Chapter 8
Roads and Airfields

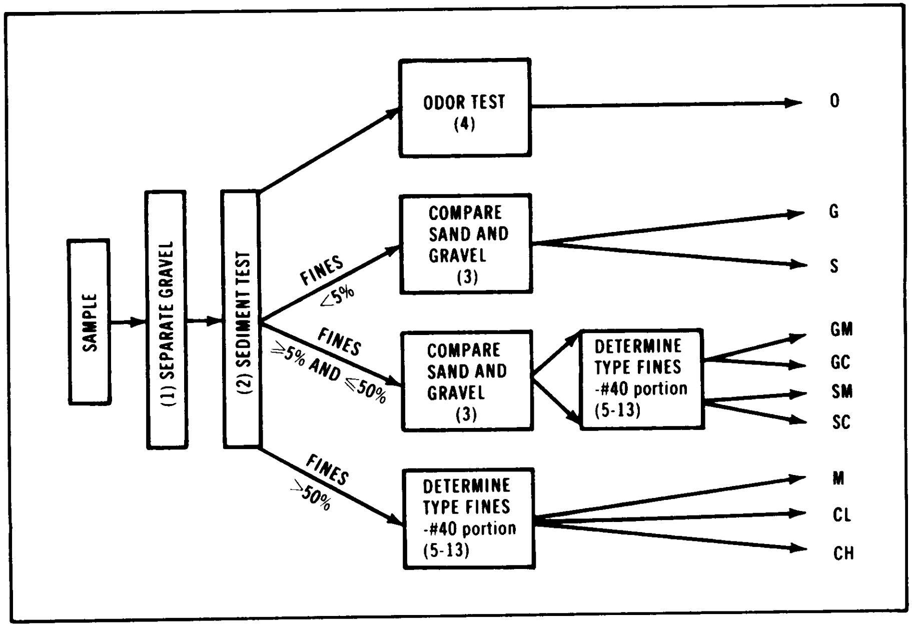
SOILS

Characteristics

Table 8-1 shows the characteristics of specific soils. Figure 8-1 outlines steps for field identification of soils.

Table 8-1. Soil characteristics

SYMBOL	DESCRIPTION	DRAINAGE CHARACTER-ISTICS	AIRFIELD INDEX (FROST SUSCEPTIBIL-ITY)	VALUE AS A SUBGRADE	VALUE AS A SUBBASE	VALUE AS A BASE	COMPACTION EQUIPMENT
G	Gravels and Sandy Gravel with little or no Fines	Excellent	None to very Slight	Good to Excellent	Good to Excellent	Fair to Good	Crawler Tractor, Rubber Tire Roller, Steel Wheel Roller
GM	Silty Gravels, Gravel-Sand Silt Mixture	Fair to Practically Impervious	Slight to Medium	Good	Fair to Good	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
GC	Clayey Gravels, Gravel, Sand-Clay Mixtures	Poor to Practically Impervious	Slight to Medium	Good	Fair	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
S	Sands and Gravels, Sands with little or no Fines	Excellent	None to very Slight	Fair to Good	Fair to Good	Not Suitable	Crawler Tractor, Rubber Tire Roller
SM	Silty-Sands, Sand-Silt Mixtures	Fair to Practically Impervious	Slight to Medium	Fair to Good	Poor to Fair	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
SC	Clayey Sands, Sand-Clay Mixtures	Poor to Practically Impervious	Slight to High	Poor to Fair	Poor	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
M	Inorganic Silts and very fine Sand Rock Flour, Clayey Silts with slight Plasticity	Fair to Poor	Medium to High	Poor to Fair	Not Suitable	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
CL	Inorganic Clays low to medium Plasticity Gravelly or Sandy Clays	Practically Impervious	Medium to High	Poor to Fair	Not Suitable	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
CH	Inorganic Clays of high Plasticity	Practically Impervious	Medium	Poor to Fair	Not Suitable	Not Suitable	Sheepsfoot Roller
O	Mineral Grains containing highly Organic Matter	Poor to Practically Impervious	Medium to High	Poor to Very Poor	Not Suitable	Not Suitable	Rubber Tire Roller, Sheepsfoot Roller
PT	Peat and Other highly decom-posed Vegetable Matter	Fair to Poor	Slight	Not Suitable	Not Suitable	Not Suitable	Compaction not Practical



NOTE: This procedure will give a very hasty classification of soils, and SHOULD NOT
BE DESIGNED OF PERMANENT OR SEMIPERMANENT CONSTRUCTION.

Figure 8-1. Field identification of soils

1. Separate Gravel
   a. Remove from sample all particles larger than ¼" diameter (#4 sieve).
   b. Estimate the percent gravel (G) by volume.
2. Sedimentation Test to determine percent sand (S)
   a. Mason jar method.
      1. Put approximately 1" of sample in glass jar
      2. Mark depth of sample with grease pencil
      3. Fill jar with 5 or 6 inches of clear water. Leave 1 inch of air at top
      4. Shake the mixture vigorously for 3 to 4 minutes
      5. Allow the sample to settle for 30 seconds
      6. Compare sediment line to grease pencil mark estimating percent settled
      7. Determine percent Sand and Fines: 100 - % Gravel = % Sand and Fines
      8. Determine percent Sand: $\frac{\text{\% Settled}}{100} \times$ % Sand and Fines = % Sand
   b. Canteen cup method
      1. Place sample (less gravel) in canteen cup and mark level
      2. Fill with water and shake mixture vigorously
      3. Allow mixture to stand for 30 seconds to settle out
      4. Pour off water
      5. Repeat Steps 2 and 4 until water poured off is clear
      6. Dry the soil left in the cup (Sand)
      7. Estimate percent Sand by comparing the level of sand with mark percent sand = (% sand in cup) (100% - % gravel)
3. Comparison of Gravel, Sand, and Fines
   a. Percent Gravel was estimated in Test 1-Step b
   b. Percent Sand was estimated in Test 2-Step #8
   c. Percent Fines = 100 - % Gravel - % Sand
4. Odor Test
   a. Heat sample with match or open flame
   b. If odor becomes musty or foul smelling, there is a strong indication that organic material is present
5. Dry Strength Test (-#40 sieve)
   a. Form moist pat 2 inches in diameter by ½ inch thick
   b. Allow to dry with low heat
   c. Place dry pat between thumb and index finger only and attempt to break
   d. Breakage easy - Silt (M)
      Breakage difficult - Low compressible Clay (CL)
      Breakage impossible - High compressible Clay (CH)
6. Powder Test
   a. Scrape portion of broken pat with thumbnail and attempt to flake particles off
   b. Pat powders or flakes - Silt (M)
      Pat does not powder or flake - Clay (C)
7. Feel Test
   a. Rub portion of dry soil over a sensitive portion of skin such as inside of wrist
   b. Feel harsh or irritating - Silt (M)
      Feel smooth and floury - Clay (C)
8. Shine Test
   a. Draw smooth surface, such as knife blade or thumbnail, over pat of slightly moist soil
   b. Surface becomes shiny and lighter in texture - Clay (C)
      Surface dull or granular - Silt (M) or Sand (S)
9. Thread Test
   a. Form ball of moist soil (marble size)
   b. Attempt to roll into ⅛ inch diameter thread (wooden match size)
   c. Thread easily obtained - Clay (C)
      Thread cannot be obtained - Silt (M)
10. Ribbon Test
   a. Form cylinder of moist soil, approximately cigar shape and size
   b. Flatten cylinder over index finger with thumb; attempting to form ribbon 8 inches to 9 inches long, ⅛ inch to ¼ inch thick, and 1 inch wide
   c. Ribbon 8 inches or larger obtained - CH
      Ribbon 3 to 8 inches obtained - CL
      Ribbon 0 to 3 inches obtained - M
11. Grit or Bite Test
   a. Place pinch of sample between teeth and bite
   b. Sample feels gritty - Silt (M)
      Sample feels floury - Clay (C)
12. Wet Shaking Test
   a. Place pat of very moist soil (not sticky) in palm of hand
   b. Shake hand vigorously and strike against other hand
   c. Observe rapidity of water rising to the surface
      Fast, positive reaction - Silty (M)
      No (negative) reaction - Clayey (C)
13. Hand Washing Test
      - Easy = Silt (M)
      - Difficult = Clay (C)

Figure 8-1. Field identification of soils (continued)

Moisture Content

To determine whether or not soil is at or near Optimum Moisture Content (OMC). mold a golf ball size sample of soil with your hands. Squeeze the ball between your thumb and forefinger. If the ball shatters into several fragments of rather uniform size, the soil is near or at OMC. If the soil is difficult to roll into a ball or it crumbles under very little pressure, the soil IS below OMC.

Stabilization

See Table 8-2 for recommended soil stabilizing agents.

Table 8-2. Recommended initial stabilizing agent given in percentage by weight

SOIL TYPE	HYDRATED LIME	QUICKLIME
GC. GM-GC	2-4	2-3
CL	5-10	3-8
CH	3-8	3-6
SOIL TYPE	**PORTLAND CEMENT**	
GW. SW	3-5	
GP. GM. SM	5-8	
GC. SC	5-9	
SP	7-11	
CL. ML	8-13	
CH	9-15	
MH. OH	10-16	

DRAINAGE

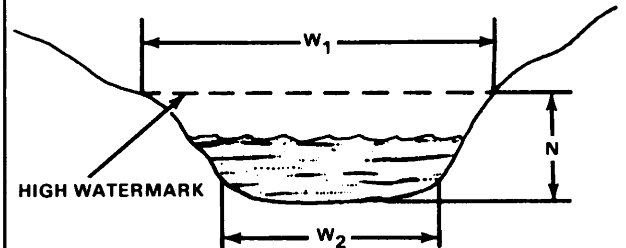
The most common drainage structures are open ditches and culverts.

Runoff Estimates

The volume of water that is to be carried by the open channel or culvert can be estimated as follows:

Cross-sectional area estimate

Compute the amount of water that has been carried by the open channel (Figure 8-2). Continue with the culvert or the open ditch design on page 8-6.



W_1 = WIDTH OF CHANNEL AT HIGH WATERMARK
W_2 = WIDTH OF CHANNEL AT BOTTOM
H = VERTICAL DISTANCE FROM BOTTOM TO HIGH WATERMARK

$$\left(\frac{W_1 + W_2}{2}\right) H = \text{AREA OF WATERWAY } (A_W)$$

SIZE OF CULVERT = AREA OF WATER + SAFETY FACTOR 100%

Figure 8-2. Cross-sectional area of water

Runoff field estimate method (Q = 2ARC)

Determine acreage contributing runoff to project area by delineating drainage areas and drawing flow lines (If drainage areas exceed 100 acres, do not use this method) Remember that water flows down hill and perpendicular to contour lines. Calculate total contributing area in acres (1 acre = 43,560 ft^2= 4.047M^2). Find your general location on Figure 8-3 and select the appropriate rainstorm intensity If your location is between two lines, select the higher value Select runoff coefficient from Table 8-3 and determine expected flow by using formula:

Q = 2ARC

Where Q = total runoff m CFS
A = drainage area in acres
R = rainfall intensity (Figure 8-3)
C = coefficient factor (Table 8-3)

Compute (cross-sectional area of water) using formula: $A_W = \frac{Q}{V}$

Where = cross-sectional area in
Q = quantny of water in CFS
V = water velocity (If not known, use 4.)

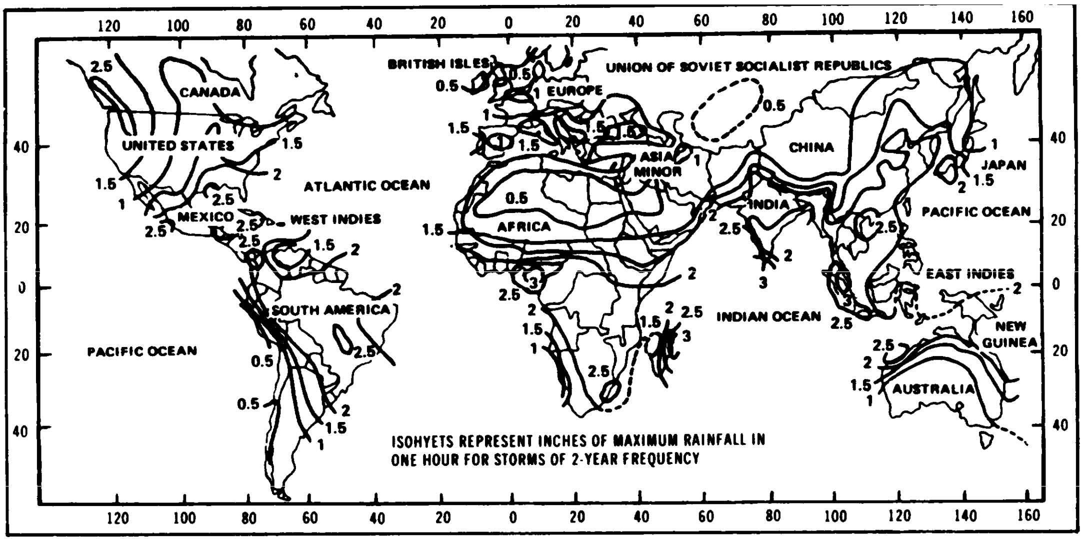


Figure 8-3. World Isohyetal map

Table 8-3. Runoff coefficient

MAJOR DIVISIONS		LETTER		DRAINAGE CHARACTERISTICS	WITH TURF	WITH-OUT TURF
Coarse-Grained Soils	Gravel and Gravelly Soils	GW		Pervious	.10	.20
		GP		Pervious	.10	.20
		GM	d	Slightly Pervious	.30	.40
			u	Impervious	.55	.65
		GC		Impervious	.55	.65
	Sand and Sandy Soils	SW		Pervious	.10	.20
		SP		Pervious	.10	.20
		SM	d	Slightly Pervious	.30	.40
			u	Impervious	.55	.65
		SC		Impervious	.55	.65
Fine-Grained Soils	Silts and Clays LL < 50	ML		Slightly Pervious	.30	.40
		CL		Impervious	.55	.65
		OL		Impervious	.55	.65
	Silts and Clays LL ≥ 50	MH		Slightly Pervious	.30	.40
		CH		Impervious	.55	.65
		OH		Impervious	.55	.65
Highly Organic Soils		P_t		Slightly Pervious	.30	.40
	Asphalt pavements, roof surfaces					.95
	Concrete pavements					.90
	Gravel or macadam pavements					.70
Wooded Areas						.20

Culverts

Design

Using previously obtained area of water (A_w), the culvert design area (A_{des}) is $2A_w$. See Figure 8-4 to determine the maximum allowabe culvert diameter, fall, and cover Round DOWN to next available culvert diameter. Determine number of pipes using formula:

$$N = \frac{2A_w}{\text{pipe area}} = \frac{A_{des}}{\text{pipe area}}$$

Start working with the largest available culvert that meets the maximum diameter requirement. Then go to smaller diameters until the most economical solution is found.

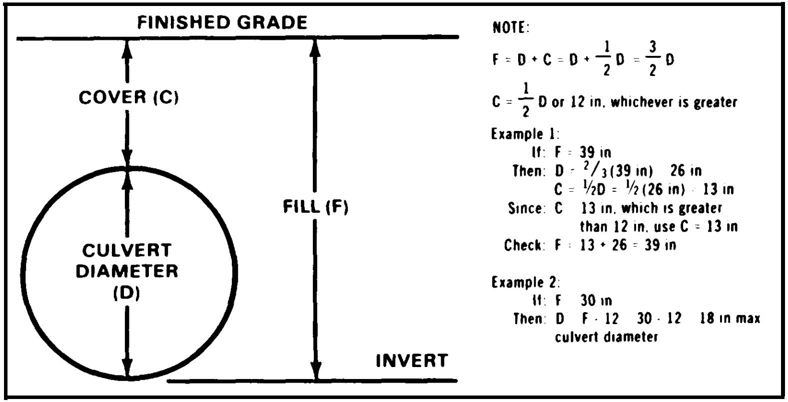


Figure 8-4. Minimum fill and cover

Length

Figure 8-5. shows length determination procedures

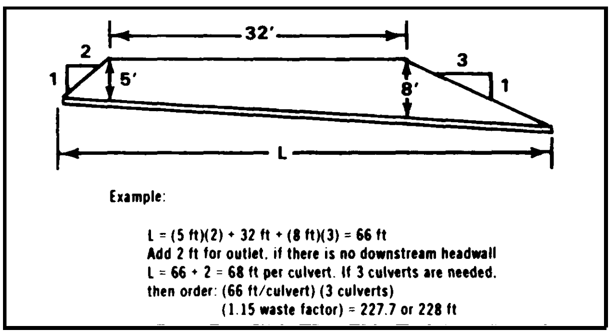


Figure 8-5. Culvert length determination

Installation

During installation, the following criteria should be adhered to whenever possible:

- Place the inlet elevation at or below the ditch bottom.
- Extend the culvert 2 feet minimum downstream beyond the fill slopes.
- Use bedding of D/10 minimum.
- Space multiple culverts a minimum of D/2 apart.
- Desired slope is 2 to 4 percent, minimum slope is 0.5 percent.
- Always use a headwall upstream.
- Riprap downstream to control erosion.

Examples

Examples of field expedient culverts are shown in Figure 8-6.

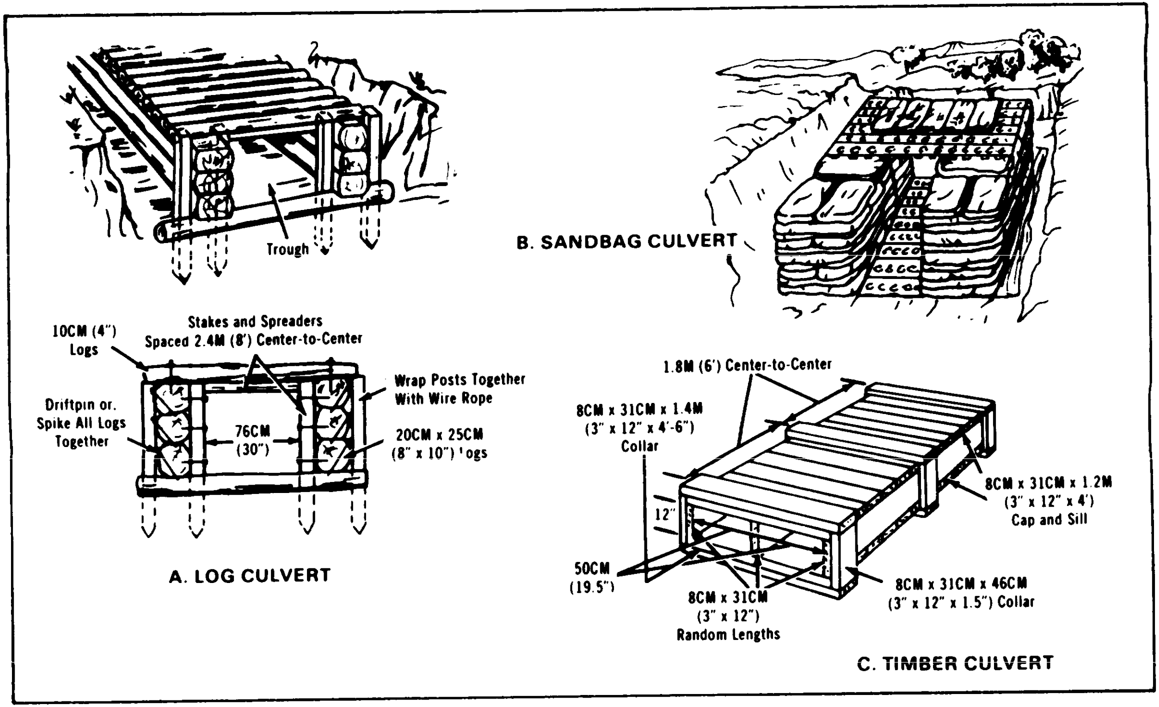


Figure 8-6. Expedient culvert examples

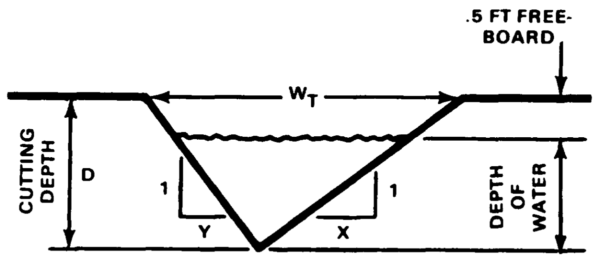
Open Ditch Design

- Determine area of water (A_W) using formula (page 8-4):

$$A_W = \frac{Q}{V}$$

- Select site slope ratio based on soil stability (Table 8-4), equipment capacity, and safety.

- Determine cutting depth IAW Figure 8-7.



$$D^{FT} = \sqrt{\frac{2A_W}{X + Y}} + 1.5$$

$$W_T = D\,(X + Y)$$

Figure 8-7. Open ditch

Table 8-4. Recommended requirements for slope ratios in cuts and fills: homogeneous soils

USCS CLASSIFICATION	SLOPES NOT SUBJECT TO SATURATION		SLOPES SUBJECT TO SATURATION	
	MAX HT OF EARTH FACE	MAXIMUM SLOPE RATIO	MAX HT OF EARTH FACE	MAXIMUM SLOPE RATIO
GW, GP, GMd SW, SP, SMd	Not Critical	1½:1	Not Critical	2:1
GMu, GC SMu, SC ML, MH CL, CH	Less Than 50 Feet	2:1	Less Than 50 Feet	3:1
OL, OH, Pt	Generally not suitable for construction			

NOTES: 1. Recommended slopes are valid only in homogeneous soils that have either an in-place or compacted density equaling or exceeding 95 percent CE55 maximum dry density. For nonhomogeneous soils, or soils at lower densities, a deliberate slope stability analysis is required.

2. Backslopes cut in to loess soil will seek to maintain a near-vertical cleavage. DO NOT apply loading above this cut face. Expect sloughing to occur.

EXPEDIENT PAVEMENTS

Expedient Road Surfaces

See Chapter 2 (pages 2-19 through 2-22).

Expedient Airfield Surfaces

Calculate requirements using Table 8-5 and Table 2-11 (page 2-24) to prepare subgrade, lay membrane. and lay matting.

Table 8-5. Mat characteristics

	M8A1	M8	M18b	M19	AM2
Bundle					
Volume (ft³)	24.7	22.7	74	85.7	62
Placing area (ft²)	269	269	432	534	288
Weight	2,036	1.960	2,400	2,484	1,980
Number of panels (Full/Half)	13/2	13/2	16/4	32/0	11/2
Panel					
Dimension (ft)	1.6x11.8	1.6x11.8	2x12	4x4.1	2x12
Weigh (lb)	144	140	120	68	140
Placing area (ft²)	19.2	19.2	24	16.7	24

Start placing matting from one corner of runway with male hinges parallel with and toward centerline. The first strip must be laid along edge of roadway. The second strip must be staggered so that the connectors from the first strip are at the center of the second strip panels. Connecting bars MUST be fully inserted (Figure 8-8).

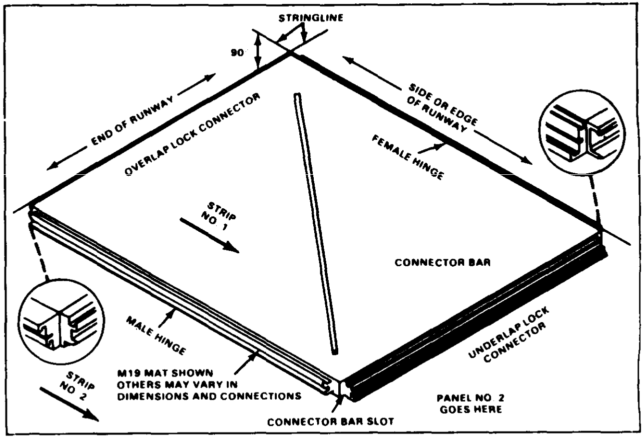


Figure 8-8. Typical mat and connectors

AIRFIELD REPAIR

Minimum Operating Strip (MOS)

The main focus is the MOS which is 15 meters x 1,525 meters (50 feet x 5,000 feet) for fighter aircraft and 26 meters x 2,134 meters (90 feet x 7,000 feet) for cargo.

Priority of Work

See Figure 8-9.

(1) Establish first MOS (15M x 1.525M/50' x 5,000').
(2) Use minimal effort to build 7.6M (25') wide access routes.
(3) Establish second MOS (15M x 1.525M/50' x 5,000').
(4) Build more 7.6M (25') wide access routes
(5) Lengthen first MOS to 2.134M (7,000')
(6) Lengthen second MOS to 2.134 M (7.000')
(7) Widen first MOS 27.4M (90')
(8) Widen second MOS to 27.4M (90')

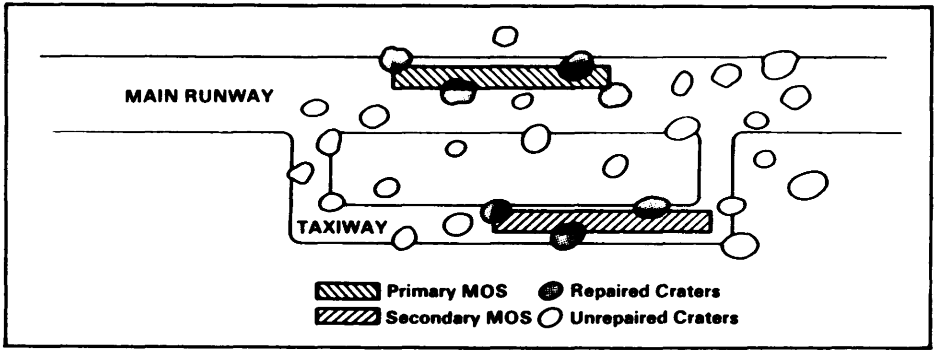


Figure 8-9. Airfield repair priority of work

Membrane and Mat Repair

Membranes

Repair tears in membranes by cutting an "X" and lifting the four flaps back. Place a new peice of membrane under the torn area to extend at least 30 centimeters (12 inches) beyond the torn area. Apply an adhesive to top of new membrane and bottom of old membrane. Allow adhesive to become tacky. Fold flaps back into position and allow adhesive to set for at least 15 minutes. Roll patched area with a wheeled roller or vehicle.

Mats

M8A1. Unlock end connector bars from damaged panel and remove locking lugs. Move panel laterally until hooks are centered on slots. Pry hooks out of slots and move panel to clear overlapping ends. Remove damaged panel. Remove locking lugs from new panel and orient to same position as damaged panel. Reverse removal procedures.

AM2.

Slide out method. Slide out entire run where damage to panel is located. Remove end connector bars. Replace damaged panel. Push new run in until it is 5 to 10 centimeters (2 to 4 inches) from next panel, and continue procedure until all panels have been replaced. Push run to its original position.

Cutting method. If special repair panels are available, cut the damaged panel as shown in Figure 8-10 and remove pieces Replace with special repair panel and accessories (Figure 8-11).

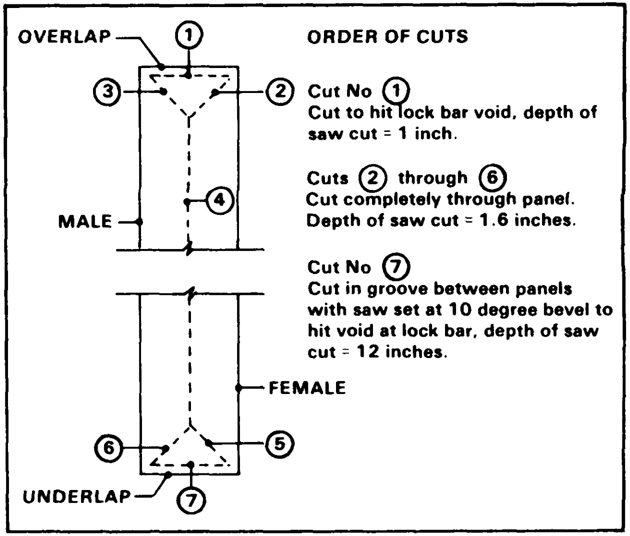


Figure 8-10. AM2 mat cutting method

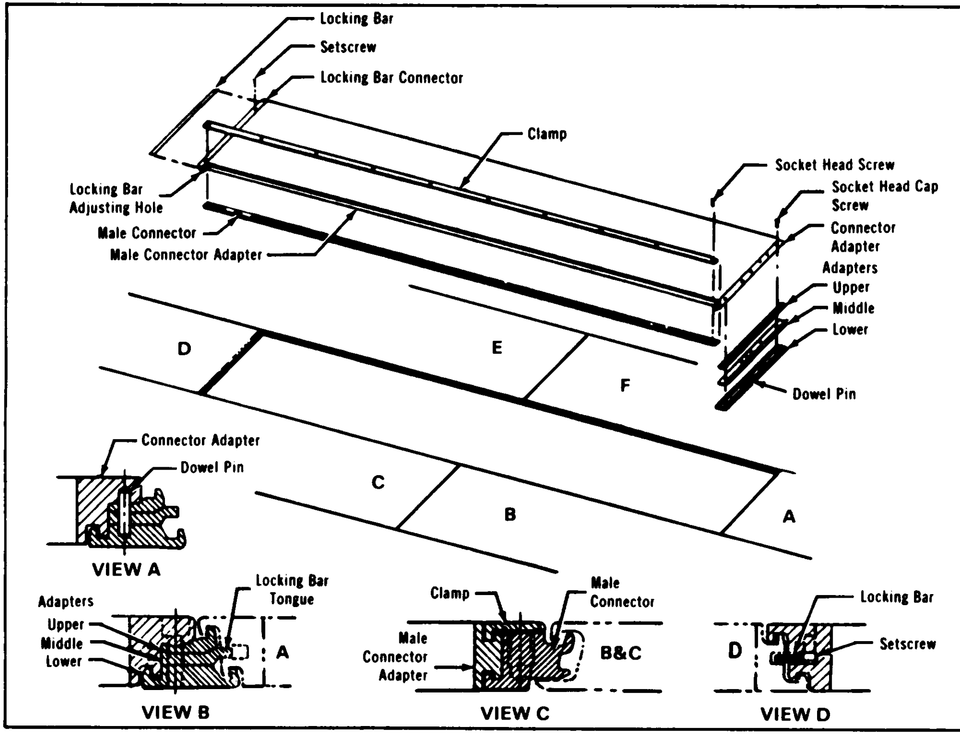


Figure 8-11. AM2 special repair panel

M19. Replace a single mat by using a clrcular saw and cut as shown in Figure 8-12. Use pry-bar and lift cut pieces. Unbolt edges of damaged panel and replace as shown in Figure 8-13.

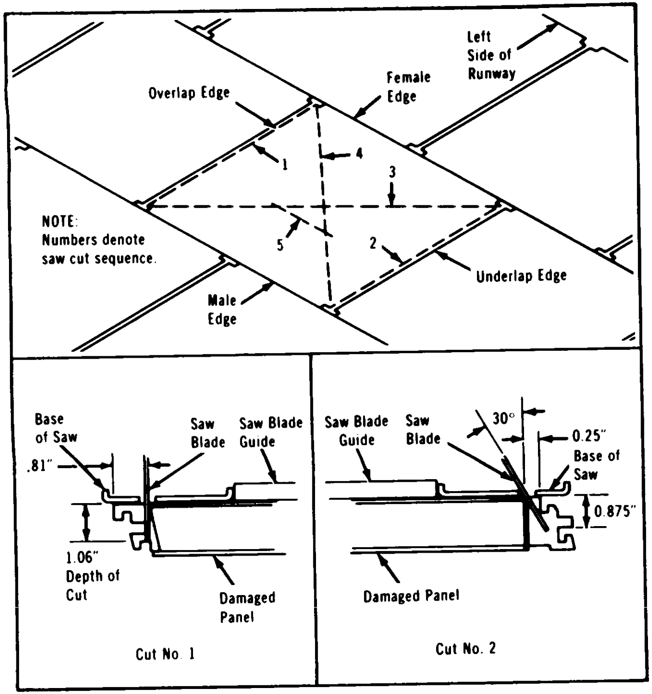


Figure 8-12. Cutting of M19 mat

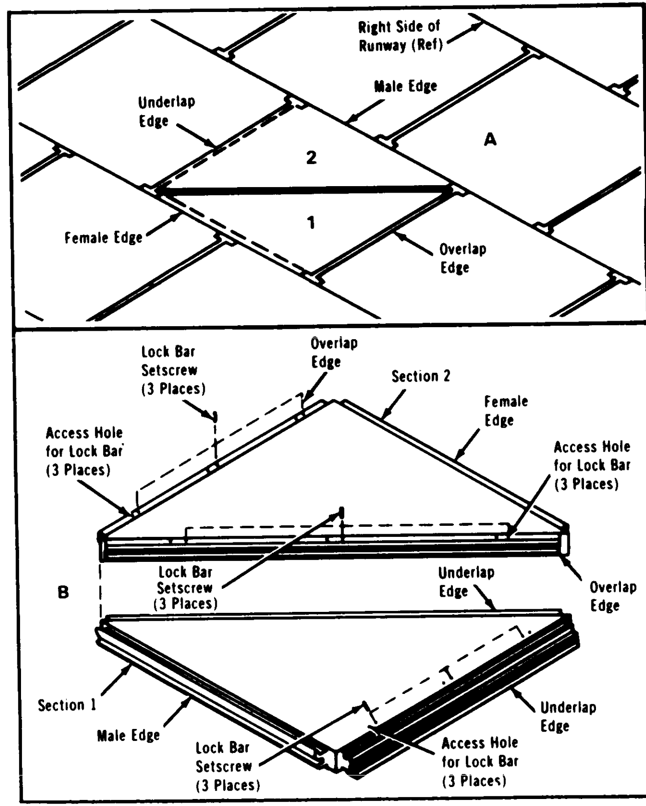


Figure 8-13. M29 repair panel replacement

For repair of large areas, create a pyramid as shown in Figure 8-14. Remove maintenance access adapter and start removing panel from the outside in until reaching the damaged area. Replace the damaged area and removed panels.

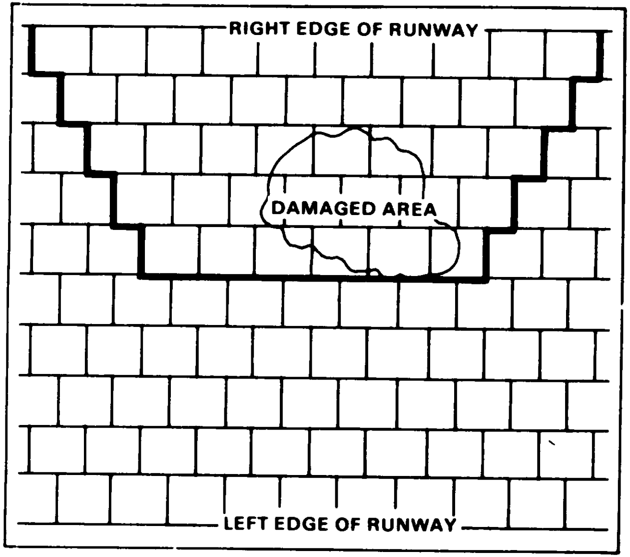


Figure 8-14. Repair of M19 large damaged areas

Other Than Membrane and Mat Surface Repairs

Figures 8-15 through 8-17 show different emergency repair methods.

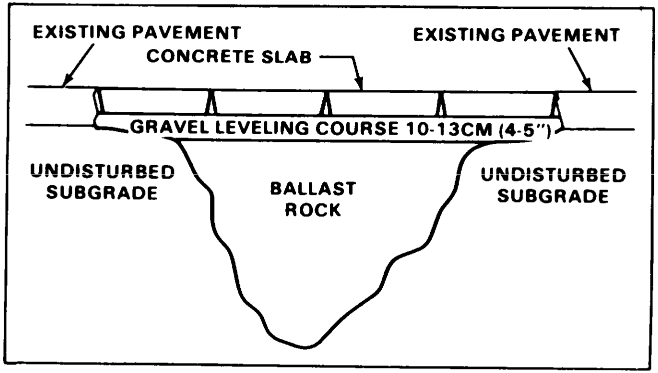


Figure 8-15. Precast concrete slab crater repair

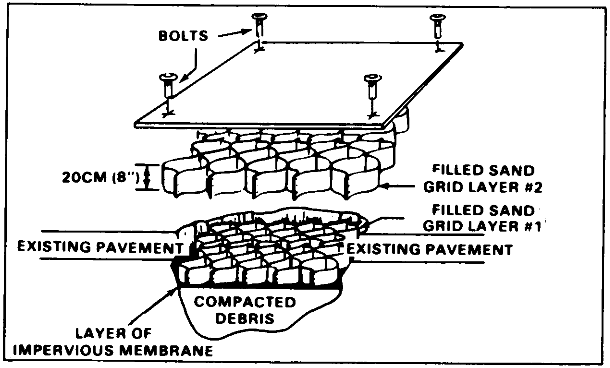
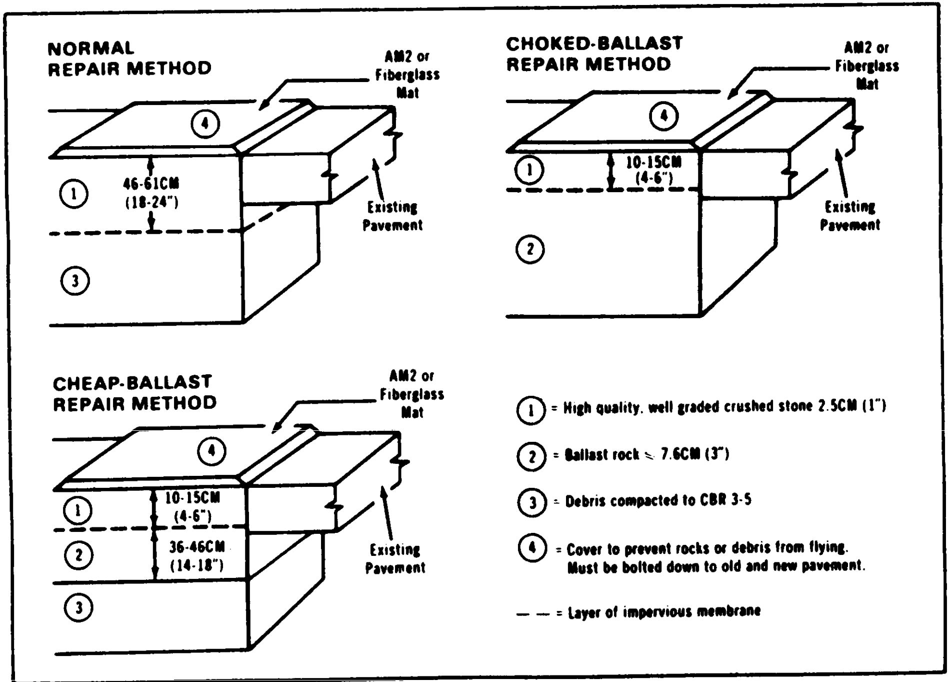


Figure 8-16. Sand grid repair method


NORMAL
REPAIR METHOD
AM2 or
Fiberglass
Mat
46-61CM
(18-24")
Existing
Pavement
CHOKED-BALLAST
REPAIR METHOD
AM2 or
Fiberglass
Mat
10-15CM
(4-6")
Existing
Pavement
CHEAP-BALLAST
REPAIR METHOD
AM2 or
Fiberglass
Mat
10-15CM
(4-6")
36-46CM
(14-18")
Existing
Pavement
1 = High quality, well graded crushed stone 2.5CM (1")
2 = Ballast rock ≤ 7.6CM (3")
3 = Debris compacted to CBR 3-5
4 = Cover to prevent rocks or debris from flying.
Must be bolted down to old and new pavement.
— — = Layer of impervious membrane