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Structural Journeyman

Volume 1. AFSC Specific Contingency

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CDC D3E351, *Structural Journeyman*, is the first of two courses that you will complete to gain the required knowledge of a structural journeyman. This course contains five volumes that lay the foundation for the other courses. When you complete this course, you will have gained the knowledge you need to perform duties and progress in this career field. When you master this course and combine this knowledge with practical experience you get from working in the shop, you can earn success, prestige, and promotions.

This volume explains some of the specific contingency responsibilities for our AFSC. Unit 1 guides you through contingency response planning, damage assessment and expedient repair methods. Unit 2 focuses on expedient field construction techniques for shelters and field latrines. Unit 3 explains your role in airfield damage repair, airfield paint striping, revetments and hardened aircraft shelter doors.

A glossary is included for your use.

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NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings, numbers, and page location. 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.

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Unit 1. Expedient Methods

THIS UNIT COVERS tasks that you do to support the Air Force mission during a contingency, wartime operation, natural disaster, or man-made disaster. In the first topic, we discuss the contingency response planning. In the subsequent topics, we talk about damage assessment and some types of expedient methods that you can use to repair or strengthen damaged facilities.

1–1. Contingency Response Planning Damage Assessment and Expedient Repair Methods

We must know how to return a base to operational status after a disaster or enemy attack—quickly. Our plan is part of the base civil engineer's (BCE) contingency response plan that is explained in Air Force Instruction (AFI) 10–211, *Civil Engineer Contingency Response Planning*. First making damage assessments and then making expedient repairs accomplishes this mission. The assessments are organized so that expedient repairs focus on restoring base areas that are mission essential. By reading the first lesson, you gain an understanding on what is involved to develop a plan for mission success. In addition, civil engineer (CE) must quickly restore the base to an operational status after a contingency, such as a disaster or enemy attack. The repairs made are usually limited to shoring weakened buildings, fixing breaks in utility lines, eliminating live electrical wires, rerouting utility lines above ground, and quick-fixing roofs, walls, and floors. These repairs require trained people. Additionally, we explain how damaged areas (airfields and facilities) are coordinated for assessment and repairs as well as discuss structural shoring and bracing concepts.

001. Contingency response planning

The BCE establishes a CE contingency response plan (response to unforeseen circumstances) to restore operations, save lives, reduce human suffering, and minimize further damage. However, an unforeseen circumstance could be a disaster or enemy attack that happens on or near the base. In this lesson, we look at how the contingency response plans affect expedient repairs through effective command and control.

Overview

In 2004, the Air Force formally adopted the National Incident Management System (NIMS) according to the presidential directive for a single integrated disaster system. The NIMS concept and organizational and/or command structure are used to respond to major accidents, natural disasters and other peacetime contingencies that go beyond the normal scope of the full-time emergency response agencies. The Air Force developed the Air Force Incident Management System (AFIMS) to ensure compliance with federal guidance while forging the civilian policies with military capabilities. Some of the changes seen at the installation level were name changes to the Disaster Response Force C2 structure; most noticeably the changes were:

- Wing operations center (WOC) changed to crisis action team (CAT).
- Survival recovery center (SRC) changed to emergency operations center (EOC).

Command and control

The command and control function is where the decisions are made to restore base operations. When the base responds to a disaster or enemy attack, the contingency response plan is put into action. The

command and control functions that you need to understand are the CAT, EOC, and the unit control center (UCC).

CAT

The wing commander runs the CAT. The CAT is responsible for controlling all activities allowing the wing to support taskings from higher headquarters. Such activities include sortie generation, aircraft maintenance, base defense, base recovery, and so forth. Since the CAT may be saturated with operational tasks and/or requirements, the EOC is established as a command and control element to direct and monitor pre-attack survival actions and post-attack recovery.

EOC

The EOC is usually located near the CAT battle staff area to allow close coordination of the recovery effort and to permit the battle staff easy viewing of the EOC displays. It receives mission requirements from the CAT and is directed by the support group commander. It, in turn, provides recovery guidance to lower level organizations—usually through their control centers.

The EOC directs all base operability, survivability, and recovery operations. The staff form the nerve center for base recovery as they collect, analyze, prioritize, display, and report information on base status. The EOC is the focal point for determining and tracking base damage and repair efforts. The CE UCC is one of several control centers that supports the EOC.

The BCE usually controls CE responses from either on-scene or the EOC depending upon the situation. Most likely, the BCE is located wherever the support group commander is located. When in the EOC, the BCE has a small staff from the readiness flight to help run the CE operations within the EOC facility.

CE UCC

CE's UCC is the command center that controls CE's base recovery efforts to repair facilities during a contingency such as a disaster or enemy attack. (**NOTE:** In this CDC, we refer to "CE's UCC" as the "UCC.") The UCC directs CE's damage assessment and repair teams and must stay updated on damage assessments and repairs. They are aware of each team location and status and what is being done or used for recovery, such as labor hours, people needed, equipment needed, and materials used. The UCC maintains communication with these teams and the EOC to assure that what is being done is the most effective way to restore base operations. The CE chief of operations commands the UCC with a staff that is predominantly staffed by senior enlisted personnel from the CE organization.

Repair priorities

The UCC uses the CE contingency response plan that shows facility repair priorities before a disaster or enemy attack occurs. This plan saves time and helps keep operations running in a priority sequence. The preparations include knowing how mission critical a facility or area is so that a repair priority can be made. The aircraft runway and command and control facilities have the highest priority for expedient repairs because they are critical to the base mission. Other facilities that support the base mission are rated and repaired in priority to the mission. The typical base has many facilities that may need repair. Let's take a look at some base areas and facilities to understand what their mission is and what CE must do to restore operation.

Navigational aids and/or runway lighting

If your base has a flying mission, the navigational aids and runway lights are vital to aircraft launching and landing. The people in the CE squadron must restore electrical power, mechanical systems, and make structural repairs to restore them to an operational condition.

Command post and/or command and control facilities

The various command and control facilities coordinate air base flying and non-flying activities and are essential for effective operation following a disaster or enemy attack. The CE support includes

structural and utility repairs, as well as continued expedient maintenance to ensure that these critical facilities remain in operation.

Communications facilities

We must have reliable communications to coordinate rescue and recovery efforts following a disaster and to manage combat resources effectively after an enemy attack. In either case, CE's function is to provide utility and structural repairs on communications facilities and to assist the communications repair crews.

Petroleum, oils, and lubricants and/or munitions facilities

We need petroleum, oils, and lubricants (POL) for aircraft and ground vehicles during any emergency. Fuel specialists generally make repairs to these facilities, but CE people may need to assist depending on the situation. After an enemy attack, munitions facility repair is critical to support future combat operations. If these facilities are damaged during a disaster, repairs can probably be delayed unless they're absolutely essential to the base mission.

Fire station

Most disasters or enemy attacks are likely to leave conditions that contribute to fires or where people need rescue. During any emergency, fire department personnel must be able to fight these fires and rescue people. Without a fire station, coordinating and performing these efforts become very difficult. The need to keep the fire station operational is important for rescuing people and restoring the base to operational status.

Medical facilities

Medical facilities are needed to give immediate medical attention to people that may have life-threatening injuries received after a disaster or enemy attack. It's easy to see why medical facilities have a high priority in contingency repairs.

Flexibility in priority assignment

Even though a facility has a high priority for repair, the situation may dictate when the repair is made. We must have flexible priority listing, considering the variations possible, from various stateside or overseas locations to different disasters or enemy attacks. You should look at these priorities as only a general guide.

002. Damage assessment

Before any repairs are made, we must know what has been damaged, how bad the damage is, and what it takes to make an expedient repair. In a contingency, you may be assigned to a team that has a specific role in assessing damage. Let's take a look at how these teams function.

Damage assessment and/or repair teams

When CE's UCC is activated, the damage assessment teams (DAT) assemble in their staging areas where their team leader reports their status. Communication is vital to command and control. The communication is primarily maintained with two-way radios; other methods include the telephone and messengers. The DATs assess damage and can make expedient repairs to recover the base during a contingency. The CE workforce (military and civilian) is organized into a number of large teams, such as damage assessment and response team (DART); airfield damage assessment team (ADAT); structural repair teams; airfield damage repair (ADR); and minimum airfield operating strip (MAOS) selection team.

Damage assessment and response team

Ideally, this team is led by an officer with an Air Force specialty code (AFSC) of 32E3 civil engineer, and composed of one each from AFSC 3E1X1 HVAC/R, AFSC 3E4X1 utilities, and AFSC 3E0X1 electrical. However, many bases use one member from AFSC 3E3X1 structural, and no officers. It

may also include other CE career fields and civilians. After an attack or disaster, the team runs a predetermined route to assess damage and to make repair estimates (time, labor, materials, and equipment). In many cases, the team is the first group to arrive in a hazardous area and must stay alert to protect themselves. The life-threatening hazards that may be found along their route or a facility include unexploded ordnance (UXO), chemical agents, ruptured gas lines, and down or broken electrical power lines. After the team identifies a hazard, they must quickly report it to the UCC.

When the team arrives at a facility, they must look for hazards before entering and ensure that the building or area is structurally sound. If it is in danger of collapsing, they must not enter it but report it immediately to the UCC. This report lets the UCC know what the status is and allows them to coordinate the most effective way to isolate the danger.

The team surveys damaged facilities and utilities to determine repair requirements or demolition. These determinations include estimates of time, manpower, and equipment necessary to complete repairs. As the team makes their assessment, it is recorded and immediately radioed back to the UCC for plotting, repair prioritization, and repair team selection. The UCC then reports the information to the EOC.

The DARTs also have tools and materials ready to make expedient repairs and to isolate utilities when directed by the UCC. Normally, the UCC keeps the DARTs on their predetermined routes until all damage assessment has been completed before directing them to other tasks.

NOTE: The DART classifies, records, and marks the location of any UXO and safes any damaged utilities within its capability.

Structural repair teams

These people are responsible for rescue assistance, wrecking, shoring, repair and restoration of damaged facilities, mechanical and POL system isolation, debris clearing, and construction of temporary facilities. The numbers of teams formed and their configuration is a local decision based on installation characteristics.

Airfield damage repair

ADR is a primary wartime mission for CE. It is a complex and difficult operation, which you may be a part. ADR requires total commitment from everyone involved in order to succeed. We start our discussion with a look at the different ADR teams and the work that they do.

ADR teams

The ADR mission is organized into teams that identify their function such as mat, crater repair, airfield lighting, or mobile aircraft arresting system (MAAS). Each of these teams has a specific job in restoring the runway to operational status. This work includes assessing damage and repairing the airfield, taxiways, airfield lighting, and arresting systems so that aircraft can take off and land.

Damage assessment team

Before repairs are made, a damage assessment must be done first. This task is done by the DAT or often called ADAT. This team normally consists of one member from AFSC 3E8X1 explosive ordnance disposal (EOD), AFSC 3E5X1 engineering assistant, and one or more augmentees to assist in assessing airfield damage and reporting it to the EOC. Each base determines the exact number of teams required. However, three teams are usually needed. The teams work together to locate and identify UXO and airfield damage. Regardless of the team member’s rank or position, the EOD person is responsible for the team’s movement when a UXO is involved. Generally, the engineering assistant’s job is to identify spalls, craters, and other information necessary for developing the MAOS. The ADAT is controlled by the EOC. In the event of communication failure between the EOC and damage assessment teams, the UCC may be required to control the damage assessment teams and should have all necessary equipment to determine the MAOS.

MAOS selection team

The primary MAOS selection team works in the EOC while a backup is maintained in an alternate EOC. Some bases also have MAOS selection teams in both primary and alternate UCCs. Normally, a MAOS selection team is comprised of at least two members—one, an engineer assistant (3E5X1) to do the data plotting, and the other is a CE member that serves as a radio operator and data recorder. The BCE normally oversees the MAOS selection process and recommends possible MAOS locations to the commander.

Airfield damage repair coordination

Once the MAOS has been plotted, repairs can be made. The EOC has the authority to determine what repairs are needed and in what priority. The EOC then forwards their decision to the UCC along with a clear route to the airfield entry control point (ECP). The UCC then dispatches and controls the ADR teams. The ADR team chief keeps the UCC aware of work progress and any conditions that affect repairs. In turn, the UCC reports repair status to the EOC.

Damage assessment techniques

Current base recovery after attack (BRAAT) planning for DART operations has two phases of activity—initial reconnaissance (phase I) and detailed damage assessment (phase II).

Phase I

In Phase I, an initial gross assessment of the base is made to quickly locate areas of UXO and major facility and utility damage. The results of this preliminary survey are used to update the preplanned DART damage assessment routes and obtain a general idea of overall base damage.

Phase II

In detailed damage assessment, the DARTs follow UCC-directed travel routes from their shelter locations to various critical facilities and utilities throughout the installation. The DARTs report the level of damage along these routes including the pre-determined facilities. Detailed damage assessment requires more accurate location and description of problems than initial reconnaissance since these reports form the basis of repair crew sizing, material and vehicle allocation, damage repair cost estimates, and to some degree, prioritization of efforts.

003. Structural shoring and bracing

Once debris has been removed and safe access is assured, your first concern in structural repairs should be shoring any weakened areas to restore a minimum degree of structural integrity to the facility. In wartime or immediately after a natural disaster, there is not time to make a detailed engineering analysis on structural soundness. Instead, rely on field experience, facility appearance, common sense, and instinct. In this lesson, we discuss some of the shoring and bracing methods available.

Types of shoring and bracing

There are many ways to shore and brace a structure. Most use relatively common engineering materials that should be available on base or from off-base vendors. Methods include guying, bracing, jacking, splinting, tension ties, and welding.

NOTE: Shoring is for temporary use; whereas, bracing is for either temporary or permanent use.

Guying

Guys are usually fashioned out of wire rope and tensioned with turnbuckles (if available). You often see power poles and tall antennas stabilized with guy wires. Guys are normally installed to function in opposing pairs (fig. 1–1) to provide lateral restraint from such forces as wind or ice loading. They are particularly effective when damage has been sustained to end or sidewalls; yet, roof members have

been essentially untouched. Depending upon the situation, they can be installed either inside or outside of a facility.

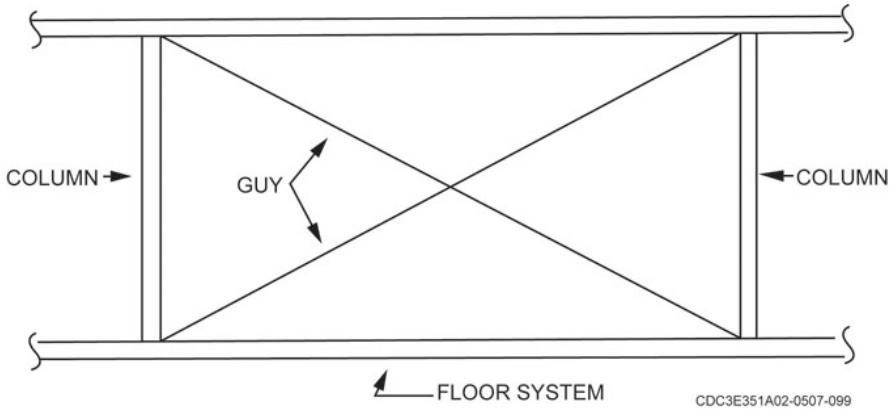

Figure 1–1. Guy configuration.

Wire rope guys are commonly attached with wire rope clips. A properly installed clip develops up to 80 percent of the rope strength. The size of the wire rope dictates the number of clips used and their spacing. A good rule of thumb is to use a minimum of three clips spaced about 3¾ inches for ½- or ⅝-inch rope and four clips spaced 4½ inches ¾- or ⅞-inch rope. This prevents the rope from kinking and fraying due to friction.

Figure 1–2 shows a typical guy wire connection on a structure. The wire rope is attached to a turnbuckle, which, in turn, is attached to the building. Note the use of a 2- by 4- as a brace to prevent the guy wire from twisting as the turnbuckle is tightened. If an external guy is used, one end of the guy must be connected to a solid, immovable object, commonly referred to as a "deadman." The deadman can be a nearby foundation, another part of the structure to be guyed, screw-anchors similar to what linemen use for pole guying, or even a piece of unserviceable equipment, providing it is heavy enough.

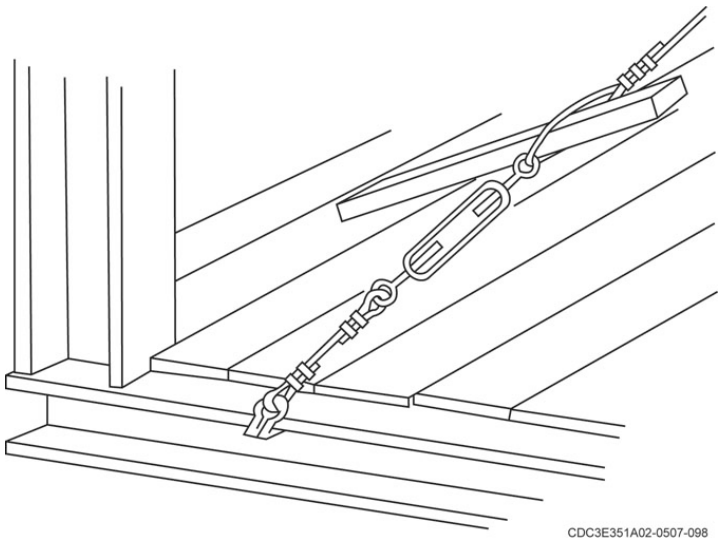

Figure 1–2. Guy wire connection.

When tightening the guys, be sure that you tighten them in pairs, concurrently. This helps avoid placing too much stress on the structure's frame at any particular point. You need to take caution against over-tightening. Your main concern is to take all the sag out of the wire ropes.

Bracing

Braces are usually made of structural steel and heavy timbers (fig. 1–3). Like guys, they can be installed either internally or externally. Sometimes they are placed in opposite pairs; other times they are used individually. When installing bracing on a facility, you must make sure that it is connected to the structure properly. If the bracing is not well attached, it could slide out of position resulting in further damages. Footings for bracing have the same problem. They must be strong enough to resist the force applied. You cannot just shove the brace into the ground and expect it to hold. In most cases, you have to install braces in pairs.

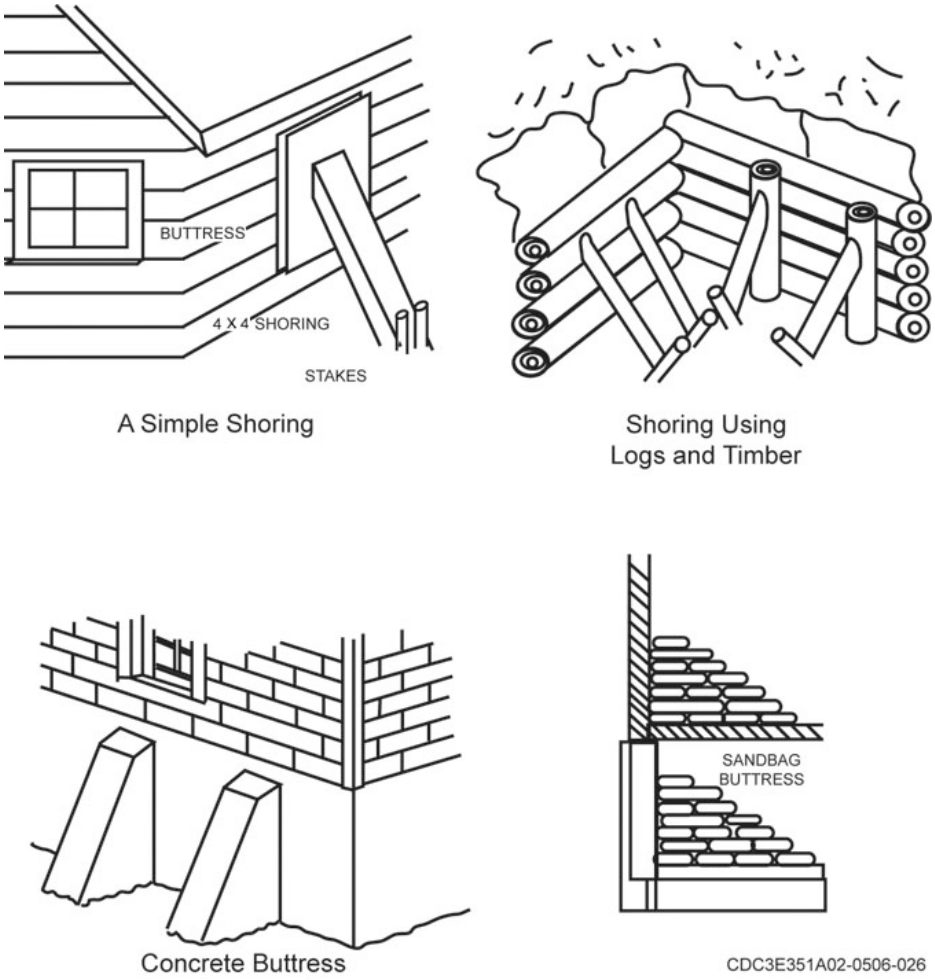

Figure 1–3. Typical brace configuration

Jacking

Guying and bracing are usually used to stabilize a facility from lateral movement (keeping a building from moving side to side). Jacking, on the other hand, is used to stabilize the structural integrity of a facility affected by vertical loads (the effects of gravity). In such situations, you often see deflected or cracked beams or girders needing vertical support, or damaged columns that may eventually need replacement.

Place shoring jacks immediately under the point of deflection or next to the damaged column and extend them until they are firmly wedged into position. You should remove any debris around the base of the jacks so that the jacks are squarely on the floor. Once the jacks are in position, you should brace them to keep them in place.

In most cases, shoring jacks are in short supply and too valuable to leave in place. An alternative to leaving the jacks in place is using timbers as supporting members. The seven steps below for installing timbers are similar to using jacks.

1. Clear the debris away from the work area.
2. Place a shoring jack immediately next to the location where the timber is placed.
3. Raise the jack until its capacity is reached or it can no longer be extended.
4. Measure the distance from the top of the jack to the floor (base) and cut the timber ½ inch shorter than this measurement.
5. Raise the cut timber into position and drive several wedges into the ½-inch gap between the top of the timber and the damaged beam to secure the timber into position.
6. Lower and remove the shoring jack.
7. Brace the timber in two directions with nails and 2- by 4- stock.

Splinting

Another method of providing basic structural integrity involves the splinting of columns, particularly the reinforced concrete type that have not been seriously damaged, yet show signs of cracking or minor fracture.

One technique is *sandwiching* the damaged column between two steel plates (splints) and secured with threaded rods. The plates should have slotted holes in them so they can be fitted to various sized columns. In this repair, splints are placed around a cracked column at the location of the crack(s) to provide a lateral restraint to keep the column from slipping along the crack's face. You can use multiple splints if cracks are at several locations on the column. This method is preferred over column replacement when a damaged column is still capable of carrying a significant load, because it requires less manpower and is a faster repair. However, if a column is severely damaged (near the point of collapse), column replacement using jacks or timber supports should be used.

A second splinting technique involves placing angle iron at the corners of a damaged column and connecting the angles with steel straps. Steel plates should be provided at the ends of the angles to avoid load-bearing problems at the bottom of the column where it is attached to the slab.

Tension ties

Some facilities at overseas locations are constructed of all reinforced concrete. In most cases, slabs and beams are formed, reinforced, and poured as a single unit. After an attack or natural disaster, you may find that some of the slabs and beams may have developed minor cracking. Tension ties provide compressive force to help prevent further cracking. For slab repair, you can anchor a threaded rod to the beams on both sides of the cracked area. For beams, you can bolt anchor plates to the beam on both sides of the crack and place a threaded rod parallel to the beam to connect the two anchor plates. As you tighten the nuts on the threaded rod, it induces a compressive force restricting further cracking.

Another method of restoring some structural integrity to a cracked concrete slab is with *stitching dogs*. These dogs are steel bars, normally rebar, formed into a U-shape and placed over the crack sort of like staples (fig. 1–4). The dogs should be of random length and variably spaced along the crack. The holes the dogs are inserted into must be well grouted to ensure a tight fit.

Welding

This method entails welding steel sections back into place to restore the steel framework's stability. Efforts in this area are usually limited to repairing a relatively small section of a facility. To attempt more than this as an expedient repair quickly adds up to too much time and effort.

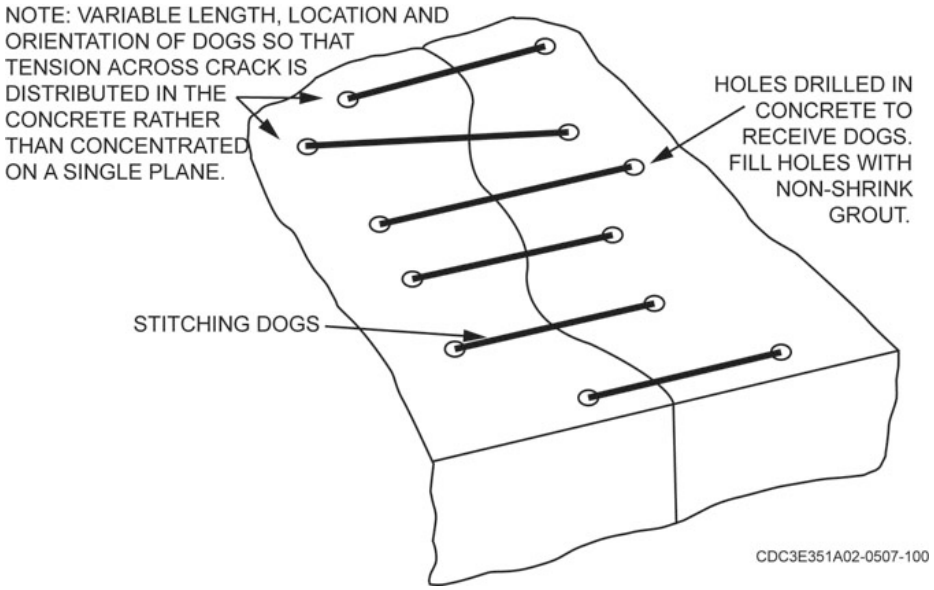

Figure 1–4. Stitching dogs.

004. Quick-fix techniques

After damage has been assessed, you may be on a team that makes expedient structural repairs. These repairs along with restoring utilities such as electricity must be done quickly so people can do their work in a safe building. The structural damage that you may repair can range from minor to extensive. A tornado or enemy attack may demolish numerous buildings or heavily damage others. An earthquake could collapse a structure or only crack the plaster in a few rooms. In any case, the major emphasis is on a quick repair that restores operations a more permanent repair can be made later. This lesson explains the considerations that you use in making an expedient structural repair.

Safety

Safety is important in any repair, but it's especially important in expedient structural repairs after a disaster or enemy attack. Many times, people become preoccupied or fatigued under these conditions and can easily be involved in an accident. You must always be aware of your surroundings and know how to find, identify, and report hazards. You may be on an assessment or repair team where you could be subject to downed electrical wires that are live; ruptured gas lines with explosive vapors; chemical, biological, or nuclear agents; a UXO; or a structure that might be ready to collapse at any time. Never enter a facility unless you're certain that it is structurally sound. After determining the facility is safe, you can enter the facility to make your assessment or repair. Use caution as you make your assessment or plan your repair. You must make sure that you know the safe and proper methods for expedient repairs to avoid becoming or causing an injury that reduces the base's ability to restore operations.

Shoring and bracing

After a disaster or enemy attack, you may find a facility that has damaged load-bearing structural members. Before you start making any expedient repairs, your first consideration is to restore enough structural integrity to keep the facility from collapsing. (**NOTE:** We discussed structural shoring and bracing concepts in the previous lesson.)

Expedient repair methods

The goal of expedient structural repair is to restore a facility to a safe condition with a degree of weather protection for occupants. When the base is operating under emergency conditions, people must make allowances for reduced comfort levels. For example, it would waste valuable time and

critical resources for you to repair a facility's air-conditioning ductwork if it is not mission essential. (**NOTE:** The remainder of this lesson focuses on expedient roof and wall repairs.)

Roof repairs

Some roofs and support systems perform various functions. While some are simply a weather cover, others act as part of a structural frame. You should analyze failed sections and holes in the roof to determine the needs for emergency repair. Your first efforts must be toward safety. Make sure that shoring and bracing are adequate. Secondly, eliminate hazardous hanging materials (i.e., lights, wires, cable trays, mechanical ducts, etc.) below the roof and assess the extent of damage to the roof support system. The third and subsequent efforts are to cover the hole, replace damaged sections of roof covering, and strengthen the support system as necessary.

Damage assessment

Inspect both the top and bottom portions of the roof to make sure that the areas are sound. The decking may be intact, but the roofing felt may have been blown off, exposing the insulation below. Some types of insulation are highly absorptive. The additional dead load from water-soaked insulation, as well as ponding of trapped water, can collapse structures, especially warehouses and large hangars. (**NOTE:** If there are any damaged roof structural members, you shore and brace until repairs can be made.)

Fire damaged roofing components

You must inspect fire damaged wood structural members for structural integrity. Scrape the charred wood off the member in various areas to check for the extent of damage. Fire damaged wood can remain in place if it retains most of its structural integrity. The amount of remaining strength depends on the extent of charring or exposure to high temperatures. There is no definitive test to determine if fire damaged wood is structurally sound; however, there are rules to follow under contingency conditions:

- Do not use brown, embrittled wood, whether or not it has been charred.
- Charred wood should only be used if at least 90 percent the wood cross section is not charred and charring itself does not extend more than $^{1}/_{16}$ of an inch into the wood.
- Emergency repair of fire-damaged trusses and/or rafters normally involve scraping off the charred material and sistering a piece next to it. (**NOTE:** Sistering, sometimes called scabbing, means attaching some type of material to the side of the damaged lumber. It could be the same material or something different.)

Weather tightness

Once the structural integrity is assured, you want to make the roof as weather-tight as practical. Under expedient conditions, you probably won't be able to completely seal the roof; however, you should do your best to keep most of the weather out. Below are some repair actions you can take:

- For flat roofs, nail sheets of plywood (a bit larger than the hole) in place. If the roof is concrete, use powder-actuated fasteners to attach the plywood. (**NOTE:** Sheet metal, plastic sheeting, and even canvas can be used in place of plywood.)
- You may need internal supports for larger patches. If so, you can use 4- by 4-inch lumber cut to fit. Nail one end under the patch and nail the other end to a 2- by 4- attached to the floor. Then, install rolled roofing (if available) to the patch for added weather protection.
- After the patches are made, you must make sure the roof still drains properly to prevent ponding. You may have to stack sandbags above the repair to divert the water or change the slope at the repair itself. For larger areas, you may have to raise the center of the tarp or sheeting to divert water.

Metal roof repair

Metal roofs (corrugated and/or ribbed panels) are repaired the same way as metal wall systems. When possible, remove the damaged surface material and replace with new or used material. Otherwise, overlap the replacement metal roofing (matching corrugation or rib section) onto the good metal roofing and catch as many purlins as possible for support. Then follow the steps below:

1. Tack in place with sheet metal screws along the edges.
2. Place caulk or silicone on the upslope side for additional water protection.

Wall repairs

The same basic concept is used for wall repairs as for roof repairs. You can cover damaged walls with standard materials such as plywood, sheet metal, tarpaulins, and plastic sheets. However, you need to be aware of the items below before beginning a wall repair:

- Make sure that the structure is strong enough to withstand any added pressure from winds when using tarps or plastic sheeting.
- Shore and brace the structure as needed.

Tarps provide good protection from rain and can withstand greater wind loads than plastic sheeting. During war, if the wall damage is near ground level and the structure is strong enough, you can create an earth berm against the facility.

Plastic sheeting protective techniques

Below is a list are standard materials used to cover a hole.

- Nailing strips—at least 1- by 2-inch furring strips or 12-gauge, 1-inch-wide metal strips.
- Plastic sheeting—at least 6-mil thick or reinforced sheeting. (**NOTE:** Avoid black, recycled plastic sheeting if the repair is exposed to harsh elements for more than a month.) This material deteriorates rapidly.
- Fasteners—long enough to penetrate the sheathing or at least 1½ inch into the stud. (**NOTE:** Use nails, staples, or screws in wood and self-tapping metal screws to fasten into metal siding.)

In addition below are standard procedures and/or steps involved in making the repair.

- Cut nailing strips to go above and below the wall opening. Cut the side nailing strips to fit between the top and bottom nailing strips.
- Cut the plastic so that it extends past the nailing strips. Wrap the plastic around the nailing strips starting at the top.
- Secure the top nailing strip (through the plastic), stretch tight, and fasten the bottom-nailing strip in place. Repeat for the left and right side. (**NOTE:** For non-nailable surfaces, you may have to use adhesive and tape to secure the top and bottom edges.)

If there are damaged intermediate studs, sister new studs to the damaged studs to allow fastening of the nailing strips. Use caulk to fill in larger gaps between the nailing strips and wall surface. For metal skin walls with deformations, use expanding foam to fill in gaps between the metal and the nailing strip.

General information

Below is some of the general information you should use based on the situation.

- For holes in plywood (or other nailable substrate) cut the nailing strips 12 to 24 inches wider than the hole and cut the plastic sheeting 24 inches wider than the nailing strip.
- For holes in a non-nailable substrate, locate the nailing strips over the closest undamaged studs. Then cut the plastic sheeting 24 inches wider than the nailing strip.

- Wrap 12 inches of plastic around both the top and bottom nailing strips. When installed, the plastic should be flat against the building with the wrapped nailing strip on the outside.

Emergency wall repairs on wood-framed structures

Wood-framed walls are typically the easiest wall systems to repair. Depending on the size of the hole, you can usually replace the damaged area, replace a wall section, or provide a structural or non-structural patch. The repair requirements vary with the hole size, location, and wall function. In this topic, we discuss three types of repairs—small hole, large hole, and sheathing repair.

Small hole repair

For small holes (less than 3 feet in diameter) when the substrate is nailable, use plywood or some other structural sheathing. Cut the sheathing to provide at least a 6-inch overlap over the undamaged siding. When the substrate is not nailable, cut the sheathing to fit between the closest studs on both sides of the hole. Position the sheathing over the hole and fasten it into a stud or nailable substrate. Be sure to caulk along the edge of the sheeting before fastening it in place.

Large hole repair

For larger holes (more than 3 feet in diameter), you'll need to remove and replace any damaged framing members. Take note of any load bearing framing members and shore and brace as needed. Try to keep the same spacing between framing members.

For partially split or gouged studs (i.e., 60 to 80 percent of the damaged stud cross section remains) and where some sheathing is still present, sister another stud to the damaged stud to strengthen it. Use construction adhesive between the damaged stud and new stud for additional strength. To add strength to walls that must withstand additional wind loads, apply construction adhesive on stud surfaces; then nail the members together.

Sheathing repair

Shear failure in plywood can be either localized to a small area, appearing as a tearing pattern in the plywood, or involve a complete failure where the sheathing itself is dislodged. Below are the steps you would follow to repair sheathing:

1. Remove the damaged wall covering and/or sheathing back to the nearest exposed stud.
2. Apply ½-inch nominal sheathing to the studs for most walls. However, for shearwalls, use ¾-inch plywood when available. If additional nailing surface is needed for securing the new sheathing, add another stud to the exposed stud.

When the wall must act as a hold down for the roof, nail the sheathing at 6 inches on center, except on the top and bottom plates—nail them 4 inches on center. (**NOTE:** You should add blocking to the wall along the sheathing edges if the wall is taller than the sheathing.)

If the repair may be exposed to heavy rains, cover it with plastic sheeting and/or caulk the butt joints. For walls wider than 4 feet, apply plywood horizontally on both sides of the wall.

Emergency wall repairs on masonry structures

When working on masonry walls, you need to approach the area with caution. Masonry walls usually have increased dead weight from the building materials and are more brittle. Also it's harder to determine the actual extent of damage by simply viewing the apparent damage. You may not be able to establish how or even if the wall is reinforced or what is holding the cracked areas together.

Damage assessment considerations

Consider the items below when assessing masonry wall damage.

- While a crack may appear to be small, the wall may still fail if there is inadequate reinforcing steel to hold the crack together.
- Reinforcing steel is usually in select cells. Does the crack cross over reinforced cells and are the cells still solid?
- If the cells do not contain reinforcing steel, can you establish if the crack is being momentarily held in place by friction from dead loads? If so, a small shift in the structure or ground tremors could cause the building to collapse.

Masonry wall variations

Emergency repairs to masonry structures usually depend on whether the wall is a load-bearing or a nonload-bearing wall. Load-bearing walls can be located on the interior, as well as the exterior. Nonload-bearing walls are usually only interior. If a load-bearing wall is damaged, then emergency shoring and bracing is probably required along with repair.

Small hole repair in non-load-bearing walls

Small holes (a few missing blocks) punched through the wall without any other damage are the simplest to repair. Since repair procedures vary, in the steps below we limit our discussion to wood sheathing repair:

1. Cut wood sheathing large enough to extend several inches past the outer edges of the surrounding *undamaged* blocks.
2. When positioning the patch on the outside of the wall, apply construction adhesive to the edges of the sheathing.
3. Drill holes through the sheathing and into the undamaged grout joint. Secure the sheathing in place with bolts, washers, and lead or expanding anchors.

NOTE: Do not use this repair method if there are loose blocks or cracks around the hole. Instead, tie the wall together with sheathing on both sides. When only a block or two are missing, it is usually easier to knock out the damaged material, square up the opening to size, and fill the void using new blocks and a fast setting-cement or epoxy grout mortar.

Large hole repair in load-bearing walls

Load-bearing masonry walls with larger holes (about five blocks high and four blocks wide) or failed sections are very dangerous. It is usually better to shore and brace the roof or floors above the failed area and then work somewhere else in the facility. However, moving to another section of the building should not be attempted until the extent of the structural damage has been thoroughly assessed. Failed sections in one part of a masonry building can often lead to a progressive collapse in the rest of the structure when wind, rain, vibration, or shifting loads are involved. For a wartime repair, you should follow the steps below:

1. Shore and brace the area around the hole.
2. Square up the hole and brace inside with 2- by 8-inch double headers and side braces, and use double 2- by 4-inch cross braces.
3. Cover over each side with 1 or 2 layers of ¾-inch plywood.
4. Install sheets horizontally and overlap the good masonry at least 8 inches.
5. Drill holes through both sheets and the masonry wall. Tie them together with threaded rods, washers, and nuts.

NOTE: When possible, use 2- by 4-s between opposing bolts to prevent the rods, washers, and nuts from tearing through the plywood. Also, leave the shoring in place if the possibility exists of continued blast or seismic shaking.

Load-bearing wall confining

Confining is used when you cannot replace broken blocks for a small hole in a structural masonry wall. This repair should be limited to small holes with 7 or 8 blocks missing and where there is no extensive cracking around the hole. Use at least 4- or 3-gauge sheet steel (about ¼-inch thick) on both sides of the hole then follow the steps below:

1. Cut the steel to provide about 8 inches of overlap between the steel and the undamaged block.
2. Drill through the steel about 4 inches from the edges in the corners and midpoint on the sides.
3. Drill through the masonry so to align with the holes in the steel.
4. Run a bead of construction adhesive around the hole on both sides and then fasten steel together with threaded rods, washers, and nuts.

Large hole repair in non-load-bearing walls

Non-load-bearing walls with large holes (about five blocks high and four blocks wide) can usually be repaired with a sheet of plywood, a couple of 2- by 8-inch braces and a header. To do so follow the steps below:

1. Square up the hole.
2. Cut one or two 2 by 8s for a header to fit the top of the squared hole. (**NOTE:** If overseas and metric blocks are used, use a wider header or nail ¾-inch plywood [cut as wide as the block] to the top of the header.)
3. Cut two side braces about ⅛ of an inch longer than the distance from the bottom of the hole to the bottom of the header.
4. Place one end of the brace at the bottom of the hole on each side and drive the top of the brace in place to hold up the header.
5. Once in position, toenail the top of each header.
6. Cut sheathing and fasten in place in the same manner as described for covering a small hole.

Utility repairs

Another important consideration during structural repair is utility repairs. If makeshift utility repairs have already been made, structural repair teams should take care to keep from disrupting service. If utility repairs haven't been made, structural repair teams may be able to modify the structure during their restoration to allow expedient utility repair.

Duct repair

After a facility is patched up, the heating or air-conditioning is usually the last item that is restored. If the existing heating or air-conditioning unit is operational, you should patch what remains of the existing duct system. If no sheet metal is available, you could use plywood, duct tape, plastic, gypsum board, or other materials that you can make into a duct. If the existing heating or air-conditioning unit isn't operational, you may need to look for a portable unit. Figure 1–5 shows a portable air-conditioning unit designed for field use. Its flexible hoses for supply and return air can be connected directly to the field shelters we discuss later, and they can be adapted to work in conventional buildings.

Figure 1–5. Portable air-conditioning unit.

Self-Test Questions

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

001. Contingency response planning

1. During a contingency, what command and control functions should you understand?

2. During a contingency, what center directs all base operability, survivability, and recovery operations?

3. Who directs the EOC?

4. Who commands and staffs CE's UCC?

5. Why do the aircraft runway and command and control facilities have a high priority for expedient repairs?

002. Damage assessment

1. When CE's UCC is activated, where do the DATs assemble?

2. Identify the career fields that *ideally* make up the DART.

3. What ADAT member is responsible for the team's movement when a UXO is involved?

4. The ADR teams are responsible for which repairs?

5. What center has the authority to determine what ADR repairs are needed and in what priority?

003. Structural shoring and bracing

1. What should be your focus when shoring any weakened areas in a facility?

2. Guys are usually fashioned out of what items?

3. How are guys normally installed?

4. As a rule of thumb when attaching wire rope clips for guys, what are the minimum requirements for ½- or ⅝-inch rope; ¾- or ⅞-inch rope?

5. What is the use of jacking?

6. When jacking with timbers, at what measurement is the timber cut?

7. What does the sandwiching technique involve when splinting a damaged column?

8. Describe the use of *stitching dogs* to restore some structural integrity into a cracked concrete slab.

004. Quick-fix techniques

1. What life-threatening hazards can you be exposed to while on a damage assessment or repair team?

2. What is the goal of expedient structural repair?

3. What type of fastener is used to attach a plywood patch over a concrete roof deck?

4. When making a metal roof repair, what action should you take to provide additional water protection on the upslope side?

5. When using the plastic sheathing protective technique to cover a hole in a wall, what size nailing strips should be used?

6. When patching holes in plywood or other nailable substrate (for walls), what size should you cut the nailing strips and plastic sheeting?

7. When using plywood to repair a small hole in a nailable substrate (wall repair), how much overlap should you allow for over the undamaged siding?

8. When repairing a large hole in a load-bearing masonry wall, what size headers should you use to brace inside the hole?

Answers to Self-Test Questions

001

1. The crisis action team (CAT), emergency operations center (EOC) and unit control center (UCC).
2. The EOC.
3. The support group commander.
4. The chief of operations commands the UCC and the staff is predominately CE's senior enlisted.
5. Because they are critical to the base mission.

002

1. In their staging areas.
2. One officer (32E3), one 3E1X1 (HVAC/R), 3E4X1 (utility), and 3E0X1 (electrical). However, many bases use one member from 3E3X1 (structural) and no officers.
3. The EOD member.
4. Assessing damage and repairing the airfield, taxiways, airfield lighting, and arresting systems.
5. The EOC.

003

1. To restore a minimum degree of structural integrity to the facility.
2. Wire rope and turnbuckles.
3. To function in opposing pairs to provide lateral restraint from such forces as wind or ice loading.
4. Three clips spaced about 3¾ inches for ½- or ⅝-inch rope; four clips spaced 4½ inches ¾- or ⅞-inch rope.

5. To stabilize the structural integrity of a facility affected by vertical loads (the affects of gravity).
6. Half inch shorter than the distance from the top of top of the jack to the floor.
7. Sandwiching a damaged column in between two steel plates (splints) and secured with threaded rods.
8. Take steel bars, normally rebar, and form it into a U-shape and place it over a crack like staples. The dogs should be of random length and variably spaced along the crack. The holes the dogs are inserted into must be well grouted to ensure a tight fit.

004

1. Downed electrical wires that are live; ruptured gas lines with explosive vapors; chemical, biological, or nuclear agents; a UXO; or a structure that might be ready to collapse at any time.
2. To restore a facility to a safe condition with a degree of weather protection for occupants.
3. Powder-actuated fasteners.
4. Place caulk or silicone on the upslope side.
5. At least 1- by 2-inch furring strips or 12-gauge, 1-inch-wide metal strips.
6. Cut nailing strips 12 to 24 inches wider than the hole and cut the plastic sheeting 24 inches wider than the nailing strips.
7. At least a 6-inch overlap.
8. 2- by 8-inch double headers.

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. (001) Which plan prepares us to react to unforeseen circumstances, such as an enemy attack, with an emphasis on restoring operations, saving lives, reducing human suffering, and minimizing further damage?
   a. Base restoration plan.
   b. Readiness recovery plan.
   c. Emergency operation plan.
   d. Contingency response plan.

2. (001) Which center is established as a command and control element to direct and monitor pre-attack survival actions and post-attack recovery?
   a. Installation recovery center.
   b. Emergency operations center.
   c. Damage control center.
   d. Unit control center.

3. (001) Who directs *all* base operability, survivability, and recovery operations within the emergency operations center?
   a. Wing commander.
   b. Base civil engineer.
   c. Chief of operations.
   d. Support group commander.

4. (002) Which center does the damage assessment and response team report hazards?
   a. Installation recovery center.
   b. Emergency operations center.
   c. Unit control center.
   d. Damage control center.

5. (002) What *must* the damage assessment and response team determine before entering a facility?
   a. Utility operation.
   b. Building usefulness.
   c. Structural soundness.
   d. Number of injured people.

6. (002) Who controls the airfield damage assessment team?
   a. Installation recovery center.
   b. Emergency operations center.
   c. Damage control center.
   d. Unit control center.

7. (002) Who normally oversees the *minimum* operating strip selection process?
   a. Wing commander.
   b. Chief of operations.
   c. Base civil engineer.
   d. Support group commander.

8. (002) Which center has the authority to determine which airfield damage repairs are needed and in what priority?
   a. Installation recovery center.
   b. Emergency operations center.
   c. Damage control center.
   d. Unit control center.

9. (003) Which type of shoring is particularly effective when damage has been sustained to end or sidewalls yet roof members have been essentially untouched?
   a. Guys.
   b. Braces.
   c. Splints.
   d. Tension ties.

10. (003) Which type of shoring is usually made of structural steel and heavy timbers?
    a. Guys.
    b. Braces.
    c. Splints.
    d. Tension ties.

11. (003) The type of shoring used to stabilize the structural integrity of a facility affected by vertical loads (the effects of gravity) is
    a. jacks.
    b. braces.
    c. splints.
    d. tension ties.

12. (003) Which shoring method is particularly useful with reinforced concrete columns that have *not* been seriously damaged, yet show signs of cracking or minor fracture?
    a. Jacks.
    b. Braces.
    c. Splints.
    d. Tension ties.

13. (003) Which shoring method restores some structural integrity into a cracked concrete slab?
    a. Jacks.
    b. Braces.
    c. Splints.
    d. Tension ties (stitching dogs).

14. (004) When performing *expedient* repairs to a roof, what should your *first* efforts be towards?
    a. Assessing the extent of damage.
    b. Ensuring adequate shoring and bracing.
    c. Eliminating hazardous handing materials.
    d. Replacing damaged sections of roof covering.

15. (004) How are *emergency* repairs made to fire-damaged trusses?
    a. No repairs needed if at least 80 percent of the wood cross section is not charred.
    b. Scraping off the charred material and sistering a piece next to it.
    c. Scraping off the charred material only.
    d. Sistering a piece next to it only.

16. (004) After expedient patches have been made to a flat roof, the next action you *must* take is
    a. allow for ponding.
    b. brace the top of the patch.
    c. install powder-actuated fasteners.
    d. ensure the roof still drains properly.

17. (004) What is the *first* action you should take to repair a large hole in a load-bearing masonry wall?
    a. Shore and brace the area around the hole.
    b. Cover the hole with 6-mil plastic sheeting.
    c. Brace inside the hole with 1- by 2-inch lumber.
    d. Install 26-gauge metal straps diagonally across the hole.

Please read the unit menu for unit 2 and continue ➔

Student Notes

Unit 2. Expedient Field Construction

THIS UNIT COVERS THE procedures used for the erection, maintenance, and disassembly of various shelters that you may be responsible for. It also covers construction techniques for some expedient types of field latrines that are used in austere environments. In this time of rapid global mobility, it is very important for you to be familiar with these shelters. You never know when you may be called to deploy on a moment's notice tasked with providing expedient beddown.

2–1. Basic Expeditionary Airfield Resource Base Shelters and Field Latrines

The Air Force deploys different shelters to provide housing, latrines, dining halls, and maintenance facilities to support a contingency operation. These shelters range from fabric to metal types while some of them are also modular and expandable. This section covers the basic information that you need to identify different shelters and keep them operational in a contingency environment.

005. Small shelter system erection, maintenance, and disassembly

In this lesson, we discuss the small shelter system (SSS) shown in figure 2–1. You may have heard it referred to as the Alaska shelter or the triple-S. This all-purpose tent type shelter is used for billeting, work areas, latrines and/or showers, or storage to name a few. 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. The SSS has been designated as the replacement for the TEMPER (Tent, Extendable Modular Personnel) tent through attrition. In comparison to the TEMPER, the SSS is more cost effective, slightly lighter, tighter, more vector (wind) proof, requires less day-to-day maintenance when erected, and its fabric is easier to repair. Figure 2–2 details the SSS components.

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 2–1. Small shelter system.

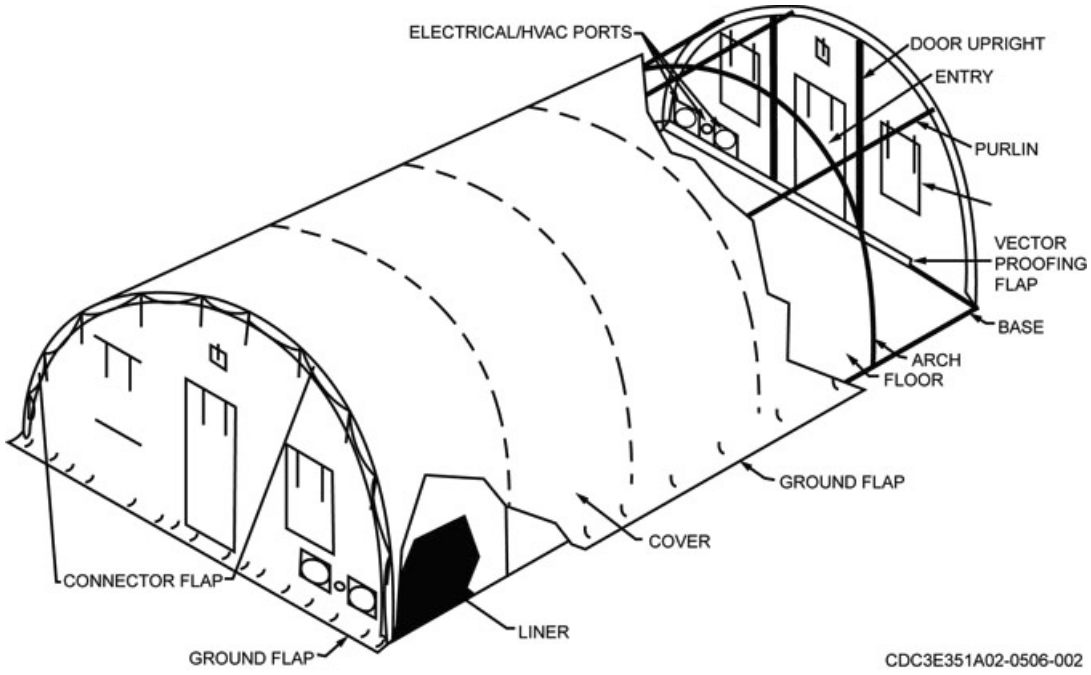

Figure 2–2. SSS breakout.

Site selection and material handling

When selecting a site, choose an area at least 30 by 40 feet. Ensure 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 being sure to keep like items together. When removing the items from the container, inspect them for damage or missing parts. After all the items and accessories are removed 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. Below are safety considerations that 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, ensure the shelter is properly anchored.
- To prevent personnel injury, ensure heavy components are handled using an adequate number of personnel.

You must also be sure to observe these 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 may dent the base frame.
- Never pound on pins or slip-fit connections. If necessary, lightly tap only.

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. To square the base; measure 38 feet 3

inches from outside corner to outside corner (diagonal method) with a rope or tape measure. 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 subfloor 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. Refer to figure 2–3 for arch assembly. 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 bottom arches coded red (without stubs) are on the same side of the shelter.

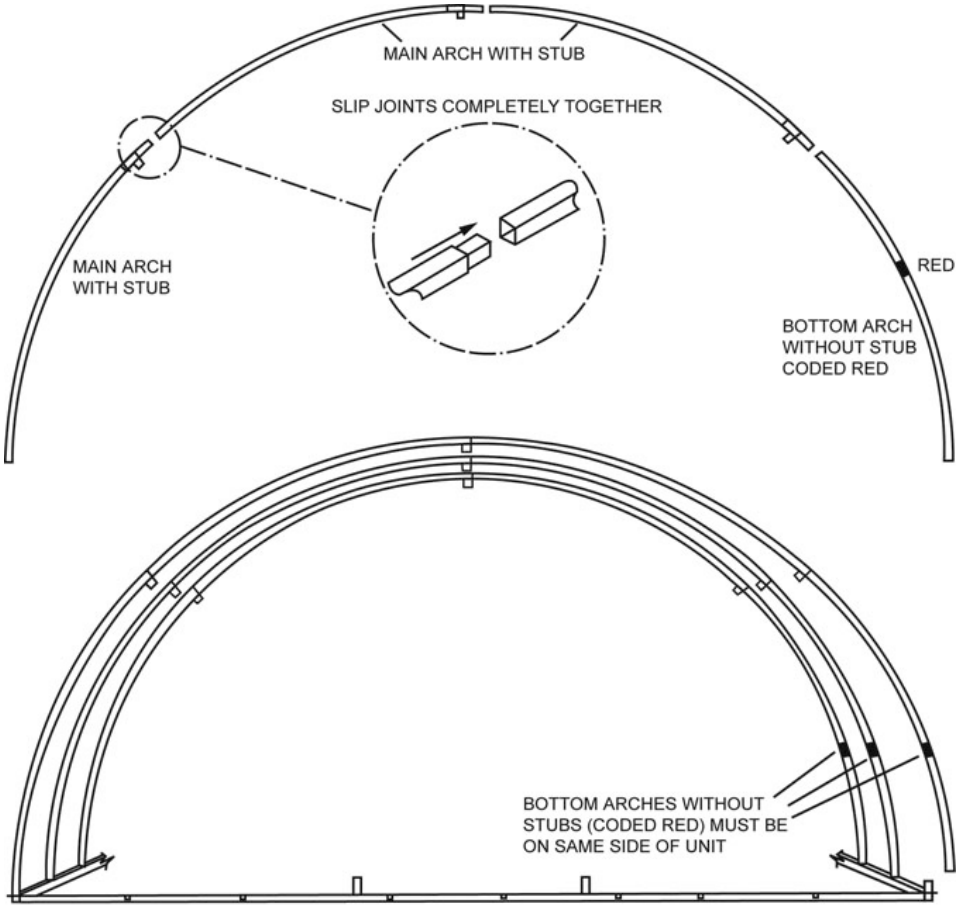

Figure 2–3. Arch assembly and installation.

Purlin installation

You are now ready to install three rows of purlins. They connect between the arches, as shown in figure 2–4. You should begin installing the red-coded purlins on one end, and then work towards the opposite (yellow) end. Notice in figure 2–4 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: The insert bolt must be placed towards the inside of the shelter. Be sure to follow the stenciled instructions located on the end uprights.

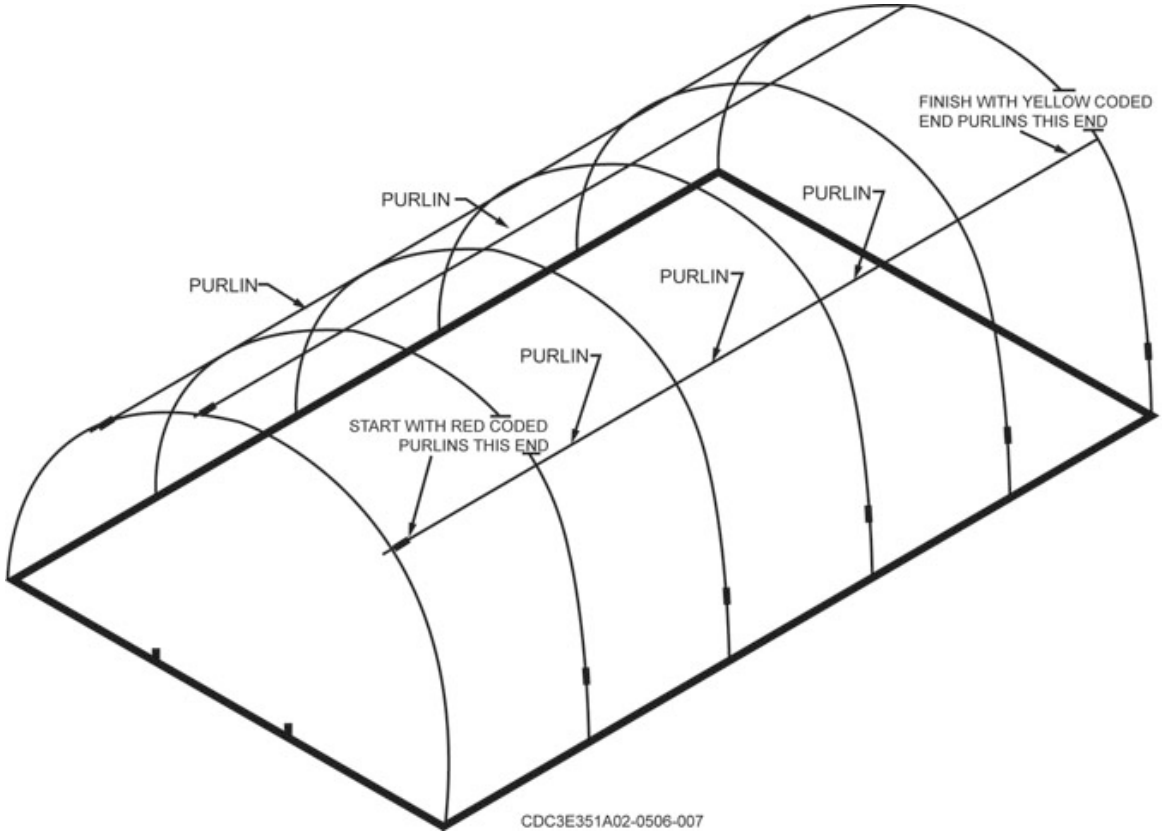

Figure 2–4. Purlin installation.

End panel installation

After the framing members are installed, the next item installed is the end panels. There are two types of end panels—zippered and hard door.

Zippered end panel

To install the zippered end panel, we recommend the steps listed below:

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. 2–5). 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 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.
8. Repeat steps to install the opposite end panel.

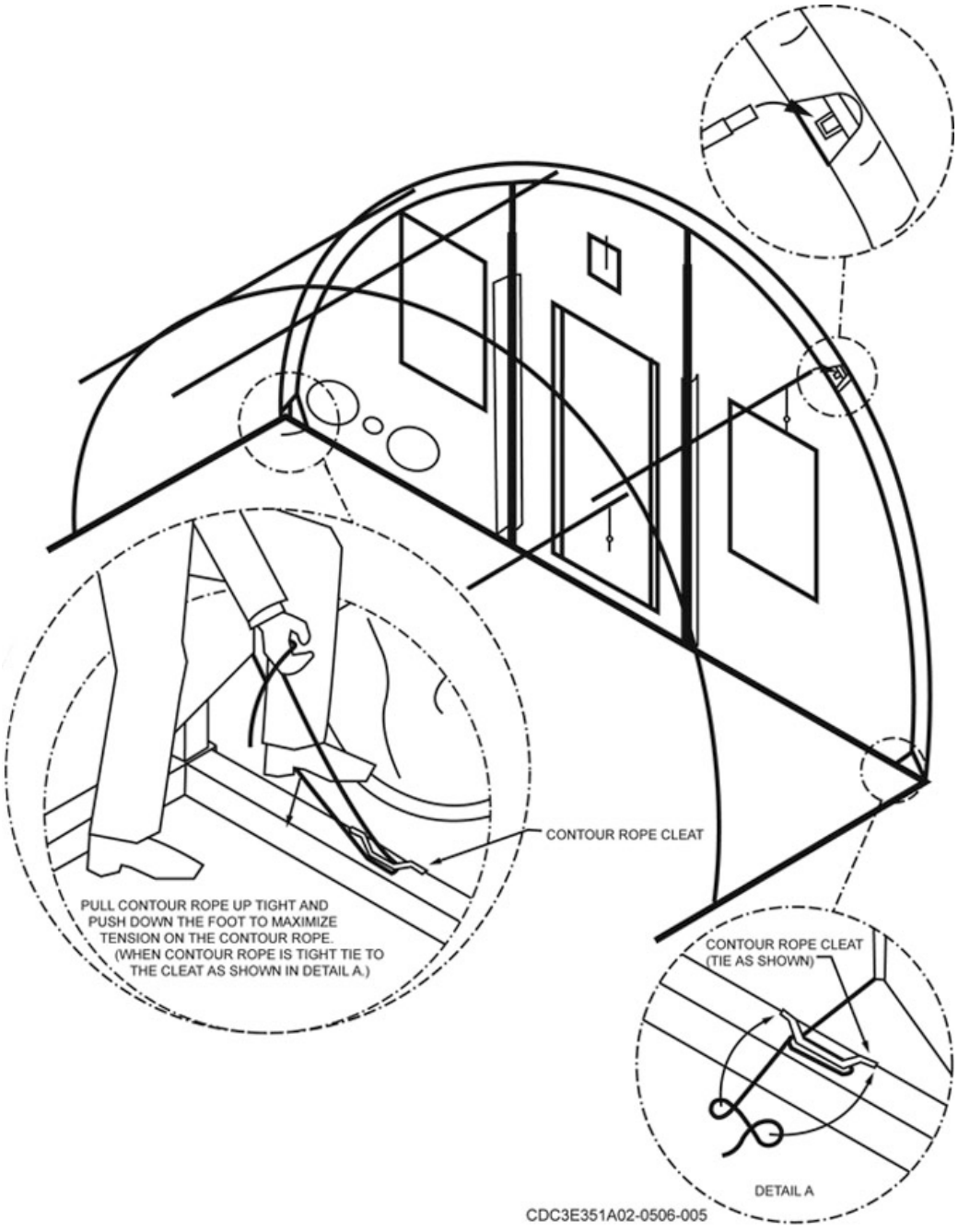

Figure 2–5. End panel installation.

Hard door end panel

To install the hard door end panel, we recommend the following steps listed below:

1. Make sure the door is installed with the white side facing inside the shelter. Place the doorframe so the stub on bottom of the 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. Working from the inside of the shelter, slide the header stubs into the top of the doorframe to connect the two together then 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 door brackets to open door, install doorknob and adjust 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 the following eight steps:

1. Lay the cover next to shelter so that when pulled over the shelter, the black side faces the inside (fig. 2–6).
2. Secure one end of the cover base rope to the *silver* tie off cleat. Stretch and secure the other end of cover base rope to the *silver* tie off cleat on the other end.
3. The cover has four black loops located at the base. They are used to attach the pullover ropes. Throw four pullover ropes over the shelter and attach to the loops.
4. With one person on each (4) rope, 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:** Ensure 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 using 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.

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. 2–7). Drive the anchors (ensure they are angled) with the top away from the shelter and inline 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.

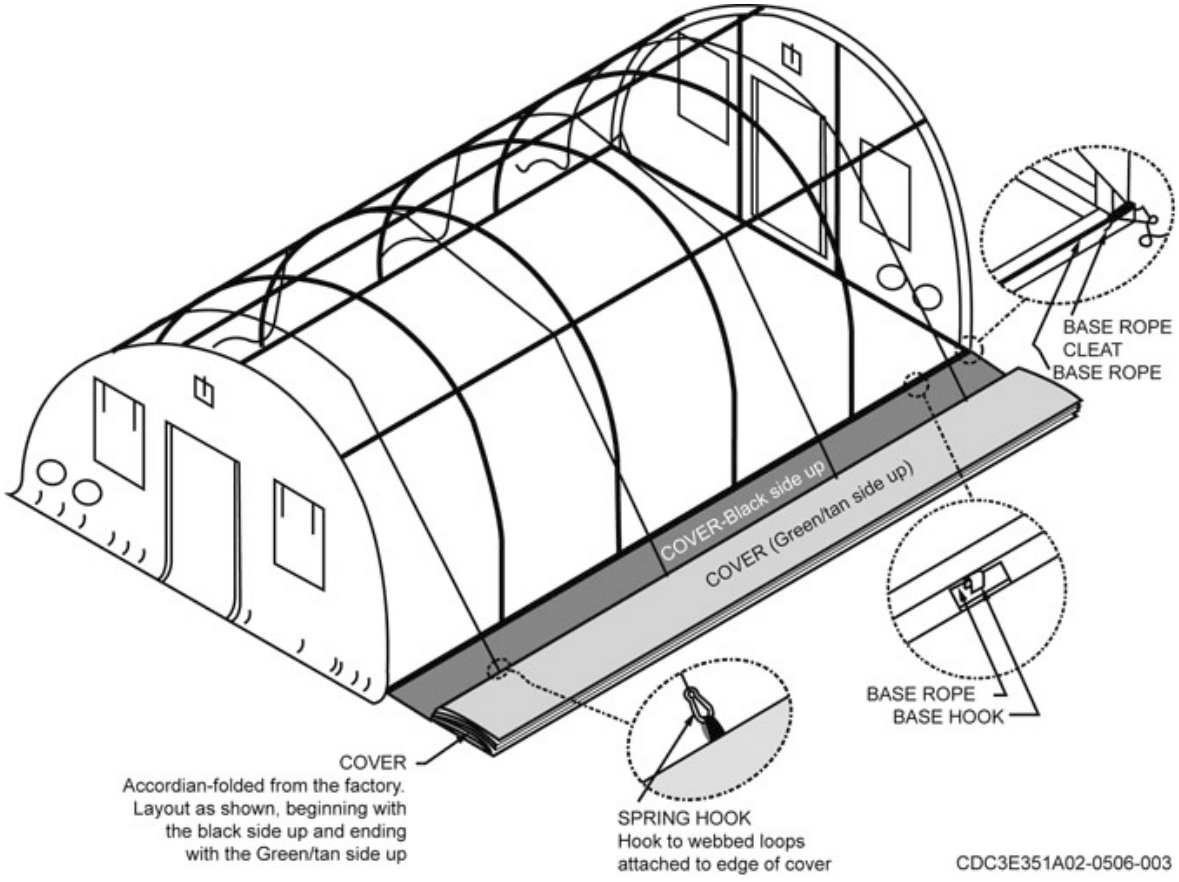

Figure 2–6. Main cover installation.

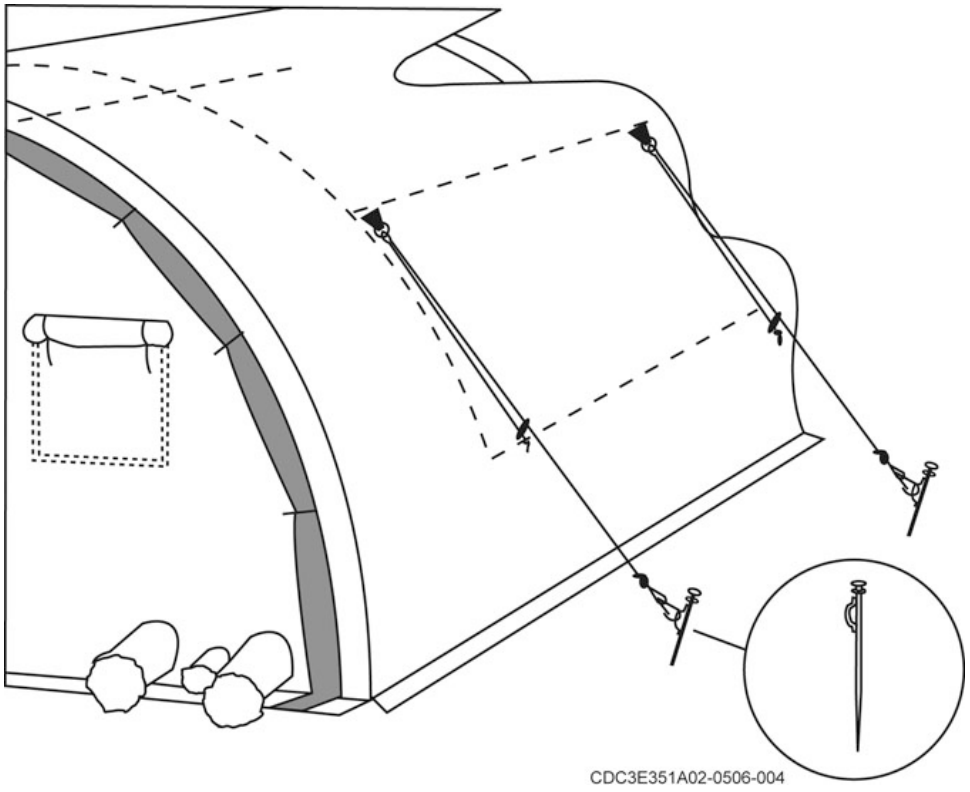

Figure 2–7. Guy rope installation.

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 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, you 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, you 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. Ensure 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, you can begin installing the electrical system. Below are the suggested steps:

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, you should layout the straight section on the shelter floor, parallel to the center purlins. Listed below are the steps to install the plenum:

1. Starting on the end wall where the environmental control unit (ECU) will 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 shelter. The fabric boot is secured to the supply duct with the fabric boot straps. Repeat procedure for the return air duct using the left hand fabric boot.

Inspection and maintenance

To keep the SSS operating at maximum capacity, you should perform periodic inspections and preventive maintenance, as required per the shelters technical order. When the shelter is placed in storage for a lengthy period, it should be inspected in 6-month intervals. The SSS should also be inspected during every assembly and disassembly for missing or broken parts. Below are the minimum inspection and/or maintenance actions:

- 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 found, refer 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 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 do the following steps:

1. Clean the area with water and dry. Patches should be placed 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 exposing 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 steps:

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 melts (fuses) the two pieces items 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 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 and/or 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, keeping the items below in mind:

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

To ease packing the container, place like items together while disassembling. Take great care in packing the container to make sure 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.

006. Medium shelter system erection, maintenance, and disassembly

In this lesson, we discuss the medium shelter system (MSS) shown in figure 2–8. These shelters are also known as the California medium shelter system (CAMSS) or M double S. This shelter is 52 feet long by 29 feet 6 inches wide by 15 feet high. It is used as an all-purpose mid-sized shelter in the maintenance area, warehouse, storage and kitchen. It is very similar to the small shelter system, only larger. The MSS is replacing the general purpose shelters (GPS) in the inventory. It provides tighter protection against dust and insects, has lower maintenance costs, and takes up less shipping space. It can also withstand 60 knots steady wind load with gust up to 90 knots. (**NOTE:** The information presented here is for training purposes only. Always refer to TO 35E5–6–21, *California Medium Shelter System,* when using this shelter.)

Figure 2–8. Medium shelter system.

Site selection and unpacking

When selecting a site to erect the MSS, try to find an area that is at least 35 by 60 feet. It should be free of debris and as smooth and level as possible. Unlatch the top latches and remove the top. When unpacking the components, be sure to keep like items together. You should inspect for damage or missing parts when removing the items from the container. After all the items and accessories are removed 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. These safety considerations must be followed or 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.
- Never leave the vehicle doors open when there are high winds present.
- To prevent injury when handling heavy components, make sure that you use an adequate number of people.

You must also be sure to observe the precautions below 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 may dent the base frame.
- Never pound on pins or slip-fit connections. If necessary, lightly tap only.

Base assembly

Assemble the base sections in sequence of the base assembly plan included with the kit. Place all base frame members with the base hooks on the outside of the frame. The center end base frame members are positioned with the elongated slots towards the inside of the shelter. To connect the adjacent frame members on either side of the center, extend their inserts into the center, tighten the wing nuts and insert the hitch pins.

NOTE: These members (one end base center and two end base off centers) at each end are designed to be removed to accommodate fully loaded vehicles or vehicles with low clearances.

Squaring the frame

After all the members of the base are connected, you need to square the frame. To do this, it's best to establish a straight side using a string line. (**NOTE:** While not mentioned in the TO, it's a good idea to drive a spike at each end of the straightened side to keep it from moving.) Use the 100-foot tape to check the frame's diagonal measurements. Depending on the ground slope, the diagonal measurements should be around 59 feet 11 inches. Adjust the frame (loose side) as necessary until you get an even measurement on both diagonals.

Driving anchors

Drive 18-inch double-headed spikes through the spike holes in the base frame to secure the base assembly. You can use either a sledgehammer or the spike driver socket and jackhammer.

NOTE: There are four single-headed spikes that are used to anchor the end base centers (two at each end).

Installing duckbill anchor loops

There are stubs along the top of various base frame members. After the base is anchored down, slip one duckbill anchor loop over the stub at each corner. Also place one on every other stub along both sides and one on all four of the end base stubs that are used for the vehicle doors.

NOTE: The loops are just slipped on at this point—not anchored.

Floor installation

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 floor pads and place them inside the base frame before installing the non-slip floor.

Arch assembly and installation

Each arch assembly consists of six sections with one bottom arch (red coded) on each assembly. Place the arches on the ground to assemble. Stand the assembled arch and set one end on the base stub. Use at least two people on each end of the arch assembly to pick up and carry it. 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 on the base.

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

Purlin installation

The MSS uses five rows of purlins to connect the arch assemblies together. Just as with the SSS, you should begin installing the red-coded purlins on one end, and then work towards the opposite end. 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 places.

Vehicle doors

You should assemble the vehicle door frames on the ground. There are top and bottom sections for the right and left doors. You can tell the difference between the right and left doors because the right side frames have an edge lip.

To assemble the top and bottom frames, slide the bottom frame insert tubes into the top frame and secure with the door bolts and wing nuts provided. (**NOTE:** The door frames are made with connector flaps with grommets. Be sure they are on the same side when assembling the top and bottom sections.)

Door panels

Locate the panels for the left and right doors. The right door panels are made with a fastening flap next to the ketter. The ketter is the edge of the panel that slides into a groove in the frame.

Below are the steps to continue door panel assembly:

1. Slide the ketter edge into the groove to attach the panel to the frame. Ensure the weather flap is at the bottom of the frame.
2. Wrap the panel around the frame. You must then lace the panel to the connector flaps and then cover and seal the lacing with the adjacent flap.
3. Clip a piece of plastic U-channel (vehicle door top guard) on the top of the door. Repeat these procedures for all vehicles doors.

End panel installation

To begin the end panel installation, first layout the end panel (with the interior facing up) on the ground at the end of the shelter and then follow these steps:

1. Slide the left and right vehicle door headers onto the end panel's horizontal ketter.
2. Pin the left and right vehicle door headers together at the center.
3. Slide the top of the personnel door onto the personnel door horizontal ketter.
4. Pull the fabric between the personnel door and vehicle door back to allow room to slide the vertical ketters down the personnel door and vehicle door simultaneously. At this time, install the vehicle door upright and pin to the header after the fabric is pulled in place.
5. Repeat step 4 for the opposite sides of the personnel and vehicle doors.
6. Slide the hook assemblies (openings up) into the top of the vehicle door headers and slide the side adjustment cables (with turnbuckles) over the hook assemblies.

With the components assembled on the ground, raise the end panel onto the square stubs at the end of the base. (**NOTE:** You need to ensure the weather flap on the end panel lays on the ground on the outside of the shelter and not towards the inside.) To set the end panel in place, place the door hook assemblies over the arches, attach the end brace hook assemblies into the horizontal braces and connect the horizontal braces to the door uprights. You must also attach the end brace hook assemblies over the end arch (placed above the bottom purlins). The last step is to slide the personnel door hook assemblies into brackets that hook over the horizontal brace located above the door.

Securing the end panel

To secure the end panel, pull the edge of the end panel over the arch. Then continue by completing these steps:

1. Loop the contour rope under the purlins (beginning at the center purlin).

   NOTE: You must temporarily remove the end purlins to slip them through the rope loop.
2. When you get to the second row of purlins, slide the adjustment cables over the purlins before slipping the purlins through the rope loop.
3. Pull and tighten the contour rope at each end of the arch. Tie off the contour rope to the cleat on the top of the end base corner.
4. Tie off the base rope to the four cleats located on the front of the base.
5. Secure the base rope to the base hooks using the hook tool.
6. Repeat steps for opposite end.

Completing door installation

After the end panel is up, you can complete the installation process for the personnel and vehicle doors.

Personnel doors

Place the exterior door handle through the hole in the door to engage the strike. Fasten the handle to the door with screws (provided). Snap on the inner plate and push the inside handle on until you hear it click.

Vehicle doors

Lift the door panels onto the bottom round tubes on the end base and then proceed with the steps listed below:

1. Push the top of the panel in position and place the vehicle door pin through the door header into the top of the door panel.
2. Turn the turnbuckles on the side adjustment cables to square the frame.
3. Attach the center adjustment cable with the turnbuckle eye attached to the door header and the other end wrapped around the top purlin after the doorframe is even.
4. After all turnbuckles are adjusted, place the exterior vertical flaps together to seal the door joints.

NOTE: The last item placed on the end panel is the high heat vents. Secure them with hook and loop fasteners.

Top liner installation

Place the top liner alongside the shelter. Be sure the liner is positioned so that the 4-inch fastener base flap is on the inside of the shelter. The suggested steps for the rest of the installation process are as follows:

1. Throw four pullover ropes over the frame and connect to the liner.
2. With one person on each rope, pull the liner over. (**NOTE:** You should have another person on the opposite side wave the liner up and down to place air under it.)
3. Work the edges of the liner over the end arches.
4. With liner in place check the frame for plumb. Hang a pullover rope from the top purlin. If the frame is plumb, the rope will hang straight down.
5. Locate the slits in the end ground flaps. Slip the liner contour ropes through these slits.
6. Place the contour rope under the base cleat located on the end side and pull up to apply tension. Step on the rope repeated to add more tension until you see about a 4-inch overhang on the end of the shelter and then tie off the rope to the cleat.
7. Repeat steps 5 and 6 for the opposite end.
8. Retighten the contour rope on the first end and then fasten the inside liner flap to the floor on both sides of the liner.

Main cover installation

To install the main cover, we recommend you complete these steps:

1. Lay the cover next to shelter.
2. Throw over six pullover ropes and fasten to the cover.
3. With one person on each (6) rope, pull the ropes in unison to pull the cover over the frame. **NOTE:** As with the liner, have one person wave the cover to reduce tension between the cover and liner.)
4. Work the cover over the end arches. Place the contour cables through the slits in the ground flaps at one end and secure both contour ropes to the base clamps.
5. Go to the opposite end and place the contour ropes around the base clamps. Check to see if the cover rests over the end arches evenly. If so, apply tension using the power pull and

extension cable. Keep applying tension until the o-rings on the outside of the cover are centered over the end arches on each end.

6. Tighten the nuts on the end base clamps to keep the cover tight. Tie off any excess contour rope to the adjacent base cleat.
7. 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.

Duckbill anchor installation

Remember the duckbill anchor loops that were installed over the base frame stubs? Now it's time to anchor them. Below are the steps to complete the task.

1. Place the anchors away from the base frame—about a few inches.
2. Drive the anchors into the ground using a steel drive rod and sledgehammer.
3. Place upward tension on the cable to set the duckbill.

NOTE: Duckbill installation is *not* required when the shelter is anchored to a 4-inch reinforced concrete slab.

Guy rope installation

There are certain spikes used for the guy ropes. Drive the spikes about six feet away from the sides of the shelter. The anchors should be driven with the top of the anchor 45 degrees away from the shelter and in-line with the arch. Install guy ropes to the guy loops on the shelter.

Electrical system installation

The suggested steps for installing the electrical system are as follows:

1. Attach the distribution panel to the right personnel door upright (as viewed from the outside of the shelter). Place the hanging bolts on the panel in the keyholes in the upright. (**NOTE:** The distribution panel has two plugs on the bottom and two on the top. The bottom plugs are for the receptacles; the top plugs are for the lights.)
2. There are two weatherproof receptacle cords—the shorter cord attaches to the side closest to the panel box. Beginning with the first arch after the end arch, install a duplex receptacle at every other arch. (**NOTE:** Receptacles should be 47 inches up from the floor. Run the longer cord over the personnel and vehicle doors to the other side and fasten the receptacles in like manner.)
3. There are two identical light cords. Plug the long end of one cord to the top of the distribution panel and run the cord above the personnel door up to the arches. Place a light at every arch (above the second row of purlins).
4. To make up the difference from one side to another, plug the *light connector cord* into the other plug at the top of the distribution panel. Run this cord up the personnel door and along the first arch. The second light cord attaches to this cord and runs along the opposite rows of purlins. Once again, attach a light to each arch just above the second row of purlins.

Liner installation

There are eight liner panels that come with the MSS (six long panels and two short for the window sections). You need to make sure that you install the liners with the center loop fasteners all facing towards the same end of the shelter. If this is not done, the liners will not mate to each other. Below are the four steps to install the liners:

1. Tie the liner's fastening straps around the center purlin. You may need to adjust the straps so that the centers of the panels hang evenly with the horizontal fastener flap on the inside of the end panel and the second rows of purlins.
2. Slip the liner behind the second rows of purlins.

3. Attach the liners (starting at the second rows of purlins) to the arches. They attach with pre-applied Velcro strips.
4. Repeat steps for each bay.

After all liners are installed, fasten the liner edges together in the center and fasten the end liners to the horizontal flaps on the end panels.

Duct installation

Two items make up the duct—the air sock start and the air sock end. Cinch the air sock start to the incoming supply duct. Then fasten the air sock end to the air sock start. With the two connected, attach the air socks to the second row of purlins. (**NOTE:** You may have to adjust the lights up the arch to keep them from interfering with the air socks.)

Environmental control unit

HVAC/R personnel are the only ones that should work on the ECU; 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 18 inches away from the shelter end wall. Make sure the ECU side labeled “Exhaust End” is facing towards the shelter duct openings.

Inspection and maintenance

To keep the MSS in top operating condition, you should perform periodic inspections and preventive maintenance, as required per the shelter’s technical order. The MSS should be inspected during every assembly and disassembly for missing or broken parts. At a minimum, the inspection and/or maintenance actions should include the items listed below:

1. 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.)
2. Inspect the cover and liners for small tears—clean and patch as required.
3. Inspect the electrical cable assemblies monthly looking for kinks, nicks, or cracks. If found, refer to electricians for repair. Also make note of any loose wires or components.
4. Inspect the shelter container periodically for punctures. Also inspect the latches and gaskets and replace them as needed.
5. Inspect miscellaneous components for damage. Items inspected include the plastic sleeves, duckbill anchors, and ropes. If any components are damaged, you must replace them.
6. The ECU should only be inspected and repaired by HVAC personnel.

Fabric repairs

The spare bag contains a patch kit used to repair rips and tears in the cover or floor. Below are the steps to make a repair:

1. Clean the area with water and dry. (**NOTE:** Patches should be placed 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 exposing 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; follow the steps below for larger tears:

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 melts (fuses) the two pieces together.
4. You must apply pressure to the area during the heating process using a pressure roller.

Liner repair

The spare bag also contains a patch kit used to repair rips and tears in the liner. Below are the steps to make a repair on a rip or tear:

1. Clean around the damaged area with water. Be sure to let it dry before attempting to patch the area.
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 exposing the self-adhesive. Then press the patch firmly over the tear and smooth.

NOTE: Tears that are longer than 18 inches should be repaired in the shop. They may be sewed with a polyester thread versus a patch.

Frame repair

Miscellaneous items such as broken hitch pins are simply replaced. Any broken items that have been welded may be rewelded. If there are significantly deformed components, you should replace them to make sure that the shelter's structural integrity is not compromised.

Arch loop fastener replacement

Below are the steps to replace damaged loop fasteners:

1. Remove the old fastener from the arch.
2. Use a cleanser to remove the excess adhesive and then apply denatured alcohol to clean the arch.
3. To install the new loop fastener, remove the backing and press it firmly in place. You must allow at least 24 hours for the adhesive to cure.

Disassembly and/or reconstitution

The first step in disassembly of the MSS is to make sure that all power is disconnected from the electrical system at the source. We recommend that you disassemble the shelter in reverse order of the erection procedures, keeping the below items in mind:

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

To ease the packing of the container, place like items together while disassembling. Great care should be given to packing the container to make sure 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.

007. Additional shelters

The purpose of most shelters is to provide protection from the elements. As a rule, BEAR shelters are employed during times of war, natural disaster, or other emergency or contingency when no other form of acceptable protection is available. They provide basic protection for troops deployed to austere locations or areas with limited or no facility support. This lesson highlights current BEAR shelters and legacy shelters used during bare base development and force beddown operations. Refer to applicable technical data for detailed guidance on erection, maintenance, and disassembly.

Bare Base Dome Shelter

The dome shelter (fig. 2–9) is a large, all-purpose shelter used as a maintenance area, warehouse, or aircraft hangar. It is available in three sizes; 4K, 5K and 8K square feet, and can be extended in length

indefinitely by adding additional modules. Each length module adds approximately 13-½ feet. Shelters receive a 120/208 VAC, 60-cycle, 3-phase, 5-wire electrical input. Although RED HORSE and the 49th MMS teams may have the lead when erecting dome shelters, Prime BEEF can expect to assist. The shelter can be erected and disassembled from ground level and all tools necessary for erection and disassembly are included in the shelter package. It can also be installed on concrete and secured with thunder studs. At least eight people are required to assemble the structure safely. Assembly time is approximately 256 man-hours. Environmental limitations of the dome shelter are listed in the table below. Consult T.O. 35E4-216-1, *Bare Base Dome Shelter*, for more details.

Dome Shelter Environmental Limitations	
Temperature	-25°F to 125°F
Solar Load	200° F
Wind Load (Sustained)	60 knots
Wind Load (Gusts)	Up to 90 knots

Figure 2–9. Dome shelter.

Large area maintenance shelter

The large area maintenance shelter (LAMS) (fig. 2–10) provides semi-portable housing for small aircraft and vehicle maintenance. Sized at approximate 129 feet long, 75 feet wide, and with a 31-foot height clearance at the center, it has electrically operated Clamshell end-doors at both ends. The shelter is equipped with Class I, Div. 1, Group C Electrical System (explosion proof lights, outlets, wiring, and switches). The overall area required to erect the hangar is approximately 100 feet x 135 feet. It can be erected on a reinforced concrete pad (100 feet minimum x 135 foot minimum x 8 to 10 inch thick), asphalt, or earth surface. Once erected, the LAMS provide an unobstructed, weatherproof work area free of vertical supports that could hinder movement of aircraft and equipment within. A minimum of ten people are required to assemble the structure safely. Assembly time is approximately 300 man-hours. Environmental limitations of the LAMS are listed in the table below. Consult T.O. 35E4-219-1, *Large Area Maintenance Shelter*, for additional information.

LAMS Environmental Limitations	
Temperature (Operate)	-20°F to 120°F
Wind Load	(set-up) 25 MPH (closed shelter w/guy lines in place) 90 MPH (operate clam shell door) See T.O. 35E4-219-1
Snow Load	8 lbs per square foot w/o snow kit

Figure 2–10. LAMS.

Frame-supported tensioned fabric shelter

The frame-supported tensioned fabric shelter (FSTFS) (fig. 2–11) is a large, all-purpose shelter used as a maintenance area or warehouse. It is available in two configurations; type A and type B shelters. The type A shelter has a minimum usable interior floor space of 60 feet by 140 feet (8400 square feet). The type B shelter has a minimum usable floor space of 60 feet by 70 feet (4200 square feet). Both shelters are portable and rapidly deployable, and require no concrete foundation. A minimum of eight people can assemble the structure safely. Assembly time is approximately 384 man-hours for type A shelters and 256 man-hours for type B. If necessary, multiple buildings can be interconnected. FSTFSs are gradually being replaced by the Dome Shelters, which provide more utility and versatility. Environmental limitations of the FSTFS are listed in the table below. See T.O. 35E4-183-1, *Frame-Supported Tensioned Fabric Shelter*, for detailed descriptions.

FSTFS Environmental Limitations	
Temperature	-25°F to 125°F
Solar Load	200° F
Wind Load (Sustained)	60 knots
Wind Load (Gusts)	Up to 90 knots

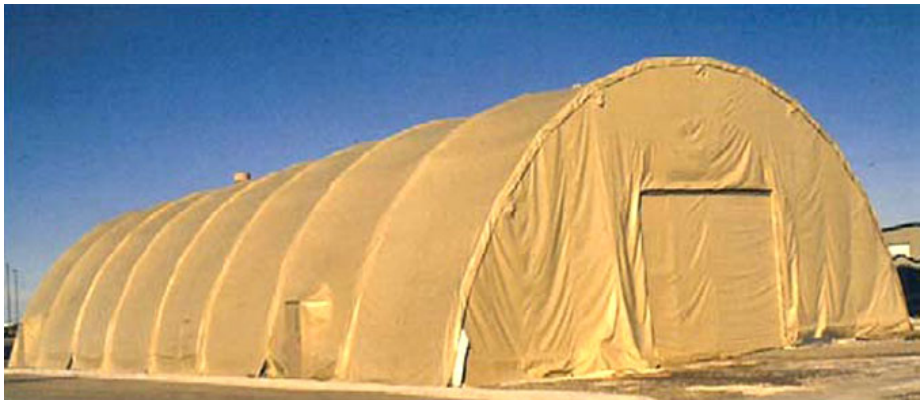

Figure 2–11. FSTFS.

Aircraft maintenance hangar

The aircraft maintenance hangar (ACH) is a lightweight structure intended for use as an aircraft maintenance shelter during bare base deployment (fig. 2–12). The hangar consists of seven arches and two endwalls providing 8,225 square feet under roof. The main structure consists of 80 rigid panels mounted on beams that form the seven arches. The four shipping and storage containers are installed in the corners of the hangar for personnel access to the hangar, equipment storage, and office space. Both hangar endwalls can be raised and lowered to permit aircraft and vehicle entry. An electrical system provides inside and outside lighting and power outlets for the containers, bare base heating

system, and the hangar work area. Erecting the ACH requires a minimum of 10 people and generally takes about 40 hours (400 labor hours). Environmental limitations of the ACH are listed in the table below. See T.O. 35E4-133-1, *Bare Base 76-Foot Aircraft Maintenance Hangar*, for more information on siting and erection procedures.

ACH Environmental Limitations	
Temperature	-25°F to 125°F
Solar Load	200°F
Wind Load (Sustained)	60 knots
Wind Load (Gusts)	Up to 90 knots

Figure 2–12. ACH.

008. Field latrine construction techniques

Depending on your location and the situation, there may not be adequate facilities for disposal of human waste. In this section, we discuss some methods used to develop field latrines under austere conditions. When you are on bivouac or at a new location, it is unlikely you will find a waterborne sewage system available for your use. You need to create temporary facilities for disposal of human waste as one of your first priorities. In this lesson, we discuss some of the types of field latrines that you may be required to construct.

General information

A number of field-type latrines are designed for temporary use; you may use one of the shelters previously discussed to house the latrine. Latrines must be at least 100 yards from water supplies and messing facilities. You should construct the latrine on level ground (preferably) and *never* uphill from the campsite or water supplies.

NOTE: Until latrines can be constructed, you may have to dig a hole (cat hole) about 1 foot deep and cover it completely with dirt immediately after use.

Straddle trench latrine

Straddle trench latrines (fig. 2–13) are commonly used. It’s recommended to have at least two trenches per 100 males and three trenches per 100 females. Construct straddle trenches as soon as you arrive at a position. While sizes can vary, we recommend the following dimensions when constructing this type latrine: 1 foot wide by 2 feet 6 inches deep by 4 feet long. There should be at least 2 feet in between trenches (if multiple trenches are located side-by-side) for footing.

NOTE: Add another foot of depth for each day you anticipate using the trench.

With this type of latrine, no seats are provided; the personnel straddle the trench as the name implies. Keep a pile of dirt (dirt removed to make the trench) and a shovel adjacent to the trench so each

person may use some of the dirt to cover their waste materials. You may want to place boards around the sides to help keep steady footing and prevent someone from slipping in.

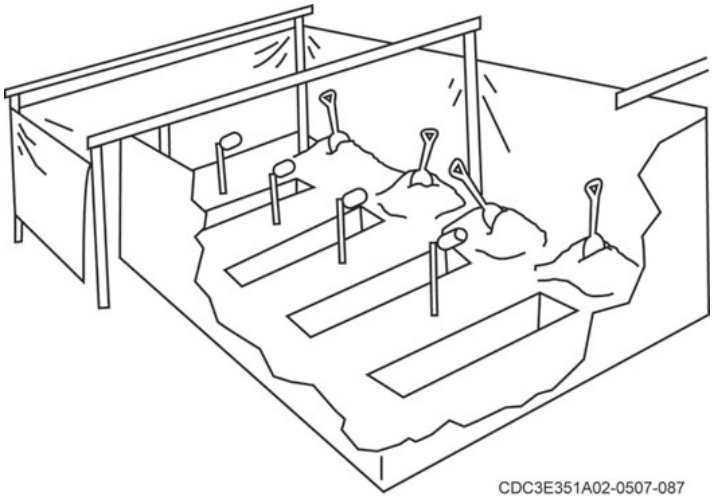

Figure 2–13. Straddle trench latrine.

Latrine closing procedures

When the latrine is filled to within 1 foot of the ground level or is to be abandoned, you should take the steps below:

1. Using an approved residual insecticide or diesel fuel, spray the pit contents, the sidewalls and the ground surface extending 2 feet from the sidewalls.
2. Fill the pit to ground level with successive 3-inch layers of earth, packing each layer down before adding the next one; then mound the pit over with at least 1 foot of dirt and spray again with insecticide or diesel fuel. This prevents flies that hatch in the closed latrine from getting out.
3. When there is a possibility that others may come into the area, you should mark the closed latrine so the site can not be used again. Place a sign “closed latrine” with the closing date firmly in the earth over the area.

Pit latrines

As soon as possible, regular pit latrines (fig. 2–14) should be dug. These latrines may be 20 to 30 feet deep if the ground permits. The sides must be straight and have no ledges that could catch feces. Latrine boxes are normally constructed of four or eight holes (seats).

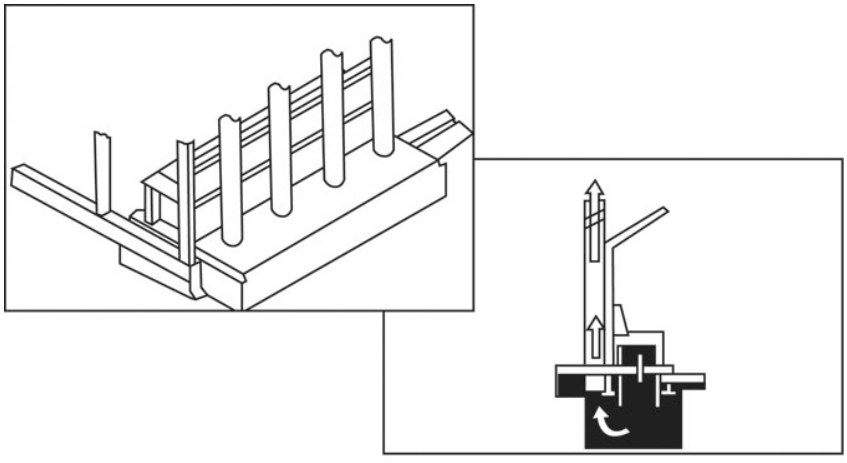

Figure 2–14. Pit latrine.

Four seat

A prefabricated four-seat latrine box can be collapsed for shipment.

Eight seat

A standard eight-seat field-type latrine uses two four-seat boxes that straddle a 3- by 7-foot pit. Below are the steps to follow after the pit is dug, but before the boxes are placed:

1. Excavate a 4-foot-wide margin around the pit to a 6-inch depth.
2. Lay a layer of oil-soaked burlap in the excavated margin.
3. Soak the excavated earth with oil and replace it, tamping it down to keep surface water out.

Two 4-foot 6-inch trough-type urinals are furnished with the eight-seat latrine. Each is mounted in a frame. Connect the urinals to a 6- by 6-foot urinal seepage (soakage) pit with the 2-inch urinal drainpipe that leads from the down pipe on each urinal.

Additional construction techniques

When the box is installed, line it with tarpaper from the top to the bottom. Be sure the boxes have a metal or tarpaper urine deflector. This deflector is converted into a trough under the front of the seat so it drains toward one end. From this end, a pipe carries the urine to an outside seepage pit. This helps to reduce the bad odor from the urine. In some cases where the soil is rather porous, the urine drains into the latrine pit itself.

You must take the necessary steps to cover all cracks in the box to help make it flyproof. There are various means of doing this, such as nailing strips of wood or tin over them. Carefully place the box over the pit. If any cracks are showing along the bottom, pack some dirt tightly around the edges to seal them.

Urinal soakage pit

You need to build a separate urine soakage pit when the latrine pit is in soil that absorbs liquids poorly. Build this pit about 4 feet square and 4 feet deep. Fill it with pieces of broken rock, brick, large stones or lava rock to within 1 foot from the top. Place oiled-burlap over the rocks and cover it with sand or earth. Insert vents, covered at the top with fine mesh screen, to reduce the odor.

Burnout type

With a burnout type latrine (fig. 2–15), the waste goes into removable barrels. The waste is then disposed of at another location. Most advanced or temporary bases use this type of latrine. The camp maintenance personnel or the assigned sanitation crew keep the burnout latrine in an orderly condition (daily). You can cover the waste material with lime or use diesel fuel to burn it.

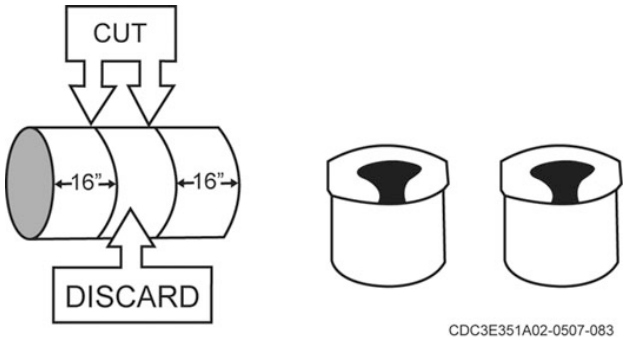

Figure 2–15. Burnout latrine.

Pail-latrine

In other cases, pail latrines (fig. 2–16) maybe used in buildings where no adequate plumbing facilities are available or where it is not practical to build deep pit latrines. Usually a standard latrine box is

adapted for use as a pail latrine. Remove the pails at least once daily and replace them with clean pails. Each pail should have about 1 inch of a 2-percent cresol solution or some slaked lime in it. The contents may be burned, buried, or placed in fly-proof concrete tanks where it decomposes.

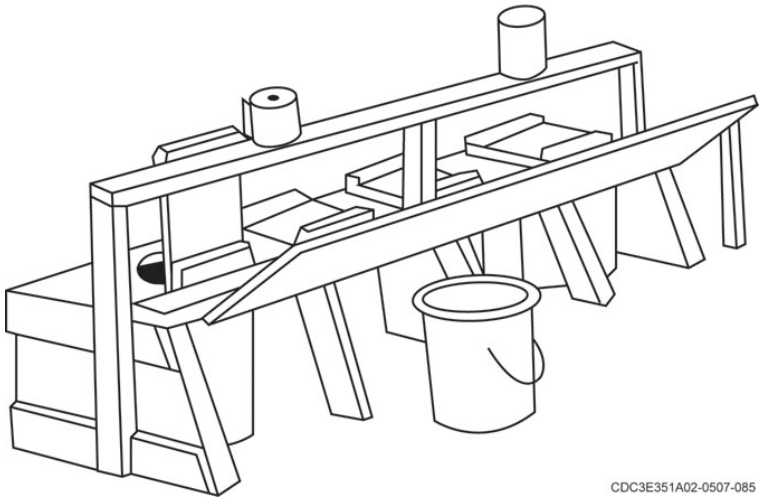

Figure 2–16. Pail latrine.

Trough urinal

A trough urinal (fig. 2–17) is usually built as part of a latrine. The trough may be made of tin, galvanized iron, or wood. When it is made of wood, it should usually be lined with tarpaper. The trough slopes toward one end and empties into a drainpipe. The drainpipe, fitted with a fine mesh fly screen, extends into the latrine or urine soakage pit. Sometimes the pipe is omitted and the trough extends into the pit.

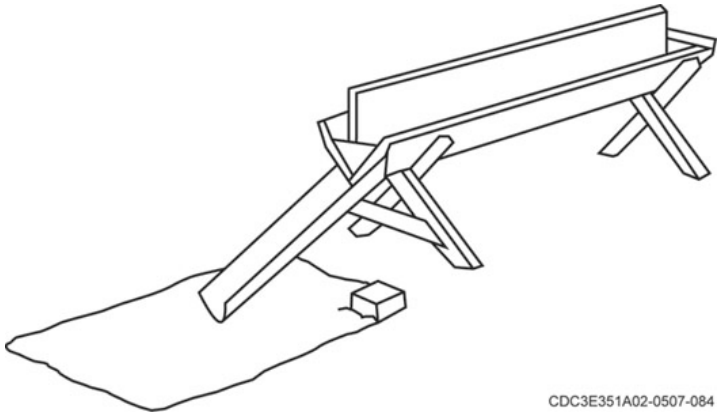

Figure 2–17. Trough urinal.

Self-Test Questions

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

005. Small shelter system erection, maintenance, and disassembly

1. How are all of the base pieces placed when assembling them?

2. When setting the arches onto the base frame, where should all of the bottom arches coded red be placed?

3. In what sequence are the red- and yellow-coded purlins installed?

4. What is used 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 are guy anchors installed for the guy ropes?

7. Which liner is installed in the SSS first?

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

9. What is used to make repairs for larger tears?

006. Medium shelter system erection, maintenance, and disassembly

1. What are the four single-headed spikes used for?

2. How is the floor installed on the MSS?

3. How many sections are assembled together to form an arch assembly?

4. When installing the purlins on the MSS, how are the pins placed?

5. What is a ketter?

6. Once the top liner is in place, how do you check the frame for plumb?

7. What is used to apply tension to the main cover?

8. When is installing the duckbill anchors *not* required?

9. When installing the receptacles in the MSS, at what height above the floor are they placed?

10. In what position should the eight liner panels that come with the MSS be installed?

007. Additional shelters

1. Which shelter can be installed on concrete using thunder studs?

2. Which shelter comes equipped with explosion proof lighting?

3. The Aircraft Maintenance hangar has how many shipping containers installed in the corners?

008. Field latrine construction techniques

1. What distance must there be between latrines and water supplies and messing facilities?

2. What are the ground requirements when siting for a latrine?

3. What size is recommended for a straddle trench latrine?

4. Within what distance of ground level should you close a straddle trench latrine?

5. What type of markings should be made to indicate there is a closed latrine?

6. What soil conditions require the construction of a separate urine soakage pit and what size should it be?

Answers to Self-Test Questions

005

1. With the hooks on the outside of the shelter facing down.
2. On the same side of shelter.
3. You should begin installing the red-coded purlins first, and then work towards the opposite end where the yellow-coded purlins are installed.
4. The hook tool provided with the kit.
5. At least a four- to five-inch overlap.
6. Approximately 36 inches away from the side of shelter.
7. The mid-liner.
8. Cut the patch large enough to extend a minimum of 3 inches on all sides of the damaged area.
9. A hand held heat welder and pressure roller.

006

1. To anchor the end base centers (two at each end).
2. Unfold the non-slip floor and slip the floor cutouts over the base stubs with the black side towards the ground.
3. Each arch assembly consists of six sections with one bottom arch (red coded) on each assembly.
4. Place pins (installed from the top down) through the purlin sleeves and purlins.
5. The ketter is the edge of the panel that slides into a groove in the frame.
6. Hang a pullover rope from the top purlin. If the frame is plumb, the rope will hang straight down.
7. The power pull and extension cable.
8. When the shelter is anchored to a 4-inch reinforced concrete slab.
9. They should be 47 inches up from the floor.
10. They should be positioned with the center loop fasteners all facing towards the same end of the shelter.

007

1. The dome shelter.
2. The LAMS.
3. Four containers.

008

1. At least 100 yards.
2. Construct the latrine on level ground (preferably) and *never* uphill from the campsite or water supplies.
3. 1 foot wide by 2 feet 6 inches deep by 4 feet long. There should be at least 2 feet in between trenches (if multiple trenches are located side-by-side) for footing.
4. Within 1 foot of ground level.
5. A sign “closed latrine” with the closing date placed firmly in the earth over the area.
6. When the latrine pit is in soil that absorbs liquids poorly; about 4 feet square by 4 feet deep.

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).

18. (005) When assembling and installing the arch assemblies on the small shelter system (SSS) where are the red-coded arches placed?
    a. On the top; same side.
    b. On the top; alternating sides.
    c. On the bottom; same side.
    d. On the bottom; alternating sides.

19. (005) In order to secure the purlins to the arches on a small shelter system (SSS) slip the purlins through the
    a. base hooks and place pins from the top down.
    b. base hooks and place pins from the bottom up.
    c. purlin sleeves and place pins from the top down.
    d. purlin sleeves and place pins from the bottom up.

20. (005) When installing the main cover on a small shelter system (SSS), you should work the cover over the ends until you have at least a
    a. 2- to 3-inch overlap.
    b. 3- to 4-inch overlap.
    c. 4- to 5-inch overlap.
    d. 5- to 6-inch overlap.

21. (005) Approximately where and how are guy anchors installed for the small shelter system (SSS)?
    a. 18 inches away from the side with the top of the anchor towards the shelter.
    b. 18 inches away from the side with the top of the anchor away from the shelter.
    c. 36 inches away from the side with the top of the anchor towards the shelter.
    d. 36 inches away from the side with the top of the anchor away from the shelter.

22. (005) Identify the proper sequence for installing liners in the small shelter system (SSS).
    a. End liners, side liners, and mid liner.
    b. End liners, mid liner, and side liners.
    c. Mid liner, end liners, and side liners.
    d. Mid liner, side liners, and end liners.

23. (005) What is the *first* step when disassembling the small shelter system (SSS)?
    a. Attach the pullover ropes to the cover.
    b. Loosen tight-fitting pins from the purlins.
    c. Refer to the technical order for the correct packing sequence.
    d. Ensure that all power is disconnected from the electrical system at the source.

24. (006) When assembling a medium shelter system's (MSS) base frame, the four single-headed spikes are used to
    a. attach the duckbill anchors.
    b. anchor the end base centers.
    c. connect the vestibule assemblies.
    d. secure the four corners of the frame.

25. (006) When the cold weather kit is used how is the medium shelter system's (MSS) floor installed?
    a. Install the floor black-side up; then install the insulated floor pads.
    b. Install the floor black-side down; then install the insulated floor pads.
    c. Install the insulated floor pads first; then install the floor with the black-side up.
    d. Install the insulated floor pads first; then install the floor with the black-side down.

26. (006) How many pullover ropes are used to install the top liner on the medium shelter system (MSS)?
    a. Two.
    b. Three.
    c. Four.
    d. Six.

27. (006) How many pullover ropes are used to install the main cover on the medium shelter system (MSS)?
    a. Two.
    b. Three.
    c. Four.
    d. Six.

28. (006) Which of the following procedures is *not* required when a medium shelter system (MSS) is anchored to a 4-inch reinforced concrete slab?
    a. Fastening the guy ropes.
    b. Securing the base clamps.
    c. Installing the duckbill anchors.
    d. Tightening the top liner contour rope.

29. (006) At which height above the floor are the receptacles installed in a medium shelter system (MSS)?
    a. 12 inches.
    b. 18 inches.
    c. 35 inches.
    d. 47 inches.

30. (007) The shelter that can be installed directly on concrete using thunder studs is the
    a. dome shelter.
    b. small shelter system.
    c. medium shelter system.
    d. large area maintenance shelter.

31. (007) Which shelter has a main structure that consists of 7 arches and two endwalls?
    a. Dome shelter.
    b. Aircraft maintenance hangar.
    c. Large area maintenance shelter.
    d. Frame-supported tensioned fabric shelter.

32. (007) The aircraft maintenance hangar (ACH) has how many shipping containers installed in the corners for office space?
    a. 2.
    b. 3.
    c. 4.
    d. 6.

33. (008) You should construct field latrines on
    a. level ground and never uphill from the campsite.
    b. level ground and never downhill from the campsite.
    c. sloped ground and never uphill from the campsite.
    d. sloped ground and never downhill from the campsite.

34. (008) When digging multiple side-by-side trenches for the saddle trench latrine, how much space should you allow in between the trenches for footing?
    a. ½ foot.
    b. 1 foot.
    c. 1 ½ feet.
    d. 2 feet.

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. Airfields, Revetments, and Shelter Doors

THIS UNIT COVERS SOME of the tasks that you may do during a contingency or wartime operation. In this ever-changing world, there is a very likely possibility that you or someone you know may have to perform a task described in this unit. How well you know the information presented could mean the difference between mission accomplishment and mission failure. The information presented here is on airfield damage repair, airfield paint striping, revetments and hardened aircraft shelter doors—all very important items in any wartime or contingency operation.

3–1. Airfield Damage Repair

Over the years, Air Force civil engineers trained under the concept known as rapid runway repair (RRR); however, we now train under the airfield damage repair (ADR) philosophy. ADR encompasses more than just pavement repair. In this section, we discuss some of the items that make up ADR.

009. Airfield damage repair philosophy

Damage assessment, explosive ordnance reconnaissance, minimum operating strip (MOS) selection, repair quality criteria, aircraft arresting system, and utility system repairs are just a few of the areas that must also be considered under ADR. In this lesson, we provide an overview of the main areas that pertain to the repair of airfield pavement.

Engineer activities

After an air base is attacked, engineer personnel respond with four activities to provide adequate launch and recovery surfaces for mission aircraft. Below are the four engineer activities:

- Damage assessment.
- MOS selection.
- Explosive ordnance safing and disposal.
- Bomb damage repair.

In this era of new global strategies, the wartime scenario is often different from that anticipated in the past. Instead of repairing a damaged airfield in friendly territory, we are restoring airfields formerly occupied by hostile troops, damaged during forcible entry, and subsequently sabotaged and booby trapped by departing unfriendly forces. Lines of communication are longer and acquisition of

materials more difficult. Thus, more emphasis is placed on force protection and sustainment engineering.

Damage assessment

Damage assessment activities are categorized into two distinct areas—airfield damage repair assessment and facility and utility damage assessment; however, we limit our discussion in this lesson to airfield damage repair assessment.

Airfield damage repair assessment includes evaluation of damage involving runway surfaces, taxiway surfaces, and other facilities that directly support aircraft operations. Since major recovery tasks cannot be started until damage assessment and MOS selection are completed, speed and accuracy during damage assessment are essential. The damage assessment teams (DAT) determine and report the location, types, and numbers of unexploded ordnance (UXO), and the location, types, and quantity of airfield pavement damage to the emergency operations center (EOC), formerly known as the survival recovery center (SRC). A qualified team from the EOC, known as the MOS selection team, uses this information to select the MOS, which must be cleared and repaired in order to launch and recover aircraft.

MOS selection

After an airbase attack, the base commander's immediate problem is to launch and recover mission aircraft as soon as possible. The base engineer must recommend the best airfield surfaces to repair; that is, those that require the least repair time but still provide adequate launch and recovery surfaces for mission aircraft. The launch and recovery surface selected for repair is called the minimum operating strip or MOS. The MOS is the area the aircraft take off and land. When a MOS is combined with access taxiways from aircraft staging areas such as shelters and parking aprons, the entire area becomes the minimum airfield operating surface (MAOS).

The length of the MOS depends on the take-off or landing distance of the mission aircraft (whichever is greater). Listed below are the typical MOS dimensions for various aircraft:

- Fighter aircraft—5,000 feet long by 50 feet wide.
- C–130 Hercules—3,500 feet long by 60 feet wide.
- C–17 Globemaster III—at least 3,500 feet long (but may be longer depending upon altitude, surface type, and runway condition rating of the airfield) and 90 feet wide.

NOTE: These dimensions do not include the requirement for the 300-foot overruns.

Explosive ordnance safing and disposal

During damage assessment, DATs must gather three types of information—location of pavement damage caused by bombs, cannon fire, and UXO data. The UXO data should include information regarding type, location, and number. UXO that may influence aircraft operations must be accurately located, reported, and recorded in sufficient detail for the EOC explosive ordnance disposal representative to determine the risk to aircraft operations. The information below should be obtained for an adequate assessment.

- Location.
- Quantity.
- Size.
- Shape.
- Color.
- Distinctive markings.
- Fuse type and condition.

All UXO within 300 feet of repair operations or aircraft operating surfaces must be identified. Holes of entry for subsurface UXO and camouflet craters must also be reported. Once an MOS site has been selected, the unit control center (UCC) is notified so that the ADR teams can be dispatched. At the same time, the EOC directs the explosive ordnance disposal (EOD) technician to dispatch the UXO safing and bomb removal teams to clear the ADR team's route to the MOS and the MOS itself of munitions.

Bomb damage repair

After selection of the MOS and removal of UXOs, debris can be removed and repairs initiated. Damage to runways, taxiways, and other aircraft operating surfaces is classified as spalls or craters based on severity of damage. Repair categories are termed expedient, sustainment, or permanent.

Pavement damage categories

The two pavement damage categories you should be familiar with are spall and craters.

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 5 feet in diameter.

Craters

Craters are damage that penetrates through the pavement surface into the underlying base and subgrade soil uplifting the surrounding pavement and ejecting soil, rock, and pavement debris around the impact area. Obviously, crater damage is more severe than spall damage. Large craters have an apparent diameter equal to or greater than 15 feet; small craters have an apparent diameter less than 15 feet.

Types of airfield damage repairs

Depending on the situation, there are different repair procedures based upon the type of repair. Below are the three types of repairs:

- Expedient repair.
- Sustainment repair.
- Permanent repair.

Expedient repair

Expedient repairs are defined as airfield pavement repairs that create an operationally capable MOS and/or MAOS, based on projected mission aircraft requirements, in the fastest manner possible. Under ideal situations, where sufficient equipment and materials are available, individual crater repairs should be completed within four hours. Austere bases where required equipment and materials are not readily available require additional time for crater repair.

NOTE: Criteria is established for expedient repairs to provide an accessible and functional MOS and/or MAOS for 100 passes of a particular aircraft at its projected mission weight or the number of passes required to support the initial surge mission aircraft.

Sustainment repair

Sustainment repairs are efforts designed to upgrade expedient repairs for increased aircraft traffic. 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 an MOS and/or MAOS are expected to support the operation of 5,000 C–17 or C–130 passes (at their respective gross weights) or the number of passes required to support mission aircraft at the projected mission weights throughout the anticipated operation. (**NOTE:** While construction time is important for conducting sustainment repairs, quality control is even more important so that further maintenance is minimized.)

NOTE: Once the conflict is over, permanent repairs can return the air base to its original condition.

010. Airfield repair procedures

Repair quality criteria (RQC) calculations and the MOS repair procedures must begin in a timely fashion to make the airfield operational. There are varying activities that are accomplished in a necessary order. In this lesson, we discuss some of these activities. (**NOTE:** The purpose of RQC is to provide a single number, expressed in inches, for each MOS crater repair.)

Airfied damage repair

ADR is the capability to repair bomb-damaged runways and taxiways in the shortest possible time. The procedures to accomplish this must be well-planned, realistic, and workable.

Crater repair process

The crater repair process is a modular and scalable team-based process. Each crater repair team is capable of repairing up to 18 craters in 6 hours 48 minutes for rapid-set concrete caps, or 6 hours 52 minutes for asphalt caps in 18-inch thick concrete with no reinforcing steel. The repair times listed here do not take into consideration the time for airfield damage assessment, time required to mitigate UXOs, time required to convoy to the repair area, chemical, biological, radiological and nuclear (CBRN) threat, or attrition.

ADR equipment sets

The Air Force ADR equipment set is a standardized set of equipment and vehicles that enables Air Force civil engineers to conduct ADR. There are four fielded ADR sets. The sets are graduated in a building-block manner to provide a designated crater repair capability.

Small ADR set

This set supports the repair of bomb craters with AM–2 matting and/or folded fiberglass mat (FFM). Small sets are designed around a 91-person team and contain 61 items of vehicles and/or construction equipment (e.g., front-end loaders, dump trucks, excavators) and additional supplemental items (flood lights, spall repair material, AM–2, fiberglass mats).

Medium ADR set

This set supports the repair of bomb craters with AM–2 matting and/or FFM. Medium sets are designed around a 164-person team and contain 135 items of vehicles and/or construction equipment (e.g., front-end loaders, dump trucks, excavators) and additional supplemental items (flood lights, spall repair material, AM–2, fiberglass mats).

Large ADR set

This set supports the repair of bomb craters with AM–2 matting and/or FFM. Large sets are designed around a 237-person team and contain 209 items of vehicles and/or construction equipment (e.g., front-end loaders, dump trucks, excavators) and additional supplemental items (flood lights, spall repair material, AM–2, fiberglass mats).

Very large ADR set

This set supports the repair of bomb craters with AM–2 matting and/or FFM. Very large sets are designed around a 310-person team and contain 283 items of vehicles and/or construction equipment (e.g., front-end loaders, dump trucks, excavators) and additional supplemental items (flood lights, spall repair material, AM–2, fiberglass mats).

Expedient crater repairs

At present, the Air Force uses three main types of crater repair methods. These are debris backfill, choke ballast over debris, and sand-grid methods. Each repair method requires basically the same crater preparation before we can install the foreign object damage (FOD) surface.

The following are the preparation steps required:

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 RQC before placement of the FOD cover surface.

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.

Repair quality criteria

Once the wing commander has selected the MOS for repair and the UCC has dispatched the ADR teams, the MOS selection team performs the mandatory portion of the RQC process. Using the initial data obtained from the crisis action team (CAT) and the crater location, size, and spacing information pertaining to the chosen MOS, RQC calculations are performed. When completed, they are compared with those obtained at the alternate EOC and the UCC (if applicable) as a crosscheck for accuracy.

As repairs progress and actual repair patch locations, lengths, and spacing are identified, the ADR team chief relays this information back to the UCC and EOC. Repair quality criteria calculations are then reaccomplished to see if criteria have been altered due to changes in actual crater locations, lengths, and spacing found during the repair process. The results of these calculations are provided to the ADR team chief. If crater repairs are within tolerance, the ADR team completes MOS cleanup and progresses to its next assigned tasking. If, however, repairs are not within RQC tolerance, the wing commander is informed of the situation and the commander makes a decision whether to attempt aircraft operations under such conditions. If the decision is negative, the ADR team must reaccomplish the out-of-tolerance crater repairs until they are suitable for aircraft use (i.e., meet RQC tolerances).

After repairs are complete and the MOS is usable, RQC calculations continue to apply for maintenance purposes. The tolerance measurements for each repair patch also provide information for maintenance purposes. With sustained aircraft use, the repaired craters on the MOS are most likely to begin to settle. This settlement, called sag, could be just as damaging to aircraft landing gear as original crater repairs that are out-of-tolerance. Therefore, periodic checks of the repair patch quality on sag must be made to ensure their suitability for continued aircraft use. If a patch is found to be nearing an out-of-tolerance condition, an arrangement must be made with the airfield operations function to allow MOS downtime for crater repairs. It is also important to note changes in weather conditions. Wide temperature changes and precipitation require RQC be recalculated.

NOTE: The filled-in crater should be flush with adjacent undamaged pavement surfaces, but ¾-inch, plus or minus, is allowed (fig. 3–1). To fully understand RQC procedures, you should refer to TO 35E2–4–1, *Repair Quality Criteria System for Rapid Runway Repair*.

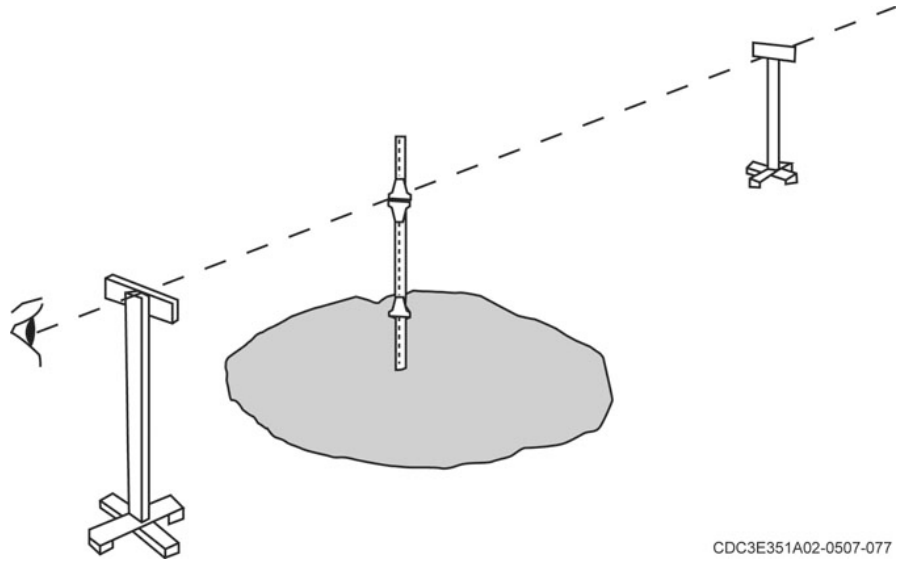

Figure 3–1. Repair quality criteria.

011. Assembling AM–2 matting

In this lesson, we discuss the standard procedures used to assemble AM–2 matting. Once the mainstay of runway crater repairs, AM–2 is now mostly used for taxiway repairs and parking apron expansions. It does, however, represent an option for runway repairs if other methods cannot be used. AM–2 mat repair must meet the RQC for its location on the runway.

General information

The AM–2 matting that we use is part of an airfield pavement patch kit. It provides us with a fast and efficient way to patch taxiways. It is rarely used on a MOS because of the bounce that an aircraft encounters when its wheels hit the height difference between the patch and the undamaged pavement. Figure 3–2 shows you a cross section of AM–2 mat.

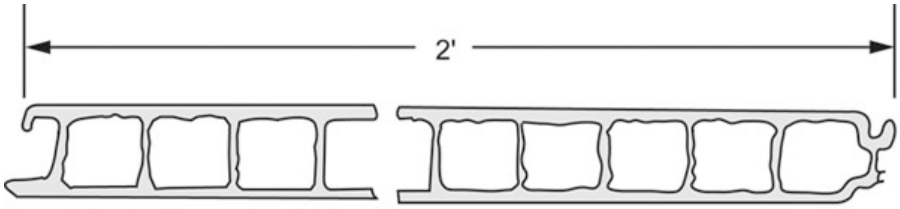

Figure 3–2. AM–2 mat cross section.

Limitations

AM–2 mat repair kits are generally acceptable for fighter aircraft and C–130s but not for jet cargo aircraft landing strips. This is due to the inadequate anchoring system, narrow patch width (54 feet wide by 77 feet 6 inches long), and susceptibility to jet blast from outboard engines. AM–2 mats can be used to repair taxiways and aprons if braking and tight turns are limited on the mat.

Base quality

Experience has shown that AM–2 performs best on a layer of clean, well-graded, compacted crushed stone subbase (fig. 3–3). The amount of maintenance required to care for this mat varies depending on the following factors: soil condition, quality of the base and/or subbase, use of a geotextile, weather, and aircraft traffic.

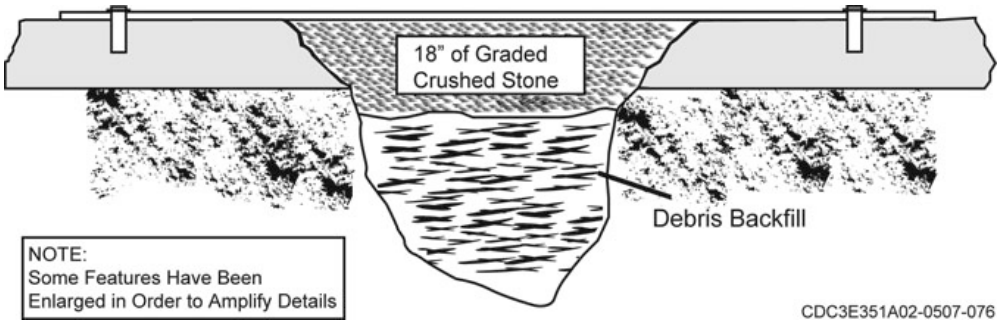

Figure 3–3. Crater fill.

Geotextile

When an inferior silt or clay base is present, AM–2 matting performs much better with geotextile placed beneath the AM–2 surface. Although the initial cost of geotextile is high, it can be cost-effective for long-term operations. The use of a medium weight geotextile is recommended for separation applications in pavements.

Traffic

The most important step in prolonging the life of AM–2 that is laid directly on a silt or clay base is to keep aircraft and vehicular traffic to an absolute minimum during and following periods of inclement weather. This allows water under the surface to drain completely from the base; otherwise, the impact of the traffic pumps the water into the base and destroys it.

Precautions in repairing and/or laying AM–2 panels

Remember that AM–2 can only be laid in one direction—right to left facing the direction the mat is placed. The proven facts below was provided through experiences with AM–2.

- It requires 200 to 300 percent more effort to place AM–2 than to remove it.
- The more exact the base course finished grade, the easier it is to lay AM–2.
- Six hours is about the maximum time a person can sustain production when handling AM–2. Due to the heat in the tropics, people can handle more matting in a six-hour night shift than in a 10-hour day shift in the heat of the day.
- Use a string line along the edge for proper alignment.
- To maintain proper alignment, always use a locking bar as a spacer behind the last joint.
- Never crowd the bundles of stacked panels next to the panels being laid. You may have to move the stacked bundles twice.

Mat team configuration

There is no set rule for team size; however, field experience shows that a 16-man team works well. Below is the recommended team configuration:

- 1 mat chief to supervise construction.
- 1 alignment person to make sure that the first mat in each row is in proper alignment.
- 2 pry bar people to adjust the individual mats and to insert the locking bars.
- 12 (six 2-person teams) mat installation people to lay the mat in place.

General AM–2 assembly guidelines

AM–2 matting can be assembled in place (taxiway and aprons) or away from the repair and towed into position (crater repair). Mats assembled in place usually don't require all the ancillary pieces, like a starter key lock, mandrels, or towing tubes that mats to be towed into place require in order to prevent them from separating during towing.

AM–2 can be assembled as a crater cover that is usually 54 feet wide by 77 feet 6 inches long, or as a FOD cover to extend a parking ramp.

Assembling AM–2 matting

The following steps are involved in assembling AM–2 matting:

1. Select the assembly area—Choose an assembly area that is undamaged, preferably on the pavement. The area should allow for a straight, single direction (either parallel or perpendicular to the crater) short pull of the assembled matting. Be sure the areas are cleared of all debris before assembling the matting. (**NOTE:** Debris may accumulate in the matting grooves if not removed.)
2. Assemble the keylock—Assemble and place the starter keylock at the appropriate extended centerline of the crater (either parallel or perpendicular to the MOS centerline). The assembled keylock is 54 feet long.
3. Assemble the towing tubes—The towing tubes serve two purposes—1) they allow the assembled patch to be pulled sideways and 2) with the towing tubes attached on both sides, the assembled matting is totally locked together and does not separate during positioning or continued use. (**NOTE:** 15 rows of matting (30 feet) are placed on one side of the keylock and 20 rows of matting (40 feet) are placed on the remaining side.)
4. Attaching towing tubes—There are various methods of attaching the towing tubes to the matting; however, we only discuss two methods.

Concurrent with keylock

Concurrent with the keylock assembly, preassemble towing tubes, mandrel, connector fittings, stops, and end caps. (**NOTE:** Do not tighten the end caps.) Towing tubes should be assembled perpendicular to the keylock assembly and are required on both sides of the assembled matting. The assembled keylock and towing tubes, before the placement of the matting, resemble the shape of a capital “H.” Below are the steps to follow for towing tubes:

1. Initially, two starter-towing tubes are placed on a 20-foot piece of assembled mandrel, centered on the special connector fitting next to both ends of the keylock. (**NOTE:** Starter towing tubes are 1 inch longer than the normal towing tubes and do not have a hole for connecting towing clamps.)
2. The starter tube that receives the first piece of matting placed on the keylock must be placed on the mandrel with the prongs facing up. The starter tube that receives the last piece of matting from the first row must be placed on the mandrel with prongs up also, but is rotated to prongs down when attached to the matting.
3. Place sufficient towing tubes (15 on one side and 20 on the other) and mandrels with connector fittings to accommodate the total patch. If there are fewer than five mats remaining at the end of the patch, use a short mandrel for each one. Towing tubes should be placed with prongs located identical to the starter tubes.
4. After all tubes are placed on the mandrels (total of 2 starter tubes and 33 towing tubes on each side), place the stop and end cap on each end of the mandrel. (**NOTE:** Do not tighten the end caps until the total matting patch has been assembled.)

Concurrent with mat assembly

This is a build-as-you-go method that is done concurrently with the mat assembly. This process is completed by accomplishing the following steps:

1. Use one long connector to connect two long mandrels on each side of the end of the keylock. After the mandrels are connected and laid out, slide in two starter tubes, centering them on each mandrel at the center connector fitting. Remember, starter tubes are 1 inch longer than towing tubes and do not have holes drilled for the towing harness.

2. Since the matting is always laid from left to right (facing the mat laying operation), the starter tube that receives the first piece of matting placed on the keylock must be placed on the mandrel with the prongs facing up. The starter tube that receives the last piece of matting from the first row must be placed on the mandrel with the prongs up and (when connected to the end of the matting) must be rotated 180 degrees on the mandrel to the prong down position.
3. Initial and final attachment of each tube on every row is locked with a locking bar. Additional towing tubes should be placed on each mandrel, as they are needed, staying ahead of the mat-laying crew at least one mandrel length until the job is done.
4. When all towing tubes have been installed on the mandrels, place stop and end caps into the ends of each mandrel. Make sure that the long ends of the stops are loose and are facing toward the patch.

Laying the mat

To keep confusion to a minimum, deliver each patch assembly in total to the selected assembly area. Off-load and position the AM–2 bundles properly to enhance the assembly effort. Bundles should be positioned on wooden dunnage to make the removal of metal and plates easier. (**NOTE:** Position the bundles to give the matting teams the shortest walking distance.) The steps below are for proper laying of the mat:

1. Starting with the full-size mats, connect a row of four 12-foot mats and one 6-foot mat to the keylock (laying from left to right). Figure 3–4 shows the first row connected to the starter keylock. Insert the locking bar at each end joint (fig. 3–5), as well as a locking bar at both of the towing tube connections. Now lay a second row using the same procedures but start with the 6-foot mat. (**NOTE:** The minimum required length of the patch is 77 feet 6 inches (including ramps), but may be longer, depending on the size of the crater. The 54-foot width is constant.)
2. Double check to make sure that the first two rows of mats and keylock are straight. Then, starting with a full-size mat lay one row of mats on the other side of the keylock to keep the keylock from shifting. After the matting has been placed on each side of the keylock, begin laying matting on both sides at the same time.
3. Use a locking bar as a spacer between mats while assembling the patch to keep the rows properly aligned. Leave the locking bar (“T” spacer) in place for at least three rows back from the row presently being installed. Figure 3–6 shows them aligning the mat rows. Placing locking bars where the arrow is pointed helps in keeping the mats properly aligned.
4. After the patch has been completely assembled, the towing tube is now assembled. Tighten the end caps as previously indicated.

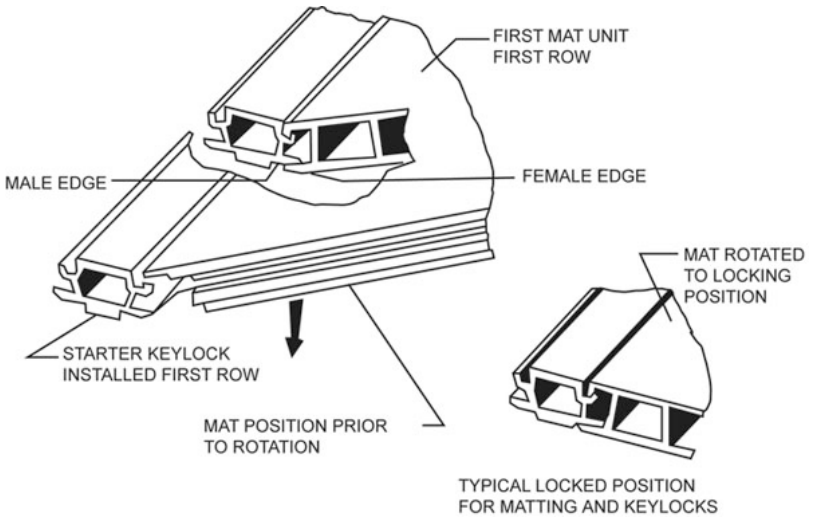

Figure 3–4. Connecting mat to starter keylock.

Ramps were developed to ease the transition from the pavement surface onto the mat. Start at the right corner of the assembled mat to connect the first ramp. Place the next ramp so that the holes in the overlapping plate are aligned with the threaded inserts on the ramp just installed. Fasten with flat-head screws coated with anti-seize compound. Use locking bar spacers between the mat and the ramp to keep it properly aligned.

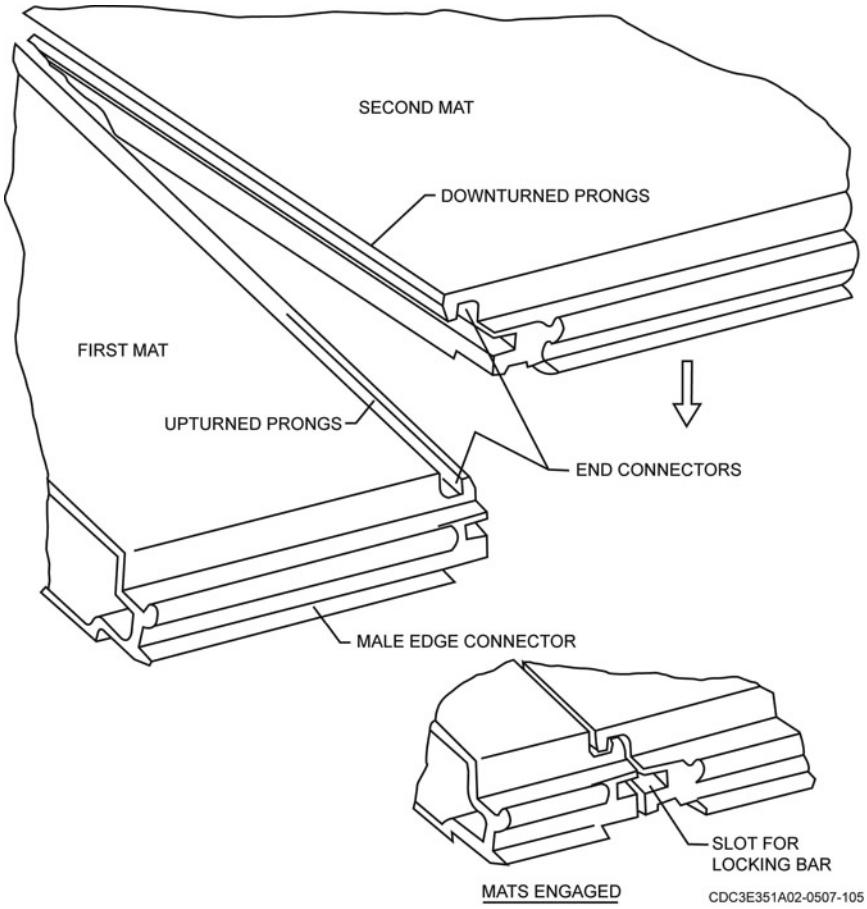

Figure 3–5. Locking bar end joint.

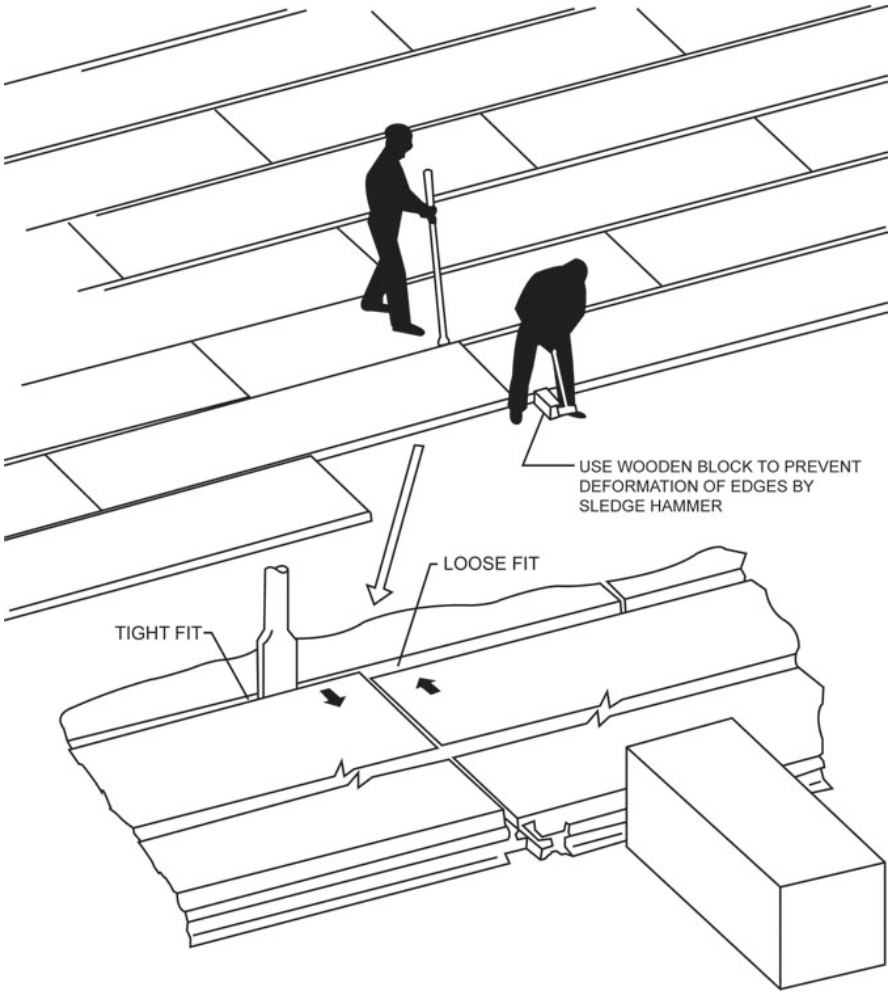

Figure 3–6. Aligning rows.

012. Assembling folded fiberglass mat

FFM is sometimes referred to as a FOD cover mat. We use it as the primary cover over filled craters on the MOS, and it can be used to cover other repaired airfield pavements. Since most repairs require that we join two FFMs together, our discussion focuses on installing two FFMs. If you need more specific information on the FFM, see TO 35E2–3–1, *Rapid Runway Repair System*.

Folded fiberglass mat

Each mat consists of nine fiberglass panels with each panel being 6 feet wide, 30 feet long, and about ⅜-inch thick. The panels are connected together with elostomer hinges that are about 3 inches wide. Figure 3–7 shows you how the mat looks folded and unfolded. The joining panels come in 24-foot lengths and 30-foot lengths and are installed with bushings and anchor bolts as shown in figure 3–8. One of each length is needed to join the two mats together. A standard patch consists of two panels when attached make the overall patch 60 feet by 54 feet.

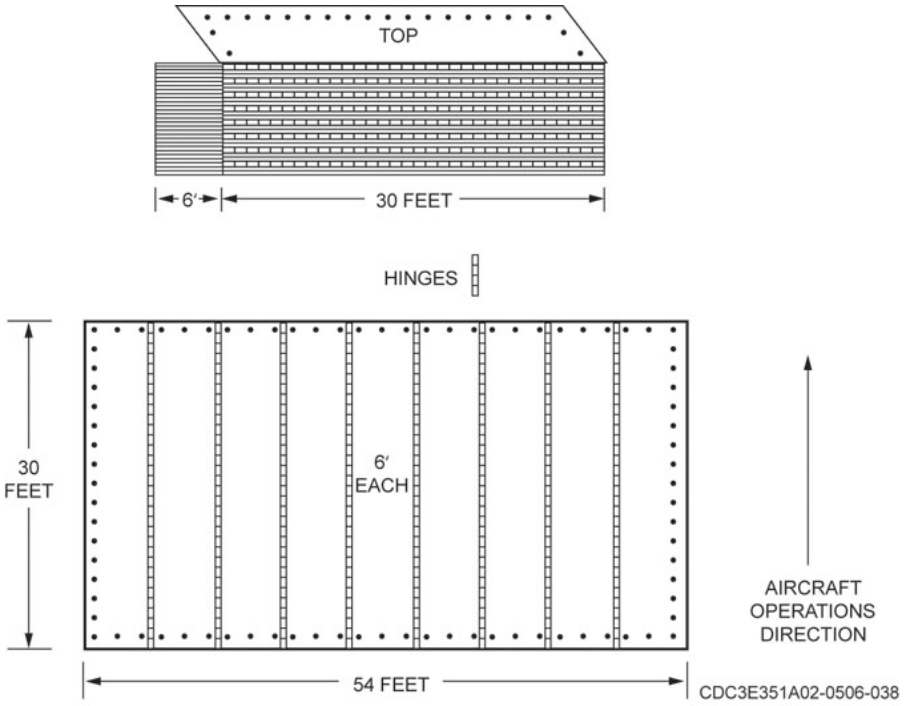

Figure 3–7. Folded and unfolded FFM.

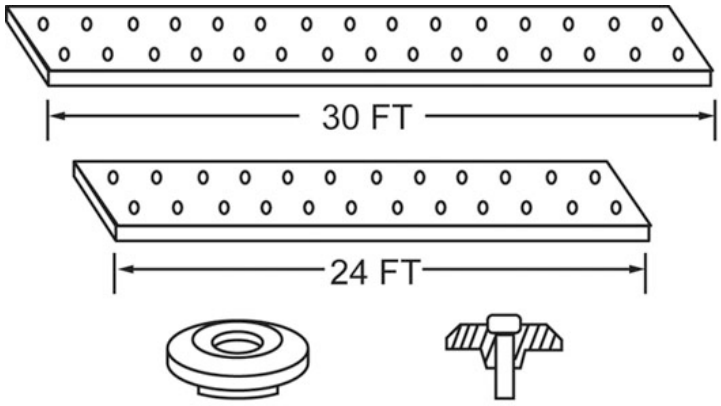

Figure 3–8. Joining panels.

Folded fiberglass mat assembly

The tools and hardware that you need to assemble, install, and maintain the FFM are included in mat kit "A." Depending on the situation, the FFM is usually placed in a dispersal location before the airfield is attacked. After the airfield is attacked, the FFM is transported from the dispersal area to an assembly location that the ADR crater team chief selects. You assemble the FFM while the crater repair team fills in the crater. The area selected must be cleared, well swept, and large enough for two mats to be unfolded without interfering with crater filling. Each mat weighs about 3,000 pounds and can be unloaded with two forklifts or two front-end loaders with fork attachments. The two mats are placed end-to-end about 4 feet apart.

To begin unfolding the mat, you attach a nylon strap to the top FFM panel, as shown in figure 3–9. You attach the other strap end to a front-end loader or other tow vehicle. This vehicle is driven slowly to pull the mat open as it is being unfolded. At least a four-member team or another front-end loader with forks is positioned on the opposite mat side to lift each successive panel as the tow vehicle pulls the mat. The steps for unfolding are shown in figure 3–10.

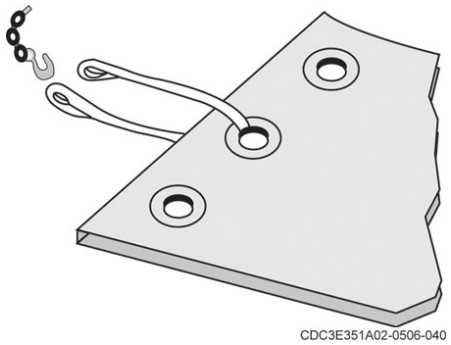

Figure 3–9. Attaching a nylon strap.

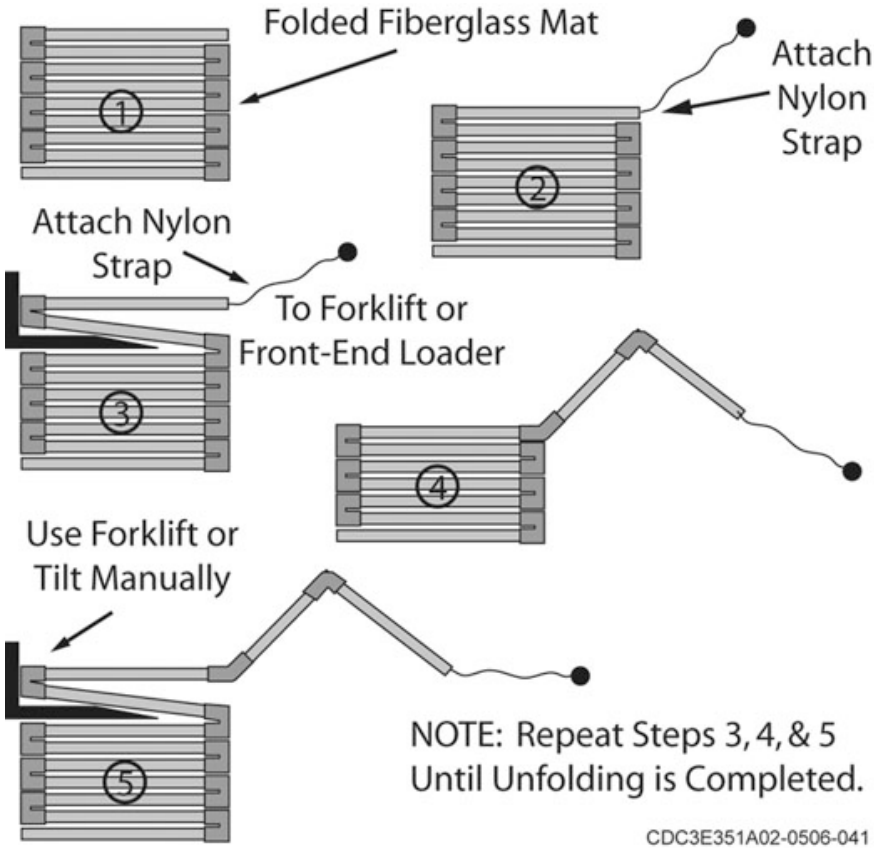

Figure 3–10. Unfolding a FFM.

After the mats are unfolded, you need to take a special step to eliminate a potential FOD problem. Field use shows that resin sometimes flakes at the hinge locations. To counteract it, have a vibratory roller make one pass down each hinge location and follow with a broom sweeper. This action normally loosens and removes the flaking resin. Now, align the mats so that the 30-foot edges are even and the 54-foot edges are roughly parallel and you are ready to join the two mats together as indicated in the eight steps below:

1. On the first mat, raise the edge on one of the 54-foot sides and slip in either the 24-foot or the 30-foot joining panel underneath it. (**NOTE:** The joining panels have female bushings installed on the bottom, as shown in figure 3–11.)
2. Align the holes in the mat with the bushing holes in the joining panels and lower the raised edge.
3. Install the top (male) joining bushings and hand-tighten them. Repeat the process for the remaining joining panel.

4. Tow the second mat (54-foot edge side) so that one bushing hole lines up over its matching hole in the joining panel.
5. Lower the second mat; install a top (male) bushing and hand-tighten it. This serves as a pivot point to align the remaining holes in the second mat and the joining panels.
6. Align the remaining holes in the second mat with the joining panel; install the top (male) bushings and tighten with an impact wrench.
7. Use the impact wrench to tighten the bushings in the first mat.
8. Tow the joined mat to cover the crater with approval from the ADR crater team chief.

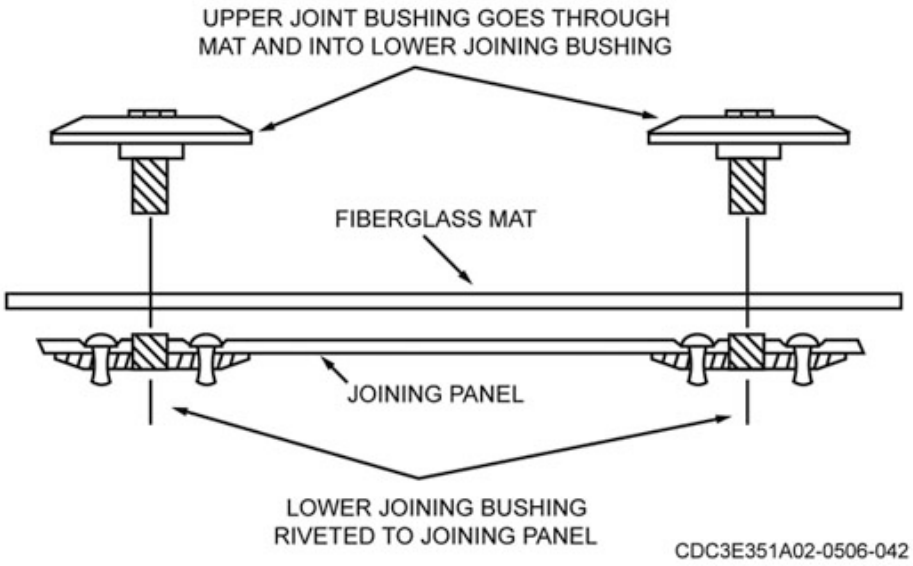

Figure 3–11. Bushing installation.

Folded fiberglass mat anchoring

Your next step is to anchor the mat to the airfield pavement using mat kit B. It contains the anchor system that you need for different airfield pavements. The FFM comes pre-drilled for anchor bolts that are only installed on the leading and trailing edges. The anchor bolts that we use have a bolt and threaded sleeve that expands when tightened in a drilled hole. All anchor bolts use a 4-inch floating anchor bushing that the bolt passes through to hold the mat down. The anchor bolt that you use depends on the pavement type. The three anchoring systems that we cover are for concrete pavements, asphalt-overlaid concrete pavements, and asphalt pavements.

Anchoring to concrete pavements

The anchor bolts that you use for concrete pavements are normally 5 to 6 inches long and ⅝ to ¾ inch in diameter. Below are steps to take at each predrilled location in the leading and trailing edges:

1. Drill holes into the pavement at least ½ inch longer than the anchor bolts.
2. Use compressed air to blow out the drilled holes.
3. Place 4-inch floating anchor bushings into the FFM surface.
4. Place the bolts through the bushings and into the drilled holes.
5. Tighten all anchor bolts with an impact wrench.

Anchoring to asphalt-overlaid concrete pavements

The anchor bolts that you use for asphalt-overlaid concrete pavements are normally 9½ to 10½ inches long and ⅝ to ¾ inch in diameter. They are used for asphalt that is about 6 inches thick with 8 inches of concrete underneath. To install them, you can follow the same procedures given for anchoring into

concrete pavements. The key factor is to make sure that you set the anchor bolts deep enough into the concrete to provide a firm grip.

Anchoring to asphalt pavements

The anchoring system that you use for asphalt pavements is normally anchor bolts that are 9½ inches long with a poured-in polymer plug. The procedure to use this system is explained in the following steps:

1. Drill holes into the asphalt 10 inches deep and 1½ inch in diameter.
2. Mix the two-part resin polymer and pour it into each drilled hole to about ½ inch below the pavement surface.
3. Place anchor bolts through 4-inch floating bushings.
4. Place each anchor bolt into each polymer-filled hole.

This system requires teamwork because the polymer hardens in about three minutes and you probably *don't* have time to drill all the holes before pouring the polymer.

Folded fiberglass mat re-anchoring

Under certain conditions, you may have to re-anchor the FFM. The statements below explain what re-anchoring methods you can use when anchor bolts become loose.

1. Remove the loose anchor bolt, drill a 1½-inch hole in the original location, and follow the anchoring method for asphalt pavements. (**NOTE:** You can use this method for asphalt pavements.)
2. Replace the loose anchor bolts with new ones that are the same length, but larger in diameter. (**NOTE:** You can use this method for anchoring into concrete pavements and asphalt-overlaid concrete pavements.)
3. Remove all anchor bolts, move the mat at least 6 inches, and use the same anchoring system that was used to originally install the FFM. (**NOTE:** You can use this method for all pavement types.)

Another condition that requires you to re-anchor an FFM involves a crater repair that has failed. Below are the steps to follow in order to make it safe for aircraft operations:

1. Remove all anchor bolts and bushings.
2. Tow the FFM away from the crater.
3. Repair the crater.
4. Check the crater to make sure it is within the tolerance for the FFM.
5. Tow the FFM over the crater.
6. Align the anchor-bolt holes so that they are at least 6 inches away from the original drilled holes.
7. Use the same anchoring system that was used to originally anchor the mat to the pavement.

013. Spall repair procedures

Spalls are surface damage (missing pieces of pavement) that *does not* penetrate the base course and *does not* damage an area greater than 5 feet in diameter. Spalls are usually expected after an airfield attack. Ordnance, strafing, bomblet detonation, and bomb fragmentation cause the typical damage. In this lesson, we discuss standard procedures used that you can use to make spall repairs.

Spall repair

To repair the damage, there are normally three spall repair teams that have four members on each team. As a structural journeyman, you could be on one of these teams. Before you apply any fill material, you must first clean the repair area and remove any loose pavement pieces. If time permits,

use a jackhammer to form 1-inch-deep sidewalls when a spall is shallow and dish-shaped. This action reduces the chance of the repair popping out when aircraft wheels repeatedly roll over the repair.

With the spalls prepared, you are ready to apply the fill material. You make repairs by filling in the missing pieces with a material that restores a smooth and level surface. There are several materials that can be used to make spall repairs; however, we limit our discussion to two—polymer concrete and magnesium phosphate cement. An important point to remember is to always follow the manufacturer's instructions for the fill material that you are using. Let's review the different procedures needed for the two different fill material types.

Polymer concrete

Polymer concrete is the preferred fill material that we use for spalls, but it is toxic and flammable before it dries. For protection, you must wear a vapor chemical cartridge respirator, impervious neoprene gloves, and splash-proof goggles or a full-face respirator. Polymer concrete ingredients include powder resin, powder hardener, liquid component, and a cold weather accelerator component. These ingredients are mixed together to make a smooth patch that fills in the spalled airfield surface. You must work quickly because once mixed, the mortar is only workable for 5 to 10 minutes and then sets up in 20 minutes. Below are common repair procedures:

1. Remove any standing water from the spalls.
2. Use compressed air or a leaf blower to dry the spalls.
3. Mix the ingredients together in the proper quantity and sequence using the mixing bag provided.
4. Hold the mixing bag over the spalls and slit the plastic bag open with a trowel. (**NOTE:** The polymer mix should flow as a liquid. If it does not, either too much aggregate was added or too much hardener was added and the mix has started to set. In either case, discard it and make a new mix.)
5. Use a trowel to tamp and level the mix over the spalls.
6. Clean all tools with the proper solvent before the mix hardens on them.

Magnesium phosphate cement

The magnesium phosphate cement that we use is a quick-setting inorganic compound that is similar to Portland cement. It is water based, and to some degree it displaces water from a wet spall. It also bonds well to wet or dry concrete or asphalt surfaces. You mix it into a mortar and smooth it into and over the spalled area. The time that this cement is workable depends on the air temperature. If it's below 32ºF, it could take several hours to set. If it's above 100ºF, it could set in 30 seconds. To control the air temperature's influence, you can add ingredients to accelerate or retard hardening. Without these added ingredients, the temperature range is 35 to 75°F. Some common repair procedures are listed below:

1. Make sure the spalls are free from oil, grease, and debris.
2. Mix only enough magnesium phosphate cement that you can use right away.
3. Mix the ingredients for 1 to 2 minutes then empty it from the mixer. (**NOTE:** If too much water is added, the patch can prematurely crack and chip under moderate aircraft use—a very unwanted consequence.)
4. Use a trowel to fill in and level the mix into the spall areas.
5. Use water to frequently clean the mixer and tools before the mix hardens on them.
6. Do not dump surplus mix on the runway surface because you may need to use a jackhammer to remove it after it hardens.

Self-Test Questions

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

009. Airfield damage repair philosophy

1. What activities do engineer personnel provide after an air base attack?

2. What does airfield damage repair assessment include?

3. What area(s) does the MAOS include?

4. What is a crater? What are the characteristics of a large crater?

5. List the three types of ADR repairs.

010. Airfield repair procedures

1. What does RQC provide?

2. What are the three main types of crater repair methods currently used in the Air Force?

3. If crater repairs are not within RQC tolerance, who makes a decision whether to attempt aircraft operations under such conditions?

4. What are the height requirements for a filled-in crater in relation with adjacent undamaged pavement surfaces?

011. Assembling AM–2 matting

1. Why is AM–2 matting rarely used on the MOS?

2. What are some of the precautions in repairing and/or laying AM–2 panels?

3. What is the recommended team configuration for AM–2 matting?

4. Where is the assembled starter keylock placed?

5. When attaching towing tubes to the matting using the concurrent with keylock assembling method, what tubes are installed first and where are they installed?

6. How are ramps properly aligned with the mat and what is used to fasten the ramps together?

012. Assembling folded fiberglass mat

1. How thick is FFM? What is the size of a standard patch?

2. What is used to join fiberglass mats?

3. When anchoring FFM to asphalt-overlaid concrete pavements, what size anchor bolts should be used?

4. Describe how you re-anchor a FFM that was removed to fix a failed crater repair.

013. Spall repair procedures

1. What is spall damage?

2. When repairing a spall, why should you use a jackhammer to form 1-inch-deep sidewalls when a spall is shallow and dish-shaped?

3. What is the preferred fill material used to repair spalls?

4. What determines the workability of magnesium phosphate cement?

5. How long should you mix magnesium phosphate cement ingredients before emptying it from the mixer?

3–2. Airfield Paint Striping

After an airfield is bombed, we do not have enough time to restore the entire airfield to a peacetime operating condition. Instead, we repair it enough to restore aircraft operations. An important part of this is planning and establishing an MOS. This section explains how we use paint to mark the MOS and other pavement areas used by aircraft. The expedient paint striping methods discussed here are used for contingency situations and *do not* replace standard runway markings during peacetime.

014. Airfield paint and equipment

You may be assigned to a MOS paint marking team. The duties include painting stripes on the MOS and painting other airfield pavements that are used by aircraft. In this lesson, we explain equipment and paint characteristics used for airfield paint.

Equipment

We accomplish the striping of the MOS by using a paint striping machine mounted on a trailer. If necessary, we can remove this machine from the trailer and mount it in the back of a pick-up truck. The paint machine pumps paint from two internal paint tanks, or from paint drums that we place on the front of the trailer. A hydraulic pump provides pressure that drives the airless paint pump, while the paint is distributed through three paint guns mounted on a towed carriage. Glass beads that are to be applied to the paint are stored in a cylindrical glass bead tank. The paint machine's air compressor pressurizes this tank. The glass beads are fed from the tank to three bead guns that are also located on the towed carriage.

NOTE: When striping the MOS, use a fast-drying white traffic paint with reflective beads. Use black traffic paint to cover any existing markings.

Paint characteristics

The paint used to mark airfield pavement is called traffic paint. For contingency repairs, we use black, white, and yellow, included in the minimum operating strip marking system (MOSMS) kit. The base civil engineer squadron also uses standard runway marking paints and should have an adequate stock on hand. These paints are lead free and are available under Federal Specification TT–P–1952, *Paint, Traffic and Airfield Marking, Waterborne.* Select Type I, "Ten Minute No Pick-up Time" or Type II, "Fast Dry, High Humidity Formula." The paint that you apply to the pavement is 12 to 14 mils thick.

To apply paint striping to a surface, you must be aware of various types of paint, their characteristics, and the uses of different paint vehicles. We begin the lesson by discussing the two types of traffic paints available—reflectorized and nonreflectorized.

Reflectorized traffic paints

Reflectorized paint is preferred for improved night visibility. It has two components—a pigmented binder and one of two types of reflective material. The types are reflectorized granules and glass spheres. The reflective particles are dropped onto the surface while the paint is still wet. When the paint dries, it cements the reflective material.

Nonreflectorized traffic paints

Nonreflectorized traffic paints are available in a moisture-cure, oil-free urethane application (liquid portion) for use on both asphalt and concrete pavements.

Glass beads

Glass beads are available under Federal Specification TT-B–1325, *Beads, Retroreflective*. Apply to painted or extruded markings using eight to nine pounds per gallon of paint. The ones we use are type I and type III.

- Use type I, gradation A beads, for all taxiway and apron markings that must be reflective.
- Use type III, gradation A beads, for all runway and helipad markings.

Colors of markings and retroreflective requirements

Use black paint to hide extraneous markings that cannot be removed without damaging the pavement. You can also use black paint to outline markings on light colored pavements. This makes them more prominent. Mark obstructions in contrasting colors to make them more conspicuous to pilots during daylight hours. (**NOTE:** Retroflective simply means the light is reflected back to the source it came from.)

- Use retroreflective white for all runway markings. ***Exceptions:*** Use retroreflective yellow on displaced threshold arrowheads and chevrons; aircraft arresting system warning markings.
- Use nonreflective yellow on all runway shoulder markings (deceptive surfaces) and closed runway markings.
- Use retroreflective yellow for all primary taxiway and taxi-lane markings. ***Exception*****:** You don't have to use retroreflective beads on secondary taxiways and apron markings; overrun chevrons; closed pavement markings; or shoulder markings (deceptive surfaces).

015. Airfield paint striping procedures

Specific tasks are required to quickly mark a runway surface following an enemy attack. As you'd expect, these vary with each situation. In combat situations, loss of people must be expected. To make sure any losses from injury or death can be overcome, advanced planning and training must be completed. In addition, many pre- and post-attack actions must be accomplished for the taskings to be met after an attack. In this lesson, we discuss these taskings, manpower requirements, and the procedures for paint striping operations.

Preattack activities

Advance planning is key to efficiency when time is critical. Below is a list of some pre-attack activities that should be addressed:

1. MOS marking teams must be trained and identified. The MOS marking team is a six-person team normally configured into two crews. Two people are assigned paint striping requirements, while four others accomplish MOS layout and marker placement procedures. An engineering technician team chief leads the larger four-person crew. As a minimum, team members must receive hands-on training on the operation of the paint-striping machine and the assembly of edge and distance-to-go markers. Team members must also be instructed on proper marking and layout procedures and typical MOS painting requirements.
2. Vehicle support for the MOS marking team must be identified. Because MOS marking vehicles aren't included as part of the ADR fleet, they must come from other civil engineer or base assets. These vehicles must become immediately available upon reaching a predefined stage of defense condition (DEFCON) alert.
3. Locations for dispersing MOS marking material and equipment must be identified. Use a minimum of two separate sites that include the same material and equipment.
4. Adequate amounts of paint and glass beads must be procured and stored. Sufficient white paint must be available to complete a 10,000-foot MOS with enough black paint to obliterate at least one half of all existing runway markings. In addition to the paint and beads, a stock of thinner or solvent must be maintained to allow for immediate cleaning of the paint striping machine.

5. Required tools for MOS marking must be gathered and stored with each of the MOS marking system components. These tools include a 200-foot tape, shovels, and brooms. Along with these tools a sufficient number of sandbags must also be included.
6. All people trained in MOS marking procedures should be assigned to shelters along with other ADR team members. However, not all MOS marking team members should be sheltered in the same location. This is to preclude any loss of MOS marking capabilities should a shelter be seriously damaged during an attack.
7. When such action is directed by the UCC, place the MOS marking vehicles, equipment, and materials in their assigned dispersal locations.

Postattack activities

When the "all clear" signal is given to commence airfield recovery operations, the UCC directs the MOS marking team, along with the ADR complement, to move to the ADR assembly area. The ADR support team officer-in-charge (OIC) then briefs the MOS marking team chief on the probable scope of the MOS and what must be accomplished. When clearance is given to commence airfield damage repair, the four-person crew proceeds to the designated MOS area to perform layout and marker placement procedures. The six steps below is the normal order of these tasks.

1. The team uses traffic cones to layout the MOS threshold.
2. As necessary, the team uses traffic cones to layout the MOS centerline "T" zones.
3. They use traffic cones to identify the location of the Mobile Aircraft Arresting System (MAAS).
4. They use traffic cones for the layout of the Precision Approach Path Indicator (PAPI) system.
5. The team uses actual markers for the placement of the edge, distance-to-go and MAAS markers. Figure 3–12A shows a typical marker used for MAAS location and figure 3–12B shows a distance-to-go marker. The number 2 indicates that there is 2,000 feet of runway remaining.
6. Use traffic cones to identify the location of approach lighting.

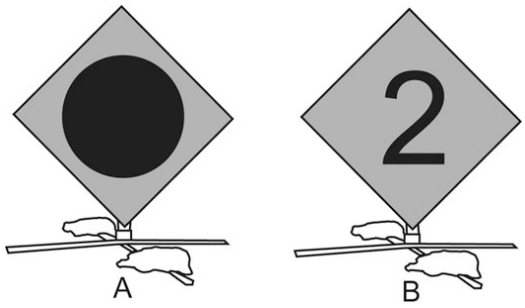

Figure 3–12. Barrier and distance-to-go markers.

After cones are placed, the MOS marking team chief makes sure the alignment is reasonable, distance-to-go markers are sequenced correctly, and no unnecessary cones have been left behind.

The final task of the four-person team is to remove any existing airfield marking signs. The ADR support team OIC makes the determination as to what markers are to be dismantled. The airfield lighting or MAAS installation crew (whichever is available) disconnects the markers. The four-person crew then removes the markers and stores them for reuse. Figure 3–13 shows a complete MOS layout.

At the same time the four-person crew is performing their postattack activities, the two-person MOS striping crew prepares the paint striping machine. They load white paint, black paint, and beads into the appropriate tanks on the machine. Although it isn't a part of the paint striping machine, they also

place a 55-gallon drum of water onto the trailer to flush the system when the paint colors are changed. They adjust the spray guns to provide a 30- to 36-inch-wide stripe. They also set the controller mechanism to maintain the 50-foot stripe intervals.

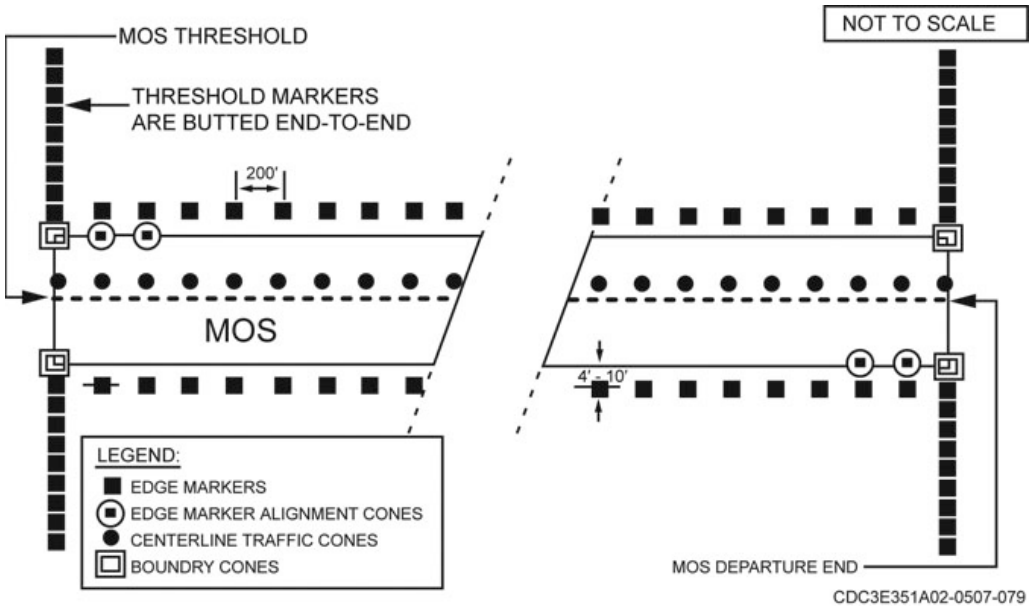

Figure 3–13. MOS layout.

The order of painting can be situation specific. For example, there may be occasions where black paint application might take precedence. Another occasion might be where the MOS is on the centerline of the original runway. In any case, the order of painting is determined by the ADR support team OIC and provided to the MOS striping crew during the postattack briefing.

MOS markings begin as soon as possible after the MOS is identified, as long as the work doesn't interfere with the activities of the runway repair crews. For example, if repair efforts are concentrated on one end of the MOS, the marking crew can begin threshold markings on the opposite end. The objective of the marking crew should be to finish marking the MOS at approximately the same time the repair crews complete their work.

Minimum operating strip paint striping procedures

AFI 32–1042, *Standards for Marking Airfields,* gives very specific requirements for marking airfield surfaces to conform to recognized standards for aircraft operations. While these markings are considered ideal under normal circumstances, it's unlikely that sufficient time exists following an enemy attack to restore the markings to their original condition. After an attack, repair crews rapidly repair craters and other attack damage. As the repair teams work, the marking crew must be ready to apply expedient techniques that mark the usable runway surface in the shortest possible time. In this way, combat aircraft can be launched and recovered in the shortest possible time. The normal marking sequence is listed below:

1. MOS striping with retroreflective white paint.
2. Blackout painting.
3. Primary access taxiways and parking aprons with retroreflective yellow paint.

NOTE: There may be times when the marking sequence is situation specific.

Repair dimensions

The dimensions of the MOS that the ADR crews repair varies primarily according to the type of aircraft the base supports. The standard dimension for *fighter aircraft* operations is 50 by 5,000 feet.

In this configuration, the runway centerline is marked as a broken line with each section 50 feet long, 30 to 36 inches wide and spaced apart 50 feet (fig. 3–14). A halfway marker indicates the midpoint of the MOS. If an arresting barrier is in operation, its location on the MOS is marked by a 2-foot wide retroreflective yellow stripe under the barrier cable.

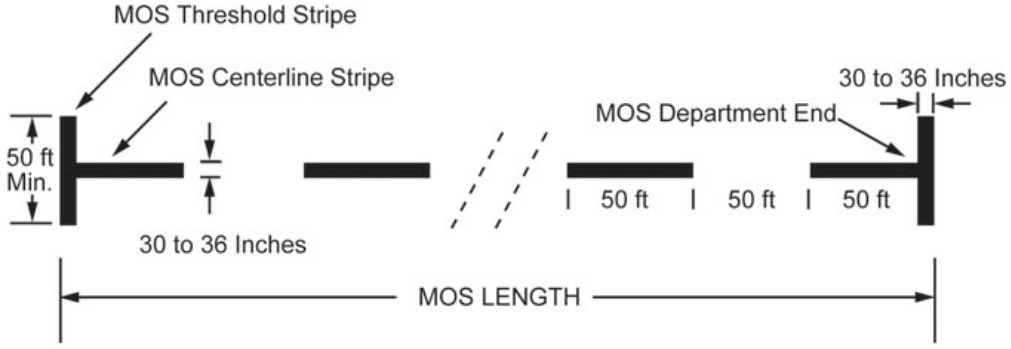

Figure 3–14. MOS dimension lines.

Edge markers

Use portable edge markers (fig. 3–15) to delineate the boundary of the MOS. These edge markers consist of a 30- to 48-inch hard rubber base plate standing about 18 inches above the ground. Place 10 edge markers side by side on each threshold and departure end of the MOS. Place them approximately 4 feet apart with the first marker 5 feet off the MOS edge. Place the remaining markers 4 to 10 feet from the outer edge of the MOS and in line with the threshold and departure end at 200-foot intervals.

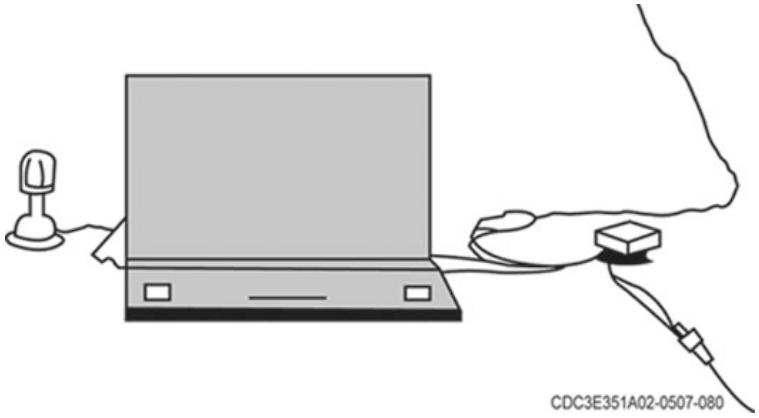

Figure 3–15. MOS edge marker.

MOS marking

After the MOS is identified, paint the end stripe (threshold or departure end as appropriate) at one of the MOS ends first. To accomplish the centerline painting, use the traffic cones or paint marks placed earlier by the four-person crew. Where access to areas is hindered due to ongoing repair efforts, you can bypass those areas for the time being. For areas that are not accessible with the paint machine, use the paint wand provided with the machine. After the centerline stripe is completed, the MOS striping crew must pick up all the centerline traffic cones (if used) that are no longer required as painting guides.

When MOS repairs near completion, the striping crew reloads the paint-striping machine with white paint and beads. Once MOS repair areas become accessible, the MOS striping crew can then proceed to stripe those areas they might have bypassed earlier. Although there may be relatively little area to paint, they must take care to maintain a reasonable approximation of the 50-foot spacing between

stripes. At completing the centerline striping, the crew picks up any remaining traffic cones in the area and departs the MOS with other ADR team members.

Immediately after leaving the airfield, the MOS striping crew flushes and cleans the paint machine. This also includes the removal of all glass beads from the bead tank on the machine. If no further paint striping or obliteration of existing markings is needed, they return the machine to storage or dispersal as the UCC determines. In all likelihood, the air field may require additional obliteration along with new markings on access taxiways. The UCC makes these arrangements that for the most part, are driven by operational flying requirements.

Obliterating existing markings

Start black painting to obliterate any existing airfield markings once you complete as much white painting as practicable. This is done so those markings don't interfere with aircraft operations or mislead the pilots. The following list identifies the order of priority for obliterating markings on the MOS:

1. Threshold markings.
2. Designation markings.
3. Centerline markings.
4. Aircraft arresting system markings.
5. Taxiway lead in and/or lead out line markings.
6. Touch down zone markings.
7. Fixed distance markings.

When you complete obliterating the existing MOS markings, and if time permits, start obliterating the markings off of the MOS. However, only attempt the off-the-MOS activity if the off-the-MOS areas are free from unexploded ordnance and if you need little or no support from the FOD removal team.

Taxiways

Taxiways aid aircraft in moving safely and orderly to and from the runway. Taxiway markings are governed by the same regulation for runways. Taxiways are marked with retroreflective yellow paint.

Taxiway centerline

Mark each taxiway with a single continuous stripe along the centerline. Below are the guidelines to use when marking the taxiway centerline:

- Make the stripe a minimum of 6 inches wide.
- At taxiway intersections with runway ends, terminate taxiway stripes in line with the nearest edge of the runway.
- When a taxiway crosses a runway, the taxiway centerline marking may continue across the runway, but it must be interrupted for the runway markings.
- At taxiway intersections, be sure the taxiway centerline markings intersect.

Identification

Where you encounter difficulty locating signs to identify taxiways, mark the identification letter on the pavement near the centerline in 6-foot block letters. At intersections, mark the identification of the intersecting taxiway with appropriate arrows near the edge of the taxiway just before the intersection.

Parking aprons

Parking apron markings are used to direct aircraft from the taxiway to their designated parking area. The width of the stripe is normally 6 inches wide and marked with retroreflective yellow paint. Parking aprons are set up to use the minimum amount of space to park the maximum amount of aircraft safely.

Self-Test Questions

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

014. Airfield paint and equipment

1. What is the main piece of equipment used by the MOS paint marking team?

2. What materials are used to stripe the MOS?

3. What three colors of traffic paint do you use to make contingency repairs to airfield pavements?

4. Which type of paint is preferred for improved night visibility?

5. What does retroflective mean?

6. Match the type paint in column B with the use in column A. Items in column B may be used once, more than once or not at all.

Column A	*Column B*
____ (1) Displaced threshold arrowheads and chevrons.	a. Retroflective white.
____ (2) Aircraft arresting system warning markings.	b. Retroreflective yellow.
____ (3) Runway shoulder and closed runway markings.	c. Retroflective black.
____ (4) All primary taxiways and taxi-lane markings.	d. Nonreflective white.
____ (5) All runway markings.	e. Nonreflective yellow.
	f. Nonreflective black.

015. Airfield paint striping procedures

1. Why is it important to have advanced planning and training in runway marking procedures?

2. How much paint must you procure and store for MOS markings and obliteration?

3. Who directs the MOS marking teams to move to the assembly area?

4. What's the final task of the four-person MOS layout crew?

5. Why do we place a 55-gallon drum of water on the paint striping machine trailer?

6. How do you mark the centerline of the MOS?

7. What do you paint first after the MOS is identified?

8. Why are existing runway markings obliterated with black paint?

9. List in order the priority areas for obliterating markings on the MOS.

3–3. Revetments and Hardened Aircraft Shelter Doors

Revetments are used to protect facilities, aircraft, and people. By using different revetments, you can provide protection from bomb blasts and shrapnel. This section covers the uses and types of revetments and hardened aircraft shelter door repair.

016. Hardening concepts

For Air Force civil engineers, hardening is the process of strengthening buildings (fig. 3–16) and utility systems to resist the destructive effects of weapons or natural forces. Hardening is used to prevent the loss of critical resources and functions inside those facilities and to protect the utility systems supporting the critical assets and functions. Hardening may be permanently constructed into facilities, either during initial construction or added later as supplemental hardening. Permanent hardening has to be done in peacetime, because there is not enough time when an enemy threatens for detailed engineering designs or elaborate construction. More often, engineers are called on to provide expedient hardening, such as rapidly erecting a sandbag wall (fig. 3–17) or building soil berms (fig. 3–18). We discuss expedient methods in this lesson.

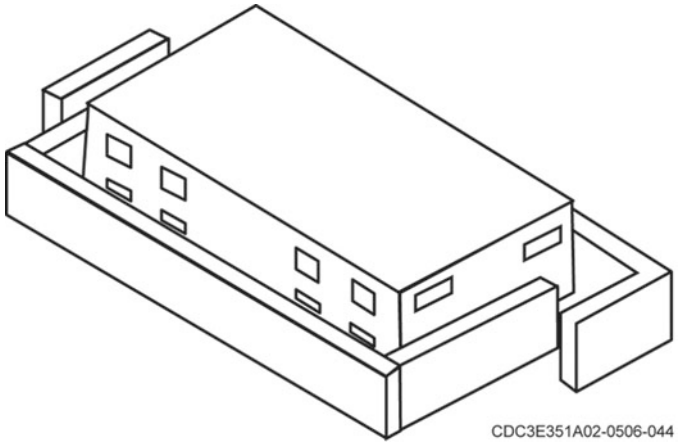

Figure 3–16. Hardened facility.

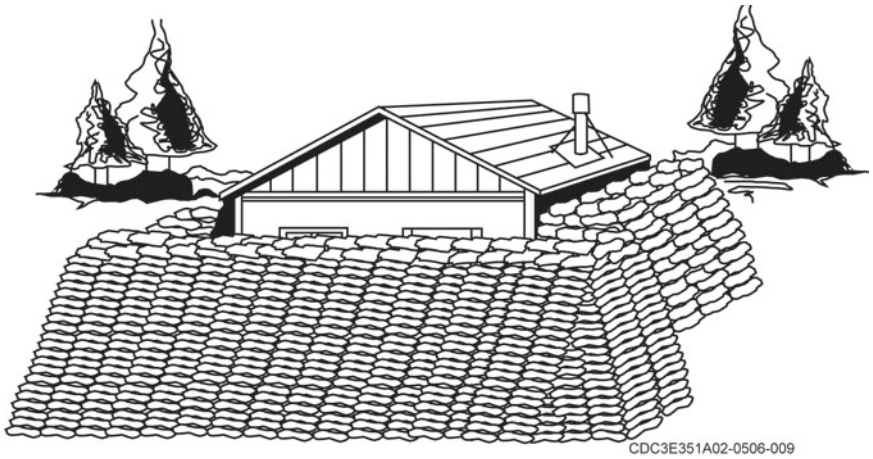

Figure 3–17. Sandbags against a structure.

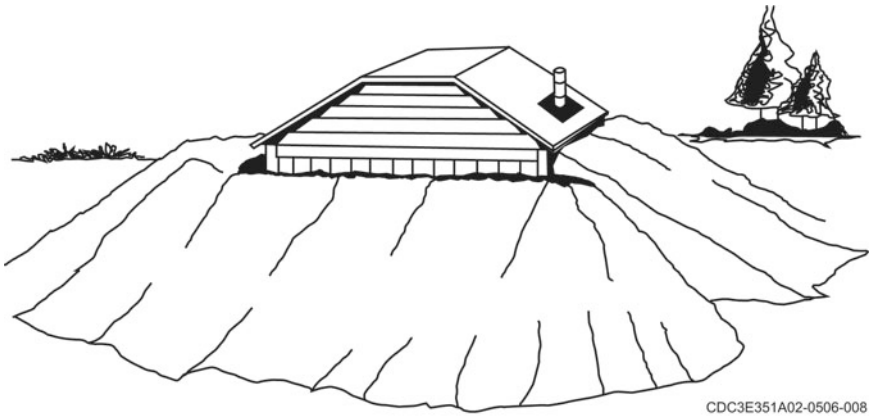

Figure 3–18. Berm against a building.

Levels of hardening

The *USAF War and Mobilization Plan* (WMP), volume 1, annex S, lists levels of hardening to protect resources and functions. There are currently six major categories of protective construction: hardened, protected, semi-hardened, collaterally protected, splinter protected, and exposure protected.

Hardened

Hardened protective construction is a belowground facility designed to resist nuclear weapons effects. These facilities have very high levels of protection, such as missile silos.

Protected or conventionally hardened

Two terms have been used to mean the same thing. The term protected is commonly used in the European theater. At other Air Force locations, the term conventionally hardened is used. Regardless, these facilities are protected from effects of a direct hit from a conventional weapon. They are usually fully or partially buried facilities and may be protected above with a sand layer to cushion the effects of a weapon. They may also have a burster barrier of rock or concrete placed on top of the sand. This acts to prematurely detonate or deflect the weapon.

Semi-hardened

Semi-hardened construction protects from effects of certain sizes and types of weapons detonated at specific distances. This includes near misses of general-purpose bombs and direct hits of artillery shells, rockets, and mortars. A common design is an above ground structure with 65 cm thick reinforced concrete walls with spall plates, blast valves, and blast doors. Examples of such protection

include semi-hardened aircraft shelters, squadron operations buildings, and petroleum, oils, and lubricants (POL) truck shelters.

NOTE: The thickness of the structure's walls or roof is not what determines if a facility is classified as semi-hardened. The determination is based on the probability of survival of the facility. The probability of survival is based on the size of the facility and the accuracy of the weapon used. This means that a large facility requires a stronger design than a smaller facility to afford the same level of survival.

Collaterally protected

This term is used to describe the level of protection provided by survivable collective protection systems (SCPS). This method protects from weapon fragments, ground shock, and blast over-pressures associated with near miss detonation of general purpose bombs. Only a few SCPS units were set up in the European theater and no additional units are planned.

Splinter protected

This method protects from weapons fragments, small arms fire, and magnification of blast pressure reflected off vertical surfaces. Examples of protection include revetments (fig. 3–19), earth berms and modular concrete sections (fig. 3–20). When combined with dispersal, splinter protection can provide a relatively high degree of survivability.

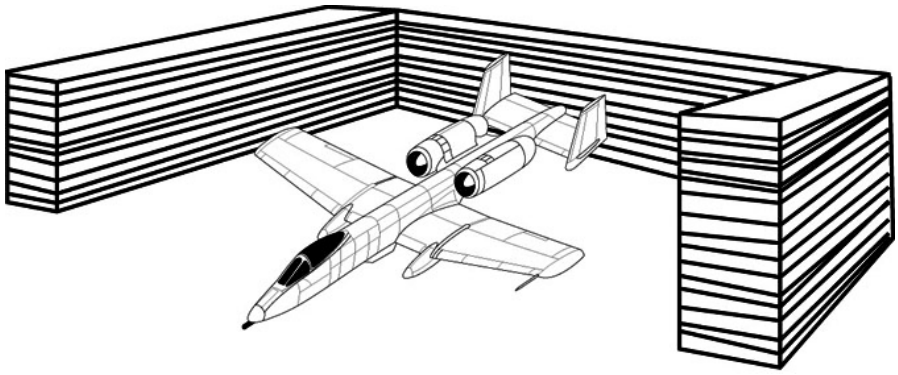

Figure 3–19. Steel bin revetment.

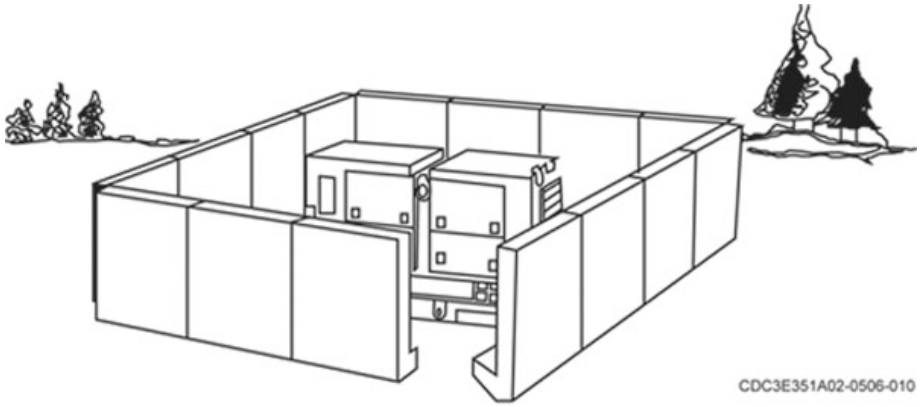

Figure 3–20. Bitburg revetments around a power generator.

Exposure protected

This method protects from nuclear blast effects and fallout. This term is generally used in conjunction with medical operations in a potentially contaminated nuclear environment where exposure control teams would be required for patient processing.

Siting considerations

When no conventional hardening protection is provided, we must create it. When determining where to site the facility and location of the functions within the facility, you should consider potential sabotage, terrorist, or other disruptive threats. Examples of considerations include a headquarters building sited away from the base perimeter or adjacent civilian highways, and a control center located in center core of the facility with controlled access.

Hardening area selection

The responsibility for the selection of facilities and equipment that must be hardened does not rest with the base civil engineer (BCE). The BCE is, however, responsible for ensuring that the hardening process is accomplished. Normally, items that are most essential to continuing the base mission receive priority for protection. Aircraft, command and control centers, personnel shelters, and communications centers are typical high priority facilities.

Hardening design

For permanent hardening, an engineer must do a structural analysis to determine how to harden a facility. To do this, they must know the threat in terms of type of weapon, fusing, size, angle of impact, and so forth. The engineer also needs to understand the function of the facility. For supplemental hardening or facility retrofits, this involves evaluating each structural component versus the expected weapon type and size. Because this analysis is very detailed, it is done only for permanent construction or peacetime retrofit of existing structures. Figure 3–21 shows the general placement that is used for berms and revetments.

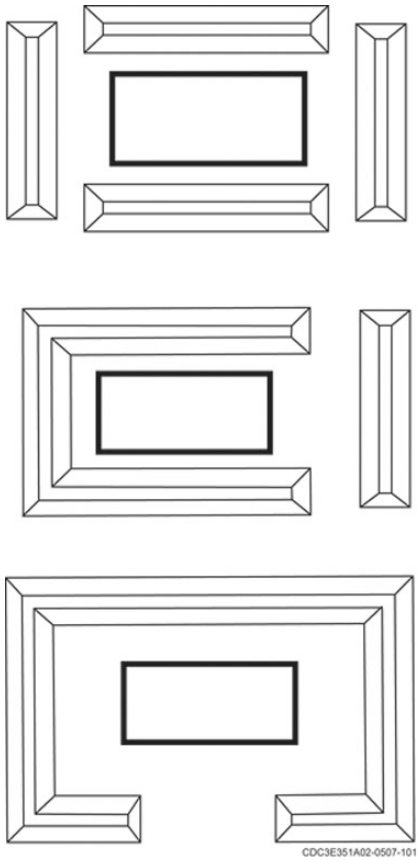

Figure 3–21. General placement for berms and revetments.

Hardening considerations

If an enemy can launch a credible attack on your base (more than one airplane dropping a couple bombs one time), consider developing permanent and expedient hardening plans. Below are some considerations to establish such plans:

- Permanent hardening is only needed when the threat is great and time permits major military construction programming, design, and construction. The expedient hardening measures you can employ may not be able to defeat all the effects of the enemy's weapons, but they are often enough to prevent the loss of critical assets. Hardening at least may save some of them.
- Few technical guides give much detail on hardening utility systems. Fortunately, buried utilities are inherently survivable. Problems occur at aboveground elements like treatment plants, pumping stations, transformer stations, and so forth. Standard hardening designs can often be used for those locations.
- Existing facilities, whether in peacetime or wartime, can require expedient hardening. This is driven by a change in function of the facility (e.g., relocation of important assets to the facility), an increase in the perceived importance of the facility, or an increase in the expected threat (temporary or long term).
- Keep in mind that with most hardening efforts, we are not trying to protect against a direct hit. That is why other passive defense measures are also important and should be used in conjunction with hardening.

017. Constructing revetments

We use various revetments to protect parked aircraft and essential facilities from weapons fragments, small arms fire, and blast pressure from explosive ordnance. There are a lot of different revetments available; this lesson will cover the Concertainer revetment.

Concertainer revetment

Concertainer is a revetment system that uses a series of baskets formed from hinged galvanized wire panels covered with a geofabric liner. The liner is resistant to rot and ultraviolet radiation. This revetment system is also called "Hesco revetments" for the company that manufactures it—Hesco Bastion Limited.

This revetment system is shipped in a folded compact configuration that allows easy expansion to form wall sections of linked, self-supporting cells that can be filled with soil, gravel, ice, or any other available material. Concertainer wall sections are available in a variety of lengths, widths, heights, and colors. A minimum of two people can easily erect the revetment; however, a third person operating the heavy equipment speeds up the operation.

Advantages

Concertainer offers many advantages over B–1 and other types of revetments.

- It provides the same amount of protection as the B–1 with substantially less shipping weight.
- Height is not limited. You can increase the height of the revetment using a variety of different sizes as long as you make sure of the proper base width to prevent overturning.
- It can be constructed in multiple configurations.

Assembly procedures

Below are some general construction and assembly procedures to follow; however, always refer to the manufacturer's instructions for proper assembly procedures.

Site preparation

The site should be as level as possible and strong enough to support the weight placed on it. Since the revetment is flexible, it conforms to the contours in the ground. We discuss two methods of preparation—minimum and improved.

- With the minimum method, you should at least remove the topsoil and organic material from the surface, then, compact any loose soil.
- With the improved method, you should excavate the ground at least 20 inches deep and 20 inches to either side of the revetment to create a trench. Line this trench with a geotextile or geogrid (preferred) fabric and backfill with course fill. Add the fill in layers and compact each layer.

NOTE: Use the improved method for large structures or when the revetment is in place for more than six months.

Construction

For U-shaped barriers, expand the first unit in the left rear corner (fig. 3–22). For straight walls, begin at any end. To form a corner, push in the coil hinges and rotate one end of the revetment 90º and pin the connection as shown in figure 3–23. (**NOTE:** You can also butt adjoining units to a straight section to form a right-angled corner.) Connect additional sections together by overlapping the coil hinges and inserting a connecting pin (fig. 3–24). Once you get the next section connected, expand the revetment along the layout line.

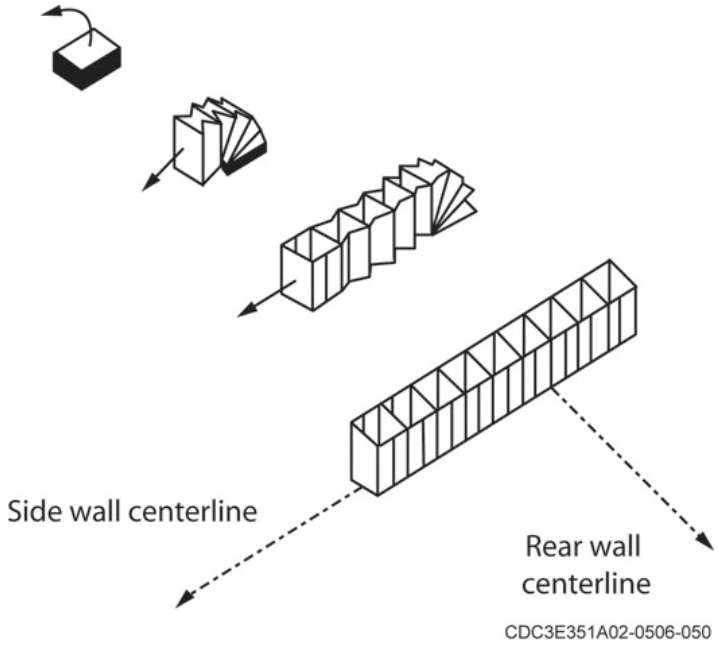

Figure 3–22. Concertainer layout.

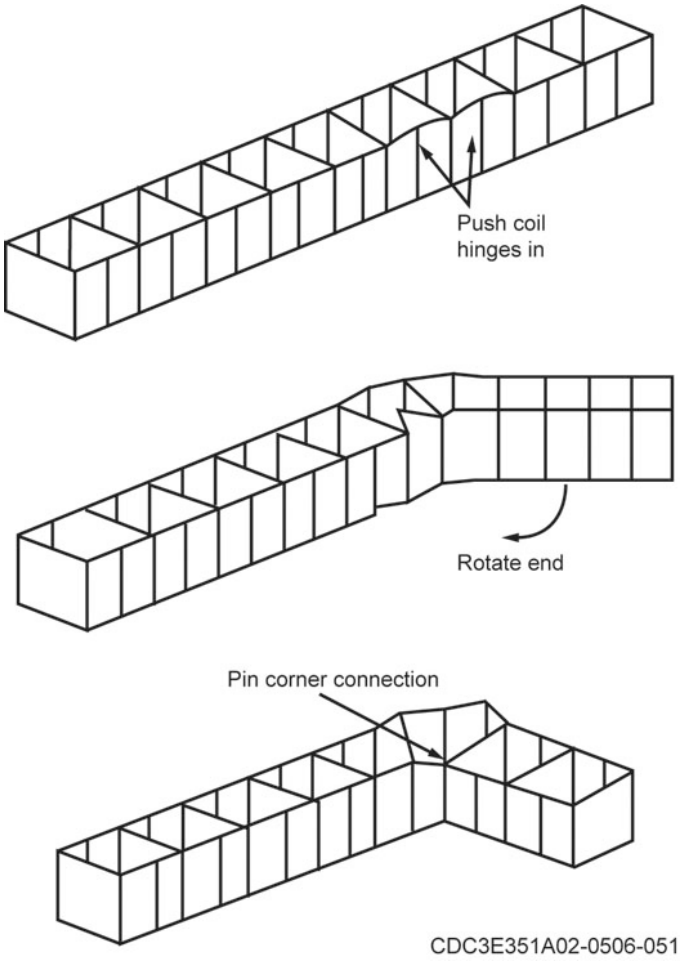

Figure 3–23. Corner assembly details.

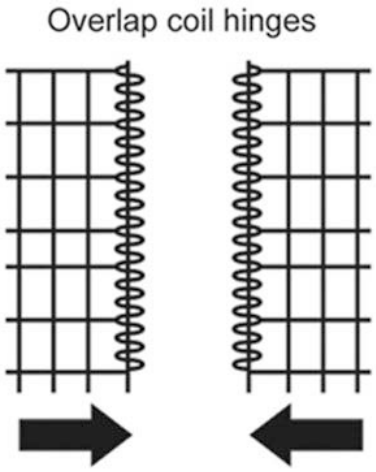

Figure 3–24. Connecting coil hinges.

Filling the cells

The best type of fill material is a sand and/or gravel mix. This offers the best protection and is less affected by water absorption than other types. The revetment fabric is permeable allowing water to

drain from the fill material. This is important because wet fill material has a lower protection factor and it creates more pressure on the cells.

After the base row is assembled, adjust the cells for the fill. Pull out the center of each cell at the base about 2 to 4 inches (fig. 3–25) to keep the panels from bulging vertically as the cells are filled. Before you begin filling the cells, you must make sure that the joining pins are connected in the first and last cells of successive revetments. During the fill process, place the fill in 6- to 12-inch lifts and manually compact the fill in between lifts. If a single cell is completely filled, it could cause the center to bulge. This bulge could, in turn, draw in the outside walls reducing the overall wall thickness.

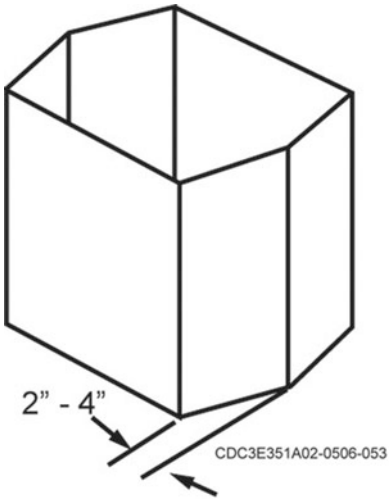

Figure 3–25. Center cell adjustment.

Multi-layer structures

When constructing multi-layer structures, fill the cells to approximately 3 inches from the top. Then, pull out the next layer on top of the previous layer and align it with the upper panels inside of the lower panels. 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 used for the first row.

Capping

The purpose of capping is to prevent water entry into the fill material. You should cap all structures that are expected to have a long service life. There are a lot of different capping options available to you, below are some methods:

- Cover the revetment with tarpaulins or other roofing material.
- Cap with a 6-inch layer of concrete or soil cement.

018. Repairing hardened aircraft shelter doors

Hardened aircraft shelters (HAS) are used throughout the world to protect aircraft from bomb and other conventional weapon damage. If you're assigned to a base that has these shelters, you might be responsible for adjusting the doors and replacing the rollers. Let's look at the different door types and repair methods that you can use.

Door types

First-generation shelters have two manually operated doors that are hinged vertically (fig. 3–26). This type is also referred to as TAB-V or TAB VEE. Modified first-generation shelters have one electrically operated door that moves laterally on rollers (fig. 3–27). Second- and third-generation shelters have two electrically operated doors that move laterally on rollers and tracks (fig. 3–28).

They are identical to each other except that the third-generation shelter is smaller in size. The proper operation of these doors is critical to mission accomplishment, especially during contingency situations.

NOTE: The rest of this lesson focuses on maintenance and repair actions for the second- and third-generation doors.

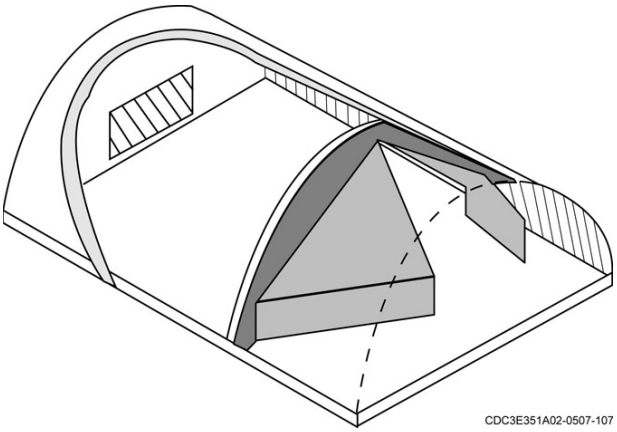

Figure 3–26. First-generation shelter.

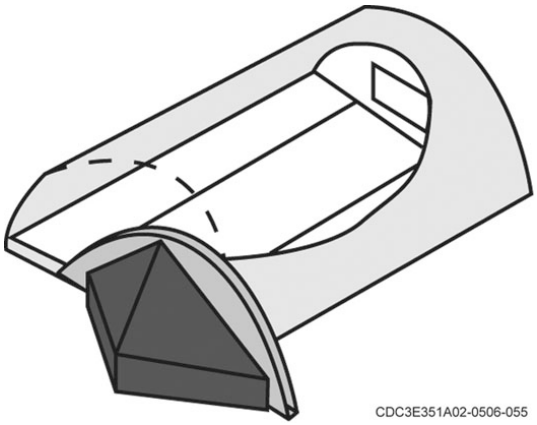

Figure 3–27. Modified first-generation shelter.

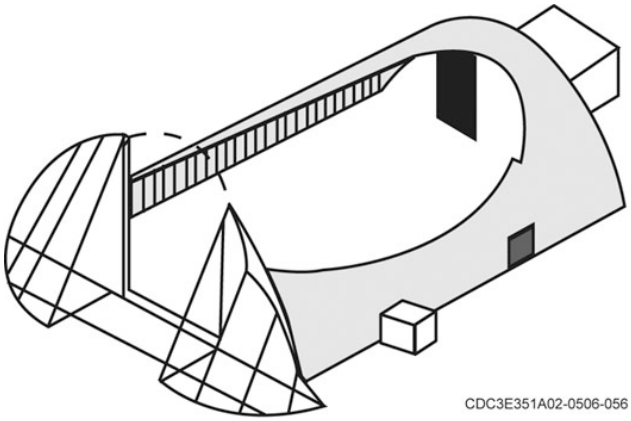

Figure 3–28. Second- and third-generation shelter.

General information

Maintenance schedules are set up through the recurring work program (RWP). HAS doors are extremely large and heavy (fig. 3–29). They are constructed of steel reinforced concrete, thick steel "H" beams and steel plate. Their size and weight can range up to 50 feet long, 30 feet high, 2 feet thick and weigh up to 250 tons.

NOTE: Shelters vary depending on the country where they were built. Always follow the specific guidance provided for the shelter you are working on. The information presented here is basic for most shelters.

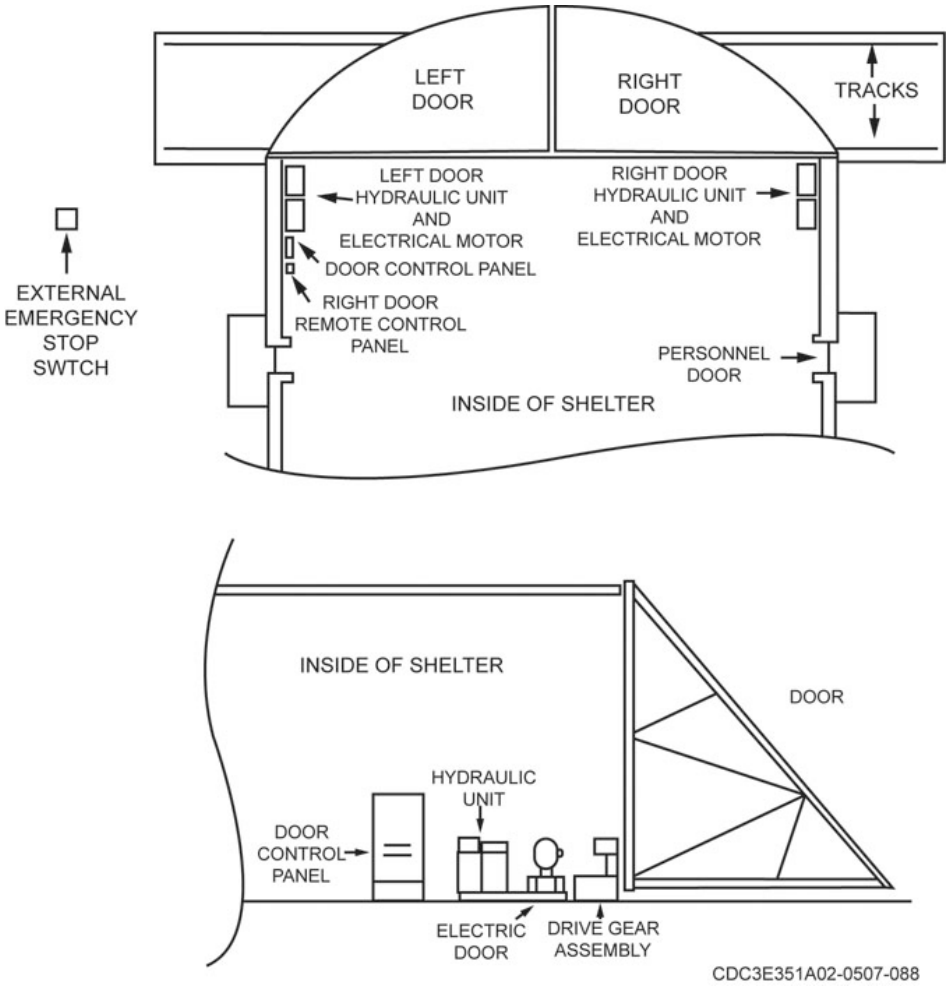

Figure 3–29. Door operating components.

HAS door adjustments

You are often tasked with ensuring that has doors are operating properly. The below components require most of the maintenance actions:

- Door tracks.
- Door rollers (turret tanks and guide rollers).
- Limit switches and/or deceleration valves.
- Door drive assembly (hydraulic unit, electric motor and speed reducer).

Door tracks

The door tracks (fig. 3–30) are made of hardened steel and are imbedded into steel reinforced concrete pads that are not adjustable. There are guide rollers located in each track below the surface of the concrete pad. You must inspect these tracks for foreign objects and damage. Oftentimes, trash and foreign objects collect inside the guide roller tracks. If not removed, it obstructs the doors travel resulting in damage.

When inspecting the top portion of the guide roller track, look for damage that includes warping, gouging, or splitting. If you notice any warping, heat the track with a torch and try to straighten it out. To repair any gouges or splits, weld over them and grind the welds smooth.

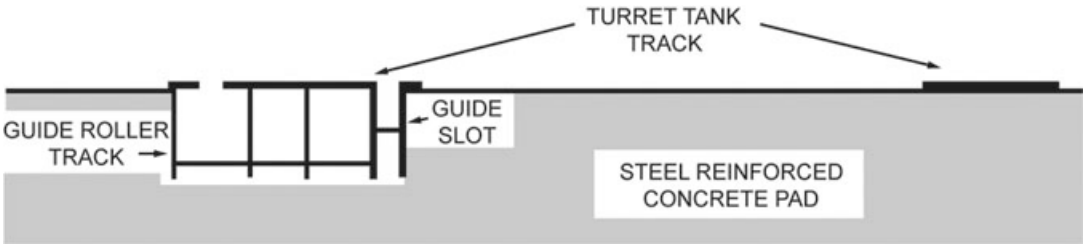

Figure 3–30. HAS door tracks.

Door rollers

Door rollers have been the cause of many stuck doors. The particular repair method that you use is usually found in the manufacturer's instructions or TO for your specific shelter. The doors open and close using track (turret tank) and guide rollers. The track rollers are mounted under the doors and on the outriggers; guide rollers provide horizontal guidance for the door as it opens and closes. If the guide rollers jam, first try to realign the track rollers to compensate. The two things that require maintenance are the turret tanks and guide rollers.

Turret tanks

Most HAS doors ride on eight turret tanks (fig. 3–31) with linked steel metal rollers. Sizes vary up to 30 inches long, 12 inches high and 12 inches wide. Three turret tanks are located under the lower inside edge at each end of the door and two are located under the steel structure of the door (fig. 3–32).

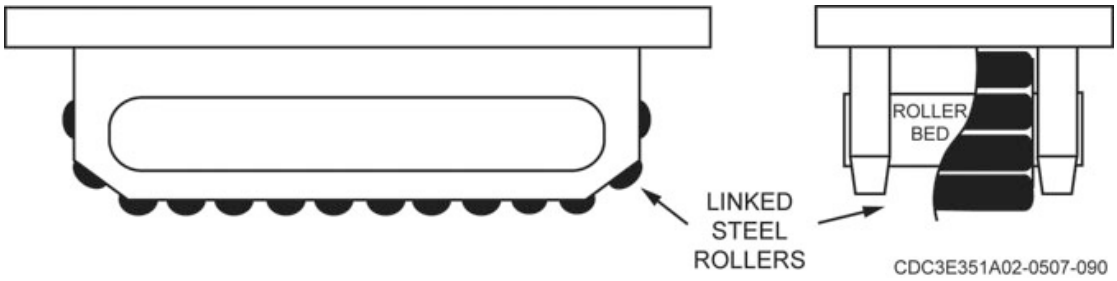

Figure 3–31. Turret tank.

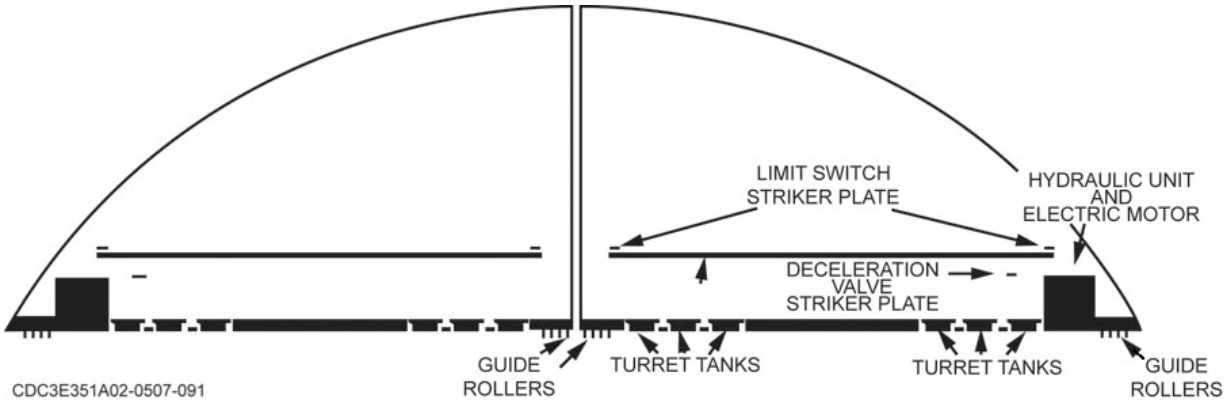

Figure 3–32. Turret tank location.

Guide rollers

The guide rollers (fig. 3–33) travel within the guide roller tracks and keep the door traveling straight. There are usually four guide roller assemblies located on the door's bottom edge.

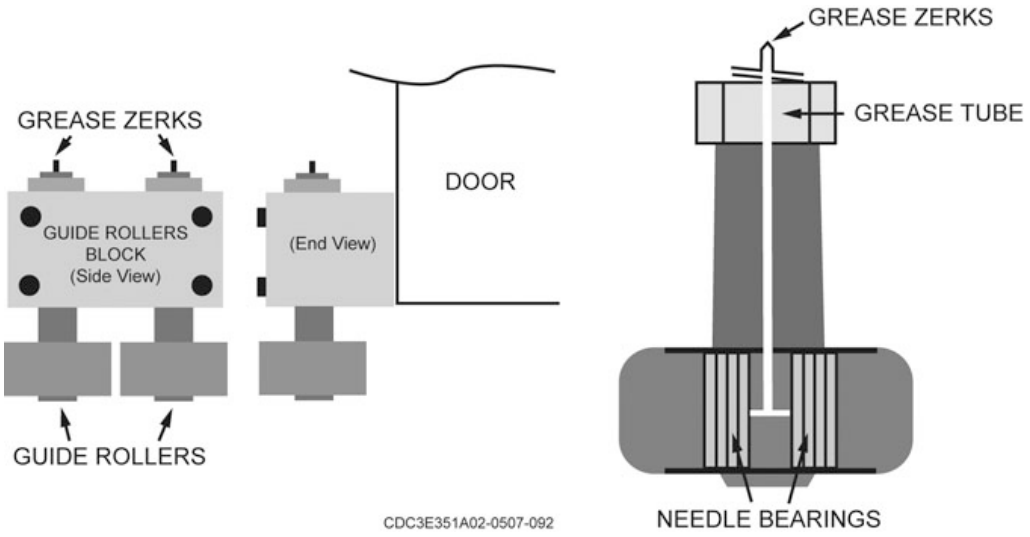

Figure 3–33. Guide roller.

Limit switches and/or deceleration valves

The standard HAS door uses one hydraulic operated deceleration valve (fig. 3–34) and one electric operated limit switch; however, many HAS doors are receiving aftermarket replacements that may change this setup.

- The deceleration valve slows down the speed of the door when the door is within approximately 5 feet of the full closed position.
- The limit switch turns off power to the door motor when it reaches the fully opened or closed position.

Both the deceleration valve and the limit switches are mounted to the door motor frame. On the backside of the door are three curved metal plates called striker plates. As the door comes within 5 feet of the full closed position, the curved metal striker plates contact the plunger on the deceleration valve and the door then moves slowly until the limit switch striker contacts the door's limit switch cutting power to the motor.

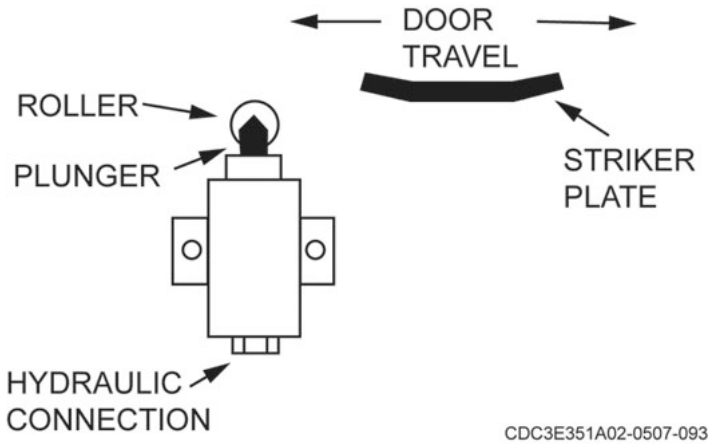

Figure 3–34. Deceleration valve.

Door drive assembly

Maintenance consists of adjusting or replacing parts as required. Refer to the manufacturers' instruction manual for valve pressure settings, fluid levels, and type of fluid required. Figure 3–35 shows a typical door-operating unit.

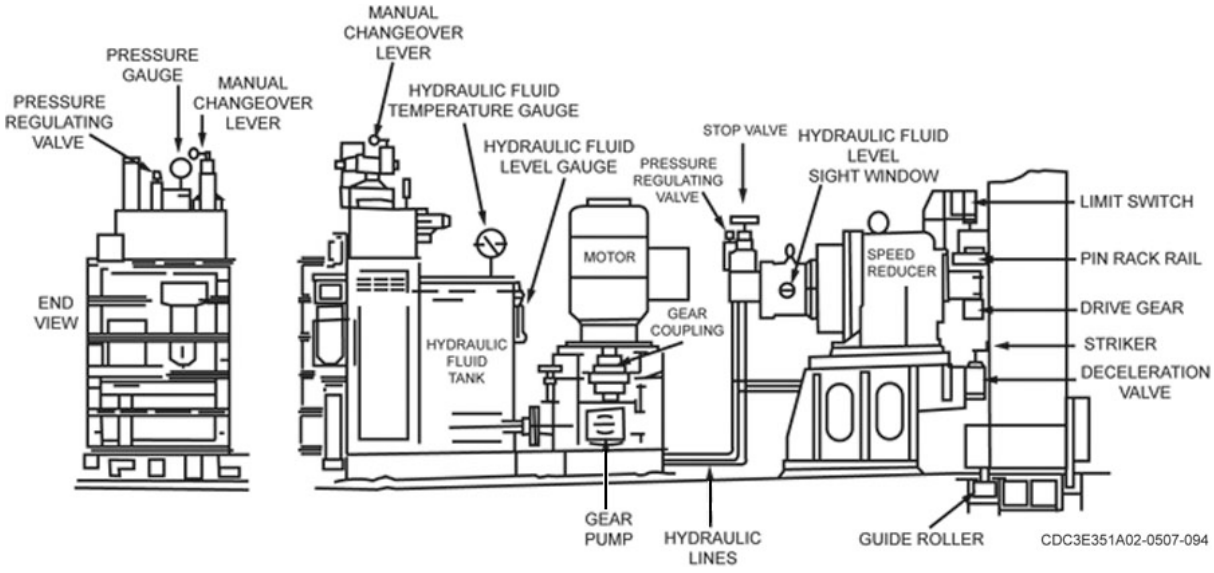

Figure 3–35. Door-operating unit.

Hydraulic pressure regulating valves

Door movement depends on the hydraulic unit. There are two valves that adjust to set the required pressure for the hydraulic unit. Be sure to adjust them to the recommended settings for the size and weight of the door. If the valves are not adjusted properly, the door may be too fast, too slow, or not move at all. To set the pressure, adjust the knob until the digital counter reads the correct setting for the size and weight of the door.

Hydraulic lines

The hydraulic lines transfer hydraulic fluid from the holding tank, through the hydraulic motor and speed reducer, and back to the tank. You must make sure the hydraulic fluid level is maintained at the required level, and the fluid and filter are changed on a regular basis.

Electric motor, gear coupling, and gear pump

These items provide the power needed to force the hydraulic fluid through the unit and to operate the speed reducer. Although rare, the torque output from the motor and the force required to push the fluid through the unit may sometimes cause misalignment of the motor, coupling, and pump. If this happens, you need to loosen the mounting bolts holding them in place, realign the items, and retighten the bolts.

Speed reducer

To best understand what a speed reducer is to compare it to a transmission’s low gear in a semi-truck. To safely move the HAS door, the hydraulic unit needs a low-geared transmission. The speed reducer transfers the high speed of the hydraulic unit to the low speed, high-torque power required to move the door. You don’t need to worry about making any adjustments on the speed reducer other than adjusting the pressure settings on the valves as described earlier. Below are the items you should inspect on the speed reducer:

- Check the drive gear located on the end of the speed reducer for wear.
- Make sure the drive shaft key is not sheared and the keyway is not worn.
- Make sure the bolts securing the gear to the shaft are tight.
- Oil level should be between the two lines on the speed reducer’s sight window.

HAS door maintenance procedures

HAS doors are extremely heavy, thus the track (turret tank) and guide rollers mounted under the door and to the outriggers often wear out and need replacement. You must remove the guide rollers before you can remove the track rollers.

NOTE: Before performing any maintenance on the HAS door, turn the main power panel off and lockout and/or tagout the switch to prevent anyone from turning it back on.

Guide roller removal

There are two cut-outs in the guide roller track for removing the guide rollers. One is located outside the shelter, while the other is located inside close to where the shelter roof and floor intersect. Below are the required steps to remove the guide roller:

1. Open the door until the inside end of the door is within approximately 6 to 8 feet from the speed reducer (fig. 3–36). With the door in this position, the guide rollers are close to the inside cut out.
2. Turn the main power off at the main control panel and lockout and/or tagout the switch.
3. Remove the nuts and bolts holding the guide roller closest to the center of the door and then slide the guide roller to the cutout and lift it out of the track.
4. Remove the nuts and bolts holding the guide roller closest to the end of the door then slide it to the cutout and lift it out.
5. Open the door completely to remove the guide rollers from the outside end of the door.
6. Follow the steps mentioned above to eliminate error.

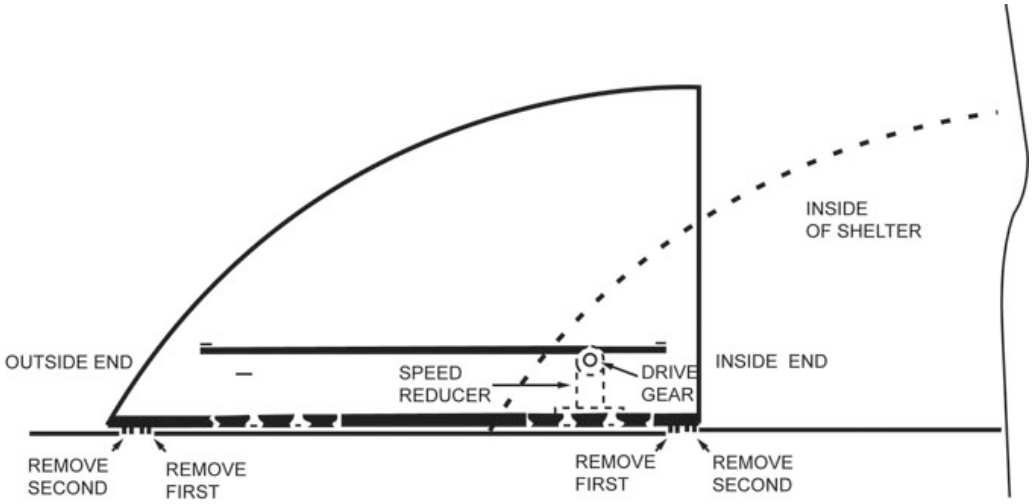

Figure 3–36. Guide roller removal.

Guide roller maintenance

Once the guide rollers are removed, you can perform the guide roller maintenance actions below:

1. Remove the grease zerks from the top end of the roller shafts.
2. Remove the nuts holding the shafts in the guide roller blocks and knock the rollers free from the guide roller block with a rubber mallet.
3. Remove the bolt holding the roller shaft and pull the shaft out of the roller.
4. Remove the needle bearings from the inside of the roller. Clean all grease from the roller, needle bearings and the grease tube.
5. Inspect each item and replace any part that is worn or damaged.
6. Grease the inside of the roller and replace the needle bearings.

7. Carefully slide the roller onto the shaft and replace the bolt that holds the roller to the shaft and tighten.
8. Slide the shaft into the guide roller block, replace the nut and tighten.
9. Follow the steps in reverse order to reinstall the guide rollers.

Turret tank removal

We suggest these procedures to remove the outside end turret tanks:

1. Open the door so the tank closest to the middle of the door clears the outside of the shelter roof (fig. 3–37).
2. Turn the main power off at the main control panel and lockout and/or tagout the switch.
3. Unbolt the guide rollers from the outside end of the door.
4. Place a 100-ton capacity jack near the middle of the tank, between the track and the bottom of the door.
5. Remove the bolts securing the turret tanks to the bottom side of the door.
6. Raise the door with the jack.
7. Place a metal spacer underneath the door and lower the door onto the spacer that is thick enough to hold the door off the turret tanks. (**NOTE:** If a spacer is not used, the weight of the door could rupture the jack's hydraulic seals.)
8. Remove the tanks from underneath the door. (**NOTE:** Turret tanks weigh approximately 300 lbs. each. Ask for help and use caution when moving them.)

To remove the turret tanks from the inside end, close the door until the tank closest to the middle of the door clears the speed reducer. Then follow the same steps as for the outside tanks.

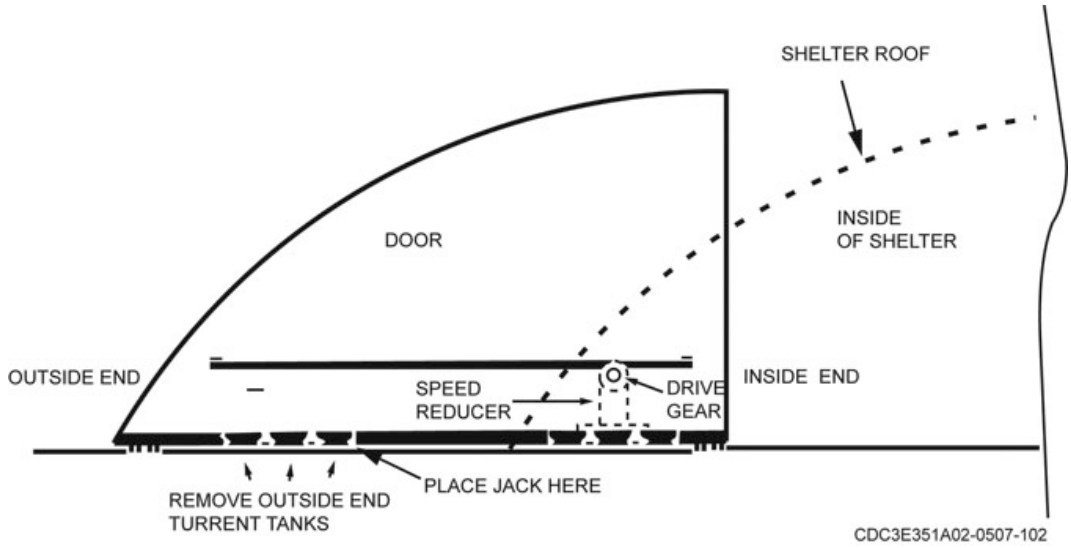

Figure 3–37. Turret tank removal.

Turret tank maintenance.

Flip the turret tank over and remove any grease that may be present. Inspect the rollers and links for any damage and wear. If they are badly damaged or worn, return the tank to the manufacturer for repairs. Re-grease between the rollers and inside edges of the turret tank. Follow the removal steps in reverse order to reinstall the turret tanks.

Self-Test Questions

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

016. Hardening concepts

1. What is hardening?

2. List the major categories of protective construction.

3. What are some of the typical high priority facilities that receive hardening protection?

017. Constructing revetments

1. What is Concertainer revetment material made from?

2. When building multi-layer Concertainer structures, to what depth are the cells filled in the previous layer before installing the second layer?

3. What is the purpose of capping the Concertainer revetments? What are some of the methods?

018. Repairing hardened aircraft shelter doors

1. What components are most maintenance actions performed?

2. Where can you usually find repair methods for your specific aircraft shelter doors?

3. What is the purpose of the deceleration valve?

4. What turns off power to the door motor when it reaches the fully opened or closed position?

5. Before performing any maintenance on HAS doors what must be done?

Answers to Self-Test Questions

009

1. Damage assessment, MOS selection, explosive ordnance safing and disposal, bomb damage repair.
2. Evaluation of damage involving runway surfaces, taxiway surfaces, and other facilities that directly support aircraft operations.
3. The MOS combined with access taxiways from aircraft staging areas such as shelters and parking aprons.
4. Craters are damage that penetrates through the pavement surface into the underlying base and subgrade soil uplifting the surrounding pavement and ejecting soil, rock, and pavement debris around the impact area. Large craters have an apparent diameter equal to or greater than 15 feet.
5. (1) Expedient
   (2) Sustainment.
   (3) Permanent repairs.

010

1. The purpose of RQC is to provide a single number, expressed in inches, for each MOS crater repair.
2. (1) Debris backfill.
   (2) Choke ballast over debris.
   (3) Sand-grid methods.
3. The wing commander.
4. It should be flush, but ¾ inch, plus or minus, is allowed.

011

1. Because of the bounce that an aircraft encounters when its wheels hit the height difference between the patch and the undamaged pavement.
2. It requires 200 to 300 percent more effort to place AM–2 than to remove it. The more exact the base course finished grade, the easier it is to lay AM–2. Six hours is about the maximum time a person can sustain production when handling AM–2. Use a string line along the edge for proper alignment. To maintain proper alignment, always use a locking bar as a spacer behind the last joint. Never crowd the bundles of stacked panels next to the panels being laid.
3. A 16-man team consisting of: 1 *mat chief* to supervise construction; 1 *alignment person* to make sure that the first mat in each row is in proper alignment; 2 *pry bar people* to adjust the individual mats and to insert the locking bars; and 12 (six 2-man teams) *mat installation people* to lay the mat in place.
4. At the appropriate extended centerline of the crater (either parallel or perpendicular to the MOS centerline).
5. The two starter-towing tubes are placed on a 20-foot piece of assembled mandrel, centered on the special connector.
6. Use locking bar spacers between the mat and the ramp to keep it properly aligned; fasten ramps together with flat-head screws coated with anti-seize compound.

012

1. About ⅜-inch-thick. A standard patch consists of two panels when attached make the overall patch 60 feet by 54 feet.
2. Joining panels that are installed with bushings and anchor bolts. One of each length (24- and 30-foot) is needed to join two mats together.
3. Normally 9½- to 10½-inch-long anchor bolts that are ⅝ to ¾ inch in diameter.
4. Remove all anchor bolts and bushings. Tow the FFM away from the crater. Repair the crater. Check the crater to make sure it is within the tolerance for the FFM. Tow the FFM over the crater. Align the anchor-bolt holes so that they are at least 6 inches away from the original drilled holes. Use the same anchoring system that was used to originally anchor the mat to the pavement.

013

1. Surface damage (missing pieces of pavement) that *does not* penetrate the base course and *does not* damage an area greater than 5 feet in diameter.
2. This action reduces the chance of the repair popping out when aircraft wheels repeatedly roll over the repair.
3. Polymer concrete.
4. The air temperature.
5. 1 to 2 minutes.

014

1. The paint-striping machine.
2. When striping the MOS, use a fast drying white traffic paint with reflective beads. Use black traffic paint to cover any existing markings.
3. (1) Black.
   (2) White.
   (3) Yellow.
4. Reflectorized paint.
5. The light is reflected back to the source it came from.
6. (1) b.
   (2) b.
   (3) e.
   (4) b.
   (5) a.

015

1. To make sure any losses from injury or death can be overcome.
2. Enough white paint for a 10,000-foot MOS and enough black paint to obliterate at least one half of all existing runway markings.
3. The UCC.
4. The removal of any existing airfield marking signs.
5. To flush the paint machine system when the paint colors are changed.
6. With a broken line with each section 50-feet long, 30 to 36 inches wide, and spaced 50 feet apart.
7. The end stripe (threshold or departure end as appropriate) at one of the MOS ends.
8. So they don’t interfere with aircraft operations or mislead pilots.
9. (1) Threshold markings.
   (2) Designation markings.
   (3) Centerline markings.
   (4) Aircraft arresting system markings.
   (5) Taxiway lead in and/or lead out line markings.
   (6) Touch down zone markings.
   (7) Fixed distance markings.

016

1. The process of strengthening buildings and utility systems to resist the destructive effects of weapons or natural forces.
2. Hardened, protected, semi-hardened, collaterally protected, splinter protected, and exposure protected.
3. Aircraft, command and control centers, personnel shelters, and communication centers.

017

1. Galvanized wire panels covered with a geofabric liner.

2. Approximately 3 inches from the top.
3. To prevent water entry into the fill material. Cover the revetment with tarpaulins or other roofing material, or cap with a 6-inch layer of concrete.

018

1. Door tracks, door rollers (turret tanks, and guide roller), limit switches, deceleration valves, door drive assembly (hydraulic unit, electric motor and speed reducer).
2. In the manufacturer’s instructions or TO.
3. It slows down the speed of the door when it is within approximately 5 feet of the full closed position.
4. The limit switch.
5. Turn the main power panel off and lockout and/or tagout the switch to prevent anyone from turning it back on.

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).

35. (009) Who determines and reports the location, types, and quantity of airfield pavement damage to the emergency operations center?
    a. Crater repair team.
    b. Damage assessment team.
    c. Rapid runway repair team.
    d. Minimum operating strip selection team.

36. (009) Which type of airfield pavement damage has an apparent diameter equal to or greater than 15 feet and penetrates through the pavement surface?
    a. Small spall.
    b. Large spall.
    c. Small crater.
    d. Large crater.

37. (009) Which type of airfield pavement repairs create an operationally capable minimum operating strip, based on projected mission aircraft requirements, in the fastest manner possible?
    a. Expedient.
    b. Permanent.
    c. Sustainment.
    d. Containment.

38. (010) Which airfield damage repair (ADR) set uses 91 persons and 61 equipment items?
    a. Small.
    b. Medium.
    c. Large.
    d. Very large.

39. (010) Which airfield damage repair (ADR) set uses 164 persons and 135 equipment items?
    a. Small.
    b. Medium.
    c. Large.
    d. Very large.

40. (010) What is the acceptable repair quality criterion that the filled-in crater should be in comparison with the adjacent undamaged pavement surfaces?
    a. Flush only.
    b. Flush, plus or minus ½ inch.
    c. Flush, plus or minus ¾ inch.
    d. Flush, plus or minus 1 inch.

41. (011) How is the AM–2 matting starter keylock placed after it is assembled?
    a. On the leading edge of the crater.
    b. Parallel to the extended crater centerline only.
    c. Perpendicular to the extended crater centerline only.
    d. Parallel or perpendicular to the extended crater centerline.

42. (011) When attaching AM–2 matting towing tubes concurrent with the keylock assembly, how is the starter tube that receives the *first* piece of matting placed on the mandrel?
    a. With the prongs facing up.
    b. With the prongs facing down.
    c. With the prongs either up or down.
    d. The starter tube does not have any prongs.

43. (011) To install the *first* row of AM–2 mats the correct procedure is to start with
    a. full-size mats and lay left to right.
    b. full-size mats and lay right to left.
    c. half-size mats and lay left to right.
    d. half-size mats and lay right to left.

44. (011) How do you keep the rows of AM–2 matting in proper alignment during assembly?
    a. Keep a string line on the keylock.
    b. Secure the last tow tube in each row.
    c. Tighten the end caps on the mandrel.
    d. Install locking bars in between the mats.

45. (012) When assembling folded fiberglass mat (FFM), the mats are placed end-to-end about
    a. 2 feet apart.
    b. 4 feet apart.
    c. 6 feet apart.
    d. 8 feet apart.

46. (012) When unfolding folded fiberglass mat (FFM), the criteria used on the side opposite the tow vehicle to lift each successive panel as the tow vehicle pulls the mat is at least a
    a. two-member team or front-end loader with forks.
    b. two-member team only.
    c. four-member team or front-end loader with forks.
    d. four-member team only.

47. (012) What action should you take to try to prevent the resin from flaking at the folded fiberglass mat (FFM) hinge locations?
    a. Spray compressed air across each hinge.
    b. Apply a polyurethane coat to each hinge.
    c. Unfold each hinge twice to remove the loose resin.
    d. Have a vibratory roller make one pass down each hinge location and follow with a broom sweeper.

48. (012) When using 9 ½-inch long anchor bolts to anchor folded fiberglass mat (FFM) to asphalt pavements, what hole diameter and how deep should you drill?
    a. ½- by 9 ½-inch.
    b. ¾- by 9 ½-inch.
    c. 1- by 10-inch.
    d. 1½- by 10-inch.

49. (012) When it is necessary to anchor folded fiberglass mat (FFM) that was moved to repair a failed crater repair, the mat positioned for reanchoring by align the
    a. original anchor-bolt holes.
    b. anchor-bolt holes at least 6 inches from the original holes.
    c. anchor-bolt holes at least 12 inches from the original holes.
    d. anchor-bolt holes at least 24 inches from the original holes.

50. (013) When repairing a spall with magnesium phosphate cement, you should mix the ingredients for
    a. 1 to 2 minutes.
    b. 2 to 3 minutes.
    c. 3 to 4 minutes.
    d. 4 to 5 minutes.

51. (014) Identify the type(s) of paint used for paint striping.
    a. Nonreflectorized and reflectorized.
    b. Nonreflectorized only.
    c. Asphalt emulsion and reflectorized.
    d. Asphalt emulsion only.

52. (014) Which of the followings paints is used for *all* runway markings?
    a. Nonreflective red.
    b. Nonreflective yellow.
    c. Retroreflective black.
    d. Retroreflective white.

53. (014) Which of the following paints is used on runway shoulder markings and closed runway markings?
    a. Retroflective white.
    b. Retroflective yellow.
    c. Nonreflective white.
    d. Nonreflective yellow.

54. (014) Identify the paints used for *all* primary taxiway and taxi-lane markings.
    a. Retroreflective white.
    b. Retroreflective yellow.
    c. Nonretroreflective white.
    d. Nonretroreflective yellow.

55. (015) After the *minimum* operating strip (MOS) layout and marker placement is complete, what is the *final* task for the four-person team?
    a. Obliterate existing lines.
    b. Prepare the paint striping machine.
    c. Remove any existing airfield marking signs.
    d. Identify the precision approach path indicator system.

56. (015) The paint striping machine's spray guns are adjusted to provide a
    a. 12- to 18-inch-wide stripe.
    b. 18- to 24-inch-wide stripe.
    c. 24- to 30-inch-wide stripe.
    d. 30- to 36-inch-wide stripe.

57. (015) Where you encounter difficulty locating signs to identify taxiways, mark the identification letter on the pavement near the
    a. centerline in 3-foot block letters.
    b. centerline in 6-foot block letters.
    c. parking aprons in 3-foot block letters.
    d. parking aprons in 6-foot block letters.

58. (016) Which type of hardening is only needed when the threat is great and time permits major military construction programming, design, and construction?
    a. Expedient.
    b. Permanent.
    c. Sustainment.
    d. Contingency.

59. (017) You can connect additional sections of Concertainer together by
    a. pushing in the coil hinges and inserting a connecting pin.
    b. overlapping the coil hinges and inserting a connecting pin.
    c. expanding the additional section and inserting a connecting pin.
    d. rotating one end of the revetment 90 degrees and inserting a connecting pin.

60. (017) When constructing multi-layer Concertainer structures, approximately how high from the top should you fill the cells?
    a. 3 inches.
    b. 6 inches.
    c. 9 inches.
    d. 12 inches.

61. (018) When removing a guide roller from a hardened aircraft shelter (HAS) door, you should open the door until the inside end of the door is within approximately
    a. 3 to 4 feet from the turret tank.
    b. 3 to 4 feet from the speed reducer.
    c. 6 to 8 feet from the turret tank.
    d. 6 to 8 feet from the speed reducer.

62. (018) When removing a turret tank from a hardened aircraft shelter (HAS) door, you should place a 100-ton capacity jack near the
    a. edge of the tank.
    b. middle of the tank.
    c. edge of the speed reducer.
    d. middle of the speed reducer.

63. (018) When removing a turret tank from a hardened aircraft shelter (HAS) door, how do you keep the weight of the door from rupturing the jack's hydraulic seals?
    a. Only fill the jack's hydraulic reservoir to within ¾ of its capacity.
    b. Only fill the jack's hydraulic reservoir to within ⅞ of its capacity.
    c. Place a metal spacer underneath the door to hold the door off the tanks.
    d. Place a wooden spacer underneath the door to hold the door off the tanks.

Glossary of Terms, Abbreviations, and Acronyms

Terms

camouflet—The resulting cavity in a deep underground burst when there is no rupture of the surface.

contingency—An emergency, such as a natural disaster, enemy attack, or other military operations, that involves military forces. Due to these uncertain conditions, contingencies require plans, rapid response, and certain procedures for safety, and readiness of people and equipment.

dispersal—Relocating forces and assets to increase survivability of an enemy attack.

ferrox—A coating that resists weathering.

folded fiberglass mat (FFM)—A 30-foot-long by 54-foot-wide fiberglass mat that is made in 6-foot-wide by 30-foot-long panels with flexible joining hinges to allow it to be folded for shipment.

foreign object damage (FOD)—Any item, such as rags, paper, rope, clothing, tools, or nuts and bolts, that when misplaced or caught by air currents can cause damage to aircraft, weapons, equipment, or injury to people.

geotextile—multi-purpose fabrics that are felt like in appearance. Useful for separation and an underlayment.

hard-back tent—Commonly used when personnel are going to be in a deployed area for more than 30 days. Hard-backing is building a frame out of 2 by 4 material and plywood sheathing and placing a canvas tent over the wooden structure.

KMU–450F—A chemical modification kit to conventional buildings, this provides an airlock and body decontamination area for long- and short-term rest and relief areas.

limit switch—An electrical safety mechanism that stops the operation of a door or gate when fully opened or closed.

minimum operating strip (MOS)—The smallest airfield surface area needed to launch and recover aircraft.

panel delamination—Occurs when a shelter's aluminum skin loses its bond to the core material.

SCPS–2—A permanent self-supporting shelter that provides chemical and conventional warfare protection. Made of precast concrete pipe sections, it is assembled, sealed, and buried under at least 1 meter of earth.

selvage—Material used to prevent unraveling.

sistering—The act of attaching some type of material to the side of damaged lumber. It could be the same material or something different. Sometimes called scabbing.

spalls—Pavement surface damage (missing pieces of surfacing material) that does not penetrate the base course.

splinter protection—The protection of facilities, aircraft, and people from bomb blast and shrapnel with the use of various revetments.

survivable collective protection system (SCPS)—A semi-hardened shelter that provides protection from blast and chemical agents. It also has a processing area to remove contaminated clothing and a toxic-free area for rest and messing. The shelter contains bunks, portable water, food, showers, and toilets.

survival recovery center (SRC)—A supplemental command post collocated with or near the wing operations center. It ensures expedient repairs are made to restore base operations after an attack.

torsion springs—Springs that act to counterbalance the weight in rollup doors. The number and size of springs depend on the size and type of door.

unit control center (uCC)—The operations center established by the base civil engineer to control and conduct postattack recovery operations with civil engineer forces.

wing operations center (WOC)—Where the wing commander controls the assigned and attached wing forces.

wire entanglements—Wire obstacles that are designed to impede movement of foot troops and, in some cases, tracked and wheeled vehicles. The material used is relatively lightweight and inexpensive, considering the protection they provide.

zerk—A grease fitting located on bushings, bearings, and axle shaft or roller hub for lubrication. Generally anywhere there is a pivot point or area of repetitive motion, you should look for a grease zerk.

Abbreviations and Acronyms

ACH	aircraft maintenance hangar
ADAT	aircraft damage assessment team
ADR	airfield damage repair
AFIMS	Air Force Incident Management System
AFSC	Air Force specialty code
BCE	base civil engineer
BRAAT	base recovery after attack
CAMSS	California medium shelter system
CAT	crisis action team
CBRN	chemical, biological, radiological, and nuclear
CCA	contamination control area
CE	civil engineer
DART	damage assessment and response team
DAT	damage assessment team
DCC	damage control center
DEFCON	defense condition
DOD	Department of Defense
ECP	entry control point
ECU	environmental control unit
EOC	emergency operations center
EOD	explosive ordnance disposal
ESC	expandable shelter container
FBR	filter/blower room
FFM	folded fiberglass mat
FOD	foreign object damage
FSTFS	frame-supported tensioned fabric shelter
GP	general purpose
gph	gallons per hour
gpm	gallons per minute
GPS	general purpose shelter
HAS	hardened aircraft shelter

HVAC/R	heating, ventilation, air conditioning and refrigeration
IOC	installation operations center
LAMS	large area maintenance hangar
LHA	liquid hazard area
MAAS	mobile aircraft arresting system
MAOS	minimum airfield operating surface
MER	mechanical equipment room
MOS	minimum operating strip
MOSMS	minimum operating strip marking system
MSS	medium shelter system
NIMS	National Incident Management System
OIC	officer-in-charge
PACAF	Pacific Air Forces
PAPI	Precision Approach Path Indicator
PDP	power distribution panel
POL	petroleum, oils, and lubricants
Prime BEEF	Prime Base Engineer Emergency Force
psi	pounds per square inch
RED HORSE	Rapid Engineers Deployable Heavy Operations Repair Squadron Engineers
rph	revolutions per hour
rpm	revolutions per minute
RQC	repair quality criteria
RRR	rapid runway repair
RWP	recurring work program
SCPS	survivable collective protection system
SRC	survival recovery center
SSS	small shelter system
TEMPER	Tent, Extendable Modular Personnel
TFA	toxic-free area
UCC	unit control center
UXO	unexploded ordnance

VHA	vapor hazard area
WMP	USAF War and Mobilization Plan
WOC	wing operations center

Student Notes

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