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EVALUATION AND MAINTENANCE OF EXPEDIENT-SURFACED AIRFIELD FACILITIES

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Army Engineer Waterways Experiment Station

Prepared for:

Office of the Chief of Engineers (Army)

May 1973

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INSTRUCTION REPORT S-73-1

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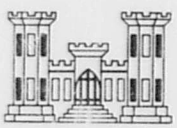
by

P. J. Vedros, Jr.



May 1973

Sponsored by Office, Chief of Engineers, U. S. Army

Conducted by U. S. Army Engineer Waterways Experiment Station
Soils and Pavements Laboratory
Vicksburg, Mississippi

ARMY-MRC VICKSBURG, MISS

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

EVALUATION AND MAINTENANCE OF EXPEDIENT-SURFACED AIRFIELD FACILITIES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Philip J. Vedros, Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
May 1973	23	6

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	Instruction Report S-73-1
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Office, Chief of Engineers, U. S. Army Washington, D. C.

13. ABSTRACT

This instruction report presents a reference of suggested guidelines on the evaluation and maintenance of expedient-surfaced airfield facilities. The expedient surfacing materials covered in this discussion are aluminum and steel landing mats and a neoprene-coated nylon membrane. Methods of repair that have performed satisfactorily for the landing mats and T17 membrane are presented.

DD FORM 1 NOV 68 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified
Security Classification

Unclassified

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Airfields						
Aluminum landing mats						
Expedient surfacings						
Membrane surfacing						
Steel landing mats						

Unclassified

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FOREWORD

This report was prepared as part of the work authorized by the Office, Chief of Engineers, in "Instruction and Outline for Technical Support, Army; FY 1967," dated May 1966.

Engineers of the Soils and Pavements Laboratory, U. S. Army Engineer Waterways Experiment Station (WES), who were actively engaged in the planning, testing, and analyzing phases of the various studies that served as a basis for the preparation of this report were Messrs. J. P. Sale, R. G. Ahlvin, and W. L. McInnis. This report was written by Mr. P. J. Vedros, Jr.

COL Ernest D. Peixotto, CE, was Director of the WES during the preparation of this report. Mr. F. R. Brown was Technical Director.

CONTENTS

CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
tons (2000 lb)	907.18474	kilograms
pounds (mass) per square foot	4.88243	kilograms per square meter

SUMMARY

This instruction report presents a reference of suggested guidelines on the evaluation and maintenance of expedient-surfaced airfield facilities. The expedient surfacing materials covered in this discussion are aluminum and steel landing mats and a neoprene-coated nylon membrane. Methods of repair that have performed satisfactorily for the landing mats and T17 membrane are presented.

EVALUATION AND MAINTENANCE OF EXPEDIENT-SURFACED AIRFIELD FACILITIES

PART I: INTRODUCTION

Purpose and Scope

1. The purpose of this report is to furnish instructions to engineer troops in the theater of operations (TO) as to when and how to maintain expedient-surfaced airfield facilities. It is realized that maximum use will be made of these facilities before maintenance or repair will be performed; however, this report points out those measures that should be undertaken at the first sign of distress so that a major repair of the facility can be deferred. The final solution to a problem in a given situation will probably arise from the ingenuity of the user; therefore, this report is intended to serve only as a reference of suggested guidelines.

2. The expedient surfacing materials discussed in this report are aluminum and steel landing mats and a neoprene-coated nylon membrane. The installation and repair of the landing mats and membrane are discussed in detail in Sections 1 and 2 of reference 1 and in references 2 and 3. Pertinent information has been extracted from these reports and is presented herein.

Definitions of Pertinent Terms

3. For information and clarity, definitions of certain terms as used in this report are given below:

a. Expedient surfacing. A means of providing a surface medium suitable for aircraft operations or vehicular traffic in lieu of more conventional construction materials.

b. Landing mat. Prefabricated structural planks which, when fitted together with similar panels, form an expedient paving for aircraft operations.

PART II: EXPEDIENT SURFACING MATERIALS

T17 Membrane

General

4. To date, the most successful membrane surfacing has been the T17 membrane, which is a neoprene-coated 2-ply nylon fabric designed to provide a dustproof and waterproof wearing surface for soil subgrades used as landing areas and roadways. The T17 membrane is currently the only prefabricated membrane in the military supply system.

Description

5. The T17 membrane consists of 54-in.-wide* runs of the fabric joined with a series of 2-1/2- to 3-in.-wide adhesive single-lap joints** (fig. 1). The size of the membrane surfacing can be varied to fit a particular area; the weight of the membrane is 0.33 lb per sq ft of placing area. Its service life is usually limited by inadequate subgrade strengths and by excessive locked-wheel braking action. Service tests have indicated that, under the effects of light Army aircraft and truck traffic, repair and maintenance of the membrane will be very minor; however, more repairs and maintenance can be expected for traffic from the heavier cargo aircraft (such as the C-130, etc.). Most repairs are generally required in the first 500 ft of the runway ends.

Types of failures

6. Two types of failure commonly occur in a facility surfaced with T17 membrane:

a. An opening in the membrane fabric.

b. A failure in the underlying soil resulting in rutting.

It is emphasized that the best practice is to repair all failed areas as soon as possible, as less time and effort will be required to repair

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* A table of factors for converting British units of measurement to metric units is presented on page ix.

** Although factory gluing of these joints is now permitted, trouble has been experienced with them in airfields in Vietnam. Steps have since been taken to ensure better quality of fabrication, but some of the earlier material is still in use.

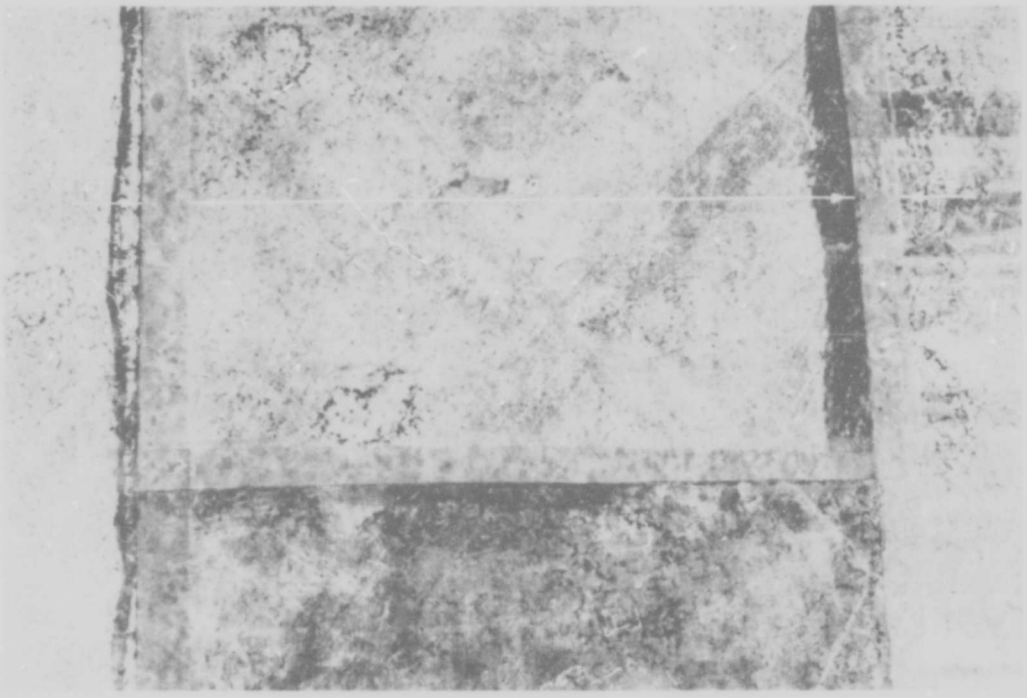


Fig. 1. Fifty-four-in.-wide runs of T17 membrane joined with 2-1/2-in.-wide adhesive single-lap joints

a small area immediately after failure than to repair a large area that may develop from a small one.

Repair methods

7. When a tear occurs in the membrane surfacing on which antiskid compounds have been applied, the failed area should be repaired by slitting it in the form of an X and folding the four flaps back. Then, adequate membrane surfacing should be removed from a roll of membrane and placed beneath the antiskid coated membrane so that it extends beyond the failed area of surfacing for approximately 2 ft on all sides. Adhesive should then be applied to the top of the membrane removed from the membrane roll and to the bottom of the surfacing coated with antiskid compound. Adhesive can be spread over the membrane with long-handled paint rollers. After the adhesive becomes tacky (2 to 5 minutes), the flaps that were folded back previously should be placed in their original positions, and the adhesive should be allowed to set for

approximately 15 minutes before the patched area is rolled with a jeep. This manner of patching should also be used for areas of surfacing that are not coated with antiskid compound, but surface patches can be used on uncoated membrane, particularly when the opening being patched is small.

8. Failure to repair a tear in the membrane surfacing will allow water to enter and soften the underlying soil. In extreme cases, neglecting to repair a failed area can also cause ballooning during aircraft operations. Ballooning is usually caused when air is forced under the membrane by the prop wash of aircraft engines. The trapped air causes the membrane to rise from the surface and become airborne. Service tests on the surfacing have shown that aircraft may be operated over small surface failures for a limited period without severe damage or ballooning of the surfacing; nevertheless, repairs should be made as soon as possible.

Subgrade failure

9. If the soil beneath the membrane surface becomes rutted by aircraft or truck traffic to the extent that the ruts constitute a further trafficking hazard then the area should be repaired. One means of repairing such an area consists of leaving the membrane surfacing in place and rolling the rutted area to smooth out the ruts and to compact the soil. Rolling can be accomplished with a steel-wheel roller (fig. 2), a rubber-tired roller, or a loaded M51 5-ton 6x6 dump truck.

Fig. 2. Using steel-wheel roller to roll out ruts in soil subgrade beneath membrane surfacing

If either the rolling or subsequent aircraft traffic causes the soil to become spongy, it will be necessary to slit the membrane, remove the wet material, and backfill with suitable material. Once the area has been repaired and the membrane surfacing returned to its original position, the slit should be repaired as discussed in the preceding paragraph.

Landing Mats

Background

10. During World War II, landing mats were developed and used extensively as expedient surfacing material. The mats developed at that time were prefabricated steel or aluminum panels known as PSP (pierced-steel planks) or PAP (pierced-aluminum planks). Later versions of these were standardized as M6 and M8 steel and M9 aluminum mats. With the advent of larger aircraft and higher tire pressures after World War II, landing mats had to be developed to sustain heavier aircraft operations. Steel mats, such as the M8A1, and aluminum mats, such as the AM2, XM18, and XM19, were developed. Small amounts of PSP and M6 and M9 mat can still be found in use in the theater of operations today; however, these mats will not be discussed in this report. Suggested procedures for evaluation and maintenance of facilities surfaced with M8, M8A1, AM2, XM18, and XM19 are presented in the following paragraphs.

Descriptions of landing mats

11. M8. The M8 is a prefabricated steel panel, 11 ft 9-3/4 in. long and 1 ft 7-1/2 in. wide, containing four parallel rows of perforations (40 holes per row) in each panel. The panels are joined together by connector hooks located along one side of the panel and by a rolled slotted edge along the opposite side (fig. 3). The M8 mat is an improved version of the M6 mat.

12. M8A1. The M8A1 mat is an improved version of the M8 mat. The panels are the same size as the M8 mat and are joined together at the sides with connector hooks, but the end connectors are different from those of the M8 (fig. 4). The M8A1 panels are not perforated, so the

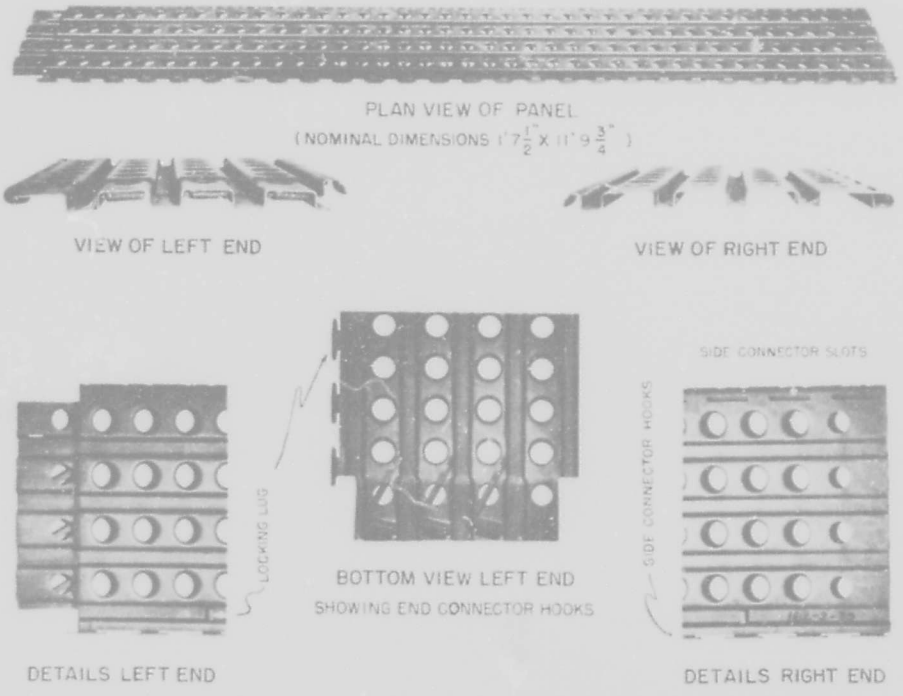


Fig. 3. M8 steel landing mat

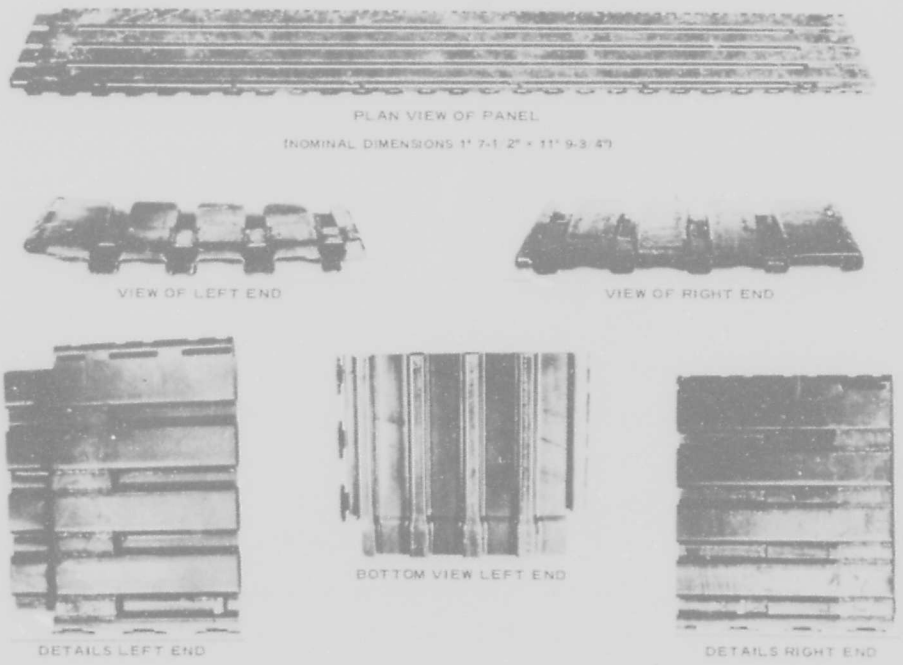


Fig. 4. M8A1 steel landing mat

weight per panel is slightly more than that of the M8. A revised design of the locking lug enables easier removal of the M8A1 panels for repair.

13. AM2. The AM2 is an extruded aluminum mat with a solid top and bottom (fig. 5). The panels are 12 ft long and 2 ft wide and are joined together with overlap and underlap connectors on the ends and with hinge-joint connectors on the sides. The side connectors are integral parts of the basic panel extrusions.

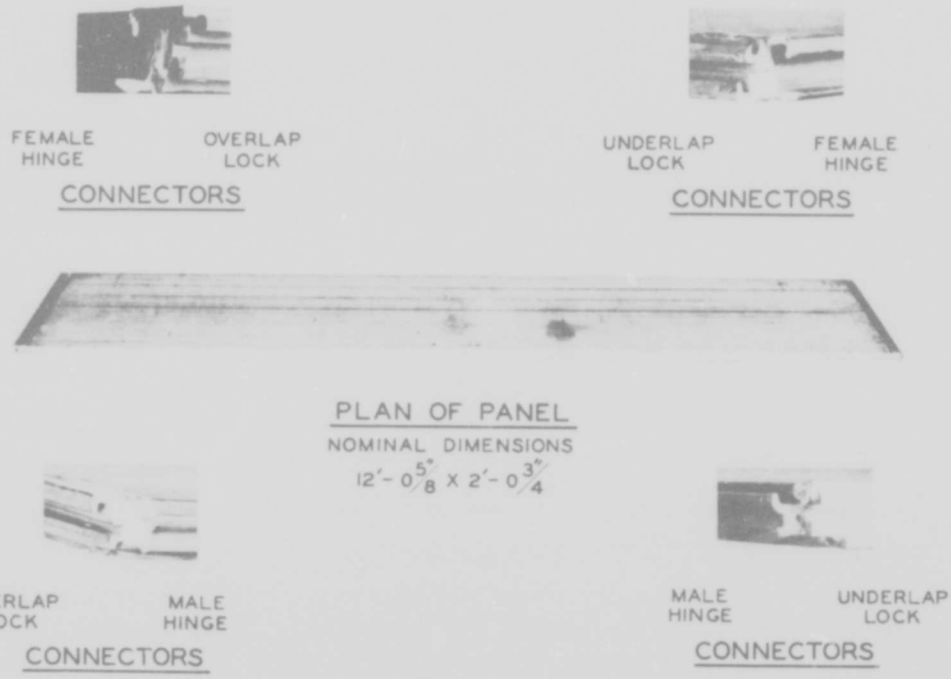


Fig. 5. AM2 aluminum landing mat

14. XM18. The XM18 is an extruded aluminum mat very similar to the AM2 (fig. 6). The primary differences in the two mats are:

a. The XM18 consists of thinner-gage aluminum, thereby decreasing the weight of the individual panels from 6.0 to 4.9 lb per sq ft of placing area.

b. The ends are reinforced with 2-in.-long internal tube inserts.

15. XM19. The XM19 mat is a sandwich-type structure containing

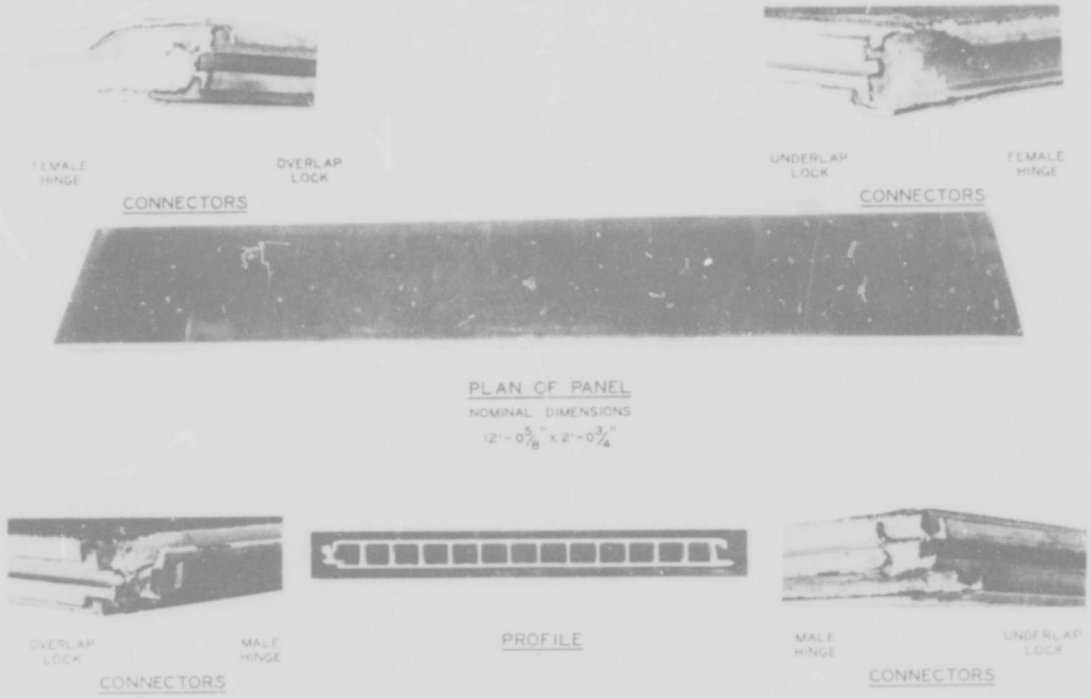


Fig. 6. XM18 aluminum landing mat

a honeycomb core of aluminum foil that is bonded to the top and bottom sheets with a fiber film epoxy adhesive (fig. 7). The connectors are welded to the top and bottom sheets and bonded to the core with a potting compound. Two edges of the panel have overlap and underlap connectors that are nested and then secured with a locking bar. The panels measure 4 ft 2-1/4 in. by 4 ft 1-1/2 in.

Evaluation and types of distress

16. As stated previously, the proper methods for installing each mat are discussed in detail in references 1, 2, and 3. It is imperative that the proper procedures for installing panels be followed so that individual panels can be removed when repair is necessary. If mat is not laid properly, damaged panels will have to be cut out with a torch and new panels cut and welded into place. In most cases, this method of repair will not be satisfactory.

17. Periodic inspections of a facility surfaced with landing mat

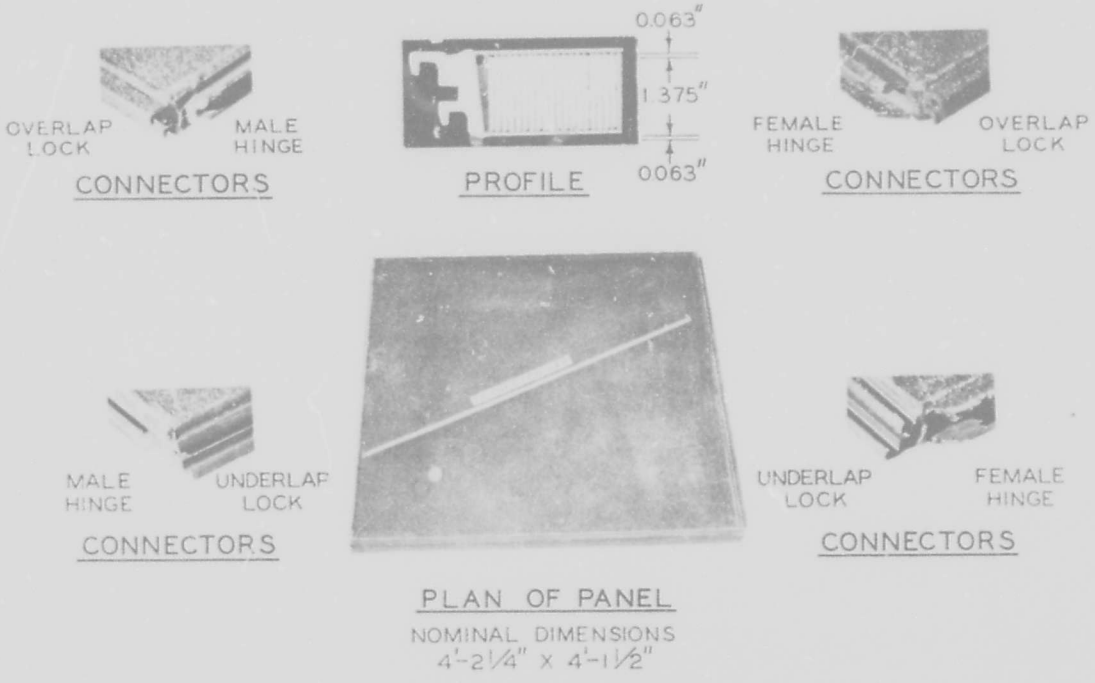


Fig. 7. XM19 aluminum landing mat

should be made so that the first evidence of impending distress can be detected. The first thing to look for in these inspections is evidence of soil being pumped up through the landing mat holes or joints. This pumping indicates that the facility is experiencing subgrade strength loss due to wetting, and it will result in deflections. The continued pumping of the soil from beneath the mat will eventually leave a cavity or void which, if not repaired, will cause failures in the mat panels. Excessive bending of the mat will cause failures in welds, breaks at connector hooks and locking-lug slots, and breaks in the side and end connectors. The aluminum mats (AM2, XM18, and XM19) can experience internal failure of the mat without the bending; however, this type of failure will usually occur only on mats that have experienced a tremendous amount of traffic. Minor damages such as skin tears, sharp corners, etc., that could create a tire hazard to aircraft operations may in some cases be repaired very easily by welding, filing, or grinding, without removal of the mat. Reference 4 explains in detail

the types of damage that the landing mats can experience as well as when and where damaged mats that have been repaired can be reused in an airfield system. Generally, landing mats that have experienced failures affecting the structural quality of the mat cannot be repaired and reused in the areas of an airfield where a majority of aircraft operate (such as the central one-third of runways, taxiways, parking stands, and taxilanes on aprons).

Maintenance and
repair procedures

18. Cavities under the mat. As stated previously, cavities or voids under landing mats are usually detected by soil being pumped out onto the surface of the mats. Field tests at WES indicate that these voids can be successfully filled by grouting, thereby effectively extending the life of most pumping landing-mat-surfaced subgrades. It should be recognized, however, that grouting cannot correct the condition leading to development of voids under the mat. Subgrades that have been allowed to deteriorate to substantially below the required subgrade strength will fail too rapidly to be satisfactorily repaired by grouting. Detailed results of the grouting study, showing materials tested, equipment used, and procedures for application, are contained in reference 5.

19. The grouting study performed was a preliminary approach to the problem; a more extensive investigation would be required to completely analyze all of the variables involved. The study did indicate, however, that mixtures of materials could be successfully pumped beneath landing mat surfaces as a temporary repair measure. In general, the study indicated that the use of asphalt as a grout was not satisfactory. Materials blended with portland cement and water gave satisfactory results in most cases. Cement content on the order of not less than 30 percent was required to give a satisfactory mix, using sand, lean clay (CL), or heavy clay (CH) as the material to be mixed with the cement. The higher the cement content, the quicker the material hardened and cured. The neat cements containing approximately 98 percent cement mixed with sand cured in about 4 hours to a sufficient strength to carry the required loads. The soil-cement mixtures (lean and heavy

clays) required approximately 2 to 4 days curing before the material could sustain traffic. As stated previously, this investigation was very preliminary; thus, other formulations of cement and soil that were not investigated could possibly provide better performance than the blends tested.

20. Weak subgrades. Subgrades that have deteriorated substantially below the required subgrade strength, as a result either of poor drainage or of water penetrating breaks in the mat and subsequently saturating the subgrade material, can only be repaired by removing or reprocessing the material. Sections of mat (AM2, XM18, or XM19) can be removed by starting at an access adaptor and removing as many runs of mat as necessary to repair the subgrade area showing distress. Access adaptors are normally placed at periodic spacings in runways to enable easy removal of runs of mat. Where access adaptors are not provided in the runway, runs of XM18 and AM2 mat may be slid or cut out, as discussed in paragraph 21. Removal of M8 and M8A1 mat is also discussed in paragraph 21. The weak subgrade can be removed and replaced with a better quality material, or it possibly can be stabilized by the addition of granular materials or chemicals as admixtures. Stabilization with admixtures should be considered only when it would be the most economical means of repair. (Classification, quality, and stabilization of soils are described in detail in Chapter 5 of reference 6.) After the distressed subgrade area has been repaired by the addition of better quality material, properly compacted, and brought to original grade, the undamaged mat panels should be reinserted in the runway. It will probably be necessary to stretch the mat in order to join the last row to be placed. This stretching can be accomplished by drilling holes in the next to last row of mats, attaching cables through the holes to heavy equipment, and pulling the mat until it is stretched close enough to connect the final row of panels.

21. Replacement of failed mat. In cases where the mat panels have failed structurally, it will be necessary to remove these panels and replace them with new panels. A single panel of M8A1, M8, XM19, or AM2 landing mat can be removed from and replaced in the interior of a

runway by the procedures described below:

a. M8A1 and M8 mats.

(1) Removal.

(a) Unlock the end-connector bars (hooks) at both ends of the panel to be removed.

(b) Remove the 12 (6 per side) side connector locking lugs that hold the panel. (Break the weld on the locking lugs of the M8.)

(c) Drive the panel laterally (approximately 1 in.) until the side connector hooks are centered in the side connector slots.

(d) Pry the side connector hooks out of the slots.

(e) Drive the panel laterally to clear the end from the overlapping end of the adjacent panel.

(f) Remove the panel from the runway.

(2) Replacement.

(a) Remove the side connector locking lugs of a new panel (break the welds on the M8) to allow the panel to slide laterally when positioned properly. Orient the new panel in all respects so that it will be in the approximate position in the run of that of the damaged panel.

(b) Drive the end of the new panel under the end of the adjacent panel so that the adjacent panel will overlap the new panel. (The panel will then be in its approximate final position.)

(c) Adjust the panel so as to align the side connector hooks with the side connector slots. Engage the two by hammering together.

(d) Drive the panel laterally (in the same direction in which panels in the same run were slid during initial placement) to hook the side connectors.

(e) Lock the end connector bars (hooks on the M8) at both ends of the panel.

(f) Replace and engage the side connector locking lugs in the lock lug slot (reweld on the M8).

b. AM2 mat.

(1) Sliding method.

(a) With a tooth of the harrow on a motor patrol or with other power equipment, engage a panel end in

the same run with the damaged panel and force the entire run to slide out until the damaged panel clears the runway or taxiway edge.

(b) Disconnect the ends of all panels that have been slid from the runway by removing the end connector bars.

(c) Discard the damaged panel. Connect a new panel in its place and lock at the end with the adjacent panel in the run. With a tooth of the motor patrol harrow, engage the panel end and slide the panel until only 2 to 4 in. of the new panel protrudes past the edge of the runway.

(d) Reinstall succeeding panels as in step (c) until all panels in the run are in their original position.

(2) Cutting method.

(a) Cut the damaged panel in seven places, as shown in fig. 8.

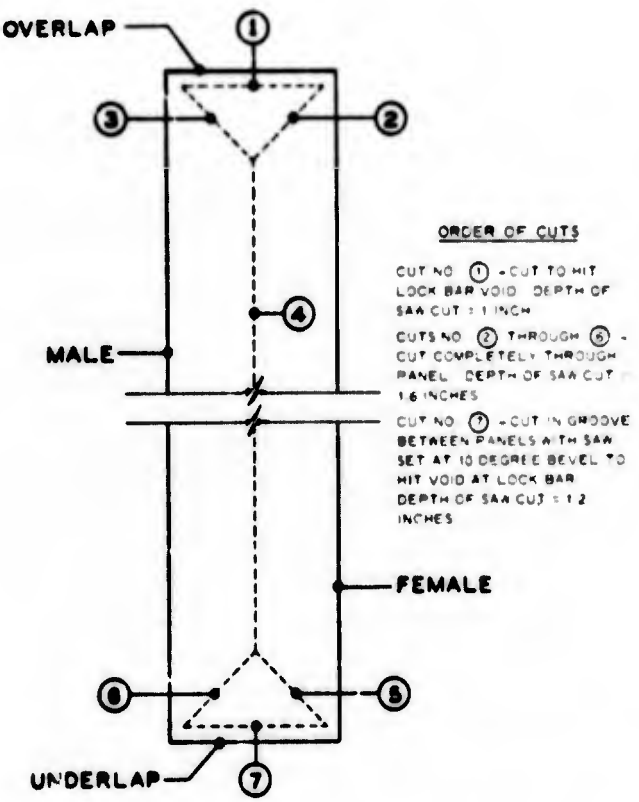
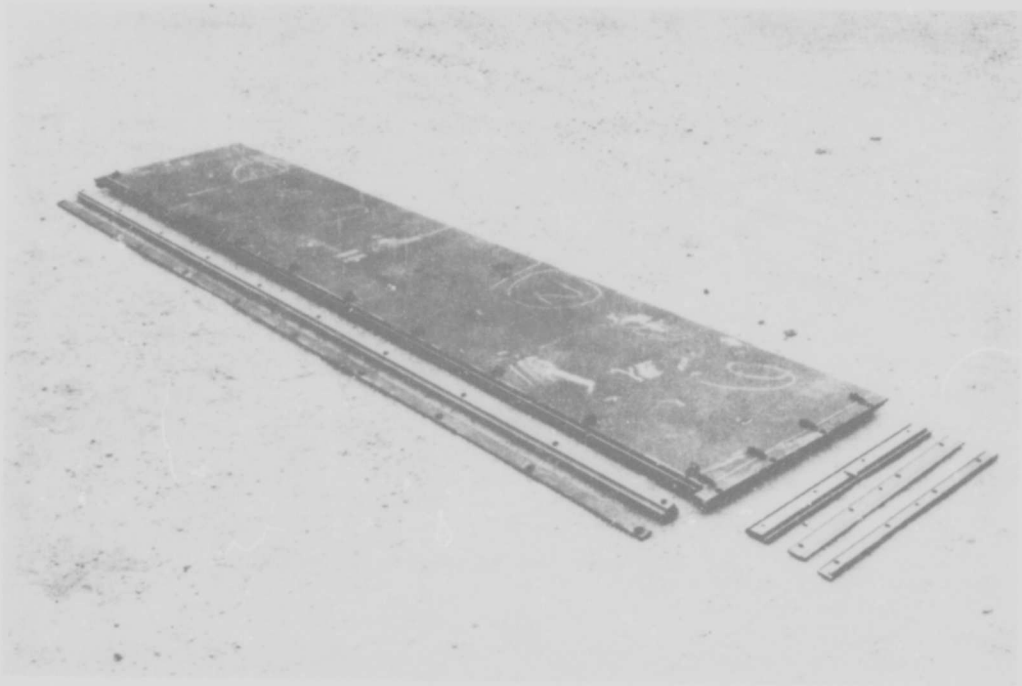


Fig. 8. Cutting method for removing AM2 or XM18 landing mats



a. Unassembled

b. Assembled

Fig. 9. Replacement panel and accessories for AM2 mat

(b) With a pry bar, force up cut No. 4 and hinge out one side of the cut panel.

(c) Force up and hinge out the opposite side.

(d) Force out the end connector bars, and remove the two triangular parts by forcing down or up and out. (The adjacent panels can be pried up so that the triangular parts can be removed more easily.)

(e) Use a special panel and accessories to replace the damaged panel. (The special panel and accessories are shown unassembled and assembled in fig. 9.)

(f) Place the accessories in the void and connect and align in such a way that the panel will fit on top of (overlap) two edges and hinge on a third edge. (The accessories assembled and connected on one side in the void area are shown in fig. 10).

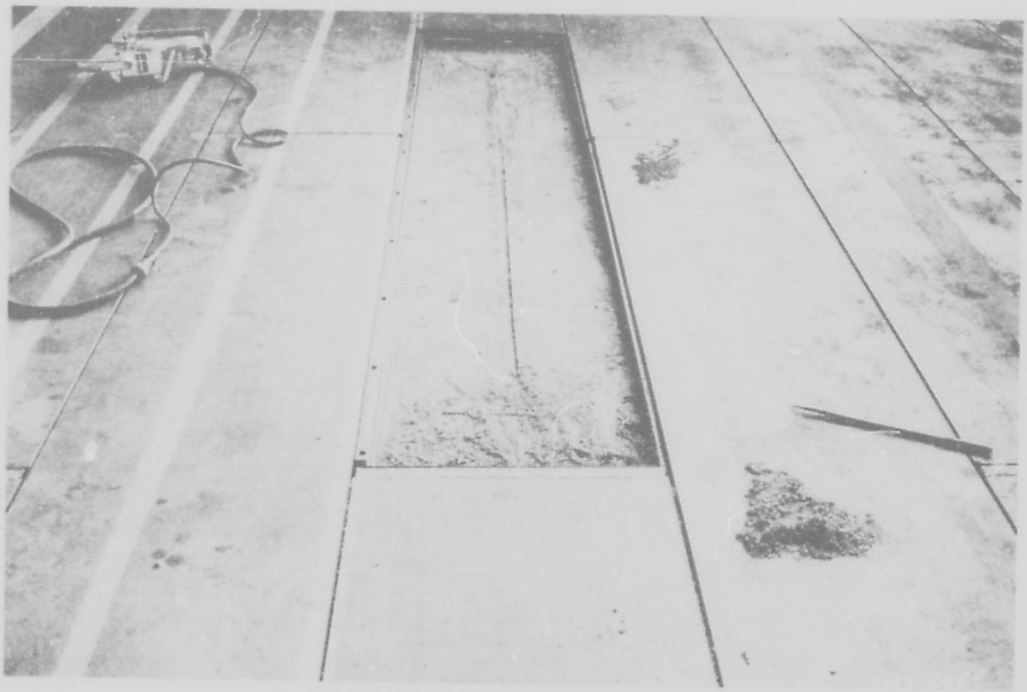


Fig. 10. Accessories in position for replacing an AM2 panel

(g) Engage the hinge on the panel and drop into position. (The normal underlapping end of the panel contains an end connector bar, recessed to prevent interference when dropped into position and

secured with two setscrews.) Remove screws and use a pointed rod to work the end connector bar into the slot of the adjacent panel. Replace the setscrews and screw down along the side edge of the end connector bar to prevent the bar from disengaging.

(h) Place the top rail for the side and secure with countersunk allen screws.

c. XM19 mat.

(1) Cutting method.

(a) Cut the damaged panel in four places as shown in fig. 11.

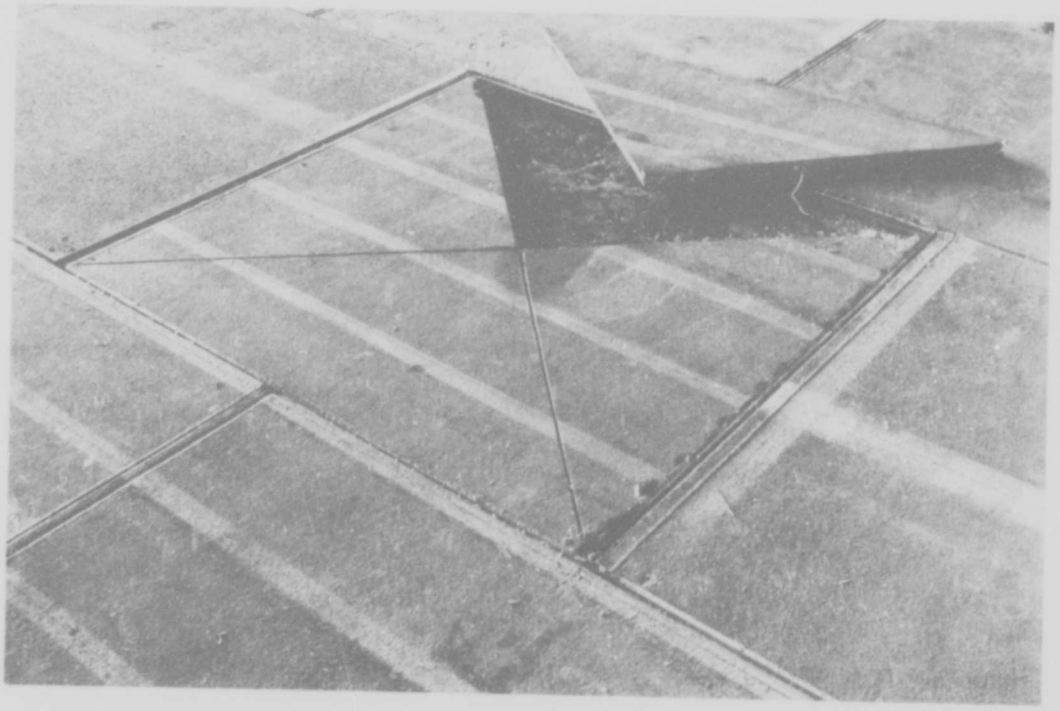


Fig. 11. Damaged panel of XM19 landing mat cut for removal from mat field

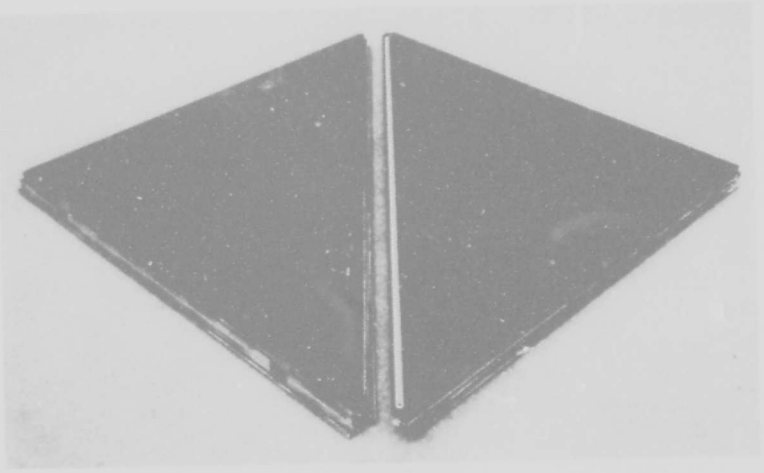
(b) With a pry bar, force up one of the triangular cuts.

(c) Pry up the remaining three pieces.

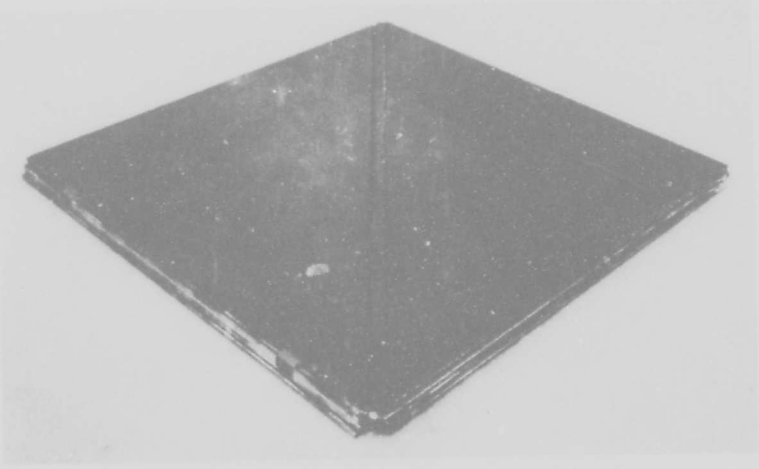
(d) Place the replacement panel in the void and engage the hinges. (The replacement panel and

accessories for XM19 mat are shown unassembled and assembled in fig. 12.)

(e) Place the connector bar in the slot and secure the countersunk allen screws.



a. Unassembled



b. Assembled

Fig. 12. Replacement panel and accessories for XM19 mat

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