.

Anchoring

There are three types of anchoring systems that can be used for FFM and are largely dependent on the type of runway surface used. FFMs are predrilled for hold-down bolts. Only anchor them on the leading and trailing edges. Since the mat must be able to absorb the shock of landing, never anchor the 60-foot (two 30-feet) sides of the mat to the pavement. Anchoring the sides would prevent the mat from flexing and could cause damage to the mat material. The type 1 anchoring system uses an expanding bolt, with a large-headed nut or "bushing." When anchoring the FFM to concrete surfaces, use a 5½-inch long by 5/8-inch diameter or similar rock bolt (used in all concrete pavements). Use the correct size drill bit because the wedge can't grip and expand in an oversized hole. Be sure to drill the holes at least ½-inch deeper than the bolt length. This allows any loose material to fall back into the hole, which allows the bolt to seat properly. The type one anchor process we just described is illustrated on figure 2–2.

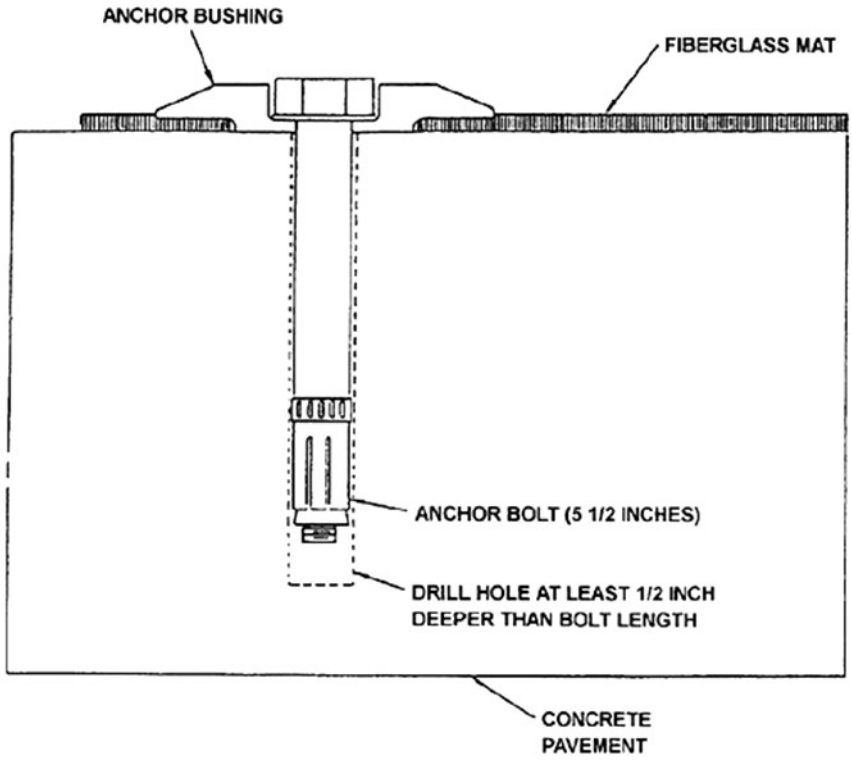


Figure 2–2. FFM anchoring bolt.

The type two anchor bolt is a 9½-inch rock bolt used with a 4-inch diameter bushing (used in asphalt overlays where the asphalt is less than 6-inches thick). The type three anchor is a polymer plug used in conjunction with the type two anchor bolt on asphalt pavement and asphalt overlays where the asphalt is thicker than 6-inches. Whenever this type of anchor is used, a 1½-inch diameter hole is drilled and filled with polymer to within ½-inch of the top of the hole. The anchor bolt and a 4-inch bushing are then placed in the hole. When the polymer hardens the bolt and mat will be secure.

Ramps

Since there are no ramps available, we must fabricate them when the repair is used over parts of the runway where aircraft tail hooks are to be used. We make up a six- to nine- inch wide ramp using a mixture of sand and polyurethane on the runway surface along the landing edge of the mat. Leave a horizontal gap of one inch between the edges of the mat and ramp to allow the mat to be removed and replaced if crater repair maintenance is required. If the concrete surface is wet, drilling a series of one-inch diameter holes, two-inches deep and at one-foot centers along the line of the mat increases the bonding action of the cement (polyurethane and sand) to the surface of the pavement.

609. Installing fiber reinforced polymer panels

The idea behind fiber reinforced polymer (FRP) is to be able to create a FOD cover specific to the size of individual repairs. A single typical FRP assembly kit has the ability to repair as many as thirteen–5ft. craters or up to one-28ft. crater and is capable of sustaining over 100 combined passes of C–17 cargo aircraft and F–15 fighter aircraft traffic with regular light maintenance. This lesson will give you a better understanding of how you will make repairs using the FRP panels.

The FRP matting system functions as a modular FOD cover for ADR. It consist of four panel types within the set and includes necessary bushings for joining/anchoring. The FRP matting system kit includes the following items:

- 7 Full-size panel (216 x 80 inches).
- 6 Half-size panel (112 x 80 inches).
- 3 Full-size anchor panel (216 x 24 inches).
- 4 Half-size anchor panel (112 x 24 inches).
- 152 Lower joining bushings.
- 175 Upper joining bushings.
- 125 Anchor bushings.

FRP panels are normally 0.4-inches thick and are joined with bushings to form a cover to be placed over a backfilled crater and anchored to the existing pavement by approved anchoring systems. Full and half-size panels have two adjacent edges recessed at the panel bottom and the two remaining panel edges recessed at the panel top yielding two “overlap edges” and two “underlap edges.” Lower joining bushings are pre-attached to receiving holes located on the underlap edges of full and half-size panels. Anchor panels are necessary to facilitate the transition from full and half-size panel underlap edges to open holed edges for anchoring.

Area prep

To prep an area for FRP it is important to identify and remove all of the upheaval from around the crater. The dimensions of the crater will be measured at this point by the Mat Chief, so the FRP cover size may be determined and laid out while the crater is being prepped. To prep the crater, utilize as the same method as you would with all craters (debris removal, upheaval marking, saw cutting, and pavement breaking and excavation), to a depth of 24 inches as shown in figure 2–3. The backfilling step consists of compacting the subgrade followed by compacting crushed stone or debris in 3–5 inch lifts until matching the surrounding pavement. The final step in area prep is to sweep the area around the repair to ensure as close to flush of a repair as feasible.

Figure 2–3. Remove damaged pavement.

Mat assembly

The Mat Chief will provide measurements of the priority crater to the FRP cover team based on crater size, available panels and projected need for using remaining panels in the event of multiple repairs. If the area is ready to receive the FOD cover, the mat construction will be done directly over the compacted crater, if not then the mat staging area will be as close to the repair as possible without interfering with area prep. The assembly team will use the telescopic-boom forklift to place the kit and begin laying out the panels to meet repair dimensions and also begin getting the power equipment set up to anchor the cover following assembly.

As the repair is being lifted and compacted the panels are being joined using upper (placed on the overlap edge) and lower bushings (pre-installed on the underlap edge) as shown in figure 2–4. These bushings are connected using a bolt which will be tightened down to approximately 110-ft-lbs torque minimum.

Figure 2–4. Assemble FRP mats.

When the mat is completely assembled to meet dimension requirements, the telescopic-boom forklift that was used to stage the kit assembly will assist in placing the cover directly over top of the repair to be anchored to the pavement. Anchors are installed on the leading and trailing edges of the FRP cover to the existing pavement. The two type of anchors used are dependent on the type of pavement being anchored to, for PCC repair a power-bolt concrete anchor will be used and for asphalt repair a tri-talon asphalt anchor is used as shown in figure 2–5.

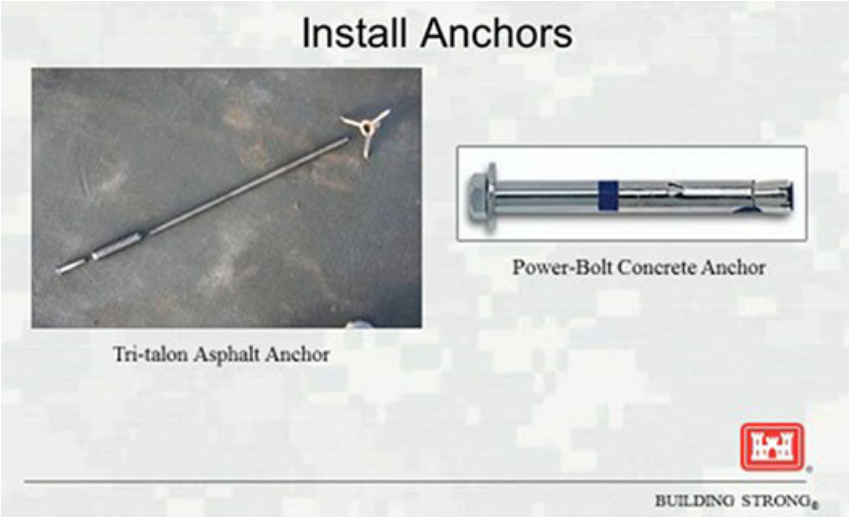


Figure 2–5. Anchor types.

Power-Bolt concrete anchors are easy and convenient to use as the installation process is very simple. With the mat in place over the repair, you will use a ¾" diameter 12" long masonry drill bit (electric hammer drill) or a ¾" diameter 24" long shaft flighted rock bit (hydraulic hammer drill). Drill your anchor holes on the leading and trail edges of the FRP cover. Once the holes are to a depth that can receive the length of the power-bolt, use pressurized air to clean out the holes, place your anchor bushing and insert power-bolt (hammer into place if necessary) and tighten to approximately 110 ft. lbs. torque.

The tri-talon asphalt anchor installation involves a bit more, understandably so since the flexural strength of asphalt is much lower than concrete. For this anchor technique, use an electric hammer drill or hydraulic hammer drill (provided with FRP kit) to penetrate though the asphalt. A hydraulic earth auger is used to remove subbase to a depth of approximately 22.5" for the tri-talon anchor to be inserted and set using the set tool/bar and a sledgehammer. Once set, a coupler is attached and bolt fully engaged on the top and both are adjusted until flush with pavement. Finally, an anchor cement or grout is mixed to a liquid consistency and poured around the coupler until it reaches 1" below the mat surface.

610. AM–2 mat packages

AM–2 matting is used mostly for taxiways and aircraft parking aprons. After reading this lesson, you'll have a better understanding of how to make pavement repairs using AM–2 matting.

Description

AM–2 mats are fabricated aluminum panels that are 1½-inches thick, two feet wide and 12-feet long. Each is composed of a hollow extruded main section with extruded end connectors welded into each end. The top surface of the mat is coated with Ferrox, a non-skid material to aid in traction. The top drawing in figure 2–6 shows how to lay the mats. The center drawing shows a longitudinal section of an AM–2 mat. The bottom drawing shows a cross sectional view of AM–2 matting.

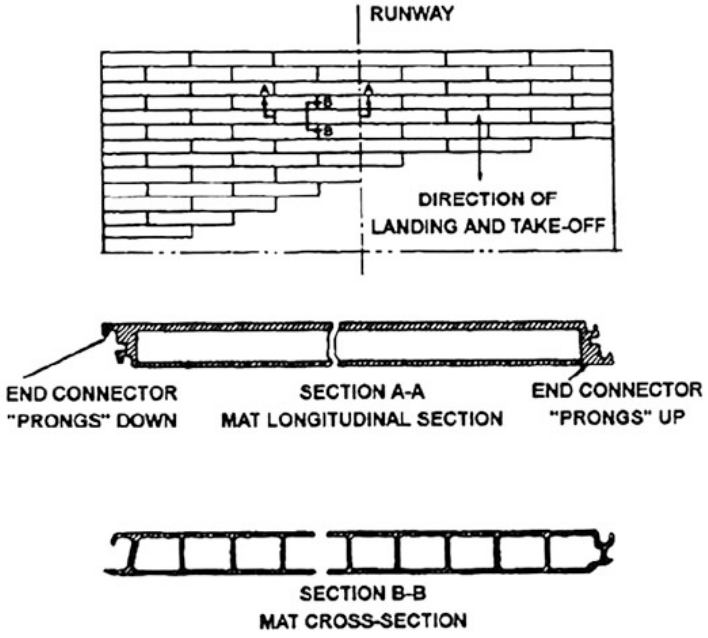


Figure 2–6. Cross section of AM–2 matting.

The sides of the mats are constructed to interlock with a rotating motion. The ends of the mats have end-connector prongs that are positioned up on one end and down on the other. Join the ends of the mats together by hooking the prong of one mat over the prong of the other mat. Lock the individual mats together with a locking bar that is 5/8-inch wide, 3/16-inch thick, and 2311/16-inches long. We discuss connecting and locking mats when we discuss laying them.

Size of standard AM–2 package

AM–2 mats are packaged in standard pallet loads for storing and shipping. Each package, or pallet, consists of eleven 12-foot mats, two 6-foot (half-length) mats, and 13 locking bars. The pallets incorporate fabricated end frames held together with tie rods. The end frames fit around the mats and become the storage place for the locking bars. The mats in a standard pallet provide a width of two rows (four feet) on a runway or taxiway that is 72-feet wide (288 square feet). To put it another way, 250 pallets make up 1,000 feet of runway that is 72-feet wide (72,000 square feet).

Main accessories

Below are the four main accessories we use with AM–2 matting:

1. Starter key-locks.
2. Typical key-lock.
3. 90 degree connectors.
4. Aircraft tie downs.

We use each of these accessories when we initially lay out the mats.

Starter key-lock

These are very narrow two-inch strips of AM–2 matting with a male joint on both ends. They're used to simplify the laying of AM–2 mats. The starter key-locks are used in the middle of the runway and allow two mat laying teams to start together and work in opposite directions towards the end of the runway.

Typical key-lock

Typical key-locks are the same as starter key-locks except that they have a male joint on one side and a female joint on the other side. Typical key-locks are placed after the first five rows of matting and every 100 feet thereafter. They're placed at the ends of the runway where the matting starts into the anchor ditch. When starter key-locks are used, narrow mats called typical key-locks are installed 100 feet on each side of the starter key-locks and every 100 feet thereafter. You can unlock them to replace a damaged section of the mat.

90 degree connectors

The 90 degree connectors are for joining mats when two areas of mats meet at right angles; for example, where a taxiway joins the runway. The mats in each area are slipped into the connectors, which are H-shaped in cross section. The connectors aren't fastened to the mats; therefore, installation is quick and simple, and no special tools are required.

Aircraft tiedowns

Aircraft tiedowns prevent aircraft from tipping over in high winds. After the mats are laid, they're drilled and tapped to accept the tiedowns. The tiedowns are easily installed, and the pattern for installation for mixed-type aircraft can be determined in the field at the time of installation.

Auxiliary accessories

The following auxiliary accessories are items that may or may not be installed when you initially lay matting:

1. Centerline lighting.
2. Arresting-gear rub rail.
3. Catapult guide rail.

Centerline lights

The centerline lights provide for a nighttime operation. These lights are installed every 100 feet and flush with the runway surface. They're small, high-intensity lights built to withstand both the landing impact and the arresting hook of landing aircraft.

Arresting gear rub rail

The arresting gear rub rail is designed to protect the arresting gear tapes from damage by the edge of the AM–2 mats. To allow for a two arresting gear installation, operating bidirectional, you need approximately 1,500 feet of rub rail on each side of the main runway. Rub rail is provided in 10-foot sections. After you put it together, you must stake it to the ground every 60 feet. Slip joints are located midway between the joints to allow for expansion. Four ramps are installed on each side of the runway to allow passage of the arresting-gear pendant/tape connector onto the matting.

Catapult guide rail

When a catapult is used with the AM–2 matting, a catapult guide rail provides stability to the dolly and the aircraft during the launch.

611. How to prepare an area for AM–2 matting

You must clear, level, and grade an area before you can lay surface mats for a runway. Grade the base so that water drains away from the mat surface. If it's necessary to install pipes, drains, or other objects beneath the runway surface, be sure to thoroughly compact the backfill.

Base preparation

The soil material that supports the AM–2 matting must have a California bearing ratio (CBR) rating (a simple density test) of at least 10. If the soil has less than a CBR of 10, you must stabilize the soil with mechanical or chemical means to increase its rating. If this isn't practical, cover the soil with material that has the proper CBR rating. The engineer assistant specialist can help you in this area; this person is the specialist in soils classification and density determination. If the base isn't prepared correctly, the base and the matting will fail.

Experience in Southeast Asia showed that irregular grading and poor compaction caused differential settlement and failure of the base. Another cause of base failure was pumping fine-grained material through the mat when the base became wet and soft. As the fine-grained material was pumped out of the base, depressions formed. These depressions became larger as they collected water and more fine-grained materials were pumped out. These large depressions caused the matting above them to fail.

To prevent pumping fine-grained materials (fines), we use a coarse gravel or plastic membrane between the matting and the base. After the base is prepared, begin cutting the anchor ditches. The purpose of these ditches is to anchor the mat at the ends of the runway in order to prevent movement. Burying the first five rows of matting on each end of the runway does this. The next step is to install an alignment line along each side of the runway. Engineering assistant personnel usually do this with a transit.

Spotting the pallets

After the base is ready, stake out the general runway configuration. The engineering assistant personnel may do this job. After the runway is staked out, bring in the mats and start laying them. Place the mats so you have to do as little manual handling as possible. Use a forklift to unload the mats from the trailer. In this case, very little manual carrying is necessary.

The edge-of-runway deployment method consists of placing mat pallets in groups along the edge of the runway. This requires each mat to be carried manually to the laying area. If they're available, you can use forklifts to deliver the mats from the edge of the runway to the mat laying area. Place the pallets in the center of the runway at 4-foot intervals. We show the usual layout of an airfield with mat pallets positioned around it in figure 2–7.

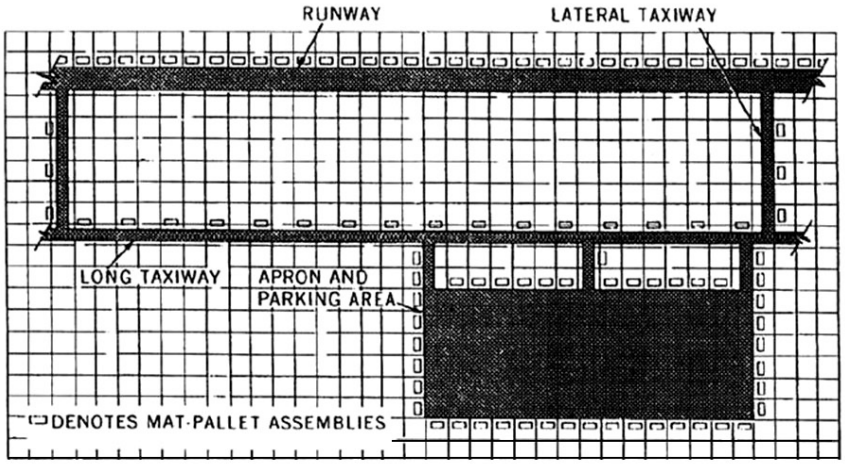


Figure 2–7. Positioning mat pallets.

Disassembly of mat pallets

After the mat pallets are deployed, you're ready to disassemble them. Place the pallets on large wooden blocks (fig. 2–8). We do this for the following two reasons:

1. Prevents the "foot" rail from resting on the ground.
2. Allows easy removal of the end frames.

To unbolt the tie rods, first release the locknuts (fig. 2–8, detail A) that are located at the end of each tie rod. There are eight of them. Back off the bolt nuts until the tie rods disconnect. The end plates are now free.

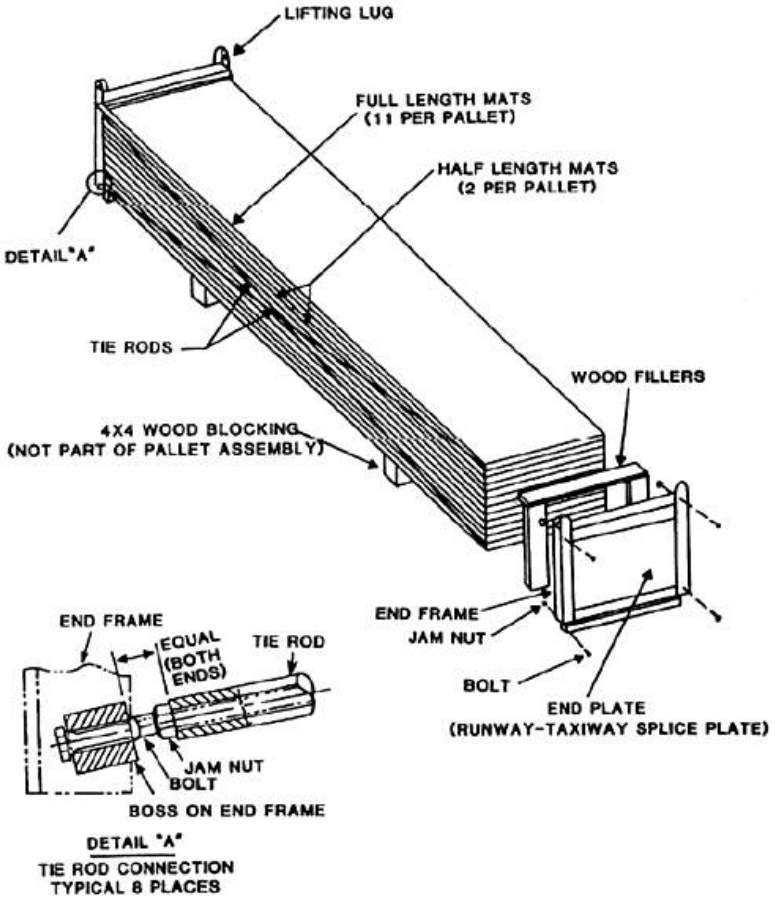


Figure 2–8. AM–2 mat pallet.

Next, remove the end plates and wood filler frame. Remove the locking bars from the end frame assembly. (They may be in either end.) Screw the bolts back into the tie rod ends and store everything except the mats and locking bars for future use. The end plates are needed for runway and taxiway junctions. The tie rods, wood fillers, and so forth, are needed to re-palletize the mats if the pavement is taken up and relocated. Remember, this airfield matting can be installed, used for a short period of time, taken up, and reinstalled someplace else.

612. How to assemble AM–2 matting

As always, there's a right way and a wrong way to install AM–2 matting. Let's discuss the proper way in this lesson.

Installation sequence

Refer to figure 2–9 as we discuss the installation sequence. Begin by placing the first mat on the left side of the runway and work toward the right side. Place the end connectors on the left end of the mat "prongs down," and on the right, "prongs up." Place the left end of the second mat on the right end of the first mat. This forms a continuous mat surface. Also, lay the mats so that the work proceeds toward you.

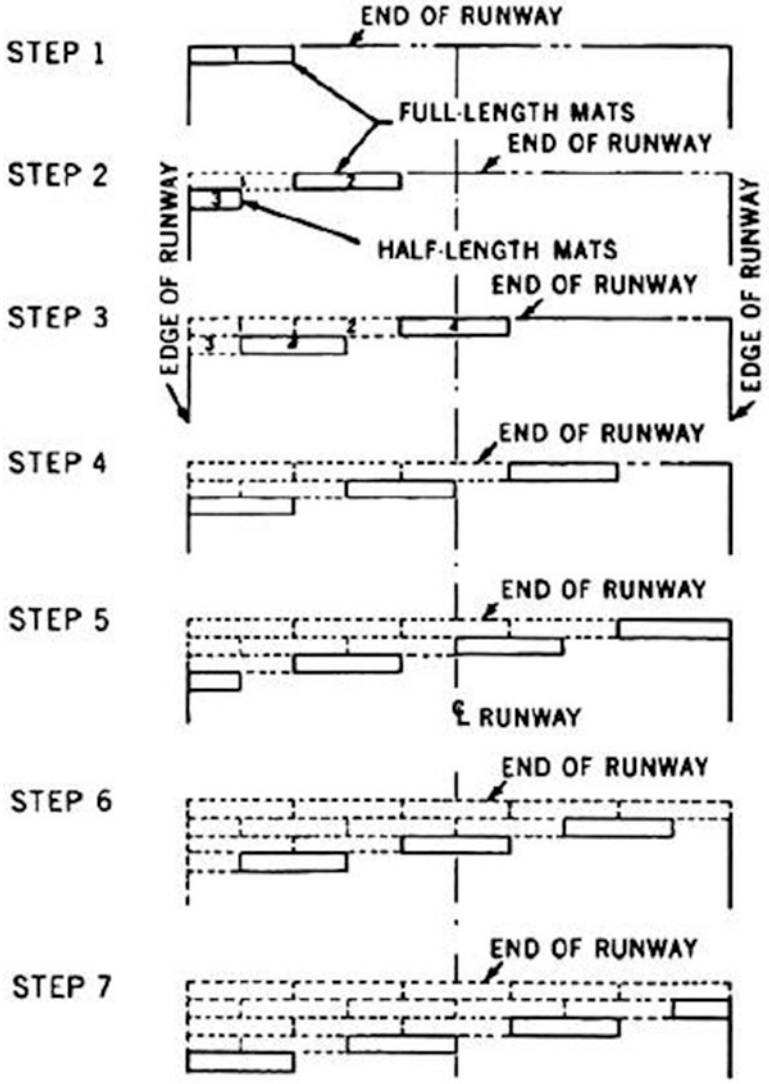


Figure 2–9. Installation sequence of AM–2 matting.

When you pick up a mat, make a quick check to determine if it's damaged. Remove any dirt or rocks that may be on the mat. You can expect difficulty trying to interlock dirty mats. Place the mats as illustrated in figure 2–10. Notice detail A shows how to place the prongs to form the slot for the locking bar. Detail B shows the slot for the locking bar, and detail C shows the mats locked together.

Make sure the mats are accurately aligned before you insert the locking bar. Misaligning the first row of mats makes it difficult to install the next row. Place the third mat (half length) at the start of the second row (fig. 2–11). This arrangement gives you a staggered joint pattern. Detail A of figure 2–11 shows how to hook the half-length mat onto the full length mat. After you have it hooked, rotate it downward to form the joint as detail B shows. This joint locks the mats together. You don't install locking bars in the sides of the mats.

Complete the first row, installing as many mats as required for the desired runway width. Make sure you align them straight across the runway. If you don't, the more rows you install the further out of alignment each row will be. Check the alignment after laying each row of mats. Install the second row just as you did the third mat with this exception: you must hook the second mat to the first row while you hold the mat at an angle. Then, rotate it downward so that the end connectors mate properly. As you lay the mats, you'll notice that they have an apparent "loose fit." They're made this way to allow the base course and subgrade to expand.

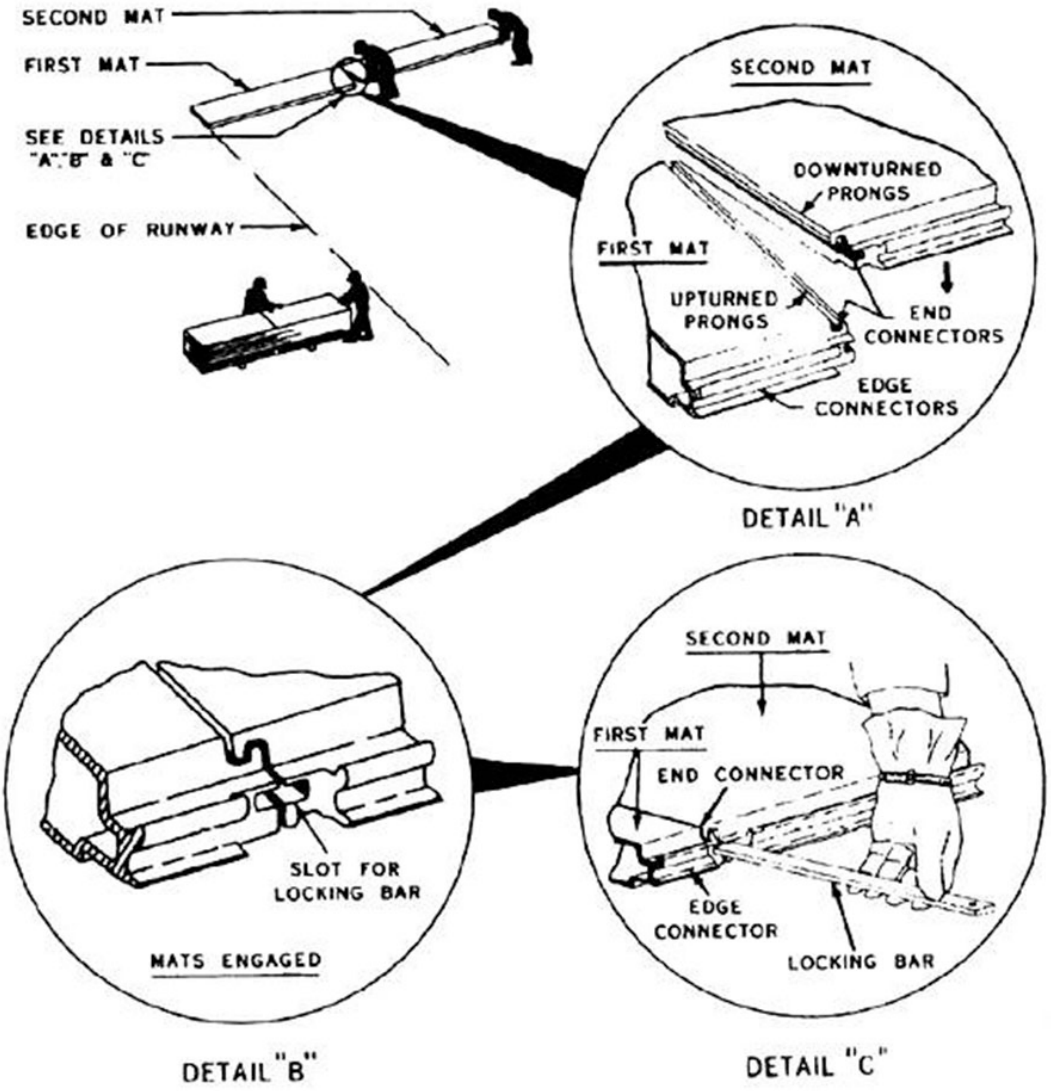


Figure 2–10. Locking mats together.

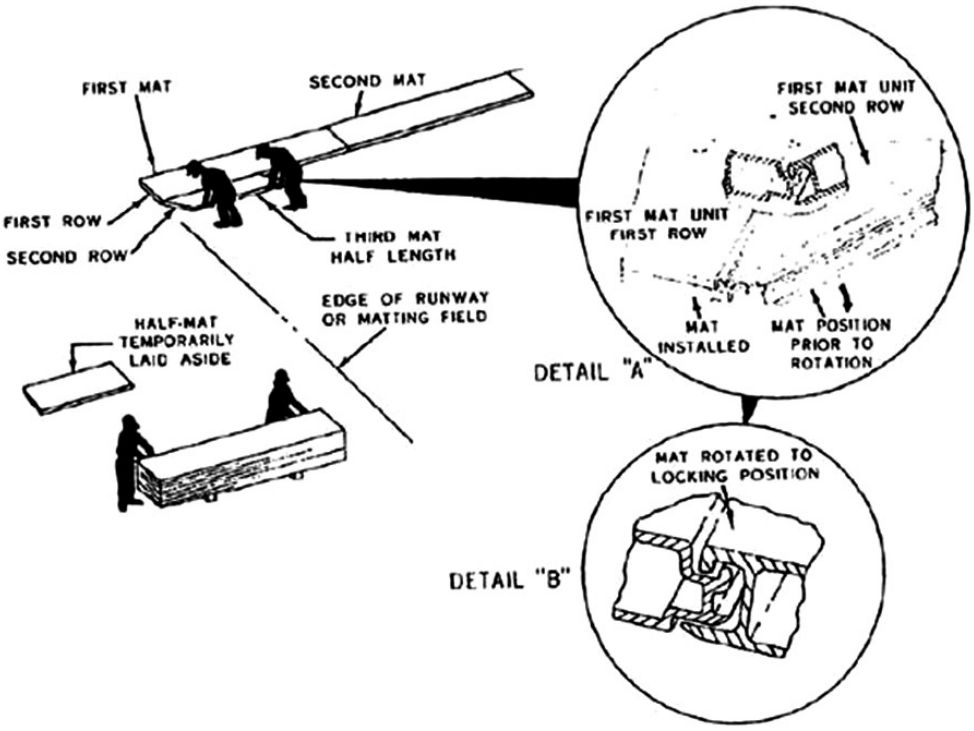


Figure 2–11. Starting the second row of matting.

You may find it impossible to hook and install one or more sections in a row. You can correct the misalignment by prying the tight mat loose and moving the loose mat in the opposite direction. Move the loose mat by placing a block of wood against it and hitting the block with a sledge hammer (fig. 2–12).

Install typical key-locks every 100 feet. If the runway is damaged, you can unlock the key-locks and remove the damaged portion.

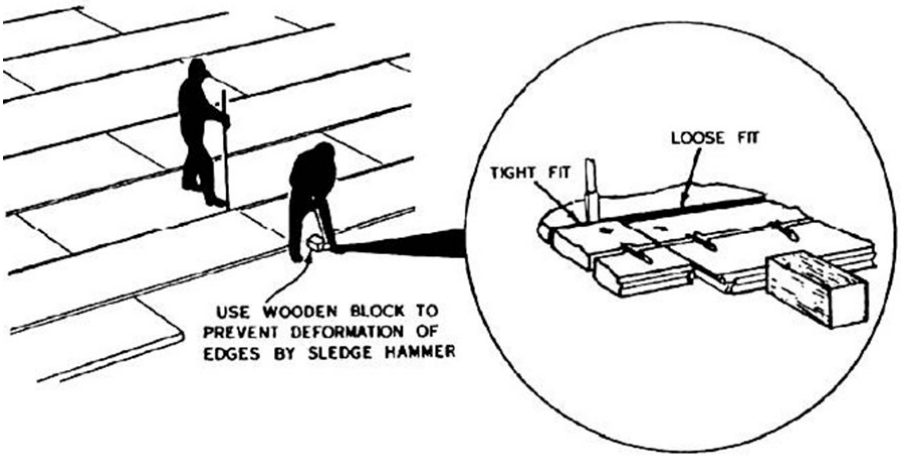


Figure 2–12. Aligning AM–2 matting.

Anchoring landing mat planks

Surface mats must be anchored to keep the end of the runway from shifting. They also prevent aircraft arresting hooks from snagging the end of a panel, which could cause the aircraft to crash. Anchor the mats by burying the first five rows of mats on each end of the runway. Make the anchor ditches 18 to 24-inches deep and cut them at a 15° to 30° angle. We show a typical anchor ditch

layout in figure 2–13. Shape the ground surface beneath the mats so that the earth and the bottom of the mats make full contact. After completing the ramp, cover it to normal ground level. Compact the fill dirt in two- to six-inch layers.

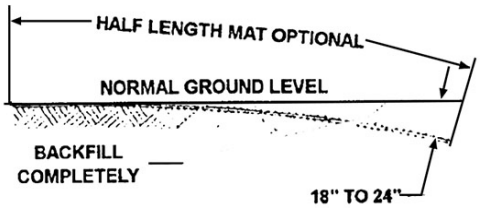


Figure 2–13. Anchor ditch.

Addition of taxiways and parking aprons

After you complete the runway, the next project is to connect the runway to the taxiways and parking aprons. You can do this in either of two ways; with 90-degree connectors or with splice plates. If you have the main accessories, the 90-degree connectors are easier and faster. All you do is connect the H-shaped 90-degree connectors onto the end connectors on the side of the runway and then hook the mats onto the connectors the same way you hooked two mats together. From here on, lay taxiway mats in the same way as you lay runway mats. If 90-degree connectors aren't available, connect the runway and taxiway with the splice plates that come as the pallet ends (shown in DETAIL "A" of fig. 2–14).

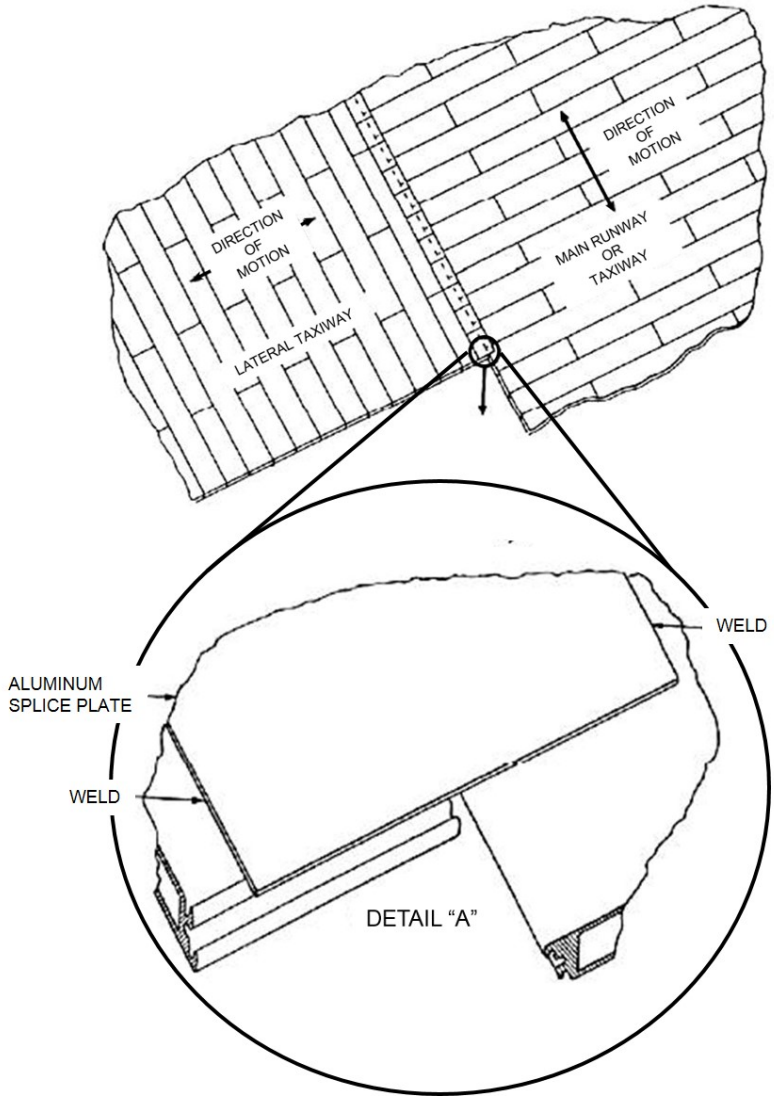


Figure 2–14. Runway and taxiway connections.

Before welding the plates to the mats, remove the nonskid surface from the mats for a minimum distance of two inches on each side of where you're to make the weld. You can remove the coating with grinders, scrapers, wire brushes, or chemical solvents. After you weld the plates, paint the welded area with enamel and let it dry for 24 hours. After it dries, apply deck covering approximately 1/16 of an inch thick over the enamel. Be sure to thoroughly stir the deck coating compound before you apply it. You can apply the compound with a brush, trowel, or spray gun.

Construct the parking and storage areas last. To do this, lay the mats and install the locking bars in the same manner as you did for runways and taxiways. Be aware that the staggered joint pattern isn't mandatory. This means that parking and storage areas can be built in any random pattern and that you can use all the leftover half-length or full length mats. Make all runway-to-taxiway, taxiway-to runway and taxiway-to-parking area connections in the same way; that is, use 90-degree connectors if they're available and splice plates if they're not.

Removing and replacing damaged mat planks

Mats may be damaged in many ways. The most likely way is by enemy munitions. Because of this, we discuss repairing mats that have been damaged by enemy action. The repair procedure is the same regardless of how the mats are damaged. If the sub base is damaged, remove the mat and repair it. If a membrane material was used over the sub base, make sure you also repair it.

Typical key-locks are installed in AM–2 runways to allow for damaged sections to be easily removed. The easiest way to remove and replace damaged mat planks is to remove the typical key-lock, pull the damaged section out, replace the damaged mat, and replace the typical key-lock.

Another method we use to remove and replace damaged mats is to remove the entire row of matting. We do this by parking a tandem wheeled truck on the mat with a set of wheels resting on each row on both sides of the row to be removed. The weight of the truck anchors the mat while we use a bulldozer, equipped with an end puller, to pull the row of matting out. When removing a single course of AM–2 matting, lubricate the joints to reduce friction. Remove the damaged panel and replace it with a new mat. Then push the row of mats back into place by placing a forklift tine on the end of the row and using it to push the mats back into place.

Disassembly of an AM–2 mat runway

Occasionally, it's necessary to take up an AM–2 runway for use in another location. The first step is to cut all the splice plates. Then remove the backfill from the apron. Locate the free end of the mat in the last row. Remove the locking bar and lift the free side of the mat until it disengages from the other mats. Continue this procedure until you remove all the mats.

As you disassemble the runway, store like items together. Some of the parts may get lost unless you're very careful. Make sure that you don't bend, break, or damage any of the parts. As you progress with disassembly, package like items together, mark them, and fasten them securely to a pallet.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

608. Folded fiberglass mats

1. What was the FFM crater repair method specifically designed to support?

2. What's the advantage of FFM?

3. How can you use a front-end loader to help off load mats?

4. When do you perform the mat joining operation?

5. How do you secure the joining panels to the mat?

6. When joining two mats together, why do you pull the mat perpendicular to the hinges?

7. What must you check before unhooking the towing gear?

8. Why do you leave a horizontal gap of one inch between the edges of the mat and ramp?

609. Installing fiber reinforced polymer panels

1. What is the number of passes that FRP panels are able to withstand?

2. Who determines crater size so mat preparation can begin?

3. What two areas are best suited for mat assembly?

4. What type of anchor is used to attach panels to asphalt and to what depth are they inserted into the subbase?

610. AM–2 mat packages

1. What are the dimensions of an AM–2 mat?

2. With what kind of material is the top surface of AM–2 mats coated?

3. With what kind of motion do you interlock the sides of the mat?

4. How many pallets does it take to make 1,000 feet of runway that is 72 feet wide?

5. What enables two mat-laying teams to work in opposite directions?

6. What components are very narrow mats that are installed every 100 feet?

7. What do you install to keep the aircraft from being tipped over by the wind?

8. In what position do you install centerline lights?

9. What do you use to protect arresting gear tapes from damage?

611. How to prepare an area for AM–2 matting

1. How do you grade the AM–2 matting's base for drainage?

2. What's the minimum CBR rating of soil bases that are used under surface mats?

3. What two methods can you use to increase the CBR of a soil?

4. Name two causes of differential settlement of soil bases?

5. To prevent the "foot" rail from resting on the ground, how do you place pallets?

612. How to assemble AM–2 matting

1. How is the second row of mats affected if the first row is misaligned?

2. How do you obtain a staggered joint pattern?

3. When correcting for misalignment, how do you move a loose mat?

4. Why do you install typical key-locks every 100 feet?

5. What must you do to the ends of the runway to prevent the tail hook of aircraft from catching the ends?

6. What are two ways of connecting a runway with a taxiway?

2–2. Shelter Systems

The shelter system we will be discussing is the small shelter system or (SSS). There are other systems available, but we will concentrate on this one as it is currently the most widely used in the AF. Also, there are similar systems to the small shelter system called medium shelter systems which are assembled the same way. The only difference is the size of the shelter and the equipment needed to assemble them. Let's begin the discussion.

613. How to erect a small shelter system

In this lesson, we discuss the SSS shown in figure 2–15. You may have heard it referred to as the Alaska shelter or the triple-S. There are other sizes available as well, but we will concentrate on the small shelter. The erecting and disassembling procedures are similar for each system, only the size is different. This AF all-purpose tent type shelter is used to support billeting, work areas, latrines/showers, storage, and so forth. It is stored and shipped in its own container. When fully erected, this shelter measures 32-feet 6-inches long by 20-feet wide by 10-feet high. It can withstand steady wind loads of 50 knots and gusts up to 60 knots. This shelter has been designated as the replacement for the TEMPER tent through attrition. In comparison to the TEMPER, the SSS is more cost effective, slightly lighter, tighter, more vector proof, requires less day-to-day maintenance when erected, and its fabric is easier to repair.

NOTE: The information presented here is for training purposes only. Always refer to Technical Order 35E5–6–11, *Alaska Small Shelter System*, when using this shelter.

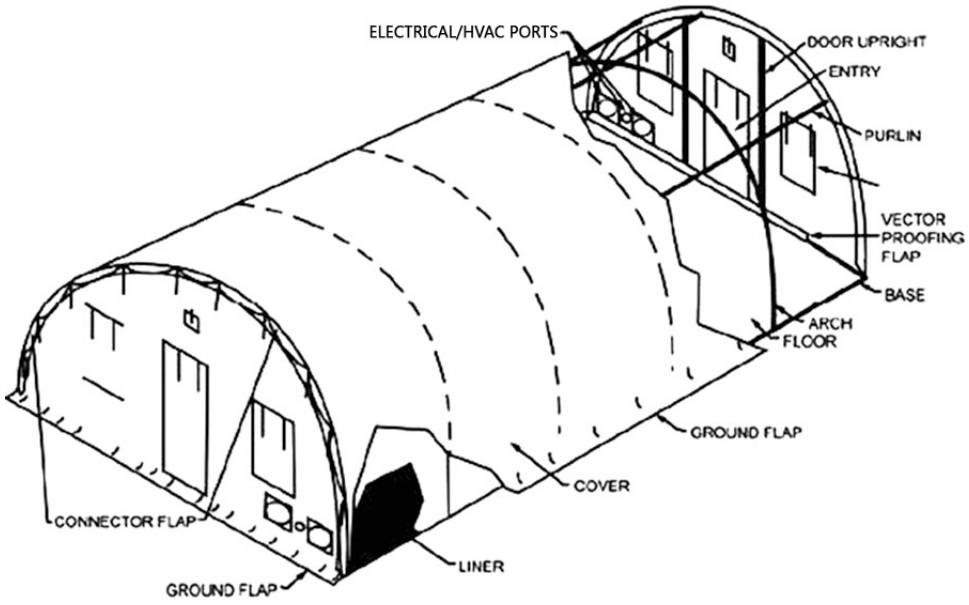


Figure 2–15. Small Shelter System.

Site selection and material handling

When selecting a site, choose an area at least 30 by 40 feet. Make sure the area is free of any debris, has adequate drainage, and is as smooth and level as possible. Unlatch the top latches and remove the top. Unpack the components, making sure you keep like items together. When removing the items from the container, inspect them for damage or missing parts. After you remove all the items and accessories from the container, reinstall the container top for storage.

NOTE: The container should be stored in this manner until it is needed again.

Safety considerations

Before we discuss the assembly procedures, you need to be familiar with some safety items. The following safety considerations must be followed or personnel injury or death may result:

- Wear safety glasses when driving stakes and anchors with a hammer.
- Wear gloves to handle structural components or pull on ropes.
- Frame members are under spring tension…beware.
- Never use a combustible heating device inside the shelter unless there is proper ventilation.
- To resist wind loads, make sure the shelter is properly anchored.
- To prevent personnel injury, make sure heavy components are handled using an adequate number of personnel.

You must also be sure to observe the following precautions to avoid damaging equipment:

- Never allow snow or ice to build up on the top of the shelter.
- Never drag fabric components over the ground or sharp objects.
- Never pound on the base frame or drive spikes in a way that will dent the base frame.
- Never pound on pins or slip-fit connections. If necessary, only lightly tap.

Base assembly and anchoring

Assemble base sections in sequence of the base assembly plan included with the kit. Place all base pieces with the hooks on the outside of the shelter facing down. Measure 38 feet 3 inches from an outside corner to a diagonally opposite outside corner with a rope or tape measure to square the base of the frame. Drive 18-inch double-headed spikes through the spike holes in the base frame to secure the base assembly.

NOTE: Do not drive a spike through the center end base pieces. This hole is used for the end panel with a hard door.

Install non-slip floor

Unfold the non-slip floor and slip the floor cutouts over the base stubs. Be sure to install it with the black side towards the ground.

NOTE: If using the cold weather kit, unfold the insulated sub-floor and place it inside the base frame before installing the non-slip floor.

Arch assembly and installation

Place the arches on the ground to assemble (fig. 2–16). Stand the assembled arch and set one end on the base stub. Hold the arch firmly and spring the other end onto its base stub on the opposite side. Repeat this procedure until all remaining arches are in place.

NOTE: Be sure that all red coded bottom arches (without stubs) are on the same side of the shelter.

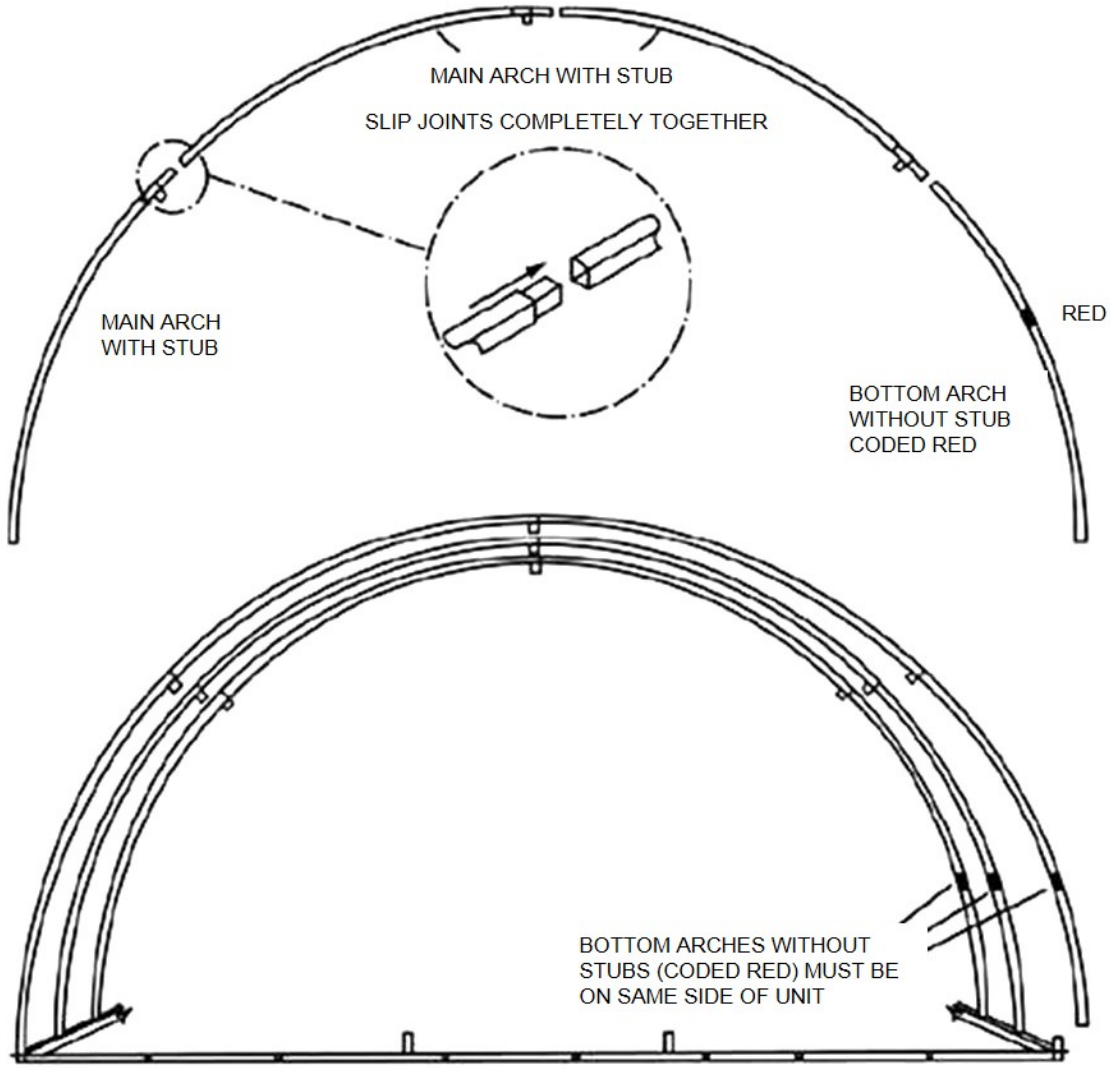


Figure 2–16. Arch assembly and installation.

Purlin installation

You are now ready to install three rows of purlins. They connect between the arches, as shown in figure 2–17. Begin installing the red-coded purlins on one end, and then work towards the opposite end. Notice in figure 2–17 that the last purlins installed are yellow-coded purlins.

NOTE: When installing purlins, slip the purlins into the purlin sleeves on the arches. Place pins (installed from the top down) through the purlin sleeves and purlins to secure them in place.

End upright installation

You may find the end uprights in two pieces. If so, slide the upright insert (with hook end) into the top of the end upright. Raise the upright and slip the insert (hook end) over the arch and then lower it onto its base stub, ensuring it is plumb.

NOTE: Place the insert bolt towards the inside of the shelter. Be sure to follow the stenciled instructions located on the end uprights.

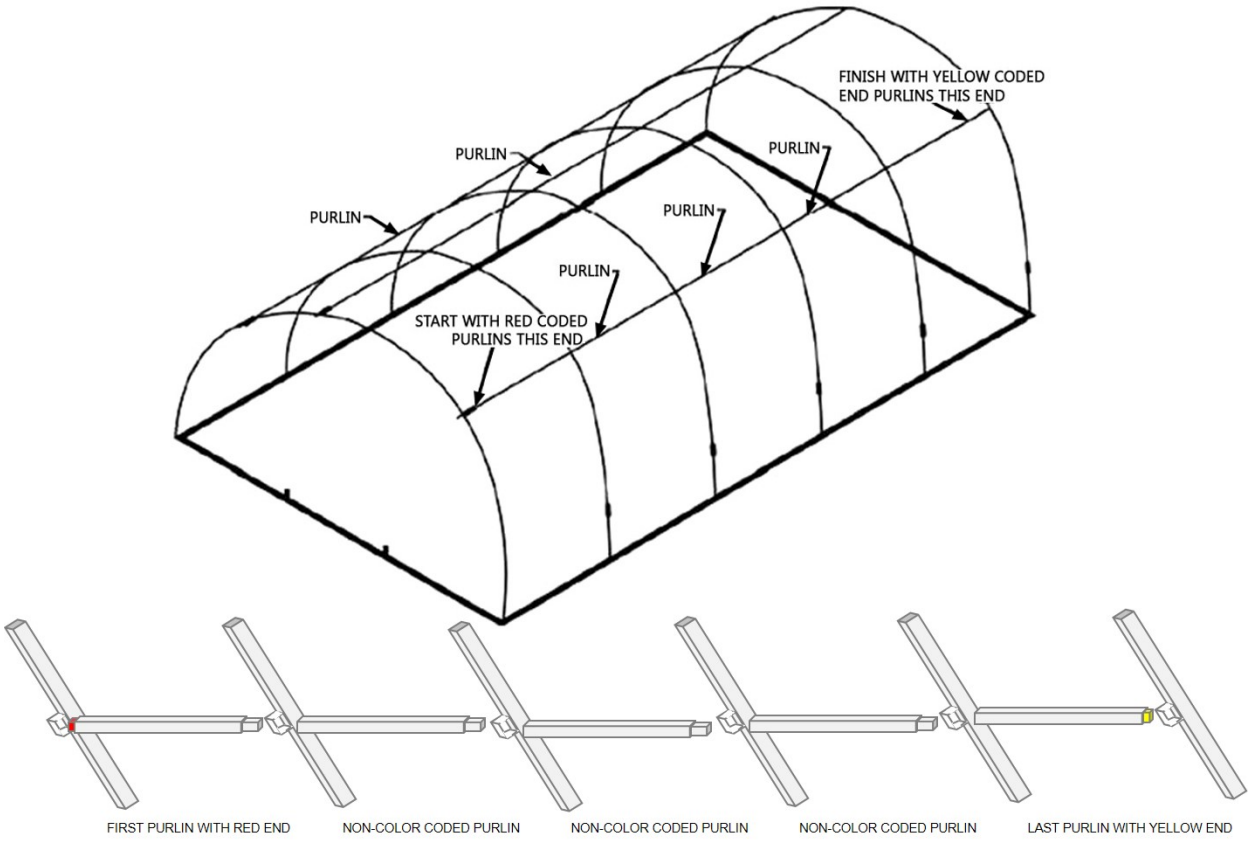


Figure 2–17. Purlin installation.

End panel installation

After the framing members are installed, the next items to install are the end panels. There are two types: zippered and hard door panels.

Zippered end panel

Follow these steps to install the zippered end panel.

1. Spread the panel (white side up) next to one end of shelter.
2. Attach one end of the base rope (rope that runs along the bottom of the panel) to the *yellow* tie off cleat on the base frame. Tightly stretch the other end and tie it off to the *yellow* cleat on the opposite side.
3. Temporarily remove the purlins from the end arch only and lift the end panel up to work the contoured edge up and over the end arch (fig. 2–18). Starting at the center purlin and working towards the sides, slip the end cover rope under the purlins and reattach the purlins to the end arch.
4. Tension the contour rope (rope that runs along the top of the panel). Run the rope under the *green* tie off cleat on both ends and use the heel of your boot to pry on the rope (add tension) while pulling on the rope.

   NOTE: You must keep the end panel centered.
5. Continue to work the end panel over the arch and then secure the rope to the *green* cleat.
6. Secure the base rope (at designated locations) to the base hooks on the outside of the base frame.

   NOTE: Due to the tension on the rope, you will have to use the hook tool provided with the kit.

7. Secure the end panel to the uprights. Depending on the style of panel, there may be either hook and loop fasteners or a Velcro strip that gets wrapped around the uprights.
8. Repeat these steps to install the opposite end panel.

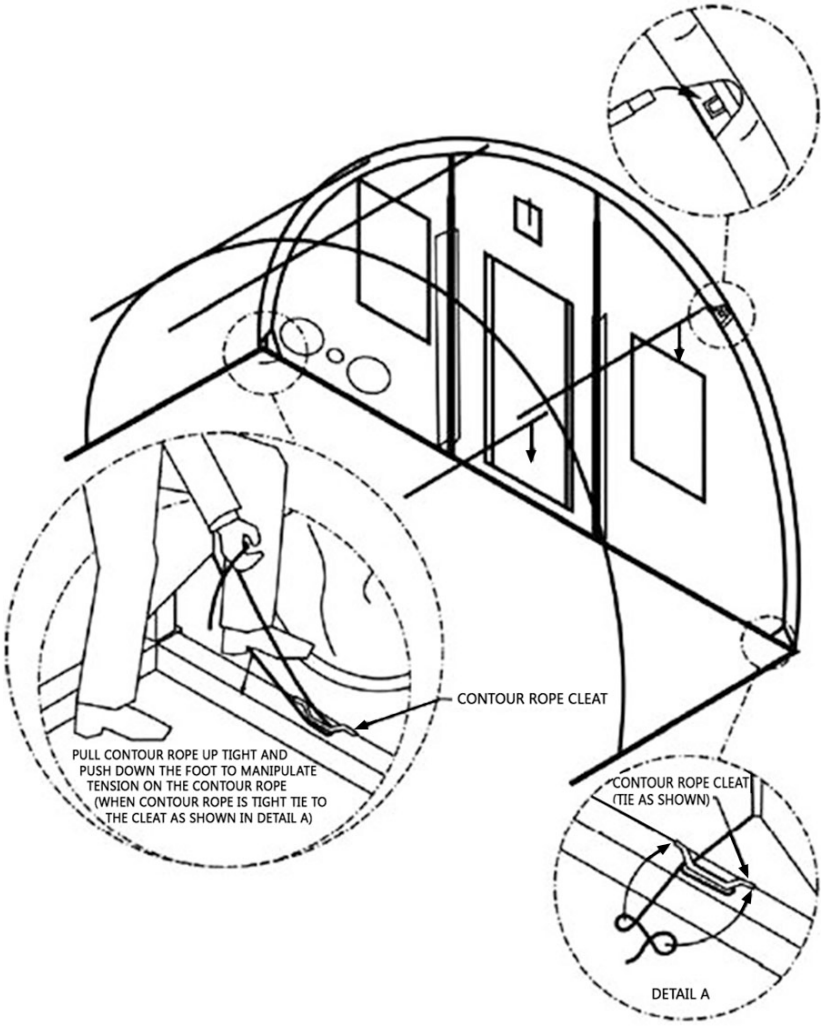


Figure 2–18. End panel installation.

Hard door end panel

To install the hard door end panel, follow these steps:

1. Make sure the door is installed with white side facing inside the shelter. Place doorframe so the stub on bottom of doorframe slides into spike hole in the center end base frame.
2. Secure the end panel to the arch following the same procedures outlined for the zippered panel installation.
3. Work from the inside of the shelter, slide the header stubs into the top of the doorframe to connect the two together. Secure with pins.
4. Secure to the end panel to the uprights. Depending on the style of panel, there may be either hook and loop fasteners or a Velcro strip that gets wrapped around the uprights.
5. Remove the door brackets to open the door, install the doorknob and adjust the strike mechanism, if needed.

NOTE: After the end panels (either type) are installed, you may install a plastic vent cap (placed at the top center of each end panel). This is secured in place with Velcro and, as the name implies, is used for ventilation.

Main cover installation

To install the main cover, we recommend you follow these procedures:

1. Lay the cover next to the shelter so that when you pull it over the shelter, the black side faces the inside (fig. 2–19).
2. Secure one end of the cover base rope to the *silver* tie-off cleat. Stretch and secure the other end of the cover base rope to the *silver* tie-off cleat on the other end.
3. The cover has four black loops located at the base of it. They are used to attach the pullover ropes. Throw four pullover ropes over the shelter and attach them to the loops.
4. With one person on each of the 4 ropes, pull the ropes in unison to pull the cover over the frame.
5. Secure the base rope on the other side using the same procedures.

   NOTE: Make sure the exposed portions of base rope align with hooks on base frame.
6. With at least one person on a ladder and two on the ground, work the cover over the ends of the shelter. You should have at least a four- to five-inch overlap. The overlap should be equal on both ends and the guy rings should be located directly over the arches.
7. Beginning on one end of the cover, attach the contour rope to the *red* tie-off cleat and tension the contour rope. Use your foot to pry (add tension). Repeat steps to tension the contour rope on the other side of the shelter.
8. After the cover is securely tensioned, use the hook tools to attach the base rope to the base hooks along each side of the shelter.

   NOTE: At this point, attach the floor to the cover and end panel using Velcro strips.

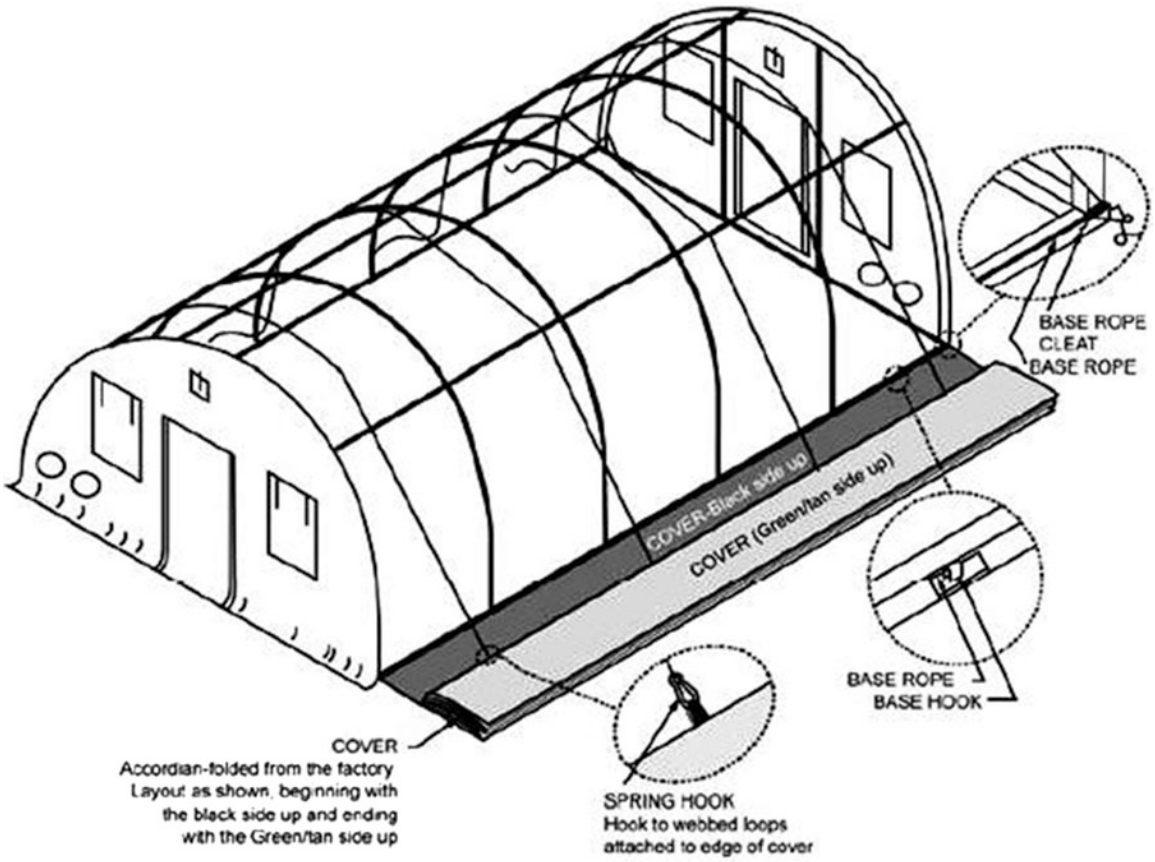


Figure 2–19. Main cover installation.

Guy rope installation

If this shelter is used in areas with wind conditions over 40 miles per hour, you must install guy ropes. To do this, drive 18-inch guy anchors approximately 36 inches away from the side of the shelter (fig. 2–20). Drive the anchors into the ground with the top angled away from the shelter and in line with each arch. The rope used has a tent slip on one end and a snap on the other. Secure the end with the tent slip to the guy loop on the shelter. Secure the other end to the guy anchor and then tighten the tent slip.

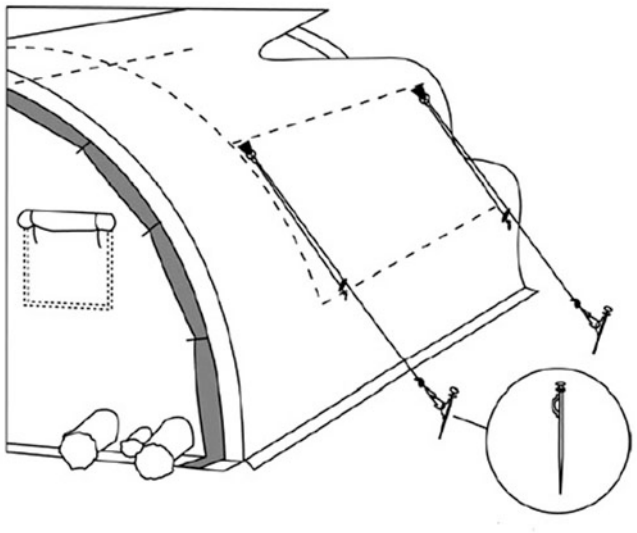


Figure 2–20. Guy rope installation.

Liner installation

The SSS uses three types of liners—a mid-liner, a side liner, and an end liner. The typical composition is one mid liner, two side liners and two end liners. The identification tag located on the material easily distinguishes these liners. The following procedures are used to install the mid, side, and end liners:

Mid liner installation

1. Begin with the mid liner. Find its center and align it under the center purlin (silver side up).
2. Take each end of the liner and slide it over the side purlins.
3. To ensure the proper position of the liner, line up the purlin cutouts on the liner with each of the side purlins.
4. There are two center hook and loop straps. Attach them around the arch, placing one on each side of the center purlin.
5. Work down the arch attaching the remaining hook and loop straps on the arch. Repeat for the other edge of the liner.

Side liner installation

1. With the mid liner installed, continue with the side liners, installing them in the same manner (silver side up).

   NOTE: Place the long edge of the side liner without hook and loop straps next to the mid liner.
2. Take each end of the liner and slide it over the side purlins.
3. To ensure the proper position of the liner, line up the purlin cutouts on the liner with each of the side purlins.
4. Attach the straps to the next bare arch using the hook and loop straps.

5. The other side of the side liner gets attached to the face of the mid liner (along the hook and loop edge.
6. Repeat the steps for the other side liner.

End liner installation

1. Layout the end liner (silver side up) adjacent to the side liner. Make sure the edge of the liner that has the hook and loop straps is facing the end arch.
2. Work the liner over the side purlins. Make certain to line up the liner's purlin cutouts with each side purlin.

   NOTE: You may have to loosen the end wall contour rope to install the liner strap. Just be sure to retighten it.
3. Using the hook and loop straps, attach the end liner to the end arch. Start at each bottom arch section of the end arch working from the side purlin down to the floor.
4. Attach the opposite edge of the liner to the side liner's face. Start at the center purlin and work towards the floor.
5. The last step is to attach the hook fastener on the liner's silver side to the loop fastener located above the doorway on the end panel. After that, attach the next two straps above the side purlins.

Electrical system installation

After the liner is installed, follow these steps to install the electrical system:

1. Install the power distribution box four-feet high on the upright pole adjacent to the air conditioner return inlet.
2. Locate the three cables with female connectors and one cable with a male connector. The female connectors are for the string lights and receptacles and the male cable is for the incoming power.
3. Connect the receptacle string (39-feet long with four receptacles) to the distribution box and run the cable along the left side of the end wall (facing the distribution box).

   NOTE: Cable should be approximately two-feet high along on the arch frame.
4. Run the cable down the left side of the shelter and attach a receptacle on each arch.
5. Connect the other receptacle string (50-feet long with four receptacles) to the power distribution box and run the cable over the doorway and alongside the right of the shelter. Once again, attach a receptacle to each arch frame.
6. Install the lights starting from the distribution box and stringing the first three lights to the purlins on the left side of the shelter about 10 feet apart.
7. Continue running the cable over alongside the fifth arch over to the purlins on the right side. Attach the next three lights about 10 feet apart.

Plenum installation

Before plenum installation begins, lay out the straight section on the shelter floor, parallel to the center purlins. To install the plenum follow these steps:

1. Starting on the end wall where the environmental control unit (ECU) is to be set up, attach the first grommet to the second center purlin.
2. Attach the plenum's next strap to the third center purlin. Continue in sequence, attaching the rest of the straight section.
3. After the straight section is installed, connect the elbow section to the air conditioner's inlet (supply). Use the available strap or strings to connect to the elbow section grommets. Then tie them to the purlins and end section arch.

Environmental control unit

Each SSS comes equipped with its own ECU to control the interior temperature of the shelter. Heating, ventilation, air conditioning and refrigeration (HVAC/R) personnel are the only ones that should work on the ECUs; however, you may be called upon to place it. Using a forklift, lift the ECU and place it on the most level area in front of shelter duct openings—approximately 12 inches away from the shelter end wall. Make sure the ECU side labeled *EXHAUST END* is facing towards the shelter duct openings.

The flexible ducts are located under the top lid of the ECU. The supply duct is identified as *not* having wire ring supports. It gets attached to the supply air vent on the ECU and placed through the right hand fabric boot on the shelter. The fabric boot is secured to the supply duct with the fabric boot straps. Repeat this procedure for the return air duct using the left hand fabric boot.

Inspection and maintenance

To keep the SSS operating at maximum capacity, perform periodic inspections and preventive maintenance as required per the shelter's technical order. When the shelter is placed in storage for a lengthy period, inspect it at six-month intervals. Also inspect the SSS during every assembly and disassembly for missing or broken parts. At a minimum, the inspection/maintenance actions should include the following:

- Inspect the exterior shelter fabric for dirt buildup or foreign matter—clean as required with soap and water.

  NOTE: *Do not* use solvents, cleaners, degreasers or abrasive products to clean the shelter.
- Inspect the electrical cable assemblies every 30 days looking for kinks, nicks, or cracks. If you find any of these, refer them to electricians for repair.
- Inspect the shelter container periodically for dirt build up. Clean with soap and water. Also inspect the latches and replace them as needed.
- The ECU should only be inspected and repaired by heating, ventilation, and air conditioning (HVAC personnel.

Fabric repairs

The spare bag contains a patch kit used to repair minor rips and tears (up to 18 inches) in the cover or floor. To make a repair:

1. Clean the area with water and dry.

   NOTE: Place patches on the cover's exterior.
2. Cut the patch large enough to extend a minimum of 3 inches on all sides of the damaged area.
3. Remove the paper backing from the patch to expose the self-adhesive. Then press the patch firmly over the tear and smooth.
4. If there is any exposed sticky area, apply talc over it.

For larger tears, you may use a hand held heat welder and pressure roller. To do this:

1. Cut a patch that extends at least 2 inches on all sides of the damaged area.
2. Place the patch over the tear and lay it on a hard surface.
3. Heat the patch and the tear area using the heat welder. This will melt (fuse) the two pieces together.
4. You must apply pressure to the area during the heating process using a pressure roller.

Arch loop fastener replacement

To replace damaged loop fasteners, remove the old fastener from the arch. You must use a cleanser to remove the excess adhesive on the arch. Afterwards, apply a denatured alcohol to clean the arch. To

install the new loop fastener to the arch, remove the backing and press firmly in place. You must allow at least 24 hours for curing.

Disassembly/reconstitution

The first step to disassemble the SSS is to make sure that all power is disconnected from the electrical system at the source. From there, disassembly is performed in reverse order of the erection procedures, keep the following in mind:

1. Pullover ropes are not needed to remove the cover.
2. If pins are tight, do not force the pins out—gently tap or wiggle them loose.
3. Do not drop or throw objects from high elevations.
4. To raise the spike heads, you must use the spike puller and place dunnage directly under the spikes to prevent damage.
5. Be sure that the cover and end wall panels are dry before packing.

To make packing the container easier, place like items together while disassembling. Take great care in packing the container to ensure that the shelter does not get damaged and is useable for its next mission. *Always* use the shelter's technical order to ensure the correct packing sequence is followed.

614. Splinter Protection

Protecting the facilities, aircraft, and people is the goal of splinter protection. By using different types of metal and pre-cast concrete revetments, you can provide protection from some types of bomb blasts and shrapnel. In this lesson we cover the uses and types of revetments.

Use of revetments

Revetments are used to protect parked aircraft and essential facilities from the effects of enemy attacks. We can use many materials to build revetments, but we only discuss the metal, pre-cast concrete, and expandable bin-type in this area. Figures 2–21 and 2–22 show the use of revetments to protect a facility and aircraft. You can see from these illustrations that revetments provide protection to critical facilities and weapon systems.

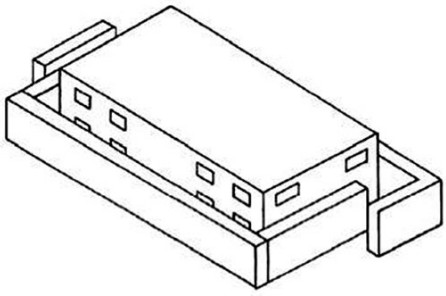


Figure 2–21. Building protected by revetment.

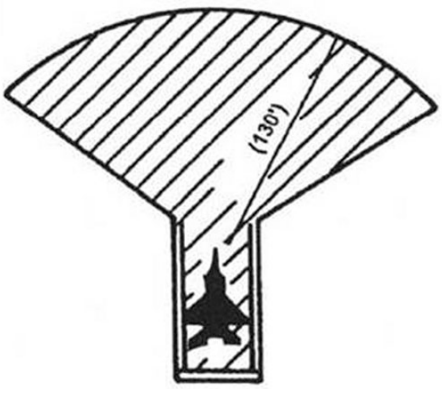


Figure 2–22. Aircraft protected by revetment.

Pre-cast concrete revetments

Pre-cast concrete type revetments are replacing the metal type revetments in most areas of operations around the world. The reason for the change is because of the manpower savings in erecting the concrete types and the low cost of their maintenance. There are several different types of pre-cast concrete revetments but for this lesson we only discuss two of the most common. They are called Bitburg and concrete chamber soil bins.

Bitburg revetment

The Bitburg revetments come in two standards sizes, 2-and-4-meters. The 4-meter (13.12-feet) Bitburg aircraft revetment shown in figure 2–23 is a one-piece, L-shaped, pre-cast concrete revetment that is 4-meters high (13.12 feet), 1-meter wide (3.3 feet), 2.2 meters (7.21 feet) deep, and 24.5 cm (9.65 inches) thick. The freestanding units can be butted together side-by-side. One line of revetments may be butted up against another line of revetments at a 90-degree angle only by reversing the direction of abutting corner revetments, as the flanges are not relieved like the Bitburg revetment's base flanges. Although cumbersome, the units are versatile in that they can be used with berms to effectively protect one story buildings, or they can be placed in double rows as shown in figure 2–24 to be used as bin revetments for greater blast protection of aircraft. If you use them in this manner, you must install a liner to prevent fill material from seeping.

There are many other configurations in which this type of revetment can be used to protect personnel and wartime equipment. Use Air Force handbook 10–222, Volume 14, *Civil Engineer Guide to Fighting Positions, Shelters, Obstacles, and Revetment,* to guide you on erecting the type or system required for force protection.

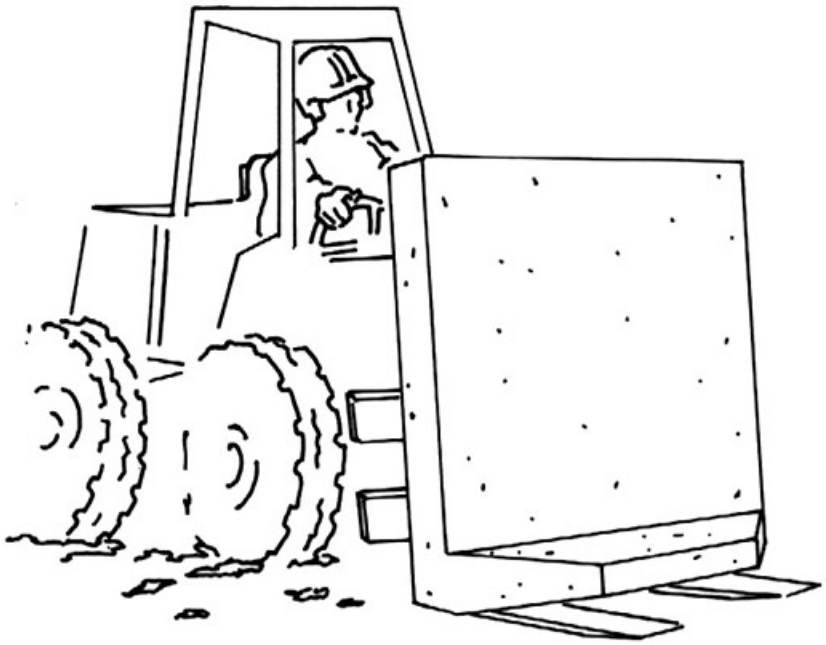


Figure 2–23. Bitburg pre-cast concrete revetment.

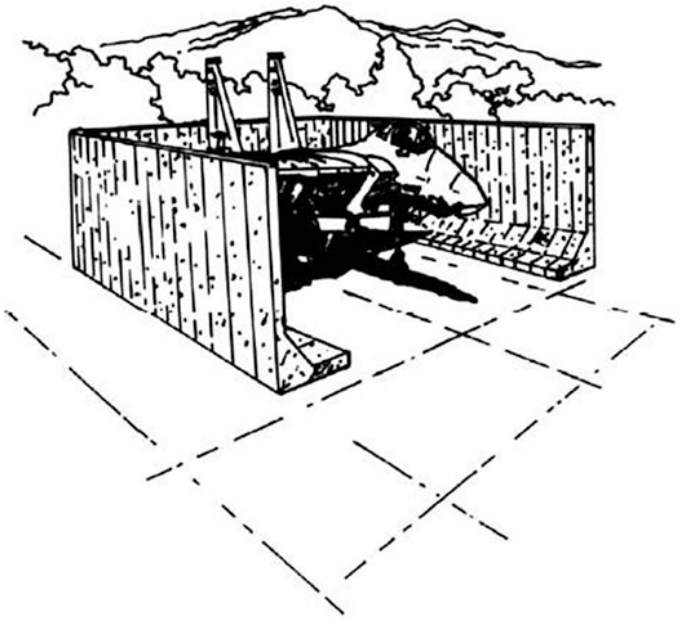


Figure 2–24. Aircraft precast revetment.

Pre-cast concrete chamber soil bin

Pre-cast concrete bins are normally used for manholes or precast concrete box culverts for drainage under roadways. Because they come in many sizes and strengths, they have been adapted to construct revetment as shown in figure 2–25.

Stacking the bins requires the use of a small crane or loader. Workers connect lifting slings to precut holes on each side of the bin and then the crane lifts them into place. Once the first rows of bins are placed, fill each bin ¾ full of sand or gravel. Continue to stack and fill one row at a time. Once your stack reaches the required height, cap the top with concrete to prevent rain and snow from soaking the fill material. Due to the very heavy weight of the stacked concrete chambers and soil fill, install these chambers on at least an eight-inch thick reinforced concrete foundation.

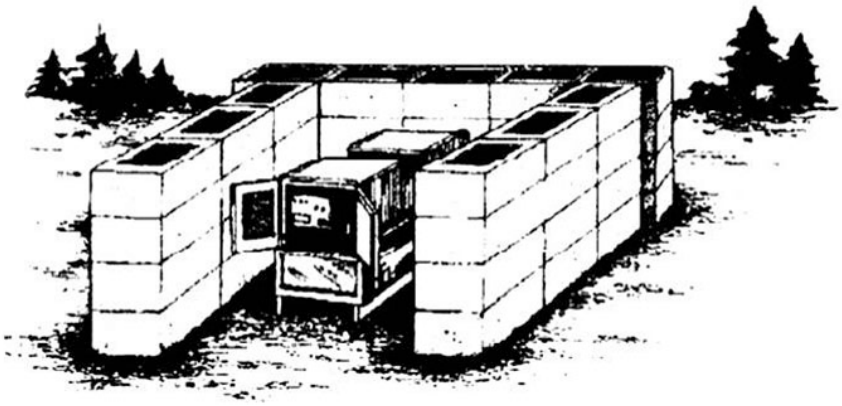


Figure 2–25. Precast concrete revetment box style.

Expandable bin-type revetment

Expandable bins are a revetment system that use a series of baskets formed from hinged galvanized wire panels covered with a geo-fabric liner. The liner is resistant to rot and ultraviolet radiation. This revetment system is shipped in a folded and compact configuration that allows easy expansion to form wall sections of linked, self-supporting cells. The cells are filled with soil, small gravel, or other available and suitable material. This provides adequate protection against ballistic and blast forces. This system is used extensively in many areas to protect fuel points, helipads, people, and vehicles.

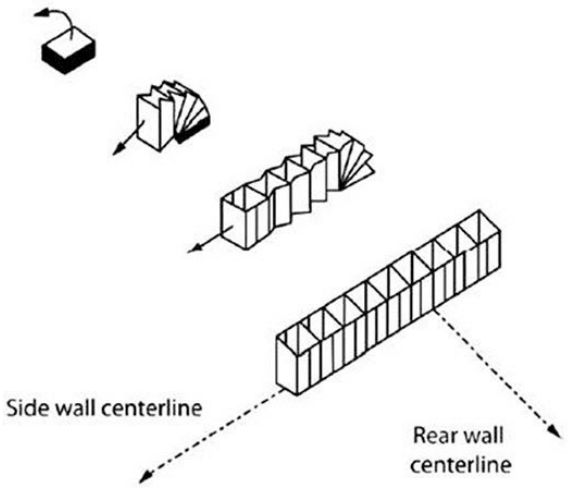


Figure 2–26. Concertainer layout.

The wall sections are available in a variety of lengths, widths, heights, and colors. A minimum of two people can easily erect the revetment. If a third person is added to operate heavy equipment, the revetment can be erected more quickly. These expandable bin revetments have many advantages over other types of revetments. They provide the same amount of protection as the old B–1 style revetment, yet the shipping weight of materials is substantially reduced. Another advantage is that the height is not limited. You can increase the height of the revetment using a variety of different sizes as long as you make sure the base is the proper width to prevent them from overturning due to instability.

Assembly procedures

Establish a layout area and compact any loose soil that may be present. For U-shaped barriers, expand the first unit in the left rear corner (fig. 2–26). For straight walls, begin at any end. To form a corner, push in the coil hinges and rotate one end 90º and pin the connection as shown in figure 2–27. Connect additional sections together by overlapping the coil hinges and inserting a connecting pin (fig. 2–28). Once you get the next section connected, expand the unit along the layout line.

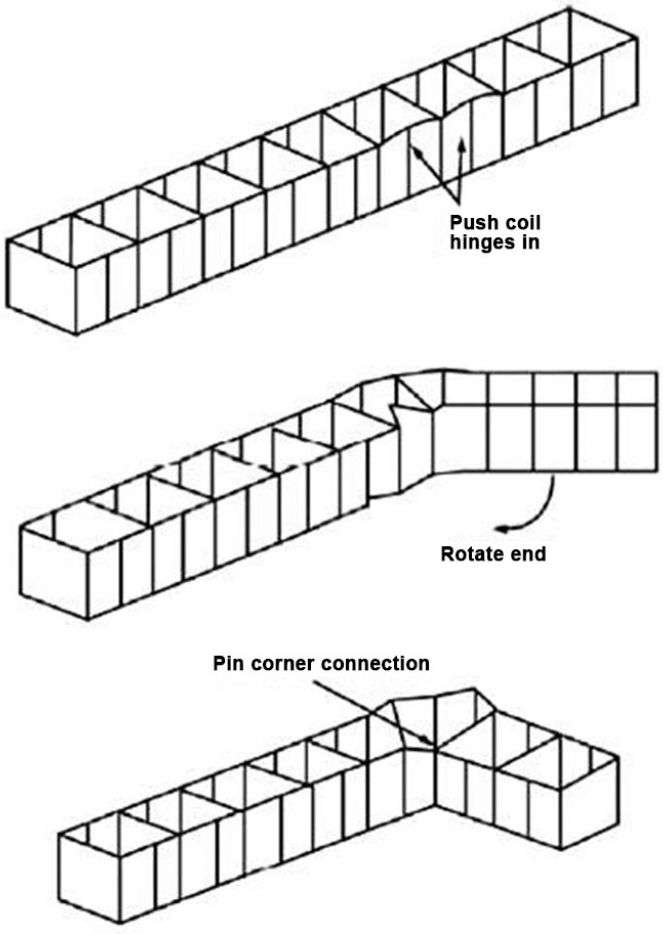


Figure 2–27. Corner assembly details.

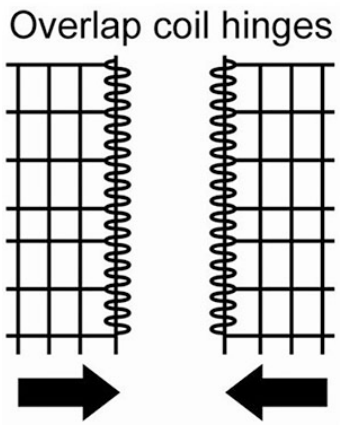


Figure 2–28. Connecting coil hinges.

After the base row is assembled, adjust the cells for the fill. Do this by pulling out the center of each cell at the base about 4-to-6 inches (fig. 2–29). For revetments with corners, half-fill the corner cells with soil, then half-fill the center two cells of each wall section. Fill the remaining cells approximately 4 inches from the top. For straight wall sections, begin by filling completely the two cells at each end of the wall and then half-fill the rest of the cells in between. You are now ready to begin constructing the second row.

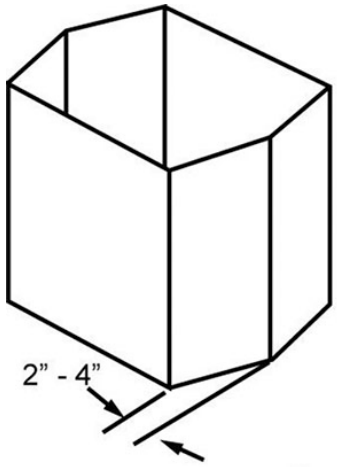


Figure 2–29. Center cell adjustment.

To install a second row, follow the foldout procedures you used for the first course. Connect the top and bottom sections together with the wire ties provided with the kit. Fold down the geotextile flaps to seal the wall junctions. After the top and bottom sections are secured, the last step is to fill the cells in the same sequence as you used for the first row.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

613. How to erect a small shelter system tent

1. How do you place all of the base pieces of a SSS tent when you must assemble them?

2. When setting the arches onto the base frame, where do you place all of the red coded bottom arches?

3. In what sequence do you install the red- and yellow-coded purlins?

4. What do you use to secure the end panel base rope (at designated locations) to the base hooks on the outside of the base frame?

5. When working the main cover over the ends of shelter, how much overlap should you have?

6. At what approximate location do you install guy anchors for the guy ropes?

7. Which liner do you install in the SSS first?

8. When making minor repairs on the cover or floor, what size patch must you cut?

9. What do you use to make repairs for larger tears?

614. Splinter protection

1. Why are revetments used?

2. What are the two most common types of pre-cast concrete the text discusses?

3. What are the two sizes of Bitburg revetments?

4. What are expandable-bin revetments?

5. What is the minimum number of people needed to erect expandable-bin revetments?

2–3. Expedient Field Construction

Field construction can include many projects including drainage, bridge construction, road construction, sanitary landfills, and wastewater disposal to name just a few. We will discuss these issues in greater detail in the following lesson. When in a contingency situation, always be ready to construct these types of projects and many more depending on the mission.

615. Culvert and timber bridge construction

In permanent construction, drainage systems are designed to maximize space usage and fully contain or control storm water runoff. In contrast, theaters of operations designs use open ditch designs almost exclusively. This is usually the case because of limited materials and equipment.

During construction of roads and airfields, adequate drainage is essential. During the construction process, rough grades must be maintained to permit water to move freely away from the worksites by gravity flow. If water is permitted to pond, the subgrade will become saturated and will fail under load. For purposes of expedient construction, be liberal in your approach to sizing drainage ditches. Keep in mind that a ditch that's too large will cause fewer problems than a ditch that's too small and allows flooding, ponding, or eroding of an essential operational surface.

In addition to open ditch drainage systems, you often encounter the need for designing and constructing culverts and temporary bridges. As a pavements and construction equipment operator, you'll be tasked with helping the engineer assistant with completing these projects. We begin our discussions with a look at culverts.

Culvert design

A culvert is a pipe like structure made out of concrete, metal, wood, stone, or sandbags. It's designed to allow water to pass under a road, footpath, or embankment. In field conditions, you must be innovative and use available materials to design the culverts needed to support the mission. To help you in this endeavor, the following culvert types are possible:

- Lean-to.
- Sandbag.
- Log.
- Metal plank.
- Pipe and stone.

Lean-to culvert

When materials aren't available to construct a culvert and one needs to be constructed, you might be able to gather some logs from the surrounding area and construct a lean-to culvert like the one shown in figure 2–30. To construct the lean-to culvert, you simply collect some stones to use as a base over which the water flows. Then construct the lean-to over the stones. As you can see, this is a quick and easily constructed temporary culvert.

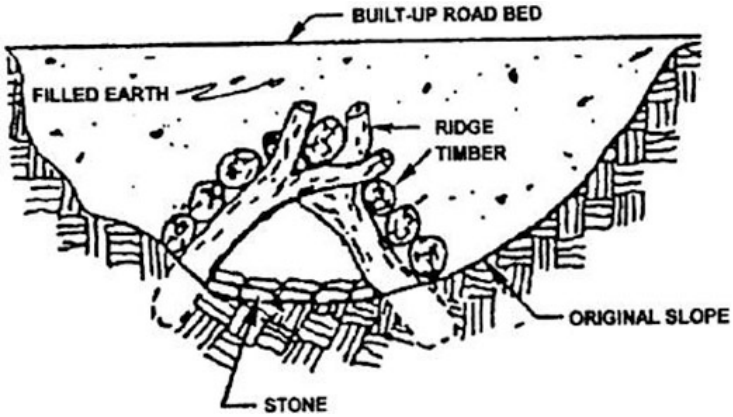


Figure 2–30. Large lean-to culvert.

Sandbag culvert

Another type culvert is the sandbag type. Figure 2–31 shows a typical example. Notice there are metal planks laid down on the ground, and then the sandbags are constructed so that two walls are formed along the outside edges; this leaves a waterway down the middle. Placing metal planking or AM–2 matting across the top of the sandbags completes the culvert. The planking is held in place with more sandbags placed on top of the metal planking.

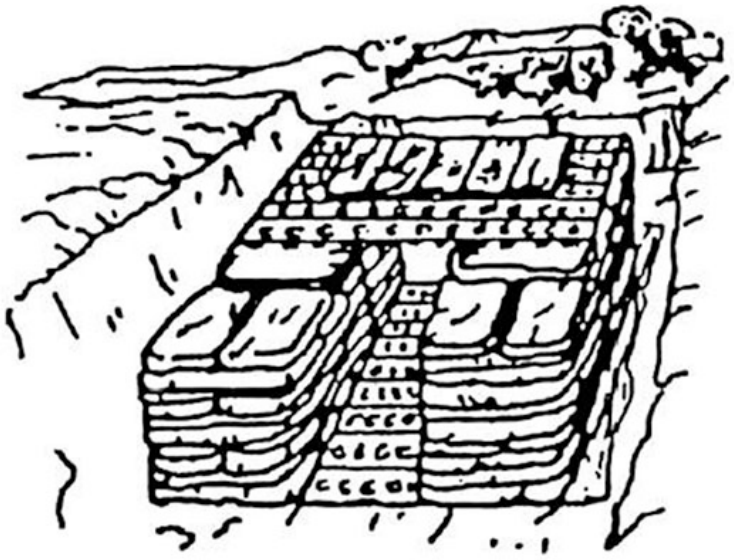


Figure 2–31. Sandbag culvert.

Log culvert

When your unit is going to be in an area where there will be heavy water drainage, you may need to construct a log culvert like that shown in figure 2–32. This is a heavier duty culvert, designed to withstand heavy water flow. When constructing this culvert, you must drive stakes into the ground. These stakes support the log walls by allowing them to be tied together for strength and durability.

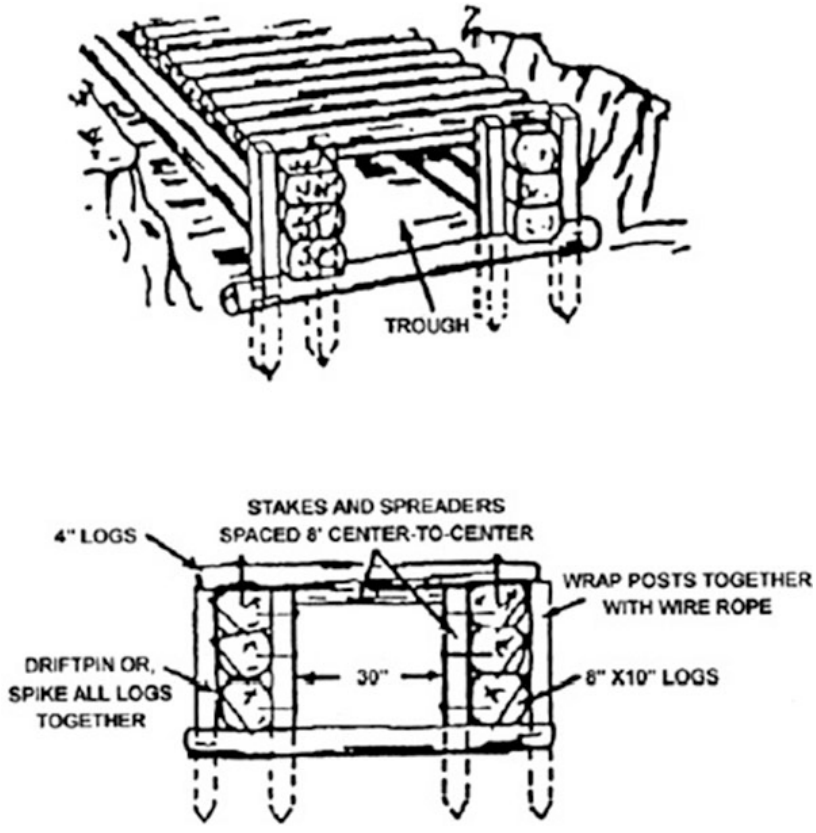


Figure 2–32. Log culvert.

Metal plank culvert

Another type culvert that can be used for a more permanent or long term use is the metal plank type shown in figure 2–33. This culvert is constructed out of metal planking and is tied together with wire. You can place sandbags, burlap sacks, or canvas around the metal planking to give it a better water tight seal.

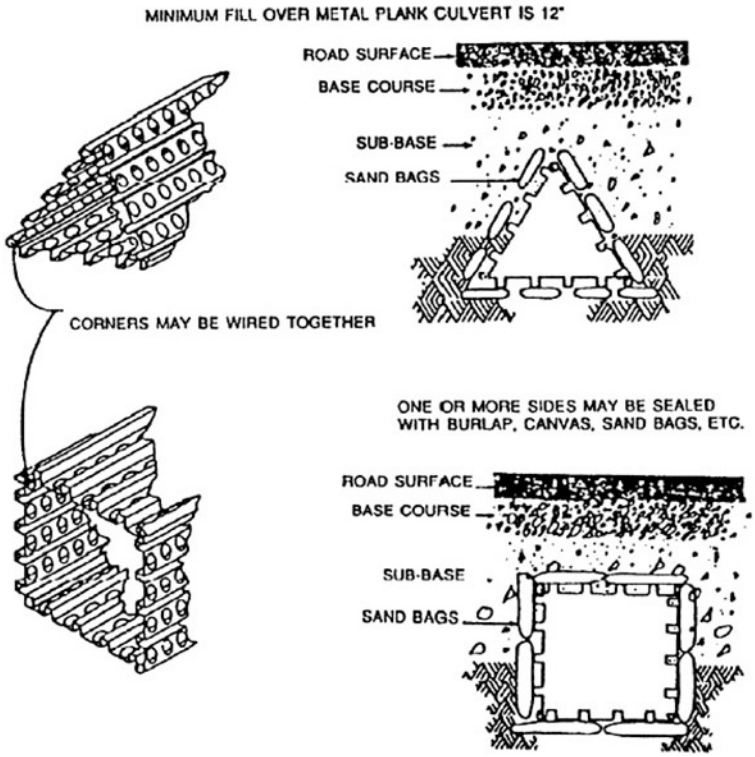


Figure 2–33. Metal plank culverts.

Pipe and stone culverts

Figure 2–34 shows two culverts that you can construct in the field with little effort. The first you construct of small pipes, while the other you construct of stones and logs. While in the field, you must be able to think of ways to accommodate mission requirements from whatever resources you have available. *Be creative,* yet be safe.

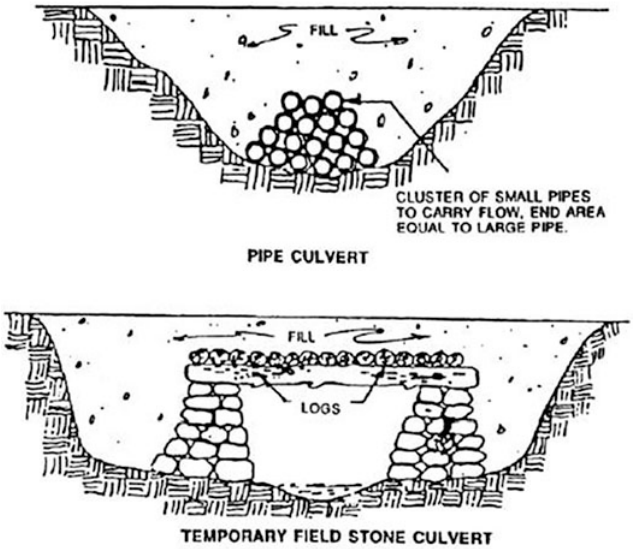


Figure 2–34. Pipe and stone culverts.

Timber bridge construction

There may be times when a ditch or ravine will be too wide to accommodate a culvert. When this happens, you'll be required to construct some type of bridge with the support of structures personnel. As with culverts, you must be able to think of ways to accommodate mission requirements from whatever resources you have available. For example, let's say logs and timbers are the only materials you have to work with. If you use them properly, these materials can provide a safe and sufficient bridge for most uses. Figure 2–35 shows a timber bridge constructed of logs. The most important thing to remember is to construct the bridge according to its projected use. If it's going to be just a foot bridge, you won't have to place as many supports in the structure as you would if vehicles are to cross the bridge. Additionally, don't construct any kind of bridge without first consulting with an engineer. They will be able to design it properly to accommodate expected loads.

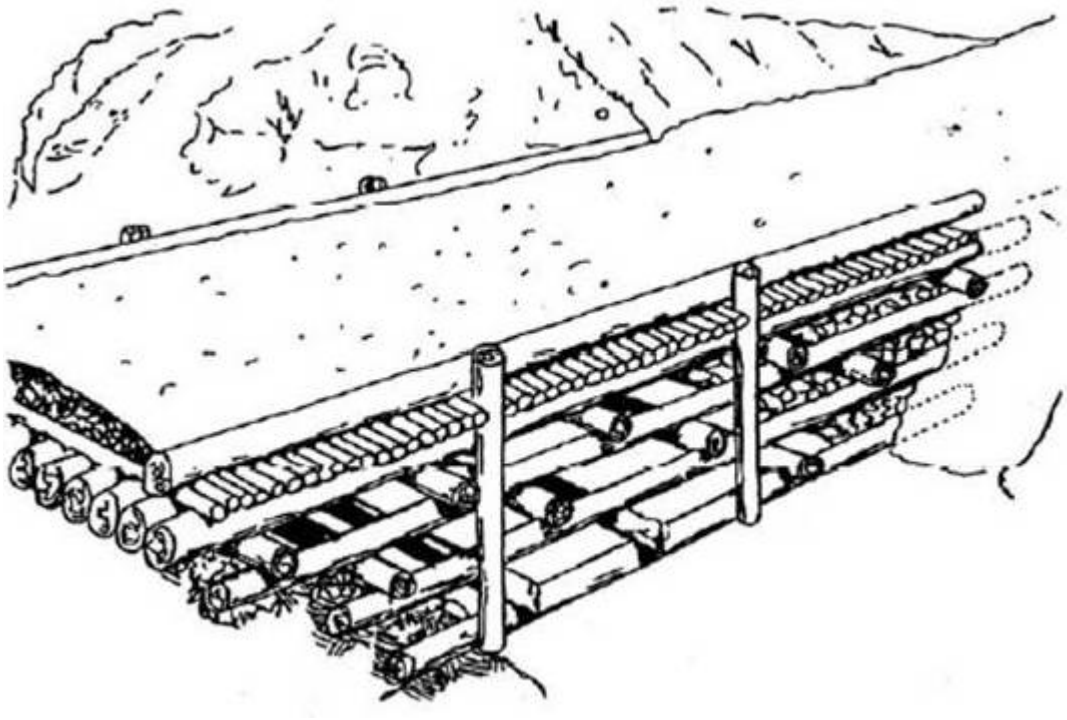


Figure 2–35. Temporary bridging.

616. Constructing a soil-cement road

There are many different kinds of roads used in traveling. They can range from old cart paths to super highways. During contingency operations, superhighways may not always be available to move and transport equipment and materials. You, as a pavements and construction equipment operator, are often called upon to construct temporary roads to provide a smooth supporting surface on which your unit can transport equipment and materials. One method you'll use is the cement stabilization process discussed in the following paragraphs.

Cement stabilization

Soil-cement and cement-treated roads are made of uniformly blended mixtures of soil or coarse aggregates, measured amounts of Portland cement, and water that have been compacted and cured. The content of the cement depends greatly upon the type of soil in the area. Consider other factors such as weather conditions, desired durability, and strength; they may govern the cement content. You can build soil-cement and cement-treated roads quickly with the proper equipment and in dry weather. If possible, restrict construction of a soil-cement road during wet or freezing weather. Generally, a curing period is required, but emergency use during the curing period is possible.

Materials

Cement stabilization requires the use of granular materials or soils that can be thoroughly pulverized. Avoid using soils and aggregates that have a high silt and clay content. Standard Portland cement is usually the stabilizing agent although you can use high early strength cement. As a general rule, a higher content of silt and clay in the soil increases the cement requirement.

Gravelly and sandy soils require less cement content for adequate application than do soils that are high in clay or silt. A well-graded mixture of gravel and sand requires five percent or less cement by weight. Poorly graded one-size sands, such as beach sands or desert blown sands, generally require about nine percent cement by weight.

Water

Water needs to be free from excess amounts of organic matter. As a general rule, any water fit for human consumption is suitable for cement stabilization. The requirements for water vary with the demand of the aggregate cement mixture, moisture contained in the aggregate, and the rate of evaporation during stabilization. In any case, don't allow the mix to become plastic or sloppy wet.

Area preparation

It's important to have a stable subgrade beneath the area to be treated when you're constructing a soil cement road. Remove all unsuitable material and soft areas and replace it with suitable materials. Organic material found in the soil has an unfavorable effect on the soil-cement. For this reason, be sure to avoid using topsoil or soil contaminated with topsoil as a subgrade. Soft areas may be caused by wet material and need to be dug out. When you stabilize the soil, loosen it with a scarifier to a sufficient depth so that when the material is compacted, it produces the required final thickness.

Divide the area to be treated into sections of such size that all necessary work, from adding cement to final finishing, can be completed in one working period. Meanwhile, preparation can proceed on forward sections and curing on compacted sections.

To obtain the required soil-cement proportions, distribute full cement sacks over the area at predetermined transverse and longitudinal spacing. Open the sacks and distribute the cement in rows by hand. Follow this by a light harrowing to give uniform distribution. Now, thoroughly mix the soil and cement by using the same equipment you used to pulverize the soil.

Add water by repeated sprinklings of ½ to one gallon a square yard, and then follow each sprinkling by harrowing or disking to facilitate absorption of the water and to minimize evaporation loss. Be sure moist mixing with cultivators, plows, and rotary tillers starts immediately. The mixing action that takes place in a rotary tiller machine is illustrated in figure 2–36. Meanwhile, bring the water content to, or slightly above, the optimum content. In some cases, you can use traveling plants to perform the operations of dry mixing, adding water, and moist mixing.

Use a sheepsfoot roller to compact the mixed material. Meanwhile, you need to maintain a proper cross section with a motor grader. You must keep the moisture at optimum content during this and succeeding operations.

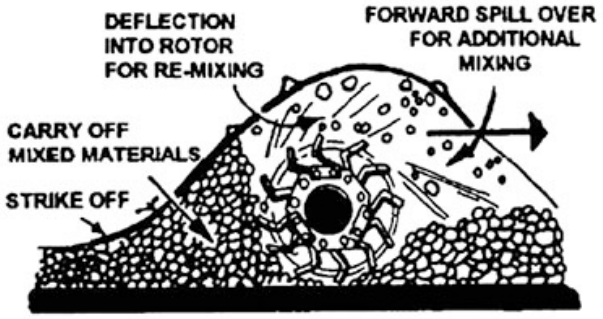


Figure 2–36. Mixing action of rotary tiller.

Do the finishing with a motor grader, rubber-tired roller, and a steel wheel roller. Keep the length of the sections so that compacting and finishing are completed in about six hours after the beginning of the water application. Soil-cement mixtures generally require a curing period between seven and eight days, depending upon the amount of cement used.

617. Constructing a sanitary landfill

A sanitary landfill, often called a garbage dump, is where communities dispose of their rubbish or solid waste. This includes garbage (waste from preparation and serving food), and rubbish (paper, cartons, boxes, and cans, etc.). If you work in the landfill, make sure the rubbish is compacted in thin layers and immediately covered with clean fill material. Covering the rubbish promptly reduces bad odors, rat populations, and litter problems. In this lesson we quickly look at constructing and covering the landfill.

Trench method

In this method, your first step is to locate the trench in an area of stable soil. Otherwise, you may only temporarily cover the waste. Avoid areas of sand dunes or other mobile earth deposits. Also, don't locate sanitary fills near springs or other fresh water supplies. Figure 2–37 shows a typical trench method of landfill operation. Start the construction of the landfill using a dozer to dig a trench into which the waste can be dumped. As the waste is dumped, use the dozer to spread and compact the waste material. Compacting the material increases the amount of rubbish that can be put into the available space.

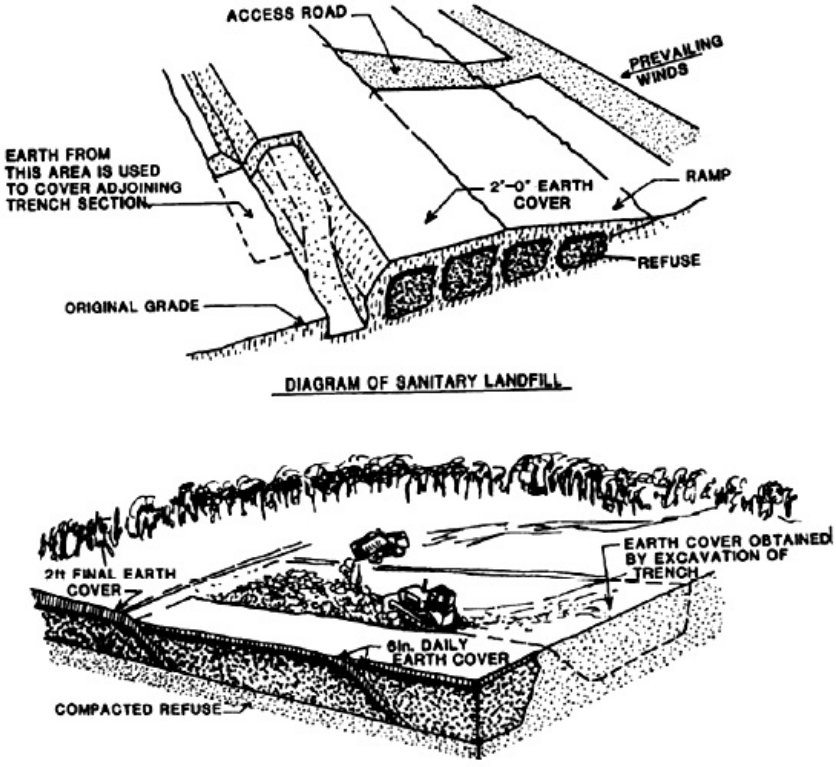


Figure 2–37. Trench method of constructing a sanitary landfill.

Covering fills

At the end of the day, cover the landfill with four to six-inches of earth cover. When the trench is going to be abandoned, cover it with at least two feet of final earth cover and mark its boundaries. As with all landfills, construct the surface with a slight grade to prevent water from ponding on it. Arrange the landfill so it doesn't interfere with other natural drainage during filling and when it is abandoned.

618. How to construct and use berms and dikes

In areas where both ammunition and above ground fuel tanks are stored, construct earth berms or dikes around them. These berms and dikes offer protection to ammunition pads and fuel tanks from enemy fire and for retaining the contents should the fuel tanks rupture.

Ammunition pads

Berms or dikes can provide protection against fragments and eliminate the risk of explosions caused from low-angle, high-speed fragments. Although natural shelters, such as underground facilities, caves, or mines in hillsides, offer the best protection, it isn't always practical to rely on such shelters to provide the protection needed. Instead, earth filled barricades can be used as an effective and expedient means of supplying the necessary protection. Make sure the fill used in constructing these barricades is select fill that is cohesive material that is free from organic matter, trash, debris, and frozen material. If you use any stones, place them in the lower center of the barricade. Don't use stones that are heavier than 10 pounds or larger than 6 inches in diameter. In addition, compact the surface well to allow for structural integrity and to control erosion. The following are considered effective barricades:

- Earth, 20 feet or less in height, having a crest at least 3-feet wide. Don't make the slope more than 2 horizontal to 1 vertical to reduce erosion and ease maintenance. See figure 2–38 for typical earth-filled barricade designs.
- Earth more than 20 feet in height, and at least 5-feet wide at the top, with earth sloping as in example 1 of figure 2–38.
- Earth meeting the requirements of examples 1 or 2 of figure 2–38, and modified by substituting a retaining wall for the slope on one side. The slope and thickness of the retaining wall (preferably of concrete) must ensure a wide enough top so the earth is held firmly in place.

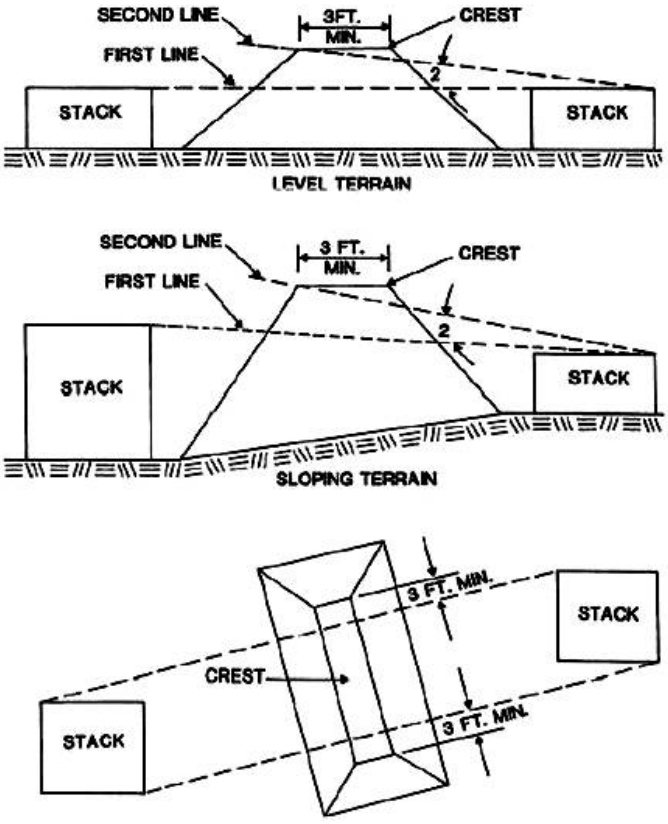


Figure 2–38. Typical earth-filled barricade.

Fuel bladders

Earth berms are normally used to provide containment around collapsible fuel bladders. Use earth fill where possible but place it 100 feet from any paved surface. Construct the berm with a flat top that is at least 2-feet wide and with sloping sides.

Don't slope the sides any steeper than 1 to 1 on both the inside and outside faces of the berm. To help cradle the bladder, add a 1 percent grade from each inside edge of the berm to the center. This keeps the bladder from moving when fuel is added. In addition, do not allow the height of the berm to exceed 6 feet above the interior grade. The construction of the berm depends upon the site conditions and the available materials.

As figure 2–39 illustrates, there are 3 general forms of berm construction. A berm above ground level is the least desirable because it must be made entirely of fill. This means a maximum amount of earth needs to be hauled to the site, which increases time, expense, and manpower. Where conditions permit, you can minimize the time needed to move the material by equating as close as possible the volume of cut to the volume of fill. Be sure the enclosed area has a capacity equal to the entire volume of the bladder plus 1 foot. Bladders are ordinarily individually enclosed, except small bladders (less than 2,500 barrels each) may be enclosed in one area up to a total combined capacity of 10,000 barrels.

FILL ONLY (TYPE I)

FOR USE WHERE:
1. EXCAVATION UNDESIRABLE (WATER, ROCK)
2. LOCAL MATERIALS ARE NOT SUITABLE
3. EXCESS SPOIL IS AVAILABLE

CUT AND FILL (TYPE II)

FOR USE WHERE:
1. SHOULD CONDITIONS PERMIT
2. SHORT HAUL EARTH EQUIPMENT CAN BE EFFECTIVELY USED
3. SPOIL NOT AVAILABLE

BULKHEAD (TYPE III)

FOR USE WHERE:
1. RETAINING WALL MATERIAL IS AVAILABLE
2. BERM MATERIAL IS IN SHORT SUPPLY
3. SPACE SAVING IS DESIRED

Figure 2–39. Types of berms for collapsible bladders.

To ensure the berm and the surface area it encloses are impervious to the stored products and to prevent erosion, you must compact and stabilize the soil. You can use soil-cement, clay, sod, or fabric membranes.

Drainage

Provide a sump in each enclosure. Locate this sump at the lowest point, with the area graded for drainage to the sump. Install a drain pipe from the sump, under the berm and to the outside. Install a lock-type rising stem gate valve in the drain line outside of the berm. This valve is normally kept closed. It's only opened when you need to drain water from inside the berm. Be sure to exercise extreme care when opening this valve. If you don't, you may allow fuel products to enter the natural watercourse, storm drains, or sanitary sewers systems. If the tank leaks or ruptures, the drain valve must remain closed. Flood the basin area with water and pump the fuel from the top of the water into a tank truck for disposal. In the event the fuel should catch fire, you can use the drain to remove fuel from the bottom of the berm to a location away from the fire. This reduces the amount of flammable material left to burn.

Only use the berms for emergency containment areas. Under no circumstances do you purposely drain fuel onto the ground or onto the surface in the bermed area. Figure 2–40 shows some expedient drainage methods that include pipes with valves or a simple drainpipe that can be elevated when drainage isn't desired.

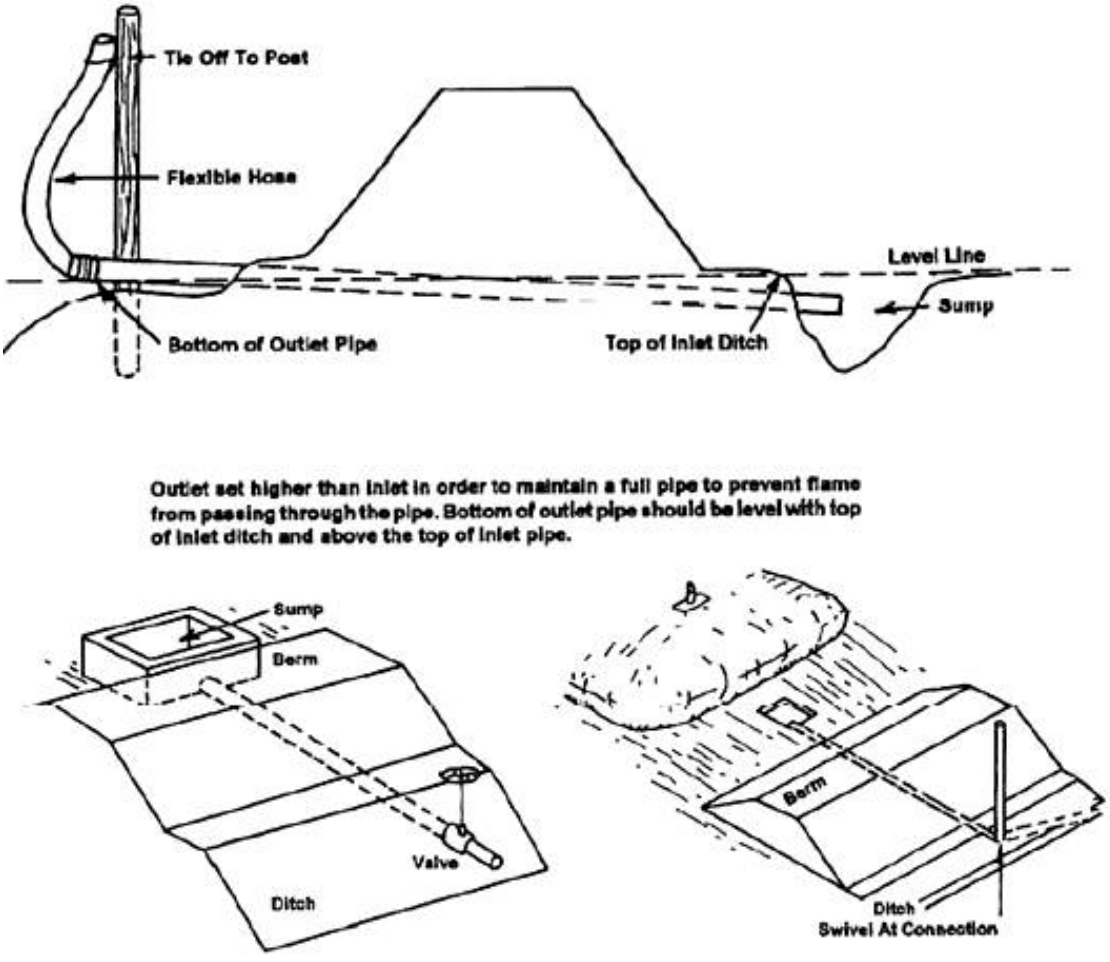


Figure 2–40. Methods of draining rainwater and excess fuel from berm.

619. Wastewater disposal

During contingency or wartime operations, wastewater disposal can be critical to the health and well-being of all personnel. An effective method of accomplishing wastewater disposal is to use wastewater treatment ponds or basins. These are often called lagoons. The pond is usually an earthen structure, consisting of one or more parts or cells that can be operated either in a straight-line or in a side-by-side flow pattern. As you'd expect, there are many important factors to take into account when you're preparing to construct a waste water lagoon. In this lesson we look at positioning lagoons and their physical features. We then look at the characteristics of oxidation and evaporation lagoons.

Lagoon site

You must consider many things when you choose the location of a lagoon. Usually, you locate a lagoon at least ¼ mile from all water supplies and downwind from the population. To prevent flooding, locate the lagoon in an area that won't collect surface runoff and is above flood level. Above all, prevent polluting ground and surface water from entering the lagoon. Repair any flood or erosion damage to the dikes or berms at once to prevent future leaks or damage.

Physical features

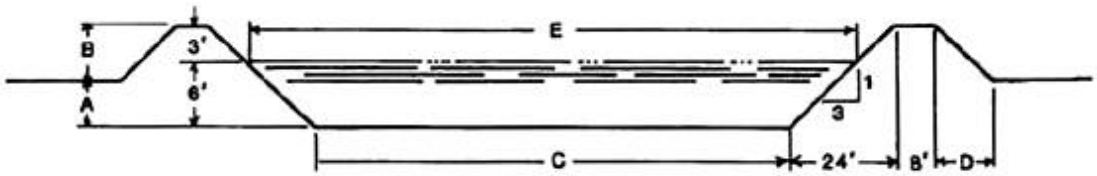
Build the slope of lagoon walls with not less than three units horizontal to one unit vertical. This is recommended for erosion control and ease of maintenance. Make the width at the top of the lagoon wall at least 8-to-10 feet for safety and ease of operating maintenance equipment. After constructing the lagoon, secure the area with a fence and post signs identifying it as a wastewater lagoon. As we said earlier, there are two types of lagoons: oxidation and evaporation.

Oxidation lagoon

An oxidation lagoon is a flat bottom pond enclosed by an earthen dike. Construct the bottom of the lagoon and compact it within impervious materials that won't allow the wastewater to seep out. Plant the lagoon sides with suitable grass directly above the waterline. Build the walls of the berms to allow a liquid depth range of 2-to-5 feet with an additional 3 feet above the liquid. The minimum depth required is 2 feet to prevent growth of rooted aquatic plants. When you construct the lagoon, build in adjustable outlet pipes to extend through the berm to control the water level or "operating depth" of the lagoon. If the soil is porous, it may be necessary for you to seal the berms. You may also need to seal the bottom of the lagoon if the bottom contains a layer of porous rock. Use flexible membranes when sealing is needed.

Evaporation lagoon

In areas where it's impossible to discharge wastewater off base, you have to construct evaporation lagoons. These lagoons don't produce an outflow; instead, waste water sent to the lagoon must either evaporate or seep through the bottom of the pond. Because of the large construction requirements, only use evaporation lagoons as a last resort. Figure 2–41 shows the construction requirements; figure 2–42 shows base populations and corresponding lagoon specifications.



LAGOON DIMENSIONS

LAGOON SIZE	A*	B	C	D	E
107' X 107'	4.50'	3.50'	77'	10.50'	107'
145' X 145"	3.75'	4.25'	115'	12.75'	145'
200" X 200"	3.10'	4.90'	170'	14.70'	200'

* SHOWS DEPTH OF CUT FROM ORIGINAL SURFACE FOR BALANCED CUT AND FILL, ON LEVEL GROUND.

Figure 2–41. Stabilization lagoon construction details.

It's often better to build two basins or one basin with a berm that separates it into two parts. With two basins, one can be kept in service while the other is being restored. Slope the bottoms of the ponds for quick and complete draining. Check the "berms" or dikes often for damage caused by erosion. Mow the berms and surrounding areas often to keep vegetation at a maximum height of 6-to-10 inches. As with the oxidation lagoon, fence the area and post it with signs to show the ponds contain wastewater and are dangerous.

BASE SIZE (POPULATION)	WASTE-WATER (GPD)	LAGOON AREA REQUIRED (FT^2)	NUMBER OF LAGOONS	DIMENSIONS
750	10,500	134,000	9	122' X 122'
1,500	21,000	267,000	9	172' X 172'
2,250	31,500	401,000	9	211' X 211'
3,000	42,000	535,000	9	244' X 244'
3,750	52,500	668,000	9	272' X 272'
4,500	63,000	802,000	9	299' X 299'
5,250	73,500	936,000	9	322' X 322'
6,000	84,000	1,069,000	9	345' X 345'
6,750	94,500	1,203,000	9	366' X 366'
7,500	105,000	1,337,000	9	385' X 385'
8,250	115,500	1,470,000	9	404' X 404'
9,000	126,000	1,604,000	9	422' X 422'
12,000	168,000	2,139,000	9	488' X 488'
15,000	210,000	2,673,000	9	545' X 545'

Figure 2–42. Evaporation lagoon.

Storm water control

Storm water is not as hazardous as waste water, but it is no less important to control. In areas where storm water has no natural course to draw it away from living areas and facilities, such as in flat areas, some sort of water retention area must be constructed. These are sometimes called retention ponds and serve to collect and store excess water that has accumulated after a storm.

Position the ponds in areas where water can be routed easily by constructing ditches or restructuring existing ditches. Construct the pond to accommodate the heaviest rainfall expected for the area. If the purpose of the retention pond is to retain the water for future use (such as watering roads and using in construction) compacting the bottom may be necessary. If the soil drains well, a liner may be necessary. If the purpose of the pond is merely to divert and control runoff, no additional preparation is necessary because the water will absorb into the soil or evaporate over time.

Warning sign placement

No matter what type of berm is built; you must place warning signs around the berm area to inform all personnel of potential hazards. If your unit is deployed to an overseas location, be sure the information on the signs is printed in both English and the host nation's language. Always contact the using organization to ensure signs are made to meet their safety requirements.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

615. Culvert and timber bridge construction

1. What happens if water is permitted to pond on roadways or airfields?

2. What purpose do culverts serve?

3. Explain how to construct a sandbag culvert.

4. Which type of culvert would you construct to prevent heavy water drainage?

5. How can you seal a metal plank culvert to make it water tight?

6. What must you do if a ditch or ravine is too wide to accommodate a culvert?

616. Constructing a soil-cement road

1. Describe the components of a soil-cement and cement-treated road.

2. When constructing a soil-cement and cement-treated road, why do you avoid using soils and aggregates that have a high silt and clay content?

3. What do you do with all unsuitable material when you're preparing soil-cement and cement treated road areas?

4. How do you distribute the cement sacks over the soil-cement and cement-treated road area?

5. What piece of equipment do you use to compact the mixed material for a soil-cement and cement-treated road?

617. Constructing a sanitary landfill

1. Why would you cover a landfill with clean fill material?

2. What would be a benefit of compacting the waste material in a sanitary landfill?

3. Why do you construct the covering for a landfill with a slight grade?

618. How to make and use berms and dikes

1. What protection do berms give to fuel tanks?

2. List materials you would *not* use in constructing berms for ammunition pads.

3. How do you construct fuel bladder berms?

4. On what does the construction of a fuel bladder berm depend?

5. What cautions must you observe when you need to drain water from the inside of a berm? Why?

6. When a fuel tank ruptures, how do you remove the fuel from the basin area?

619. Wastewater disposal

1. How can you construct lagoons to prevent flooding?

2. Why do you make the tops of lagoon walls 8- to 10-feet wide?

3. Describe an oxidation lagoon.

4. What would you do with wastewater if you were in an area where it is impossible to discharge it off base?

5. Why is it better to have two basins instead of one?

Answers to Self-Test Questions

608

1. Tactical aircraft operations conducted over a crushed stone repair.
2. Deploy ability. Also air transportable and can be moved easily by vehicle.
3. Lift the mat slightly off the trailer and have the tractor-trailer drive slowly out from underneath the mat.
4. At the same time the crater crew is repairing the crater
5. By using two part bushings which you then screw together.
6. To eliminate scooping up debris with the joining panels.
7. If the area is sound for anchoring purposes.
8. Allows the mat to be removed and replaced if crater repair maintenance is required.

609

1. Capable of sustaining over 100 combined passes of cargo and fighter aircraft
2. Crater will be measured by the Mat Chief to determine FRP size
3. Mat construction will be done directly over the repair or as close to the repair as possible.
4. The Tri-talon asphalt anchor will be set to a depth of 22.5 inches

610

1. 1½-inches thick, two feet wide, and 12-feet long.
2. Nonskid.
3. Rotating.
4. 250.
5. Starter keylock.
6. Typical keylock.
7. Tiedowns.
8. Flush with the runway surface.
9. Rub rails.

611

1. Grade so that the water drains away from the mat surface.
2. 10.
3. (1) Mechanical.
   (2) Chemical soil stabilization.
4. (1) Irregular grading.
   (2) Poor compaction.
5. Place the pallets on large wooden blocks.

612

1. The second row will be difficult to install.
2. By starting every other row with a half-length mat.
3. Place a block of wood against it and hit the block with a sledge hammer.
4. If the runway is damaged you can unlock the keylocks and remove the damaged portion.
5. Bury the runway ends 18 to 24 inches below ground level.
6. (1) 90-degree connectors.
   (2) Splice plates.

613

1. Assemble base sections in sequence of the base assembly plan included with the kit.
2. Be sure that all red coded bottom arches (without stubs) are on the same side of the shelter.
3. Begin installing the red-coded purlins on one end, and then work towards the opposite end, the last purlins installed are yellow-coded purlins.
4. Continue to work the end panel over the arch and then secure the rope to the *green* cleat.
5. 4-5 inches of overlap.
6. Install guy anchors approximately 36 inches away from the side of the shelter.
7. Mid liner.

8 Cut the patch large enough to extend a minimum of 3 inches on all sides of the damaged area.

9. Use a hand-held heat welder and pressure roller.

614

1. To protect parked aircraft and essential facilities from enemy attacks.
2. Bitburg and concrete chamber soil bins.
3. 2 and 4 meter sizes.
4. Series of baskets formed from hinged wire panels covered with a geo-fabric liner.
5. 2.

615

1. The subgrade will become saturated and will fail under loads.
2. They are designed to allow water to pass under a road, footpath, or embankments
3. Metal planks laid down on the ground, then two sandbag walls are built on either side creating a waterway down the center. Metal planking or AM-2 is placed on top of the sandbags completing the culvert.
4. Log culvert.
5. Use sandbags, burlap sacks, or canvas around the metal planking.
6. You'll be required to construct some type of bridge with the support of structures personnel.

616

1. Uniformly blended mixtures of soil or coarse aggregates, measured amounts of Portland cement, and water that have been compacted and cured.
2. The higher contents of silt or clay in the soil increases the cement requirement.
3. Remove all unsuitable material and replace with suitable.

4. Distribute full cement sacks over the area at predetermined transverse and longitudinal spacing.
5. Sheepsfoot roller.

617

1. Reduces bad odors, rat populations, and litter problems.
2. Increases the amount of rubbish that can be put into the available space.
3. To prevent water from ponding on it, as with all landfills.

618

1. Protection from enemy fire and for retaining the contents should the fuel tanks rupture.
2. Organic matter, trash, debris, and frozen material.
3. Construct the berm with a flat top that is at least 2-feet wide and with sloping sides.
4. Site conditions and the available materials.
5. Exercise extreme care when opening this valve, you may allow fuel products to enter the natural watercourse, storm drains, or sanitary sewers systems.
6. Flood the basin area with water and pump the fuel from the top of the water into a tank truck for disposal.

619

1. Locate the lagoon in an area that won’t collect surface runoff and is above flood levels.
2. For safety and ease of operating maintenance equipment.
3. Flat bottom pond enclosed by an earthen dike.
4. You have to construct evaporation lagoons.
5. With two basins, one can be kept in service while the other is being restored.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

53. (608) When unfolded, what are the dimensions of a single folded fiberglass mat?
    a. 54-foot long by 60-foot wide.
    b. 24-foot long by 30-foot wide.
    c. 30-foot wide by 54-foot long.
    d. 30-foot wide by 24-foot long.

54. (608) Before mats are to be unloaded, whose responsibility is it to ensure the area near the crater is cleared of debris and well swept?
    a. Minimum operating strip (MOS) marking team.
    b. Rapid runway repair (RRR) crater team chief.
    c. Kick-broom operator.
    d. Debris removal team.

55. (608) Joining two folded fiberglass mats together requires the use of a two foot,
    a. 1-inch wide by 24 foot long two-ply panel.
    b. 1¼-inch wide by 30 foot long two-ply panel.
    c. 1-inch wide by 24 foot long single-ply panel.
    d. 1¼-inch wide by 30 foot long single-ply panel.

56. (608) When anchoring the folded fiberglass mat, which side(s) must be secured?
    a. The two 30 foot side of the mat.
    b. The leading and trailing edges.
    c. The leading or trailing edge.
    d. The leading edge only.

57. (608) Because there are no ramps available with the folded fiberglass matting, they must be fabricated using
    a. sand and polyurethane mix.
    b. sand and polymer mix.
    c. mortar and sand mix.
    d. cold mix asphalt.

58. (608) A horizontal gap of 1 inch between the edges of the folded fiberglass mat and the ramp is required to allow for
    a. drainage.
    b. mat expansion.
    c. absorption of shock.
    d. mat removal or replacement.

59. (609) The idea behind the fiber reinforced polymer panels is to create
    a. a more durable longer lasting foreign object damage (FOD) cover.
    b. a lighter, more easily transportable FOD cover.
    c. a FOD cover capable of supporting larger aircraft.
    d. a FOD cover specific to the size of individual repairs.

60. (609) If the fiber reinforced polymer (FPR) panels were not constructed directly over top of the crater, who assists with placing the foreign object damage (FOD) cover directly over the repair?
    a. Excavator.
    b. Mat assembly team.
    c. Telescopic-boom forklift.
    d. FRP cover team.

61. (609) Whose responsibility is it to measure crater dimensions to determine the fiber reinforced polymer (FRP) panel size while the crater is being prepped?
    a. Mat Chief.
    b. Crater Chief.
    c. FRP cover team.
    d. Upheaval removal team.

62. (610) How many rows will one standard pallet of AM–2 mats cover if the runway width is 72 feet?
    a. 1.
    b. 2.
    c. 3.
    d. 4.

63. (610) Which item allows two AM–2 mat laying teams to start work in the middle of a runway and work in opposite directions towards the end of the runway?
    a. Typical key-lock.
    b. Starter key-lock.
    c. Towing tube.
    d. Starter tube.

64. (610) The centerline lights are used for a nighttime operation in an AM–2 mat package. How many feet apart are these light installed?
    a. 50.
    b. 75.
    c. 100.
    d. 150.

65. (611) Soil material supporting AM–2 matting *must* have a California bearing ratio (CBR) rating of at *least*
    a. 6.
    b. 8.
    c. 10.
    d. 15.

66. (611) You are spotting AM–2 mat pallets around a mat laying area. To do this properly, you should place them in the center of the runway at
    a. 2-foot intervals.
    b. 4-foot intervals.
    c. 6-foot intervals.
    d. 10-foot intervals.

67. (612) When you install the required number of mats for the desired runway width, you should check the alignment of AM–2 matting after
    a. laying each mat.
    b. laying each row.
    c. installing the key-locks.
    d. installing the locking bars.

68. (612) Why are AM–2 mats made to fit together with a loose fit?
    a. Prevents buckling.
    b. Prevents misalignment.
    c. Allows for drainage to the base course and subgrade.
    d. Allows for expansion of the base course and subgrade.

69. (612) When placing AM–2 matting, install typical key-locks at intervals of how many feet?
    a. 50.
    b. 100.
    c. 150.
    d. 200.

70. (612) When anchoring AM–2 matting, make the anchor ditch
    a. 24 to 48 inches deep and cut it at a 30°to 45°angle.
    b. 48 to 60 inches deep and cut it at a 45°to 60 °angle.
    c. 18 to 24 inches deep and cut it at a 45°to 60°angle.
    d. 18 to 24 inches deep and cut it at a 15°to 30°angle.

71. (612) What is the *first* step in *disassembling* an AM–2 mat runway?
    a. Cut all splice plates.
    b. Remove the locking bars.
    c. Remove the starter key-locks.
    d. Remove backfill from the apron.

72. (613) The Small Shelter System Tent can withstand steady wind loads of
    a. 30 knots.
    b. 40 knots.
    c. 50 knots.
    d. 60 knots.

73. (613) When selecting a site for the Small Shelter System (SSS), how large *must* the area be?
    a. 32.5 x 20 feet.
    b. 32.5 x 40 feet.
    c. 30 x 40 feet.
    d. 30 x 20 feet.

74. (613) How many types of liners does the Small Shelter System (SSS) tent use?
    a. 2.
    b. 3.
    c. 4.
    d. 5.

75. (613) The environmental control unit should be approximately how many inches away from the Small Shelter System (SSS) tent end wall?
    a. 12.
    b. 15.
    c. 24.
    d. 30.

76. (613) When the shelter is placed in storage for a lengthy period, inspect it at
    a. twelve month intervals.
    b. three month intervals.
    c. four month intervals.
    d. six month intervals.

77. (613) Inspect the Small Shelter System (SSS) tent electrical cable assemblies every
    a. 10 days.
    b. 20 days.
    c. 30 days.
    d. 60 days.

78. (614) The purpose of revetments are to
    a. protect parked aircraft and essential facilities.
    b. construct contingency water storage tanks.
    c. store unneeded fill material.
    d. serve as attack decoys.

79. (614) What two types of pre-cast concrete revetments the Air Force is using to replace the A1 and B1 metal revetments?
    a. ARMCO and barrels.
    b. Bitburg and ARMCO.
    c. Concrete bins and barrel.
    d. Bitburg and concrete chamber soil bins.

80. (614) What is the *minimum* amount of people required to erect an expandable bin revetment?
    a. 1.
    b. 2.
    c. 3.
    d. 4.

81. (614) While providing the same amount of protection as the old B–1 metal revetments, which is a major advantage the expandable type has over it?
    a. Reduced shipping weight.
    b. Increased ballistic protection.
    c. Decreased area preparation required.
    d. Decreased height of finished revetment.

82. (614) Expandable bin revetment sections are connected together using
    a. rebars.
    b. zip strips.
    c. angle irons.
    d. connecting pins.

83. (615) When building a metal plank culvert for more permanent construction, why do you place sandbags, burlap sacks, or canvas around a metal planking culvert?
    a. Reduce voids around the culvert.
    b. Give more strength to the culvert.
    c. Keep debris from falling into the culvert.
    d. Give the culvert a better watertight seal.

84. (615) If you are preparing to construct a timber bridge, what is your *most* important consideration?
    a. To determine if the bridge is a temporary or a permanent type of construction.
    b. Make sure the bridge is constructed so that it will withstand heavy loads.
    c. Make sure the bridge is constructed according to its projected use.
    d. Decide where the bridge is to be located.

85. (616) If at all possible, constructing a soil-cement road should be *restricted* during
    a. peace time.
    b. dry periods.
    c. the nighttime.
    d. wet or freezing weather.

86. (617) At the *least*, how many feet of final earth cover should you use when abandoning a sanitary landfill trench?
    a. 1.
    b. 2.
    c. 3.
    d. 4.

87. (618) Where do you place stones that weigh *less than* 10 pounds when you are constructing berms or dikes?
    a. Top of the barricade.
    b. Lower center of the barricade.
    c. Lower outside of the barricade.
    d. Stones under 10 pounds should never be used.

88. (618) Which fuel bladder berm is the *least* desirable?
    a. Above ground level.
    b. Below ground level.
    c. Partially excavated berm.
    d. One constructed with a flat top.

89. (618) In the event fuel should catch fire in a berm, what can you do to reduce the amount of flammable material left to burn?
    a. Dump sand into the berm.
    b. Flood the berm with water.
    c. Pump the fuel out into nearby fuel truck.
    d. Open the drain to remove fuel from the bottom.

90. (619) What can be constructed to collect and store storm water runoff?
    a. Aqueducts.
    b. Storm drains.
    c. Water towers.
    d. Retention ponds.

Students Notes

Glossary of Abbreviations and Acronyms

ADR	airfield damage repair
ADR/OIC	airfield damage repair/officer in charge
AFCEC	Air Force Civil Engineering Center
AFCENT	Air Forces Central
AFOG	Air Force Operations Group
AFPAM	Air Force pamphlet
ANG	Air National Guard
AOR	area of responsibility
BCE	base civil engineer
BEAR	basic expeditionary airfield resources
BEEF	Prime Base Engineering Emergency Force
CAT	contingency action team
C/JTF	combined joint task force
CBR	California bearing ratio
CDF	cargo deployment function
CE	civil engineer
CEDCC	civil engineering damage control center
CONOPS	contingency operations
CONPLAN	contingency plans
CPM	crater profile measurement
CRG	contingency response group
CSAF	Chief of Staff of the Air Force
CTK	consolidated tool kit
CTL	compact-track loader
DCC	deployment control center
DOD	Department of Defense
EALS	emergency airfield lighting system
ECU	environmental control unit
EM	emergency management
EOD	explosive ordinance disposal
EOR	explosive ordinance removal
ETL	engineering technical letter
FDM	force development manager
FFM	folded fiberglass mat

FOD	foreign object damage
FOLs	forward operating locations
FRP	Fiber Reinforced Polymer
ft.-lbs.	feet-pounds
GeoExPT	Geospatial Expeditionary Planning Tool
GPS	Global Positioning System
hp	horse power
HVAC	heating, ventilation, and air conditioning
HVAC/R	heating, ventilation, air conditioning and refrigeration
IAW	in accordance with
IOC	initial operating capability
kW	kilowatt
lb.	pound
MAAS	Mobile Aircraft Arresting System
MAJCOM	major command
MAOS	minimum airfield operating surface
MOS	minimum operating strip
MRAP	Mine-Resistant Ambush Protected
MURS	Multiple UXO Removal System
NAVAIDS	navigational aids
NCOIC	noncommissioned officer in charge
OIC	officer in charge
P&E	pavements and equipment
PAR	post-attack reconnaissance
PB	Prime BEEF
PCC	Portland cement concrete
Prime BEEF	Prime Base Engineer Emergency Force
RADAS	Rapid Airfield Damage Assessment System
RADBO	Recovery of Airfield Denied by Ordinance
RADR	Rapid Airfield Damage Repair
REDHORSE	Rapid Engineer Deployable Heavy Operational Repair Squadron Engineer
RQC	repair quality criteria
RRR	rapid runway repair
SECDEF	Secretary of Defense
SSS	Small Shelter System
SuPR	sustainment pavement repair

TO	technical order
UCC	Unit Control Center
UFC	Unified Facilities Criteria
UTC	unit type code
UXO	unexploded ordnance
WRM	war reserve material

Student Notes

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AFSC 3E251
3E251 04 1701
Edit Code 02