MISCELLANEOUS PAPER S-69-5

EVALUATION OF MO-MAT GROUND COVER FOR USE IN ARMY DEPOT OPEN-STORAGE AREAS

by

H. L. Green
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January 1969

Sponsored by

U. S. Army Materiel Command

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FOREWORD

The general authorization for this investigation is contained in Research and Development Project Card for Mobility Engineering Support, Project No. 1T062103A046, Task 05, approved June 1960. The specific authorization for conducting the tests reported herein is given in a letter dated 4 November 1966, subject "Unsolicited Proposal - STRATOGLAS Light-Duty Landing Mat and Storage Area Cover," from Headquarters, U. S. Army Materiel Command (AMC), to the Director, U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., as a part of the research program.

The engineering traffic tests pertinent to this investigation were performed at WES during March-May 1967. Engineers of the WES Soils Division who were actively engaged in the planning, testing, analyzing, and reporting phases of this investigation were Messrs. W. J. Turnbull, A. A. Maxwell, W. L. McInnis, R. Turner, H. L. Green, and C. J. Gerard. This report was prepared by Messrs. Green and Gerard.

Directors of the WES during the conduct of this investigation and the preparation of this report were COL John R. Oswalt, Jr., CE, and COL Levi A. Brown, CE. Technical Director was Mr. J. B. Tiffany.

CONTENTS

CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

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

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
square inches	6.4516	square centimeters
square feet	0.092903	square meters
cubic feet	0.0283168	cubic meters
pounds	0.45359237	kilograms
kips	453.59237	kilograms
tons	907.185	kilograms
pounds per square inch	0.070307	kilograms per square centimeter
pounds per cubic foot	16.0185	kilograms per cubic meter

SUMMARY

This report describes an investigation to evaluate a fiber glass-reinforced plastic material (STRATOGLAS) molded into a waffle-like configuration for use in Army depot open-storage areas. The mat, termed MO-MAT, was designed and fabricated by the Air Logistics Corporation, Pasadena, California. Individual panels are 50 ft long, 11 ft wide, and 0.085 in. thick, and weigh 570 lb.

A single layer of mat was investigated in test series I on two different subgrades: a wet sand and a dry, loose sand. Traffic was applied with a Hyster Model RT-150 forklift with payloads of 0, 5000, 10,000, and 15,000 lb; a 2-1/2-ton M35 cargo truck with 35-psi tire pressure and a gross weight of 18,000 lb; a 5-ton M54 cargo truck with 35-psi tire pressure and a gross weight of 30,000 lb; and a Towmotor Model 540-RS forklift without a payload. Initial traffic with the solid-tire Towmotor indicated that vehicles with small, solid tires should not be used on the mat. A total of 8 cycles was completed on the test section, with 3870 passes applied to the high-intensity traffic areas with the test vehicles. Of the three pneumatic-tired vehicles tested the Hyster RT-150 with the 15,000-lb payload was the most critical load applied to the test section. Minor maintenance was necessary on the test section during the investigation.

In test series II, the single layer of mat was placed on two heavy clay subgrades: one with a CBR of 3 and one with a CBR of 6 to 7. Traffic was applied with the Hyster RT-150 forklift with payloads of 0, 5000, 10,000, and 15,000 lb. Eight cycles of traffic were applied to the test area, with a total of 4390 passes of traffic applied to the mat with the test vehicle. The most critical load, again, was the Hyster RT-150 with a 15,000-lb payload. Minor maintenance was necessary on the test section during the investigation.

From these tests it was concluded that a single layer of MO-MAT was adequate as tested for use in Army depot open-storage areas, except on low-strength material (CBR of 3 or less). There was no distinct difference between the performance of the mat when placed on a dry sand or a wet sand. In single layers, the mat will perform satisfactorily for a period of several months with little maintenance.

EVALUATION OF MO-MAT GROUND COVER FOR USE IN ARMY DEPOT OPEN-STORAGE AREAS

PART I: INTRODUCTION

Background

1. In remote areas, natural conditions, such as extremely low-strength soil and sandy areas, hamper the construction of hardstand areas and prevent the operation of conventional vehicles without some type of prefabricated support medium. The use of ground mat for vehicular traffic in storage areas would eliminate the necessity of using airplane landing mat as ground mat, thus allowing the heavier landing mat to be used primarily as airfield surfacing. The ground mat lends itself to various other uses such as walkways, roadways, revetments, etc.; however, only its use as a surfacing material for depot open-storage areas was considered in this investigation. The ground mat described herein, a fiber glass-reinforced plastic material designated MO-MAT, was developed by the Air Logistics Corporation, Pasadena, California.

Objective

2. The overall objective of this investigation was to determine if MO-MAT is capable of supporting the operations of vehicular traffic, both forklifts and cargo trucks, when placed on a medium-strength clay subgrade and on a sand subgrade similar to that found in Southeast Asia. The specific objectives of this investigation were as follows:

- a. Determine the ease of assembling the mat.
- b. Determine the average placement rate of the mat.
- c. Evaluate the need for anchoring the mat.
- d. Determine the feasibility of the recovery and reuse of the mat.
- e. Determine the performance of the mat when subjected to forklift and truck traffic and typical pallet loading.

_f_. Determine the amount of traffic the overlap joints can sustain before failure.

_g_. Evaluate the effect of moisture, in a sand subgrade, on mat performance.

Scope

3. This report describes the results of accelerated engineering traffic tests conducted to evaluate the MO-MAT. The desired data were obtained by engineering tests as follows:

_a_. In laying the mat during assembly of the test sections, the speed of placement was recorded, and the placing rate was computed.

_b_. Traffic was conducted on test sections prepared without anchors.

_c_. After traffic tests, the mat was removed from the test sections, and its reuse potential was evaluated.

_d_. The mat was trafficked with both forklifts and cargo trucks, and the edges of the test sections were subjected to pallet loading.

_e_. Overlap joints were trafficked until failure.

_f_. The mat was placed on both dry and wet sand to determine the effect of moisture on the performance of the mat.

Definitions of Pertinent Terms

4. For clarity, certain terms used in this report are defined below:

Coverage. One application of the test wheel over every point in the traffic lane.

Traffic lane. Area of the test section that is subjected to traffic of the test vehicle.

Pass. One trip of the test vehicle down the test lane.

Cycle. Generally, one complete operation of the test vehicles on the test section at a given number of passes.

High-intensity traffic areas. Intersection of two traffic lanes that receives double the normal traffic in a lane.

CBR (California Bearing Ratio). A measure of the bearing capacity of the soil based upon its shearing resistance. The CBR value is calculated by dividing the unit load required to force a piston into the soil by the unit load required to force the same piston the same depth into a standard sample of crushed stone and multiplying by 100.

<u>Hardstand area.</u> Any surfaced area that will support vehicular traffic (i.e. concrete, asphalt, or wooden floors).

PART II: MAT TESTED AND TEST EQUIPMENT

Mat

Panels

5. MO-MAT is a reinforced plastic mat molded into a waffle-like configuration called a Stress Panel. Individual strips of mat are 50 ft* long, 11 ft wide, and 0.085 in. thick (sheet thickness). The average weight per strip of mat is 570 lb, and the weight per square foot of placing area is approximately 1.0 lb. Each panel is composed of nine 6- by 11-ft sections bonded together by epoxy resin during fabrication. One strip of mat had 0.328-in. rivet holes spaced on 4-in. centers along both edges for the entire length of the mat. The other two strips had similarly spaced holes on one side only.

Bundles

6. A rolled bundle of MO-MAT was shipped in a wooden crate 11 ft 5 in. long, 4 ft 10 in. wide, and 4 ft 9 in. high (photograph 1). The crate contained three 50-ft MO-MAT strips, which were bound by five metal bands (photograph 2). The roll had an inside diameter of 3 ft 2-1/2 in., and an outside diameter of 4 ft 5-3/4 in. The total weight of each bundle was 2065 lb, and the cubage was 262 cu ft. Also included in the crate were the adhesive, cleaning compound, rivets, and rivet gun recommended by the manufacturer.

Test Equipment

7. Four test vehicles were used in this investigation to simulate traffic to which the mat would be subjected. The vehicles, two forklifts and two cargo trucks, are described below. The loads and tire pressures of the trucks represented cross-country or off-highway loading requirements.

a. Towmotor Model 540-RS forklift. The 540-RS forklift (photograph 3) has a capacity of 6000 lb. It weighs 10,990 lb

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

empty and is supported by four solid rubber tires. The front or drive axle carries 36 percent of the load when the vehicle is empty and 86 percent when the vehicle is loaded to the maximum of 6000 lb. Data pertaining to this vehicle are presented in table 1. A graphical interpretation of the loads carried by the front and rear axles under various loading conditions is shown in diagram a of plate 1. The contact areas and pressures of the tires are plotted versus the various payloads in plate 2. The drive wheels or front axle carries a major portion of the load after the payload exceeds 1 ton.

b. Hyster Model RT-150 forklift. The RT-150 forklift (photograph 4) has a payload capacity of 15,000 lb. The gross weight of the vehicle, 17,070 lb, is supported on two axles. The front or drive axle has dual wheels; the rear axle has single wheels used for steering. The tire inflation pressure for each of the six pneumatic tires was 80 psi. A graphical interpretation of the loads carried by the axles is shown in diagram b of plate 1. Contact area and pressure versus payload are shown in plate 3. When the forklift is empty, the front axle supports 34 percent of the total load. However, when the forklift is loaded to maximum capacity, the front axle supports 89 percent of the total load. The loading transfer conditions are illustrated in plate 4. Data on weights, wheel spacing, tire size, and ground clearance are given in table 1. Other pertinent information on this vehicle is presented in tables 1 and 2.

c. Truck, cargo, 2-1/2-ton, 6x6, M35. The 2-1/2-ton cargo truck (photograph 5) was loaded with a 5000-lb payload. The tire inflation pressure was 35 psi, as required for off-highway travel. The rear axle is composed of a single-tandem tire configuration and supports 66 percent of the total load (table 2). The gross weight of the loaded vehicle is 18,495 lb, with each axle supporting approximately one-third of the load.

d. Truck, cargo, 5-ton, 6x6, M54. The 5-ton cargo truck (photograph 5) was loaded with a 10,000-lb payload, and tire inflation pressure was 35 psi. The total weight of the vehicle when loaded was 30,280 lb. The wheel configuration is illustrated in table 2. When loaded, the rear tandem axles carry 70 percent of the load.

PART III: TEST SERIES I

Description of Test Section

8. The test section for test series I was located in an open area since control of the subgrade CBR was not required in this phase of testing.

Preparation of subgrade

9. The test section was located in the vicinity of a previous ground mat investigation in order that existing in-place sand, a membrane cutoff wall, and French drains could be used. The test section was approximately 48 ft long, 32 ft wide, and 24 in. deep. The section was divided into two 24-ft test items, with item 1 composed of dry sand and item 2 composed of wet sand (plate 5). The wet and dry sands were separated by a membrane cutoff wall. To obtain the dry condition desired in item 1, the sand was excavated, processed through a dryer, and then replaced in the test section in two 12-in. lifts. Each lift was leveled and then compacted initially with eight passes of a D4 tractor (photograph 6). Six passes of a D7 tractor were used for final compaction on the top lift. Water content, density, and CBR were determined both prior to placing the mat and at the completion of traffic (table 3). The gradation curve for the sand used is shown in plate 6 along with a curve typical of sand in Southeast Asia. The U. S. Army Engineer Waterways Experiment Station (WES) sand was coarser than the Cam Ranh Bay sand, but was judged to be satisfactory for this investigation.

Mat assembly and placement

10. The MO-MAT was uncrated and the three 50-ft panels were unrolled near the test area (photographs 7-9). The mat was laid with the 50-ft sides parallel and was oriented so that the sides containing the rivet holes were adjacent.

11. The interior edges of the panels were cleaned with methyl-ethyl-ketone. Using a hand applicator, an adhesive was then applied to the panel edges in a stripe 1/8 in. thick and 4 in. wide (photograph 10). Joints were formed by overlapping the panels 4 in., and placing them so that the rivet holes coincided. One side panel was staggered 8 in. so that the

factory-made resin joints would not be aligned in the longitudinal traffic lane (photograph 11). Joints were reinforced by placing 9/32-in. rivets in the predrilled holes with a hand-operated rivet gun (photograph 12). Four men required 3 man-hr to construct each 50-ft joint.

12. The adhesive bond required a curing time of 24 to 36 hr to dry and form a waterproof joint. After the curing period, the mat was hand rolled, moved to the edge of the test area by a forklift (photograph 13), and unrolled onto the test section.

Layout of test section

13. As previously stated, the test section, approximately 48 by 32 ft, was divided into two test items. Lane 1, a 10-ft-wide traffic lane, was laid out down the longitudinal center of the mat. Lanes 2 and 3 were 10-ft-wide traffic lanes located in the transverse center of test items 1 and 2, respectively. This arrangement allowed all traffic in lane 1 to run parallel to the overlap joints and perpendicular to the resin joints, and all the traffic on lanes 2 and 3 to run perpendicular to the overlap joints and parallel to the resin joints. Pallets loaded to 8000 lb were placed in the areas designated in plate 5. Initially, pallets were located only along one side of the test section. The completed test section prior to traffic is shown in photograph 14.

Test Program

Traffic tests

14. The traffic testing was applied in cycles. At the start of testing, one cycle consisted of the following traffic applied to each traffic lane:

a. 100 passes of the RT-150 forklift, no payload.

b. 50 passes of the RT-150 forklift, 5000-lb payload.

c. 50 passes of the RT-150 forklift, 10,000-lb payload.

d. 50 passes of the M35 cargo truck, 18,000-lb gross weight.

e. 50 passes of the M54 cargo truck, 30,000-lb gross weight.

f. 100 passes of the 540-RS forklift, no payload.

g. 50 passes of the 540-RS forklift, 2000-lb payload.

h. 50 passes of the 540-RS forklift, 4000-lb payload.

i. 50 passes of the 540-RS forklift, 6000-lb payload.

Table 4 describes in detail each of the eight cycles of traffic applied to the test section. The remarks column gives a complete summary of mat behavior under traffic. Photographs 15-17 show the section after 100 passes of the RT-150 forklift with no payload. A slight wave action was present from the start of traffic. Very little roughness was observed until traffic was applied with the RT-150 forklift with a 10,000-lb payload. Traffic using the 540-RS forklift without a payload was stopped after 30 passes during cycle 1. The undercarriage of the forklift had begun to scrape the mat surface, causing tears in the mat (photograph 18). Also, the small solid tires of this vehicle tended to crack the body of the MO-MAT and cause localized stress due to the small wheel diameter. MO-MAT can normally be rolled into an 18-in.-diam roll; however, this vehicle tended to cause an 8- to 10-in.-diam roll. The 540-RS forklift should be used only on a hardstand material and is not recommended for use on MO-MAT placed on a sand subgrade.

15. As traffic was continued through cycle 4 (photographs 19-22), the mat was not visibly damaged. Rutting occurred and increased gradually in depth until a maximum of approximately 5 in. was reached. Rutting was more extensive in item 1 than in item 2. No damage appeared to be caused by traffic of the cargo trucks.

16. During cycle 5, the adhesive on the overlap joint (3.5 ft left of the center line in lane 1, item 1) lost its bond to the upper mat. At the completion of cycle 5, the length of the tear was approximately 17 ft.

17. Prior to the start of cycle 6, several variations were made in the test plan. Pallets loaded to 8000 lb were placed on the south edge of the mat to further evaluate the effects of the pallet loading. Because the cargo truck traffic caused no apparent damage to the mat during previous cycles, the truck traffic was stopped. The testing was accelerated by placing 200 passes on each lane with the RT-150 with a 10,000-lb payload. After trafficking with this load, fairly deep ruts were present in all traffic lanes (photograph 23). The unconfined east and west ends of the mat had a tendency to curl.

18. Cycle 7 consisted of 200 passes of the RT-150 forklift loaded to the maximum payload of 15,000 lb. The effect of this increased loading was evident as the traffic progressed. In lane 1 after 150 passes, two rivets had pulled through the mat, and at 170 passes, the overlap joint had completely failed for approximately 10 ft. After completion of this cycle, 25 rivets had pulled through the mat (photograph 24). Deep rutting developed in all traffic lanes (photograph 25). Cycle 8 consisted of 20 passes per lane of the RT-150 forklift with the 15,000-lb payload. No additional damage was done to the mat. The test section was considered failed when the testing was stopped; however, the adhesive joint was actually the only part of the mat to fail structurally during the investigation. Profiles and cross sections are shown in plates 7 and 8.

Mat removal

19. At the completion of traffic testing, the mat was rerolled by four men. The mat was considered reusable providing some maintenance work was done to repair the damaged joint. The test items, after the removal of the mat, are shown in photograph 26.

PART IV: TEST SERIES II

Description of Test Section

20. Test section 2 was located under a hangar to provide protection from the elements and to maintain control of the subgrade conditions during traffic tests.

Preparation of subgrade

21. The plan of investigation specified that the subgrade of one item be prepared to an in-place CBR of 3, and the second to a CBR of 6 to 7. Subgrades were controlled to a depth of 24 in. The specified CBR items were constructed from a heavy clay placed in 6-in. lifts. Each lift was compacted with three coverages of a seven-wheel rubber-tired roller. The items were then bladed to final grade with a motor grader. CBR, water content, and density tests were made during construction to ensure that the desired strength was obtained. Complete soil data are shown in table 5. A gradation curve for the heavy clay used in items 1 and 2 is shown in plate 6.

Mat placement

22. The mat was placed on the test section in the same manner as it was placed for test series I (photograph 27). However, prior to mat placement, a new joint was constructed to replace the failed joint that resulted from test series I. The failed joint was sawed out, and new rivet holes were drilled on 4-in. centers. The new joint was then constructed as described in test series I and after a 72-hr curing period, the mat was rolled onto the test section.

Layout of test section

23. The test section was divided into three traffic lanes oriented as in test series I. The test section layout is shown in plate 9. Prior to traffic, pallets loaded to 8000 lb each were placed on both edges of the mat in designated areas shown in plate 9. The completed test section prior to traffic is shown in photograph 28.

24. Traffic was applied in cycles. At the start of testing, one cycle consisted of the following traffic applied in each lane:

a. 100 passes of the RT-150 forklift, no payload.

b. 50 passes of the RT-150 forklift, 5000-lb payload.

c. 50 passes of the RT-150 forklift, 10,000-lb payload.

d. 50 passes of the RT-150 forklift, 15,000-lb payload.

Table 6 describes in detail each of the eight cycles of traffic applied in test series II. A complete summary of mat behavior is given in the remarks column. During cycle 1 after 25 passes of the RT-150 forklift with a payload of 15,000 lb, a 3-ft length of resin joint lost its bond. This failure occurred in lane 2, item 1. A 2- by 4-ft piece of MO-MAT was placed over the failure and secured with adhesive and rivets (photograph 29). Two men spent approximately 45 min (1-1/2 man-hr) repairing the joint. When the cycle was completed, slight rutting was observed.

25. Rutting became more apparent in item 1 during cycle 2. After 10 passes of the RT-150 forklift with a payload of 5000 lb, the undercarriage of the test vehicle began to scrape the surface of the mat (photograph 30). The result of the scraping action is shown in photograph 31. At the end of 30 passes with a 15,000-lb payload, rutting had become so severe that item 1 was considered failed. A total of 790 passes had been applied to item 1. Traffic was continued for eight cycles in lanes 1 and 3 on item 2. At the completion of cycle 8, no additional damage to the mat in item 2 had occurred. Only slight rutting had developed due to concentrated traffic (photograph 32). Profiles and cross sections are shown in plates 10 through 13.

26. After removal of the MO-MAT from the test section (photograph 33), the subgrade was leveled with a motor grader, and traffic was applied with the RT-150 forklift with a payload of 15,000 lb. After one pass, ruts of 1.32 and 0.28 in. were measured in items 1 and 2, respectively.

PART V: SUMMARY OF RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

Results

27. The following results were obtained in this investigation:

- a. The average placement rate, including joint fabrication but not uncrating, was 413 sq ft per man-hour. No difficulty was encountered in assembling the mat panels.
- b. The mat required little maintenance when used in single layers.
- c. Direction of traffic had no effect on the performance of the mat.
- d. The use of a forklift with solid rubber tires caused severe damage to the mat.
- e. Traffic on MO-MAT placed on the clay subgrade with a CBR of 3 caused excessive rutting that hindered traffic movement. Mats placed on 6-CBR clay, wet sand, and dry sand subgrades met test criteria.
- f. Prolonged traffic had no detrimental effect on the reinforced material from which MO-MAT is molded.
- g. The adhesive recommended by the manufacturer for constructing joints did not perform as desired.
- h. Static pallet loads placed on the mat tended to serve as anchors and produced little settlement.
- i. Removal and reuse of trafficked mat was accomplished successfully, and failed joints were easily repaired.
- j. There was no difference in the performance of the mat on dry sand or wet sand.

Conclusions

28. The following conclusions are believed to be warranted based on the results of this investigation:

- a. Placement rate and ease of assembly of the mat are acceptable.
- b. Traffic on the mat placed on a subgrade with a CBR of less than 3 will cause excessive rutting that will hinder traffic movement.
- c. Little maintenance is necessary when mat is used in a single layer.

d. The adhesive furnished by the manufacturer for constructing the overlap joints will not perform as desired.

e. The removal and reuse of the trafficked mat is economically feasible.

f. MO-MAT will withstand the traffic of most pneumatic-tired vehicles on wet or dry sand or on clay with a CBR of 6 or greater.

g. Static loads on the mats have little effect on settlement.

Recommendations

29. Based on the results of the investigation reported herein, the following recommendations are believed to be warranted:

a. Factory-fabricated joints should be staggered when constructing field joints with the mat.

b. An adhesive stronger than the one supplied by the manufacturer for constructing the overlap joints should be provided.

c. Vehicles with solid rubber tires should not be used on the mat.

d. Small pieces of mat to be used for repairs should be included in bundle shipments.

Table 1

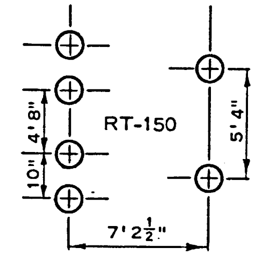
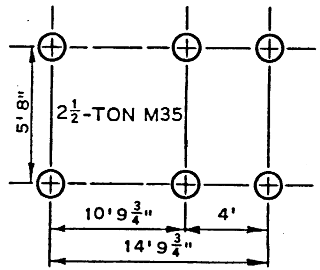
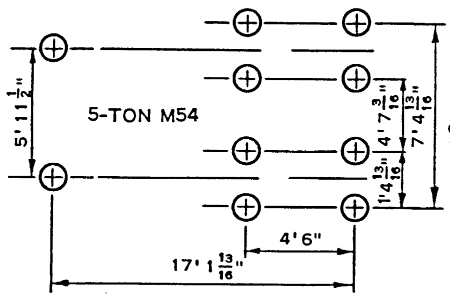
Test Vehicle Data

Towmotor Model 540-RS and Hyster Model RT-150 Forklifts

	Forklift	
	540-RS	RT-150
Gross weight (empty)	10,990 lb	17,070 lb
Gross weight (with maximum capacity payload)	16,990 lb	32,070 lb
Length (axle to axle)	4 ft 6 in.	7 ft 2-1/2 in.
Spacing of drive wheels (center to center of tires)	3 ft 0 in.	10 in.-4 ft 8 in.-10 in.
Spacing of steering wheels	3 ft 0 in.	5 ft 4 in.
Tire size, drive and steering (pneumatic)	Solid tire	8.25x15
Tire pressure (pneumatic)	Solid tire	80 psi
Tire diameter, drive wheels (solid)	21 in.	--
Tire diameter, steering wheels (solid)	16-3/4 in.	--
Thickness of rubber (solid)	2-1/2 in.	--
Hoist bar clearance (empty)	2-1/2 in.	7 in.
Differential clearance (empty)	--	8 in.

Table 2

Load-Tire Data

Vehicle	Tire Size, in.	Tire Pressure, psi Front	Tire Pressure, psi Rear	Wheel Configuration	Axle Loading, kips Front	Axle Loading, kips Rear*	Contact Area per Axle, sq in. Front	Contact Area per Axle, sq in. Rear	Contact Pressure psi Front	Contact Pressure psi Rear
Forklift RT-150 at 0 payload	8.25x15	80	80		6.3	10.8	145	126	43.4	85.7
Forklift RT-150 at 5000-lb payload	8.25x15	80	80		13.0	8.5	198	114	65.7	74.6
Forklift RT-150 at 10,000-lb payload	8.25x15	80	80		20.5	6.0	253	100.5	81.0	59.7
Forklift RT-150 at 15,000-lb payload	8.25x15	80	80		28.0	3.5	308	88	90.9	39.8
2-1/2-ton cargo truck 6x6 M35 A-1 at 18,000-lb load	11.00x20, 12 Ply	35	35		6.3	6.1	120	185	52.5	33
5-ton cargo truck M54 at 30,000-lb load	11.00x20, 12 Ply	35	35		9.2	10.6	256	320	35.9	33.1

* For total rear load, double the load given.

Table 3

Summary of Results of CBR, Water Content, and Density Determinations

Test Series I

Item	Before Traffic				After Traffic			
	Depth in.	CBR	Water Content %	Density pcf	Depth in.	CBR	Water Content %	Density pcf
1	Sfc	1.1	0.32	98.4	Sfc	3.8	0.08	100.3
	6	2.6	0.02	101.6	6	6.1	0.05	101.6
	12	6.0	0.05	101.3	12	10.0	0.21	101.6
	18	4.4	0.03	94.7	18	8.0	0.09	98.7
	Avg	3.5	0.11	99.0	Avg	7.0	0.11	100.3
2	Sfc	3.9	3.2	92.1	Sfc	4.2	2.2	96.2
	6	7.0	3.2	95.2	6	10.0	3.9	95.7
	12	9.0	3.6	95.5	12	15.0	4.0	96.4
	18	8.0	3.7	91.4	18	17.5	4.3	96.4
	Avg	7.0	3.4	93.6	Avg	12.0	3.6	96.2

Table 4

Summary of Traffic in Test Series I

Cycle	Lane	Item	Vehicle	Weight lb*	Passes	Remarks
1	1	1 & 2	RT-150	0	100	Mat was anchored only by pallets, as indicated in the layout of the test section
	2	1	↓	0	100	
	3	2	↓	0	100	
	1	1 & 2	↓	5,000	50	After 30 passes of the RT-150 on lane 1, wave action occurred. As payloads were increased, wave action increased slightly
	2	1	↓	5,000	50	
	3	2	↓	5,000	50	
	1	1 & 2	↓	10,000	50	No damage was done to mat by truck traffic. However, use of 540-RS was discontinued after 30 passes in lane 1 because the low clearance between the mat and forklift caused scraping of the mat
	2	1	↓	10,000	50	
	3	2	↓	10,000	50	
	1	1 & 2	2-1/2-ton, M35	18,000	50	
	2	1	↓	18,000	50	
	3	2	↓	18,000	50	
	1	1 & 2	5-ton, M54	30,000	50	
	2	1	↓	30,000	50	
	3	2	↓	30,000	50	
	1	1 & 2	540-RS	0	30	
2	1	1 & 2	RT-150	0	100	At the start of cycle 2, the mat was in good condition. Shallow ruts developed in all lanes
	2	1	↓	0	100	
	3	2	↓	0	100	
	1	1 & 2	↓	5,000	50	After 50 passes of the 2-1/2-ton M35 truck, small cracks were noticed 4 ft right of center line of lane 1
	2	1	↓	5,000	50	
	3	2	↓	5,000	50	
	1	1 & 2	↓	10,000	50	No further damage was caused to the mat during cycle 2
	2	1	↓	10,000	50	
	3	2	↓	10,000	50	
	1	1 & 2	2-1/2-ton, M35	18,000	50	
	2	1	↓	18,000	50	
	3	2	↓	18,000	50	
	1	1 & 2	5-ton, M54	30,000	50	
	2	1	↓	30,000	50	
	3	2	↓	30,000	50	
3	1	1 & 2	RT-150	0	100	No damage was done to mat during cycle 3
	2	1	↓	0	100	The depth of the ruts had increased slightly in all traffic lanes. Rutting appeared to be slightly greater in item 1 than in item 2
	3	2	↓	0	100	
	1	1 & 2	↓	5,000	50	
	2	1	↓	5,000	50	
	3	2	↓	5,000	50	
	1	1 & 2	↓	10,000	50	
	2	1	↓	10,000	50	
	3	2	↓	10,000	50	
	1	1 & 2	2-1/2-ton, M35	18,000	50	
	2	1	↓	18,000	50	
	3	2	↓	18,000	50	
	1	1 & 2	5-ton, M54	30,000	50	
	2	1	↓	30,000	50	
	3	2	↓	30,000	50	
4	1	1 & 2	RT-150	0	100	There was no visible damage to the mat at the completion of cycle 4 other than minor delaminations and small tears where the undercarriage of the forklift dragged across the mat
	2	1	↓	0	100	
	3	2	↓	0	100	
	1	1 & 2	↓	5,000	50	
	2	1	↓	5,000	50	
	3	2	↓	5,000	50	
	1	1 & 2	↓	10,000	50	
	2	1	↓	10,000	50	
	3	2	↓	10,000	50	
	1	1 & 2	2-1/2-ton, M35	18,000	50	
	2	1	↓	18,000	50	
	3	2	↓	18,000	50	
	1	1 & 2	5-ton, M54	30,000	50	
	2	1	↓	30,000	50	
	3	2	↓	30,000	50	

(Continued)

* For RT-150, payloads are listed; for 2-1/2-ton M35 and 5-ton M54 trucks, gross weights are listed.

Table 4 (Concluded)

Cycle	Lane	Item	Vehicle	Weight lb	Passes	Remarks
5	1	1 & 2	RT-150	0	100	At the completion of cycle 5, the adhesive bonding the longitudinal joint of lane 1 3.5 ft left of center line came loose. As a result, rivet bonding was used. The tear occurred in item 1, and was approximately 17 ft long Rutting increased after each cycle
	2	1		0	100	
	3	2		0	100	
	1	1 & 2		5,000	50	
	2	1		5,000	50	
	3	2		5,000	50	
	1	1 & 2		10,000	50	
	2	1		10,000	50	
	3	2		10,000	50	
	1	1 & 2	2-1/2-ton, M35	18,000	50	
	2	1		18,000	50	
	3	2		18,000	50	
	1	1 & 2	5-ton, M54	30,000	50	
	2	1		30,000	50	
	3	2		30,000	50	
6	1	1 & 2	RT-150	10,000	200	Before start of cycle 6, pallets similar to those on north side of mat were placed on south side of mat The tear that had occurred during cycle 5 did not increase in length Deeper rutting had occurred due to concentrated traffic with the 10,000-lb payload The mat had a tendency to curl at the east and west ends after the additional pallets had been placed on the south side
	2	1		10,000	200	
	3	2		10,000	200	
7	1	1 & 2	RT-150	15,000	200	The 15,000-lb load was the most critical load applied to mat during investigation After 150 passes on lane 1, two rivets had pulled through the mat in item 1 where the adhesive bond had broken After 170 passes on lane 1, the longitudinal joint had completely failed for a length of approximately 10 ft At the completion of this cycle, 25 rivets had pulled through the mat
	2	1		15,000	200	
	3	2		15,000	200	
8	1	1 & 2	RT-150	15,000	20	The tire pressure of the RT-150 was increased to 90 psi. No further damage was done to mat Deep rutting occurred in all traffic lanes
	2	1		15,000	20	
	3	2		15,000	20	

Table 5

Summary of Results of CBR, Water Content, and Density Determinations

Test Series II

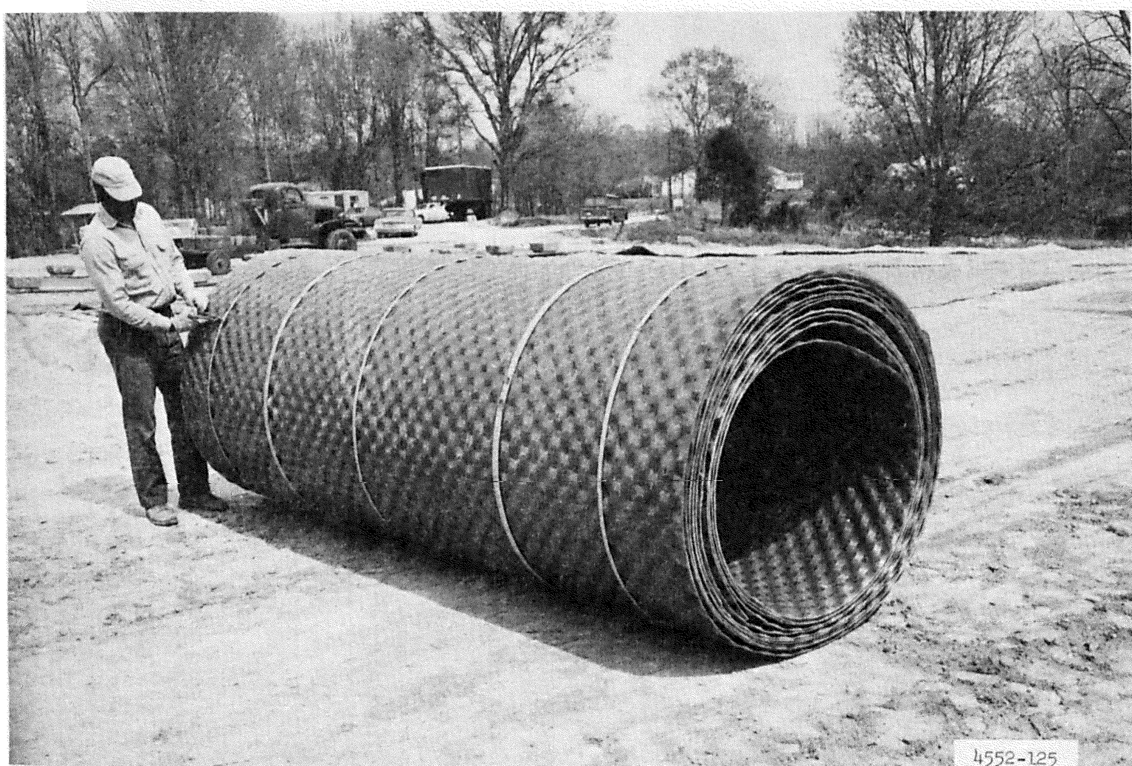
Item	Before Traffic				After Traffic			
	Depth in.	CBR	Water Content %	Density pcf	Depth in.	CBR	Water Content %	Density pcf
1	Sfc	3.0	26.3	91.1	Sfc	4.1	24.7	96.9
	6	2.9	26.0	94.1	6	3.0	25.8	94.6
	12	2.4	27.5	93.7	12	3.4	25.8	93.2
	18	2.7	27.4	93.9	18	4.7	26.1	94.8
	Avg	2.8	26.8	93.2	Avg	3.8	25.6	94.9
2	Sfc	7.0	23.5	96.2	Sfc	6.0	22.8	100.6
	6	7.0	23.5	97.9	6	6.0	23.2	99.3
	12	7.0	23.5	100.7	12	10.0	22.9	99.1
	18	9.0	23.5	100.8	18	11.0	22.3	100.8
	Avg	7.5	23.5	98.9	Avg	8.0	22.8	100.0

Table 6

Summary of Traffic in Test Series II

Cycle	Lane	Item	Vehicle	Payload lb	Passes	Remarks
1	1	1 & 2	RT-150	0	100	Prior to traffic, pallets were placed on both edges of the mat as shown in the test section layout. At 25 passes of RT-150 forklift with 15,000-lb payload, the resin joint, 12 ft in from south edge of the mat, had failed for a length of 3 ft, left of center line of lane 1 in item 1. A 2- by 4-ft piece of MO-MAT was placed over the failure and sealed into place. The failure occurred as traffic was being applied in lane 2. Slight rutting was also present in lane 2
	2	1	↓	0	100	
	3	2	↓	0	100	
	1	1 & 2	↓	5,000	50	
	2	1	↓	5,000	50	
	3	2	↓	5,000	50	
	1	1 & 2	↓	10,000	50	
	2	1	↓	10,000	50	
	3	2	↓	10,000	50	
	1	1 & 2	↓	15,000	50	
	2	1	↓	15,000	50	
	3	2	↓	15,000	50	
2	1	1 & 2	RT-150	0	100	Prior to cycle 2, rutting was more apparent in item 1 than in item 2. After 10 passes of 5000-lb payload in lane 2, the undercarriage of the RT-150 forklift was tearing the mat. Traffic was stopped in lane 2. After 30 passes with the 15,000-lb payload, traffic was stopped in lane 1, item 1. At this point, item 1 was considered failed
	2	1	↓	0	100	
	3	2	↓	0	100	
	1	1 & 2	↓	5,000	50	
	2	1	↓	5,000	10	
	3	2	↓	5,000	50	
	1	1 & 2	↓	10,000	50	
	3	2	↓	10,000	50	
	1	1	↓	15,000	30	
	1	2	↓	15,000	50	
	3	2	↓	15,000	50	
3	1	2	RT-150	0	100	No further damage was done to the mat. The item was reacting satisfactorily to traffic. Slight rutting was present
	3	↓	↓	0	100	
	1	↓	↓	5,000	50	
	3	↓	↓	5,000	50	
	1	↓	↓	10,000	50	
	3	↓	↓	10,000	50	
	1	↓	↓	15,000	50	
	3	↓	↓	15,000	50	
4	1	2	RT-150	0	100	No noticeable damage was done to the mat in item 2. Very slight rutting was present
	3	↓	↓	0	100	
	1	↓	↓	5,000	50	
	3	↓	↓	5,000	50	
	1	↓	↓	10,000	50	
	3	↓	↓	10,000	50	
	1	↓	↓	15,000	50	
	3	↓	↓	15,000	50	
5	1	2	RT-150	0	100	Everything satisfactory; slight rutting in item 2
	3	↓	↓	0	100	
	1	↓	↓	5,000	50	
	3	↓	↓	5,000	50	
	1	↓	↓	10,000	50	
	3	↓	↓	10,000	50	
	1	↓	↓	15,000	50	
	3	↓	↓	15,000	50	
6	1	2	RT-150	0	100	No damage; slight rutting
	3	↓	↓	0	100	
	1	↓	↓	5,000	50	
	3	↓	↓	5,000	50	
	1	↓	↓	10,000	50	
	3	↓	↓	10,000	50	
	1	↓	↓	15,000	50	
	3	↓	↓	15,000	50	
7	1	2	RT-150	0	100	No damage; slight rutting
	3	↓	↓	0	100	
	1	↓	↓	5,000	50	
	3	↓	↓	5,000	50	
	1	↓	↓	10,000	50	
	3	↓	↓	10,000	50	
	1	↓	↓	15,000	50	
	3	↓	↓	15,000	50	
8	1	2	RT-150	0	100	No damage; slight rutting
	3	↓	↓	0	100	
	1	↓	↓	5,000	50	
	3	↓	↓	5,000	50	
	1	↓	↓	10,000	50	
	3	↓	↓	10,000	50	
	1	↓	↓	15,000	50	
	3	↓	↓	15,000	50	

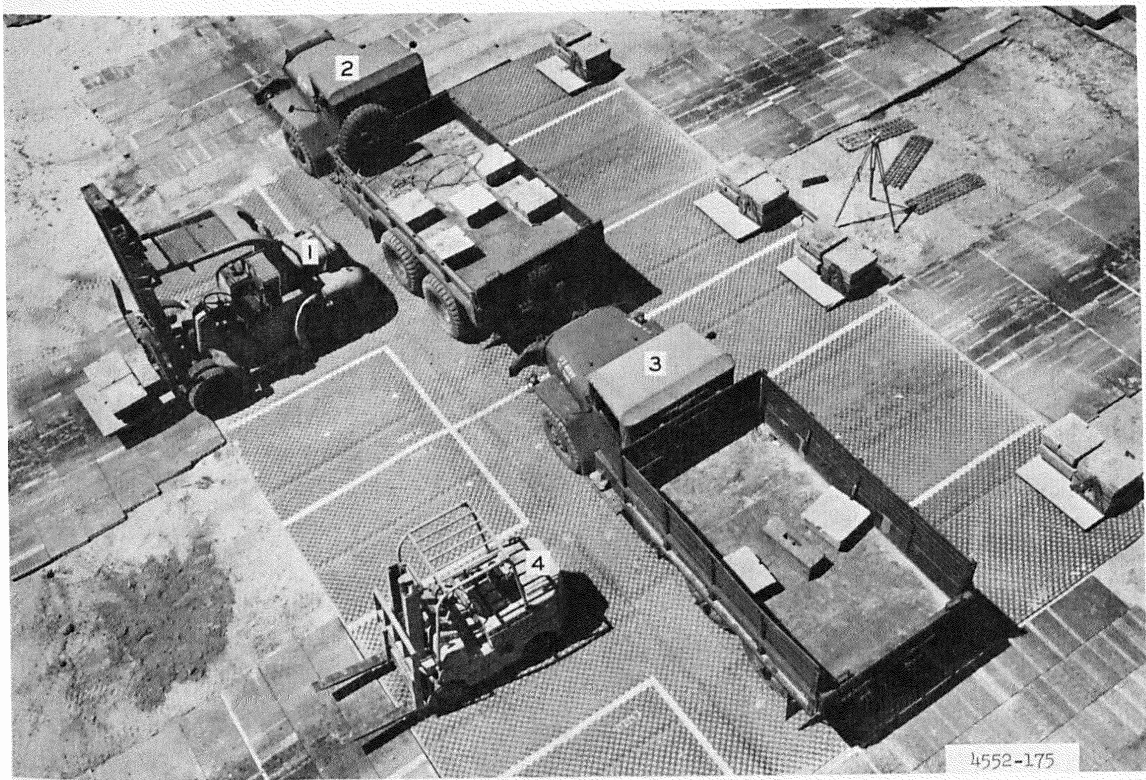
Photograph 1. Transporting MO-MAT bundle to test site



Photograph 2. Preparing to unbind MO-MAT bundle

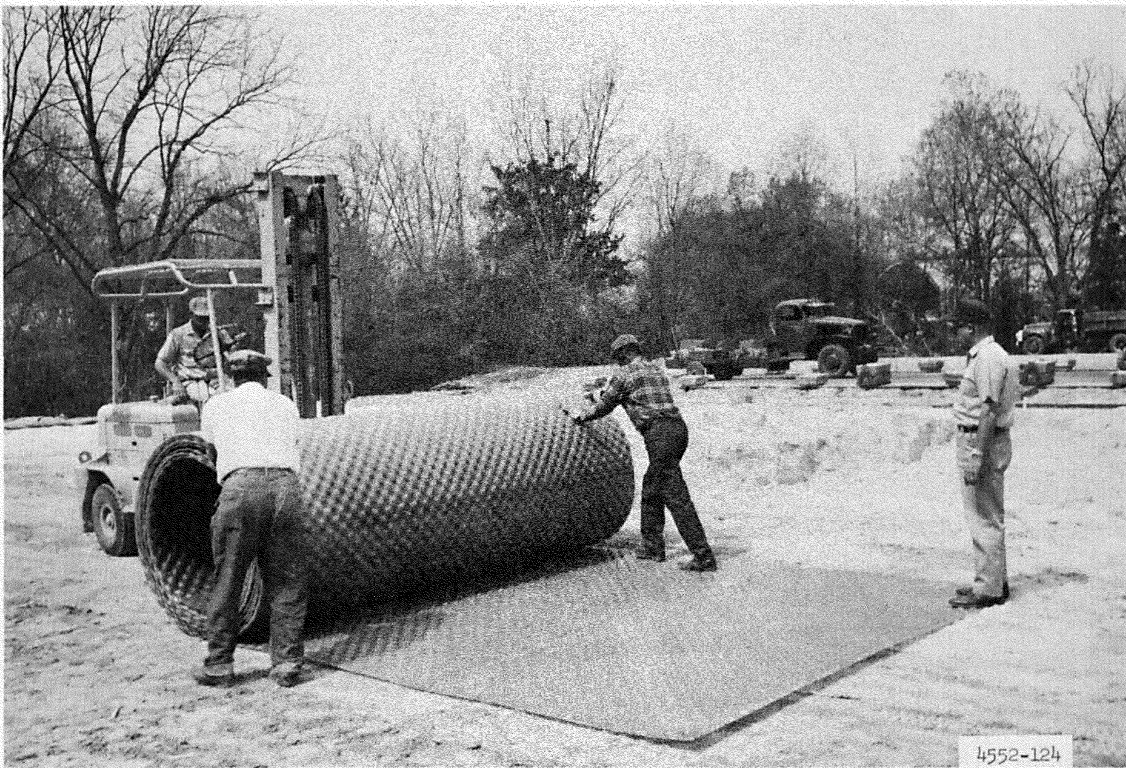
Photograph 3. Towmotor Model 540-RS forklift

Photograph 4. Hyster RT-150 forklift



Photograph 5. Four test vehicles: (1) RT-150 forklift, (2) M54 5-ton truck, (3) M35 2-1/2-ton truck, (4) 540-RS forklift

Photograph 6. Leveling and compacting sand with D4 tractor

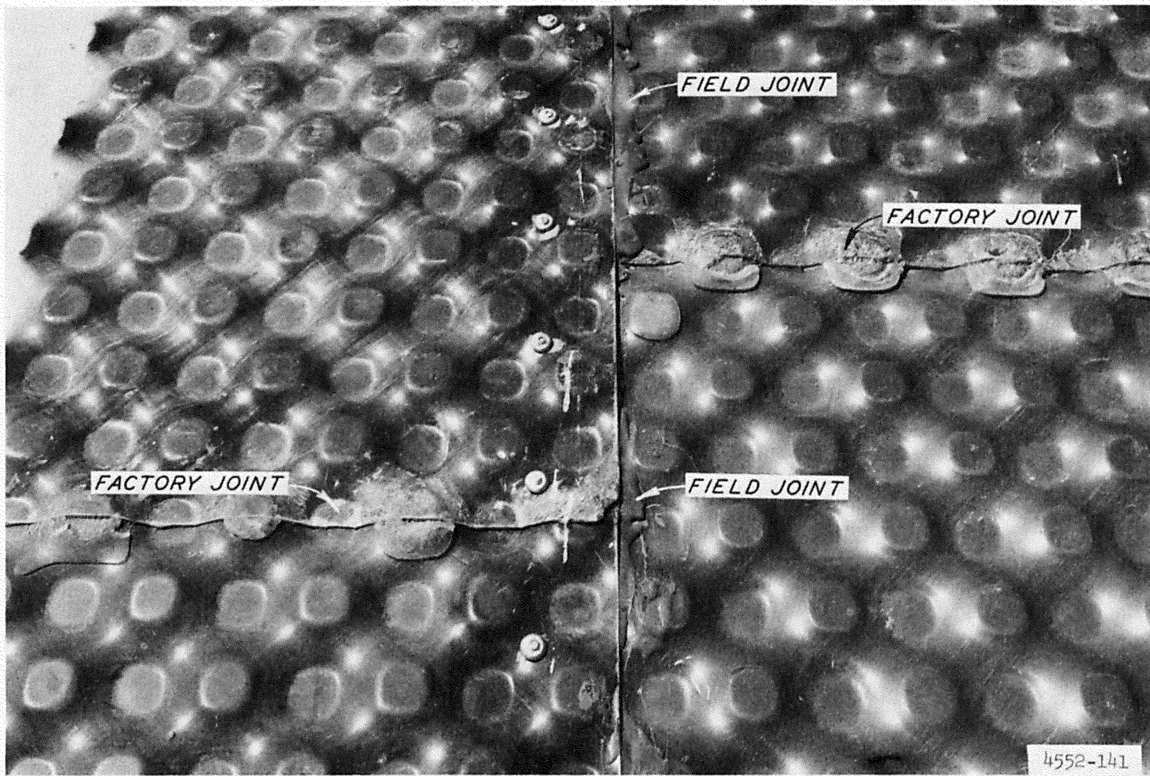


Photograph 7. Unrolling a MO-MAT panel by hand

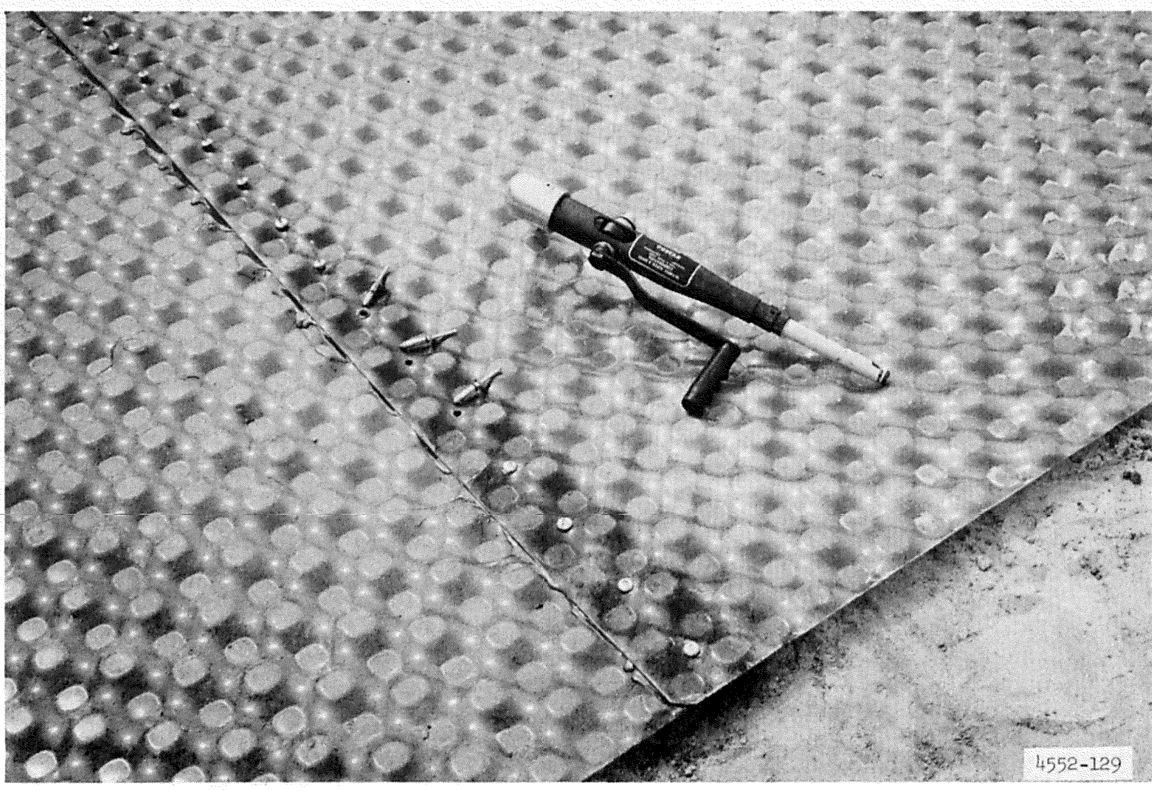
Photograph 8. Panel of MO-MAT unrolling unassisted

Photograph 9. A 50-ft MO-MAT panel fully extended

Photograph 10. Applying the adhesive to longitudinal joint



Photograph 11. Staggering the factory-made resin joints

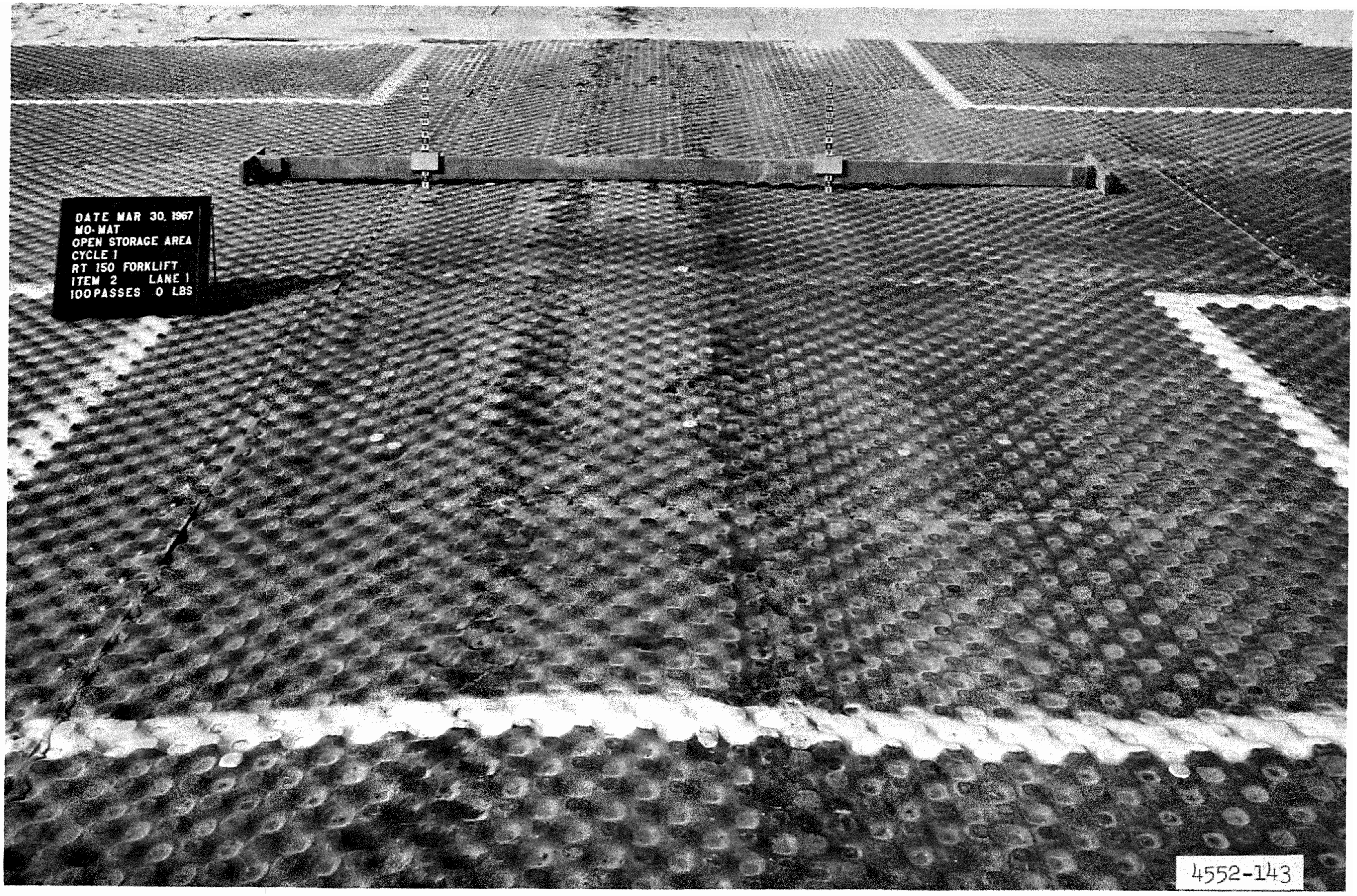


Photograph 12. The hand-operated gun used for rivet placement

Photograph 13. The assembled mat being placed on the edge of the test section

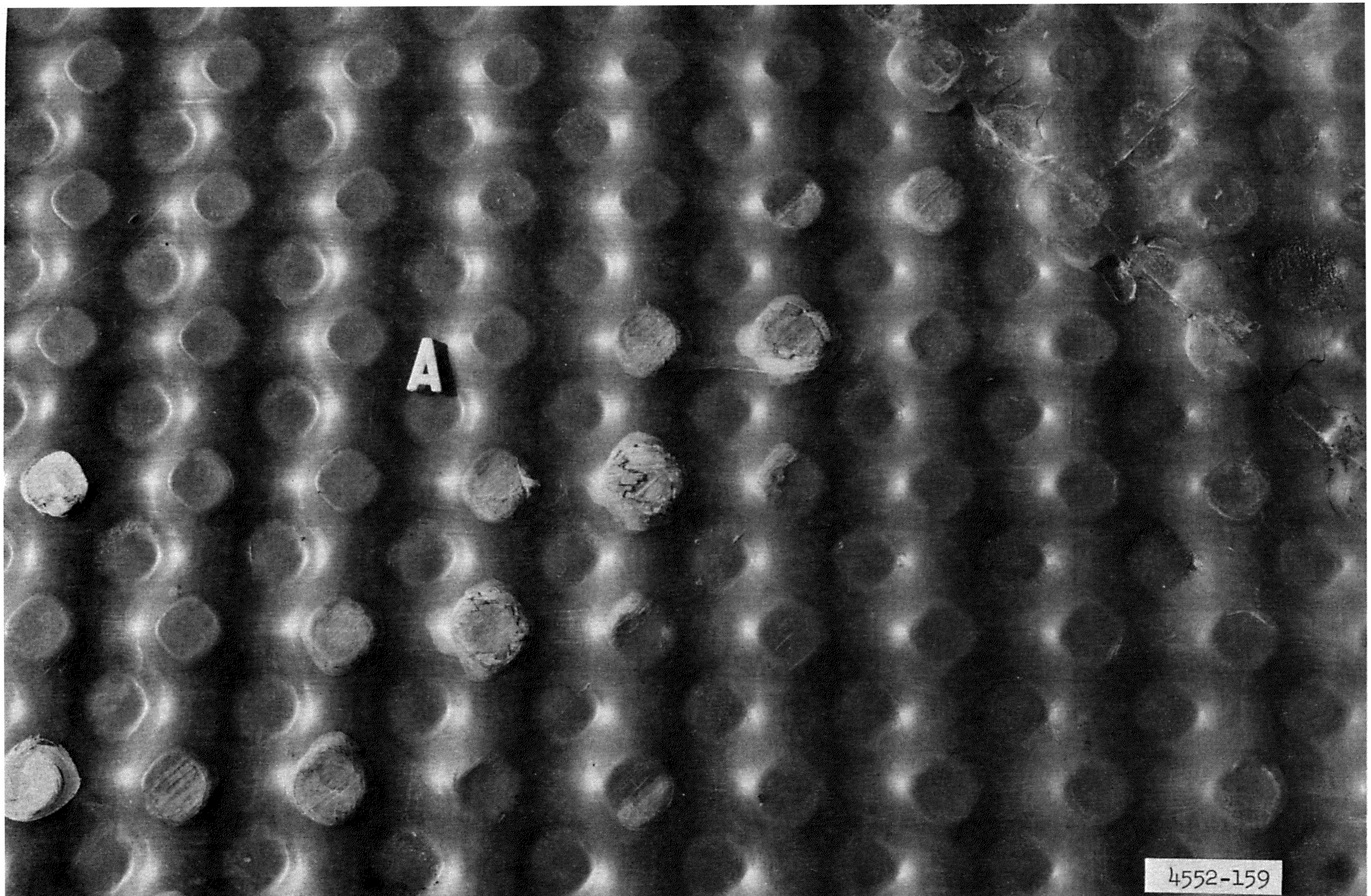
Photograph 14. The completed test section prior to trafficking

Photograph 15. Item 1, lane 1, after 100 passes of the RT-150 forklift with no payload in test series I, cycle 1

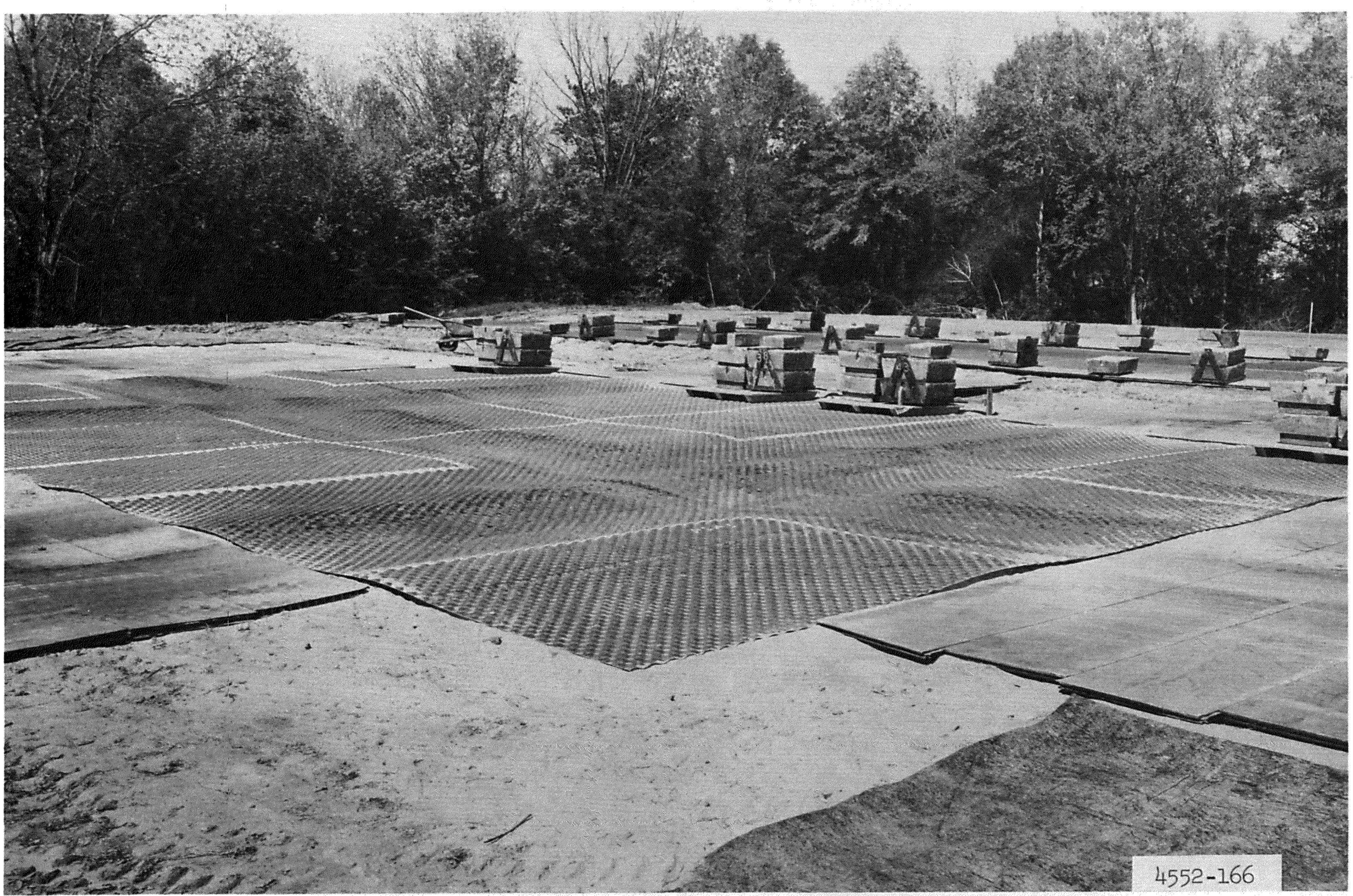


Photograph 16. Item 2, lane 1, after 100 passes of the RT-150 forklift with no payload in test series I, cycle 1

Photograph 17. Item 1, lane 2, after 100 passes of the RT-150 forklift with no payload in test series I, cycle 1

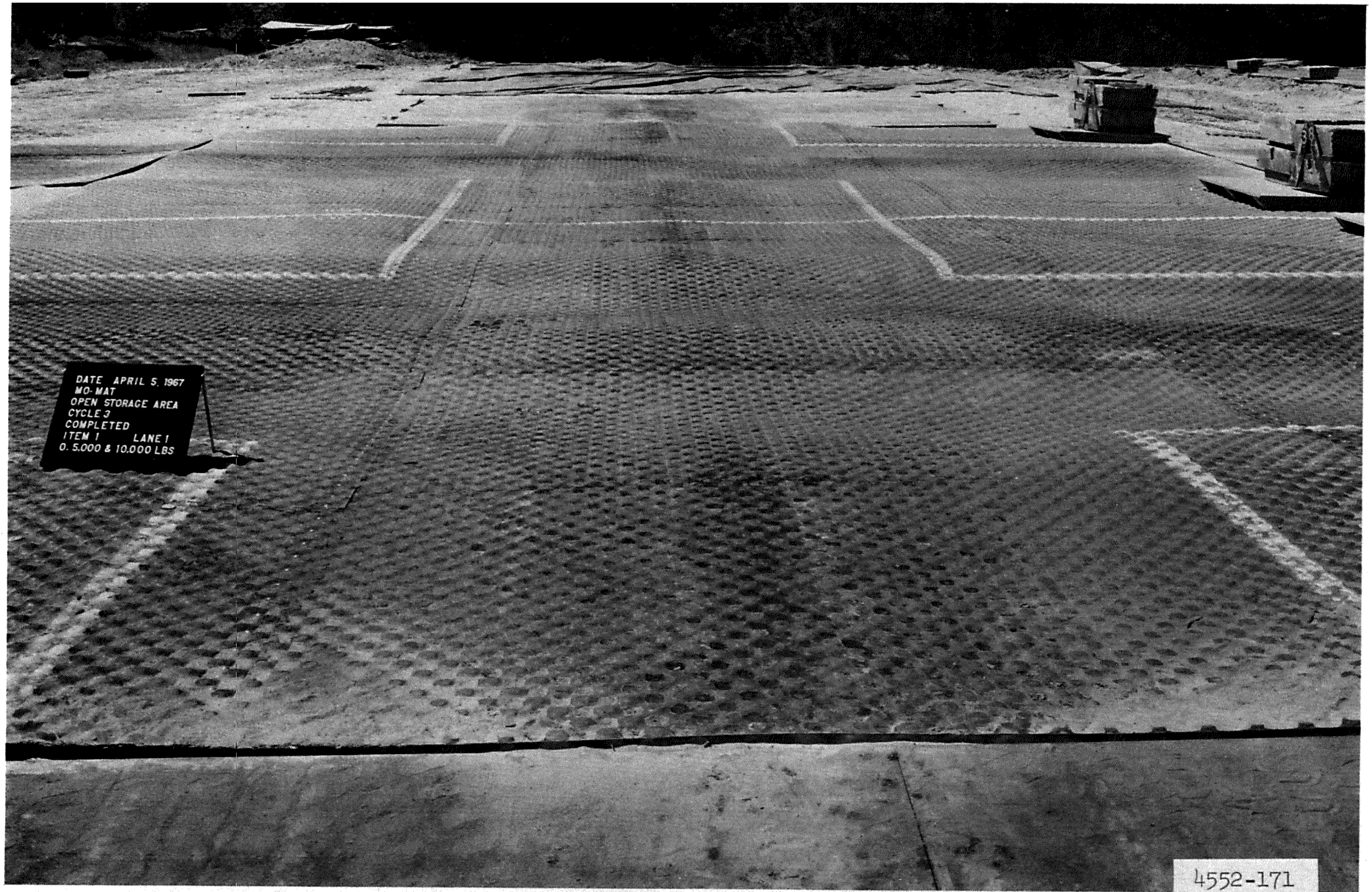


Photograph 18. Tears caused by the undercarriage of the 540-RS forklift scraping the surface of the mat



Photograph 19. Test section 1 after completion of cycle 1

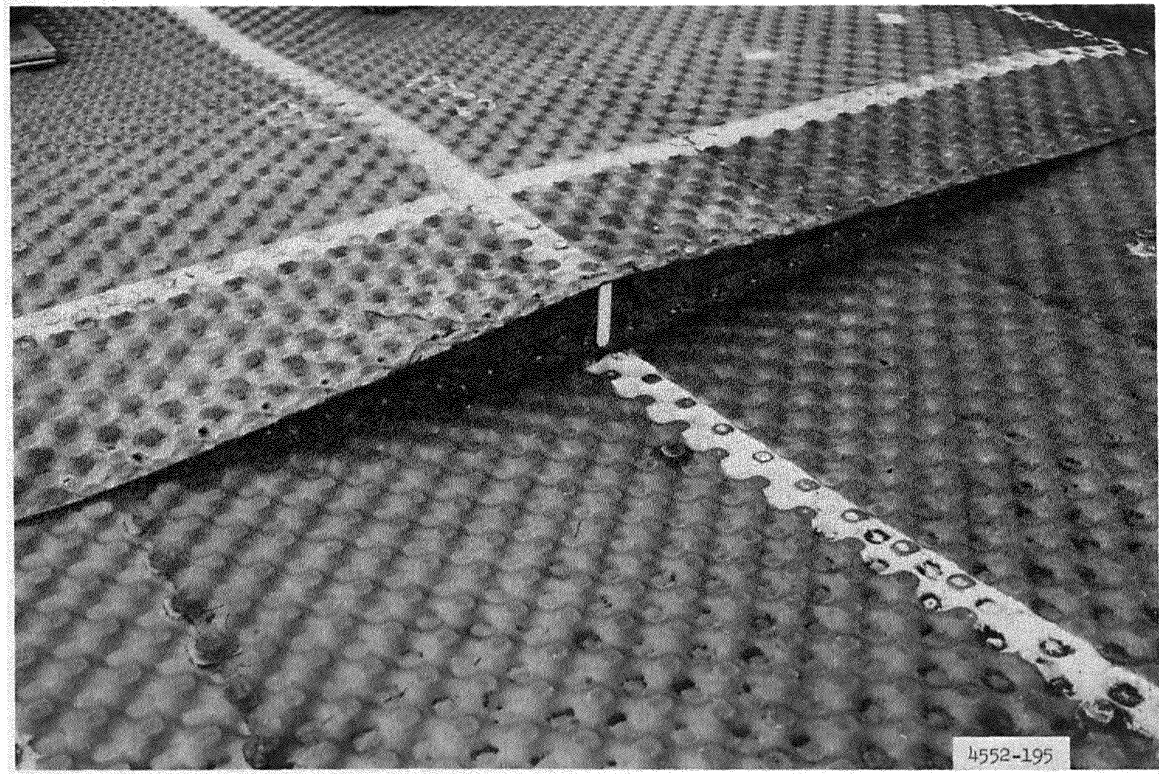
Photograph 20. Item 1, lane 1, after the completion of cycle 2



Photograph 21. Item 1, lane 1, after the completion of cycle 3

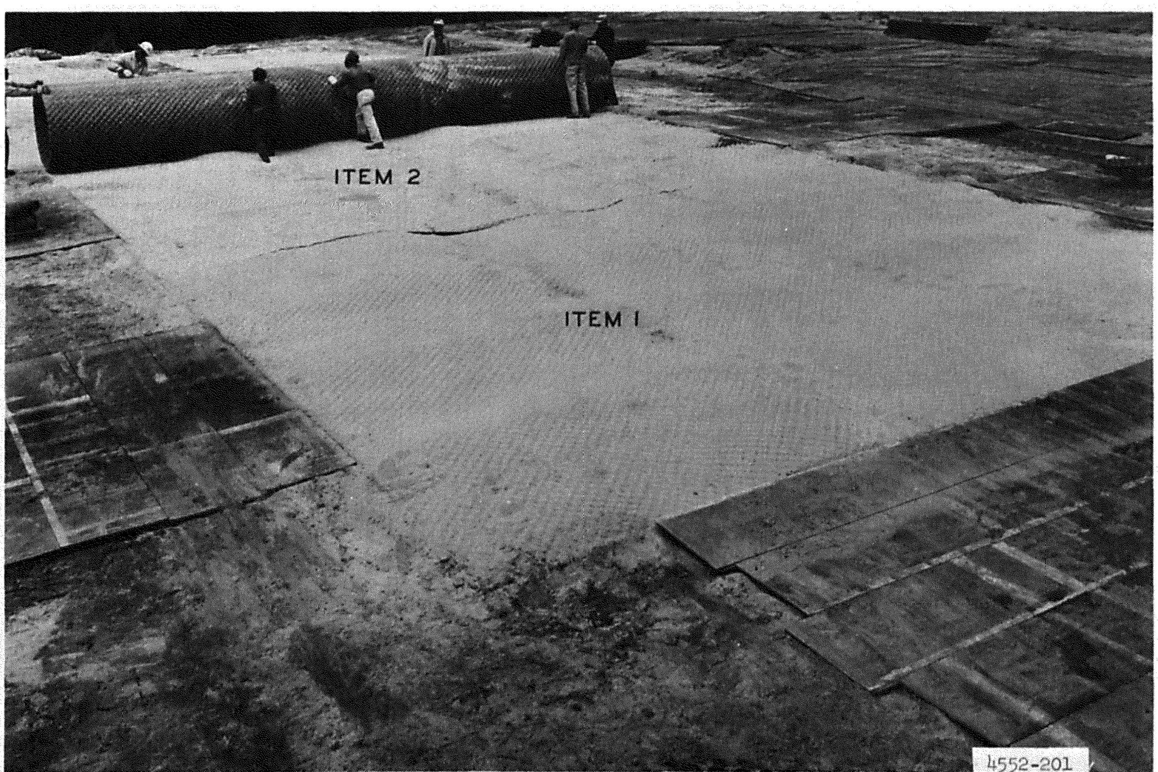
Photograph 22. Item 1, lane 1, after the completion of cycle 4

Photograph 23. Item 1, lane 1, after 200 passes of the RT-150 forklift with a 10,000-lb payload (cycle 6)



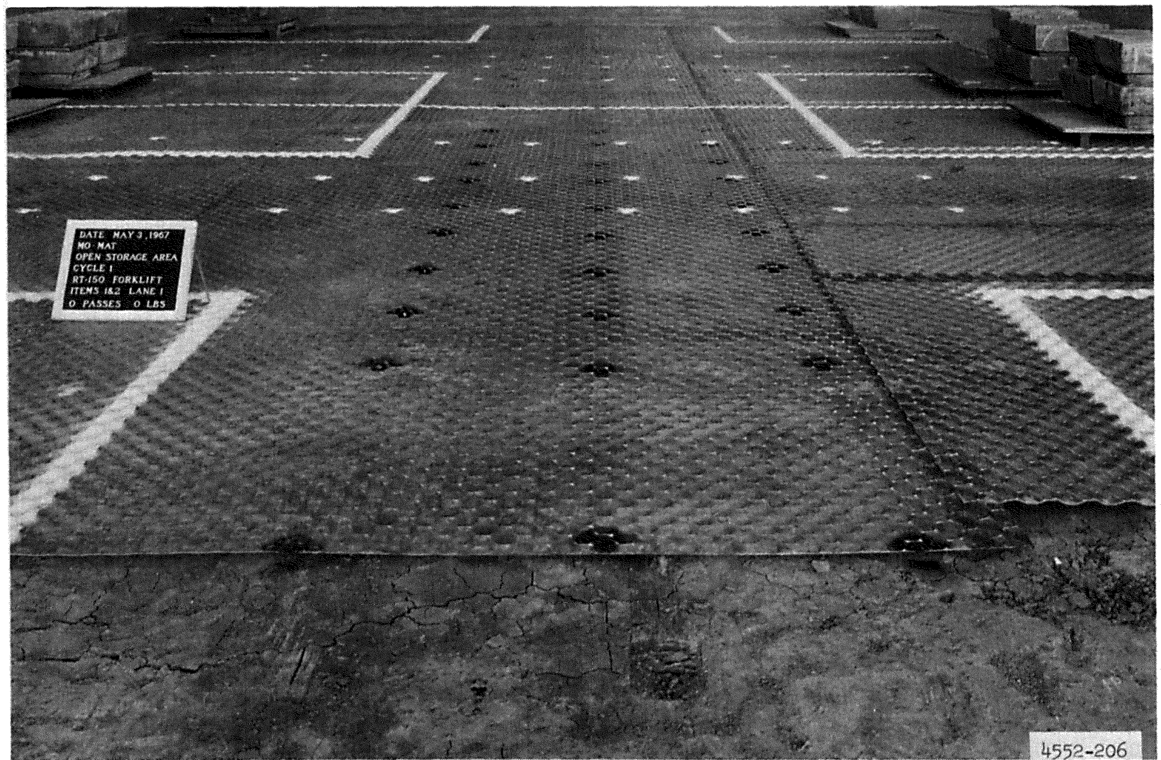
Photograph 24. The failure of the longitudinal joint in lane 1 after 8 cycles of traffic

Photograph 25. Item 1, lane 1, after 200 passes with the RT-150 forklift with a 15,000-lb payload (cycle 7)

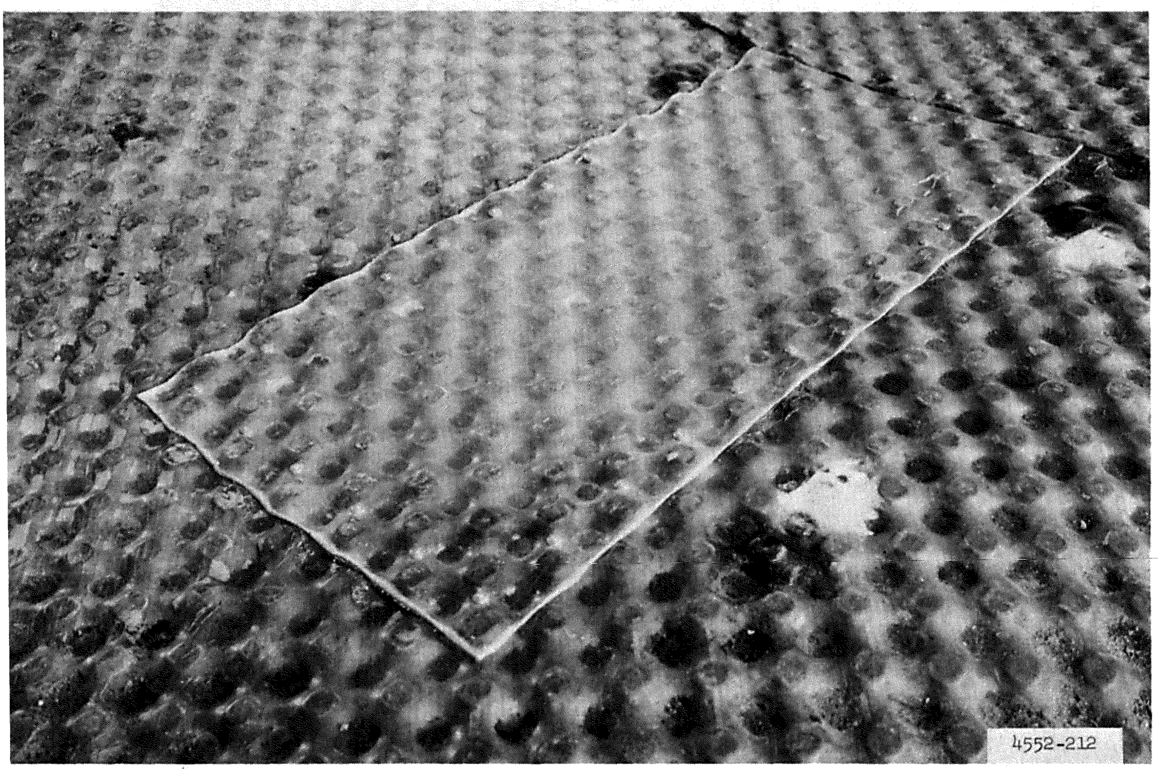


Photograph 26. Removing the mat from test section 1 after the completion of testing

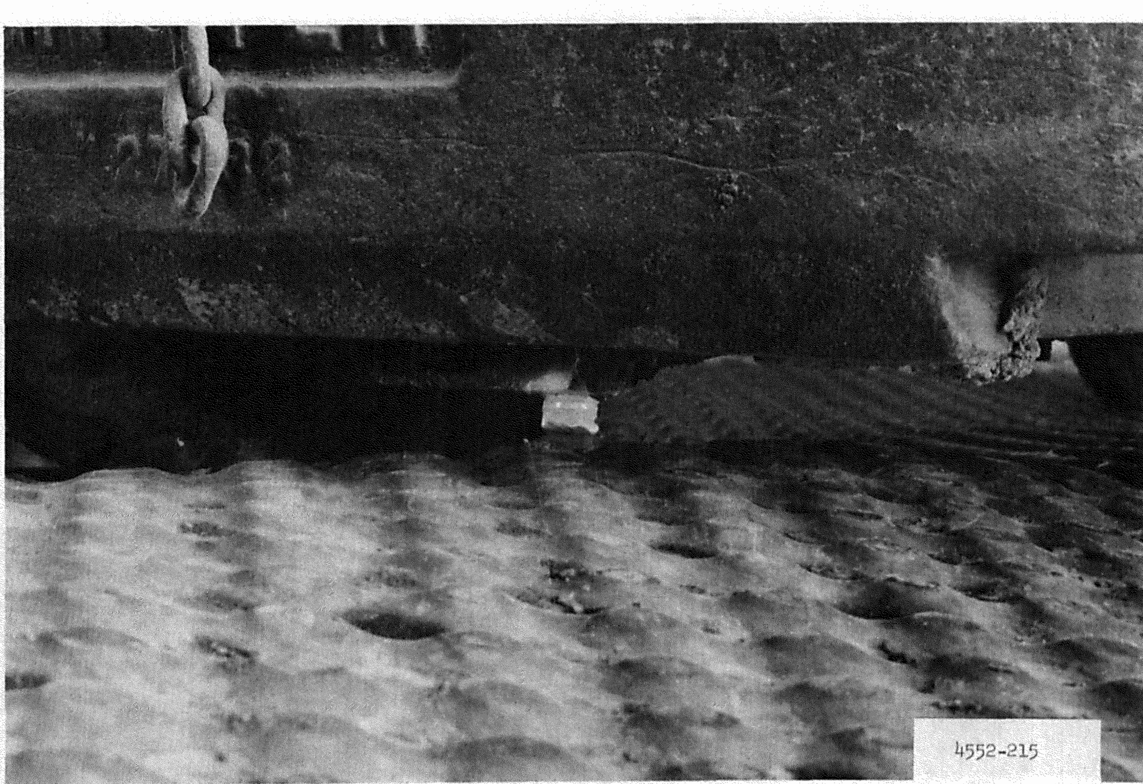
Photograph 27. Subgrade prior to placing MO-MAT on test section 2



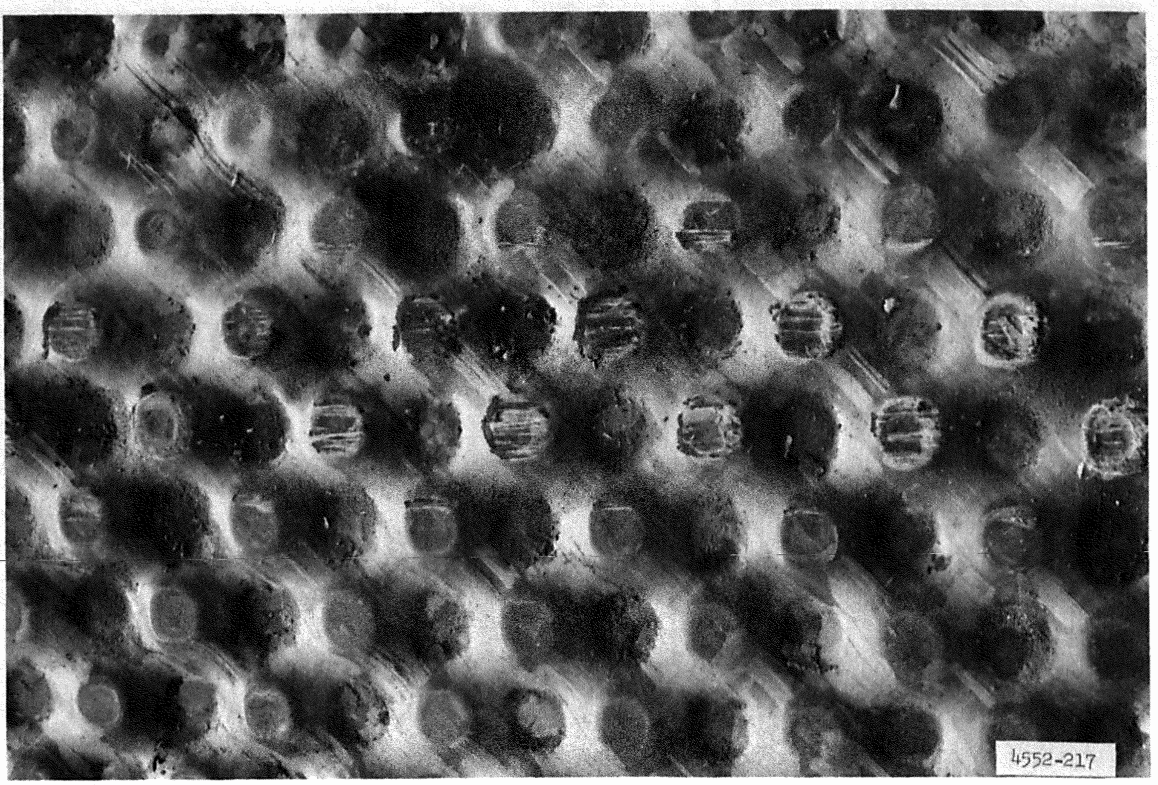
Photograph 28. Test section 2 prior to traffic



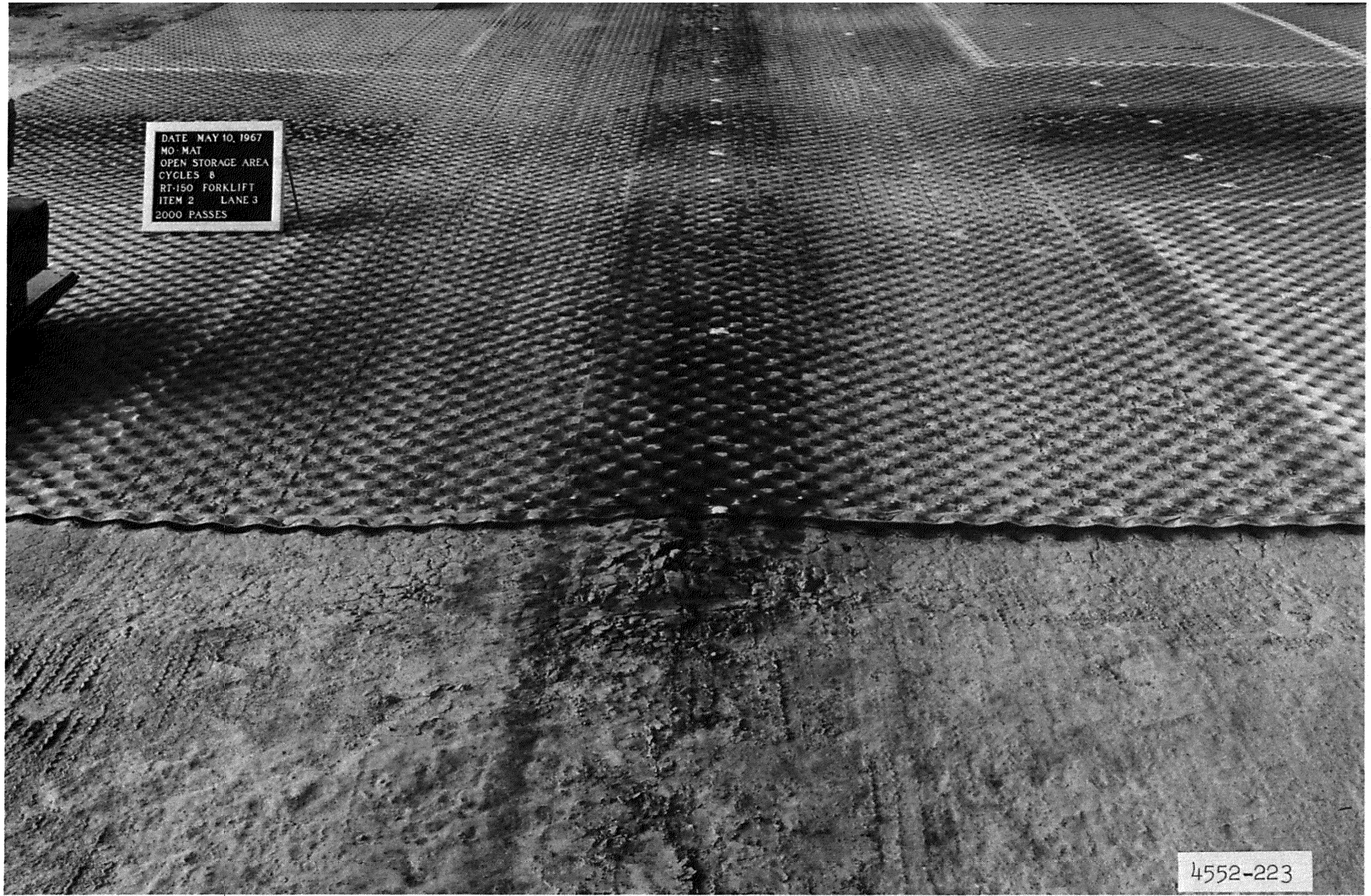
Photograph 29. A 2- by 4-ft patch used to repair joint



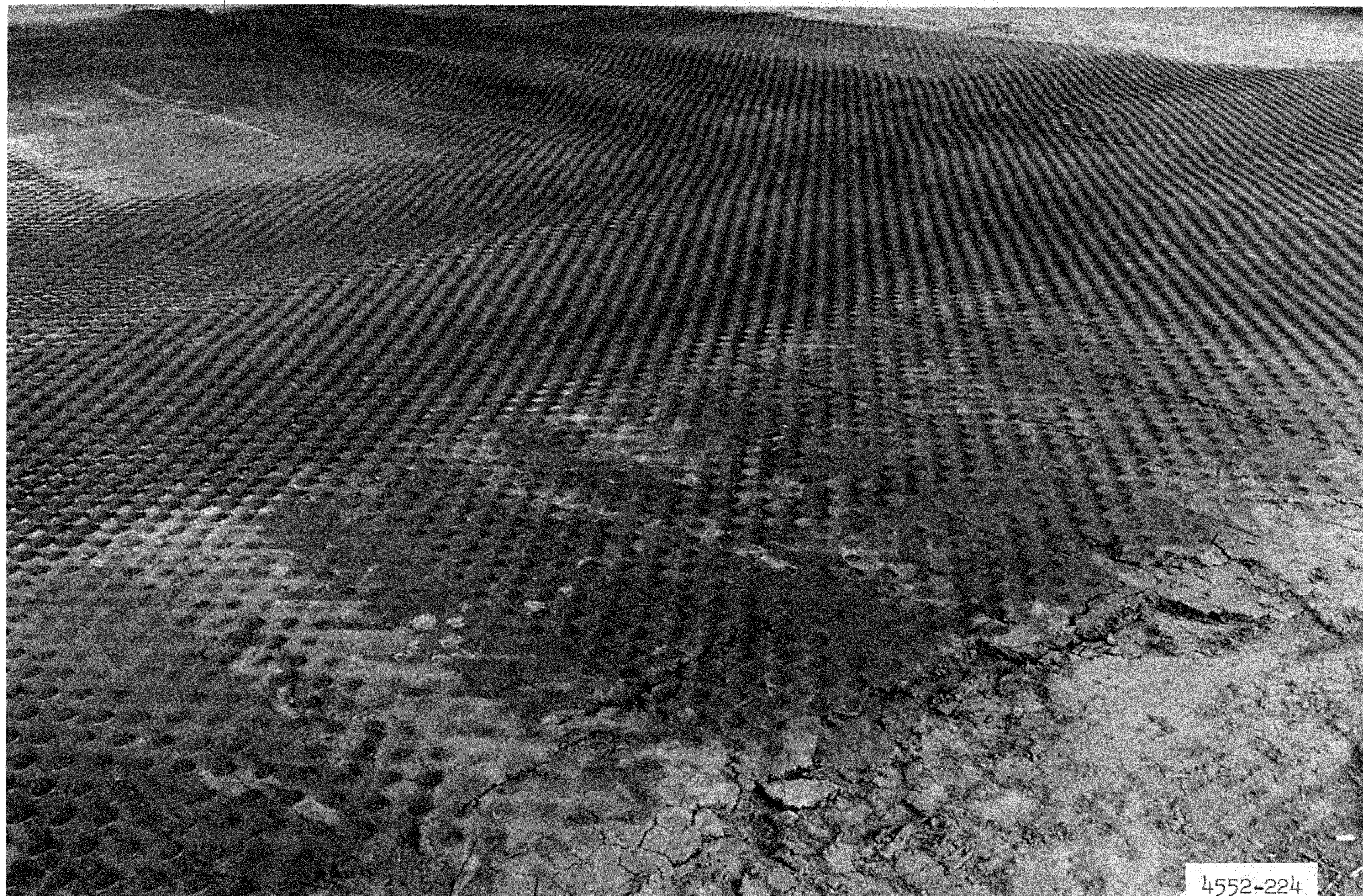
Photograph 30. Low clearance between undercarriage of RT-150 forklift and mat surface



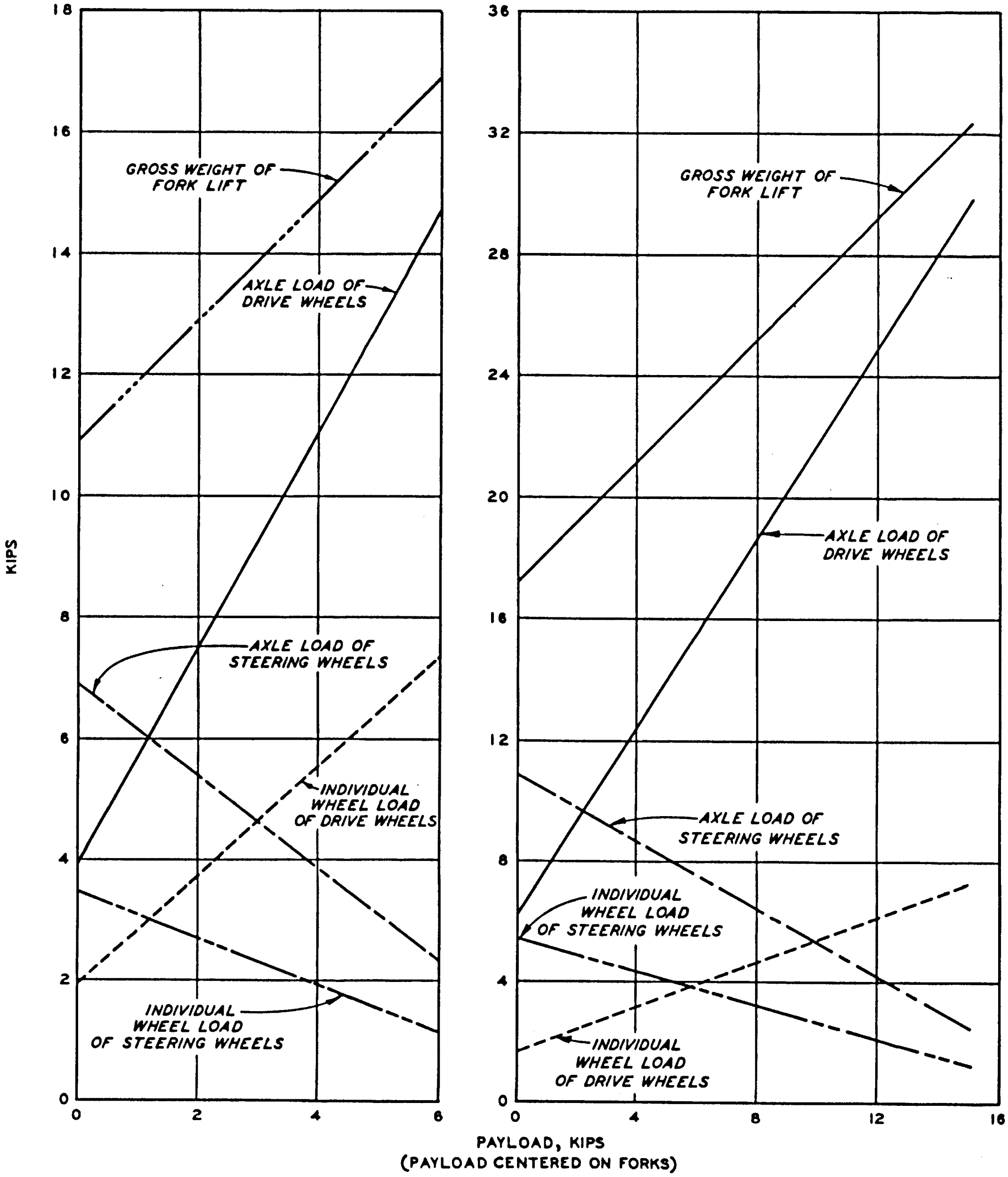
Photograph 31. Damage resulting from Hyster undercarriage's dragging surface of mat



Photograph 32. Item 2, lane 3, after 2000 passes of the RT-150 forklift



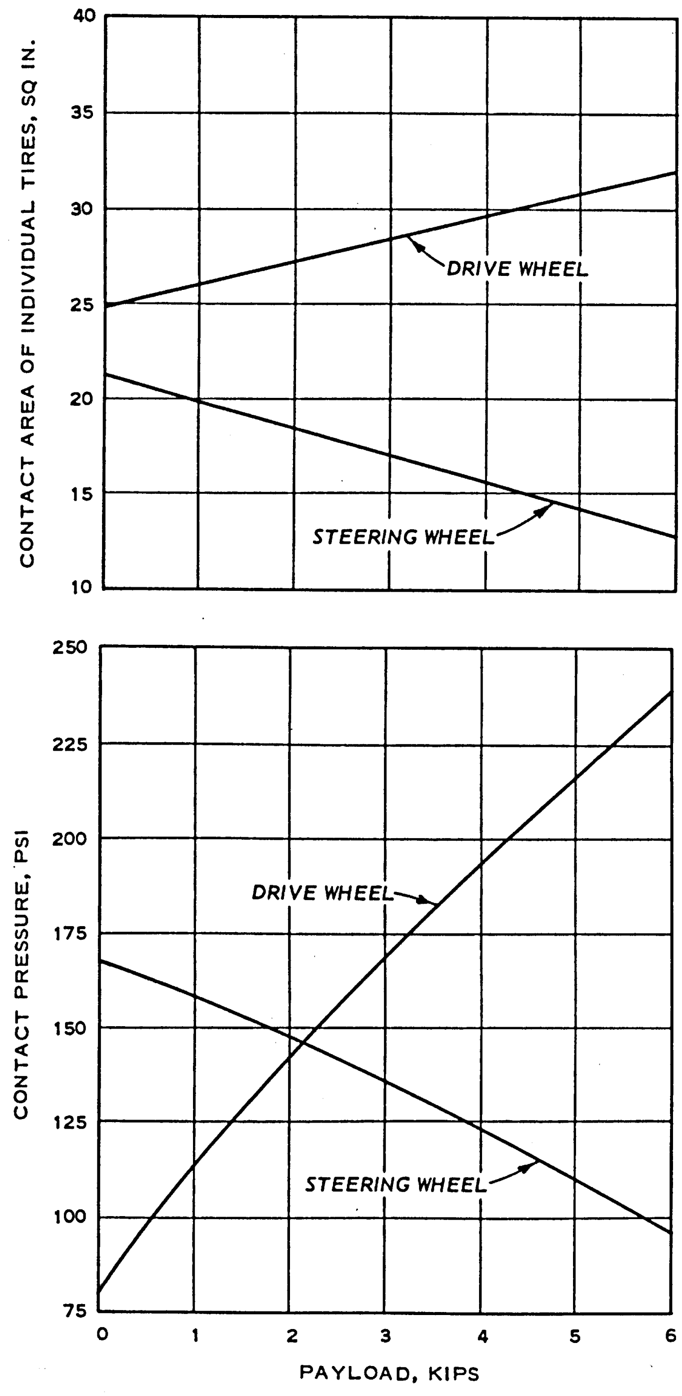
Photograph 33. Subgrades of items 1 and 2 at the completion of mat testing. Picture was taken before the additional traffic was run on the unsurfaced subgrade



a. 540-RS FORKLIFT

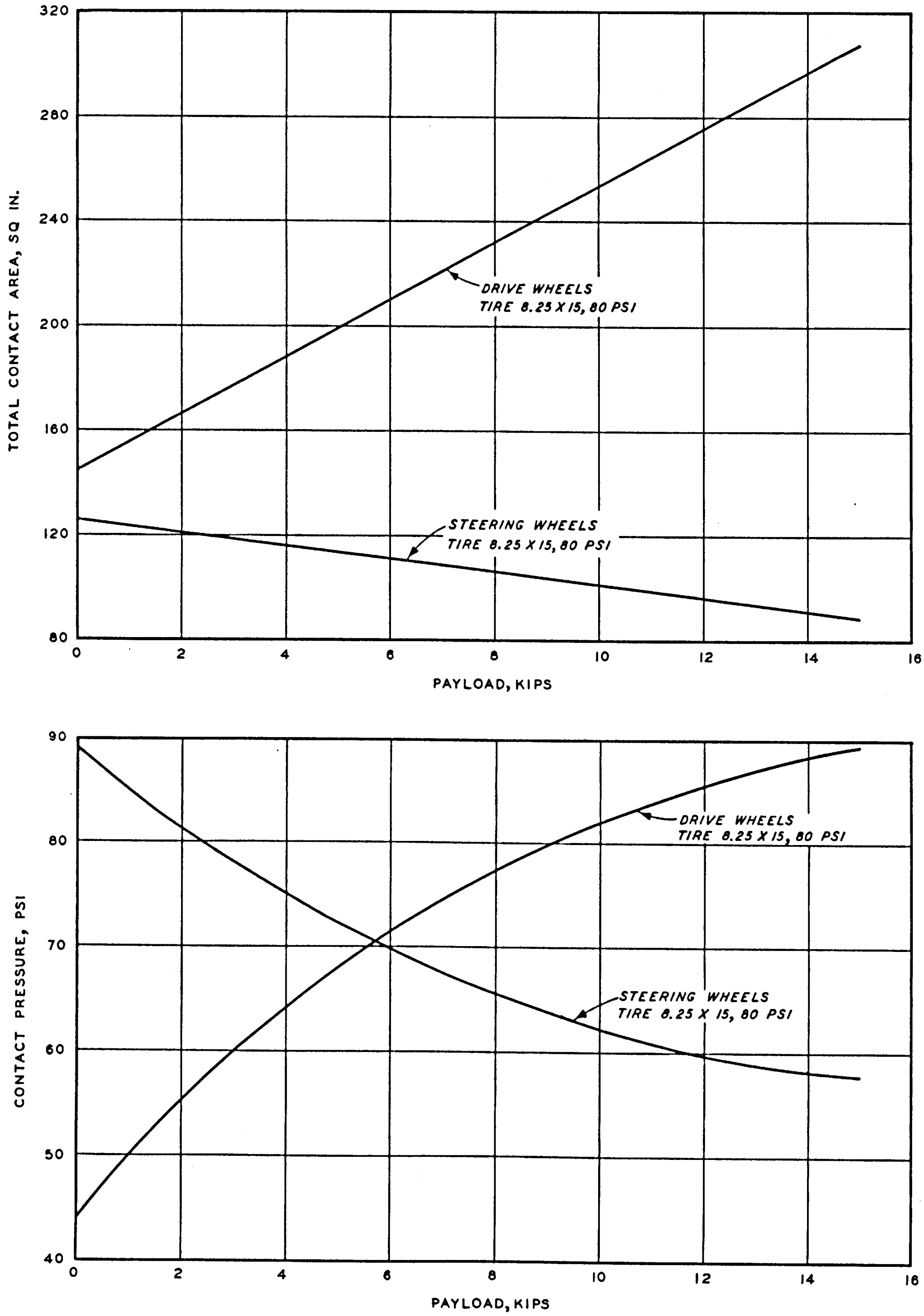
b. RT-150 FORKLIFT

LOAD COMPARISONS FOR VARIOUS LOADINGS OF MODELS 540-RS AND RT-150 FORKLIFTS

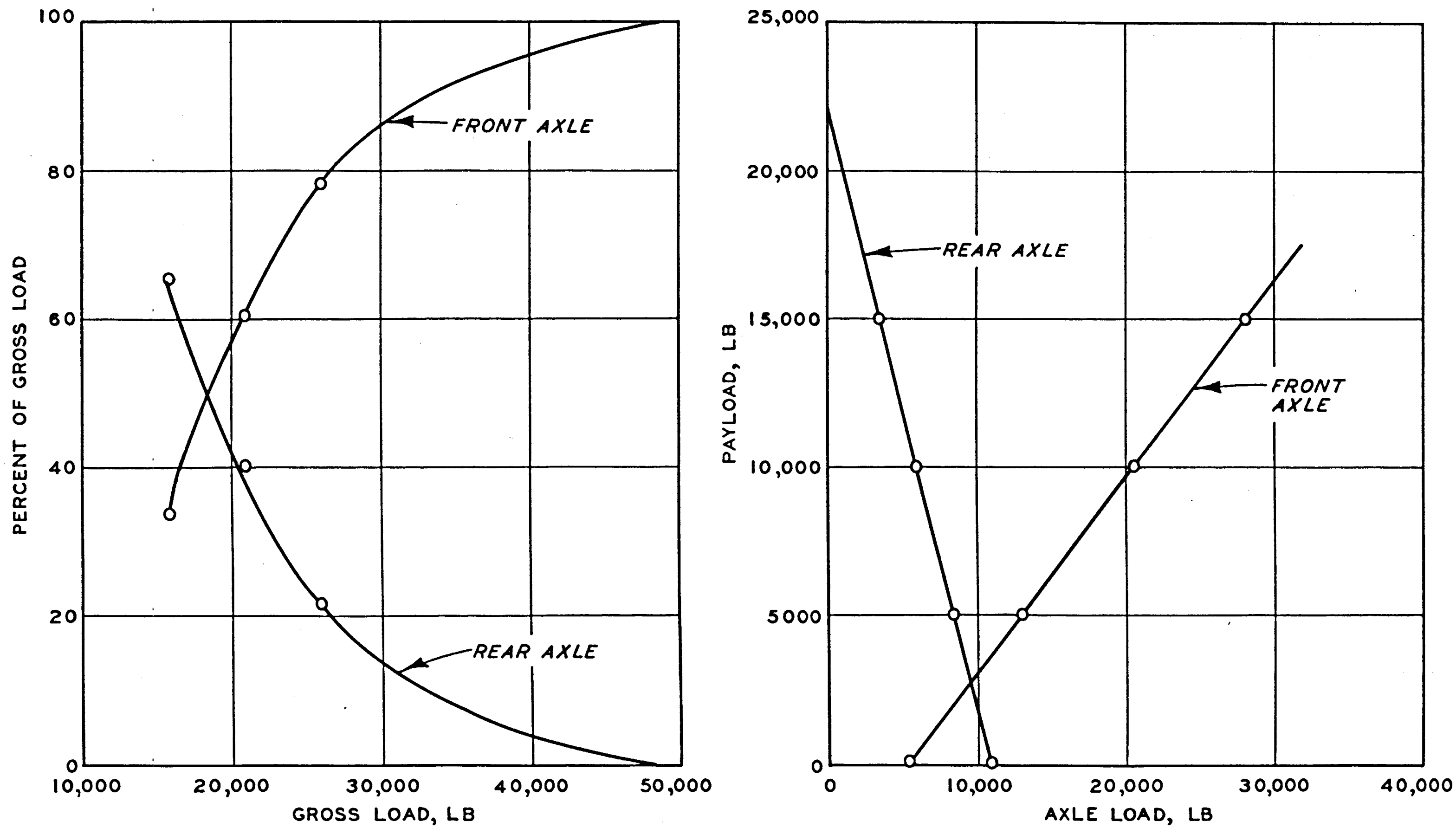


CONTACT AREA AND
CONTACT PRESSURE
VS PAYLOAD
MODEL 540-RS FORKLIFT

PLATE 2

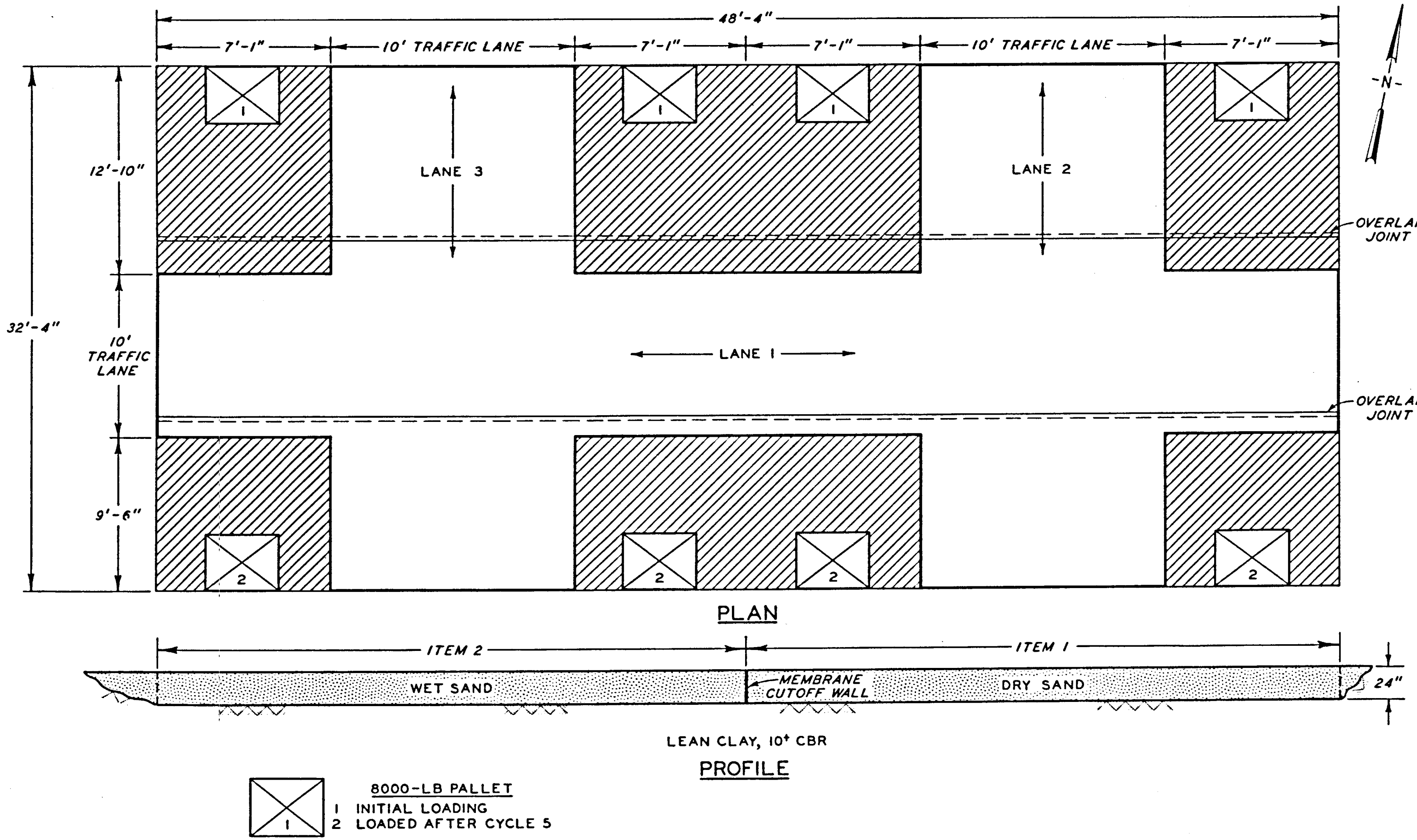


CONTACT AREA AND
CONTACT PRESSURE
VS PAYLOAD
MODEL RT-150 FORKLIFT

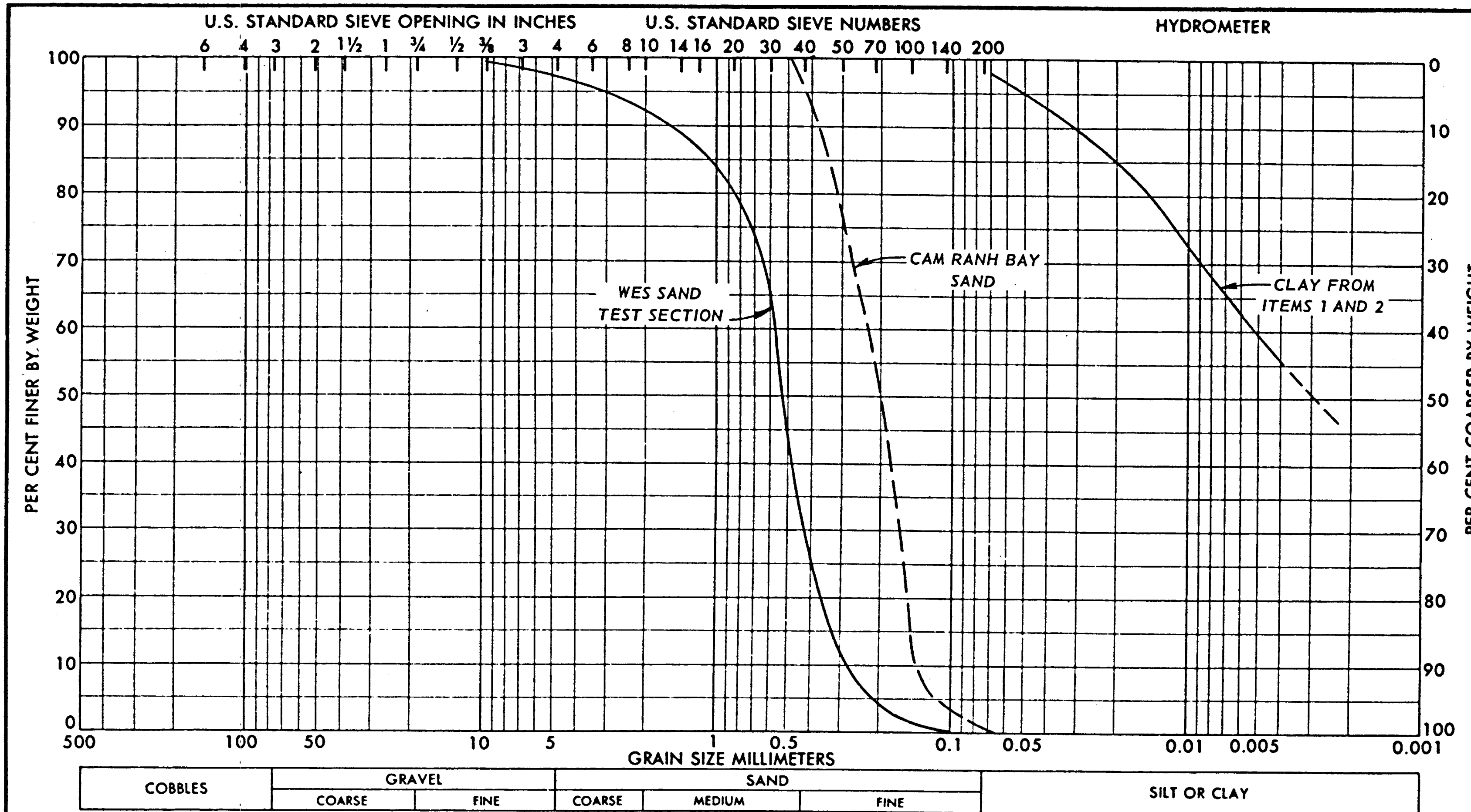


NOTE: GROSS WEIGHT (EMPTY)
= 17,070 LB.

LOAD DISTRIBUTION CURVES
HYSTER MODEL RT-150



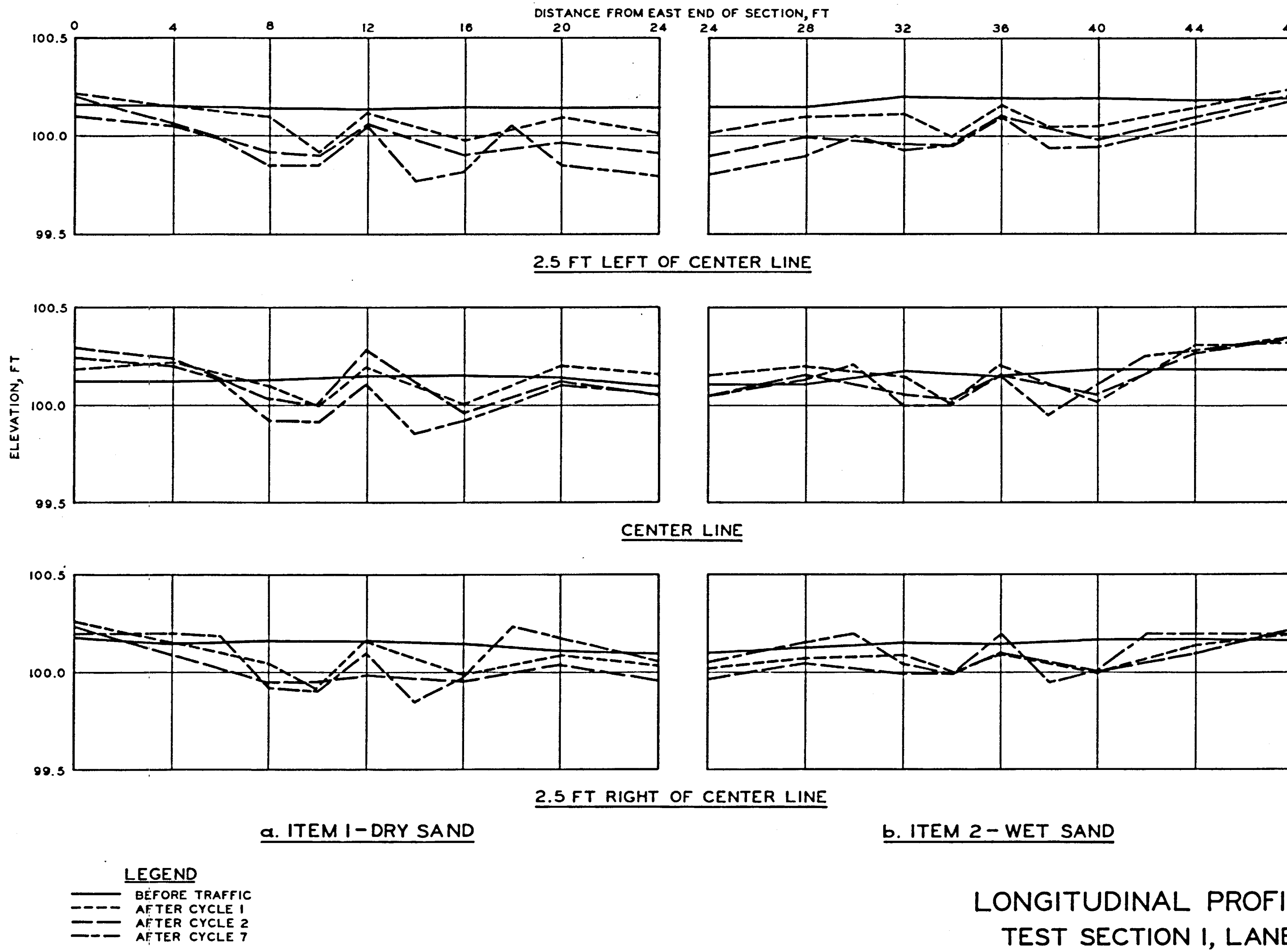
TEST SECTION LAYOUT
TEST SERIES I



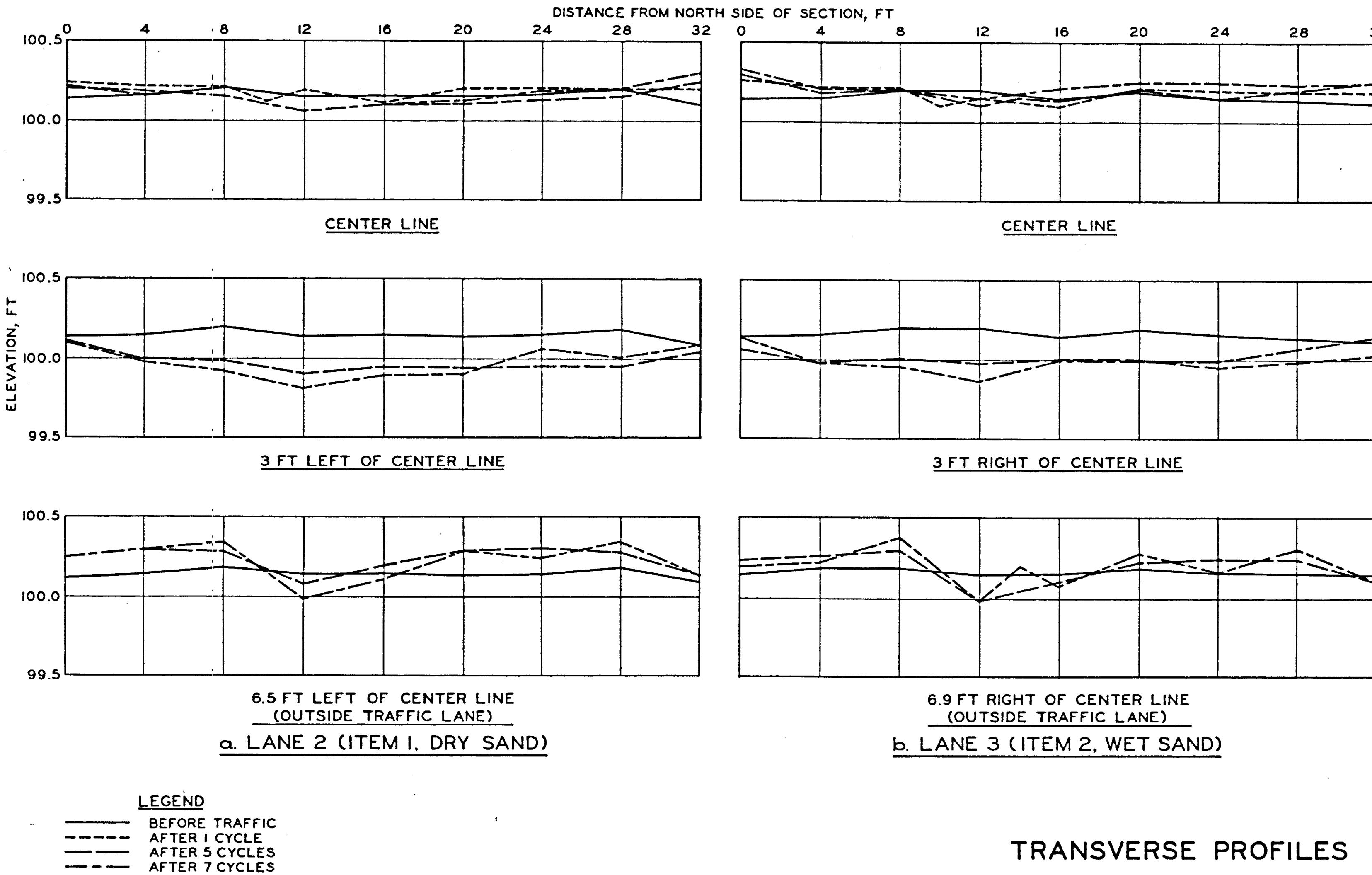
SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
WES	0-24"	SAND (SP) (NONPLASTIC)				
CAM RANH BAY		SAND (SP) (NONPLASTIC)				
WES	0-24"	HEAVY CLAY (CH)		58	25	33

COMPARISON OF CLASSIFICATION DATA AND GRADATION CURVES

WES SAND TEST SECTION, CAM RANH BAY SAND, AND CLAY USED IN ITEMS 1 AND 2

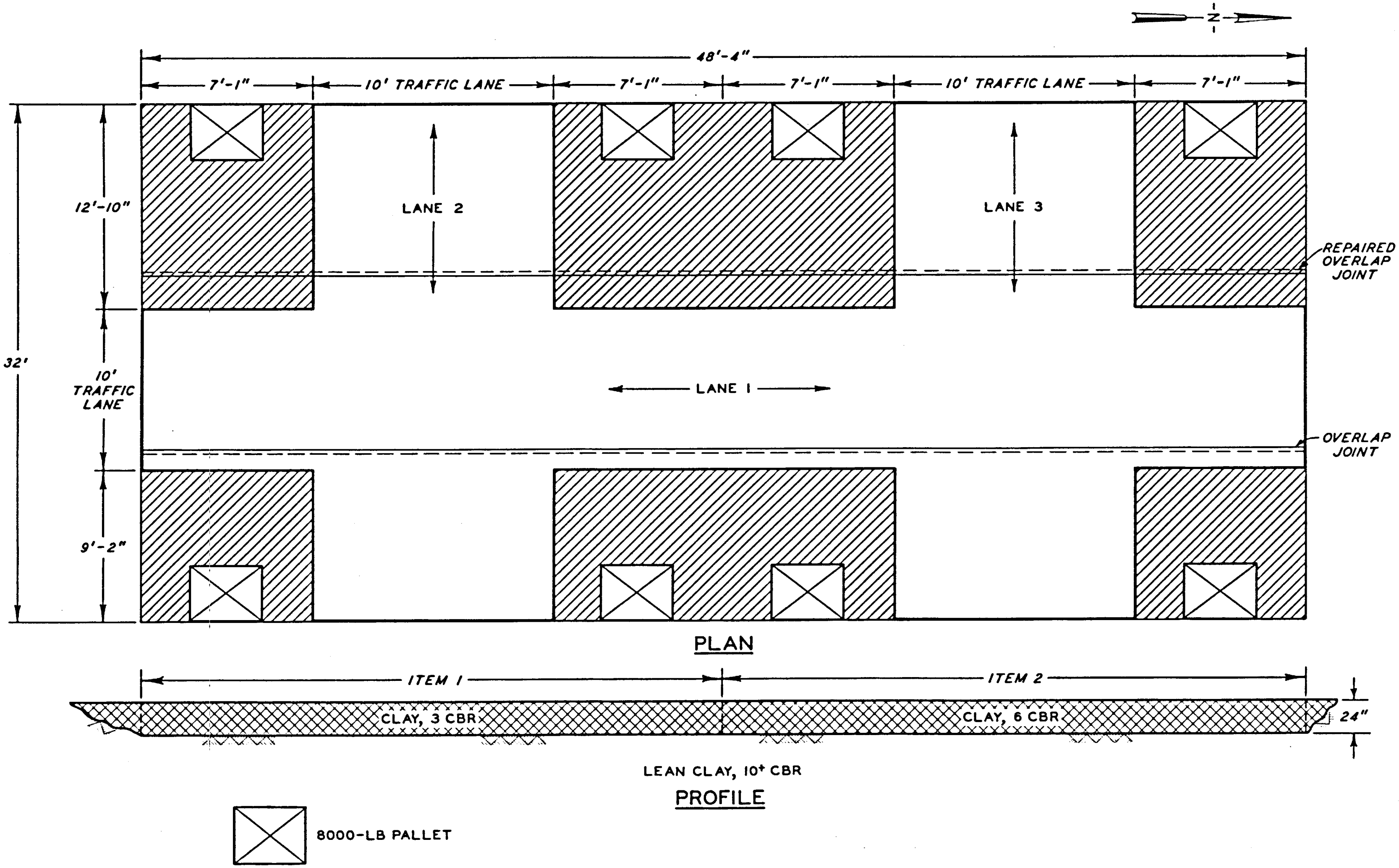


LONGITUDINAL PROFILES
TEST SECTION 1, LANE 1



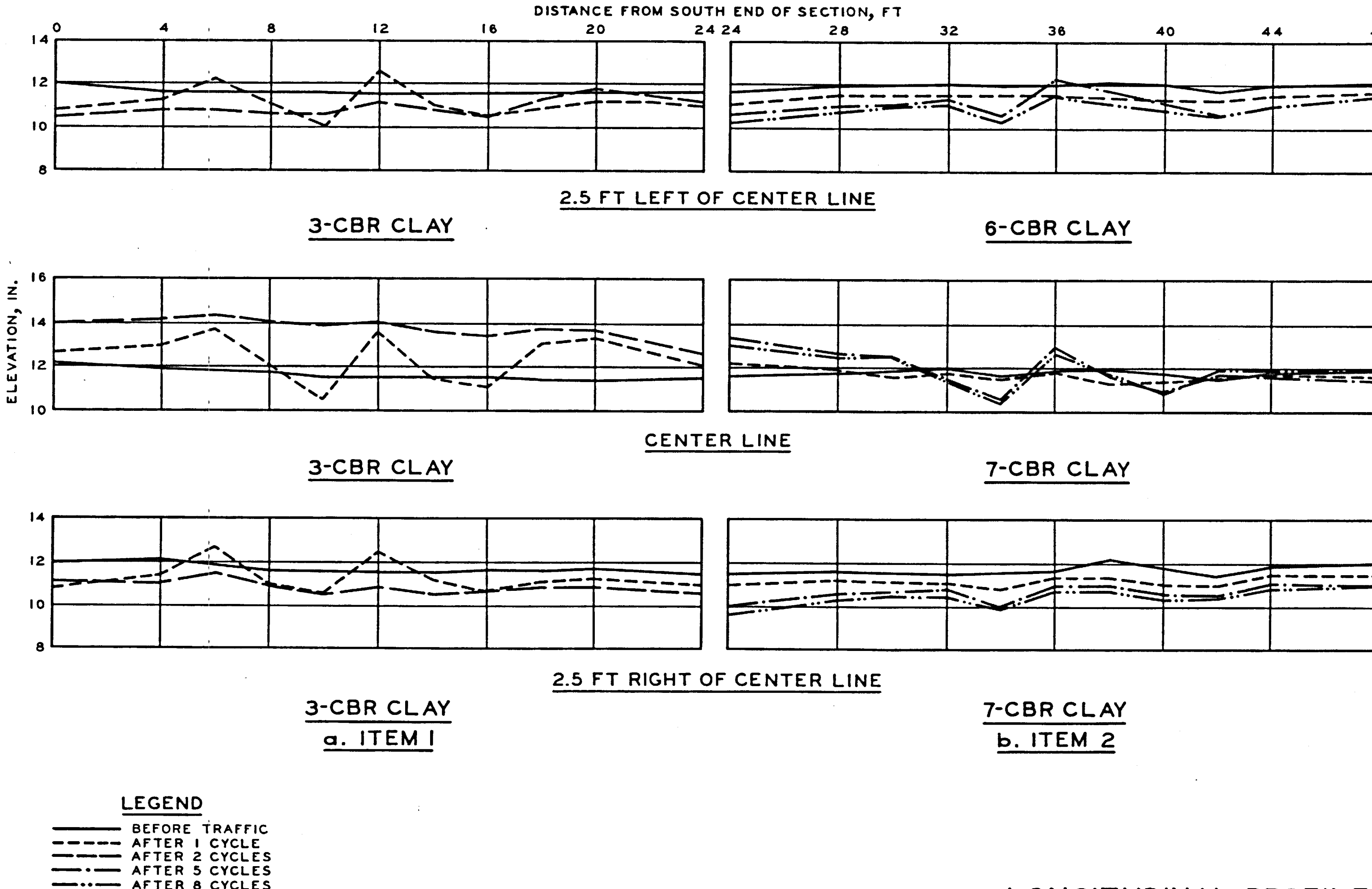
TRANSVERSE PROFILES

LANES 2 AND 3, TEST SECTION 1

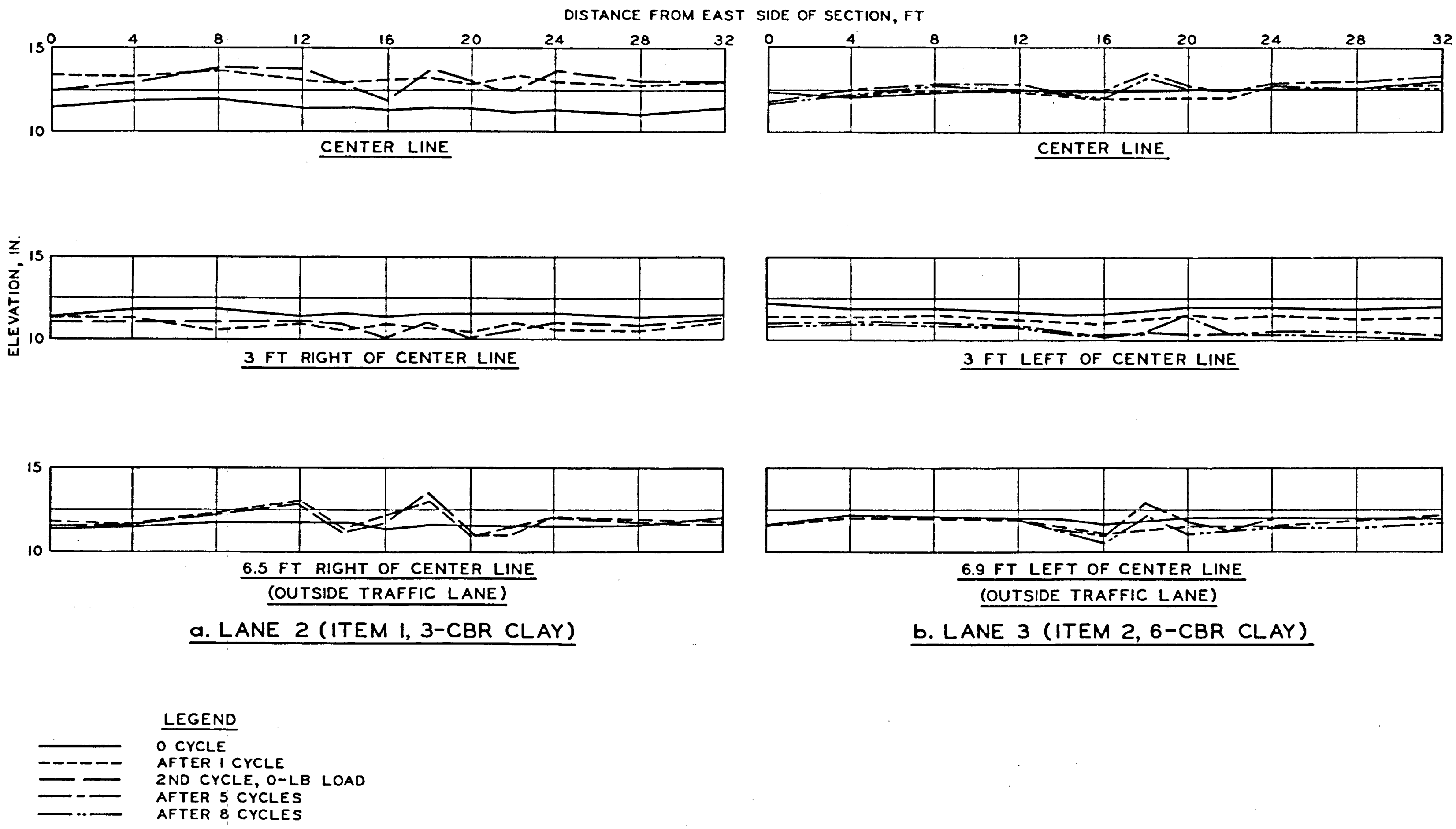


TEST SECTION LAYOUT
TEST SERIES II

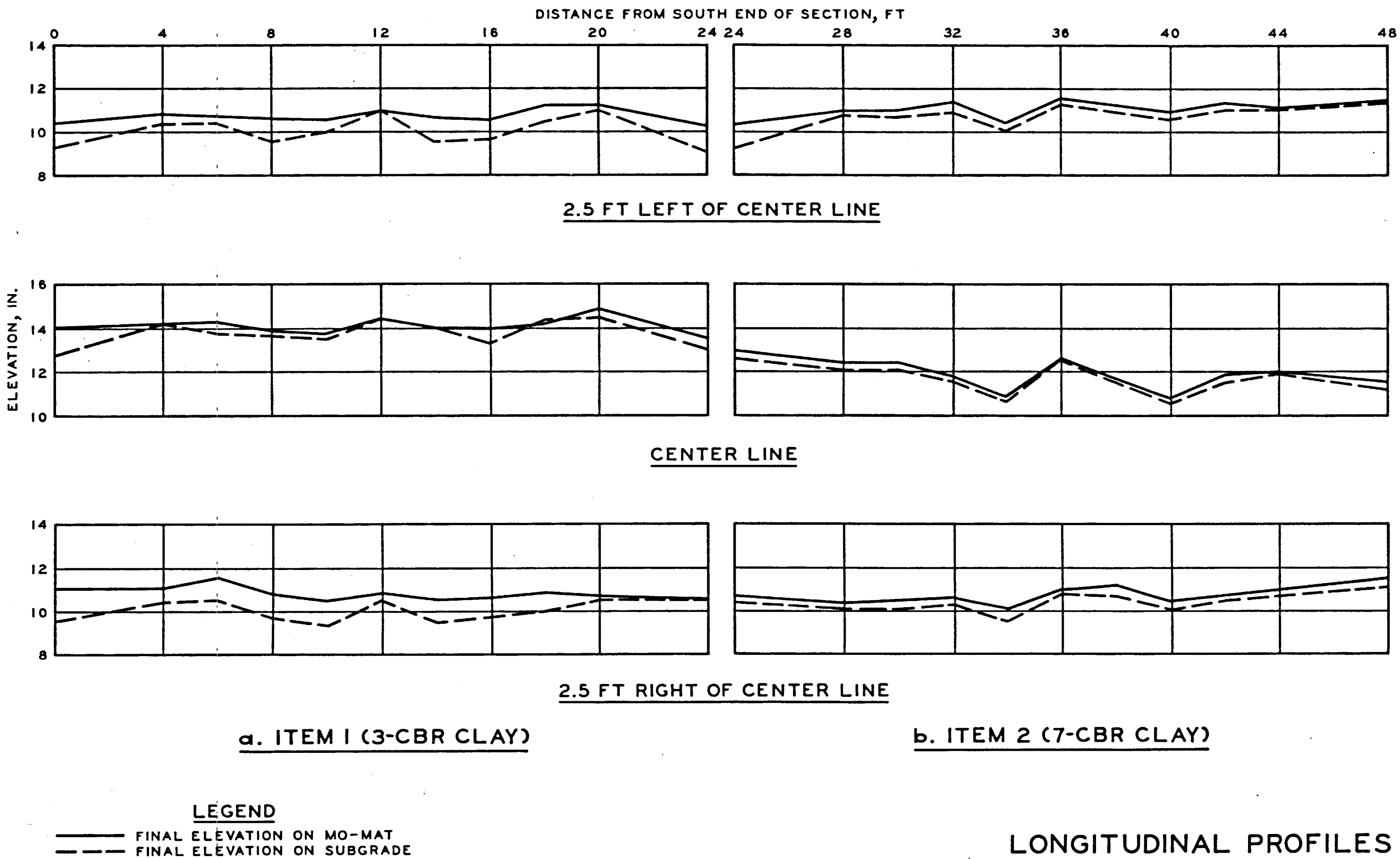
PLATE 9



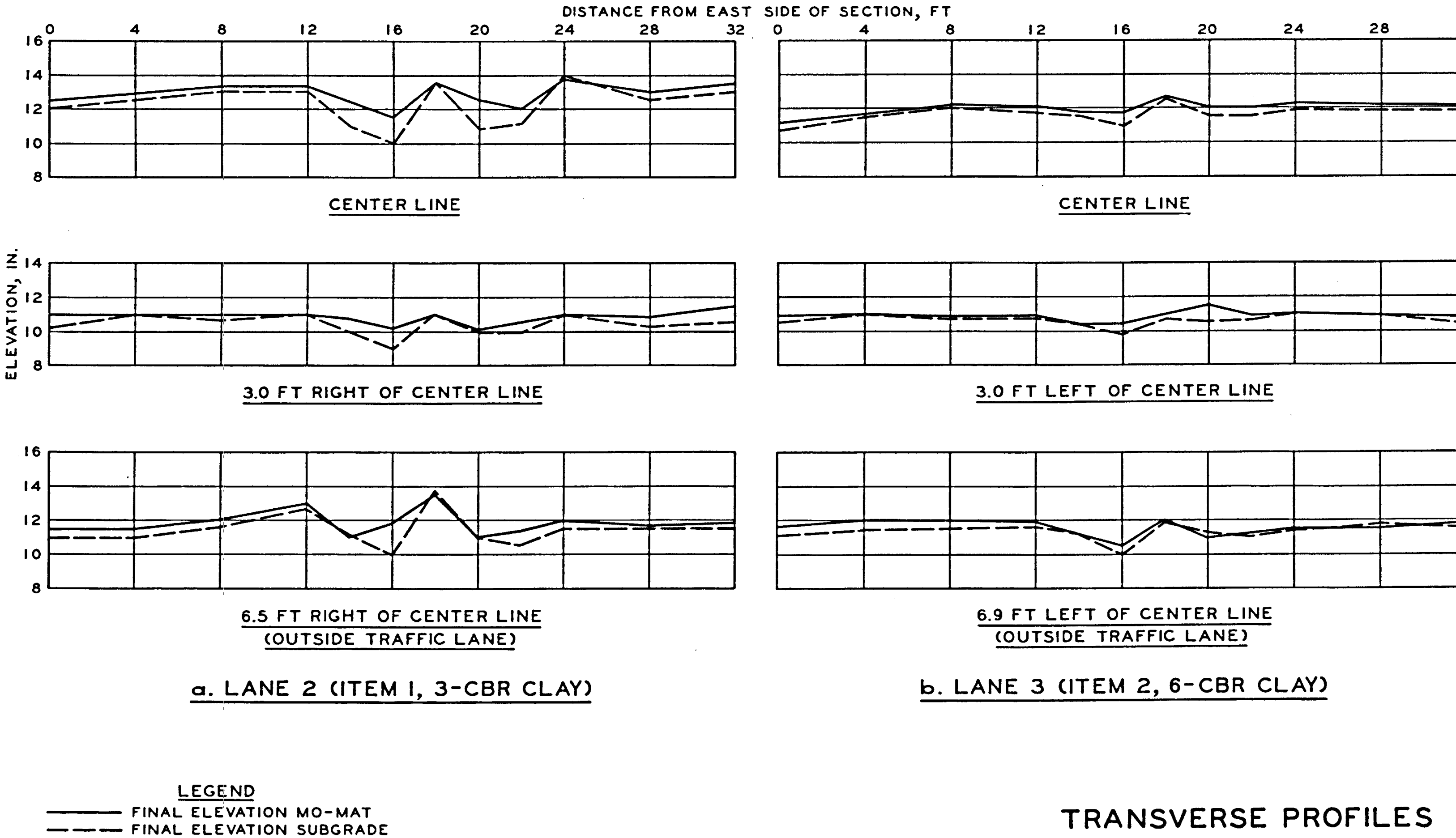
LONGITUDINAL PROFILES
LANE 1, TEST SECTION 2



TRANSVERSE PROFILES
TEST SECTION 2, LANES 2 AND 3



LONGITUDINAL PROFILES OF MAT AND SUBGRADE SHOWING BRIDGING
LANE 1, TEST SECTION 2
AFTER TRAFFIC



TRANSVERSE PROFILES
OF MAT AND SUBGRADE
SHOWING BRIDGING
LANES 2 AND 3, TEST SECTION 2
AFTER TRAFFIC

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

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

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[redacted]

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

U. S. Army Materiel Command
Washington, D. C.

13. ABSTRACT This report describes an investigation to evaluate a fiber glass-reinforced plastic material (STRATOGLAS) molded into a waffle-like configuration for use in Army depot open-storage areas. The mat, termed MO-MAT, was designed and fabricated by Air Logistics Corp., Pasadena, Calif. Individual panels are 50 ft long, 11 ft wide, and 0.085 in. thick, and weigh 570 lb. A single layer of mat was investigated in test series I on two different subgrades: a wet sand and a dry, loose sand. Traffic was applied with a Hyster Model RT-150 forklift with payloads of 0, 5000, 10,000, and 15,000 lb; a 2-1/2-ton M35 cargo truck with 35-psi tire pressure and a gross weight of 18,000 lb; a 5-ton M54 cargo truck with 35-psi tire pressure and a gross weight of 30,000 lb; and a Towmotor Model 540-RS forklift without a payload. A total of 8 cycles was completed on the test section, with 3870 passes applied to the high-intensity traffic areas. The Hyster RT-150 with the 15,000-lb payload was the most critical load. Minor maintenance was necessary on the test section during the investigation. In test series II, the single layer of mat was placed on two heavy clay subgrades: one with a CBR of 3 and one with a CBR of 6 to 7. Traffic was applied with the Hyster RT-150 forklift with payloads of 0, 5000, 10,000, and 15,000 lb. Eight cycles of traffic were applied to the test area, with a total of 4390 passes of traffic applied to the mat with the test vehicle. The most critical load, again, was the Hyster RT-150 with a 15,000-lb payload. Minor maintenance was again necessary. From these tests it was concluded that a single layer of MO-MAT was adequate as tested for use in Army depot open-storage areas, except on low-strength material (CBR of 3 or less). There was no distinct difference between the performance of the mat when placed on a dry sand or a wet sand. In single layers, the mat will perform satisfactorily for a period of several months with little maintenance.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified

Security Classification

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Mats						
MO-MAT						
Structural plastics						

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