AD NUMBER
AD805281
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; SEP 1966. Other requests shall be referred to Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH 45433.**
AUTHORITY
AFFDL ltr 29 Dec 1971

AFFDL-TR-66-43
PART XVIII

AIRCRAFT GROUND-FLOTATION INVESTIGATION

PART XVIII — DATA REPORT ON TEST SECTION 17

J. WATKINS and W. HILL, JR.

U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION

TECHNICAL REPORT AFFDL-TR-66-43, PART XVIII

SEPTEMBER 1966

AIR FORCE FLIGHT DYNAMICS LABORATORY
RESEARCH AND TECHNOLOGY DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

NOTICES

200 - December 1966 - C0192-15-276

AIRCRAFT GROUND-FLOTATION INVESTIGATION

PART XVIII — DATA REPORT ON TEST SECTION 17

J. WATKINS and W. HILL, JR.

FOREWORD

The investigation described herein constitutes one phase of studies conducted during 1964 and 1965 at the U. S. Army Engineer Waterways Experiment Station (WES) under U. S. Air Force Project No. 410-A, MIPR No. AS-4-177, "Development of Landing Gear Design Criteria for the CX-HLS Aircraft." (The CX-HLS is now designated C-5A.) This project was sponsored and directed by the Landing Gear Group, Air Force Flight Dynamics Laboratory, Research and Technology Division, Mr. R. J. Parker, Project Engineer.

These tests were conducted by personnel of the WES Flexible Pavement Branch, Soils Division, under the general supervision of Messrs. W. J. Turnbull, A. A. Maxwell, and R. G. Ahlvin, and the direct supervision of Mr. D. N. Brown. Other personnel actively engaged in this study were Messrs. C. D. Burns, D. M. Ladd, W. N. Brabston, J. E. Watkins, H. H. Ulery, Jr., A. J. Smith, Jr., and W. J. Hill, Jr. This report was prepared by Messrs. Watkins and Hill.

Directors of WES during the conduct of this investigation and preparation of this report were Col. Alex G. Sutton, Jr., CE, and Col. John R. Oswalt, Jr., CE. Technical Director was Mr. J. B. Tiffany.

Publication of this technical documentary report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

K H Digges

KENNERLY H. DIGGES
Chief, Mechanical Branch
Vehicle Equipment Division
AF Flight Dynamics Laboratory

ABSTRACT

This data report describes work undertaken as part of an overall program to develop ground-flotation criteria for the C-5A aircraft. A test section was constructed to a width adequate for two test lanes. The test lanes were unsurfaced and each lane was divided into two items having different subgrade CBR values. Traffic was applied to both lanes using a 35,000-lb load with a single-wheel assembly. For one lane the wheel assembly consisted of a single 56x16, 38-ply aircraft tire and for the other lane a single 56x16, 24-ply aircraft tire was used. Tire inflation pressure was 100 psi for both assemblies.

This report presents the data collected during trafficking on soil strengths, surface deformations and deflections, and drawbar pull. The traffic-coverage level at which each test item was considered failed is also given.

CONTENTS

ILLUSTRATIONS AND TABLES

SUMMARY

Tests on Section 17 are one phase of a comprehensive research program to develop ground-flotation criteria for heavy cargo-type aircraft. Section 17 consisted of two similar unsurfaced test lanes, lanes 36 and 37, each of which was divided into two items having different subgrade CBR values (figure 9).

Traffic was applied to the two lanes using a 35,000-lb load on a single-wheel assembly. On lanes 36 and 37, the wheel assemblies consisted of a 56x16, 38-ply aircraft tire and a 56x16, 24-ply aircraft tire, respectively. Tire inflation pressure was 100 psi. Figure 10 gives pertinent tire-print dimensions and tire characteristics.

The lanes were trafficked to failure in accordance with the criteria designated in Part I of this report. Data were recorded throughout testing to give a behavior history of each item. Using the test criteria mentioned above, it was possible to directly compare the effects of trafficking with identical single-wheel assemblies having different ply tires. Basic performance data are summarized in the following paragraphs.

Lane 36

Item 1

The item was considered failed at 4 coverages due to rutting and excessive transverse differential deformations. The rated CBR was 6.7.

Item 2

The item was considered failed at 16 coverages due to rutting and excessive transverse differential deformations. The rated CBR was 9.2.

Lane 37

Item 1

The item was considered failed at 10 coverages due to rutting and excessive transverse differential deformations. The rated CBR was 6.7.

Item 2

The item was considered failed at 50 coverages due to excessive transverse differential deformations. The rated CBR was 11.

AIRCRAFT GROUND-FLOTATION INVESTIGATION

PART XVIII DATA REPORT ON TEST SECTION 17

SECTION I: INTRODUCTION

The investigation reported herein is one phase of a comprehensive research program being conducted at the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., as part of U. S. Air Force Project 410-A, MIPR No. AS-4-177, to develop ground-flotation criteria for the C-5A, a heavy cargo-type aircraft. Specifically, the tests reported herein were conducted to determine the effect of tire ply rating of single-wheel landing-gear assemblies on unsurfaced soils under identical conditions of loading.

Prosecution of this investigation consisted of constructing two similar test lanes and subjecting them to traffic of 35,000-lb loads on single-wheel assemblies differing only in tire ply rating. This report presents a description of the test section and wheel assemblies, and gives results of traffic. Equipment used, types of data and method of recording them, and general test criteria are summarized in this part; more complete explanations and illustrations appear in Part I of this report.

SECTION II: DESCRIPTION OF TEST SECTION AND LOAD VEHICLE

Description of Test Section

Test Section 17 (figure 9) was constructed within a roofed area in order to allow control of the subgrade CBR (California Bearing Ratio) in the test items. Section 17 was located on the same site as prior Test Sections 14, 6, 4, and 2 in this series; the original construction of the site is described in Part III of this report. The underlying subgrade was undisturbed by prior tests on the site so that in construction of Section 17 only the upper 24 in. of soil was excavated. The surface exposed by excavation was scarified and recompacted before backfilling the area in four compacted lifts with a heavy clay soil (buckshot; classified as CH according to the Unified Soil Classification System, MIL-STD-619). The fill material used was a local clay with a plastic limit of 27, liquid limit of 58, and plasticity index of 31. Gradation and classification data for the subgrade material are given in Part I.

Two unsurfaced traffic lanes, each divided into two items, were constructed in the test section. Different subgrade strengths were obtained in the items (figure 9) by controlling the water content and compaction effort.

Load Vehicle

The load vehicle used for trafficking the test lanes in Section 17 is shown in figure 2. Load cart construction, details of linkage between the load compartment and prime mover, and method of applying load are explained in Part I. For trafficking lanes 36 and 37, single-wheel assemblies were used with a 35,000-lb load. A 56x16, 38-ply aircraft tire and a 56x16, 24-ply aircraft tire were used on lanes 36 and 37, respectively. Tire inflation pressure was 100 psi for both assemblies. Tireprint data and pertinent tire characteristics are given in figure 10.

SECTION III: APPLICATION OF TRAFFIC, FAILURE CRITERIA, AND DATA COLLECTED

Application of Traffic

Traffic was applied to the test lanes in a nonuniform pattern with intensity of traffic being varied within each lane to produce three zones of approximately 100, 80, and 20 percent traffic coverage. Traffic so distributed within a traffic lane simulates as nearly as possible the bell-shaped traffic distribution curve which results from the wander of aircraft from the lane center line. The coverage levels recorded in the tables and text of this report are the total number of coverages applied to the 100 percent coverage zone. The corresponding number of coverages applied to the outer traffic zones is proportional to the percentage factor for the respective zones as shown in figure 1.

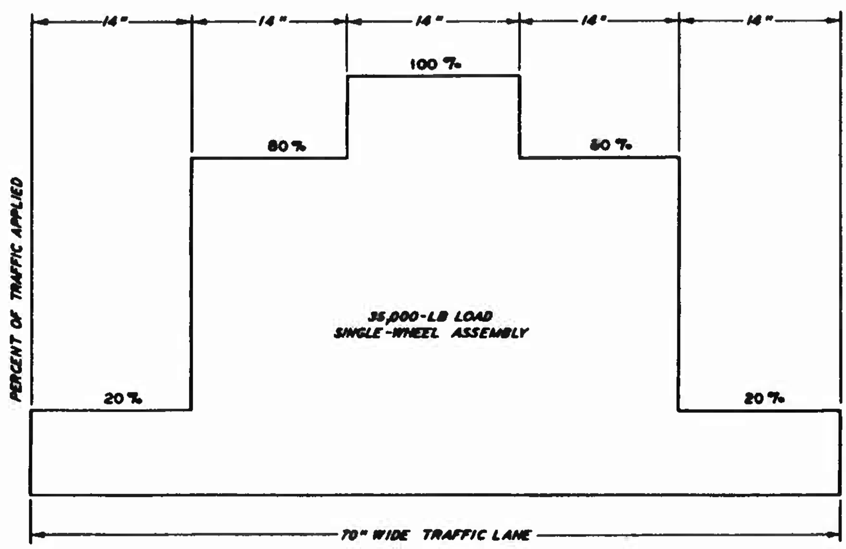


Figure 1. Traffic distribution pattern for lanes 36 and 37

Failure Criteria and Data Collected

Failure criteria used in this investigation and descriptive terms used in presentation and discussion of data in all reports in this series are presented in Part I. A general outline of types of data collected is given in the following paragraphs. Details on apparatus and procedure for obtaining specific measurements are given in Part I.

CBR, water content, and dry density

CBR, water content, and dry density of the subgrade were measured for each test item prior to application of traffic, at intermediate coverage levels, and at failure. After traffic was concluded on an item, a measure of subgrade strength termed "rated CBR" was determined. Rated CBR is generally the average CBR value obtained from all the determinations made in the top 12 in. of soil during the test life of an item. In certain instances, extreme or irregular values may be ignored if the analyst decides that they are not properly representative.

Surface roughness, or differential deformation

Surface roughness, or differential deformation, measurements were made using a 10-ft straightedge at various traffic-coverage levels on all items. Rut depths were also measured.

Deformations

Deformations, defined as permanent cumulative surface changes in cross section or profile of an item, were charted by means of level readings at pertinent traffic-coverage levels.

Deflection

Deflection of the test surface under an individual static load of the tracking assembly was measured at various traffic-coverage levels. A pin and cap device was used to measure deflection directly beneath the load wheel. Both total and elastic (recoverable) deflections were measured.

Rolling resistance

Rolling resistance, or drawbar pull, measurements were performed with the load vehicle over each test item at designated coverage levels. Apparatus and procedure for determining drawbar pull values are illustrated and explained in Part I.

SECTION IV: BEHAVIOR OF ITEMS UNDER TRAFFIC AND TEST RESULTS

Lane 36

Behavior of items under traffic

Item 1. Item 1 prior to traffic is shown in figure 3. The surface of the subgrade deformed readily under traffic and at 4 coverages the item was considered failed due to rutting and excessive differential deformations (figure 4). The rated CBR of the item was 6.7.

Item 2. Item 2 prior to traffic is shown in figure 3. At 16 coverages the item was considered failed due to rutting and excessive differential deformations (figure 5). The rated CBR of the item was 9.2.

Test Results

Results of trafficking lane 36 are summarized in table 1. Soil test data are given in table 2.

Item 1. Item 1 was considered failed at 4 coverages. The following information was obtained from traffic tests on item 1.

a. Roughness. Transverse and diagonal differential deformations and rut depths were about equal throughout trafficking (table 1), with each averaging 4.75 in. at failure. Longitudinal differential deformations were insignificant.

b. Deformation. Average cross-section deformations at 4 coverages are shown in figure 11. Considerable soil upheaval above the original grade level is evident in the figure. Figure 12 shows a profile along the lane center line at 4 coverages, illustrating the uniform longitudinal subsidence.

c. Deflection. The total and elastic subgrade deflections at 0 and 4 coverages are shown in table 1. Total deflection increased from 1.5 to 1.6 in. while elastic deflection increased from 0.5 to 1.0 in.

d. Rolling resistance. Drawbar pull values at 0 and 4 coverages are shown in table 1. Peak drawbar pull increased with traffic from 3.7 to 5.0 kips while rolling drawbar pull increased only slightly from 2.4 to 2.8 kips.

Item 2. Item 2 was considered failed at 16 coverages. The following information was obtained from traffic tests on item 2.

a. Roughness. Rut depths and differential deformations increased consistently with traffic (table 1). Transverse differential deformation and rut depths averaged 3.84 in. at failure while average diagonal differential deformation was 3.97 in.

b. Deformation. Average cross-section deformations at 4 and 16 coverages are shown in figure 11. Figure 12 shows a profile along the item center line at 4 and 16 coverages illustrating progressive subsidence of the subgrade along the entire item length as traffic continued.

c. Deflection. Application of traffic produced no significant change in total and elastic subgrade deflections (table 1). Elastic deflection increased from 0.5 to 0.6 in. while total deflection was 0.8 in. before and after traffic with an intermediate measurement of 1.0 in. at 4 coverages.

d. Rolling resistance. Peak and rolling drawbar pull increased with traffic, measuring 3.0 and 2.1 kips, respectively, at failure.

Lane 37

Behavior of items under traffic

Item 1. Item 1 prior to traffic is shown in figure 6. At 10 coverages the item was considered failed due to rutting and excessive differential deformations (figure 7). The rated CBR of the item was 6.7.

Item 2. Item 2 prior to traffic is shown in figure 6. At 50 coverages the item was considered failed due to rutting and excessive differential deformations (figure 8). The rated CBR of the item was 11.

Test results

Results of trafficking lane 37 are summarized in table 1. Soil test data are given in table 2.

Item 1. Item 1 was considered failed at 10 coverages. The following information was obtained from traffic tests on item 1.

a. Roughness. Differential deformations and rut depths developed consistently with traffic (table 1). Transverse and diagonal differential deformations and rut depths each averaged 4.63 in. at failure.

b. Deformation. The average cross-section deformation at 10 coverages is shown in figure 11. The longitudinal center-line rut indicated in the cross-section plot is the area represented in the center-line profile shown in figure 12 where general subsidence along the lane is indicated.

c. Deflection. Total subgrade deflection (0.9 in.) was unchanged with traffic while elastic subgrade deflection increased from 0.4 to 0.7 in. (table 1).

d. Rolling resistance. Drawbar pull values at 0 and 10 coverages are shown in table 1. Peak drawbar pull increased from 2.0 to 4.3 kips while rolling drawbar pull increased from 1.5 to 3.5 kips.

Item 2. Item 2 was considered failed at 50 coverages. The following information was obtained from traffic tests on item 2.

a. Roughness. Average transverse differential deformation was 3.56 in. at failure. Average diagonal differential deformation and average rut depth were both 3.31 in. (table 1).

b. Deformation. Average cross-section deformations at 10 and 50 coverages are shown in figure 11. Severity of rutting increased considerably between the two coverage levels. Figure 12 shows center-line profiles at 10 and 50 coverages, and indicates that longitudinal subsidence increased consistently with traffic.

c. Deflection. Total subgrade deflection increased from 0.4 to 0.7 in. with traffic while elastic subgrade deflection increased from 0.1 to 0.2 in. (table 1).

d. Rolling resistance. Drawbar pull values at 0, 10, and 50 coverages are shown in table 1. Peak drawbar pull increased from 1.5 to 2.6 kips while rolling drawbar pull increased from 1.2 to 2.0 kips.

SECTION V: PRINCIPAL FINDINGS

From the foregoing discussion, the principal findings relating test load, wheel assembly, tire inflation pressure, subgrade CBR, and traffic coverages are as follows:

Load, Wheel Assembly, and Tire Pressure	Test Item	Rated Subgrade CBR*	Coverages at Failure
	Lane 36		
35,000-lb load; single-wheel assembly; 56x16, 38-ply tire at 100-psi inflation pressure	1	6.7	4
	2	9.2	16
	Lane 37		
35,000-lb load; single-wheel assembly; 56x16, 24-ply tire at 100-psi inflation pressure	1	6.7	10
	2	11	50

* All test items were unsurfaced.

TABLE 1

SUMMARY OF TRAFFIC DATA, TEST SECTION 17

Test Item	Cover-ages	Rated CBR	Differential Deformation (in.) Transverse Max	Differential Deformation (in.) Transverse Avg	Differential Deformation (in.) Diagonal Max	Differential Deformation (in.) Diagonal Avg	Rut Depths (in.) Max	Rut Depths (in.) Avg	Drawbar Pull (kips) Peak	Drawbar Pull (kips) Roll-ing	Subgrade Deflection at Center Line of Wheel Assembly (in.) Total	Subgrade Deflection at Center Line of Wheel Assembly (in.) Elastic	Remarks
Lane 36													
1	0		--	--	--	--	--	--	3.7	2.4	1.5	0.5	Item failed
Unsurfaced	2	6.7	4.63	4.22	4.75	4.28	4.63	4.22	--	--	--	--	at 4
	4		6.25	4.75	6.38	4.75	6.25	4.75	5.0	2.8	1.6	1.0	coverages
2	0		--	--	--	--	--	--	2.3	1.5	0.8	0.5	Item failed
Unsurfaced	2	9.2	2.0	1.91	2.0	1.83	2.0	1.91	--	--	--	--	at 16
	4		3.0	2.31	2.5	2.25	3.0	2.31	2.4	2.0	1.0	0.6	coverages
	16		4.0	3.84	4.5	3.97	4.0	3.84	3.0	2.1	0.8	0.6	
Lane 37													
1	0		--	--	--	--	--	--	2.0	1.5	0.9	0.4	Item failed
Unsurfaced	2	6.7	1.75	1.28	--	--	1.75	1.28	--	--	--	--	at 10
	10		5.00	4.63	5.00	4.63	5.00	4.63	4.3	3.5	0.9	0.7	coverages
2	0		--	--	--	--	--	--	1.5	1.2	0.4	0.1	Item failed
Unsurfaced	2		0.50	0.44	--	--	0.50	0.44	--	--	--	--	at 50
	10	11.0	1.38	1.06	1.38	1.00	1.38	1.00	1.8	1.5	0.4	0.1	coverages
	30		2.88	2.28	2.63	2.19	2.88	2.28	--	--	--	--	
	50		4.50	3.56	4.00	3.31	4.00	3.31	2.6	2.0	0.7	0.2	

Note: A 35,000-lb load on a single-wheel assembly was used for trafficking. On lane 36 a 56x16, 38-ply tire was used and on lane 37 a 56x16, 24-ply tire was used. Tire inflation pressure was 100 psi.

TABLE 2

SUMMARY OF CBR, DENSITY, AND WATER CONTENT DATA, TEST SECTION 17

Test Item*	Coverages	Depth (in.)	CBR	Water Content (%)	Dry Density (lb/cu ft)	Remarks
			Lane 36			
1	0	0	6	24.7	98.1	Item failed at 4 coverages
		6	7	23.6	97.9	
		12	7	23.3	100.0	
	0	0	6	23.5	100.4	
		6	7	23.8	99.4	
		12	7	23.1	99.3	
	4	0	6	23.9	99.7	
		6	7	22.3	101.2	
		12	7	25.2	97.2	
2	0	0	10	22.2	102.6	Item failed at 16 coverages
		6	9	24.7	98.1	
		12	10	22.8	101.3	
	0	0	10	21.4	102.6	
		6	9	22.2	100.9	
		12	10	21.4	101.7	
	16	0	7	22.7	100.9	
		6	8	22.1	102.6	
		12	11	20.9	103.6	
			Lane 37			
1	0	0	6	24.7	98.1	Item failed at 10 coverages
		6	7	23.6	97.9	
		12	7	23.3	100.0	
	0	0	6	23.5	100.4	
		6	7	23.8	99.4	
		12	7	23.1	99.3	
	10	0	7	23.4	99.6	
		6	6	23.9	99.1	
		12	7	24.2	98.8	
2	0	0	10	22.2	102.6	Item failed at 50 coverages
		6	9	24.7	98.1	
		12	10	22.8	101.3	
	0	0	10	21.4	102.6	
		6	9	22.2	100.9	
		12	10	21.4	101.7	
	50	0	11	21.8	102.3	
		6	9	21.2	102.7	
		12	14	21.0	104.1	

Note: All items were unsurfaced.
* Subgrade material was a heavy clay (buckshot; classified as CH) in all items.

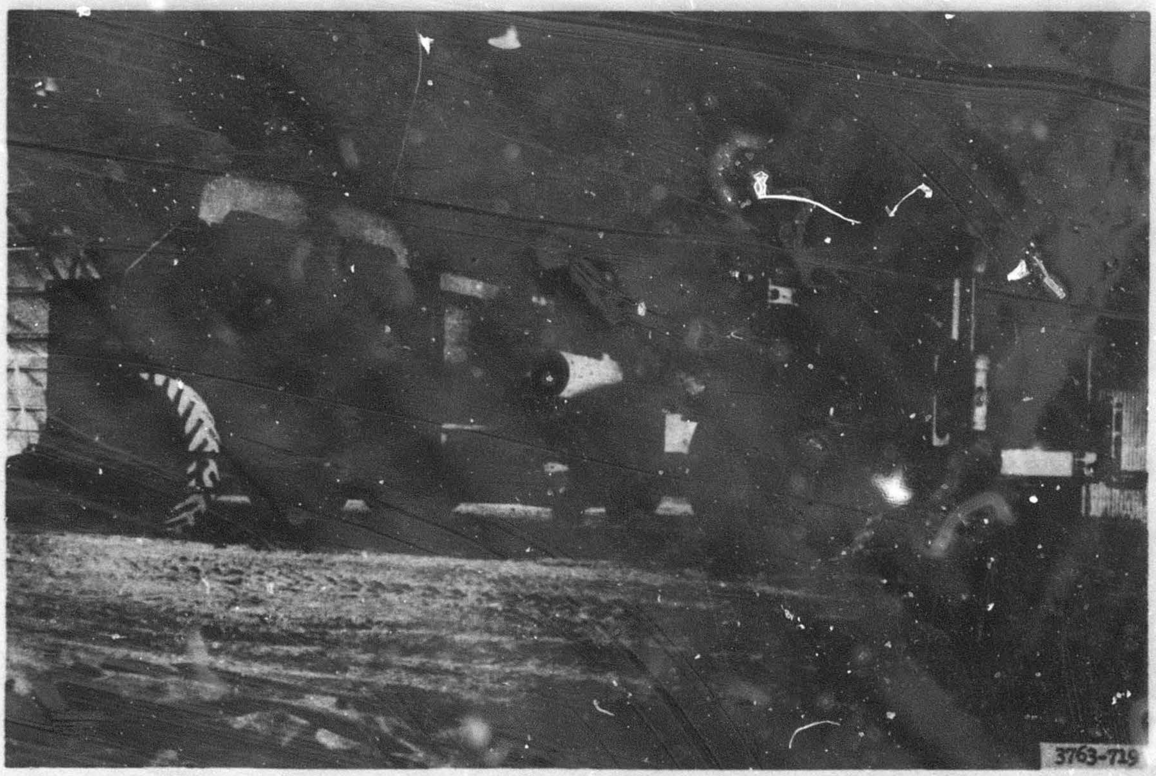


Figure 2. Load vehicle used in trafficking Test Section 17

Figure 3. Lane 36, items 1 and 2, prior to traffic

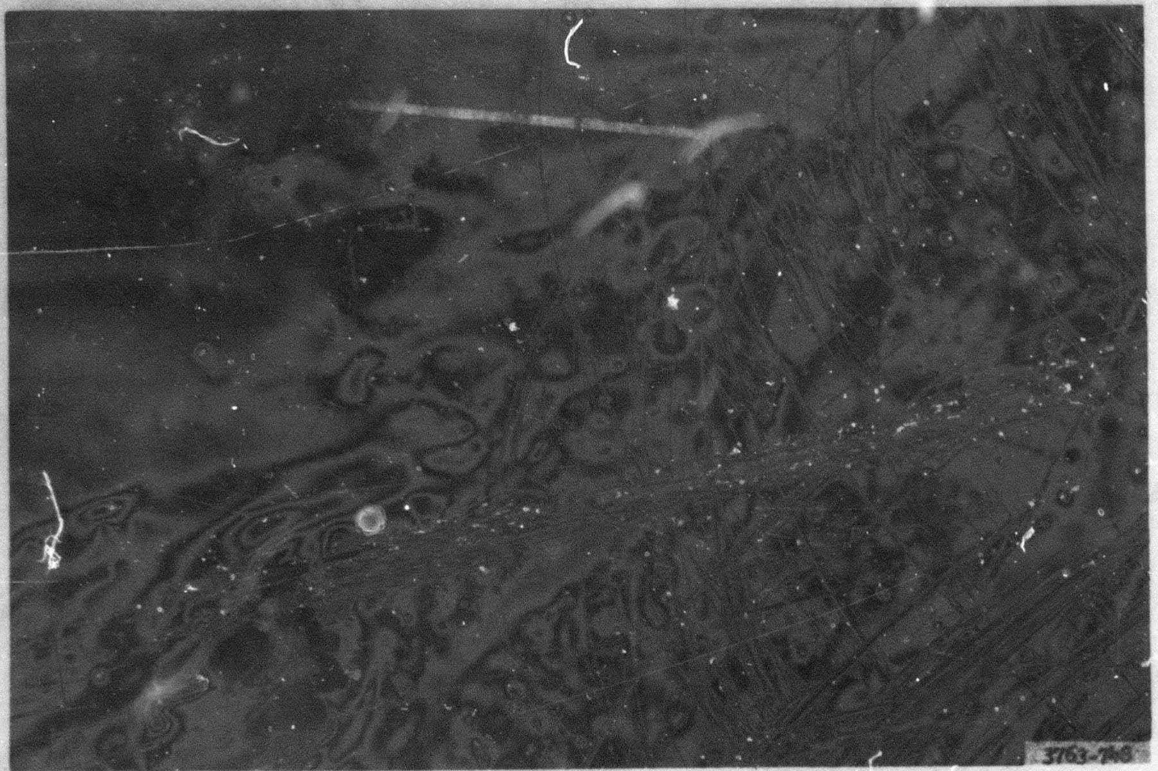


Figure 4. Lane 36, item 1. Transverse straightedge shows roughness at 4 coverages (failure)

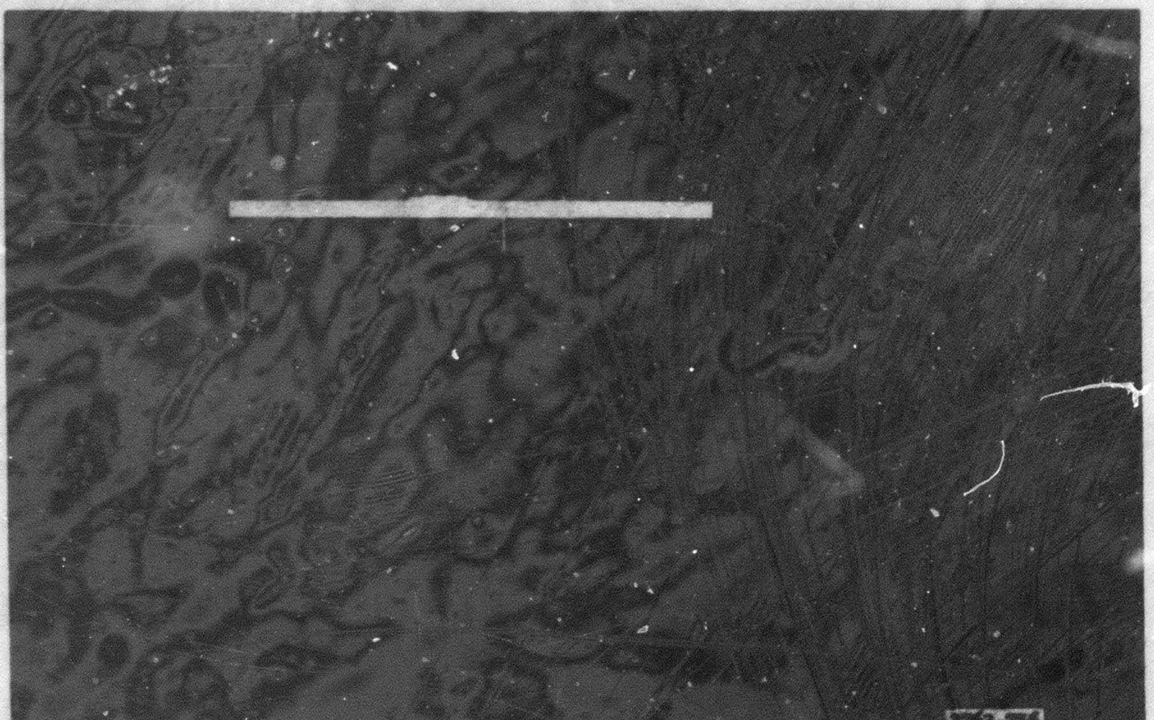


Figure 5. Lane 36, item 2. Transverse straightedge shows roughness at 16 coverages (failure)

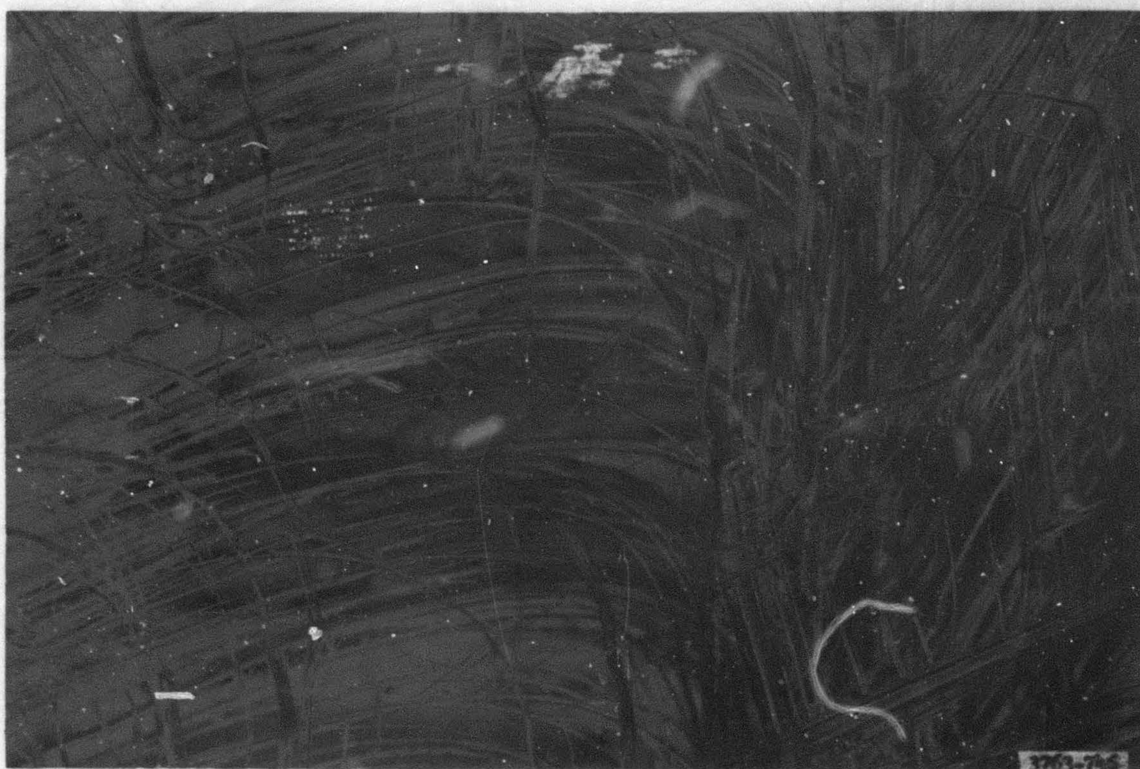


Figure 6. Lane 37, items 1 and 2, prior to traffic

Figure 7. Lane 37, item 1. Transverse straightedge shows roughness at 10 coverages (failure)

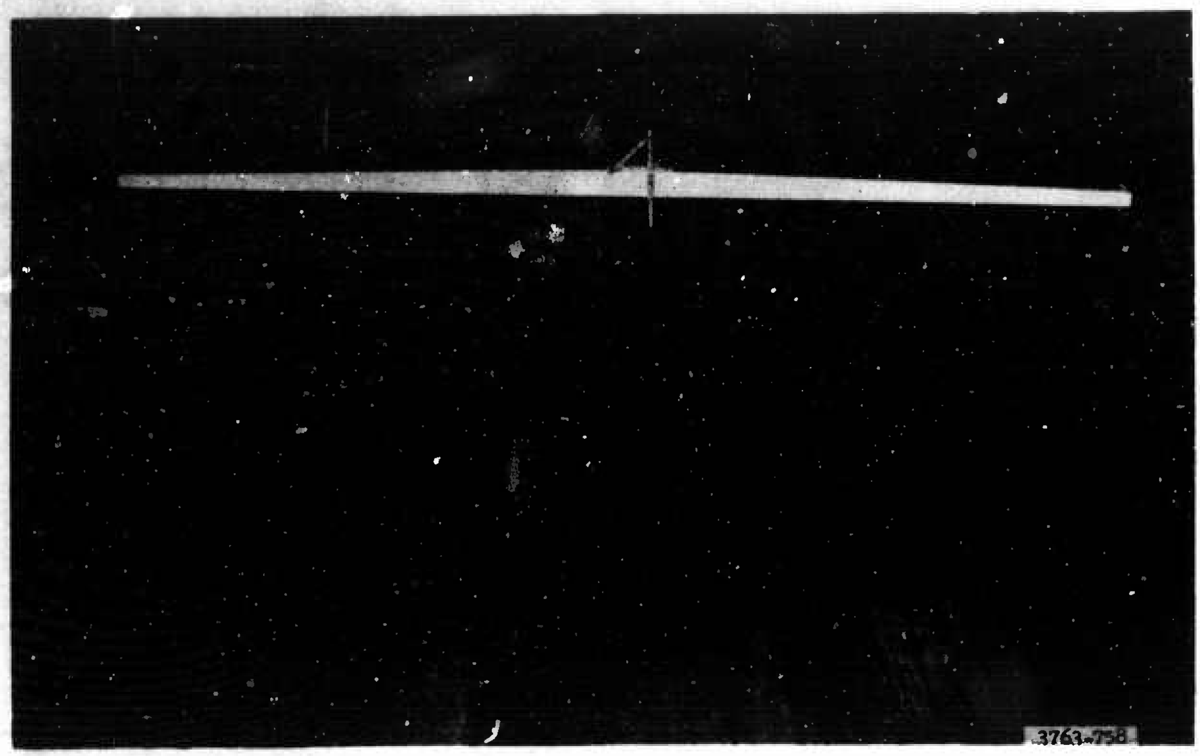
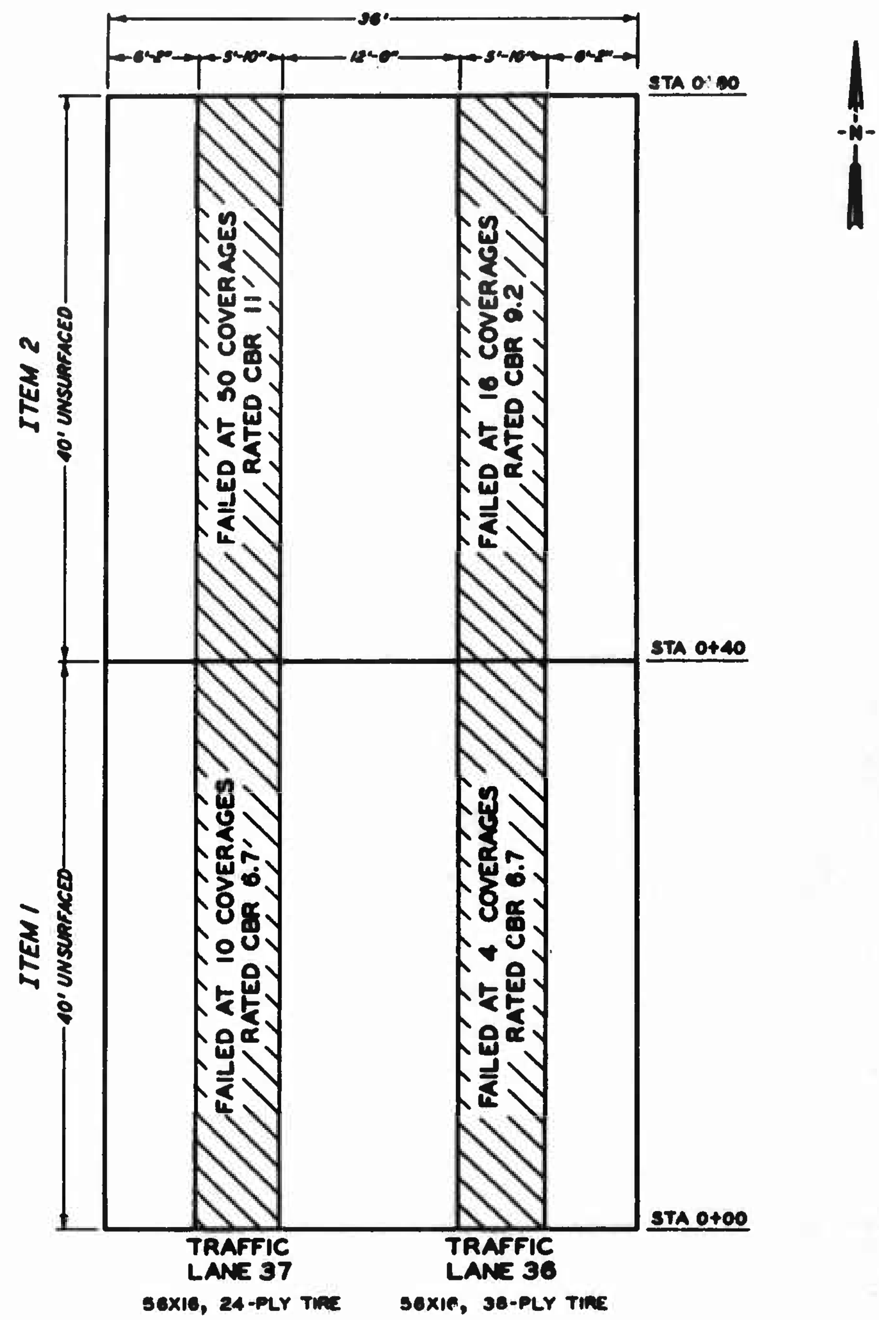
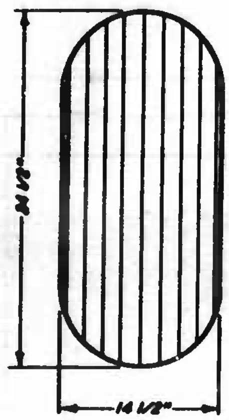


Figure 8. Lane 37, item 2. Transverse straightedge shows roughness at 50 coverages (failure)



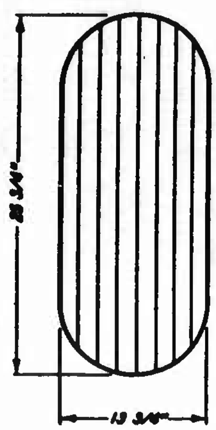
LAYOUT OF
TEST SECTION 17 AND
SUMMARY OF TEST RESULTS
35,000-LB, SINGLE-WHEEL LOAD
100-PSI INFLATION PRESSURE

Figure 9



TIRE SIZE	56X16
NO. OF PLYS	38
CONTACT AREA, SQ IN.	312
CONTACT PRESSURE, PSI	112
INFLATION PRESSURE, PSI	100
DEFLECTION, %	37
GROSS ASSEMBLY LOAD, KIPS	35

LANE 36



TIRE SIZE	56X16
NO. OF PLYS	24
CONTACT AREA, SQ IN.	319
CONTACT PRESSURE, PSI	109
INFLATION PRESSURE, PSI	100
DEFLECTION, %	43
GROSS ASSEMBLY LOAD, KIPS	35

LANE 37

TIRE-PRINT DIMENSIONS AND TIRE CHARACTERISTICS
TEST SECTION 17
LANES 36 AND 37

Figure 10

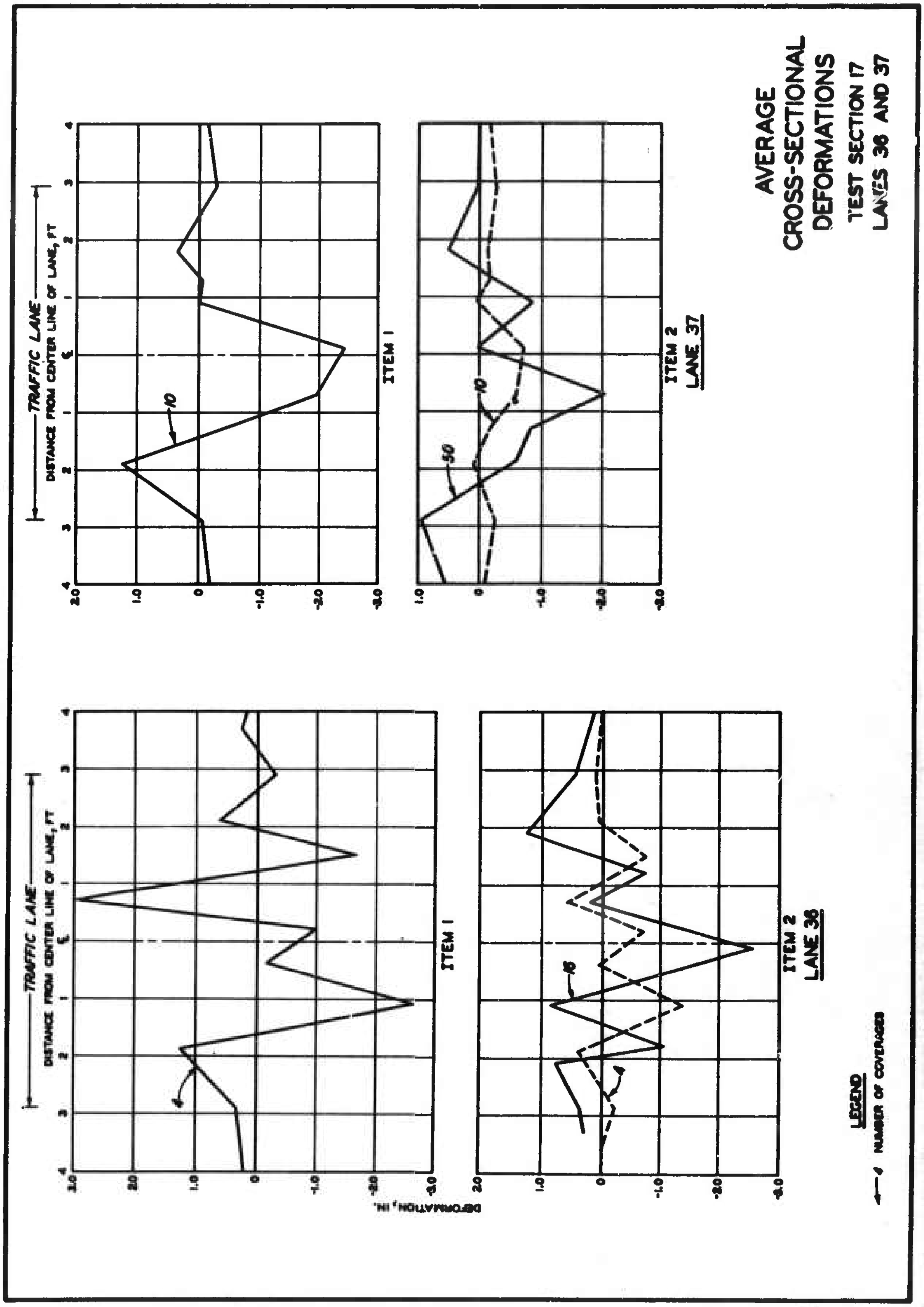
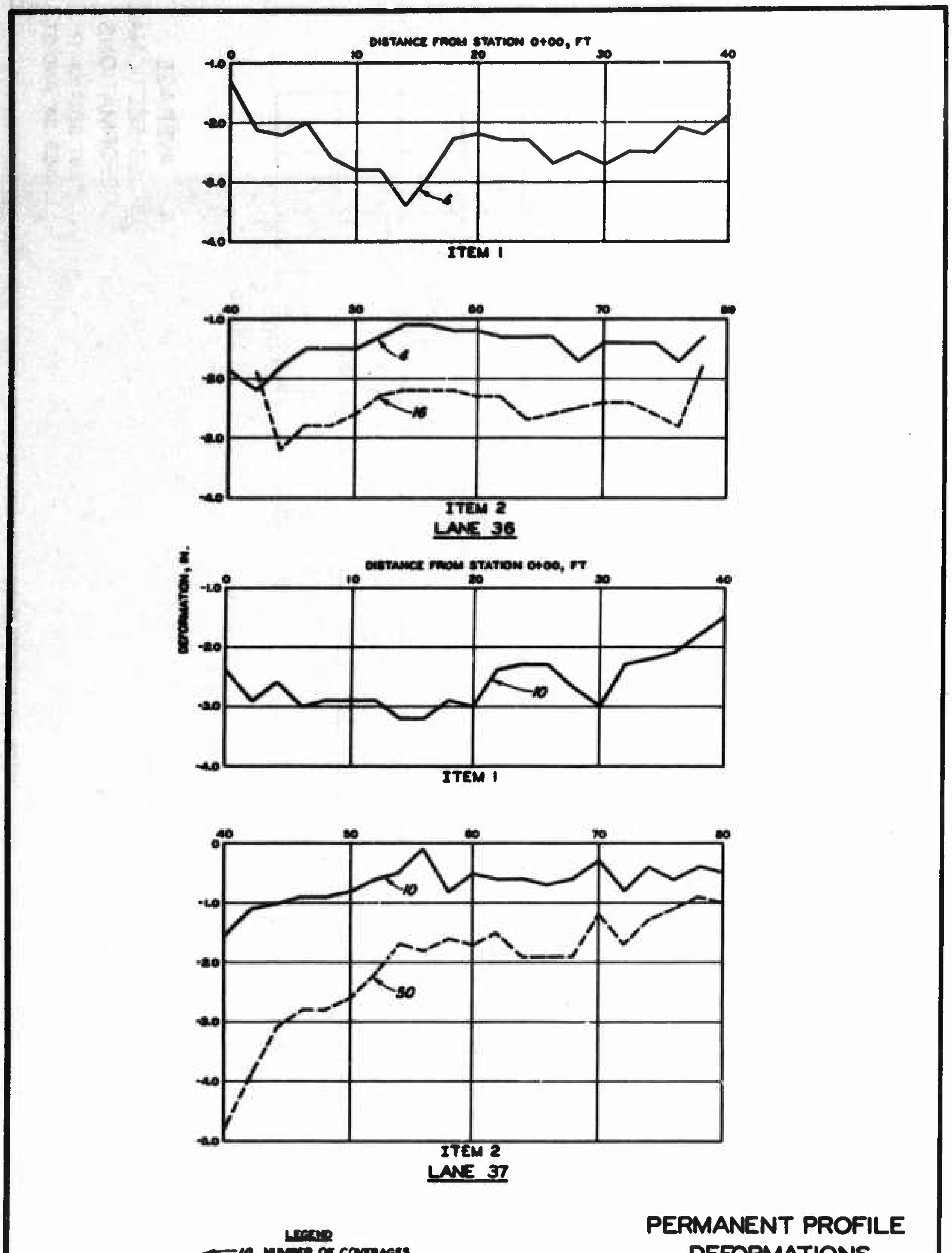

AVERAGE
CROSS-SECTIONAL
DEFORMATIONS
TEST SECTION 17
LANES 36 AND 37
TRAFFIC LANE
DISTANCE FROM CENTER LINE OF LANE, FT
DEFORMATION, IN.
ITEM 1
ITEM 2
LANE 37
ITEM 1
ITEM 2
LANE 36
LEGEND
NUMBER OF COVERAGES

Figure 11



PERMANENT PROFILE DEFORMATIONS
TEST SECTION 17
LANES 36 AND 37

Figure 12

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R&D	
(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)	
1. ORIGINATING ACTIVITY *(Corporate author)* U. S. Army Engineer Waterways Experiment Station	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP
3. REPORT TITLE Aircraft Ground-Flotation Investigation Part XVIII Data Report on Test Section 17	
4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)* Final Technical Report	
5. AUTHOR(S) *(Last name, first name, initial)* Hill, W. J., Jr. Watkins, J. B.	

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1966	18	

8a. CONTRACT OR GRANT NO. MIPR AS-4-177 b. PROJECT NO. 410A c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) AFFDL-TR-66-43, Part XVIII. 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)* None

10. AVAILABILITY/LIMITATION NOTICES This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of the Air Force Flight Dynamics Laboratory (FDFM), Wright-Patterson AFB, Ohio 45433.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Air Force Flight Dynamics Laboratory Research and Technology Division AF Systems Command, WPAFB, Ohio

13. ABSTRACT

This data report describes the results of work undertaken as part of an overall program to develop ground-flotation criteria for the C-5A aircraft.

DD FORM 1 JAN 64 1473

UNCLASSIFIED

Security Classification

UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Aircraft Ground Flotation Rolling Resistance Rear Area Airfields Support Area Airfields Forward Area Airfields Vehicle Mobility						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through

_______________________________________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through

_______________________________________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through

_______________________________________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.

UNCLASSIFIED

Security Classification