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USAGE OF LANDING MAT AS OVERLAY ON ASPHALT RUNWAY DURING MILITA--ETC(U)  
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes four military exercises conducted at Oak Grove, N. C., in which XM18 landing mat was placed over a deteriorating asphalt runway to provide a landing strip for C-130 cargo aircraft. In the past, studies had been conducted at the WES on this subject; however, this was the first opportunity to gain firsthand knowledge on the behavior of the aircraft and the landing mat during a field exercise. This report is based on Memorandums for Record (MFR's) prepared for each of the exercises, which were conducted over a four-year period. Details of each exercise are described in the MFR's, which (Continued)		

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20. Abstract (Continued).

are presented in their entirety as appendixes in this report. The lessons learned that may be helpful in future installations of landing mat over asphalt are listed in the form of conclusions and recommendations. It is concluded that (a) the use of landing mats over an existing deteriorating asphaltic pavement will upgrade the pavement, and prevent foreign object damage to aircraft from occurring; (b) if there are no major potholes or "birdbaths" in the runway that would cause mat bridging, it is not necessary to place a leveling course of sand between the mat and the pavement; (c) if the deteriorated condition and roughness of the field dictate that a leveling soil course is required, a light-weight membrane should be placed between the soil and the landing mat to prevent pumping of the soil at the mat joints during inclement weather; and (d) plank-type landing mat, such as the XM18, can sustain horizontal movement in the direction of aircraft landings in the magnitude of approximately 25 in. without structural mat damage or adverse effects to the runway complex; however, based on similar exercises, a detrimental bow wave may develop if joints become tightly closed and this should be closely observed and avoided. This report should prove to be a valuable aid to a unit commander responsible for installation of landing mat over asphalt pavement.

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## PREFACE

The summary of the exercises reported herein was prepared at the U. S. Army Engineer Waterways Experiment Station (WES) as part of the landing mat program under "General Purpose Expedient Engineering Materiel," DA Project No. 1T162112A528, Task 04, under sponsorship of the Research Division, Research, Development and Engineering Directorate, U. S. Army Materiel Development and Readiness Command.

This summary was prepared during August 1976 under the general supervision of Mr. James P. Sale, Chief, Soils and Pavements Laboratory (S&PL). Personnel of the Materiel Development Division, S&PL, actively engaged in the exercises were Messrs. William L. McInnis, Hugh L. Green, Dewey W. White, Jr., Gordon L. Carr, Carroll J. Smith, and Dave A. Ellison. This report was written by Mr. Green.

Director of WES during the preparation of this report was COL John L. Cannon, CE. Technical Director was Mr. F. R. Brown.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)  
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
inches	25.4	millimetres
feet	0.3048	metres
miles (U. S. statute)	1.609344	kilometres
square feet	0.09290304	square metres
pounds (mass)	0.4535924	kilograms
degrees (angular)	0.01745329	radians

USAGE OF LANDING MAT AS OVERLAY ON ASPHALT RUNWAY  
DURING MILITARY FIELD EXERCISES

PART I: INTRODUCTION

Background

1. During the early spring of 1973, the U. S. Army Engineer Waterways Experiment Station (WES) was contacted by the Office, Chief of Engineers (OCE), the XVIII Airborne Corps, Ft. Bragg, N. C., and Headquarters, Tactical Air Command, Langley Air Force Base, Va., concerning a proposed field exercise which would involve the use of XM18 landing mat over an existing asphalt runway. The exercise was an annual joint service training maneuver located in an area near the vicinity of North Carolina's coast. One phase of the exercise involved aircraft operating from an abandoned World War II airfield which had no facilities other than runways. The auxiliary airfield, known as Oak Grove (HOLF), is located approximately 100 miles\* east of Ft. Bragg, N. C., and 2 miles northwest of Pollocksville, N. C.

2. The existing complex consisted of three runways, each approximately 4000 ft long and 150 ft wide, surfaced with 2 in. of sand asphalt over a 6-in. shell rock base material. The runways were deteriorated and contained numerous cracks which were considered serious since broken or crumbled asphalt would be a potential hazard should it be ingested into aircraft engines or become airborne and struck by propeller blades of the aircraft and cause additional structural damage to the aircraft. Thus the XM18 landing mat which was available on loan from a depot in Alabama was selected for use as an overlay on the Oak Grove main runway primarily as a safety precaution and to prevent further deterioration to the aging asphalt. Since there were no large depressions or "birdbaths" in the runway surface, the decision was made

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\* A table of factors for conversion of U. S. customary units of measurement to metric (SI) units is presented on page 4.

to place the mat directly on the asphalt without the use of a sand cushioning layer between the asphalt and mat. WES personnel were asked by the XVIII Airborne Corps and Headquarters, 9th Air Force, to provide technical assistance in the initial runway evaluation, during the mat laying, and during the conduct of the exercises.

#### Purpose

3. The purpose of the WES participation in these exercises was to study procedures for placing landing mat on existing asphalt pavement, evaluate manuals which pertained to installations of this type, and provide data, manuals, advice, and assistance to military elements involved. The specific purpose of this report is to cite some of the lessons learned during the four exercises in which matting was used and in which WES participated and to make recommendations for future situations in which landing mats will be deployed in this manner.

#### Description of Mat Used

4. The landing mat used in the exercises described herein was the medium-duty XM18 aluminum mat. It was available on loan from the Anniston, Alabama, depot and was capable of easily meeting the surfacing requirements of the C-130 cargo aircraft used in all four exercises. It was stored in the open at Ft. Bragg, N. C., during the intervening periods between exercises.

5. The XM18 is a one-piece extruded section with extruded end connectors welded to each end. The side connectors are integral parts on the basic extrusion. The basic section is partially hollow with 12 internal vertical ribs. The full panel is 1-1/2 in. thick, 2 ft wide, and 12 ft long, and provides 24 sq ft of placing area (Figure 1). Half panels are 2 ft wide and 6 ft long. The XM18 mat, fabricated from aluminum alloy, weighs 4.8 lb per sq foot of placing area. This mat is painted green and the top surface is coated with an antiskid material of the same color. The side connectors (female and male) are constructed to interlock with a rotating motion. The end connectors are



FEMALE HINGE

OVERLAP LOCK

CONNECTORS



FEMALE HINGE

UNDERLAP LOCK

CONNECTORS



PLAN OF PANEL  
NOMINAL DIMENSIONS  
12'-0<sup>5</sup>/<sub>8</sub>" X 2'-0<sup>3</sup>/<sub>4</sub>"



OVERLAP LOCK

MALE HINGE

CONNECTORS



PROFILE

MALE HINGE



UNDERLAP LOCK

CONNECTORS

AIRPLANE LANDING MAT, ALUMINUM, TYPE XM18

Figure 1

arranged with the flanges of the connectors up on one end of the panel (underlap connector) and down on the other end (overlap connector). When the end connector on one panel is properly placed over the end connector of a previously placed panel, a continuous run of mat is formed. A flat locking bar is then inserted into the locking bar slot of two connected panels to form a nonseparable joint. One locking bar per panel of mat is included in each mat bundle. Normally the XM18 mat is laid with the male-female joint perpendicular to the direction of traffic. A detailed description of installation instructions for the XM18 mat and related ancillary items is presented in the installation manual.<sup>1</sup>

## PART II: DISCUSSION OF EXERCISES

### General

6. During the time period which this report covers (1973-1976) there were four exercises conducted in which the XM18 landing mat was placed on the north-south runway at Oak Grove. Each year there was a slight difference in either the length of the runway, the method of end anchorage, the method of side anchorage, or the number of landings in one given direction. These slight modifications were made in the overall complex each year in an attempt to restrict the mat movement which was experienced due to the majority of landings occurring in one direction. The WES had conducted studies<sup>2</sup> of this type in the past; however, these exercises afforded a chance to gain additional information from actual situations involving aircraft operating under full-scale condition. An overall layout of the runway complex at the Oak Grove site is shown in Plate 1.

### EXOTIC DANCER VI (1973)

7. The exercise conducted in 1973 was the sixth of the EXOTIC DANCER series; however, it was the first in which landing mat was placed over asphalt. Appendix A describes the exercise as applicable to landing mat. The north-south runway which was surfaced was 4000 ft long and 150 ft wide; however, the matting surfaced an area 3500 ft long and 60 ft wide and included a turnaround at the south end (Plate 2). In lieu of the conventional auger-type anchors which are contained in the XM18 mat set, shop-fabricated anchors were used. Neither end of the landing mat runway was buried since the mat complex was contained within the confines of the existing asphalt runway; however, cold-mix asphalt was placed at the north end to provide a transition onto the matting.

8. Approximately 300 sorties (one landing and one takeoff) occurred with approximately 95% of these being in a south direction.

Mat shifting occurred in the runway in the area in which aircraft braking occurred and was measured as approximately 25 in. total to the south, which was the direction of landing. Also in this area the matting along the runway center line moved farther than the mat along either edge, with the difference in movement being approximately 2-3/4 in. Although heavy rainfall occurred during the exercise and substantial mat movement occurred, no mat or antiskid damage was observed, and the matting performed satisfactorily. Break-up of the asphalt in areas not surfaced by mat but in which C-130 aircraft operated confirmed that the decision to use matting was necessary. Debriefing of the pilots revealed that no problems were experienced on operating on the mat from the pilot's viewpoint. The main observation gained in this type of mat deployment was that when a majority of aircraft operations are in one direction, there will be substantial mat movement. However, unless bow waves are occurring there are apparently no major problems.

#### SOLID SHIELD 74

9. The second exercise involving the use of landing mat over asphalt was conducted in the spring of 1974 (Appendix B). The major change in the landing mat complex from the previous year was the surfacing of an adjoining parallel taxiway loop with mat and the burying of the north end of the mat runway for anchorage (Plate 3). There were 331 sorties of C-130 aircraft plus numerous operations of OV-1 aircraft, with a majority of all operations being again from north to south. The shop-fabricated anchors were made from 3/8-in.-diam reinforcement bars instead of the 7/8-in. material previously used, and resulted in the top plate breaking off, often during installation of the anchor. In the taxiway at various transition and turn areas, asphalt was used to fill the voids and resulted in no positive connection between mat runs in several locations.

10. Again movement of the mat was experienced in the direction of landing along the runway and in the turn areas in the taxiway. Although some panels had moved as much as 30 in., the anchored end of the field

did not move; this indicated that movement developed from the initial slack in the joints between mat runs. After the second use of the same XM18 mat in successive exercises, there was apparently no structural damage to the matting and it was satisfactorily supporting aircraft operations. Although the mat runway length was approximately 650 ft longer than in the previous exercise, the movement of the mat was still evident.

#### SOLID SHIELD 75

11. In the spring of 1975, SOLID SHIELD 75 was held using the same XM18 mat, but with modifications to the overall runway layout (Appendix C). Both ends of the main landing mat runway were anchored by burying approximately 18 ft of mat in a 2-on-1 sloped trench. The taxiway was again surfaced, but except for the turn areas it was not anchored (Plate 4). Runway edges and ends were anchored every 8 ft with the 7/8-in. steel drive anchors. In lieu of the combination "H" connector and asphalt transition at turns on the taxiway, positive connections were made using the 90-deg turn adapters contained in the XM18 mat set. During the mat laying operation, a military tractor was used to tension the mat and remove any slack in the joints. It was thought that with this extra tensioning, together with the mass of the taxiway which was now positively connected to the runway, and with both ends of the runway anchored, the movement of the mat field in the direction of landing would be reduced if not contained.

12. After 300 C-130 sorties, with approximately 93% of the operations to the south, mat movement as much as 20 in. was recorded in the aircraft braking area. The mat movement along the center line was again more than that at the runway edges. The drive-type anchors tended to pull out of the asphalt in the areas of the runway subjected to heavy braking and some of the welded anchor heads tended to pop off, but these were considered only a minor maintenance problem. Thus it again appeared that it was difficult to prevent mat movement caused

by sustained operations of cargo aircraft in one direction, although no structural mat damage had developed.

#### SOLID SHIELD 76

13. For the fourth consecutive year the same XM18 landing mat was placed on the asphalt runway and taxiway at the Oak Grove test site during SOLID SHIELD 76 (Appendix D). Again both ends of the mat field were buried, the edges of the runway anchored, and the turn areas in the taxiway anchored (Plate 5). The only change in laying procedure was to use two tractors in parallel pulling the mat to remove slack in the joints. The 7/8-in. anchors with steel cap plates were fabricated slightly differently in that the reinforcement bar was placed through a hole in the plate and then welded to both sides of the plate. This was more satisfactory.

14. A total of 301 sorties were made during the exercise, with approximately 80% of these being made to the south. Maximum mat movement was approximately 11-1/2 in. in the runway, with maximum bowing along the center line of 1-1/4 in. Again no structural damage was observed on any of the mat panels due to aircraft operations. Even after the fourth year of usage, the mat was still easily assembled and in such good condition that plans were made to return it to the depot for future reissue.

### PART III: LESSONS LEARNED

#### General

15. Prior to the SOLID SHIELD and EXOTIC DANCER exercises conducted at the Oak Grove site, the WES had conducted studies involving mat placement over deteriorated asphalt. However, the four exercises at Oak Grove provided data with live aircraft operating under actual conditions in a field atmosphere, and thus unanticipated events such as mat movement could be studied more realistically. Thus, as modifications were made to existing procedures, they could be evaluated immediately and the results validated. Thus, over the four-year period many of the lessons learned were field validated and will prove most helpful in future situations of this type. A summary tabulation of mat movement is shown below.

<u>Year</u>	<u>Total No. of Sorties</u>	<u>No. of Sorties Toward the South</u>	<u>Maximum Mat Movement, in.</u>
1973	300	385	25
1974	331	315	30
1975	300	280	20
1976	301	236	11-1/2

The lessons learned will be summarized as conclusions and recommendations in the following paragraphs. Generally, the respective installation manuals for the various landing mats should be followed as closely as possible in any matting installations.

#### Conclusions

16. Based on the results of the exercises conducted during the past four years and related investigations<sup>3</sup> involving landing mats, the following conclusions are drawn:

- a. The use of landing mats over an existing deteriorating asphaltic pavement will upgrade the pavement, and prevent foreign object damage to aircraft from occurring.

b. If there are no major potholes or "birdbaths" in the runway that would cause mat bridging, it is not necessary to place a leveling course of sand between the mat and the pavement.

c. If the deteriorated condition and roughness of the field dictate that a leveling soil course is required, a lightweight membrane should be placed between the soil and the landing mat to prevent pumping of the soil at the mat joints during inclement weather.

d. Plank-type landing mat, such as the XML8, can sustain horizontal movement in the direction of aircraft landings in the magnitude of approximately 25 in. without structural mat damage or adverse effects to the runway complex; however, based on similar exercises, a detrimental bow wave may develop if joints become tightly closed and this should be closely observed and avoided.

#### Recommendations

17. Based on the lessons learned in the exercises discussed herein and similar investigations involving landing mat studies, the following recommendations are offered as an aid in future operations which involve the combination of landing mat and deteriorated pavement:

a. The ends and edges of the runway should be securely anchored to minimize excess slippage and horizontal mat movement and subsequent development of a transverse compression hump or bow wave in front of the aircraft tires.

b. If steel reinforcement bars are used in lieu of the standard screw-type anchor issued with the mat sets, the bars should be a minimum of 2 ft long and 7/8 in. in diameter.

c. If the anchors fabricated from plates are used, the plates should have holes in the center with the bar placed through the holes and welded on both sides of the plates.

d. Locking bars should be used with all anchor adapters to make a positive connection between the anchors and the mat.

e. All elements in a mat-surfaced complex (turnarounds, aprons, anchor adapters, turn adapters, etc.) should be installed

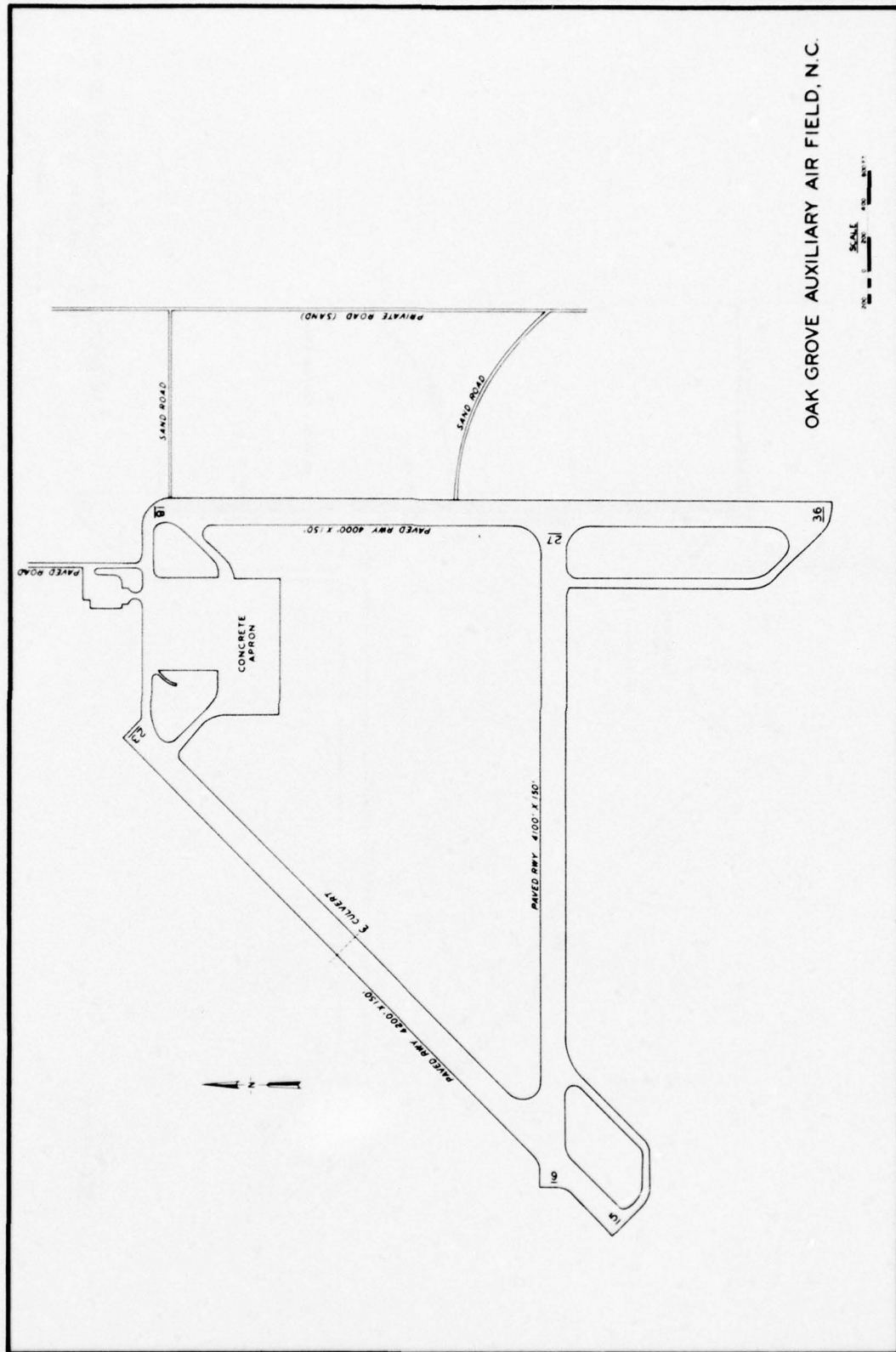
during initial mat placement. Positive connectors should be used at all intersections or changes of mat direction of runways and taxiways with asphalt fillers at these connections eliminated to prevent a potential hazard to aircraft.

f. An approach ramp should be provided for the transition between the landing mat and the pavement at any location of aircraft access or egress where the mat is not buried.

g. Two pieces of motorized equipment spaced at approximately third points should be used in parallel on the runway/taxiway width to tension the mat and remove any excess slack in the connector joints.

#### REFERENCES

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OAK GROVE AUXILIARY AIR FIELD, N.C.



PLATE 1





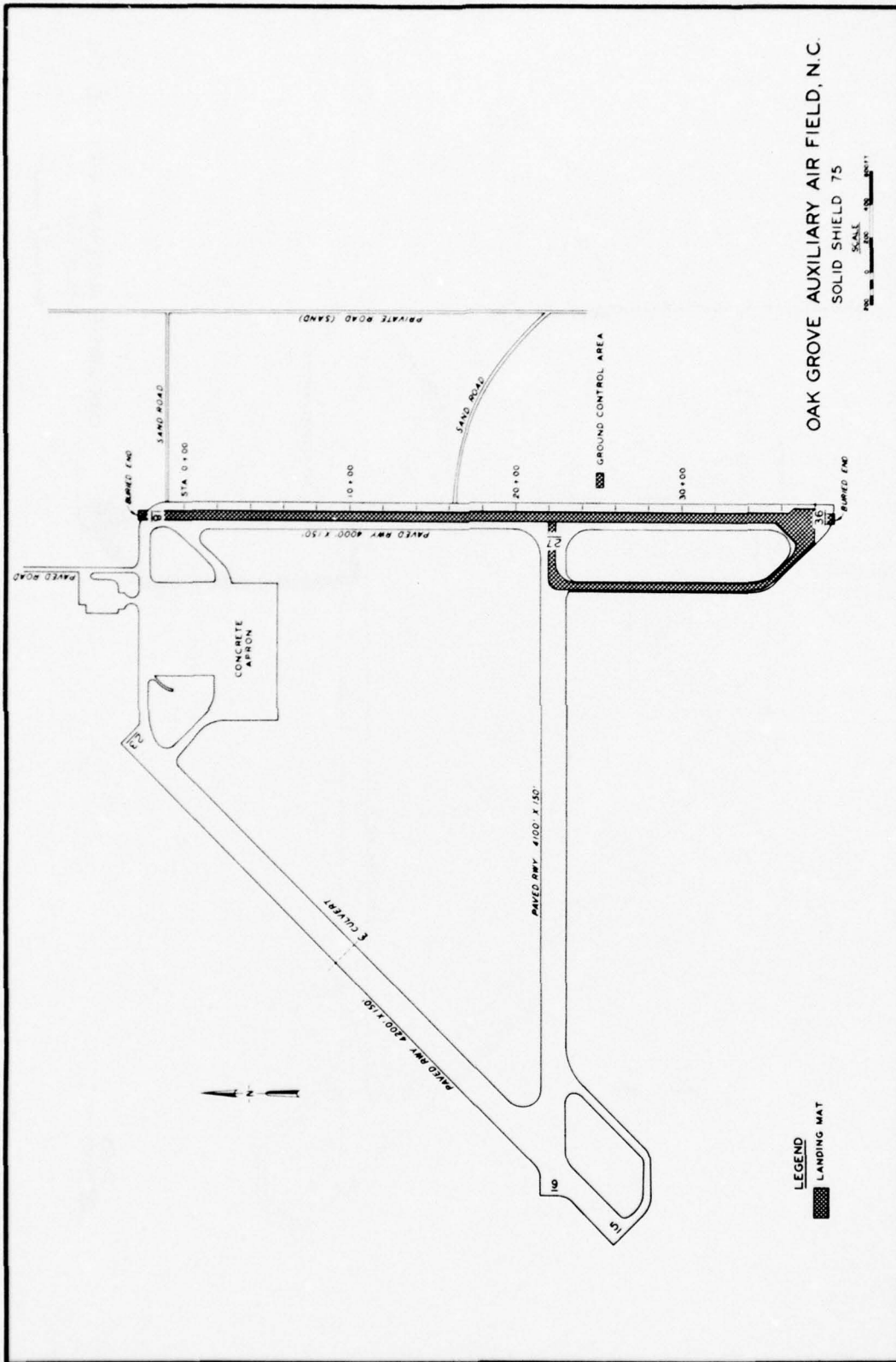
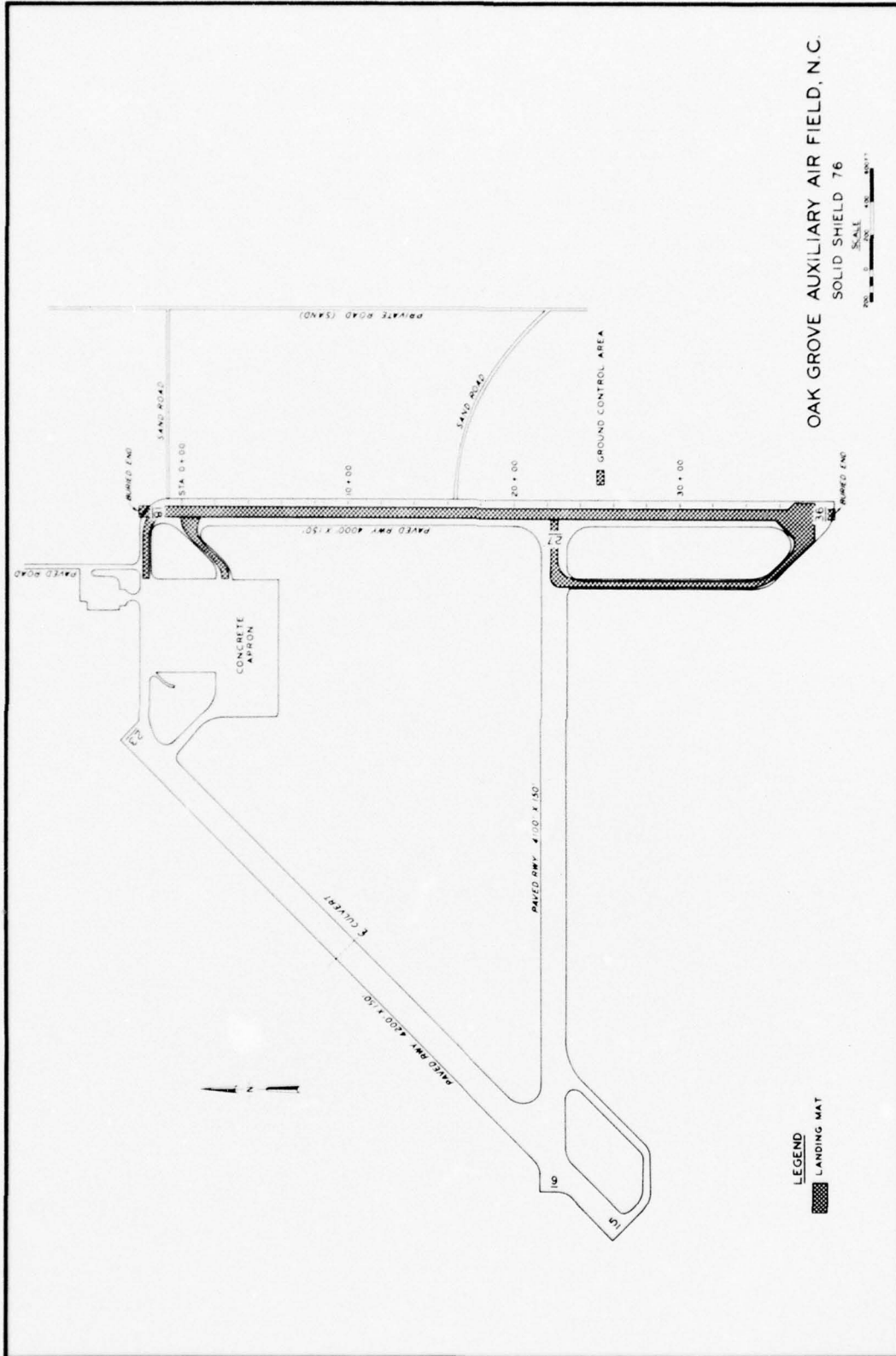


PLATE 4



OAK GROVE AUXILIARY AIR FIELD, N.C.  
SOLID SHIELD 76

LEGEND  
LANDING MAT

APPENDIX A: USE OF LANDING MAT IN CONJUNCTION WITH EXOTIC DANCER VI



DEPARTMENT OF THE ARMY  
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS  
P. O. BOX 631  
VICKSBURG, MISSISSIPPI 39180

IN REPLY REFER TO: WESSS

15 May 1973

MEMORANDUM FOR RECORD

SUBJECT: Use of Landing Mat in Conjunction with EXOTIC DANCER VI

1. EXOTIC DANCER VI, an annual military training exercise for the Atlantic Command, was held this year in an area along North Carolina's coast near Jacksonville and involved 42,000 troops. The joint training exercise involved Army, Air Force, and Navy units and consisted of a mass airborne assault utilizing C-130 aircraft and 2000 paratroopers jumping with full combat gear and an amphibious assault involving 8000 marines in a beach landing. Air Force F-4 Phantom jets flew photo reconnaissance flights and simulated air strikes, and the C-130 cargo aircraft were additionally involved in heavy equipment delivery by air-drops with G-11 cargo parachutes, the low altitude parachute extraction system, and ground delivery by means of an assault airfield. The exercise was somewhat hampered by high winds and excessive rainfall, which occurred and increased problems in ground mobility.
2. The XM18 extruded aluminum landing mat used in this exercise was deployed at Oak Grove AFB, N. C., an abandoned World War II air base which had no major facilities other than runways. At the request of OCE, the WES provided assistance to the Corps Engineer of the XVIII Airborne Corps. The WES became involved after the decision was made to utilize XM18 mat over the existing 2-in. sand/asphalt runway which was deteriorating due to age and which contained numerous cracks in the surface. This condition posed a potential hazard to aircraft if the asphalt were to crumble and be ingested into the engines or be struck by the propeller blades of the C-130 aircraft.
3. WES personnel inspected the Oak Grove runway complex prior to mat placement (see MFR dated 8 February 1973, subject: Visit to Oak Grove AFB and Ft. Bragg, N. C.); assisted Corps Engineer personnel in mat installation (see MFR dated 16 March 1973, subject: Visit to Oak Grove AFB, N. C.); monitored several days of aircraft operations; photographed various phases of the operation; and made measurements of mat movements. This MFR describes the EXOTIC DANCER VI Exercise as pertains to the XM18 landing mat at the Oak Grove AFB test site. WES personnel involved in this exercise were Messrs. W. L. McInnis, Dewey W. White, Jr., and Dave A. Ellison and the undersigned of the Materiel Development Division, and Mr. Thomas L. Guynes, Jr., Photographer, Reproduction and Reports Division.

WESSS

15 May 1973

SUBJECT: Use of Landing Mat in Conjunction with EXOTIC DANCER VI

4. The existing airfield at Oak Grove AFB consisted of a triangular runway complex, with each leg of the complex consisting of a runway 4000 ft long and 150 ft wide (Incl 1), surfaced with 2 in. of sand/asphalt over a 6-in. shell rock base material. Runway 18-36, oriented in a north-south direction, was the primary runway and was used for all landing and takeoff operations. The adjacent two runways (27-90 and 05-23) were used for taxiing operations of the C-130 aircraft and as helicopter pads. Since there were no major "birdbaths" or potholes in the primary runway, a sand blanket was not required beneath the mat placed on the runway nor was membrane utilized. There was a depression across runway 05-23 located at about the midpoint of the length which was attributed to subgrade sinkage around a 48-in. concrete drainage culvert beneath the surface. This area was overlaid with local sand and surfaced with XM18 matting to a width of 60 ft.

5. For this exercise, two sets of XM18 mat with ancillaries were procured by the XVIII Airborne Corps from the Anniston Army Depot on loan as a PEMA item, with the matting transported to the airfield by truck. The matting was placed on the pavement of runway 18-36 to surface an area 60 ft wide and 3500 ft long. Since the maximum crown of the runway was less than 2 percent, the conventional lay of mat was utilized. Mat laying began at the approximate longitudinal midpoint of the field. By using a starter adapter (Incl 2), two laying crews laid the mat in opposite directions, with a total of two 10-men crews plus one forklift operator. Access adapters were installed generally at intervals of 250 lin ft. Although rain hampered the mat placement, the mat was installed at placing rates ranging from 296 to 381 sq ft per man-hour, depending on prevailing weather conditions. Anchorage along each edge was accomplished by placing of shop-fabricated anchors at 4- to 8-ft intervals. The conventional auger-type anchors contained in the mat set were not used since it would have been necessary to drill an 8-in.-deep hole through the asphalt and supporting shell rock and later refill the holes to restore the runway to its original condition. The anchors consisted of 24-in., No. 7 reinforcement bars (7/8 in. in diameter) with 3-in. square plates, 3/8 in. thick welded to one end as anchor heads. The opposite end of the anchor was a sawed end and not pointed. These anchors were used in combination with the conventional overlap/underlap anchor adapter. An air-powered jack hammer with a pointed tool was initially used to drive a hole approximately 8 in. deep through the asphalt and supporting base material. After the anchor was placed through the attachment and in the hole, it was driven in-place with the jack hammer with a flat tamping head attachment. Approximately 10 to 12 seconds were required to install an anchor using a three-man crew. The approaches at the ends of the runway and at a turnoff ramp were surfaced with cold-mix asphalt for a distance of 3 to 4 ft from the mat

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15 May 1973

SUBJECT: Use of Landing Mat in Conjunction with EXOTIC DANCER VI

edges (Incls 3 and 4). The asphalt varied in thickness from 0 to 1.5 in. Anchorage at runway ends utilized anchors and adapters. However, the anchors initially were not driven through the attachments; thus, the anchors did not prevent nor restrict horizontal movement at the ends. Although it was recommended that the runway ends be anchored against horizontal movement, Air Force personnel indicated these anchors would be a potential hazard to aircraft tires if touchdown occurred at this point. Thus, anchors were initially driven behind the anchor attachments to present a low profile anchor head and to attempt to prevent vertical movement of the attachments (Incl 5). The depression over the drainage culvert on runway 05-23 was surfaced initially with a 60- by 96-ft landing mat pad over a sand blanket. No membrane was utilized with the pad, however, anchors were placed along all sides.

6. The XM18 landing mat runway was subjected to approximately 300 landings and 300 takeoffs of the C-130 aircraft plus additional transient operations by lighter Army aircraft. During the exercise period, the surrounding area was subjected to rainfall varying from 4 to 8 in., high winds, and flooding. A river inundated an adjacent swamp backwater area to within an elevation of approximately 1 ft of the runway elevation. The C-130 aircraft were loaded with cargo resulting in total aircraft gross weights of up to 124,000 lb with tire pressures of 95 psi.

7. For reporting purposes, the north end of the mat runway was designated sta 0+00 and the south end was designated sta 35+00. Inclosure 6 shows cold-mix asphalt placed at the north end of the runway and resulting horizontal movement of the mat away from this approach area. Skid marks indicate a touchdown which occurred short of the mat runway. Touchdowns occurred 5 to 10 ft short of sta 0+00 on the runway and ranged up to sta 6+00 (Incls 7 and 8). Approximately 15 touchdowns occurred at the south end of the field. Total roll-out and stopping length occurred generally from sta 10+00 to sta 35+00. Touchdown speeds were approximately 120 mph with landings made in which initial contact was on from one to four wheels with one landing made in which the aft portion of the aircraft actually made initial mat contact. Many times, cloud ceiling was reduced to 400 ft with visibility only 1/2 mile, and instrument landings were required. This resulted in landings not always being symmetrical with the runway center line and also in fairly hard impacts on the mat surface. Approximately 95 percent of the landings were made in the direction toward the south as a planned mission due to ground clearance required over trees, location of radar approach equipment, and prevailing wind conditions. A 90-deg turn at sta 22+93 was available for turning off the mat runway onto the east-west taxiway in order that landing aircraft could taxi on the two asphalt runways to the off-load area located near the north end of the primary mat runway. After off-loading, the normal procedure was to return to the north end of the mat runway and take off in a due south direction. Time lapse between touchdown and takeoff was approximately 15 to 20 minutes.

WESSS

15 May 1973

SUBJECT: Use of Landing Mat in Conjunction with EXOTIC DANCER VI

8. Due to inclement weather conditions, many times the aircraft was unable to reduce speed in time to make use of the 90-deg turnoff and a 180-deg turn was made on the asphalt turnaround at the south end of the field. However, after approximately 132 landings, this overrun area became rutted and the asphalt began to break up and deteriorate (Incl 9). Rainfall became heavy during this period, the water table was within approximately 1 ft of the runway surface, and rainwater tended to pond in birdbaths (Incls 10 and 11) which developed in the asphalt. To alleviate the turnaround problem, the south end of the mat field was widened on each side of the runway to provide a turnaround area on the mat (Incl 12). The main problem encountered in the widening was in adding mat to the west edge of the existing mat runway since an underlap connector on mat being added had to be joined to an overlap connector on the in-place matting. This required prying up of previously laid mat along the existing runway edge, thus dictating a "backward" mat laying procedure (Incl 13). As shown on Incl 14, some movement occurred of the mat pad placed over the drainage culvert on runway 05-23.

9. A summary of mat and airfield movements is shown on Incl 15. Shifting of the mat field occurred primarily between sta 0+00 to sta 30+00 as indicated by measurements made along each edge of the runway and by string-line measurements made across the width of the field at several locations. The bow line effect (movement of mat along center line in direction of landing more than mat in the same run at edges of runway) occurred as far southward as sta 28+00; however, due to several landings in a northward direction, a slight reverse bow line occurred at the extreme south end of the runway although too small to measure. Maximum edge movement of mat occurred between sta 7+00 and sta 16+50 and was approximately 25 in. in a south direction. The maximum bow line measurement was approximately 2-3/4 in. occurring in the touchdown area at sta 7+00. Inclosure 16 shows bow line effect occurring at sta 5+00 due to aircraft touchdowns. Generally, mat movement along the east edge was greater due to aircraft landings not occurring down the center line of the runway, but slightly to the east of the center line. On one occasion, individual runs of mat began shifting laterally at the 90-deg turnoff; however, a forklift was used to realign the runs. Mat runs in the south turnaround shifted laterally approximately 3-1/2 in. due to the turning action of the aircraft; additional anchorage in the turn areas would probably have prevented this. Total movement measured at the center of the field at sta 0+00 was 8 in.; however, after approximately 200 landings, the anchors were relocated and driven through the adapters and movement ceased.

10. As the asphalt taxiways became softened due to traffic (Incl 17) and because of congestion due to excessive helicopter traffic, it became necessary for aircraft to turn on the south mat turnaround after landing without utilizing the 90-deg turnoff or runways. The aircraft would taxi north along the mat runway in returning to the off-loading

WESSS

15 May 1973

SUBJECT: Use of Landing Mat in Conjunction with EXOTIC DANCER VI

area prior to takeoff, thus creating three movements on the runway per sortie. Inclosure 18 shows skid marks on the mat runway in the touch-down area indicating the intensity of landings occurring in this area. Heavy rainfall caused some pumping of the sand blanket beneath the matting placed over the drainage culverts on runway 05-23. To correct this situation, the matting was removed, sand redistributed, and mat replaced and lengthened to cover an area 60 ft wide and 146 ft long. No failures were present, although the pad surface became somewhat wavy. This situation probably could have been eliminated by use of membrane beneath the mat or by use of a clay soil blanket underlay; however, only native sand was available in this vicinity as borrow material. The mat movement along the runway edges resulted in slightly irregular edges and caused the anchors to initially bind at panel joints and then to be pulled up slightly as movement continued. To alleviate a possible bow-wave condition and prevent anchors from protruding above the runway surface, the anchors in the area of mat movement were relocated approximately 1 ft and redriven. The anchor holes were observed to contain water due either from rainfall or the high water table.

11. In general, participants involved in the exercise reported the mat gave satisfactory results, was smooth to land on, and performed well during heavy rainfall. The antiskid material on the mat was not affected appreciably by the assault landings and ever present moisture. Lessons learned in this exercise involving placement of mat over an existing pavement include the following:

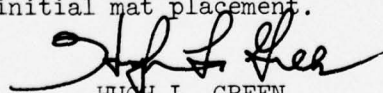
a. The ends of runways should be securely anchored against horizontal movement. This is especially important if traffic is primarily in one direction. Anchorage of mat edges is also required.

b. If a sand blanket is placed beneath mat, membrane should also be used to prevent pumping of the sand during inclement weather. If possible, an underlay soil should contain cohesive material to alleviate pumping.

c. Unless the surface is irregular, a soil blanket is not needed beneath mat placed over an existing pavement.

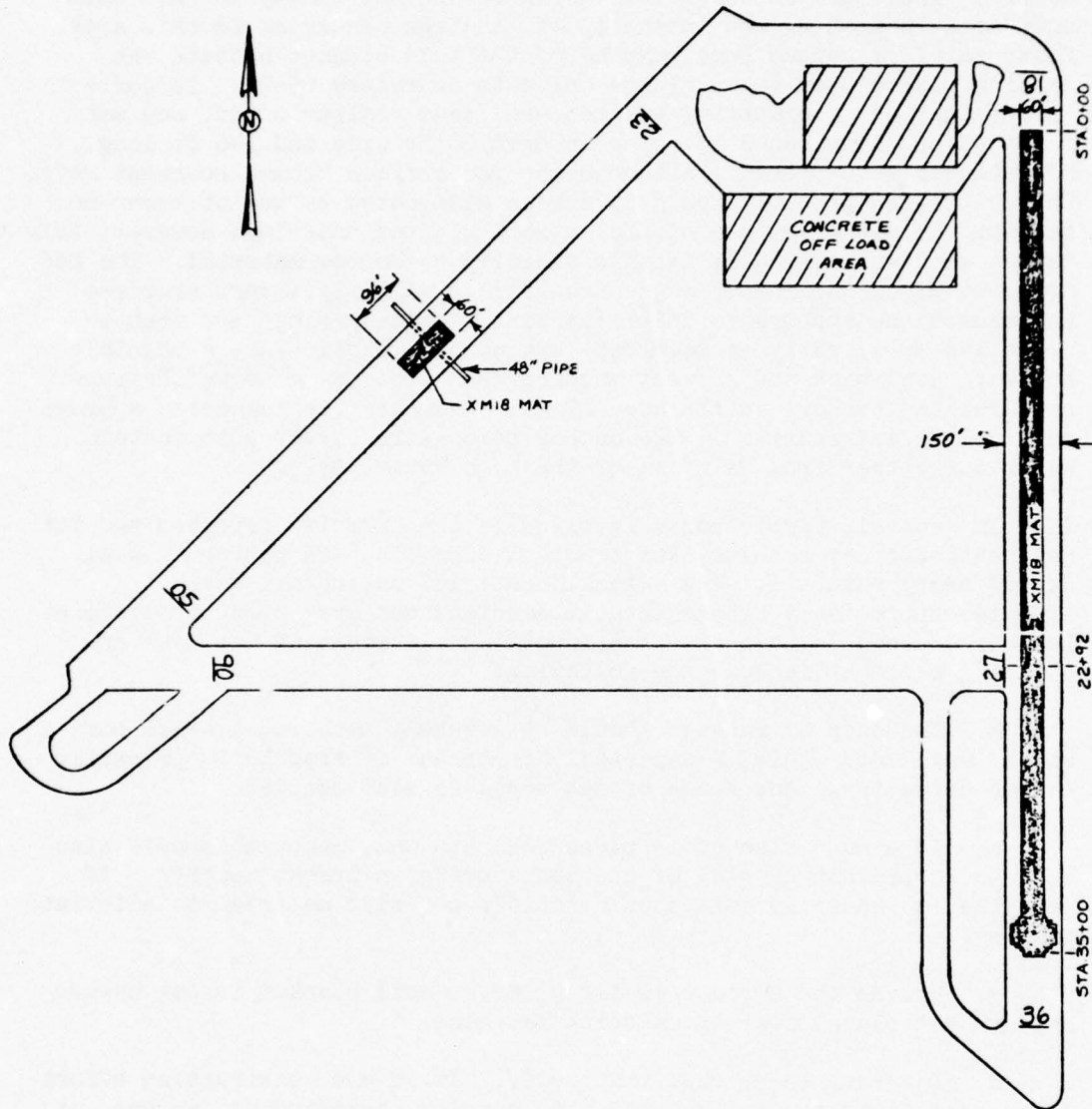
d. In order to prevent undue difficulties and construction effort later, all elements in a mat-surfaced complex (turnarounds, aprons, etc.) should be installed during initial mat placement.

18 Incl  
as



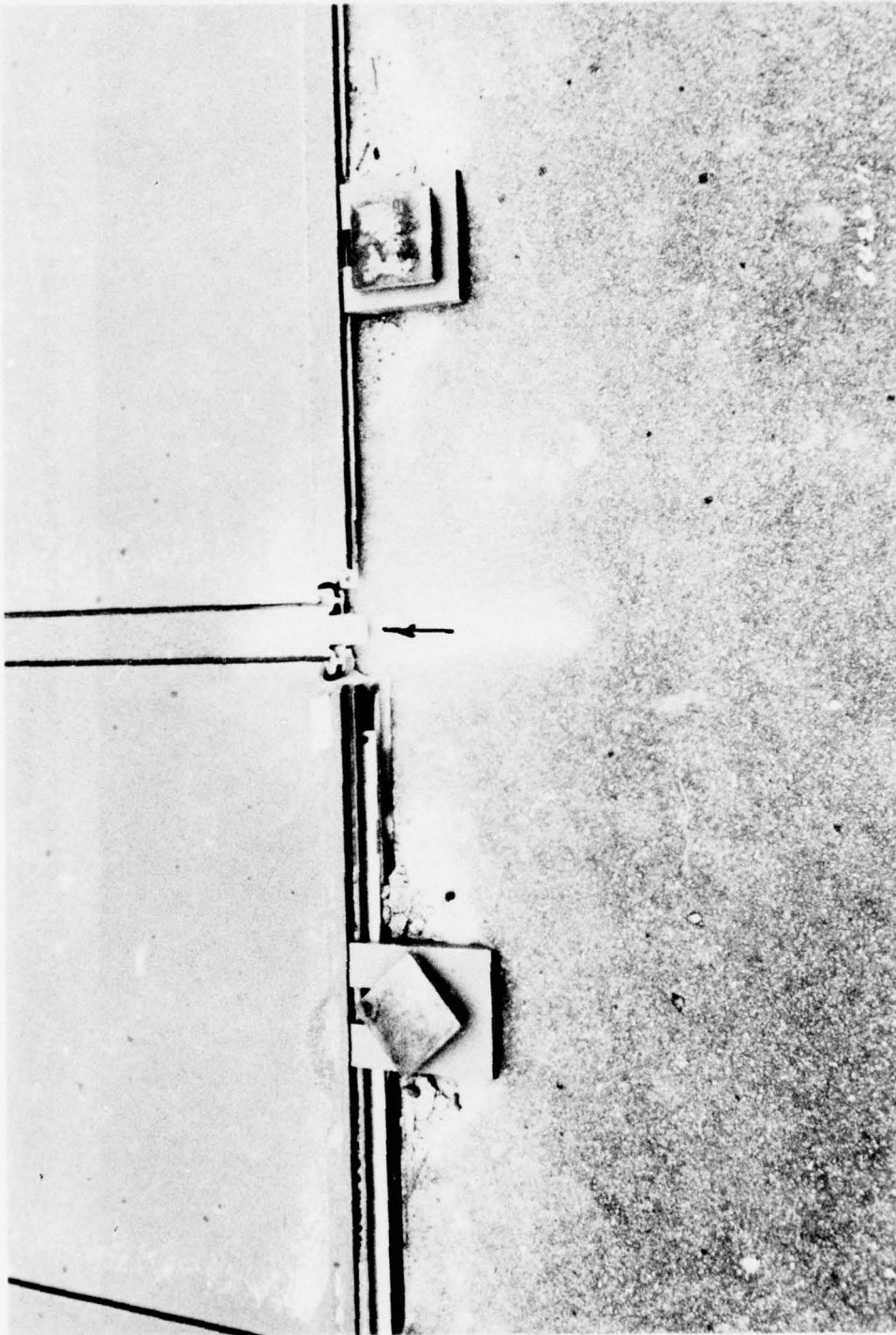
HUGH L. GREEN  
Engineer  
Chief, Landing Mat Branch

CF w/incl:  
HQDA (DAEN-MER-M/Mr. G. R. Kozan) and (DAEN-MER-D/Mr. Paul F. Carlton)  
AMC, ATTN: AMCRD-GM (Mr. R. G. Marshall)  
COL Cleatus J. Cox, XVIII Airborne Corps, Ft. Bragg, N. C. 28307



AIRFIELD COMPLEX  
 OAK GROVE, AFB, N.C.  
 EXOTIC DANCER VI  
 SCALE: 1" = 600'

Incl 1



Starter adapter utilized near midpoint of mat runway to facilitate laying of mat in both directions

Incl 2



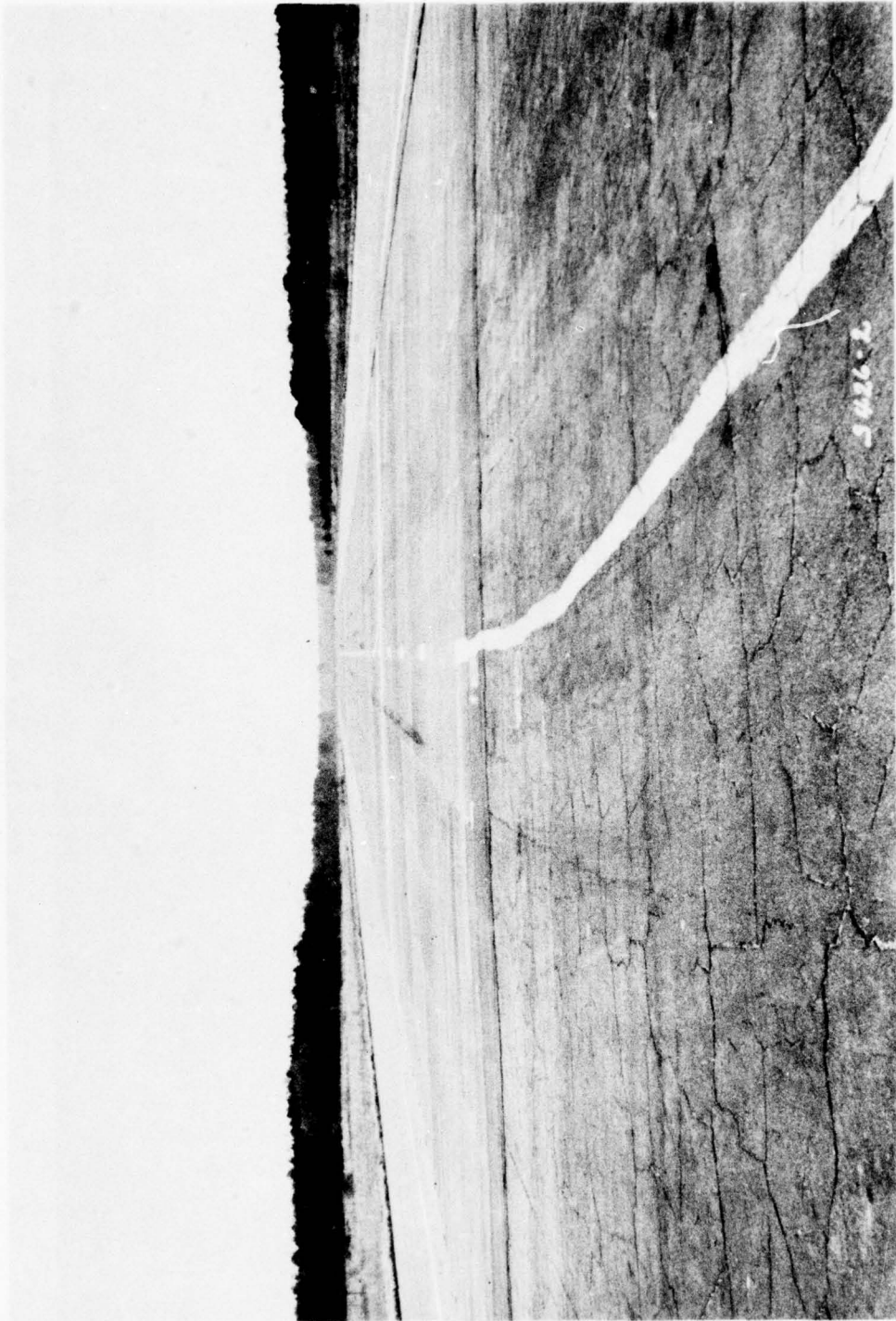
South end of landing mat runway looking north, with cold mix  
asphalt approach in foreground

Incl 3



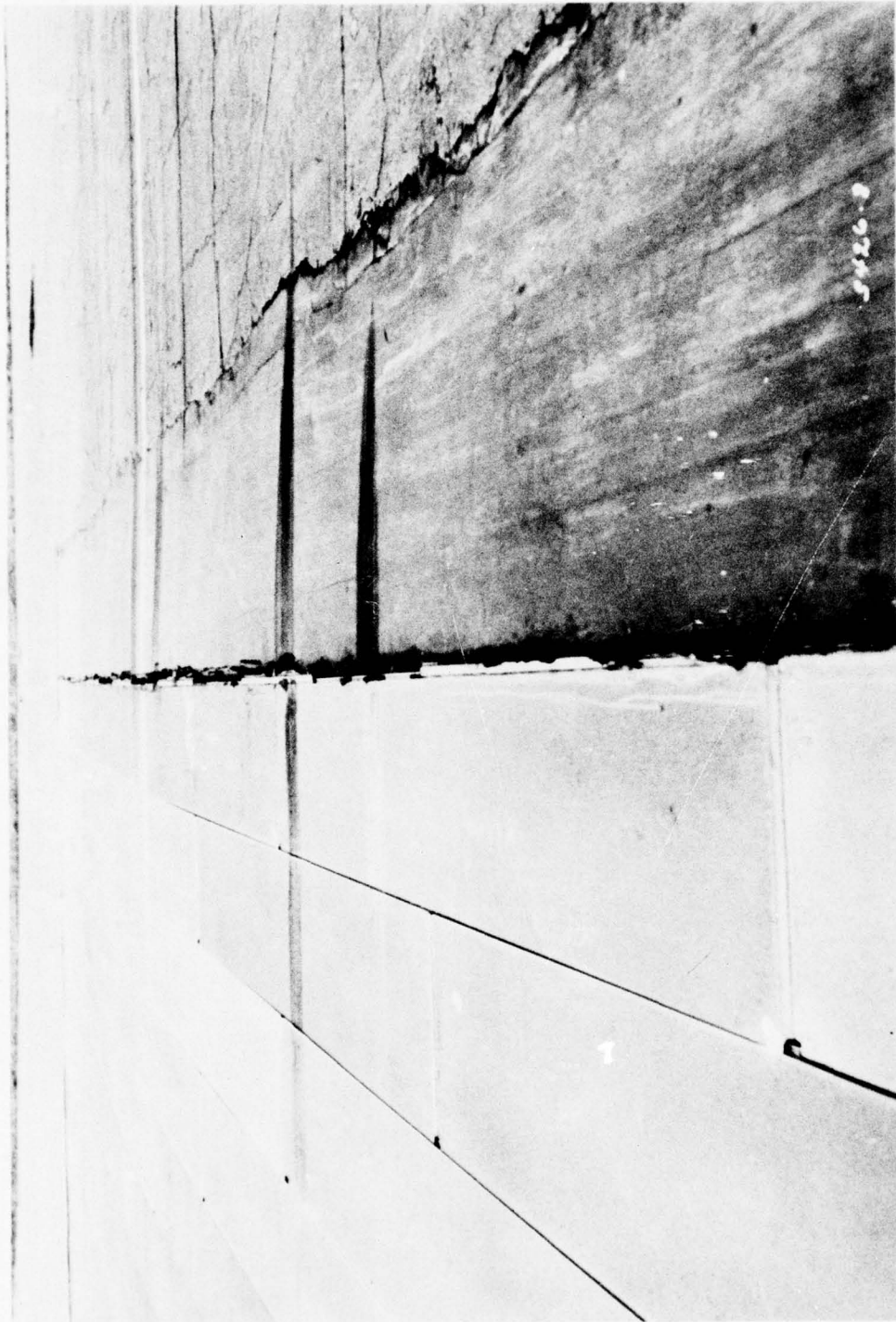
Turnoff from landing mat runway at sta 22+92

Incl 4



Overall view of runway 18-36 looking south

Incl 5



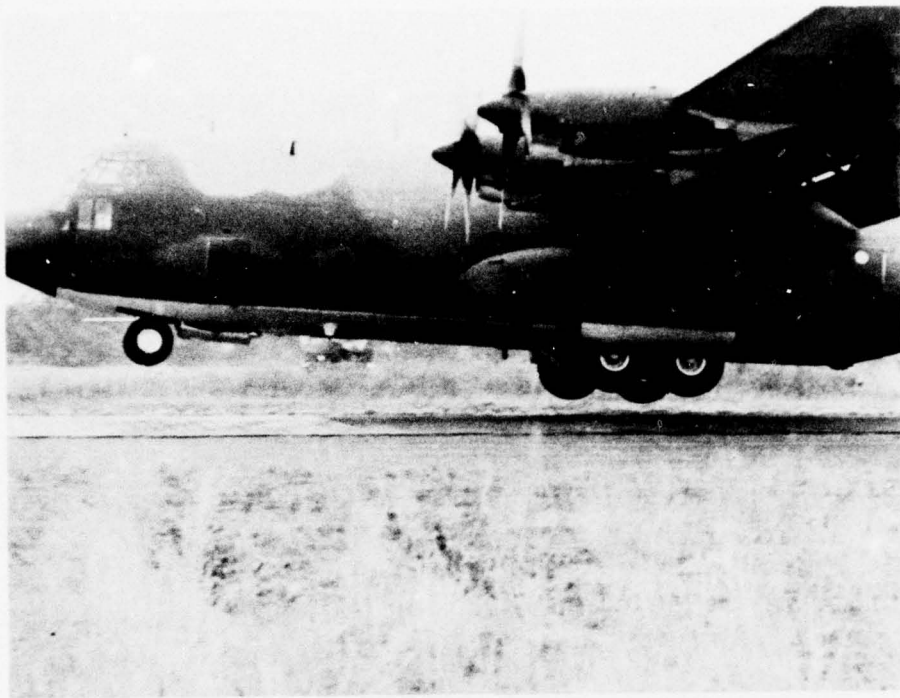
North end of landing mat runway showing transition between mat and asphalt. Aircraft skid marks are visible showing premature touchdown

Incl 6



C-130 aircraft making landing on landing mat surfaced runway

Incl 7

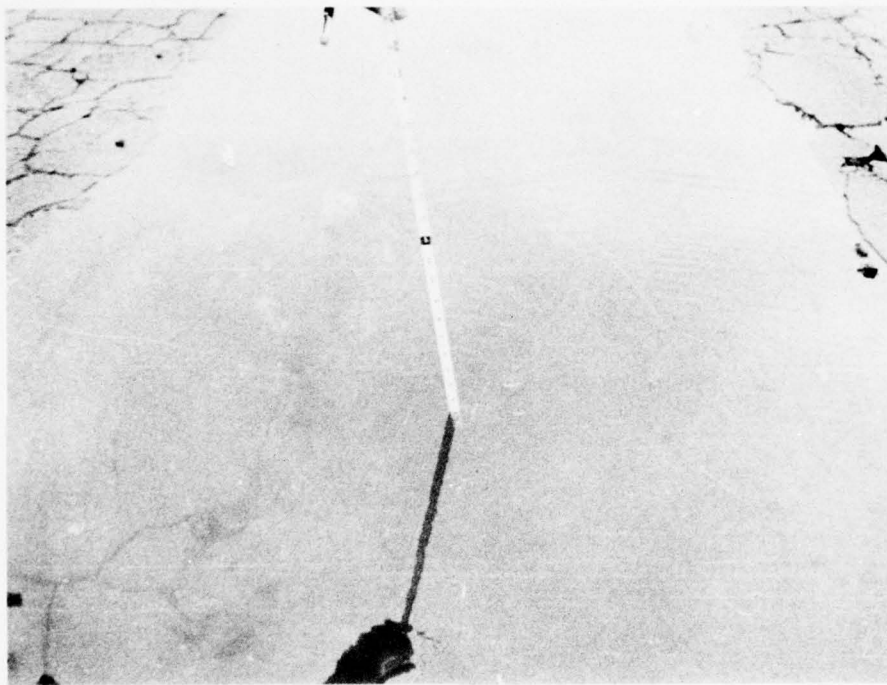


C-130 aircraft making touchdown on mat



Rutted and broken asphalt in overrun area on south end of runway 18-36

Incl 9



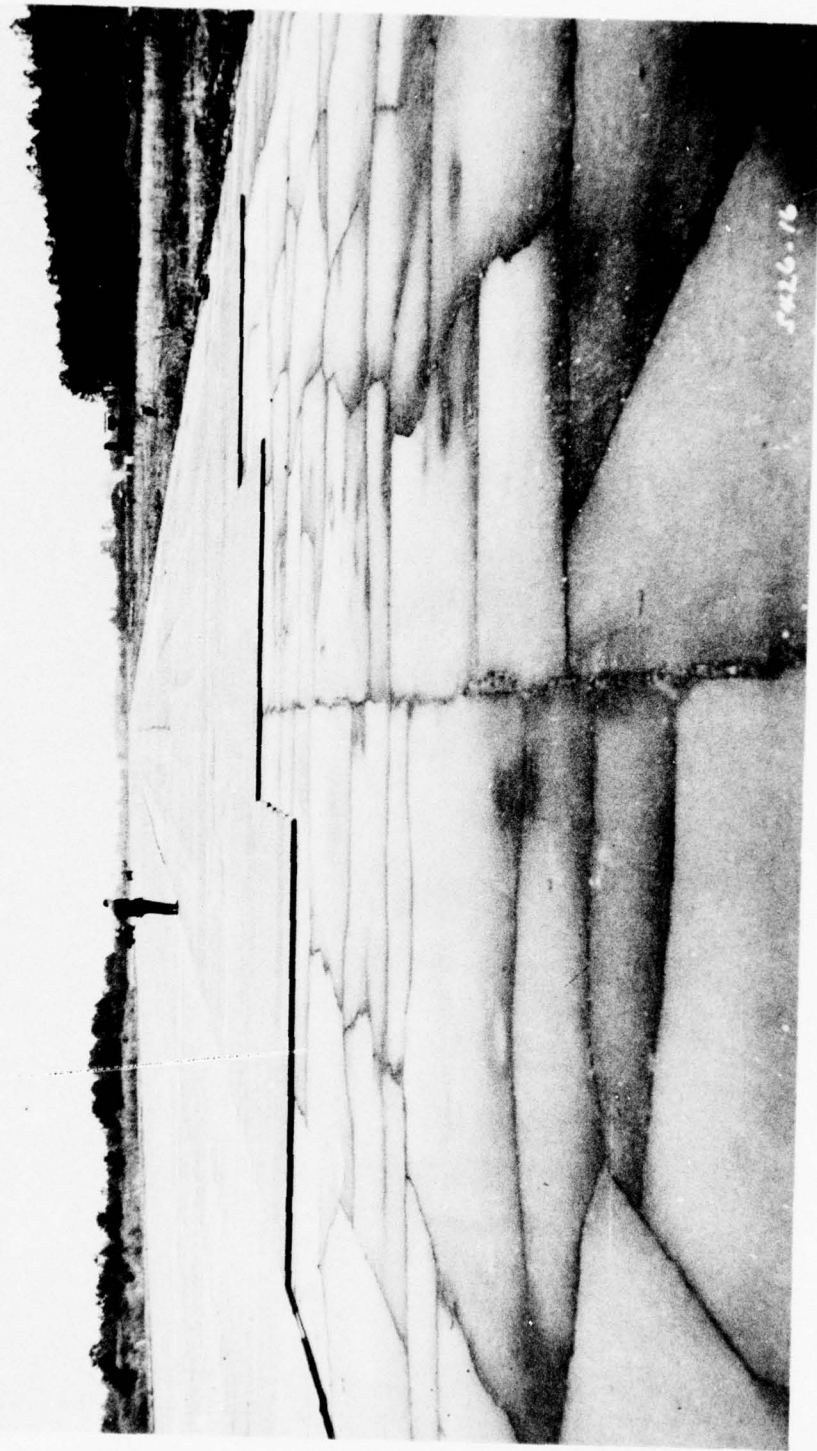
Water ponding in "birdbath" on runway 27-90

Incl 10



Deteriorating asphalt on runway 27-90

Incl 11



Landing mat turnaround added at south end of mat runway



Troops adding mat along west edge of runway during inclement weather  
to form turnaround at south end of mat runway



View across approach end landing mat pad over drainage culvert on  
runway 05-23

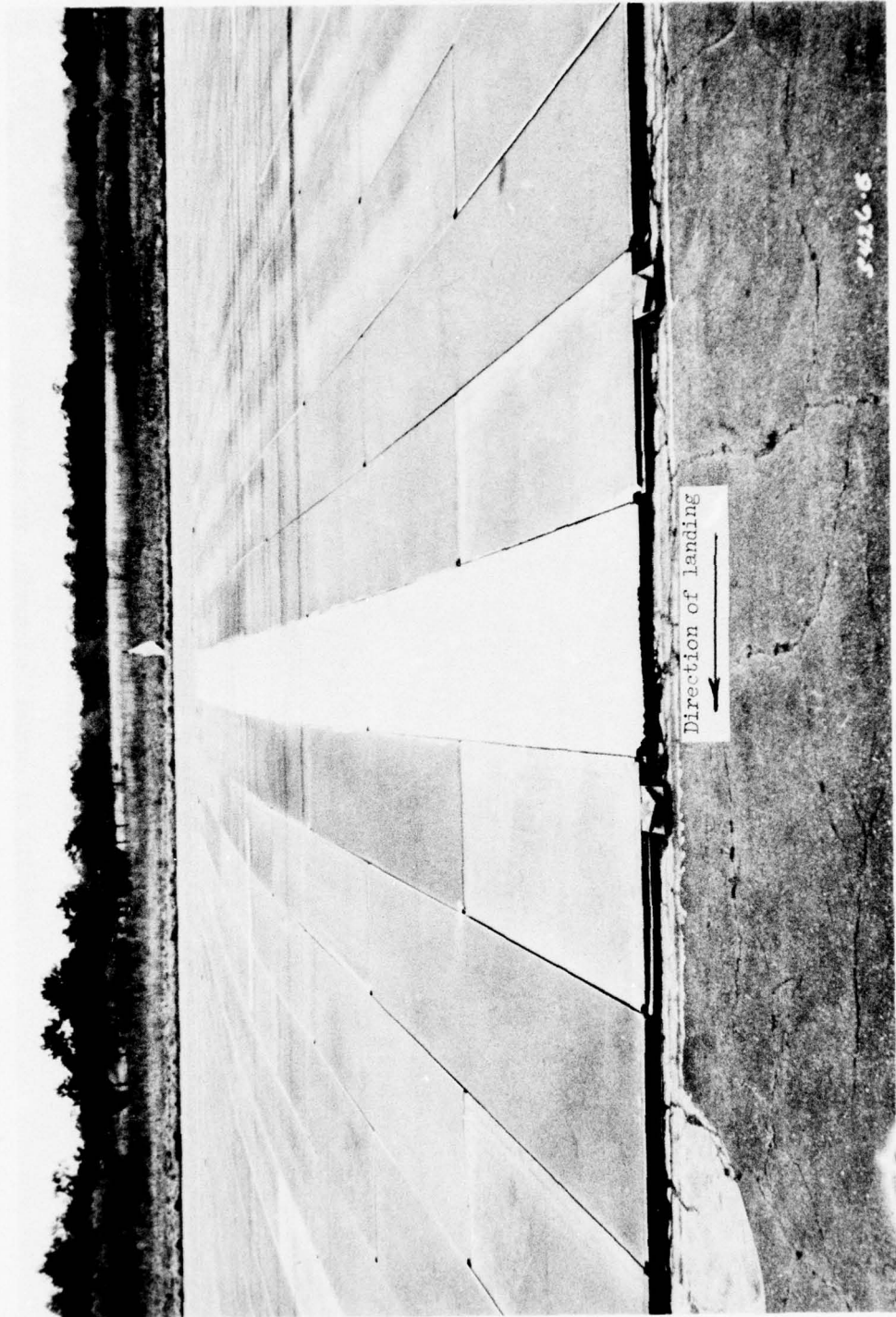
Incl 14

Table 1

MAT MOVEMENT AT OAK GROVE AFB, N. C.

Station	West Edge (Mat Movement in inches)		Center Line (Mat Movement in inches)		East Edge (Mat Movement in inches)		Bow Line (Mat Movement in inches)	
	Landings	Landings	Landings	Landings	Landings	Landings	Landings	Landings
0+00	2		3-1/2	5-1/4	8*	5		
0+93	1-1/2	2-1/4	4-3/4	5-3/8	11-3/4	6-1/2	8-1/2	13
7+00	12	12	13-1/4	14-1/2	23	10	13	25
16+50	8-3/4	10-1/2	10-1/2	13-5/8	23-7/8	10	13-1/4	24-3/4
22+00	1-3/4	2-1/2	4-1/2	5-1/2	9-3/4	5	6-1/2	10-1/2
22+54	-1/2	1-1/2	-	3	7-1/8	4	4-1/2	6-3/4
28+00	0	0	-	3/8	0	1-1/2	3/4	1
30+12	0	0	-	0	0	0	0	0
33+00	0	0	-	0	0	0	0	0
35+00	0	0	-	0	0	0	0	0

\* Total movement of 8 in. was recorded at 200 landings after which transverse anchors were installed at the north end to prevent further horizontal movement.



Bow line visible at sta 5+00



Rutting of asphalt occurring in taxiway

Incl 17



View looking north at sta 5+00 showing skid marks in touchdown area

APPENDIX B: LANDING MAT OVERLAY AT OAK GROVE AFB, NORTH CAROLINA



DEPARTMENT OF THE ARMY  
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS  
P. O. BOX 631  
VICKSBURG, MISSISSIPPI 39180

IN REPLY REFER TO: WESSS

24 June 1974

MEMORANDUM FOR RECORD

SUBJECT: Landing Mat Overlay at Oak Grove AFB, North Carolina

1. On 11 June, Mr. Dave Ellison and I visited Oak Grove AFB, North Carolina to inspect the landing mat overlay and record any movement of the mat after Solid Shield 74 had been concluded.
2. A portion of the existing airfield at Oak Grove AFB was overlaid with mat consisting of a runway 4000 ft long and 60 ft wide and an adjoining taxiway loop which was 2100 ft long and 36 ft wide (Incl 1). Runway 18-36 was used for all landing, taxiing, and takeoff operations. A majority of the C-130 aircraft landed from the north, taxied around the taxiway loop and then back to the north end of the runway, and took off from the north end of the runway.
3. The mat runway was extended 150 ft north of sta 0+00 in order that seven runs of mat could be buried for anchoring. There was no visual evidence that the buried mat had moved during the military exercise. Skid marks indicated that a majority of the 331 touchdowns were between sta 0+00 and 8+00; however, a few touchdowns occurred at the south end of the airfield. Numerous OV-1 operations were also performed on the mat. There was no surface structural damage nor any loss of antiskid in this area or any other areas on the runway and taxiway. An inspection of the runway edges indicated approximately 5 percent of the anchors had been pulled 2 to 3 in. above the anchor attachments. Several of the 2-ft-long anchors used for anchoring the mat were only 3/8-in.-diam rebars (compared to 7/8-in. bars used in the exercise last year) with a flat square plate welded to one end of the bar. This small bar was the probable cause for many of the flat plates to break off during emplacement and the traffic period, and the cause of some of the anchors to bend.
4. The staggered portion of mat between pad 1 and the main taxiway (Incl 1) was anchored; however, in numerous locations, anchor attachments were not used along the edges. The anchors were driven with the rebars touching the ends of the mat and after being driven, half the anchor plate overlapped the mat surface. The staggered mat shown at positions 1, 2, and 3 on Incl 1 consisted of void areas which were filled with asphalt. At the completion of landing operations a 3- to 4-in. gap between the asphalt and mat had occurred at positions 1 and 2. A 8-1/2-in. space was observed at position 3. These gaps occurred at the south edge of the mat and were caused by the aircraft turning and braking as it traversed in a slightly circular path from the runway onto the main taxiway.

WESSS

24 June 1974

SUBJECT: Landing Mat Overlay at Oak Grove AFB, North Carolina

We observed only slight movement of the mat along the north edge of the mat at positions 1, 2, and 3.

5. As shown on Incl 1, pad 2 was laid from east to west and the connecting taxiway was laid from west to east. The adapter which was needed for a positive connection at position 4 was a starter adapter. However, the connection was made by a combination of two overlap/male turn adapters. The resulting adapter formed by this combination consisted of a male connector turned upside down along one side and a male connector positioned correctly along the other side (Incl 2a ). The correct male connector was hooked into the connecting taxiway but the upside down male connector was simply slid into the female connector of pad 2. This type connection at position 4 resulted in a separation of mat of 4 to 5 in.

6. Prior to traffic there was a 23-in. gap at position 5 (Incl 1) which was filled with asphalt. As landings progressed the gap closed and after 250 operations the connecting taxiway mat began to ride up onto the asphalt filler. A run of the connecting taxiway mat was removed and the edge of the mat was anchored. At the end of the exercise, a 14-in. void area was noted between the connecting taxiway mat and the asphalt filler. One anchor plate was broken off and laying in the void area and numerous chunks of loose asphalt were noticed at position 5 (Incl 2b ).

7. For comparison with the previous exercise (Exotic Dancer VI), mat movement measurements were taken at sta 0+00, 7+00, 16+50, and 35+00. A summary of mat and bow movements is shown on Incl 3. The maximum edge movement of mat occurred between sta 7+00 and sta 16+50. The mat moved in a southward direction a maximum of 30 in. on the west side of the airfield (Incl 4a ). The maximum bow line measurement was 1-1/8 in. occurring at sta 16+50 (Incl 4b). At the conclusion of the previous exercise in which 250 C-130 landings were made, the maximum edge movement of mat occurred between sta 7+00 and sta 16+50 and was approximately 25 in. in a south direction on the east side of the airfield. The maximum bow line measurement was 2-3/4 in. at sta 7+00. As indicated on Incl 3, the bow line measurements at the center line of the runway after 331 landings were less than the measurements after 250 landings at sta 16+50 and 35+00. This was apparently caused by several aircraft landing in a northward direction.

8. Recommendations for future exercises of this type are as follows:

a. The ends of runways should be securely anchored against horizontal movement.

b. If steel rebars are used in lieu of the standard screw-type anchor, the rebars should be at least 2 ft long and a minimum of 7/8 in. in diameter.

c. In order to prevent the mat from disconnecting at various changes of lay direction, the proper adapters should be installed during initial mat placement. Asphalt fillers should be minimized at these connection

WESSS

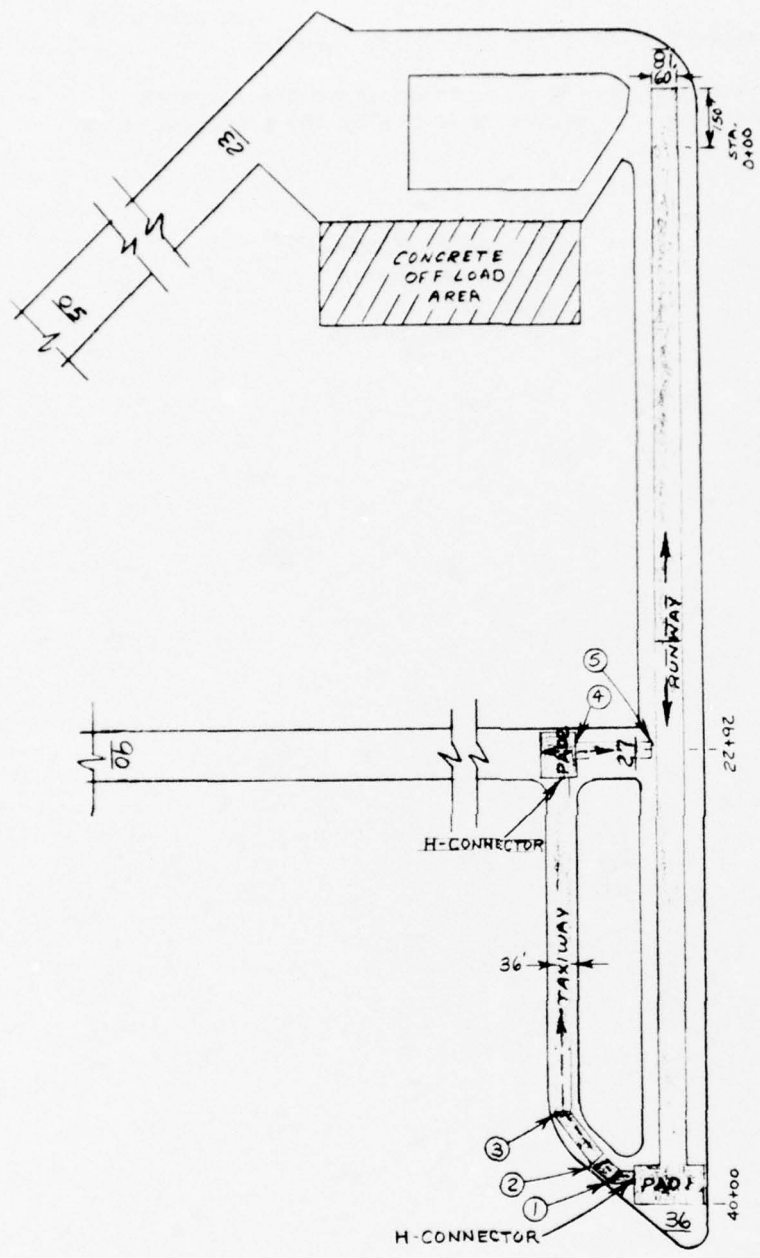
24 June 1974

SUBJECT: Landing Mat Overlay at Oak Grove AFB, North Carolina

locations to prevent a potential hazard to aircraft since deteriorated asphalt could be ingested into the engines or struck by the propeller blades of the C-130 aircraft.

4 Incl  
as

*Carroll J. Smith*  
CARROLL J. SMITH  
Engineer  
Landing Mat Branch



---> MAT LAY DIRECTION

MAT OVERLAY  
 OAK GROVE AFB, N.C.  
 SOLID SHIELD '74

Incl 1



- a. Two connected overlap/male turn adapters used to connect pad 2 and the connecting taxiway



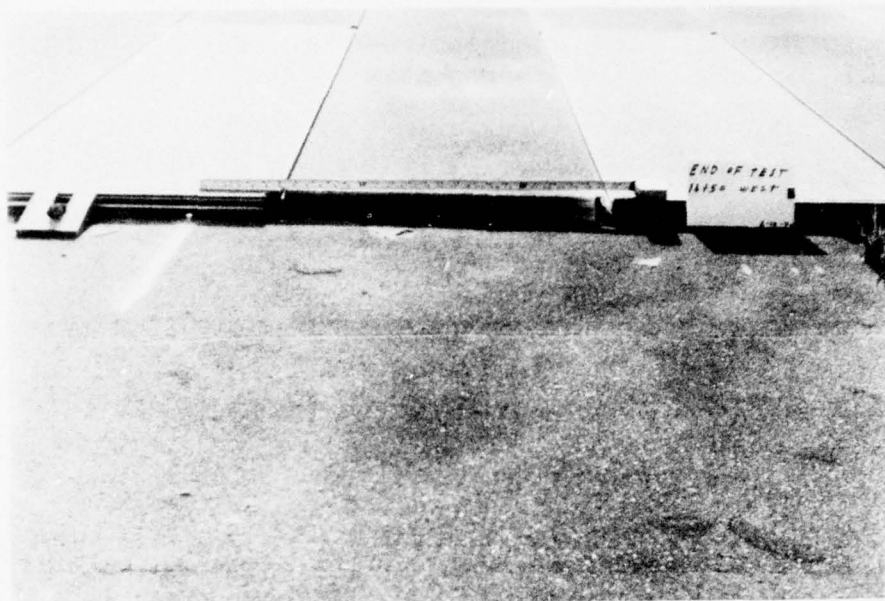
- b. Void area and loose asphalt at the junction of the connecting taxiway loop and the runway

24 June 1974

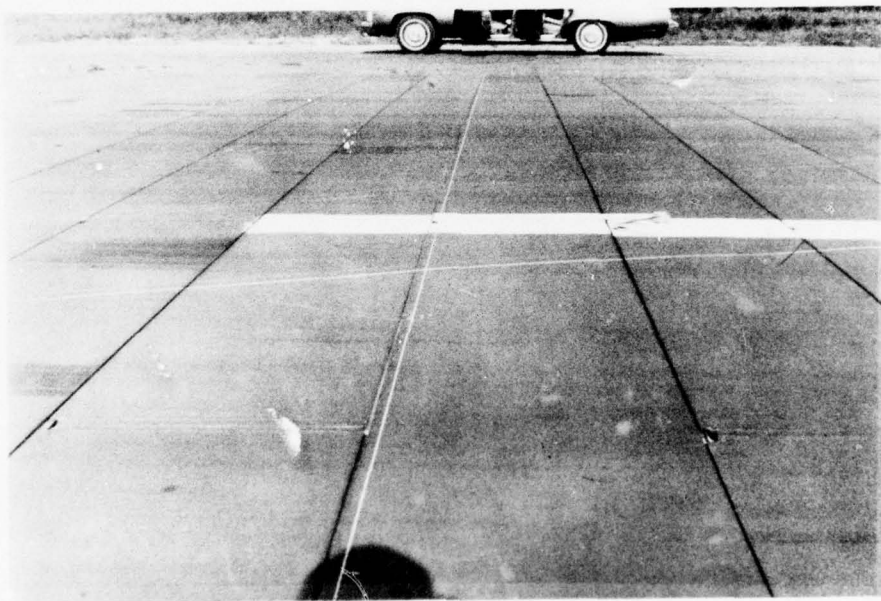
SOLID SHIELD '74

MAT MOVEMENT AT OAK GROVE AFB, N.C.

Station	EAST SIDE OF AIRFIELD		WEST SIDE OF AIRFIELD		BOW IN MAT AT CENTERLINE	
	(Mat Movement in inches)	Landings	(Mat Movement in inches)	Landings	(Mat Movement in inches)	Landings
0 0+00	250	331	250	331	250	331
1- 7+00	3	3-1/2	5	5-1/4	0	0
4 16+50	16	17-1/2	9-1/4	12-5/8	5/8	7/8
7 35+00	14-1/4	15-3/4	21-1/2	30	2-1/4	1-1/8
	8-1/4	11-1/4	6-1/4	8-1/2	1-1/2	0



a. 30-in. mat movement on the west side of the airfield at sta 16+50



b. Bow line measurement of 1-1/8 in. at sta 16+50

APPENDIX C: VISIT TO OAK GROVE AIRFIELD, N. C., ON 4 AND 11 JUNE 1975



DEPARTMENT OF THE ARMY  
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS  
P. O. BOX 631  
VICKSBURG, MISSISSIPPI 39180

IN REPLY REFER TO: WESSS

15 July 1975

MEMORANDUM FOR RECORD

SUBJECT: Visit to Oak Grove Airfield, N. C., on 4 and 11 June 1975

1. On 4 June 1975, I visited the Oak Grove Airfield, N. C., to inspect the XML8 landing mat airfield and to record mat movement after approximately 225 sorties of C-130 aircraft. A layout of the test area is given on Incl 1. The runway was anchored every 8 ft along both longitudinal edges and each end 18 ft was buried in a 2 to 1 sloped trench. The taxiway along the straightaway was not anchored.
2. The following personnel of the Ninth Air Force, Shaw AFB, S. C., were contacted: LTC Miller, LTC McNamara, MAJ Bob Blauth (Safety Officer), CPT Guenter S. Posjena, and SGT Walker. MAJ Blauth escorted me on the airfield complex and assisted in obtaining mat movement measurements.
3. The C-130 aircraft had a weight and tire pressure range of 125,000 to 135,000 lb and 85 to 95 psi, respectively. All aircraft to date (4 June) have landed from north to south and touchdowns have been in the touchdown area from sta -1+00 to 4+00 (Incl 2). Maximum braking and reverse props for braking have been occurring from sta 8+00 to 16+50 which have caused a maximum lateral mat movement in this area of 14-1/4 in. (Incl 3). This movement has caused anchor heads to fail (Incl 4a) and some anchors have sheared the asphalt and soil subbase (Incl 4b). Some anchors in this area have been replaced twice and constant maintenance is required to keep the anchors driven down.
4. No structural mat failures were noted in any area. The welds were performing adequately and no stress lines were observed in the male/female connectors.
5. On 11 June 1975, Mr. C. J. Smith and I visited the test site to take end of traffic data after approximately 300 sorties of C-130 aircraft had been completed. We met with LT Lindbergh (Company B, 27th Engineer Battalion, Ft. Bragg, N. C.) who was in charge of taking up the mat. LT Lindbergh said 45 sorties of C-130 aircraft were made on Thursday, 5 June, and 30 sorties on Friday, 6 June, for a total of 300 sorties on the mat airfield. Six to ten of these landings were made from south to north. We also met with E7 W. R. Robertson (New River - H&HS - S4) who is in charge of the Oak Grove area.

WESSS

15 July 1975

SUBJECT: Visit to Oak Grove Airfield, N. C., on 4 and 11 June 1975

6. The lateral mat movement as described in paragraph 3 was again recorded at the end of tests or after 300 sorties of the C-130 (Incl 5). A maximum movement of 20 in. at sta 7+00 was recorded on the east edge of the runway (Incl 6a). A maximum movement of 19-3/4 in. occurred at sta 16+50 (Incl 6b) along the west edge of the runway. Also, the transverse center line of the taxiway (which was not anchored and only 36 ft wide) moved a maximum of 18-3/4 in. (Incl 7a) in a northerly direction (direction of traffic). Only minor shifting (approximately 2 in.) of the mat occurred in the radius of the taxiways (Incl 7b). Photographs and slides of the airfield were made and are on file in the Landing Mat Branch.

7. The center line of the mat runway moved south further than the edges of the mat runway producing lateral bow in the mat as follows:

<u>Sta</u>	<u>Bow, in.</u>
3+00	1
5+00	3/4
7+00	3/4
10+00	2-1/8
11+00	1-3/4

There did not appear to be any significant bowing in the 36-ft-wide taxiway similar to that above. The mats were again inspected for structural failure after 300 sorties and none were noted.

8. We inspected the taxiways not covered with landing mat and the asphalt concrete continues to deteriorate under C-130 traffic.

9. In future use of mat at this test site, it is recommended that:

a. Locking bars be used with all anchor adapters to make a positive connection with the mats.

b. Screw-type anchors be used to determine if the mats can be prevented from shifting along the ground.

c. Mat be placed on all asphalt concrete where traffic is scheduled to prevent continued deterioration of the airfield.

d. Positive connectors be used at all intersections or change of mat direction of runway and taxiways.

*Gordon L. Carr*

GORDON L. CARR  
Civil Engr Technician  
Landing Mat Branch

7 Incl  
as

CF w/incl:  
CPT G. S. Posjena (LGX)





Touchdown area between sta -1+00 and 4+00

Incl 2

SOLID SHIELD 75

MAT MOVEMENT (IN INCHES) AT OAK GROVE AIRFIELD, N. C.  
AFTER 225 SORTIES OF C-130 AIRCRAFT ON 4 JUNE 1975

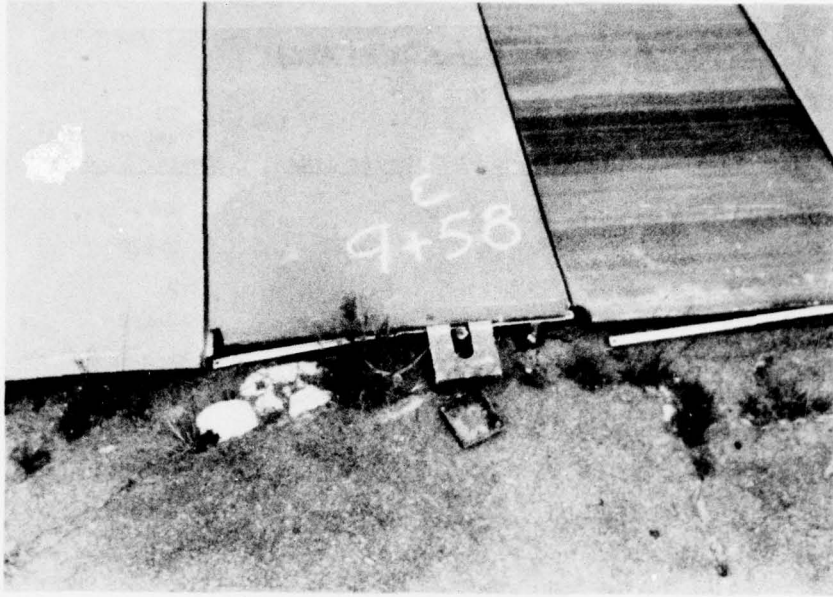
Runway (Moved South)

<u>Sta</u>	<u>East Edge</u>	10 ft East of <u>Center Line</u>	<u>Center Line</u>	10 ft West of <u>Center Line</u>	<u>West Edge</u>
-2+82	-	-	-	-	1
0+00	3	3-1/2	3-1/8	2-1/2	1-1/2
7+00	5	11-3/4	11	9	5
10+00	12-3/4	13-3/4	13-1/2	12-1/2	10
16+50	4-1/2	8-1/4	10-1/4	11-3/4	14-1/4
21+00	1-1/4	1-1/4	1-1/2	1-3/4	3/4
33+00	2-3/4	3-3/4	3-3/4	3-1/4	1-3/4
35+00	2-3/4	3	3-1/4	3-1/4	3

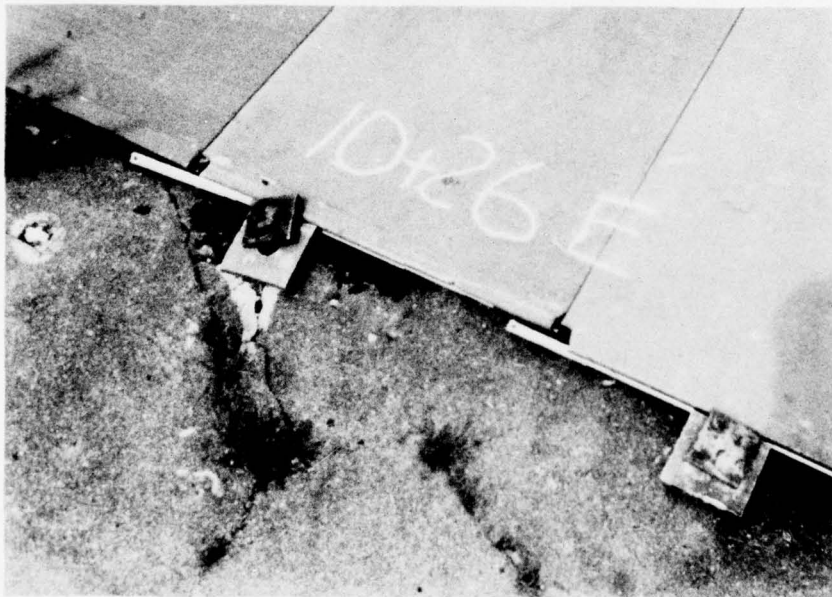
Taxiway (Moved North)

29+10	13-1/2	13-3/4	13-1/2	13-1/4	13
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ANCHORS



a. Failed anchor head



b. Anchor sheared asphalt

Incl 4

SOLID SHIELD 75

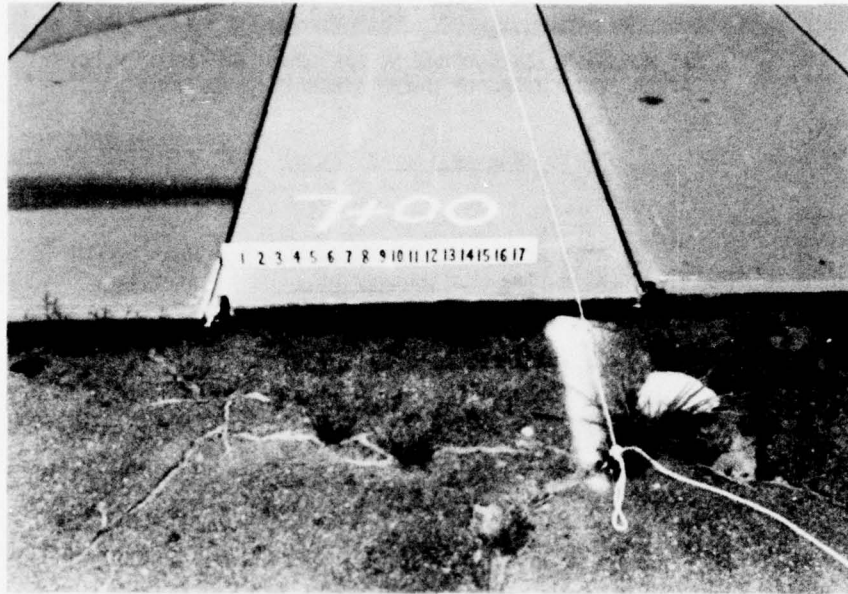
MAT MOVEMENT (IN INCHES) AT OAK GROVE AIRFIELD, N. C.  
AFTER 300 SORTIES OF C-130 AIRCRAFT ON 11 JUNE 1975

Runway (Moved South)

<u>Sta</u>	<u>East Edge</u>	10 ft East of <u>Center Line</u>	<u>Center Line</u>	10 ft West of <u>Center Line</u>	<u>West Edge</u>
-2+82	-	-	-	-	1
0+00	4	4-1/4	4	3-3/4	2-1/2
7+00	20	16-1/8	14	11-3/4	7
10+00	17-1/4	16-3/4	16	14-1/2	10-1/4
16+50	6-1/2	10-3/4	13-1/8	15-1/4	19-3/4
21+00	2-1/4	2-3/8	2-1/2	2-1/2	1-1/2
33+00	3-5/8	4	3-7/8	3-5/8	2-1/8
35+00	3	3-1/2	3-1/2	3-3/8	3

Taxiway (Moved North)

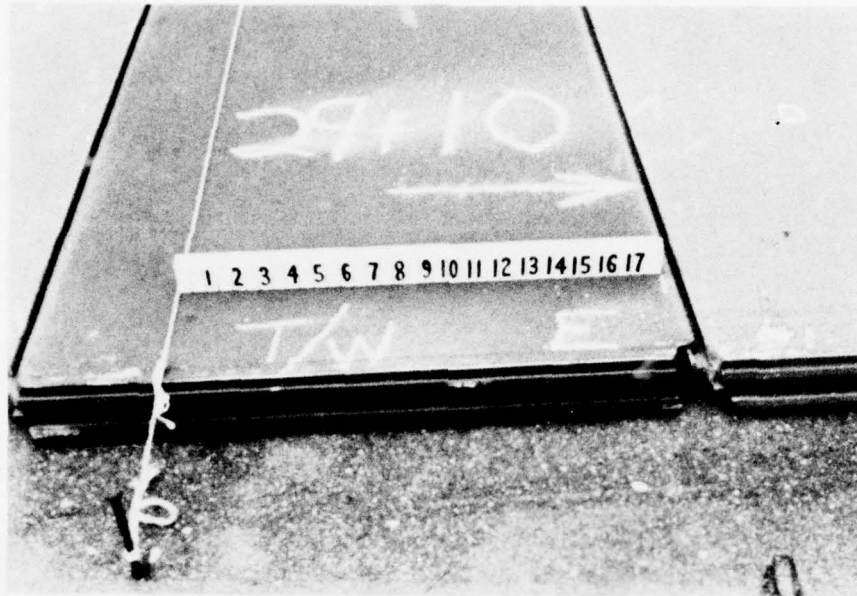
29+10	18-3/4	18-1/2	18-1/2	18-1/4	18-1/4
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a. Mat moved 20 in. along east edge



b. Mat moved 19-3/4 in. along west edge  
Runway moved south (left) after 300 sorties



a. East edge of taxiway moved north 18-3/4 in. (right) after 300 sorties



b. Radius mat shifted west away from anchor  
Taxiway shifting at 300 sorties

APPENDIX D: VISIT TO OAK GROVE, N. C.



DEPARTMENT OF THE ARMY  
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS  
P. O. BOX 631  
VICKSBURG, MISSISSIPPI 39180

IN REPLY REFER TO: WESSS

14 July 1976

MEMORANDUM FOR RECORD

SUBJECT: Visit to Oak Grove, NC

1. During 24-26 May 1976, Mr. Carroll J. Smith and I visited Oak Grove, NC, to observe aircraft operations and take end-of-traffic data on the XM18 landing mat surfaced airfield. This mat was placed in a north-south direction over a deteriorating asphaltic pavement in order to protect it and to permit aircraft operations to support the military exercise SOLID SHIELD 76. The following personnel were contacted during the visit:

314th Tactical Airlift Wing,  
Little Rock AFB, AR

Company B, 27th Engr Bn,  
Fort Bragg, NC

COL Charles O. Hopingardner  
LTC David Glamm  
CPT Bob Traylor

LT Thomas J. Davis  
SGT Nickles  
SGT T. McDonald

2. A summary of our inspection, observation, and data recorded is given below.

a. When we arrived at Oak Grove on the afternoon of 24 May 1976, a total of 290 aircraft sorties had been completed, and the Air Force had begun to remove their flight operation equipment using C-130 aircraft (Incl 1, photos 1-3). We observed one C-130 takeoff and noted that at sta 10+00 and 16+50, some of the anchors were protruding about 4 in. However, these were driven down prior to aircraft operations on 25 May 1976.

b. An additional 11 sorties were completed on 25 May with the last aircraft scheduled to leave during the late afternoon; however, two aircraft encountered mechanical problems which delayed the completion of the operations. All aircraft landed empty and took off loaded with equipment. We observed four landings and six takeoffs of the aircraft with all operations from south to north. Since the runway was still active, we were not allowed access to the runway other than to be driven in a jeep by military personnel down the runway to make visual observations. No problems areas were noted.

c. LT Davis told us they would begin removing the mat as soon as all aircraft operations were complete. He said they had to inspect and repackage all the mat for depot storage since the mat will be returned to

WESSS

14 July 1976

SUBJECT: Visit to Oak Grove, NC

the depot rather than to Fort Bragg as it had been in the past. He estimated they would be at Oak Grove for about a month.

d. On 26 May 1976, Mr. Smith and I made final movement measurements. A total of 301 sorties were completed in this exercise with approximately 80 percent of these being from north to south. Skid marks on the north end of the runway also indicated that most of the landings were from north to south (Incl 1, photo 4). Bowing in the mat runs as well as mat movement (Incl 2, photos 5-6) was measured. Measurements are shown on Incl 3. The XM18 landing mat panels were originally designed and fabricated for a loose fit at the connector joints. This allows for the mat expansion and compensates for the natural waviness inherent in extruded panels. After each 25 runs (50 ft) of the mat were placed, they were stretched in the direction of placement by two pieces of motorized equipment pulling parallel to remove slack from the male-female connector joints and tension the runway. This was done to prevent the mat from buckling at the joints when compressed. At the completion of the exercise, there was very little slack in the male-female joints (Incl 2, photo 7). The anchors were loose in the maximum braking area (sta 10+00 to 16+50). A typical anchor is shown on Incl 2, photo 8. This anchor was fabricated with the reinforcement bar placed through a hole in the plate and then welded to both sides of the plate. This type anchor worked more satisfactorily than those used in previous exercises in which the reinforcement bar was butted against the plate and welded only on one side. The plates that were butted against the end of the reinforcement bars frequently broke off when the anchor was driven into the soil, and some of the plates failed due to the mat movement. No anchor failures were observed where the plates were welded on both sides. The maximum mat movement in the runway amounted to 11-1/2 in. south at sta 16+50 (Incl 4, photos 9-10). Movement of the mat panels in the direction of landing (north to south) resulted in transverse bowing between sta 2+00 and 16+50. Maximum bowing occurred along the centerline at sta 10+00 and amounted to 1-1/4 in. A view of the south end of the runway looking north is shown on Incl 4, photo 11.

e. Mat movement of 20-1/2 in. was recorded at sta 27+20 in the parallel taxiway near the south end of the runway (Incl 4, photo 12). However, the taxiway was only 36 ft wide and was not anchored along the edges.

f. Two approach legs were constructed with the mat on the west side of the runway at approximately sta -1+50 and 1+20. A combination of anchor adapters and 90 deg turn adapters were used as ramps at the ends of these legs to negotiate the 1.5 in. change in elevation from pavement to mat surface (Incl 5, photos 13-14).

g. One of the uncovered ends of the runway, which had been buried during the exercise, is shown on Incl 5, photos 15 and 16.

3. The mat movement of 11-1/2 in. on the runway during the 1976 exercise was less than that in SOLID SHIELD 75. The mat movement in 1975 was 20 in. after 300 sorties. No problems developed in either exercise as a result of the mat shifting. It is believed that the smaller mat movement

WESSS

14 July 1976

SUBJECT: Visit to Oak Grove, NC

recorded in SOLID SHIELD 76 can possibly be attributed to the following:

a. Reduced number of operations to the south. Some of the aircraft landings were made from south to north which probably caused the mat to shift to the north and thus reduced the total mat movement to the south.

b. Improved method of removing the slack in the mat joints. The mat this year was tensioned using two vehicles in parallel whereas only one vehicle was used in 1975.

c. Improved fabrication of anchors (described in para 2d).

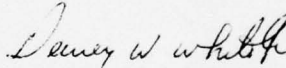
d. Reduced rainfall during exercise. Possible greater friction occurred between mat and pavement.

4. In the future, if the XM18 landing mat is used at Oak Grove or at a similar installation over pavement, it is recommended that the following procedures in addition to those given in Instruction Report, IR S-69-3, "Installation of XM18 Extruded Aluminum Airfield Landing Mat" be followed:

a. An approach ramp be provided for the transition between the landing mat and pavement at any location of aircraft access or egress where the mat is not buried.

b. In exercises where the screw type anchors are not used and anchors fabricated from plates welded to reinforcement bars are used, the plates should have holes in the center with the bars placed through the holes and welded on both sides of the plates.

c. Two pieces of motorized equipment should be used in parallel spaced at approximately third points on the runway/taxiway width to tension the mat and to remove any looseness in the male-female connector joints.

  
DEWEY W. WHITE, JR.  
Mechanical Engineer  
Landing Mat Branch

5 Incl  
as

CF w/Incl  
COL Philip D. Engle, FT Bragg, NC  
LTC David Glamm, Little Rock AFB, AR  
CPT G. S. Posjena, Shaw AFB, SC

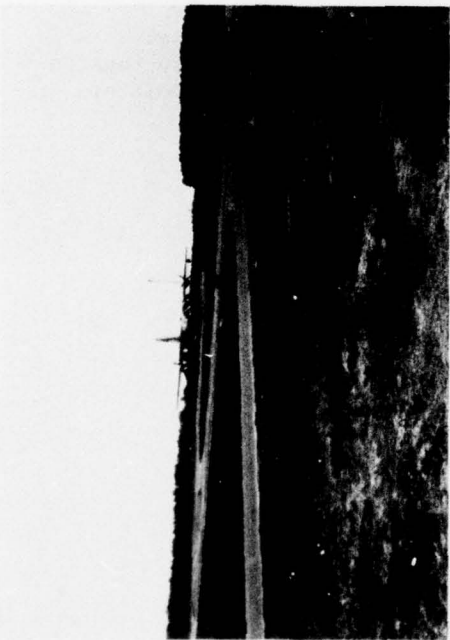


Photo 1. C-130 aircraft on north end of runway

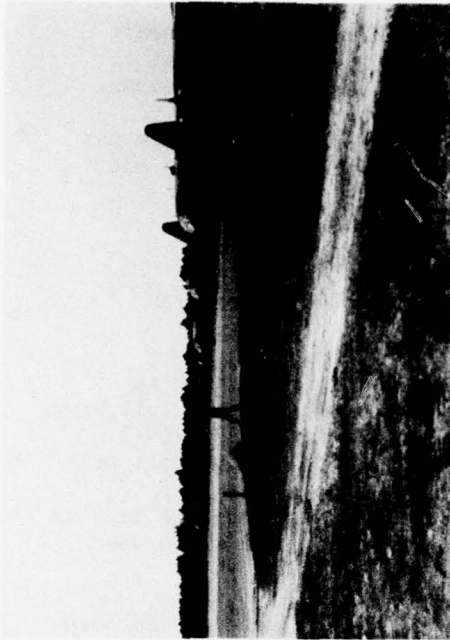


Photo 2. C-130 aircraft on concrete loading apron

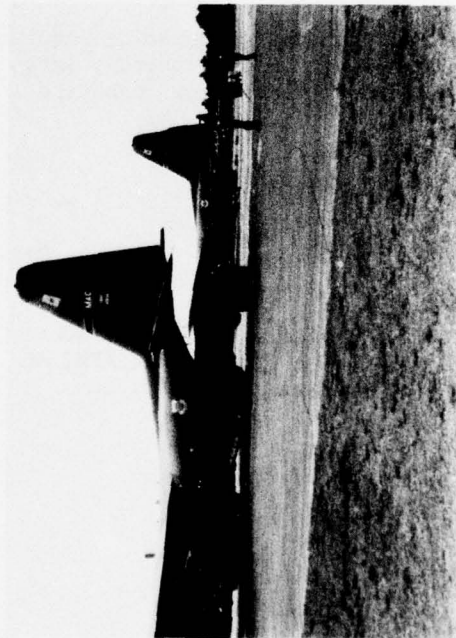


Photo 3. Equipment being loaded into C-130 aircraft

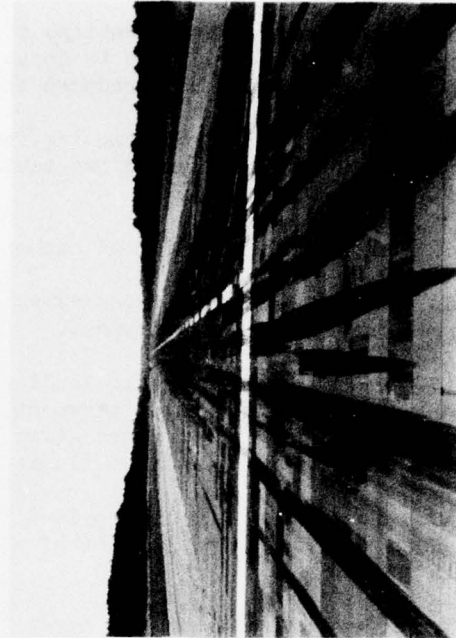


Photo 4. Touchdown area at north end of runway (looking south)

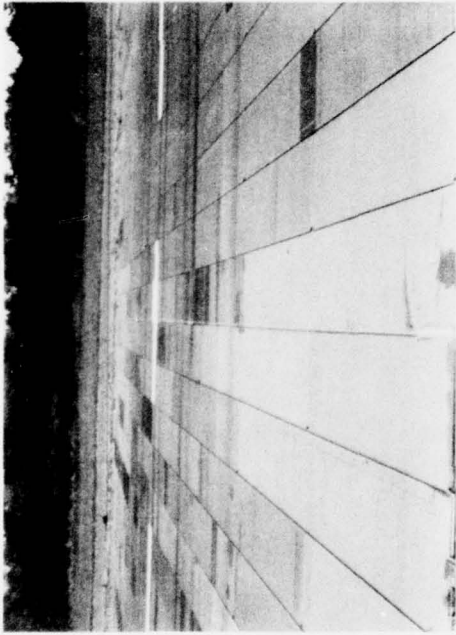


Photo 5. Bow in mat at Sta 10+00

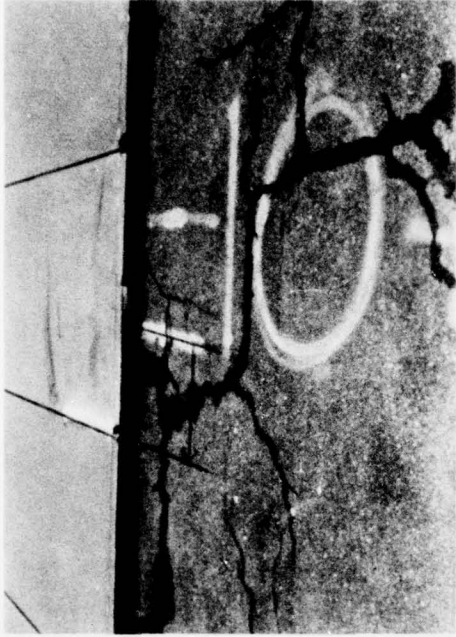


Photo 6. Mat movement at east edge of runway,  
Sta 10+00

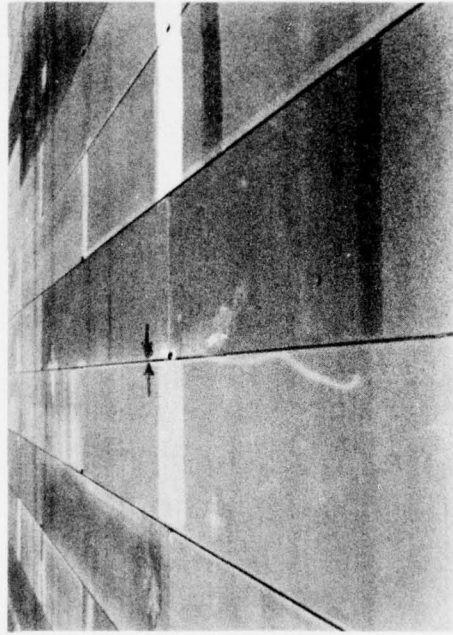


Photo 7. Slack removed in mat joints in runway at  
the completion of operations



Photo 8. Loose anchor at east edge of runway in  
maximum braking area

SOLID SHIELD 76

Mat Movement (in inches) measurements taken on  
26 May 1976 at Oak Grove Airfield, NC

Runway (Moved South)

<u>Station</u>	<u>East Edge</u>	10 Ft East Of <u>Center Line</u>	<u>Center Line</u>	10 Ft West Of <u>Center Line</u>	<u>West Edge</u>
0+00	2 7/8	3 1/4	3 1/4	3	2 1/2
7+00	6 7/8	7 1/2	7 5/8	7 3/8	6 5/8
10+00	8 5/8	9 5/8	9 3/4	9 5/8	9
16+50	9 3/8	11	11 1/2	11 3/8	11 1/2
21+00	7 3/4	8 3/4	8 7/8	8 1/2	6 7/8
33+00	5 1/2	4 7/8	4 5/8	4 1/2	4 1/4
35+00	5 5/8	5 1/4	4 7/8	4 3/8	3 1/8

South Parallel Taxiway (Moved North)

27+20	20 1/2	20 1/4	20 3/8	20 1/4	20 1/4
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<u>Station</u>	<u>Mat Bow Bow, Inches</u>
7+00	1
10+00	1 1/4
16+50	1

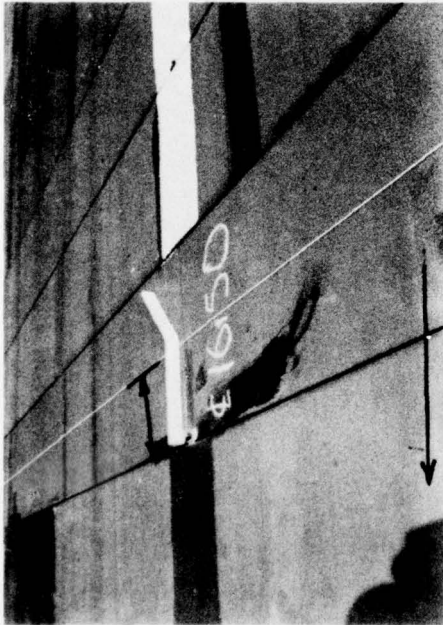


Photo 9. Mat movement at center line of runway,  
Sta 16+50



Photo 10. Mat movement, east edge of runway,  
Sta 16+50

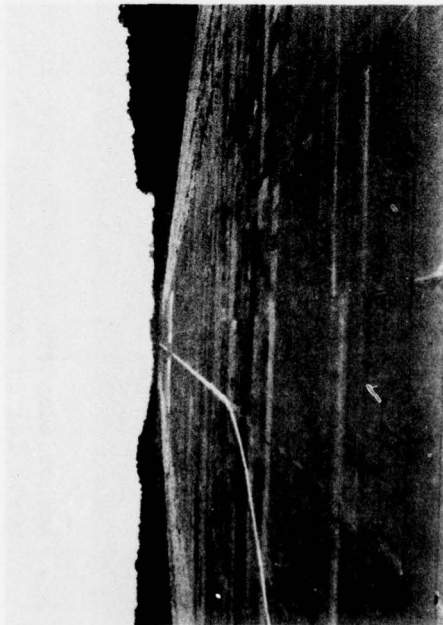


Photo 11. South end of runway, looking north

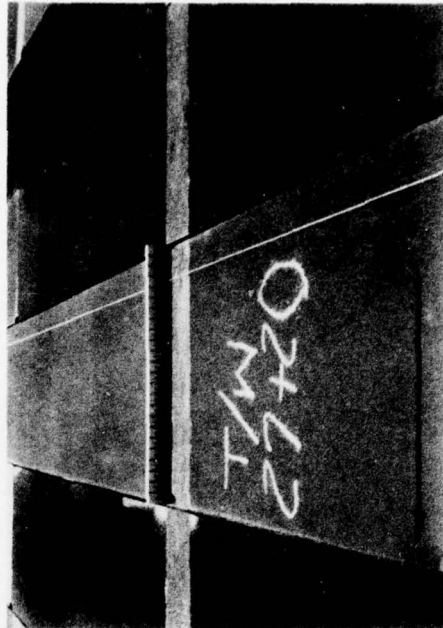


Photo 12. Mat movement at center line of parallel  
taxiway at south end of runway

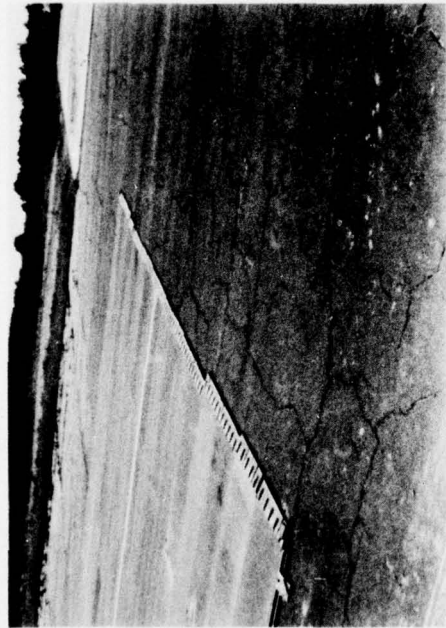


Photo 13. Anchor adapters used for approach ramp, north leg of taxiway, north end of runway

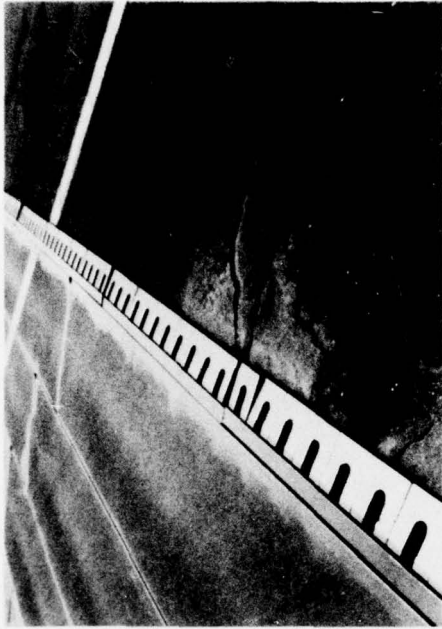


Photo 14. Anchor adapters used for approach ramp, south leg of taxiway, north end of runway



Photo 15. Removing soil from buried mat at south end of runway



Photo 16. Soil removed from mat at south end of runway

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Green, Hugh L

Usage of landing mat as overlay on asphalt runway during military field exercises, by Hugh L. Green. Vicksburg, U. S. Army Engineer Waterways Experiment Station, 1976.

1 v. (various pagings) illus. 27 cm. (U. S. Waterways Experiment Station. Miscellaneous paper S-76-24)

Prepared for U. S. Army Materiel Development and Readiness Command, Alexandria, Virginia, under Project No. IT162112A528, Task 04.

Includes bibliography.

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