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EVALUATION OF MODIFICATIONS OF AM2 AND XM18 LANDING MAT

C. D. Burns, et al

Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

February 1970

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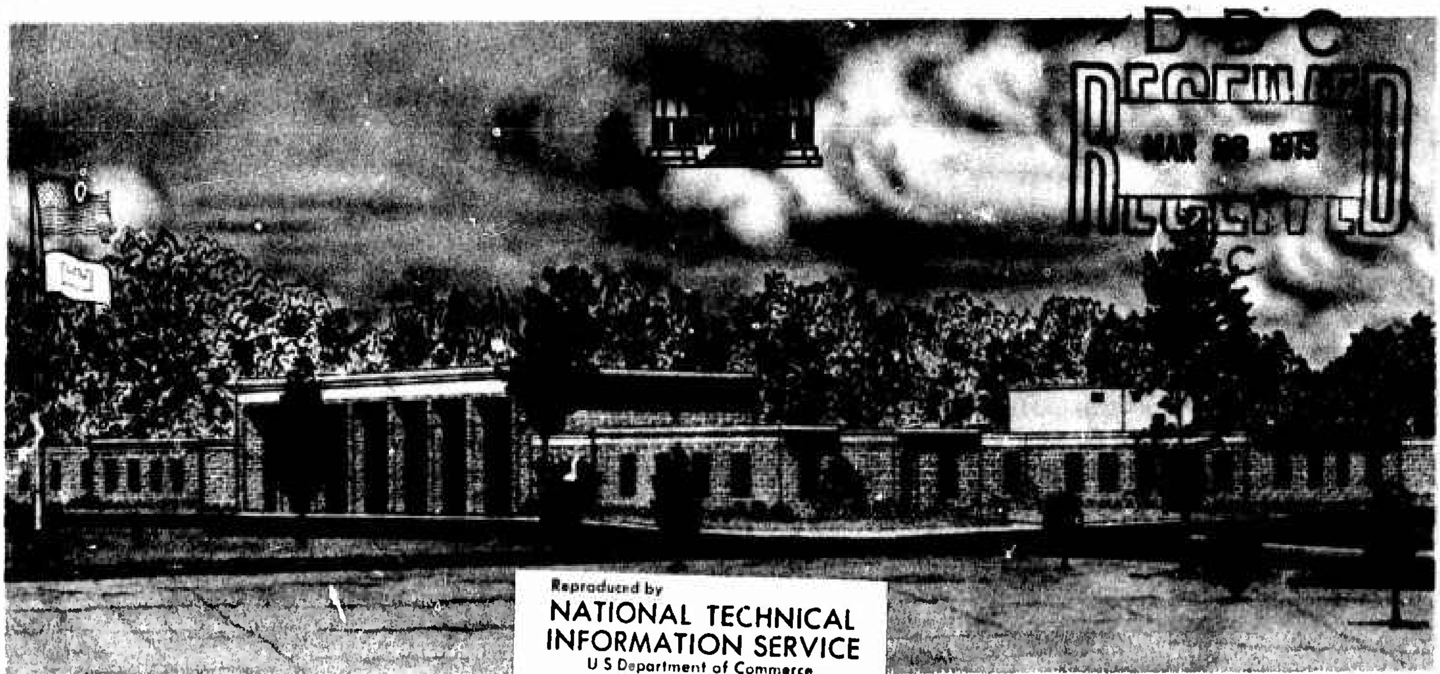
by

C. D. Burns, D. P. Wolf



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56

ASSOCIATED REPORTS

Report No.	Title	Date
MP 4-501	Development of CBR Design Curve for M9M2 Landing Mat	June 1962
MP 4-581	Evaluation of M9M1 Landing Mat	July 1963
MP 4-599	Development of CBR Design Curves for AM1 Landing Mat	Sept 1963
MP 4-615	Development of CBR Design Curves for Harvey Aluminum Landing Mat (AM2)	Jan 1964
MP 4-655	Development of CBR Design Curve for Modified AM1 Landing Mat	June 1964
MP 4-656	Evaluation of Convair Landing Mat	June 1964
MP 4-747	Evaluation of Harvey Modified AM2 Landing Mat	Oct 1965
MP 4-753	Evaluation of Washington Aluminum Company AM2 Landing Mat	Jan 1966
MP 4-786	Evaluation of Various Sizes of Harvey Aluminum AM2 Landing Mat	Jan 1966
MP 4-787	Evaluation of Various Sizes of Butler AM1 Landing Mat	Jan 1966
MP 4-788	Evaluation of AM2 Landing Mat Replacement Panels and Keylock Assemblies	Jan 1966
MP 4-789	Evaluation of Butler AM2 Landing Mat	Feb 1966
MP 4-850	Evaluation of Guide Rail in Conjunction with Kaiser and Harvey Landing Mat (AM2)	Oct 1966
MP 4-852	Evaluation of Harvey Two-Piece Landing Mat (AM2)	Nov 1966
MP 4-886	Evaluation of Three-Piece AM2 Aluminum Landing Mat	Apr 1967
MP 4-954	Comparative Performance Tests of AM2 Mat from Various Extruders and Fabricators	Dec 1967
MP S-68-11	Evaluation of May Two-Piece AM2 Landing Mat	July 1968
MP S-69-3	Evaluation of Washington Aluminum Company, Inc., Production AM2 Landing Mat	Jan 1969
MP S69-13	Evaluation of Harvey Electron Beam Welded AM2 Landing Mat (AM2 MOD 2)	Apr 1969
MP S-69-29	Evaluation of Harvey Nonwelded Aluminum Landing Mat	July 1969
MP S-69-39	Evaluation of XM20 Aluminum Landing Mat	Sept 1969
MP S-69-40	Evaluation of Dow XM18-E and Alcoa AM2 Landing Mat	Sept 1969
MP S-69-41	Evaluation of Harvey and Kaiser Production AM2 Landing Mat	Sept 1969
MP S-70-4	Evaluation of Harvey New-Profile AM2 Landing Mat	Feb 1970

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13. ABSTRACT

This investigation was conducted to evaluate the performance of Alcoa AM2 and electron beam welded XM18 landing mat. The test section was subjected to traffic representing 1600 operational cycles of an aircraft having a 60,000-lb gross weight with a single-wheel main-gear assembly load of 27,000 lb and a 30x7.7 tire inflated to 400 psi. Based on the results obtained in this investigation, it is concluded that Alcoa AM2 landing mat will sustain 1600 cycles of uniformly distributed aircraft operations with a 27,000-lb single-wheel load and 400-psi tire inflation pressure when placed on a sub-grade having a CBR of approximately 6 or greater. This does not meet current minimum requirements for SATS set by NAEC. Electron beam welded XM18 landing mat will sustain 1600 cycles of uniformly distributed aircraft operations with a 27,000-lb single-wheel load and 400-psi tire inflation pressure when placed on a subgrade having a CBR of 4.3 or greater. This performance is marginal with respect to compliance with current mini-mum requirements.

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FOREWORD

This report is the 25th in a series published on landing mat tests performed by the U. S. Army Engineer Waterways Experiment Station (WES) for the Naval Air Engineering Center (NAEC), Philadelphia, Pa. The investigation reported herein was authorized by the NAEC in Project Order No. 8-4077 dated 3 June 1968 and was conducted by the WES during March and April 1969.

Engineers of the Soils Division who were actively engaged in the planning, testing, analyzing, and reporting phases of the investigation were Messrs. R. G. Ahlvin, C. D. Burns, and D. P. Wolf. Engineering technicians responsible for the conduct of the tests were Messrs. W. J. Harper and R. T. Sullivan. The investigation was under the general supervision of Mr. A. A. Maxwell, Acting Chief of the Soils Division, WES. This report was prepared by Messrs. Burns and Wolf.

The Director of WES during the investigation and preparation of this report was COL Levi A. Brown, CE. Technical Director was Mr. F. R. Brown.

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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
square inches	6.4516	square centimeters
pounds	0.45359237	kilograms
kips	453.59237	kilograms
pounds per square inch	0.070307	kilograms per square centimeter
pounds per square foot	4.88243	kilograms per square meter
pounds per cubic foot	16.0185	kilograms per cubic meter

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SUMMARY

This investigation was conducted to evaluate the performance of Alcoa AM2 and electron beam welded XM18 landing mat. The test section was subjected to traffic representing 1600 operational cycles of an aircraft having a 60,000-lb gross weight with a single-wheel main-gear assembly load of 27,000 lb and a 30x7.7 tire inflated to 400 psi.

Based on the results obtained in this investigation, it is concluded that:

a. The Alcoa AM2 landing mat will sustain 1600 cycles (188 coverages) of uniformly distributed aircraft operations with a 27,000-lb single-wheel load and 400-psi tire inflation pressure when placed on a subgrade having a CBR of approximately 6 or greater. This, however, does not meet the current minimum requirements for SATS set by NAEC.

b. The electron beam welded XM18 landing mat will sustain 1600 cycles (188 coverages) of uniformly distributed aircraft operations with a 27,000-lb single-wheel load and 400-psi tire inflation pressure when placed on a subgrade having a CBR of 4.3 or greater. This performance is marginal with respect to compliance with the current minimum requirements.

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EVALUATION OF MODIFICATIONS OF AM2 AND XM18 LANDING MAT

PART I: INTRODUCTION

Background

1. For several years the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., has been engaged in a study for the Naval Air Engineering Center (NAEC), Philadelphia, Pa., for the purpose of evaluating various types of landing mat to be used in surfacing small airfields for tactical support (SATS) in combat air operations. A SATS has been defined as a short, quickly constructed, tactical support airfield of a temporary nature, capable of sustaining operations of the Marine Corps' modern jet aircraft, which employ assisted takeoffs and arrested landings.

2. The service criterion established by NAEC for landing mat is that it remain in serviceable condition with minimum maintenance for at least 1600 aircraft operation cycles during a 30-day period when placed on a subgrade having a 4 CBR or less. The heaviest proposed Marine Corps' aircraft that will utilize SATS weighs 60,000 lb* (27,000 lb per main gear wheel) and is equipped with 30x7.7 tires inflated to 400 psi. Therefore, for the evaluation of various landing mats considered for use in SATS, NAEC has standardized the test load at 27,000 lb on a single wheel with a 30x7.7, 26-ply tire inflated to 400 psi. NAEC generally requires that a test section of the particular mat under consideration, when placed on a subgrade having a CBR of 4 or less, remain serviceable with minimum maintenance (a) for 188 coverages (equivalent to 1600 cycles) of the test load applied uniformly over a 10-ft-wide traffic lane, and (b) for 1600 passes of the test load applied in a single path (one tire print width). The uniform-coverage traffic simulates landings and normal takeoffs in which no catapult is used, and the single-path traffic simulates takeoff runs in which a catapult system is employed. At the request of NAEC, no single-line traffic tests were run in this study.

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

3. The tests reported herein were conducted on Alcoa Lightweight Brazed AM2 mat manufactured by the Aluminum Company of America, New Kensington, Pa., and XM18 mat extruded by Dow Chemical Company and electron beam welded by Harvey Aluminum Company, Torrance, Calif.

Objective and Scope of Investigation

4. The objective of this investigation was to evaluate the performance of Alcoa AM2 and electron beam welded XM18 mat. The objective was accomplished by:

a. Constructing a test section that consisted of a clay subgrade and surfacing it with Alcoa AM2 and electron beam welded XM18 landing mat.
b. Performing accelerated traffic tests with a 27,000-lb single-wheel load on a 30x7.7, 26-ply tire inflated to 400 psi.
c. Observing the behavior of the mat and subgrade during traffic tests and recording pertinent test data.
d. Analyzing the performance and data from the AM2 and XM18 mat test.

This report describes the landing mat, the test section, the tests conducted, and the results obtained, and presents an analysis of the test data.

Definitions of Traffic Terms

5. Traffic terms having special meaning in this report are defined below:

a. Cycle. A cycle is one takeoff and one landing of an aircraft. For this test, a cycle is considered one round trip on a runway or a taxiway.
b. Pass. One traverse of a load wheel along a given length of runway, taxiway, or test section surface. Load

repetitions applied in a single path (one tire print width) are referred to as passes.

c. Coverage. The application of the wheel of an aircraft or test load vehicle over every point of the entire area within the limits of the test lane being subjected to traffic. Since the traffic is applied incrementally in passes and the width of each of the passes is equal to one tire print width, the number of passes required to complete one coverage is equal to the test lane width divided by the tire print width.

PART II: TEST SECTION, MATS, AND TEST LOAD CART

Test Section

Location

6. The traffic test was conducted at the WES on a special test section that was constructed and trafficked under shelter in order that water content and strength of the subgrade soil could be controlled.

Description

7. A layout of the test section is shown in plate 1. The subgrade was constructed of a heavy clay at a 4 CBR and was approximately 24 ft wide and 80 ft long. Classification data for the subgrade soil are shown in plate 2. Alcoa AM2 and electron beam welded XM18 landing mats were used to surface the test section.

Subgrade construction

8. The test subgrade was to be constructed to a total thickness of 24 in.; therefore, the existing material at the test site was excavated to a depth of 24 in. below finished grade, and then the excavation was backfilled with special test soils. The soil at the bottom of the excavation was a lean clay having a CBR value of approximately 10. The soil for the test section was processed to the desired water content to result in the desired CBR when compacted, hauled to the test site by truck, spread, and compacted in 6-in.-thick lifts. Compaction of each lift was accomplished by applying eight coverages of a self-propelled, rubber-tired roller loaded to 35,000 lb with its tires inflated to 65 psi. The surface of each lift was scarified prior to the placement of the next lift. After placement and compaction of the fourth and final lift, the surface of the subgrade was fine-bladed to grade by a motor patrol.

Mats

Descriptions

9. The Alcoa AM2 panels were received at the WES in three bundles. Full and half panels were packaged in each bundle. The aluminum panels were fabricated by a brazing process in which the top and bottom skins and side and end connectors were bonded to an eggcrate-type core. The side and end connectors were then welded to the top and bottom skins around the perimeter of the panels. The eggcrate-type core and perimeter welding were new design features of the nonwelded honeycomb core Alcoa AM2 mat previously tested at WES. The top surface of the panels was smooth.

10. The XM18 panels were received at the WES in three bundles, each containing both full and half panels. The aluminum panels were fabricated from one extrusion to which the end joints were electron beam welded. The top surface of each panel was coated with an antiskid compound. The average weights and dimensions of both types of mat are as follows:

Mat	Length ft	Width in.	Height in.	Thickness in.	Unit Weight lb	Weight psf
			Bundles			
AM2	12.38	25.25	33	--	1920	--
XM18	12.08	28.25	26	--	1420	--
			Panels			
AM2 (full)	12.07	24.75	--	1.5	107.25	4.31
(half)	6.07	24.75	--	1.5	55.50	4.44
XM18 (full)	12.08	24.75	--	1.5	113.19	4.55
(half)	6.08	24.75	--	1.5	58.25	4.65

Individual full and half panels are shown in figs. 1 and 2 for Alcoa AM2 and XM18 mat, respectively.

Placement procedures

11. The mat was placed on the test section by a crew of six experienced laborers under the supervision of a foreman. The mat bundles were placed along the side of the test section with a forklift, and

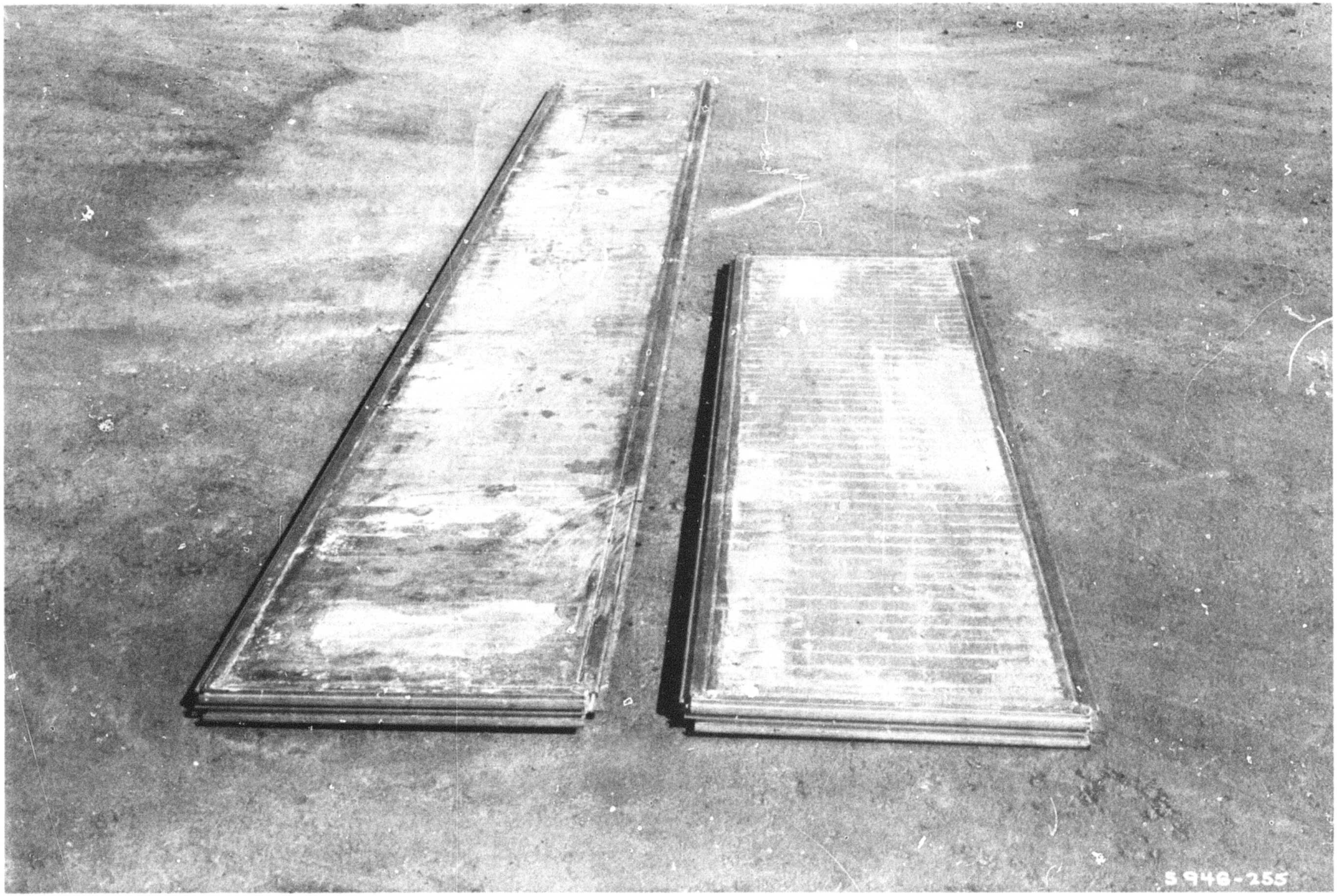

Fig. 1. Full and half panels of AM2 mat

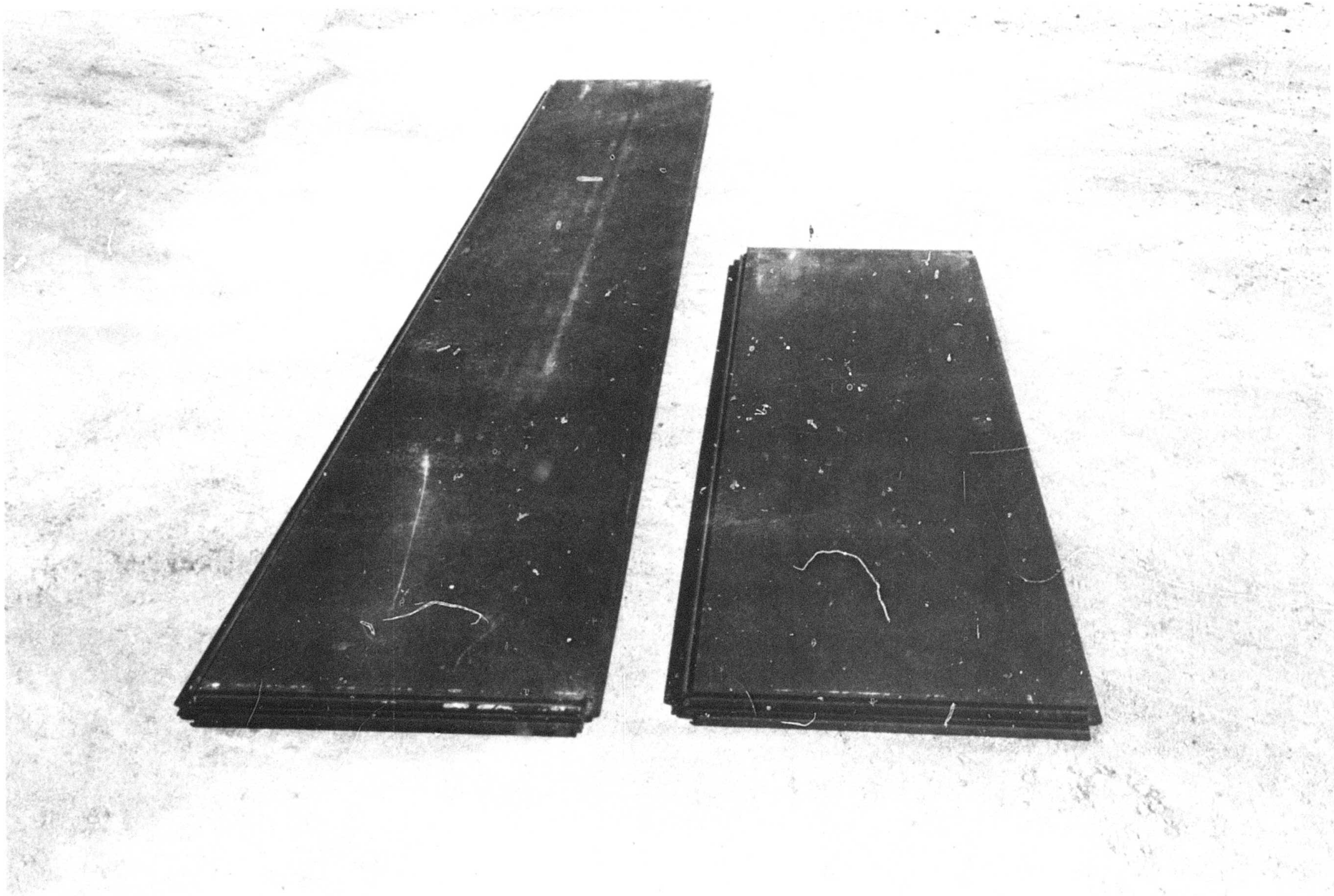

Fig. 2. Full and half panels of XM18 electron beam welded mat

the individual panels were carried a distance of about 30 ft by laborers and placed in position. One laborer inserted end-connecting rods between the panels at the end joints.

12. The test section was divided into test items 1 and 2, which were surfaced with AM2 and XM18 mat, respectively. The panels were placed with the long axis perpendicular to the direction of traffic, as shown in plate 1. The surfaced test section was approximately 24 ft wide and 80 ft long. The first run of mat consisted of two full panels placed end to end, and the second run consisted of one full panel in the center with half panels on each end; this alternating pattern was continued throughout the test section of 40 runs and provided a staggered-joint configuration, as shown in plate 1. After surfacing the section with mat, lead weights were placed on each edge of the section (photograph 1) to prevent lateral movement of the mat panels during the traffic period.

Test Load Cart

13. A specially designed single-wheel test cart (fig. 3) loaded to 27,000 lb was used in the traffic test. It was equipped with an outrigger wheel to prevent overturning and was powered by the front half of a four-wheel-drive truck. The load cart was equipped with the specified 30x7.7, 26-ply rating tire inflated to 400 psi. With the 27,000-lb wheel load, the tire had a contact area of about 78 sq in. and an average contact pressure of 348 psi.

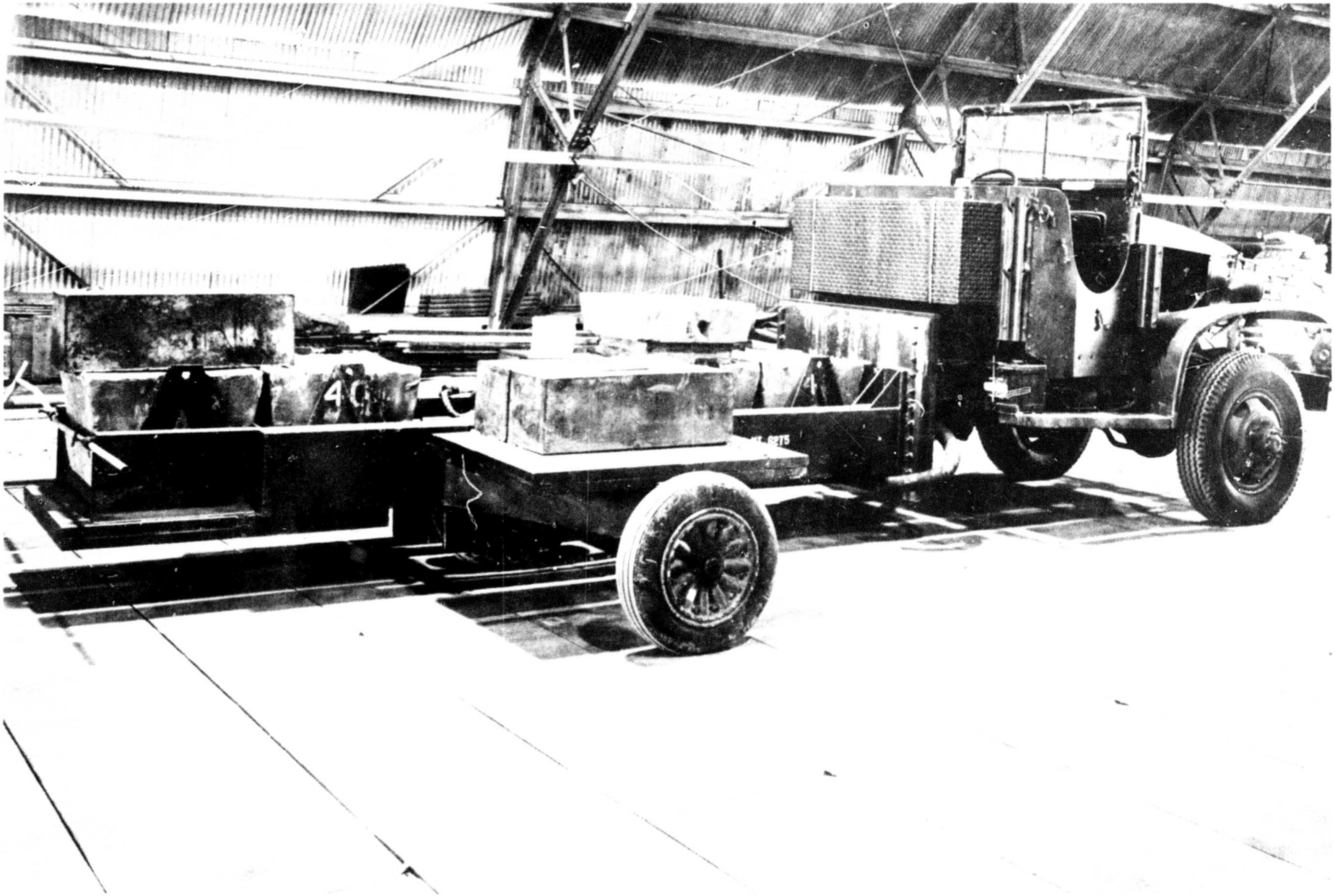

Fig. 3. Test load vehicle

PART III: TESTS AND RESULTS

Traffic Tests

14. Uniform-coverage traffic was applied in a 10-ft-wide traffic lane (plate 1) to simulate the traffic distribution pattern of a main landing gear wheel on a mat surface that would occur during landings and normal takeoffs when no catapult was used. Traffic was applied by driving the load cart forward and then backward over the length of the test section, shifting the path of the cart laterally about 7 in. (one tire print width) on each forward pass. This procedure resulted in two complete coverages of traffic on the test lane each time the load cart was maneuvered from one side of the test lane to the other. Traffic was continued on each item in this manner until failure of the mat in the test item had occurred.

15. A specially instrumented Alcoa AM2 panel was placed in item 1 (panel 22) to record stress and strain prior to traffic. Plate 3 shows the locations of the strain gages. The load wheel positions for the strain gage readings are shown in plate 4.

Soil Tests and Miscellaneous Observations

16. Water content, dry density, and in-place CBR tests were conducted prior to traffic tests, at intervals during traffic, and after failure of the section. These tests were made at depths of 0, 6, and 12 in., and at least three tests were made at each depth. The data obtained from the tests are summarized in table 1. The values listed in table 1 corresponding to the various depths are averages of the values measured at each particular depth.

17. Visual observations of the behavior of the test section and other pertinent data were recorded throughout the traffic test period. These observations and data were supplemented by photographs. Level readings were taken on the mat prior to and at intervals during

traffic to show the development of permanent mat deformation and deflection of the mat under the wheel load.

Failure Criteria

18. The criteria for mat failure were the same as those used in previous tests of this series and are based primarily on mat breakage. It was assumed that a certain amount of maintenance would be performed in the field during actual usage and that minor metal or weld breaks could be easily repaired. It is considered feasible to replace up to 10 percent of the panels with new mat during the design service life of a runway; however, replacement in excess of 10 percent of the panels is not considered practical. Therefore, in this test, it was assumed that up to 10 percent of the mat panels could be replaced, and when an additional 10 percent of the panels had failed (a total of 20 percent failed), the entire section was considered failed.

Behavior of Mat under Traffic

Visual observations

19. Item 1, Alcoa AM2. A general view of item 1 prior to traffic is shown in photograph 2. Dishing of 5/8 in., as shown in photograph 3, was observed in panel 6 on the first pass of the load cart. After six coverages, the dishing had become so severe that the panel was considered failed. By six coverages, panels 20 and 27 had also failed in a similar manner, and the three panels were replaced. Photographs 4 and 5 show, respectively, panel 6 at failure before removal from the test item and the damaged core after removal.

20. After 16 coverages, end-joint weld cracks averaging about 1/2 in. in length were observed in three panels. All the weld cracks originated at the C-rail corner. After 28 coverages, dishing had developed in panels 9, 18, and 30, and by 36 coverages, panel 18 was

considered failed and was replaced (see photograph 6). By 72 coverages, dishing had become so severe in several more panels that traffic was stopped and item 1 was considered failed. A total of eight panels had failed due to severe dishing throughout the period of traffic. An overall view of item 1 at failure is shown in photograph 7.

21. Additional traffic was requested by representatives of Alcoa so that design features of the landing mat could be tested rather than quality control of the production process. All of the damaged panels were removed from the test item, the undamaged panels were relaid, and traffic was resumed. After 120 coverages, panel 14 was considered failed due to weld failure along the overlapping end joint and was replaced. After 130 coverages, three additional panels had developed severe dishing, and traffic was stopped. A total of 34 panels were trafficked throughout the test period. Of these, 35 percent had failed. An additional 18 percent of the panels had received slight damage, but were not considered a hazard to tire operation when traffic was stopped.

22. Item 2, XM18. A general view of item 2 prior to traffic is shown in photograph 8. Peeling of the antiskid compound on the XM18 mat, as shown in photograph 9, occurred prior to the application of traffic. Mat breakage was first observed after 16 coverages, with small weld cracks occurring along the end joints. These cracks, which averaged about 3/8 in. in length, had developed in 19 panels. The cracks developed slowly in most panels; however, after 78 coverages, the weld break had progressed across the width of panel 55, and the underlapping end joint had sheared off. Photographs 10 and 11 show, respectively, panel 55 before and after removal from the test item. With increased traffic, top skin tears began to develop at the weld cracks along the end joints and ran parallel to the C-rail. Traffic was stopped after 188 coverages due to excessive mat breakage. Typical skin tears are shown in photograph 12. Photograph 13 shows slight dishing of a panel caused by an internal rib failure. A total

of nine panels were failed throughout the traffic period. An overall view of item 2 at failure is shown in photograph 14.

Permanent deformation

23. Plots showing permanent deformation as determined from level readings taken prior to and at failure of the test items are shown in plate 5. Cross sections were taken at several locations, and the results shown in plate 5 are averages of all the readings. The maximum deformation for items 1 and 2 was 0.4 and 0.7, respectively. A plot of deformation along the center line of the traffic lane is shown in plate 6.

Elastic mat deflection

24. Elastic deflection of the mat surface prior to and after traffic is shown in plate 7. These plots indicate the elastic deflection, or rebound, of the mat as the wheel load moved over the surface. Two types of data were taken: one with the load wheel centered on the joint of two panels, and the other with the load wheel centered on the midpoint of a panel. In both cases, the load wheel was positioned in the center of the traffic lane. The maximum deflection was 0.84 and 0.95 in., respectively, for items 1 and 2.

Stress-strain data

25. Stress-strain data taken before traffic on the Alcoa AM2 mat are summarized in table 2. The modulus of elasticity used for determining stress in table 2 was 10.3×10^6 psi. Values of stress over 40,000 psi were determined from a stress-strain diagram provided by Alcoa. Included in table 2 are the load wheel position numbers and the gage numbers which were recorded at each position. These can be referenced from plates 3 and 4. Stress and strain are recorded in either the tension or compression columns of the X and Y axes. These data were collected for and will be analyzed by Alcoa.

PART IV: ANALYSIS OF RESULTS

26. A summary of the test results is shown in table 3. Included in the table are the rated subgrade CBR, mat breakage and deflection data taken at various stages of traffic, and the performance rating of the test section based on the failure criteria described in paragraph 18. The rated CBR for the clay subgrade is based on the numerical average of the CBR values measured at 0-, 6-, and 12-in. depths prior to and during the traffic.

27. Test item 1 (Alcoa AM2) sustained 72 coverages of traffic before failure. A total of eight panels were failed due to excessive dishing. A cross-sectional view of a failed panel is shown in photograph 5. It can be seen in the photograph that the core has separated from the bottom skin. This separation in turn led to the buckling of the core (dishing) with increased traffic. Small end-joint weld cracks were observed in three panels at failure; however, the weld cracks did not present a tire hazard and did not contribute to the failure of the test item. Soil strength of the subgrade for item 1 during the period of traffic was rated at 4.3 CBR.

28. The damaged panels were removed after the test item had failed, and traffic was continued to further test the design features of the landing mat. By 130 coverages, three additional panels were failed due to excessive dishing. One panel had also failed due to a weld break along the overlapping end joint. Of the 34 panels that received traffic, 18 showed no signs of damage when traffic was stopped at 130 coverages. Although the Alcoa AM2 landing mat did not meet the minimum test requirements set by NAEC, the eggcrate core design and welded perimeter contributed to a considerable improvement in the performance of the mat over the Alcoa AM2 mat previously tested at WES.*

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* C. D. Burns and D. P. Wolf, "Evaluation of Dow XM18-E and Alcoa AM2 Landing Mat," Miscellaneous Paper in preparation, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

29. Test item 2 (XM18) supported 188 coverages of traffic before failure. Weld cracks along the end joints were first observed after 16 coverages, and by 78 coverages, the end joint of one panel had completely sheared off due to weld failure. An examination of the panel after removal from the test section (photograph 11) revealed that the electron beam weld had not penetrated the thickness of the mat on several of the vertical ribs. With increased traffic, top skin tears began to develop at right angles to the weld breaks, and by 188 coverages, item 2 had failed due to excessive mat breakage. Soil strength of the subgrade for item 2 during the period of traffic was rated at 4.3 CBR.

30. A total of nine panels were failed throughout the period of traffic, and all the failures resulted from weld breaks. In previous traffic tests conducted on XM18 landing mat (referenced in paragraph 28 above), the electron beam welded mat did not perform as well as metal-inert-gas welded mats with inserts. On heavier AM2 landing mat,* the electron beam welding of the end joints resulted in considerable improvement in the performance of the mat as compared to the metal-inert-gas welded AM2 mat.

31. A plot of CBR versus coverages is shown in plate 8. The rated CBR value listed in table 3 for the subgrade was plotted at the corresponding number of coverages at failure of each test item. From previous tests on landing mat, it has been established that the CBR-coverage relation for landing mat is essentially a straight line when plotted to a log-log scale. By use of the CBR equation,** the CBR versus coverage plots for the AM2 and XM18 mat in plate 8 were obtained by extrapolation from the known failure points at 72 and 188 coverages, respectively, for the AM2 and XM18 mat. Therefore, the linear projection indicates the CBR required to support the test load for various coverage levels. The indicated CBR required

* C. D. Burns and D. P. Wolf, "Evaluation of Harvey Electron Beam Welded AM2 Landing Mat," Miscellaneous Paper S-69-13, Apr 1969, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

** W. B. Fenwick, "Development of CBR Design Curves for Harvey Aluminum Landing Mat," Miscellaneous Paper No. 4-615, Jan 1964, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

to support 188 coverages is approximately 6 CBR for the AM2 mat and 4.3 CBR for the XM18 mat.

32. Plate 9 shows CBR design curves for 188 coverages of a 27,000-lb single-wheel load with a tire inflation pressure of 400 psi. The lower curve is a standard flexible pavement CBR design curve. The curves for the AM2 and XM18 mat were developed as follows: in plate 8, it was shown that subgrades with CBR's of 6 and 4.3, respectively, for the AM2 and XM18 mat would support the 27,000-lb single wheel for 188 coverages when surfaced with the mat. It can be seen from plate 9 that a flexible pavement design based on subgrades of 6 and 4.3 CBR would require 15.8 and 18.4 in. of base course, respectively. In prior similar studies, CBR design curves have been developed by merely reducing standard curve thickness by the thickness pertaining to the 188-coverage service life. This considers that the effective thickness of the mat plus a strengthening layer beneath it will be equal to the total thickness of an equivalent pavement structure. However, studies of soil thickness requirements beneath landing mat being conducted by WES indicate the effective thickness of the mat plus the strengthening layer is only 80 to 85 percent of the simple sum of the two thicknesses. Therefore, the CBR design curve for the AM2 and XM18 mat, also shown in plate 9, was obtained by establishing the layer thickness so that the thickness of the underlying layer plus the effective mat thickness when reduced by 20 percent will yield a satisfactory effective combined thickness.

PART V: CONCLUSIONS

33. Based on the data presented in this report, the following conclusions are drawn:

a. The Alcoa AM2 landing mat will sustain 1600 cycles (188 coverages) of uniformly distributed aircraft operations with a 27,000-lb single-wheel load and 400-psi tire inflation pressure when placed on a subgrade having a CBR of approximately 6 or greater. This does not meet the current minimum requirements for SATS set by NAEC.

b. The electron beam welded XM18 landing mat will sustain 1600 cycles (188 coverages) of uniformly distributed aircraft operations with a 27,000-lb single-wheel load and 400-psi tire inflation pressure when placed on a subgrade having a CBR of 4.3 or greater. This performance is marginal with respect to compliance with the current minimum requirements.

Table 1

Summary of CBR, Water Content, and Dry Density Data

Test Item	Traffic Coverages	Depth in.	CBR	Water Content %	Dry Density pcf
1	0	0	3.2	29.4	88.1
		6	3.7	28.8	86.6
		12	3.6	29.5	89.3
	72	0	4.7	29.7	89.8
		6	5.5	29.4	89.6
		12	4.9	29.2	89.7
2	0	0	3.7	28.7	89.6
		6	3.2	29.5	87.5
		12	3.6	29.9	87.8
	188	0	5.8	28.8	90.6
		6	4.6	29.5	89.6
		12	4.8	30.1	89.3

Table 2

Summary of Zero-Coverage Stress and Strain Data on Alcoa AM2 Mat

Load Wheel Position No.	Strain Gage No.	Strain 10^{-6} in./in.		Stress psi	
		X-Axis	Y-Axis	X-Axis	Y-Axis
1	2	50 c	257 t	515 c	2,647 t
	3	118 c	438 t	1,215 c	4,511 t
	4	355 c	1342 t	3,657 c	13,823 t
	5	582 c	1748 t	5,994 c	18,004 t
	8	1399 c	1453 t	14,409 c	14,965 t
	10	1120 c	1710 t	11,536 c	17,613 t
	11	1335 c	1626 t	13,571 c	16,748 t
	16	1188 c	1080 t	12,236 c	11,124 t
2	2	215 c	345 t	2,215 c	3,554 t
	3	458 c	655 t	4,717 c	6,747 t
	4	492 c	1477 t	5,068 c	15,213 t
	6	715 c	870 t	7,365 c	8,961 t
	7	860 c	1027 t	8,858 c	10,578 t
	9	863 c	1117 t	8,889 c	11,505 t
	12	816 c	100 t	8,405 c	1,030 t
	13	1058 c	482 t	10,897 c	4,965 t
	16	1391 c	1130 t	14,327 c	11,639 t
3	2	42 c	262 t	433 c	2,999 t
	3	145 c	528 t	1,494 c	5,438 t
	4	525 c	2082 t	5,408 c	21,445 t
	5	1325 c	2470 t	13,647 c	25,441 t
	6	517 c	593 t	5,325 c	6,108 t
	7	763 c	1097 t	7,859 c	11,299 t
	8	507 c	2180 t	5,222 c	22,454 t
	9	533 c	1222 t	5,490 c	12,587 t
	10	410 c	2317 t	4,223 c	23,865 t
	11	765 c	2088 t	7,880 c	21,506 t
	17	1125 c	1730 t	11,587 c	17,819 t
	31	1544 c	905 t	15,903 c	9,322 t
4	2	107 c	625 t	1,102 c	6,438 t
	6	703 c	1297 t	7,241 c	13,359 t
	7	675 c	2057 t	10,990 c	21,187 t
	9	578 c	1877 t	5,953 c	19,333 t
	12	518 c	435 t	5,335 c	4,481 c
	13	98 c	880 t	1,009 c	9,064 t
	15	1096 c	1610 t	11,289 c	16,583 t
	24	1210 c	305 t	12,463 c	3,142 t
	25	1350 c	440 t	13,905 c	4,532 t

Note: The numerical values of stress and strain are followed by c or t for compression or tension, respectively.

(Page 1 of 4)

Table 2 (Continued)

Load Wheel Position No.	Strain Gage No.	Strain 10^{-6} in./in. X-Axis	Strain 10^{-6} in./in. Y-Axis	Stress psi X-Axis	Stress psi Y-Axis
5	5	665 c	2395 t	6,850 c	24,668 t
	8	1458 t	2760 t	15,017 t	28,428 t
	10	605 t	2865 t	6,232 t	29,506 t
	11	1128 t	2698 t	11,618 t	27,789 t
	16	1010 t	2098 t	10,403 t	21,609 t
	17	1350 t	2726 t	13,905 t	28,078 t
6	4	567 c	2152 t	5,840 c	22,166 t
	5	437 c	1570 t	4,501 c	16,171 t
	7	1150 c	2390 t	11,845 c	24,617 t
	9	500 t	2145 t	5,150 t	22,094 t
	12	927 t	1785 t	9,548 t	13,386 t
	13	1435 t	1625 t	14,781 t	16,738 t
	14	1613 t	1222 t	16,614 t	12,587 t
	16	1340 t	2370 t	13,802 t	24,411 t
	17	780 t	1583 t	8,034 t	16,305 t
	21	583 t	685 t	6,005 t	7,056 t
	22	290 t	632 t	2,987 t	6,510 t
	24	315 t	530 c	3,245 t	5,459 c
7	2	65 t	173 c	670 t	1,782 c
	3	72 t	277 c	742 t	2,853 c
	4	50 t	98 c	515 t	1,009 c
	5	5 c	58 t	51 c	597 t
	13	590 t	50 c	608 t	515 c
	14	578 t	215 c	5,953 t	2,215 c
	16	155 t	145 c	1,597 t	1,494 c
	17	152 t	122 c	1,566 t	1,257 c
	21	593 t	292 c	6,108 t	3,008 c
	22	423 t	270 c	4,357 t	2,781 c
8	18	1395 t	198 t	14,369 t	20,415 t
	19	2380 t	2285 t	24,514 t	23,536 t
	20	2607 t	2429 t	26,852 t	25,019 t
	23	2728 t	2270 t	28,098 t	23,381 t
	27	2578 t	1128 t	26,553 t	11,618 t
	28	2247 t	1580 t	23,144 t	16,274 t
	29	2770 t	1958 t	28,531 t	20,167 t
	30	2568 t	2173 t	26,450 t	22,382 t
	31	2675 t	2200 t	27,553 t	22,600 t

Table 2 (Continued)

Load Wheel Position No.	Strain Gage No.	Strain 10^{-6} in./in. X-Axis	Strain 10^{-6} in./in. Y-Axis	Stress psi X-Axis	Stress psi Y-Axis
9	21	3925 t	1613 t	40,428 t	16,614 t
	22	2923 t	920 t	30,107 t	9,476 t
	24	2545 t	2470 c	26,214 t	25,441 c
	25	3505 t	730 t	36,102 t	7,519 t
	26	2725 t	612 t	28,068 t	6,304 t
	27	*	1761 t	*	18,138 t
	31	1863 t	967 t	19,189 t	9,960 t
10	21	2075 t	160 t	21,373 t	1,648 t
	22	1153 t	353 c	11,867 t	3,636 c
	24	1352 t	685 c	13,926 t	7,056 c
	25	1935 t	615 c	19,931 t	6,335 c
	26	1060 t	508 c	10,918 t	5,232 c
11	35	1713 t	593 t	17,829 t	6,108 t
	36	2495 t	1578 t	25,699 t	16,253 t
	40	2379 t	865 t	24,504 t	8,910 t
	41	3767 t	2147 t	38,800 t	22,114 t
12	32	2352 t	1345 c	24,226 t	13,854 c
	33	2625 t	378 t	27,038 t	3,893 t
	34	2955 t	657 t	30,437 t	6,767 t
	35	2478 t	1160 t	25,523 t	11,948 t
	36	2192 t	530 t	22,578 t	5,459 t
	37	4270 t	2334 c	41,700 t	24,040 c
	38	4417 t	393 t	42,250 t	4,048 t
	39	4145 t	653 t	40,800 t	6,726 t
	40	4379 t	1610 t	41,200 t	16,583 t
	41	3560 t	672 t	36,668 t	6,922 t
13	32	3735 t	1837 c	38,471 t	18,921 c
	33	3690 t	342 c	38,007 t	3,523 c
	34	3617 t	310 c	37,255 t	3,193 c
	35	2328 t	482 c	23,978 t	4,965 c
	37	6342 t	3662 c	44,800 t	37,719 c
	38	6142 t	390 c	44,300 t	4,017 c
	39	5153 t	442 c	43,500 t	4,553 c
	40	4339 t	587 c	41,000 t	6,046 c

* Strain gage broken on X-Axis.

Table 2 (Concluded)

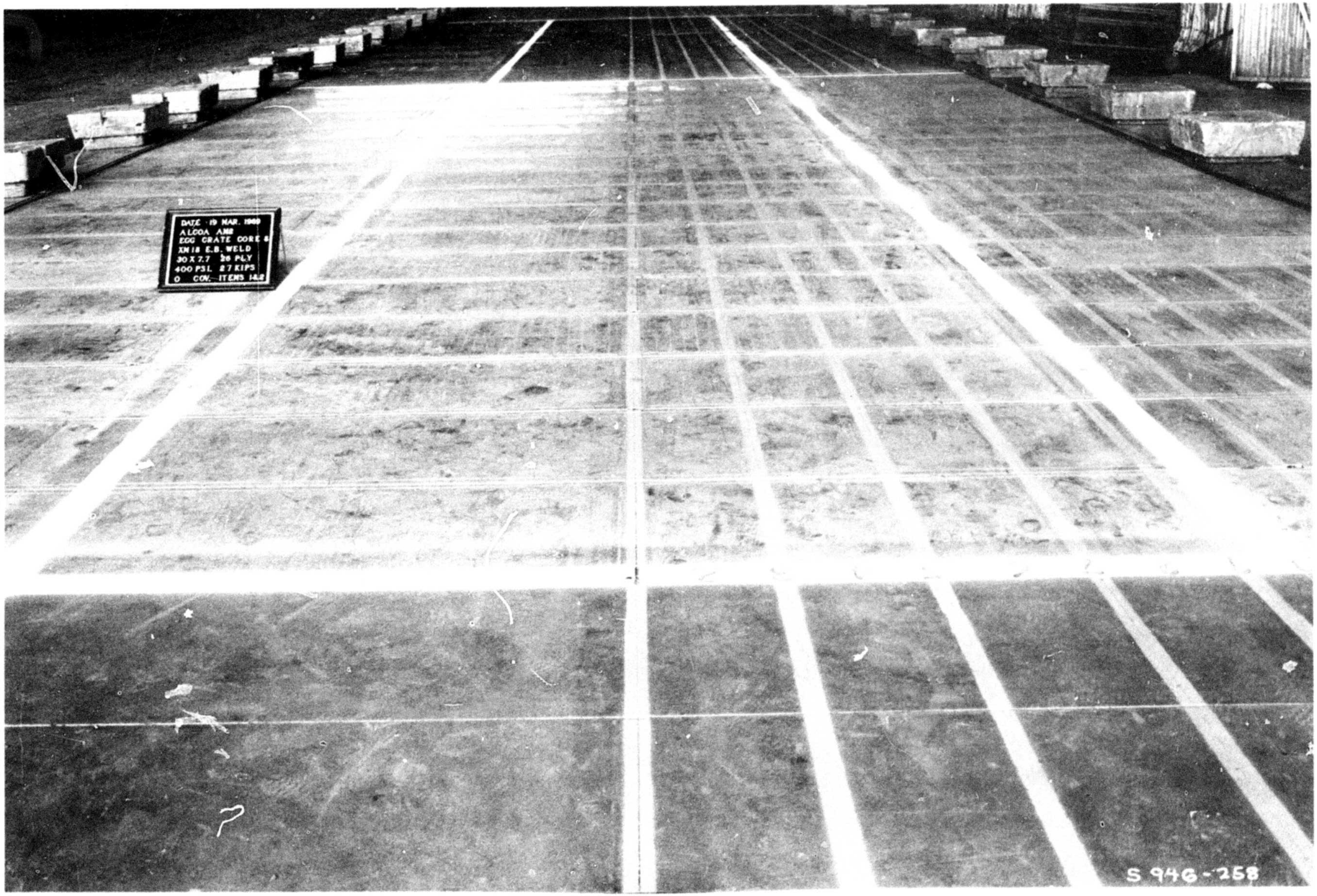
Load Wheel Position No.	Strain Gage No.	Strain 10^{-6} in./in. X-Axis	Strain 10^{-6} in./in. Y-Axis	Stress psi X-Axis	Stress psi Y-Axis
14	32	2442 t	1000 c	25,153 t	16,300 c
	33	2257 t	684 c	23,247 t	7,045 c
	34	2125 t	820 c	21,888 t	8,446 c
	35	1408 t	769 c	14,502 t	7,921 c
	37	4565 t	2219 c	42,400 t	22,856 c
	38	4217 t	922 c	41,000 t	9,497 c
	39	3325 t	1057 c	34,248 t	10,887 c
	40	2799 t	860 c	28,830 t	8,858 c
	8	1408 t	*	14,502 t	*
	10	518 t	*	5,335 t	*
	11	1022 t	*	10,527 t	*
	8	1456 t	*	14,996 t	*
	10	585 t	*	6,026 t	*
	11	1107 t	*	11,402 t	*

* Recordings were made on X-Axis only.

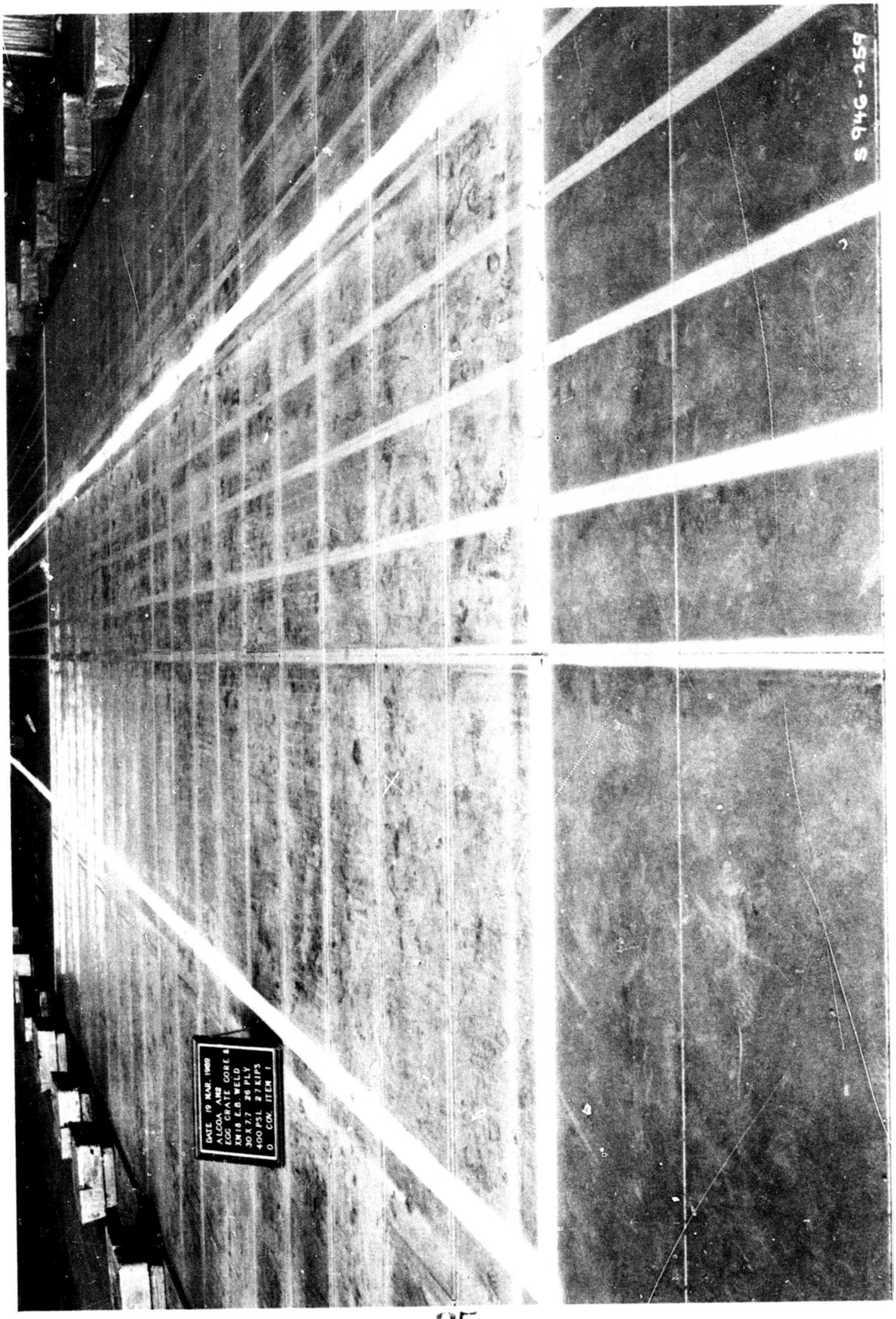
Table 3

Summary of Test Results

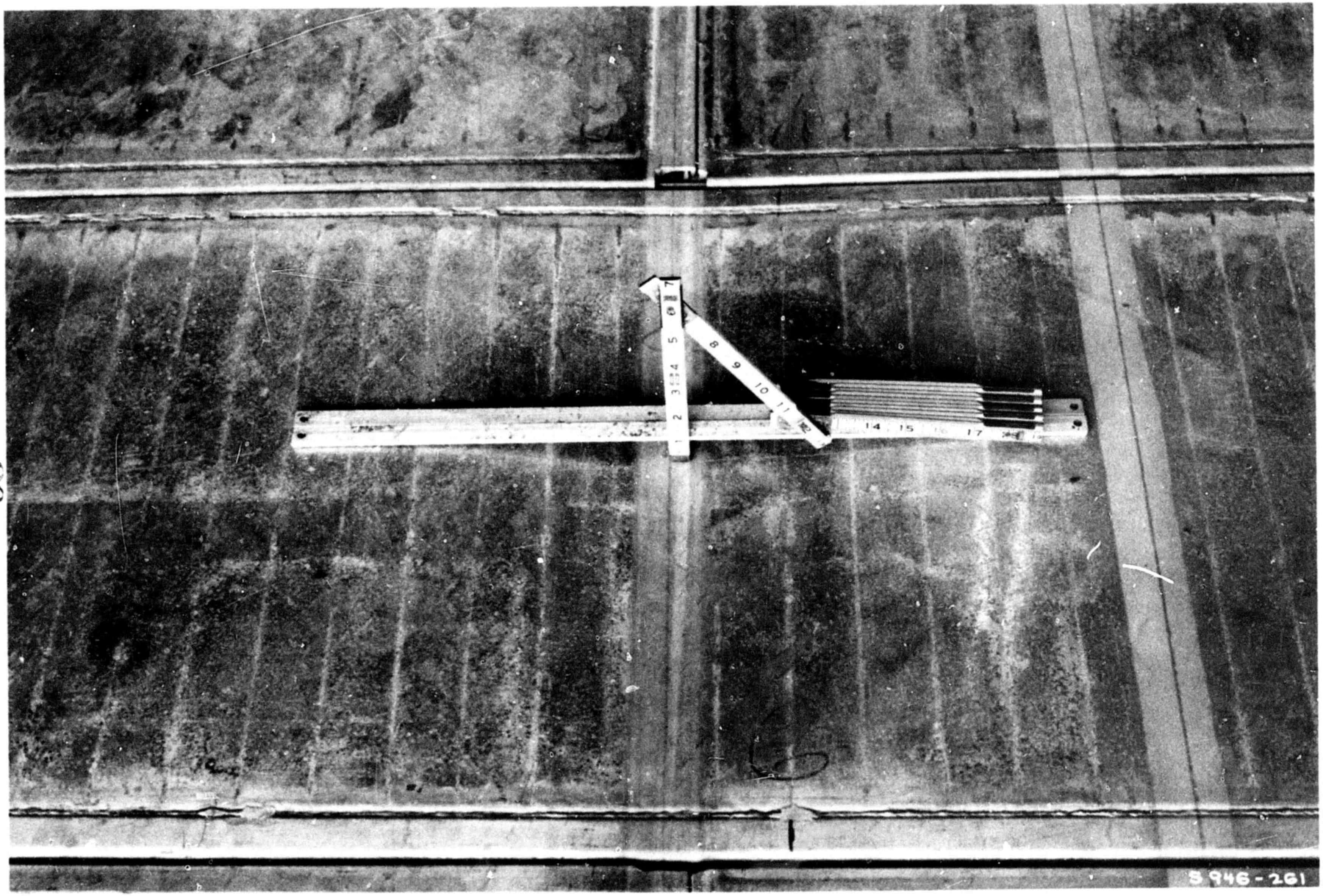
			Mat Breakage						Mat Deflection in.		
Test Item	Rated Subgrade CBR	Traffic Coverages	Dishing of Core	Weld Breaks	Top Skin Tears	Internal Rib Failures	C-Rail Breaks	Sheared End Joint	On Joint	Center of Panel	Rating of Item
1	4.3	0	-	-	-	-	-	-	0.84	0.58	
		40	6	3	1	-	-	-	-	-	
		72	9	4	1	-	-	-	0.65	0.62	Failed
2	4.3	0	-	-	-	-	-	-	0.78	0.65	
		80	-	19	-	2	-	1	-	-	
		188	-	20	11	6	22	1	0.95	0.70	Border-line



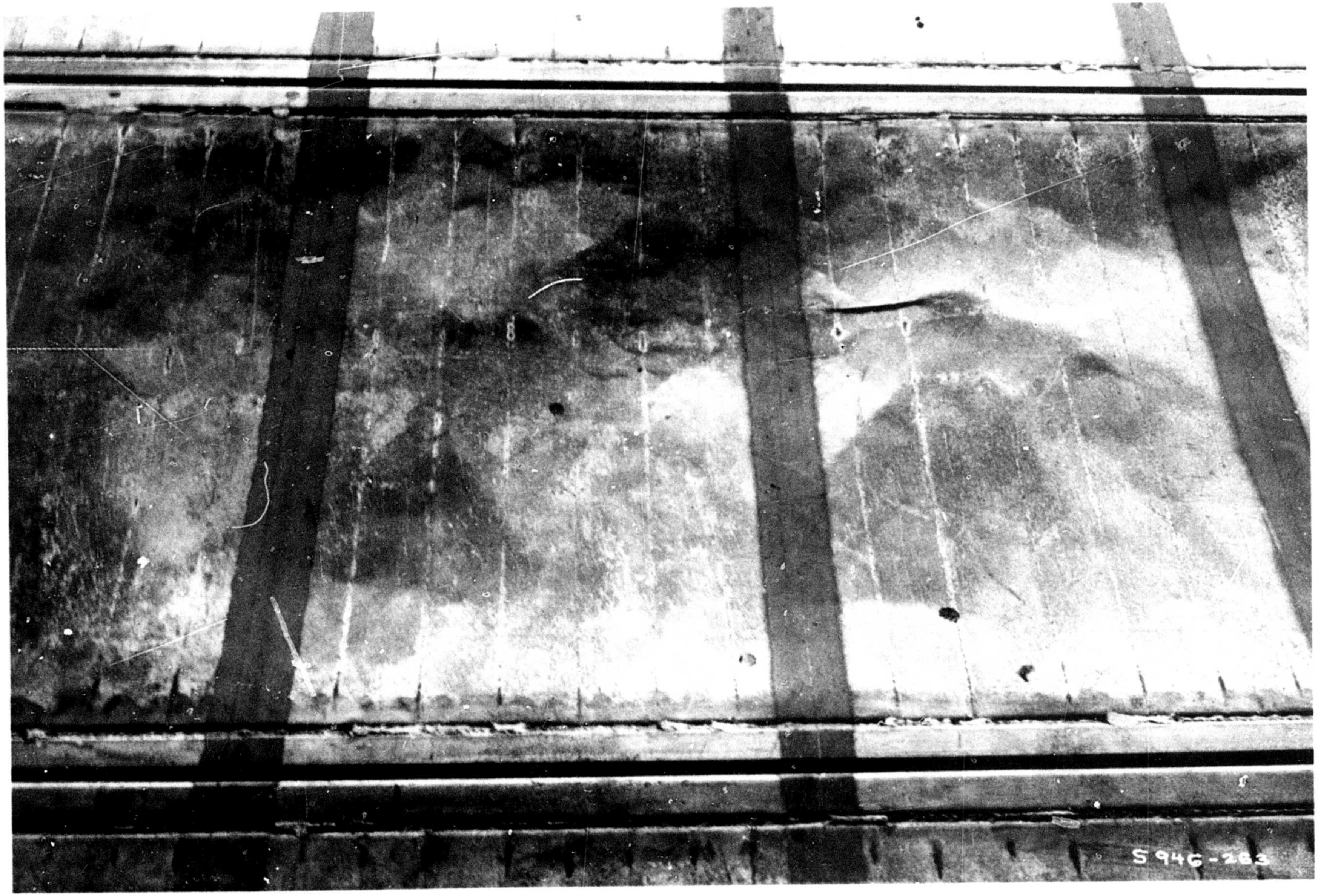
Photograph 1. Test section prior to traffic



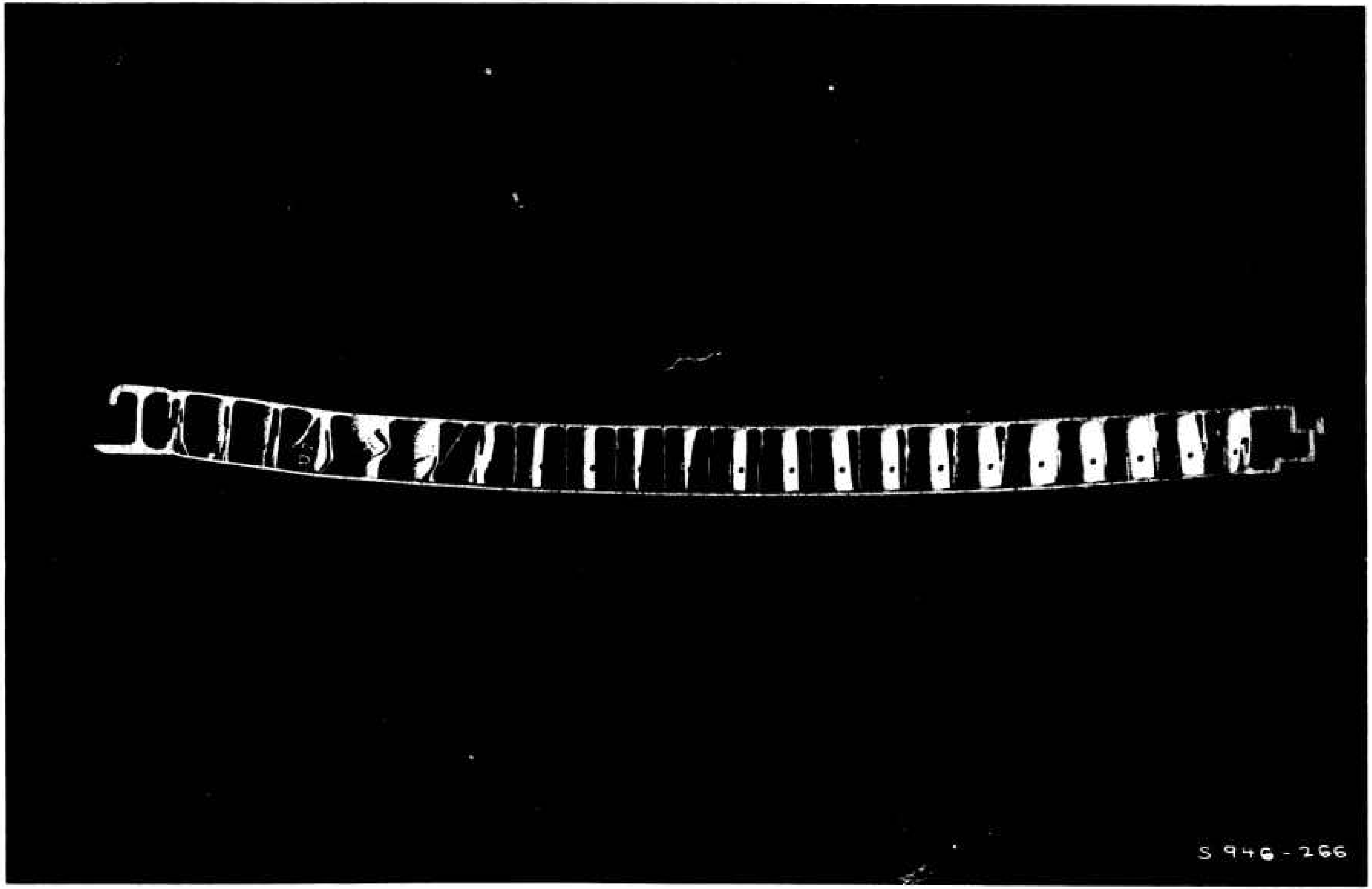
Photograph 2. Item 1 prior to traffic



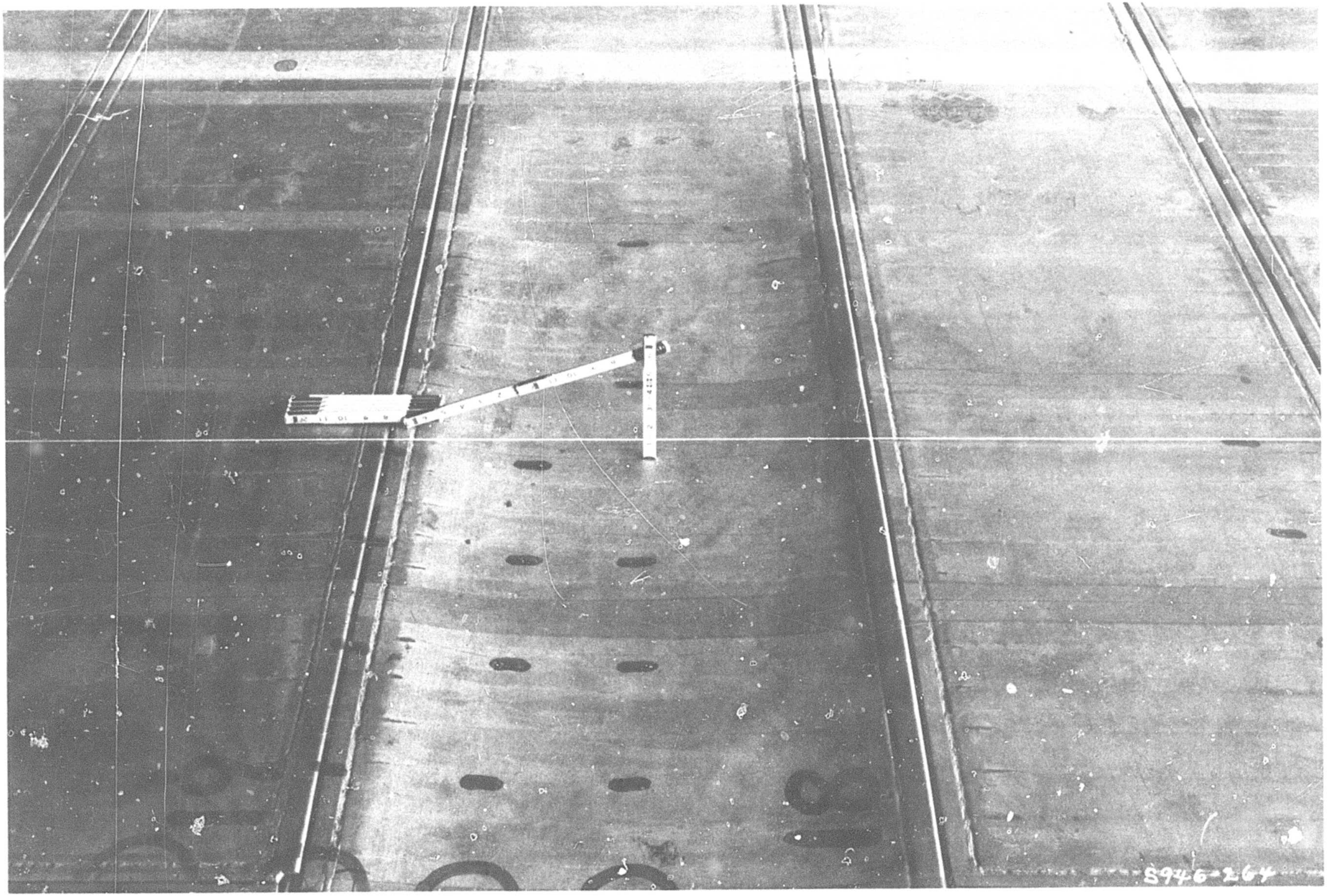
Photograph 3. Dishing of 5/8 in. observed in AM2 panel 6 after first pass of load cart



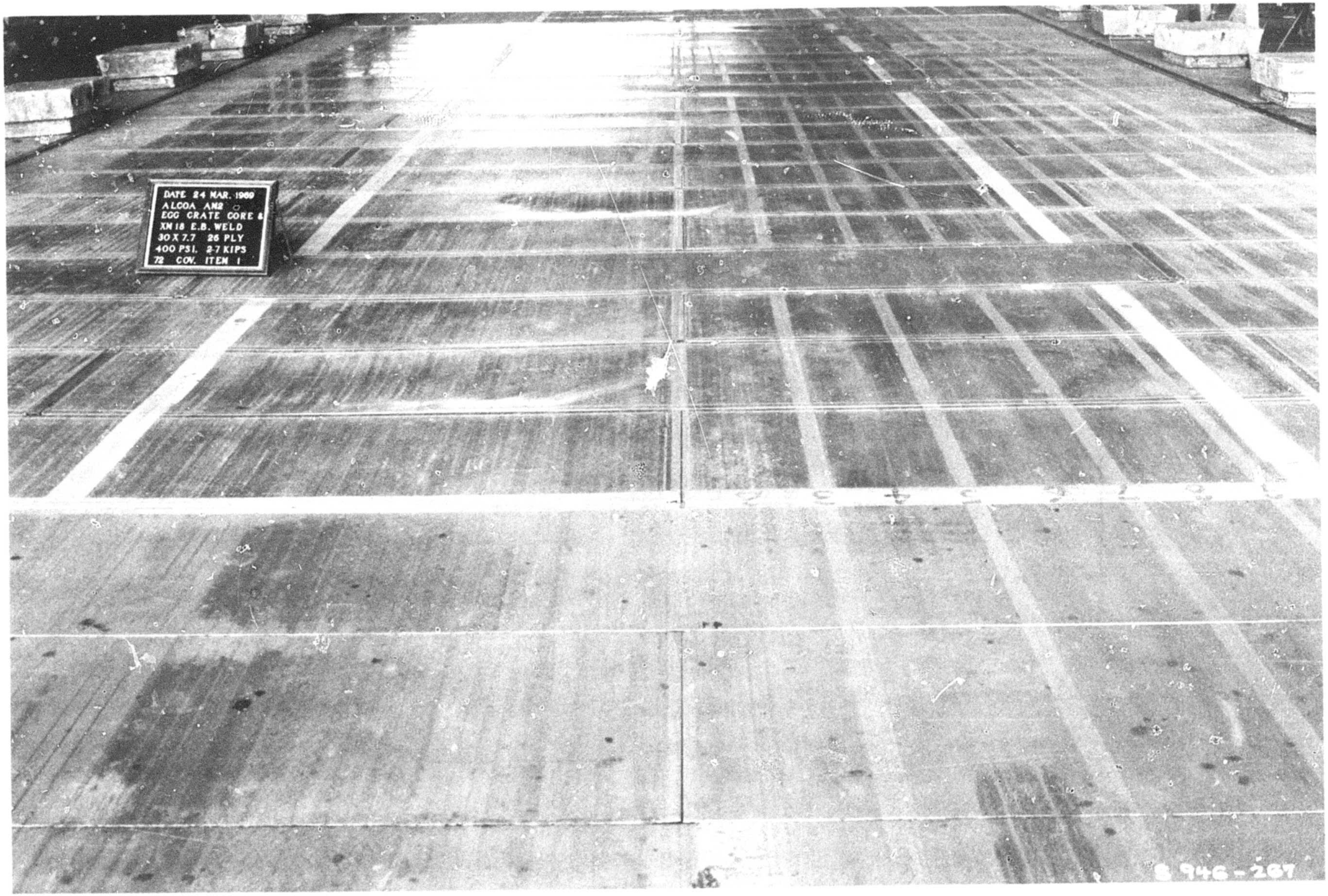
Photograph 4. AM2 mat panel 6 after failure at six coverages



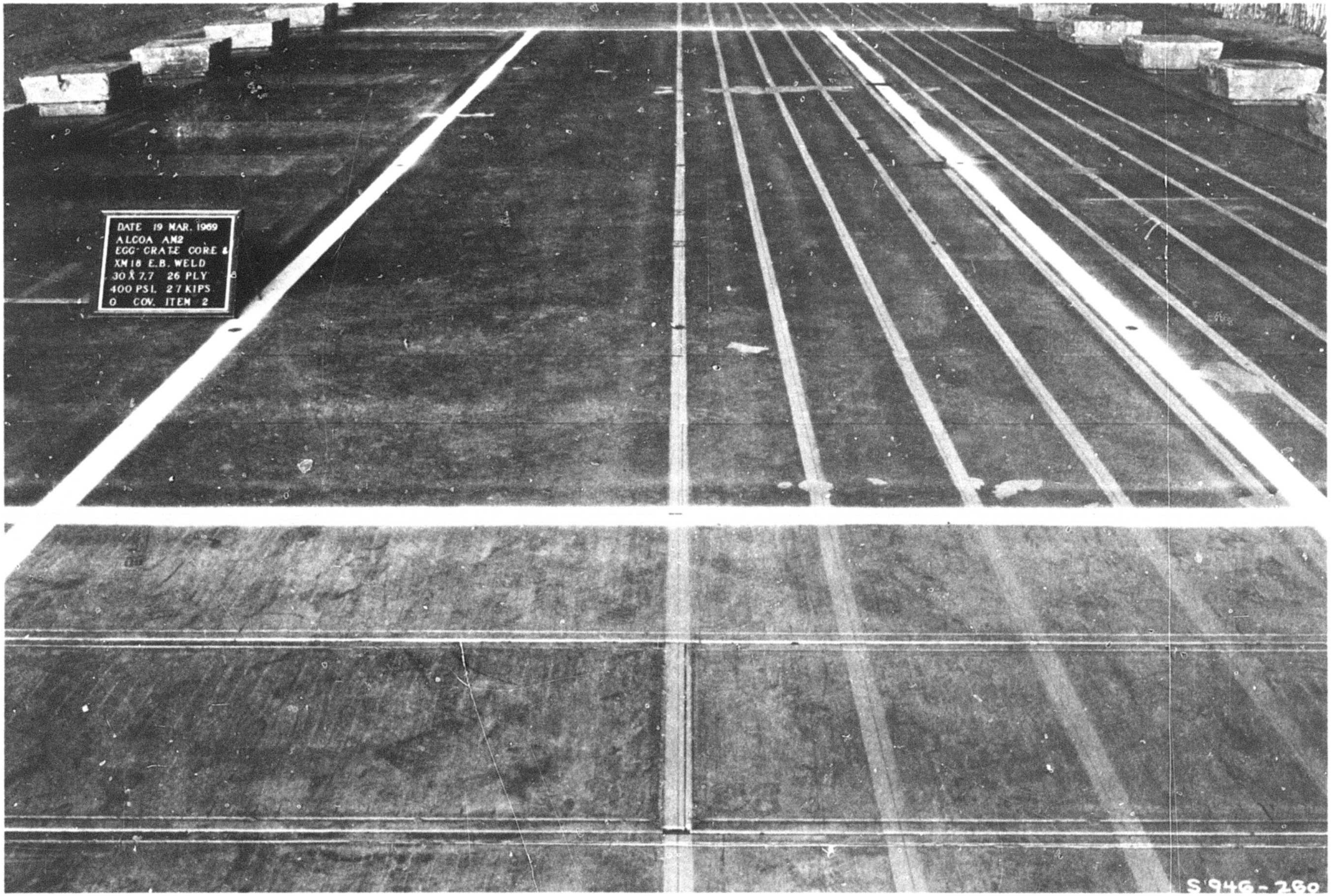
Photograph 5. Cross section of AM2 mat panel 6 after failure at six coverages. Damaged plank removed from test section and cut for inspection



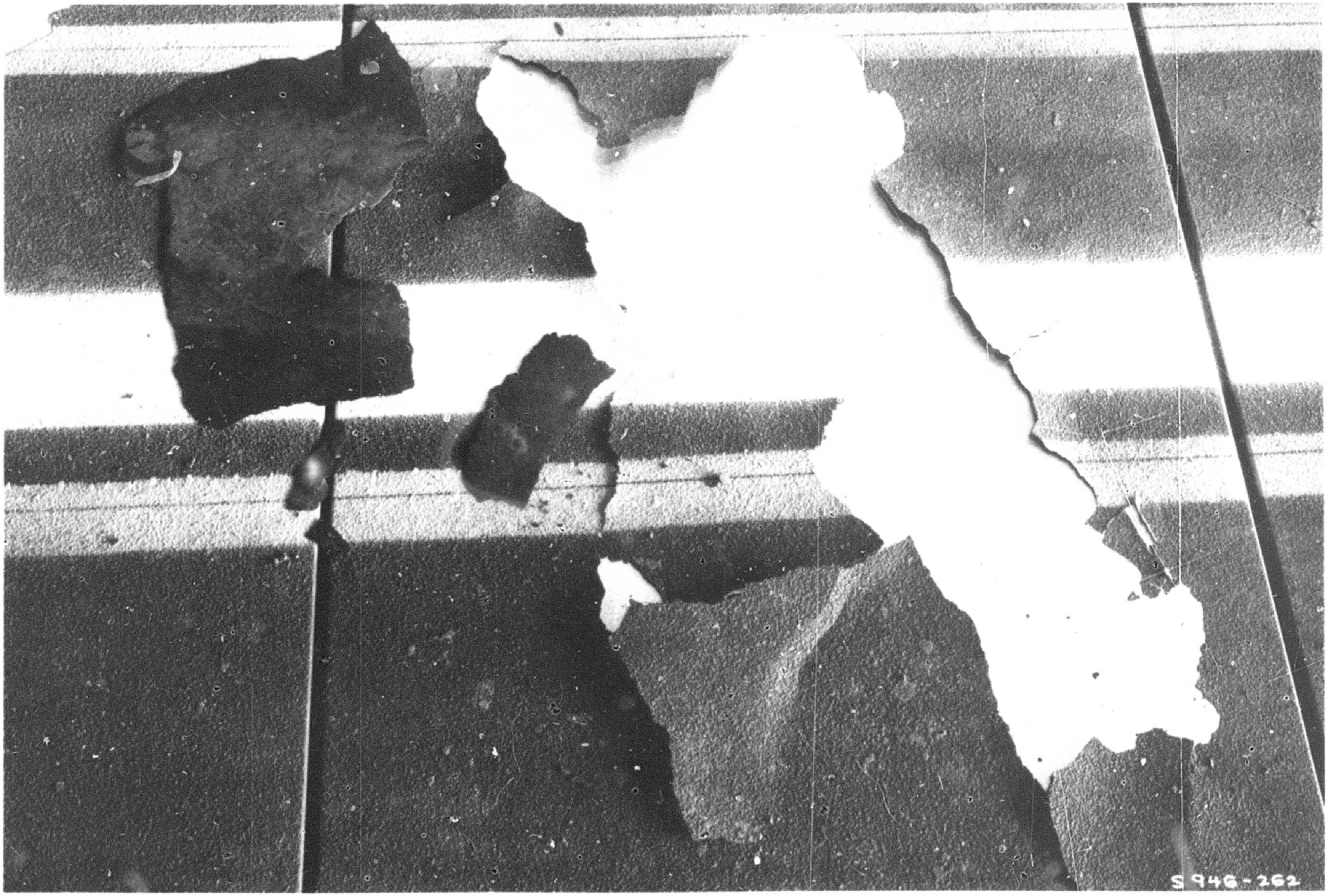
Photograph 6. Dishing of 1-1/8 in. observed in AM2 panel 18 at failure after 36 coverages



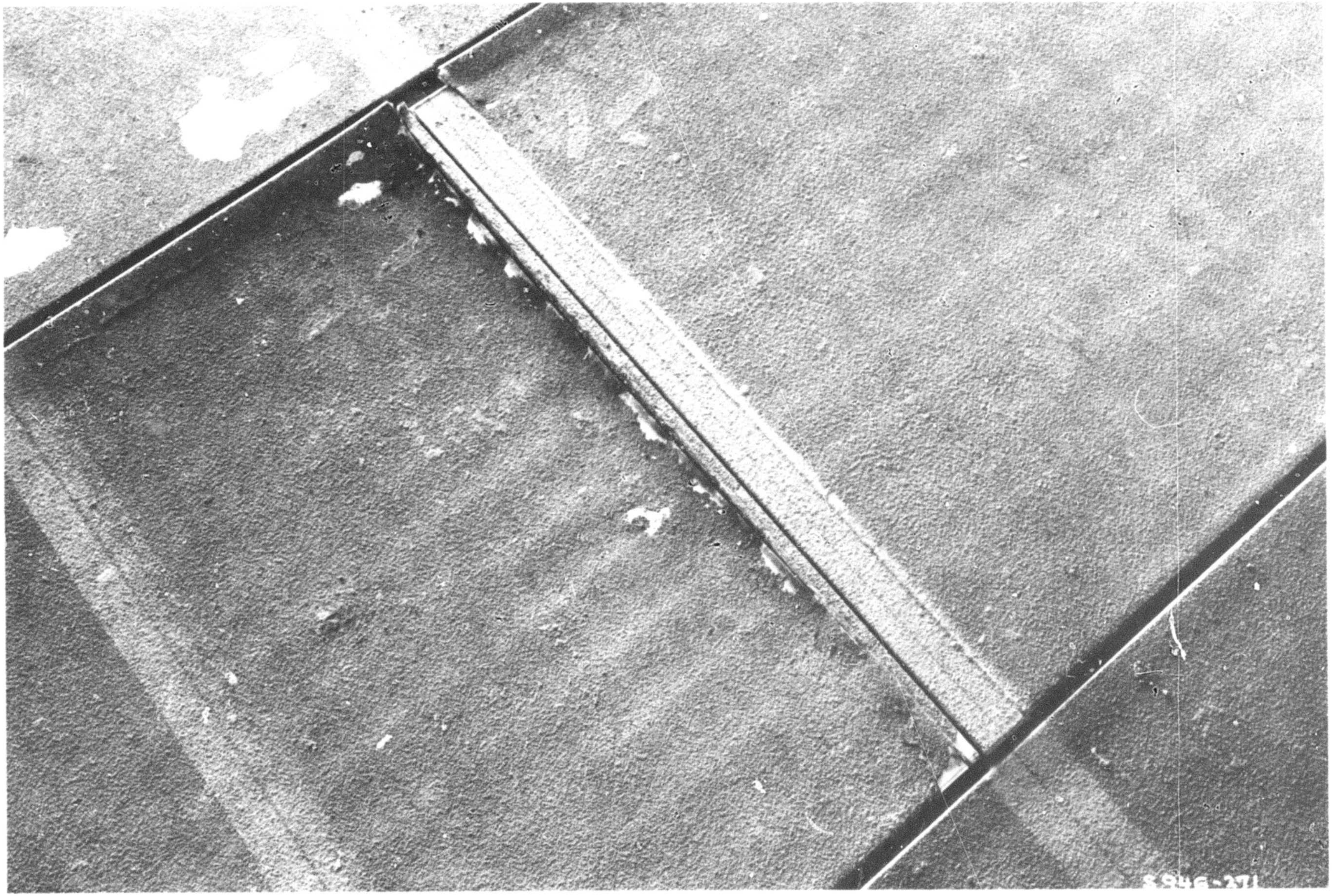
Photograph 7. Item 1 after failure at 72 coverages



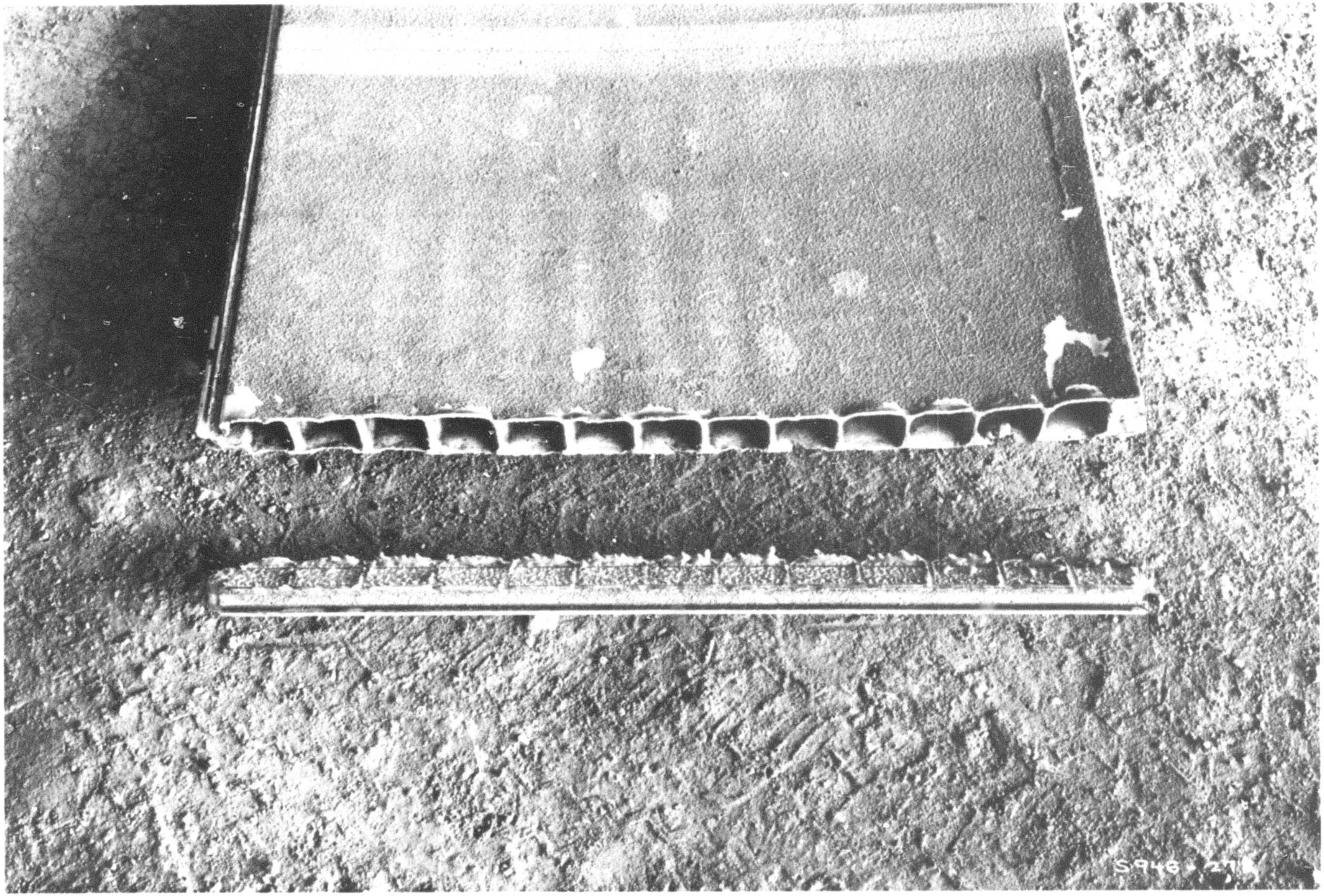
Photograph 8. Item 2 prior to traffic



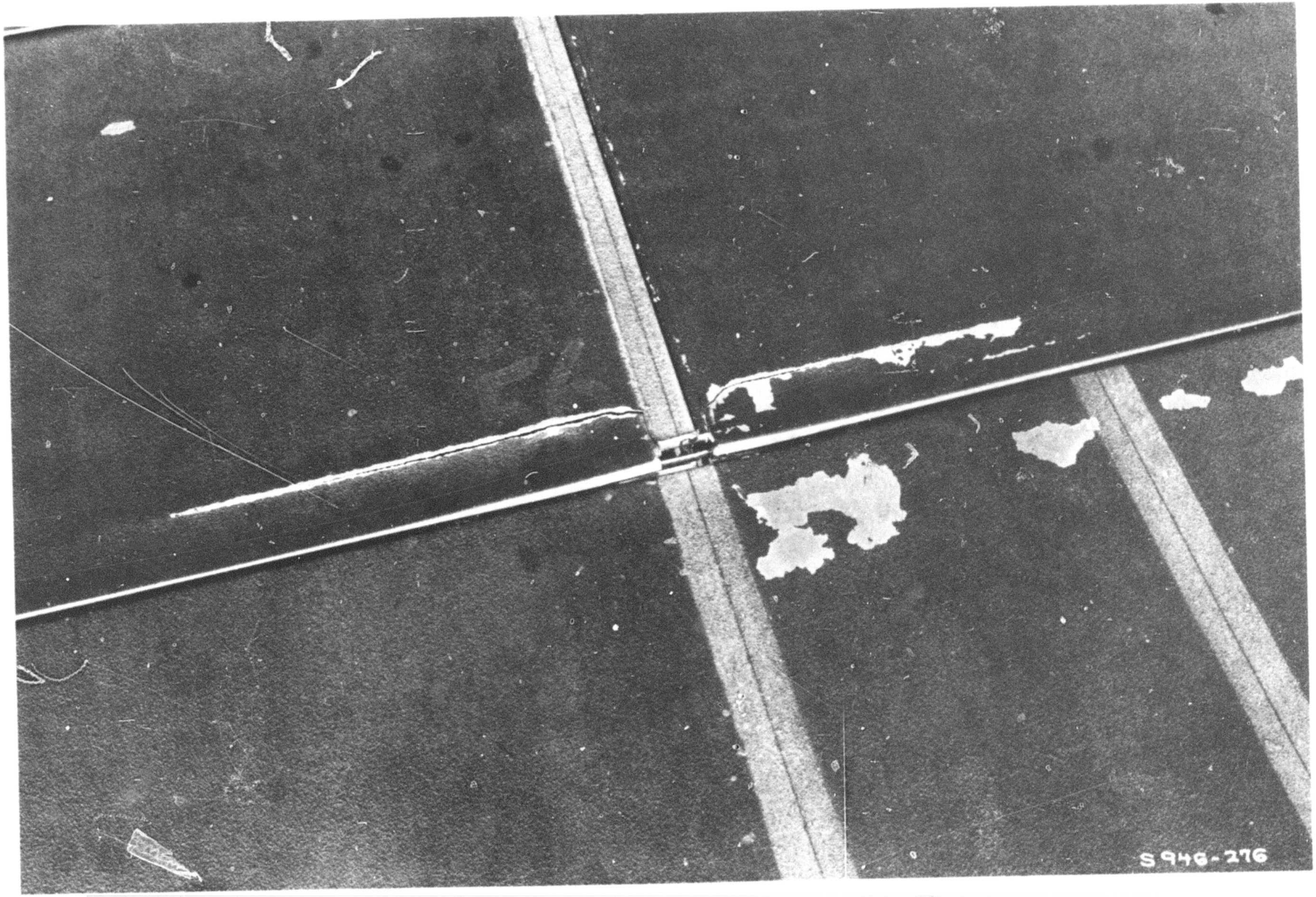
Photograph 9. Peeling of antiskid compound from XM18 mat prior to traffic



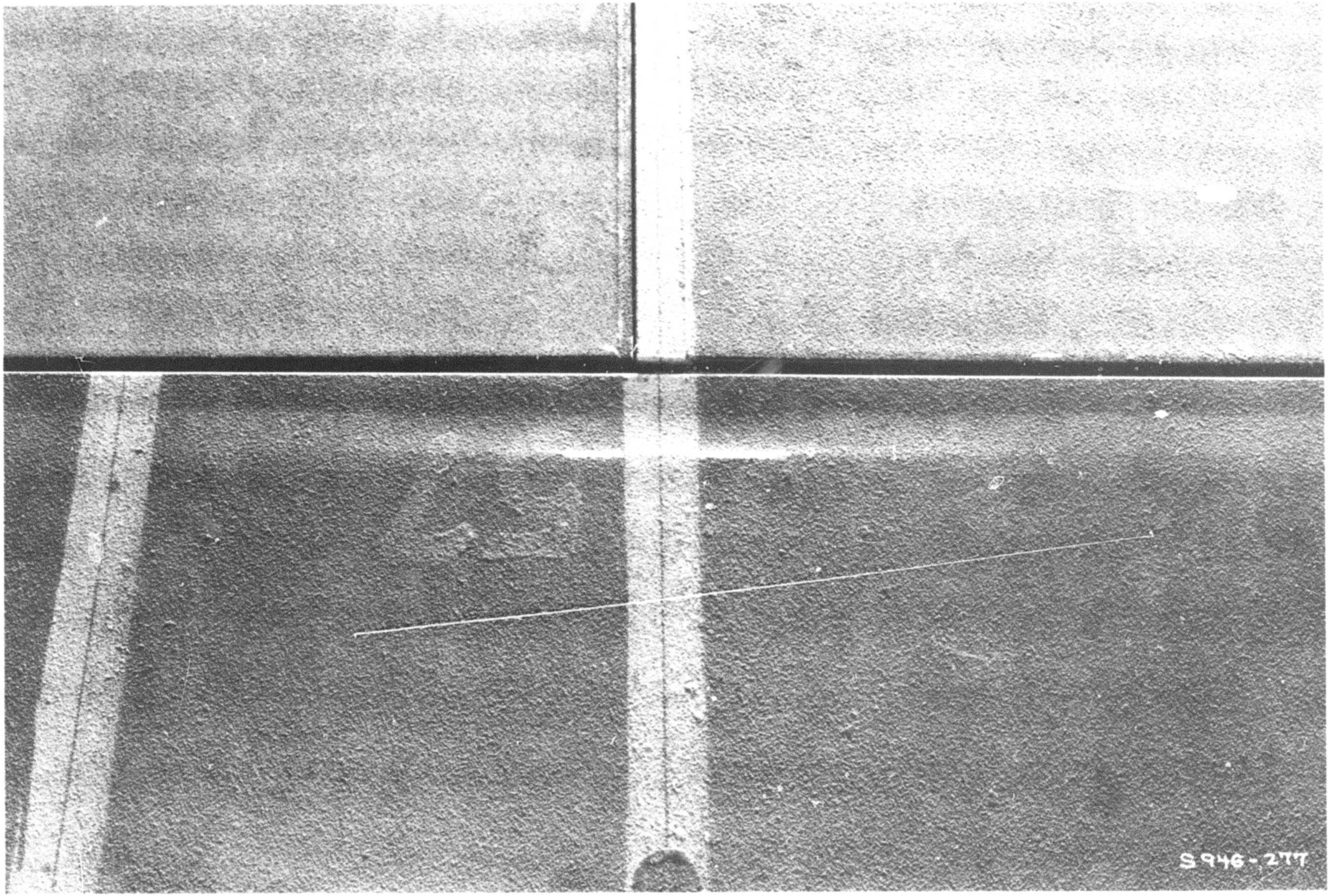
Photograph 10. Weld break along underlapping end joint of XM18 mat panel 55 after 78 coverages



Photograph 11. Panel 55 after removal from test item after 78 coverages

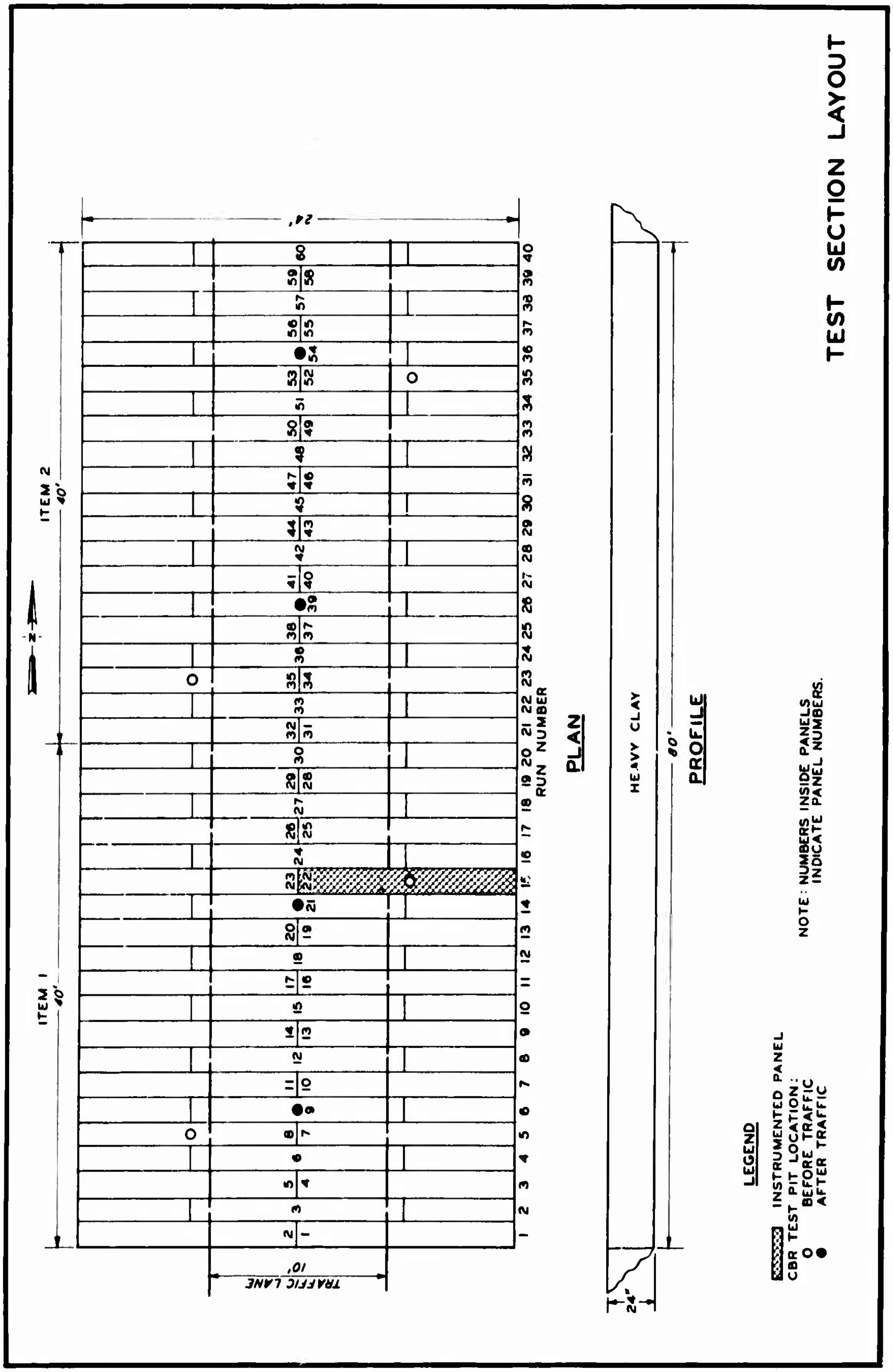


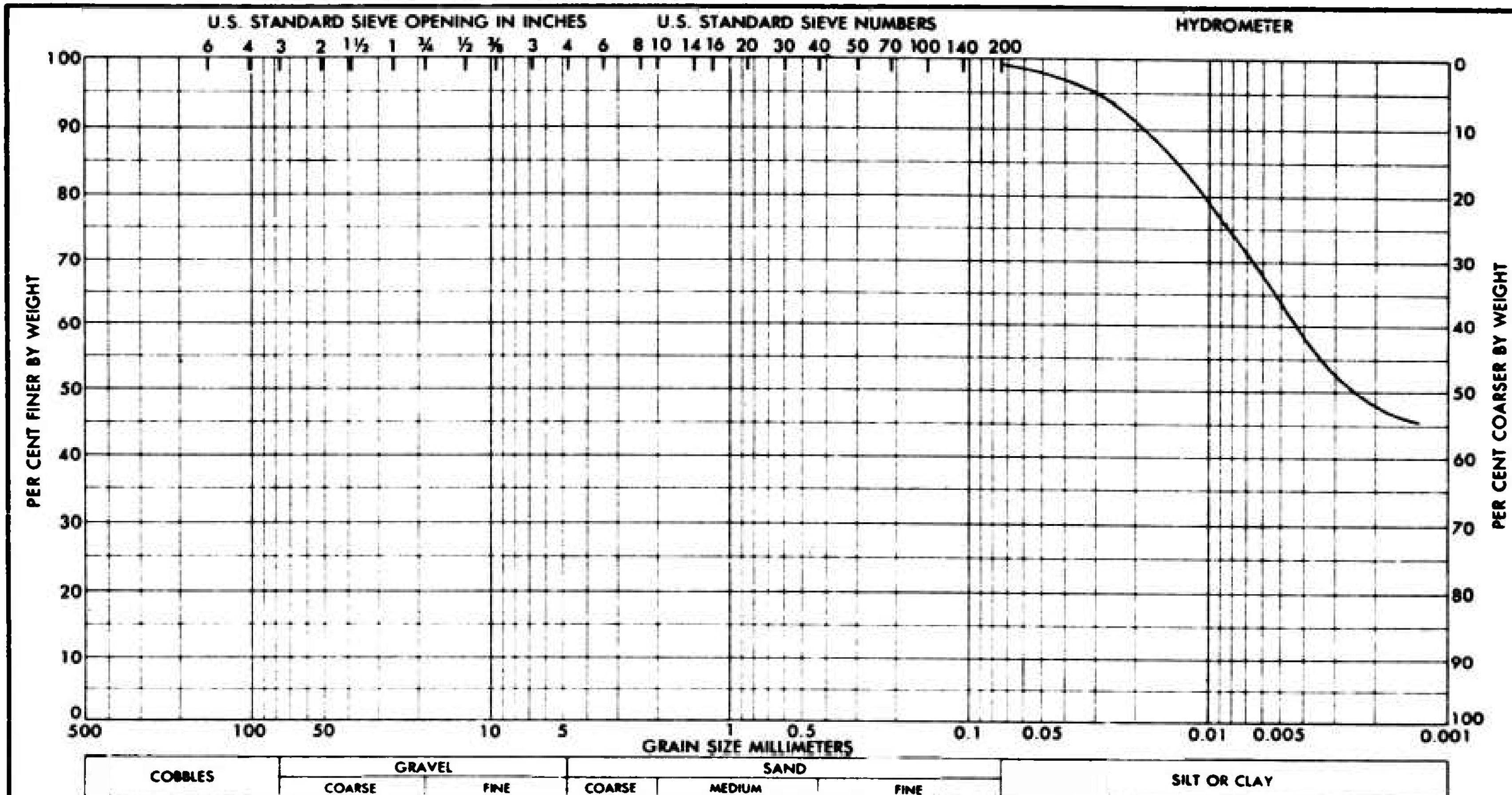
Photograph 12. Typical skin tear of XM18 mat after 188 coverages



Photograph 13. Dishing caused by internal rib failure

Photograph 14. Item 2 at failure after 188 coverages


TEST SECTION LAYOUT
PLAN
PROFILE
ITEM 1
40'
ITEM 2
40'
N
24'
TRAFFIC LANE
10'
RUN NUMBER
HEAVY CLAY
80'
24"
LEGEND
INSTRUMENTED PANEL
CBR TEST PIT LOCATION:
BEFORE TRAFFIC
AFTER TRAFFIC
NOTE: NUMBERS INSIDE PANELS INDICATE PANEL NUMBERS.



SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
		HEAVY CLAY (CH)		68	28	40

CLASSIFICATION DATA
SUBGRADE SOIL

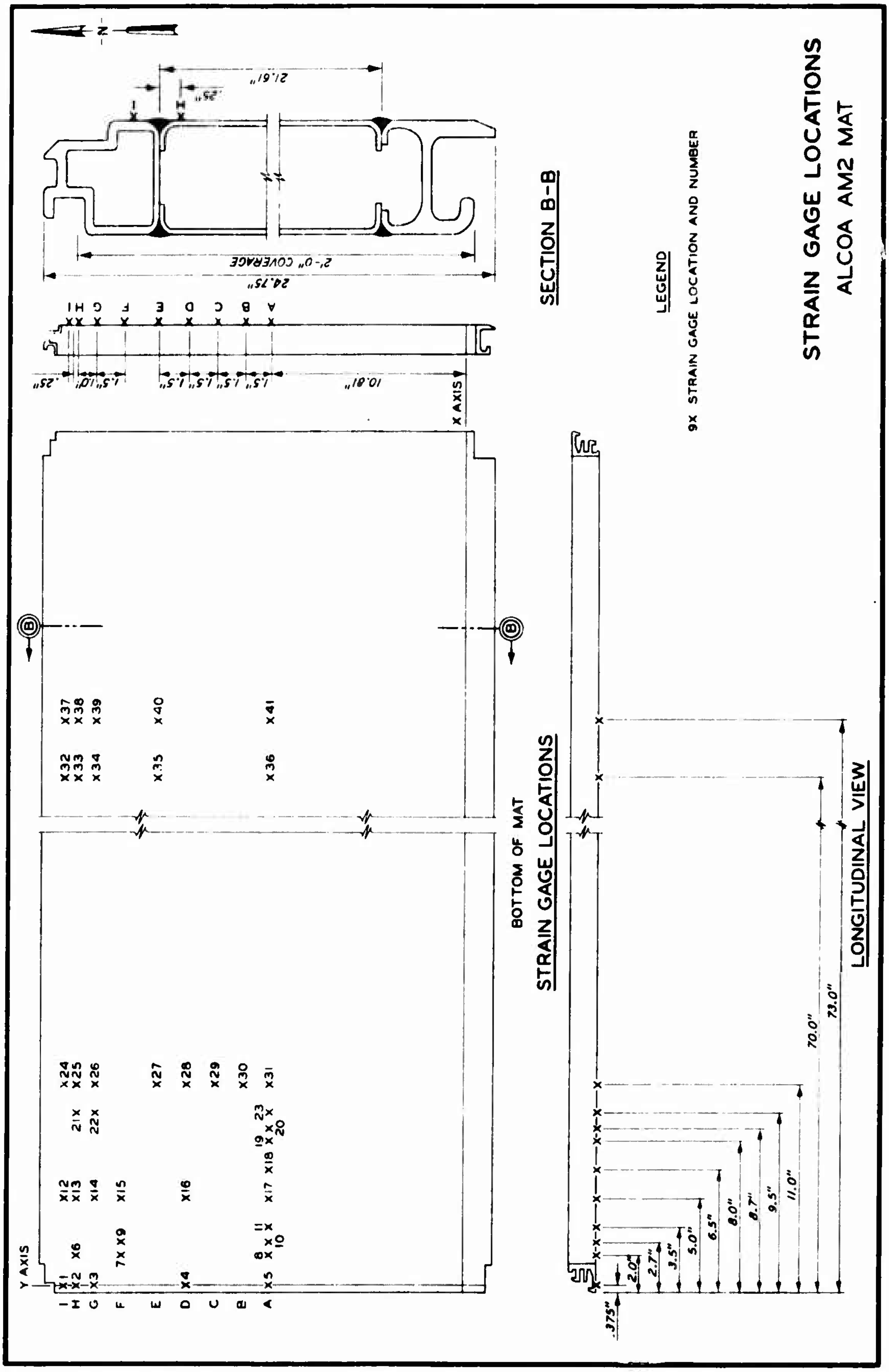
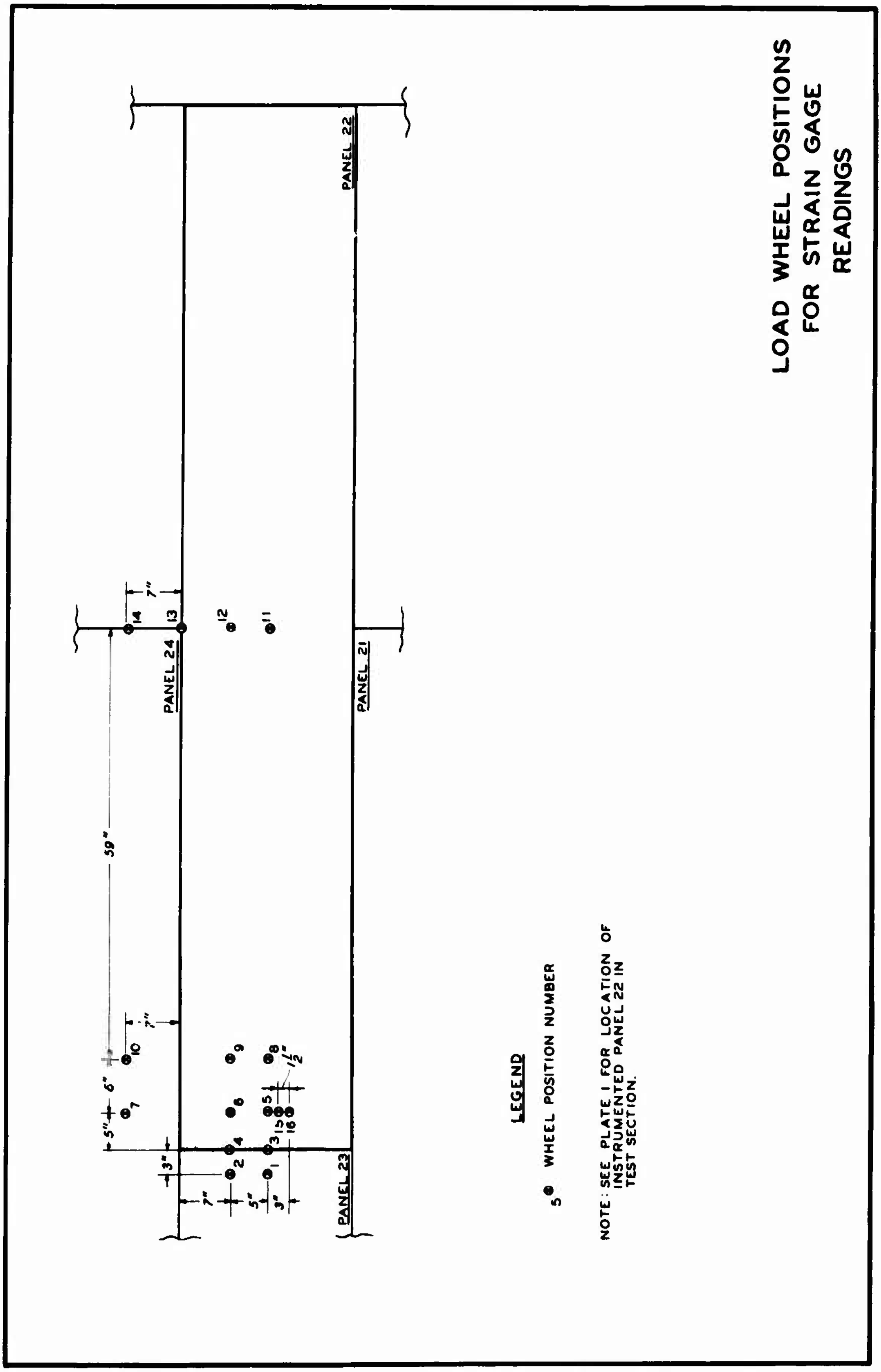
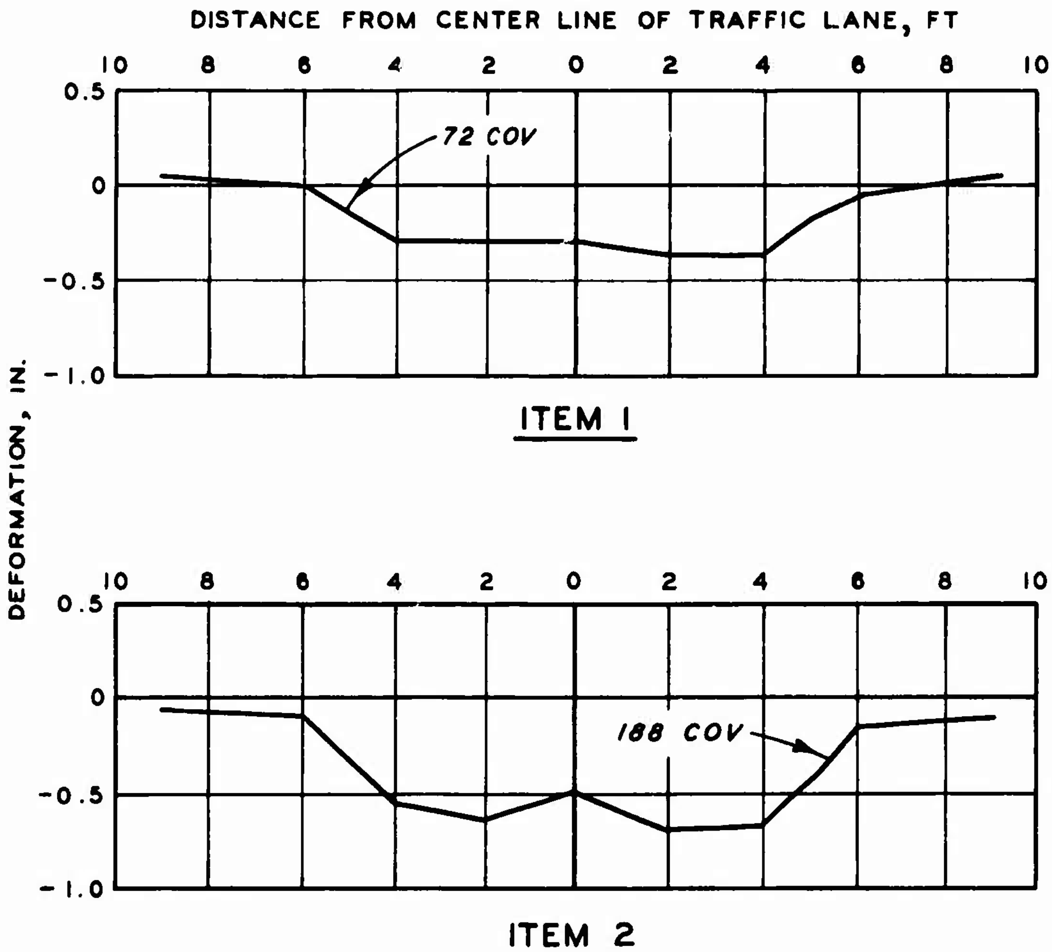
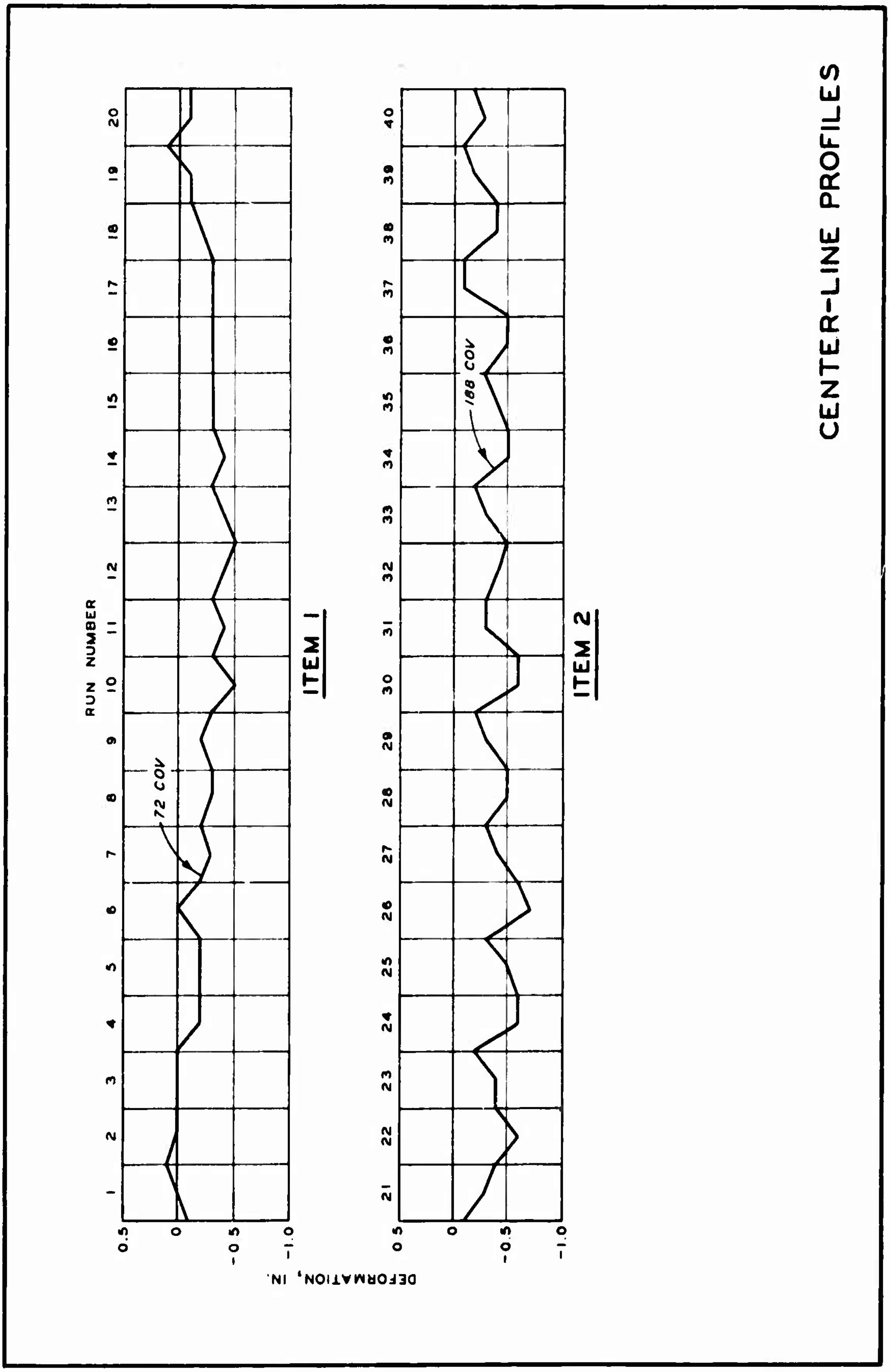

STRAIN GAGE LOCATIONS
ALCOA AM2 MAT
SECTION B-B
21.61"
.25"
2'-0" COVERAGE
24.75"
10.81"
X AXIS
Y AXIS
LEGEND
9X STRAIN GAGE LOCATION AND NUMBER
BOTTOM OF MAT
STRAIN GAGE LOCATIONS
LONGITUDINAL VIEW
70.0"
73.0"
11.0"
9.5"
8.7"
8.0"
6.5"
5.0"
3.5"
2.7"
2.0"
.375"

PLATE 3


LOAD WHEEL POSITIONS
FOR STRAIN GAGE
READINGS
PANEL 22
PANEL 24
PANEL 21
PANEL 23
59"
7"
5"
6"
3"
1 1/2"
LEGEND
5 ● WHEEL POSITION NUMBER
NOTE: SEE PLATE 1 FOR LOCATION OF INSTRUMENTED PANEL 22 IN TEST SECTION.



PERMANENT MAT
DEFORMATION



CENTER-LINE PROFILES
RUN NUMBER
DEFORMATION, IN.
72 COV
188 COV
ITEM 1
ITEM 2
0.5
0
-0.5
-1.0

PLATE 6

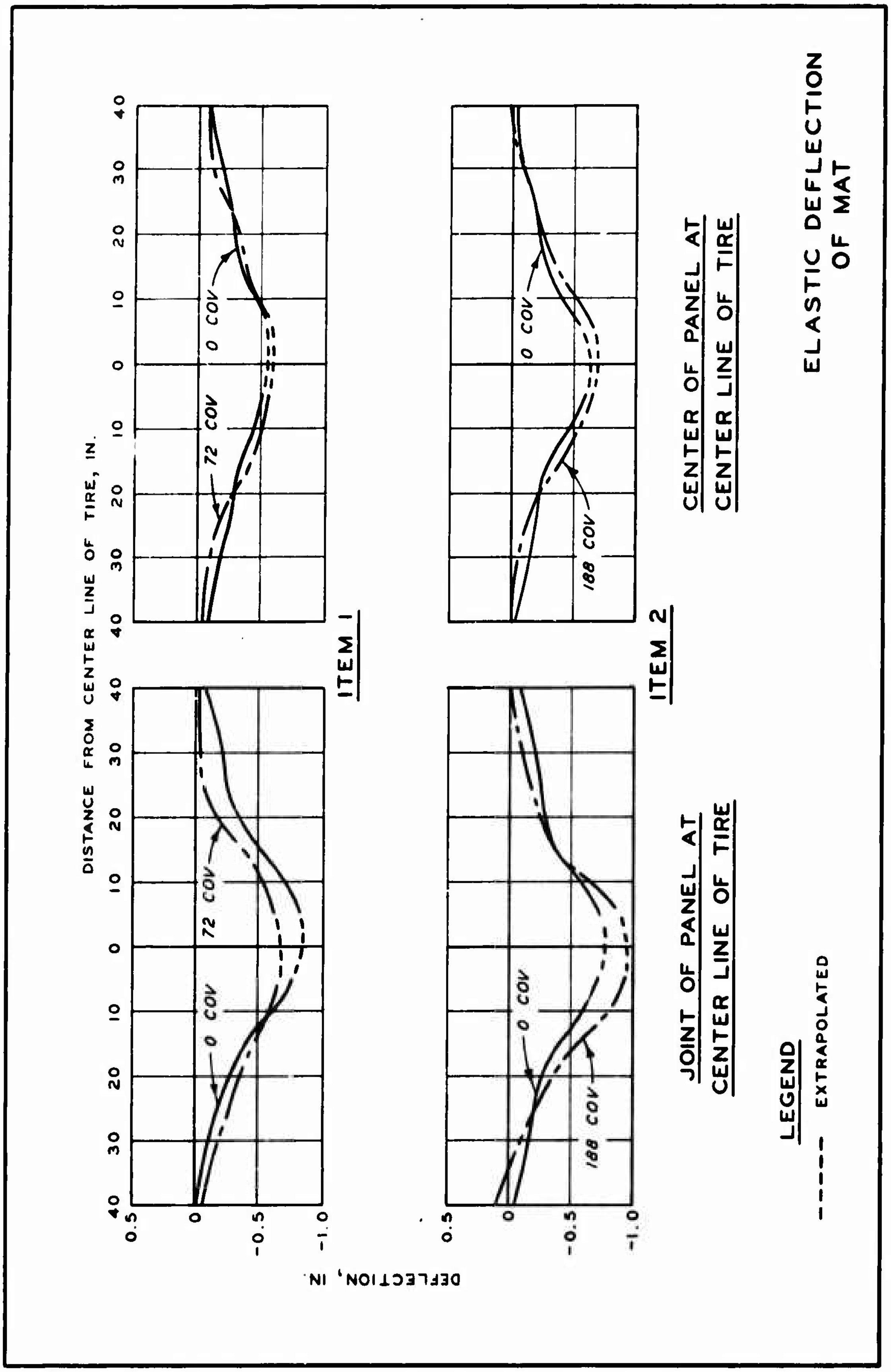
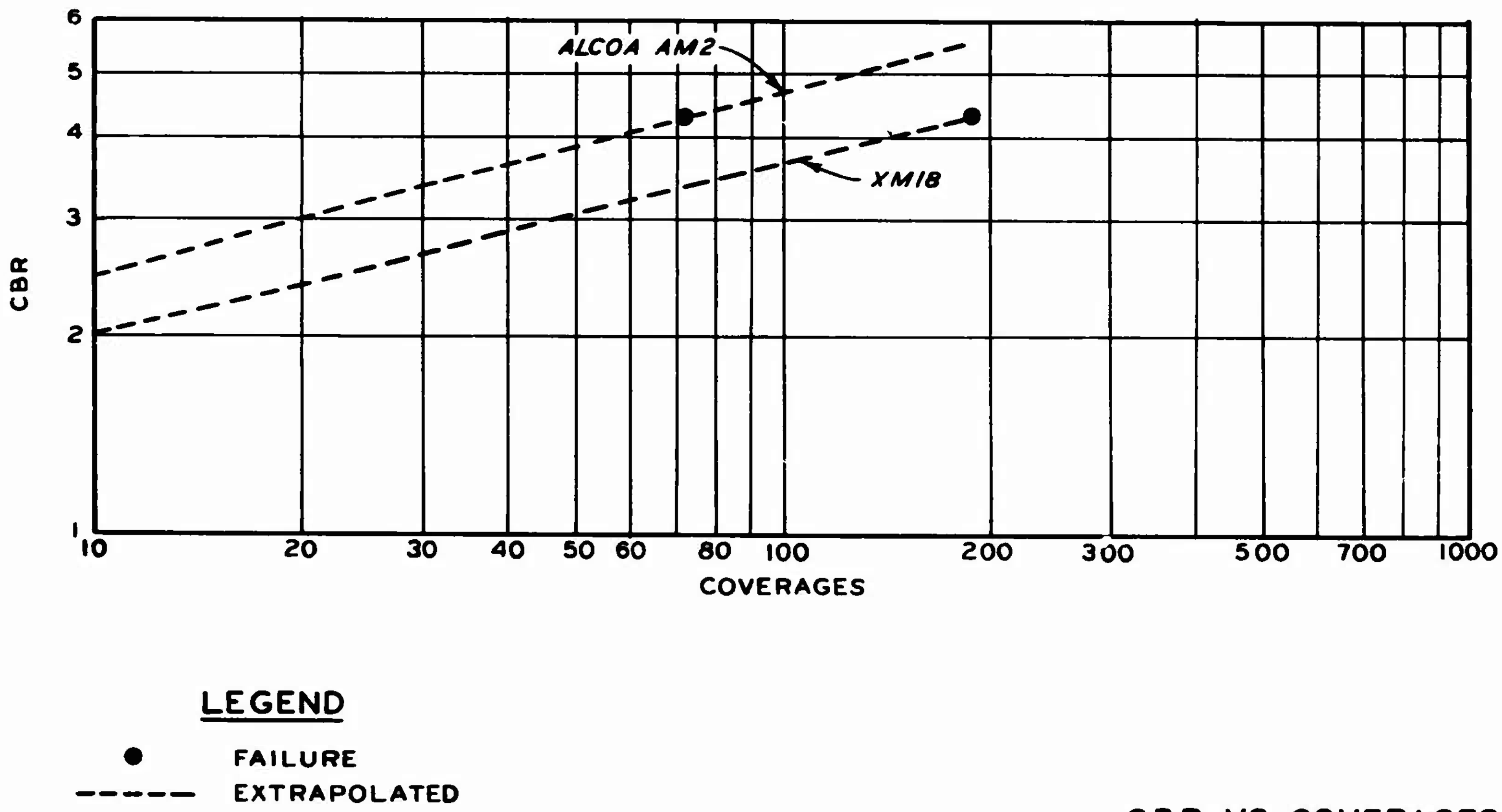

ELASTIC DEFLECTION OF MAT
ITEM 1
ITEM 2
JOINT OF PANEL AT CENTER LINE OF TIRE
CENTER OF PANEL AT CENTER LINE OF TIRE
DISTANCE FROM CENTER LINE OF TIRE, IN.
DEFLECTION, IN.
40
30
20
10
0
0.5
-0.5
-1.0
0 COV
72 COV
188 COV
LEGEND
EXTRAPOLATED

PLATE 7



CBR VS COVERAGES
UNIFORM-COVERAGE TRAFFIC

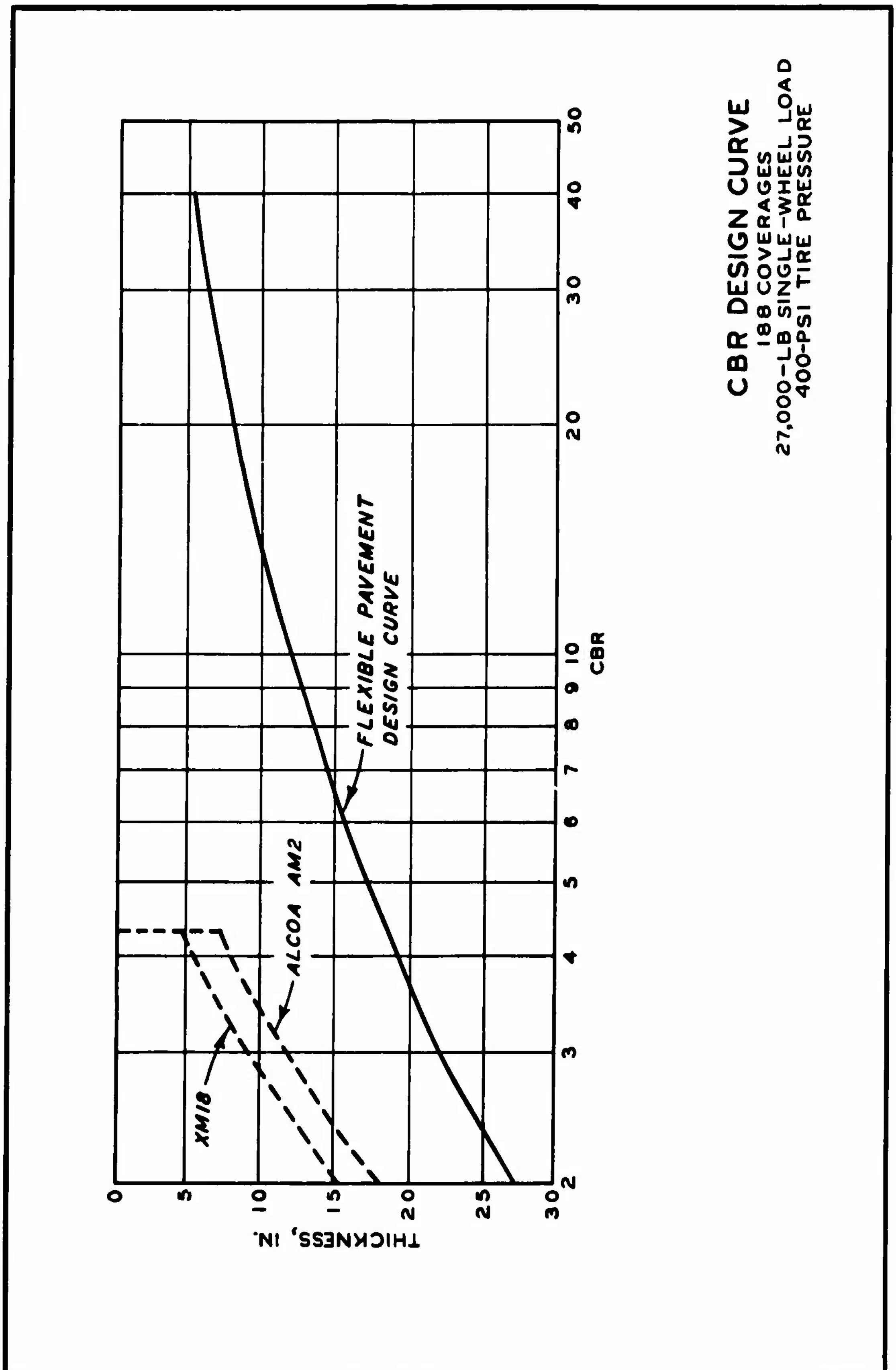

CBR DESIGN CURVE
188 COVERAGES
27,000-LB SINGLE-WHEEL LOAD
400-PSI TIRE PRESSURE
FLEXIBLE PAVEMENT DESIGN CURVE
ALCOA AM2
XM18
THICKNESS, IN.
CBR
0
5
10
15
20
25
30
2
3
4
5
6
7
8
9
10
20
30
40
50

PLATE 9