DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

Technical Report 1717-TR

AN ATTEMPT TO ISOLATE THE BLAST PHENOMENA WHICH CONTRIBUTE MOST TO THE EARTH-WALL FAILURE OF EXCAVATIONS

Project 8S12-95-001

26 July 1962

U S Army Engineer Research And Development Laboratories

FORT BELVOIR, VIRGINIA

AD_____ Accession No._____

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - AN ATTEMPT TO ISOLATE THE BLAST PHENOMENA WHICH CONTRIBUTE MOST TO THE EARTH-WALL FAILURE OF EXCAVATIONS - James E. Stilwell and Andrew J. Romano

Report 1717-ER, 26 Jul 62, 39 pp, 21 illus, 3 tables
DA Project 8R12-95-001 Unclassified Report

Report covers one of U. S. projects of the 100-ton high-explosive test at the Suffield Experimental Station on 3 August 1961. This project was designated UE-5. The objectives were: (1) To obtain an insight into the blast phenomena which contribute most to failure of earth walls of excavations and (2) to determine vulnerability of the two-man foxhole to blast considering the soil type existing at the Canadian test site. To accomplish these objectives, 11 test excavations were exposed to the blast at overpressure ranges of 15, 25, and 30 psi. The report concludes: (a) Damage to foxholes at the 15-psi overpressure level indicates that the incident blast wave and its reflections in the excavation are primarily responsible for earth-wall damage; (b) damage to foxholes at the 25-psi overpressure level indicates that air-induced ground shock may be an important factor in earth-wall failure; (c) in the soil existing at the Canadian test site, the standard two-man foxhole showed, qualitatively, a high resistance to collapse from peak overpressure ranging up to 30 psi.

UNCLASSIFIED

1. Atomic Warfare - Effects of nuclear weapons
2. Contracts - None

AD_____ Accession No._____

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - AN ATTEMPT TO ISOLATE THE BLAST PHENOMENA WHICH CONTRIBUTE MOST TO THE EARTH-WALL FAILURE OF EXCAVATIONS - James E. Stilwell and Andrew J. Romano

Report 1717-ER, 26 Jul 62, 39 pp, 21 illus, 3 tables
DA Project 8R12-95-001 Unclassified Report

Report covers one of U. S. projects of the 100-ton high-explosive test at the Suffield Experimental Station on 3 August 1961. This project was designated UE-5. The objectives were: (1) To obtain an insight into the blast phenomena which contribute most to failure of earth walls of excavations and (2) to determine vulnerability of the two-man foxhole to blast considering the soil type existing at the Canadian test site. To accomplish these objectives, 11 test excavations were exposed to the blast at overpressure ranges of 15, 25, and 30 psi. The report concludes: (a) Damage to foxholes at the 15-psi overpressure level indicates that the incident blast wave and its reflections in the excavation are primarily responsible for earth-wall damage; (b) damage to foxholes at the 25-psi overpressure level indicates that air-induced ground shock may be an important factor in earth-wall failure; (c) in the soil existing at the Canadian test site, the standard two-man foxhole showed, qualitatively, a high resistance to collapse from peak overpressure ranging up to 30 psi.

UNCLASSIFIED

1. Atomic Warfare - Effects of nuclear weapons
2. Contracts - None

AD ______________ Accession No. ______________

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - AN ATTEMPT TO ISOLATE THE BLAST PHENOMENA WHICH CONTRIBUTE MOST TO THE EARTH-WALL FAILURE OF EXCAVATIONS
- James E. Stilwell and Andrew J. Romano

Report 1717-TR, 26 Jul 62, 39 pp, 21 illus, 3 tables
DA Project 8S12-95-001 Unclassified Report

Report covers one of U. S. projects of the 100-ton high-explosive test at the Suffield Experimental Station on 3 August 1961. This project was designated UB-5. The objectives were: (1) To obtain an insight into the blast phenomena which contribute most to failure of earth walls of excavations and (2) to determine vulnerability of the two-man foxhole to blast considering the soil type existing at the Canadian test site. To accomplish these objectives, 11 test excavations were exposed to the blast at overpressure ranges of 15, 25, and 30 psi. The report concludes: (a) Damage to foxholes at the 15-psi overpressure level indicates that the incident blast wave and its reflections in the excavation are primarily responsible for earth-wall damage; (b) damage to foxholes at the 25-psi overpressure level indicates that air-induced ground shock may be an important factor in earth-wall failure; (c) in the soil existing at the Canadian test site, the standard two-man foxhole showed, qualitatively, a high resistance to collapse from peak overpressure ranging up to 30 psi.

UNCLASSIFIED

1. Atomic Warfare - Effects of nuclear weapons
2. Contracts - None

AD ______________ Accession No. ______________

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - AN ATTEMPT TO ISOLATE THE BLAST PHENOMENA WHICH CONTRIBUTE MOST TO THE EARTH-WALL FAILURE OF EXCAVATIONS
- James E. Stilwell and Andrew J. Romano

Report 1717-TR, 26 Jul 62, 39 pp, 21 illus, 3 tables
DA Project 8S12-95-001 Unclassified Report

Report covers one of U. S. projects of the 100-ton high-explosive test at the Suffield Experimental Station on 3 August 1961. This project was designated UB-5. The objectives were: (1) To obtain an insight into the blast phenomena which contribute most to failure of earth walls of excavations and (2) to determine vulnerability of the two-man foxhole to blast considering the soil type existing at the Canadian test site. To accomplish these objectives, 11 test excavations were exposed to the blast at overpressure ranges of 15, 25, and 30 psi. The report concludes: (a) Damage to foxholes at the 15-psi overpressure level indicates that the incident blast wave and its reflections in the excavation are primarily responsible for earth-wall damage; (b) damage to foxholes at the 25-psi overpressure level indicates that air-induced ground shock may be an important factor in earth-wall failure; (c) in the soil existing at the Canadian test site, the standard two-man foxhole showed, qualitatively, a high resistance to collapse from peak overpressure ranging up to 30 psi.

UNCLASSIFIED

1. Atomic Warfare - Effects of nuclear weapons
2. Contracts - None

AD ______________ Accession No. ______________

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - AN ATTEMPT TO ISOLATE THE BLAST PHENOMENA WHICH CONTRIBUTE MOST TO THE EARTH-WALL FAILURE OF EXCAVATIONS
- James E. Stilwell and Andrew J. Romano

Report 1717-TR, 26 Jul 62, 39 pp, 21 illus, 3 tables
DA Project 8S12-95-001 Unclassified Report

Report covers one of U. S. projects of the 100-ton high-explosive test at the Suffield Experimental Station on 3 August 1961. This project was designated UB-5. The objectives were: (1) To obtain an insight into the blast phenomena which contribute most to failure of earth walls of excavations and (2) to determine vulnerability of the two-man foxhole to blast considering the soil type existing at the Canadian test site. To accomplish these objectives, 11 test excavations were exposed to the blast at overpressure ranges of 15, 25, and 30 psi. The report concludes: (a) Damage to foxholes at the 15-psi overpressure level indicates that the incident blast wave and its reflections in the excavation are primarily responsible for earth-wall damage; (b) damage to foxholes at the 25-psi overpressure level indicates that air-induced ground shock may be an important factor in earth-wall failure; (c) in the soil existing at the Canadian test site, the standard two-man foxhole showed, qualitatively, a high resistance to collapse from peak overpressure ranging up to 30 psi.

UNCLASSIFIED

1. Atomic Warfare - Effects of nuclear weapons
2. Contracts - None

AD ______________ Accession No. ______________

U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia - AN ATTEMPT TO ISOLATE THE BLAST PHENOMENA WHICH CONTRIBUTE MOST TO THE EARTH-WALL FAILURE OF EXCAVATIONS
- James E. Stilwell and Andrew J. Romano

Report 1717-TR, 26 Jul 62, 39 pp, 21 illus, 3 tables
DA Project 8S12-95-001 Unclassified Report

Report covers one of U. S. projects of the 100-ton high-explosive test at the Suffield Experimental Station on 3 August 1961. This project was designated UB-5. The objectives were: (1) To obtain an insight into the blast phenomena which contribute most to failure of earth walls of excavations and (2) to determine vulnerability of the two-man foxhole to blast considering the soil type existing at the Canadian test site. To accomplish these objectives, 11 test excavations were exposed to the blast at overpressure ranges of 15, 25, and 30 psi. The report concludes: (a) Damage to foxholes at the 15-psi overpressure level indicates that the incident blast wave and its reflections in the excavation are primarily responsible for earth-wall damage; (b) damage to foxholes at the 25-psi overpressure level indicates that air-induced ground shock may be an important factor in earth-wall failure; (c) in the soil existing at the Canadian test site, the standard two-man foxhole showed, qualitatively, a high resistance to collapse from peak overpressure ranging up to 30 psi.

UNCLASSIFIED

1. Atomic Warfare - Effects of nuclear weapons
2. Contracts - None

U. S. ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES
Fort Belvoir, Virginia

Technical Report 1717-TR

AN ATTEMPT TO ISOLATE THE BLAST PHENOMENA WHICH CONTRIBUTE MOST TO THE EARTH-WALL FAILURE OF EXCAVATIONS

Project 8S12-95-001

26 July 1962

Distributed by

The Commanding Officer
U. S. Army Engineer Research and Development Laboratories

Prepared by

James E. Stilwell and Andrew J. Romano, Sp/4, U. S. Army
Demolitions and Fortifications Branch
Military Department
U. S. Army Engineer Research and Development Laboratories
Fort Belvoir, Virginia

PREFACE

The test covered by this report was conducted under the authority of Project 8S12-95-001, with funds provided by the Defense Atomic Support Agency. A copy of the project card is included in Appendix A.

The test was performed and the report prepared by James E. Stilwell and Andrew J. Romano. The authors would like to express their appreciation to the Suffield Experimental Station personnel whose assistance and cooperation made this test possible and to the Ballistics Research Laboratories for blast instrumentation and photographic support.

CONTENTS

ILLUSTRATIONS

SUMMARY

This report covers one of the U. S. projects of the 100-ton high-explosive test at the Suffield Experimental Station on 3 August 1961. This project was designated US-5. The objectives were: (1) To obtain an insight into the blast phenomena which contribute most to the failure of earth walls of excavations and (2) to determine the vulnerability of the two-man foxhole to blast considering the soil type existing at the Canadian test site. To accomplish these objectives, 11 test excavations were exposed to the blast at overpressure ranges of 15 psi, 25 psi, and 30 psi.

The report concludes:

a. Damage to foxholes at the 15-psi overpressure level indicates that the incident blast wave and its reflections in the excavation are primarily responsible for earth-wall damage.

b. Damage to foxholes at the 25-psi overpressure level indicates that air-induced ground shock may be an important factor in earth-wall failure.

c. In the soil existing at the Canadian test site, the standard two-man foxhole showed, qualitatively, a high resistance to collapse from peak overpressures ranging up to 30 psi.

AN ATTEMPT TO ISOLATE THE BLAST PHENOMENA WHICH CONTRIBUTE MOST TO THE EARTH-WALL FAILURE OF EXCAVATIONS

I. INTRODUCTION

1. Subject. This report covers Project US-5 of the 100-ton high-explosive detonation which was conducted at the Suffield Experimental Station, Ralston, Alberta, Canada, on 3 August 1961. This project was sponsored by the Defense Atomic Support Agency and was conducted by the Nuclear Effects Section (formerly Special Projects Branch), Demolitions and Fortifications Branch, U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia. The objectives of the project were: (a) To obtain an insight into the blast phenomena which contribute most to the failure of earth walls of excavations and (b) to determine the vulnerability of the two-man foxhole to blast, considering the soil type existing at the Canadian test site.

2. Background and Previous Investigation. In several nuclear tests, specific field fortifications were tested to determine their response in various overpressure regions and to determine the protection offered by these fortifications against thermal and nuclear radiation. In these previous tests, however, no attempt was made to determine exactly what blast phenomenon was primarily responsible for fortification failure. An attempt was made during the US-5 test to isolate the various blast phenomena and thus determine the factors that contribute most to earth-wall failure in excavations.

II. INVESTIGATION

3. Description of Test. The standard two-man foxhole was chosen as the basic excavation with which to accomplish the objectives of this test. Simple construction methods were used to vary the blast loading. Including the basic open foxhole configuration (loading not altered), five different designs (11 test excavations) were exposed to the blast from the 100-ton high-explosive detonation. Table I lists each design, its purpose, and the estimated peak over-pressures at which the designs were exposed. Drawings of the designs are presented in Figs. 1 through 5. All designs were exposed with the broadside to ground zero, as indicated in the figures. Figure 6 indicates the arrangement of the excavations at the test site.

Table I. Purposes of Designs and Overpressures at Which They Were Exposed

Design	Purpose	Approximate Overpressure (psi)
A	Basic foxhole configuration	30, 25, and 15
B	Vertical pressure magnification with ground shock	25 and 15
C	Pure ground shock	25 and 15
D	Minimize ground shock	25 and 15
E	Magnification of sudden drawdown and reflected pressure effects	25 and 15

4. Field Procedure. The excavations were dug by hand, and the earth walls were trimmed as smooth as hand tools and soil conditions would permit.

Pre-shot and post-shot wall measurements were made in order to determine the amount of earth-wall sloughing or collapse. Horizontal measurements were made from a plumb line suspended from a straight-edged member positioned horizontally across the excavation. Stakes were driven in the bottom of each excavation at the corners to use as references to position the horizontal member. Measurements were made at 6-inch horizontal and vertical intervals along the walls of the excavations.

Photographs of the excavations were taken before and after the detonation. The end walls and sides were spray painted with yellow and white water-base paint, respectively, to provide better contrast, thus enhancing photographic detail.

After photographs of all the test units had been taken, the timber covers were placed on designs B, C, and D and anchored as shown in Figs. 3, 4, and 5.

5. Instrumentation. Ballistics Research Laboratory, self-recording, pressure-time gages were used to obtain measurements of peak overpressure. Two gages (one 360 feet and one 450 feet from ground zero) embedded flush with the ground surface recorded free-field pressure. A third gage was mounted on the bottom of unit 15C and held in place by sandbags.

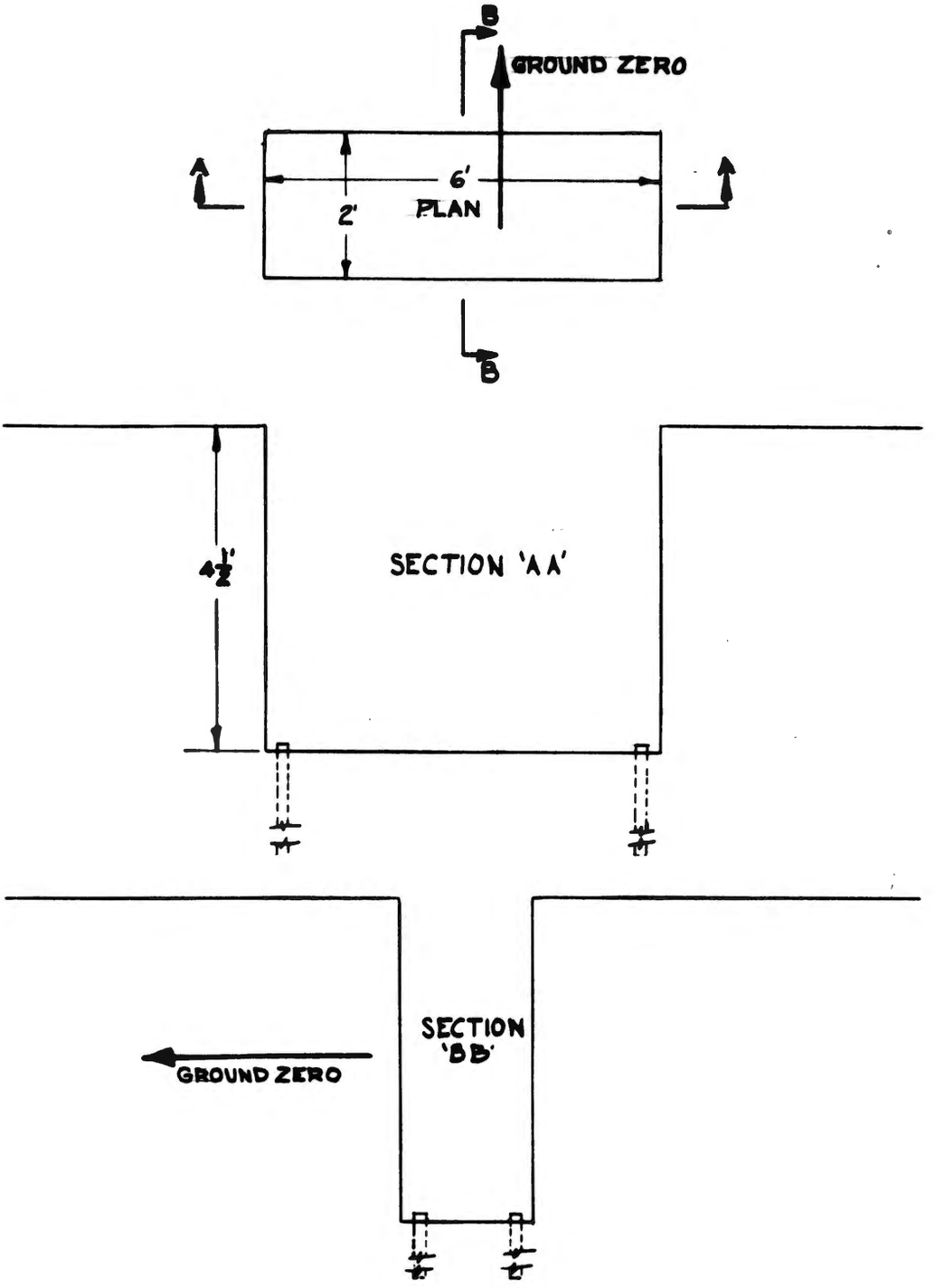


Fig. 1. Design A, standard two-man foxhole.

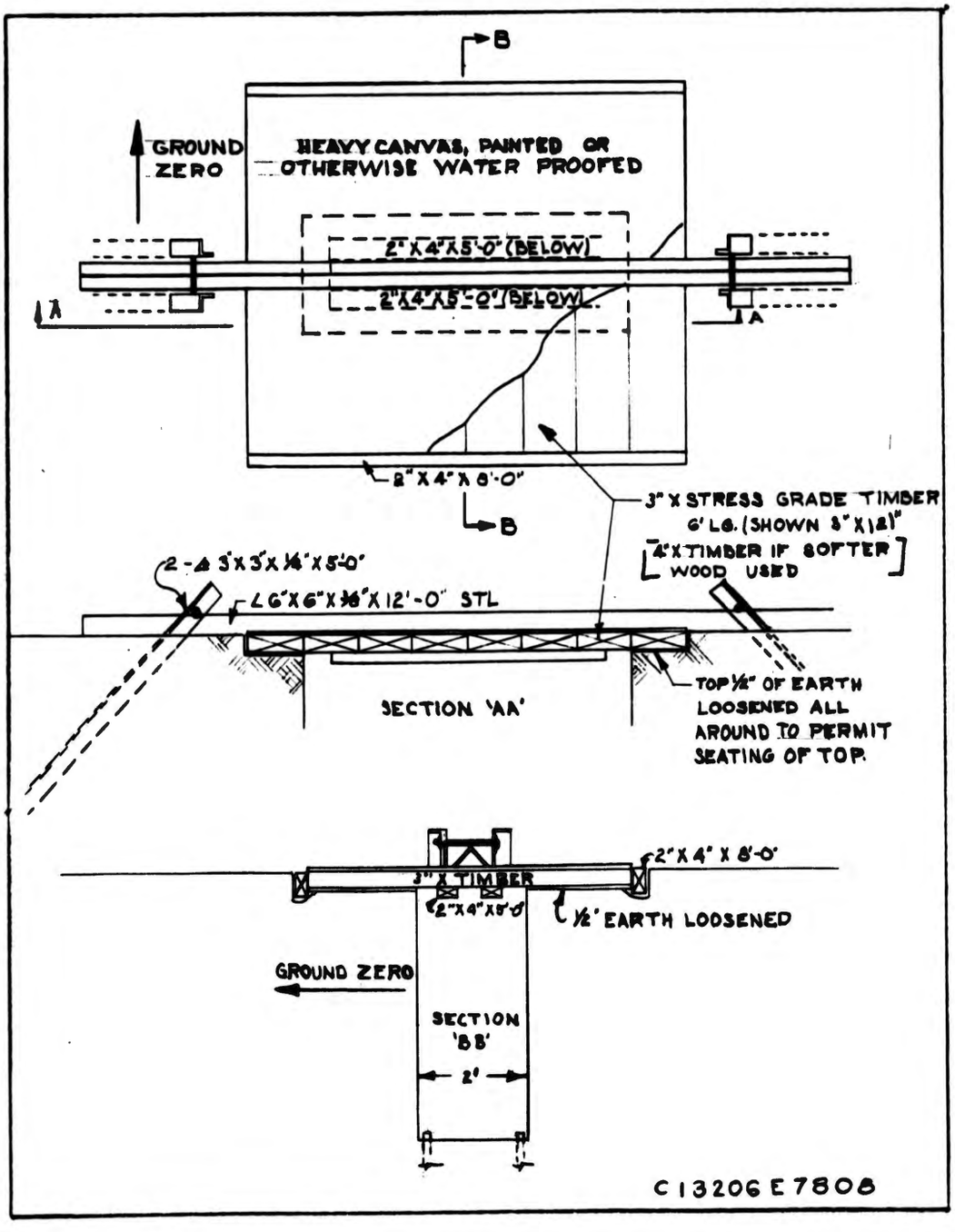


Fig. 2. Design B.

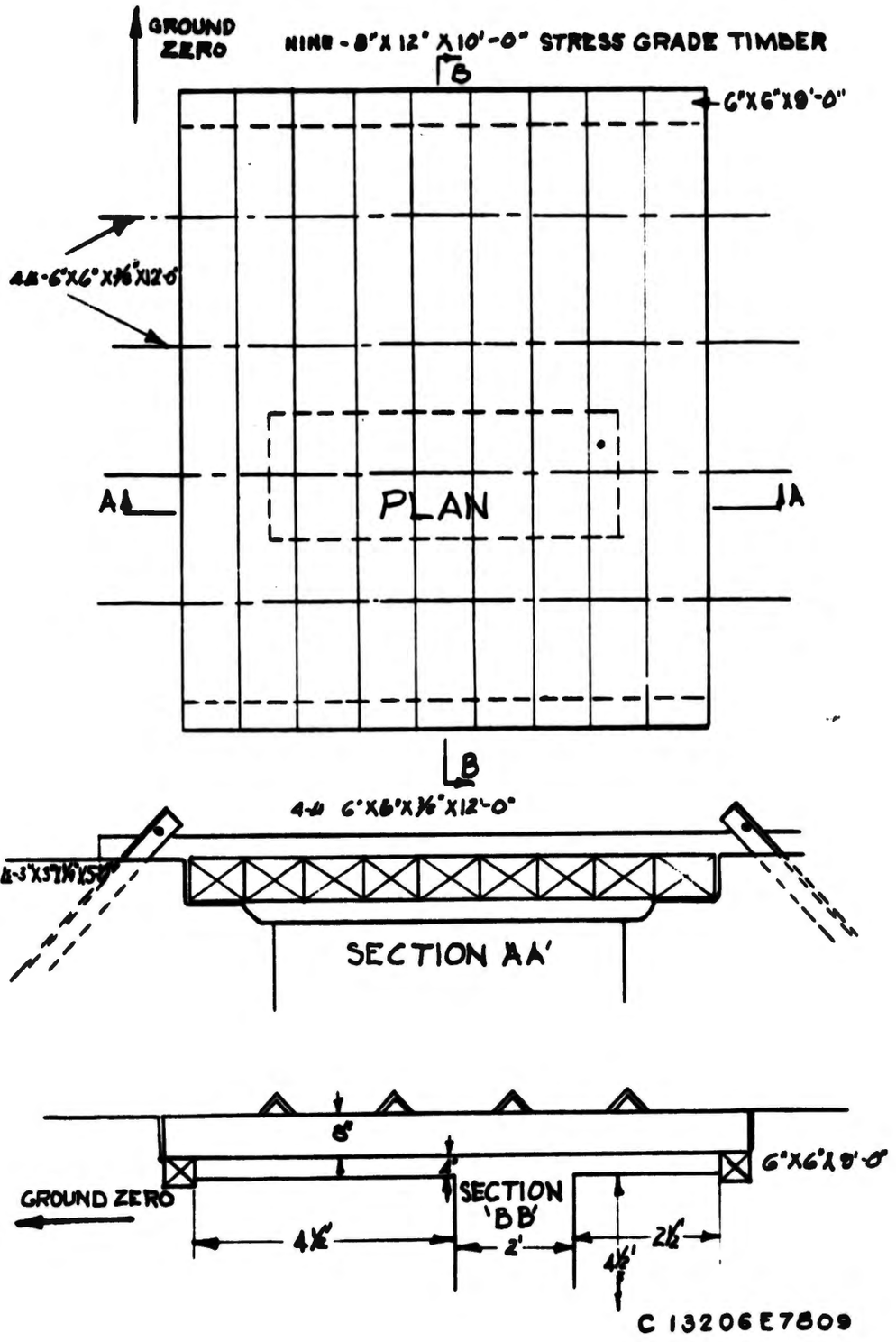
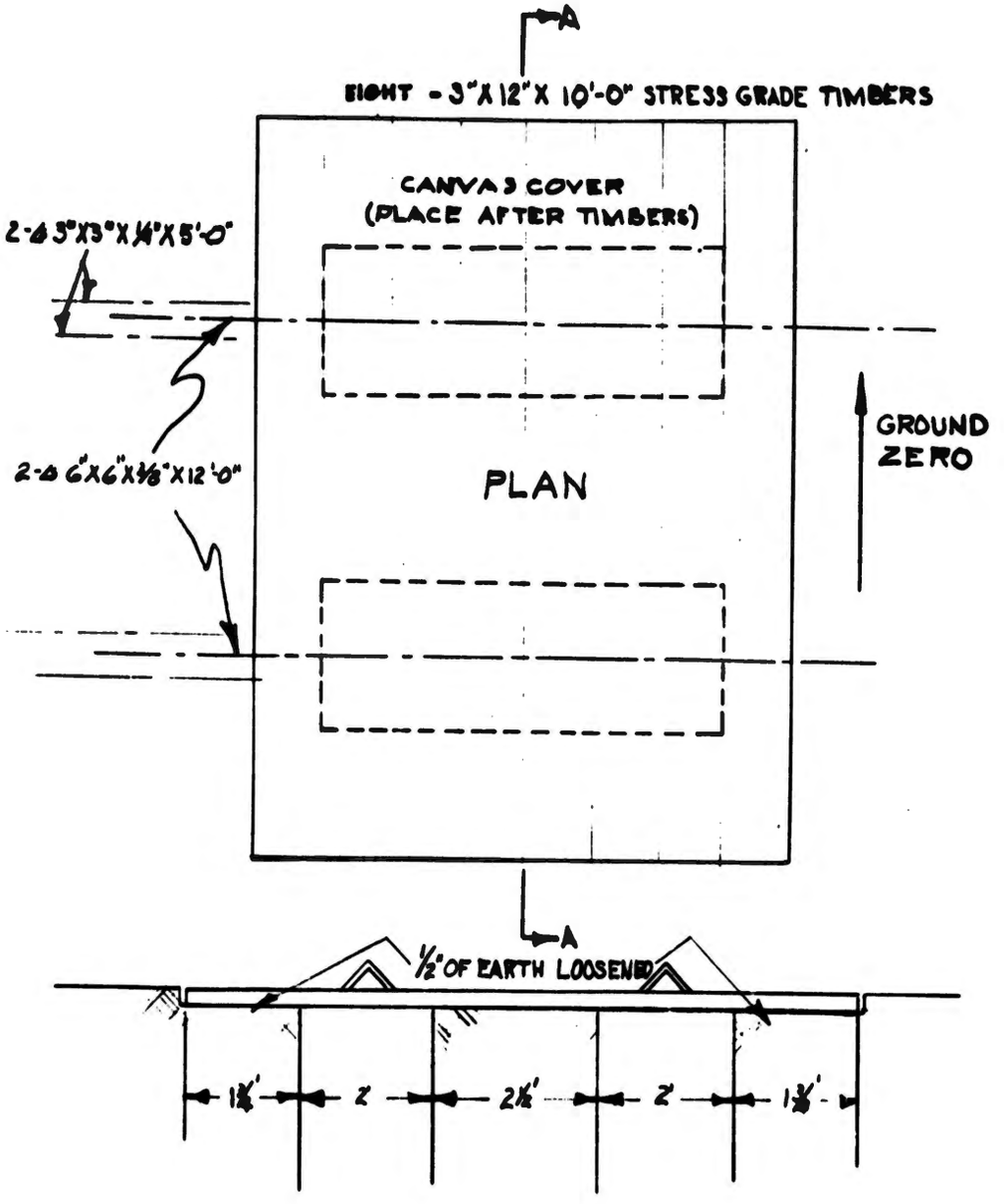
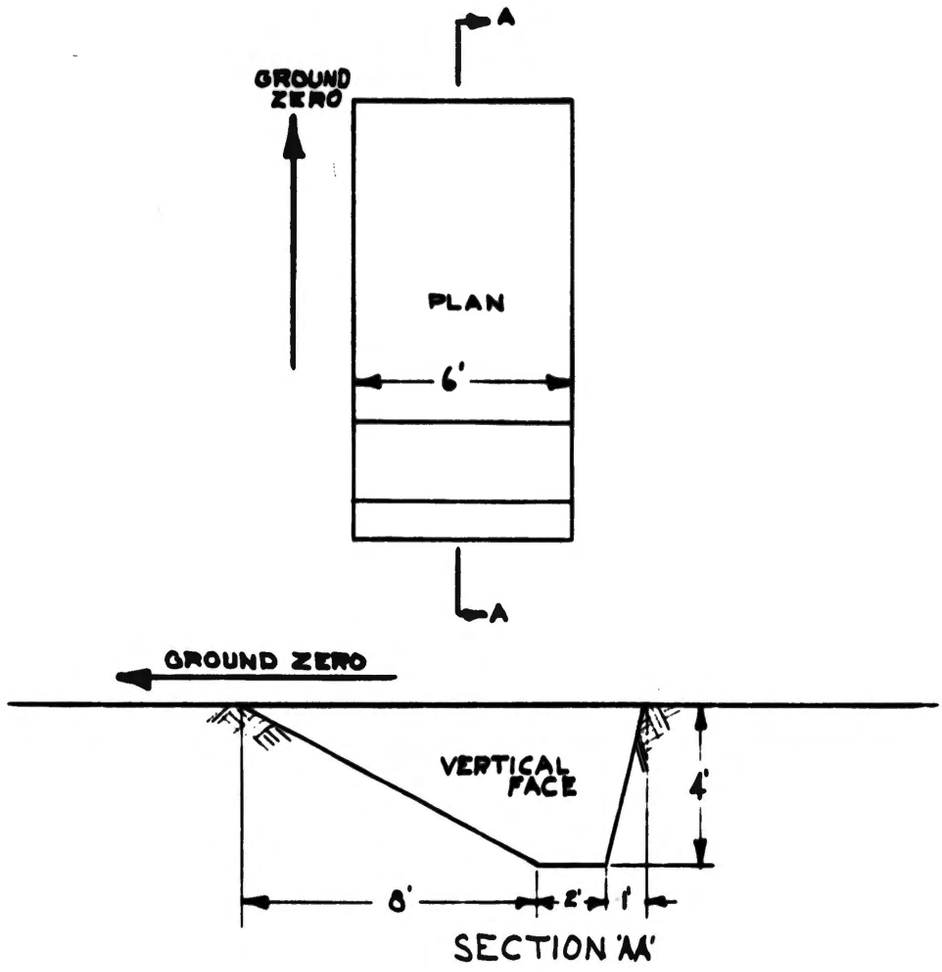


Fig. 3. Design C.



C 1320 G E 7810

Fig. 4. Design D.



C 13206E7811

Fig. 5. Design E.

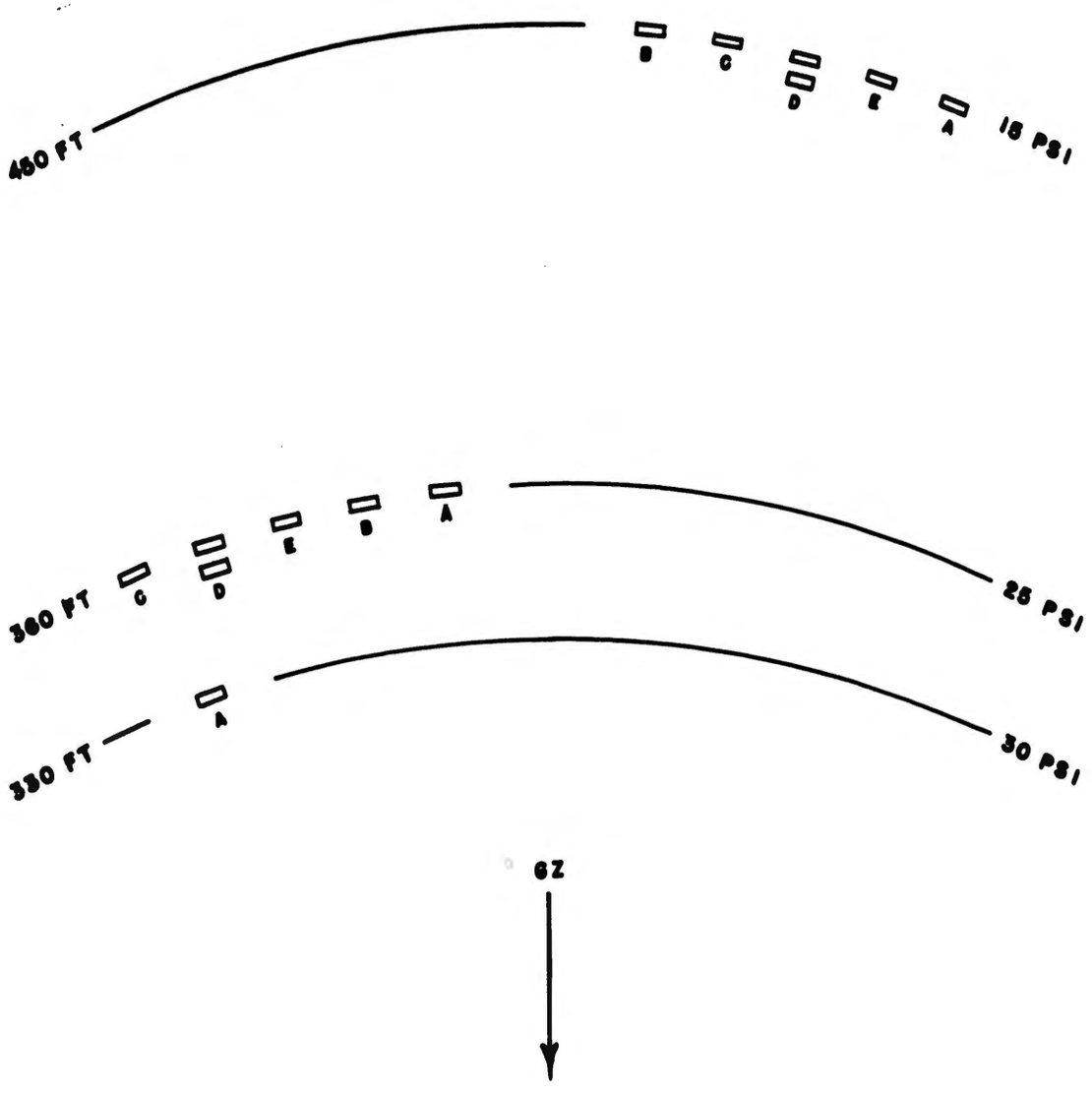


Fig. 6. Arrangement of excavations at test site.

6. Test Results. The peak overpressures recorded by the two surface gages and by the gage placed in unit 15C are presented in Table II.

Table II. Pressure Gage Data

Gage Distance from Ground Zero (ft)	Estimated Overpressure (psi)	Recorded Overpressure (psi)	Duration (ms)
330	30	32.5[a]	--
360	25	27.0	116.2
450	15	17.4	124.5
450[b]	--	2.5	Recorded peak pressure only

(a) Value based on reading from pressure-distance curves furnished by Ballistics Research Laboratories.
(b) Gage on bottom of unit 15C.

Of the 11 test units, only one (25C) was severely damaged. Damage to unit 25C consisted of sloughing of the front wall (wall nearer ground zero) and weakening of the rear wall, as shown by cracks at the surface.

Cracks appeared around all the test units located at the 30- and 25-psi ranges and around units 15A and 15E. Test units 15B, 15C, and 15D were almost undamaged, with no cracks forming around the holes at the surface.

Before the detonation, the 3/4-inch bolts (inserted through the ends of the 3-inch angle-irons used as anchor stakes) were in contact with the 6-inch angle-irons, holding them tightly against the timber covers. After the explosion, the bolts were no longer in contact with the angle-irons; a 1.5-inch gap between each bolt and angle-iron was observed in units 25B, 25C, and 25D, while a 0.7-inch gap was observed in units 15B, 15C, and 15D.

Table III contains descriptions of damage sustained by each unit. Figures 7 through 17 show the units before and after detonation.

Figures 18 through 21 show the amounts of deformation (in inches) which occurred in the walls of the foxholes as a result of the detonation. A negative figure indicates a bowing-in of the wall, while a positive figure indicates that the wall sloughed off

Table III. Description of Damage

Design	Damage		
	30 psi	25 psi	15 psi
A	Front and rear walls bowed in toward center. Cracks around front and rear walls at surface, largest (2 in.) at center, extending 12 in. out. End walls relatively undamaged, only small vertical cracks. (Fig. 7.)	Front and rear walls bowed in toward center. Cracks around front and rear walls in pattern similar to 30A. Largest crack (1 in.) extending 15 in. from edge at center. No damage or signs of weakening of end walls. (Fig. 8.)	Very slight damage. Cracks similar to 30A and 25A but not as wide. End walls undamaged. (Fig. 9.)
B	--	Approx. ½-in.-wide cracks at surface around front and rear walls approx. 9 in. from edge at center. No damage to end walls. (Fig. 10.)	No damage to unit. No cracks observed. (Fig. 11.)
C	--	End walls bowed slightly. Small cracks at surface around end walls approx. 6 in. from edge. Front wall sloughed at top to within 1 ft of bottom, rear wall severely weakened. Cracks around rear wall. (Fig. 12.)	No damage to unit. No cracks observed. (Fig. 13.)
D	--	Cracks around side walls of both foxholes, nearly parallel to side walls. Ends undamaged. (Fig. 14.)	No damage to unit. No cracks observed. (Fig. 15.)
E	--	Little sloughing of left wall. Cracks similar to other units at 25-psi range. Crack in Fig. 16 obscured by loose dirt thrown from crater.	Slight damage. Cracks similar to 25E. (Fig. 17.)

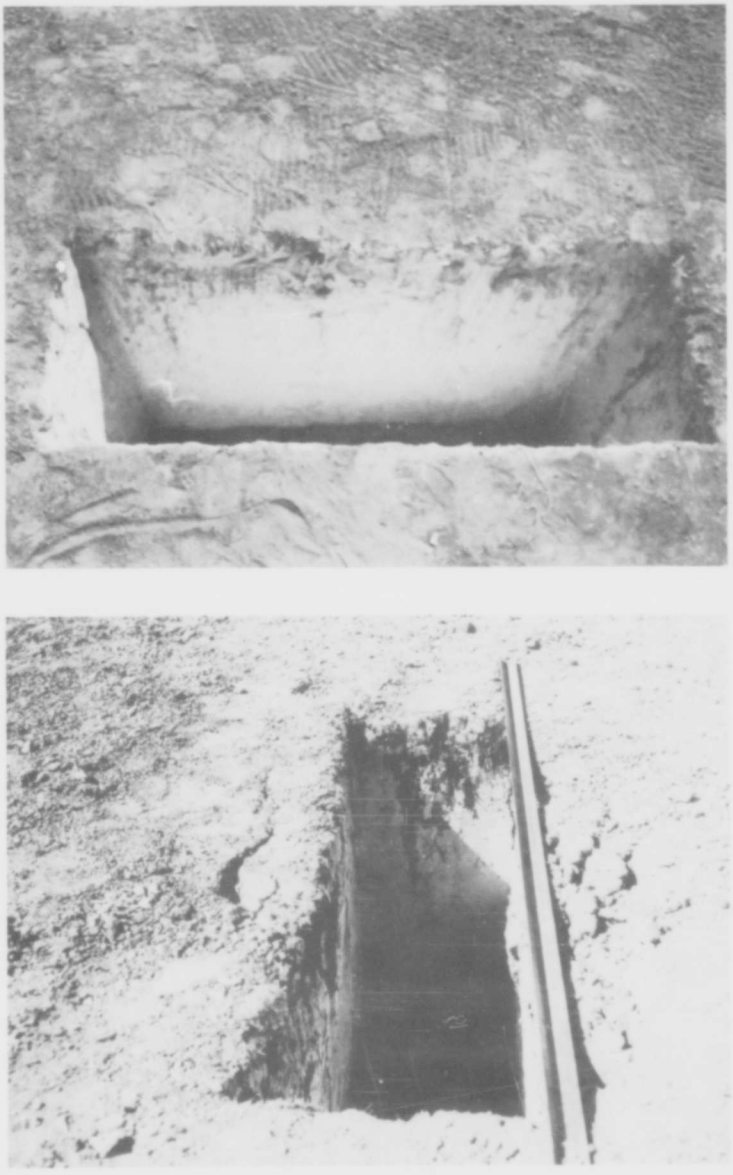


Fig. 7. Unit 30A. Top: pre-shot, ground zero toward top of photograph; bottom: post-shot, ground zero to left.

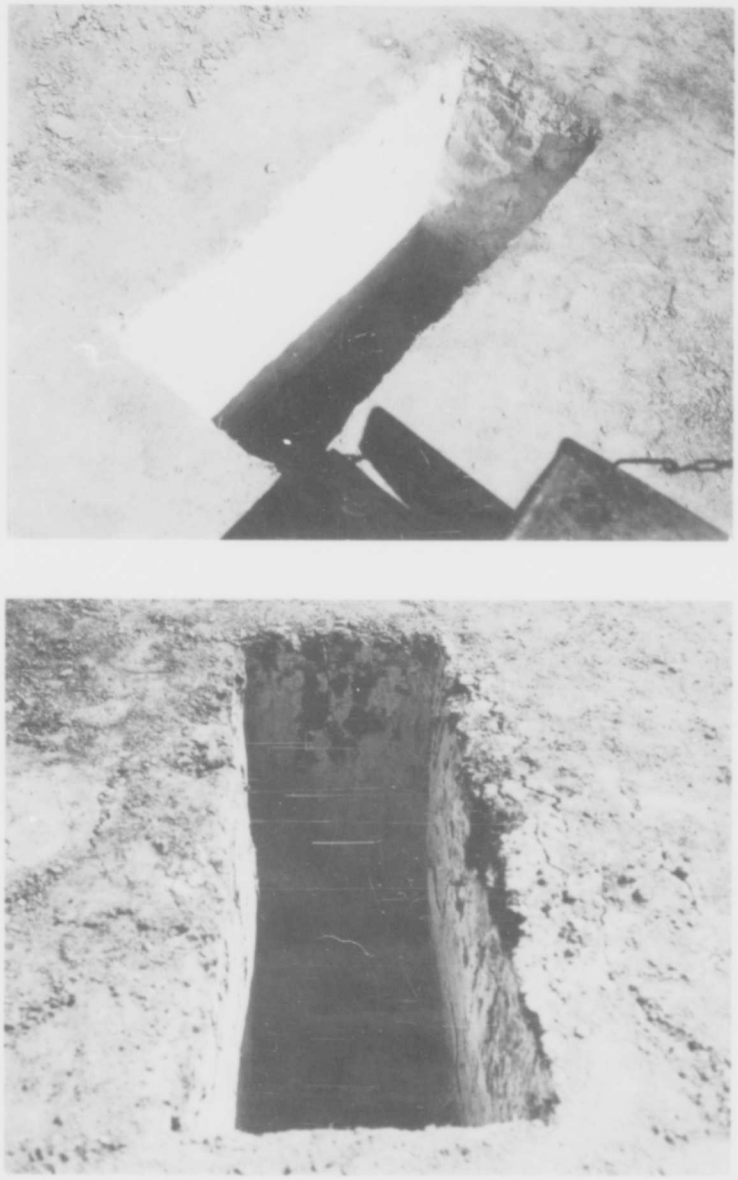


Fig. 8. Unit 25A. Top: pre-shot, ground zero toward right lower corner; bottom: post-shot, ground zero to left (note cracks around side walls and bow in walls).

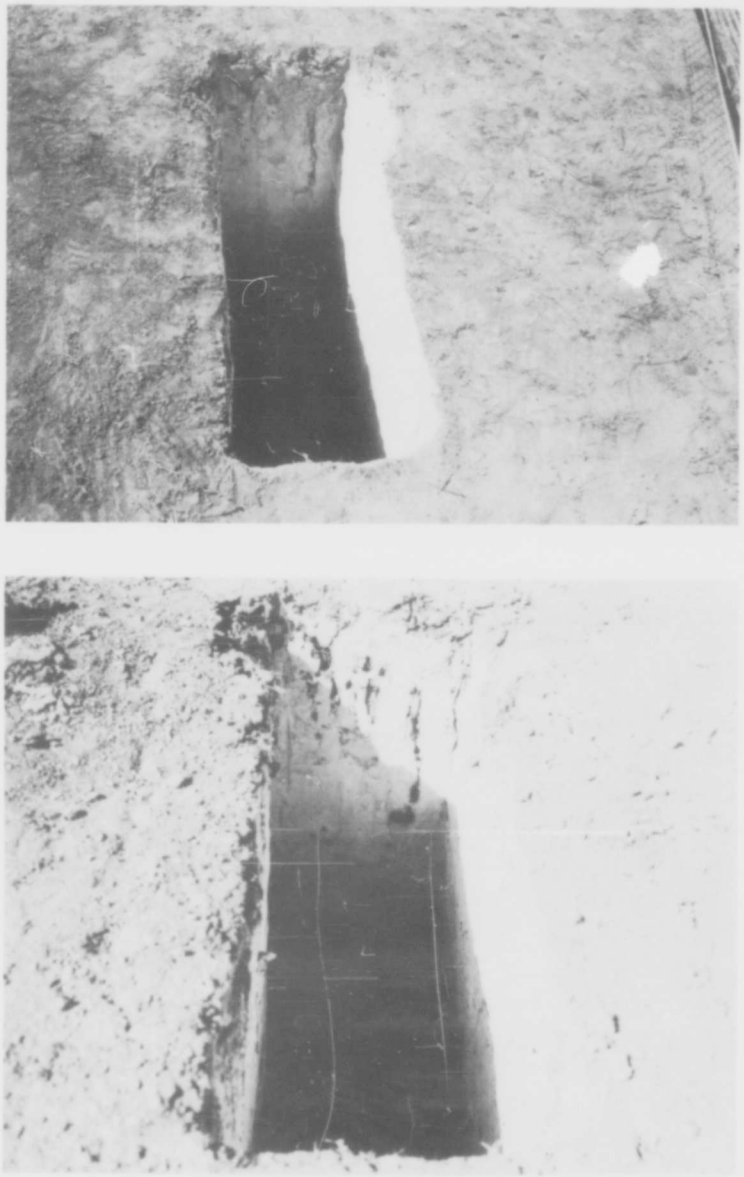


Fig. 9. Unit 15A. Top: pre-shot, ground zero to left; bottom: post-shot, ground zero to left.

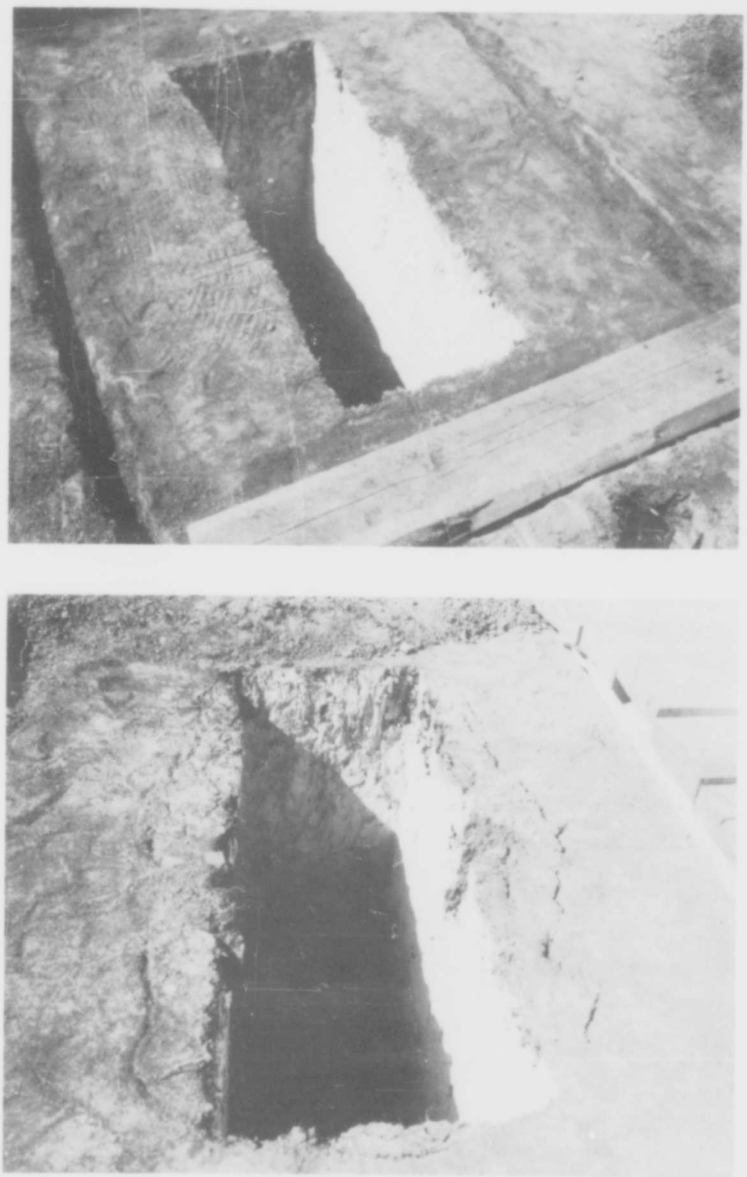


Fig. 10. Unit 25B. Top: pre-shot, ground zero to left; bottom: post-shot, ground zero to left.

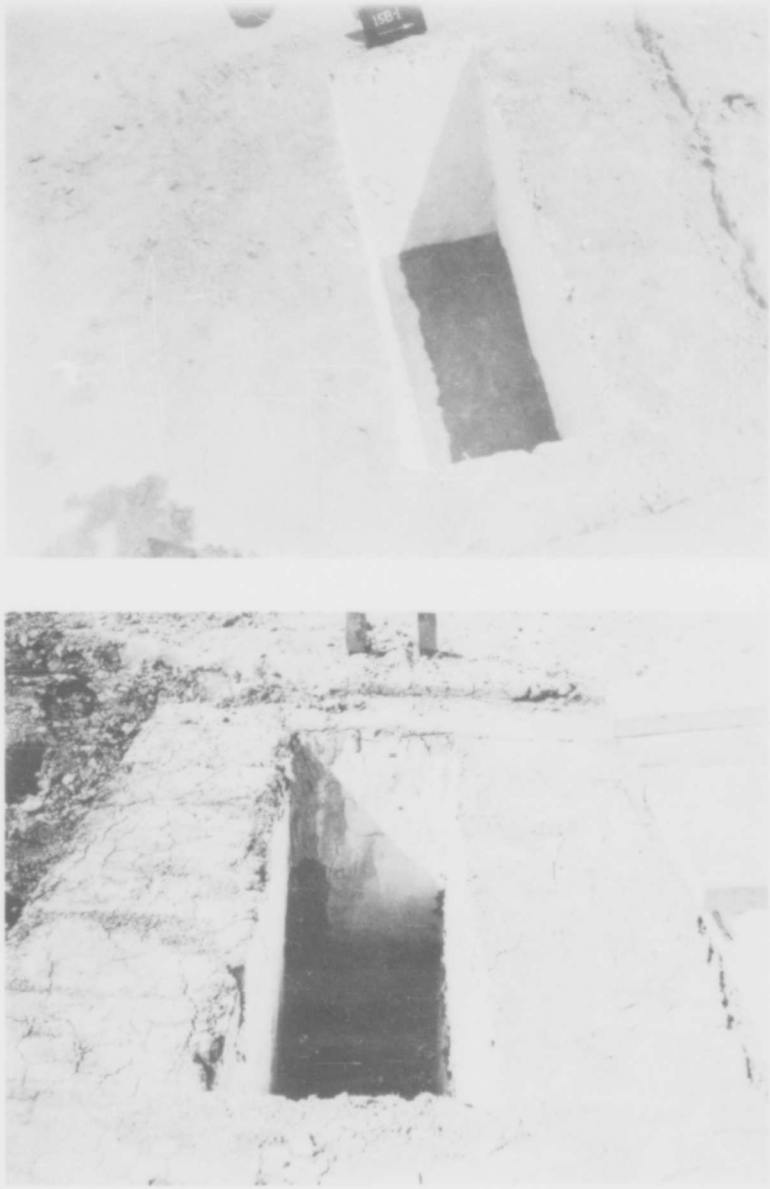


Fig. 11. Unit 15B. Top: pre-shot, ground zero indicated by arrow; bottom: post-shot, ground zero to left.

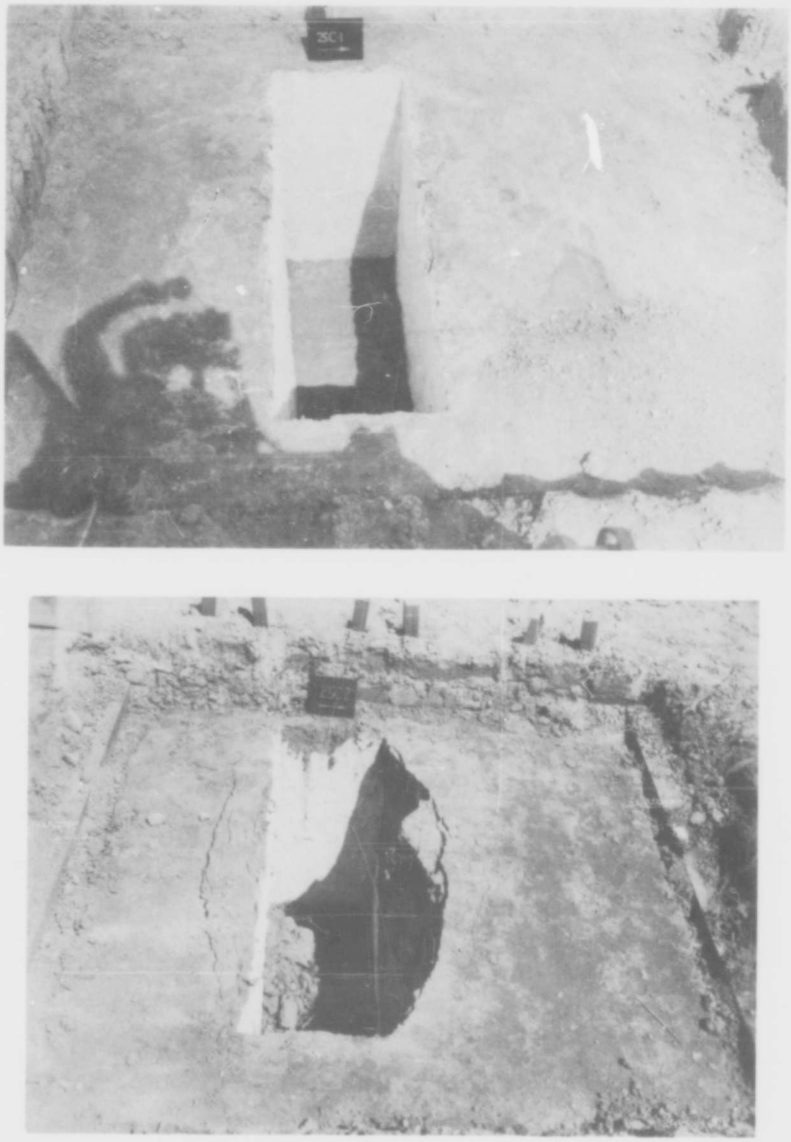


Fig. 12. Unit 25C. Top: pre-shot, ground zero indicated by arrow; bottom: post-shot, ground zero indicated by arrow (on right side of hole, note imprint made by one of the timbers, indicating cover struck ground when blast wave passed).

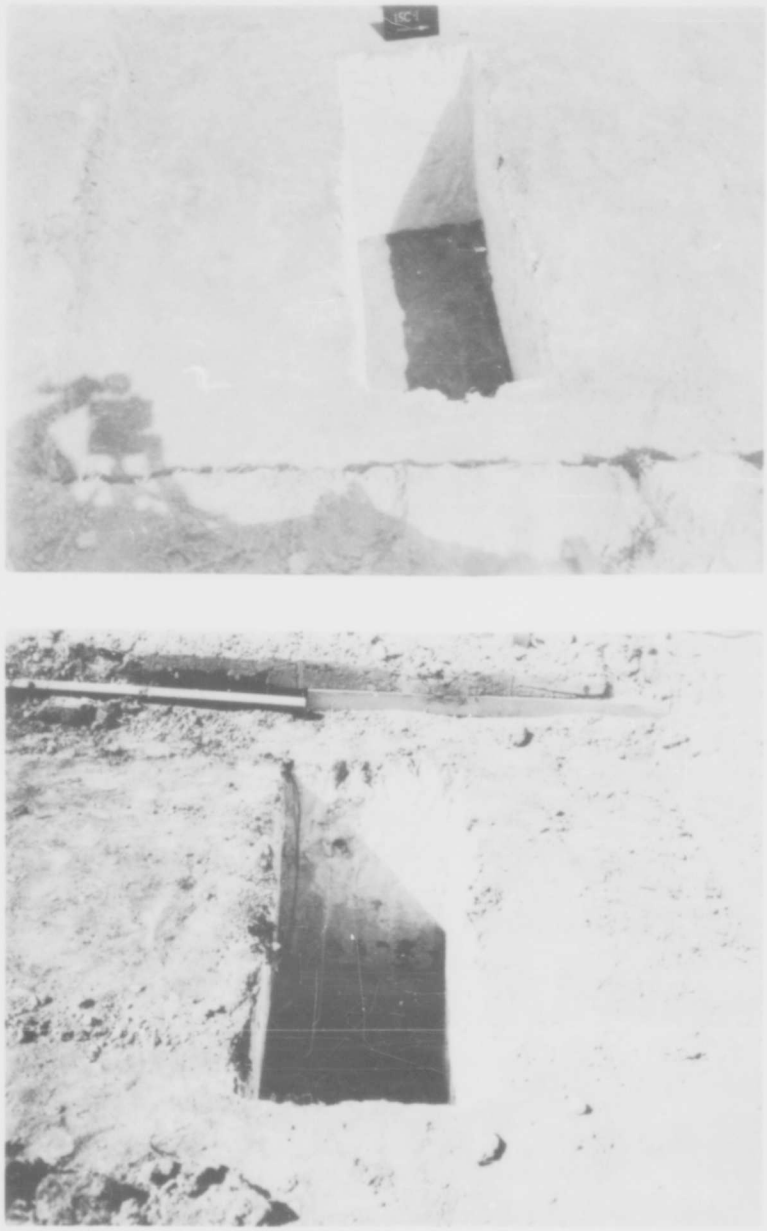


Fig. 13. Unit 15C. Top: pre-shot, ground zero indicated by arrow; bottom: post-shot, ground zero to left.

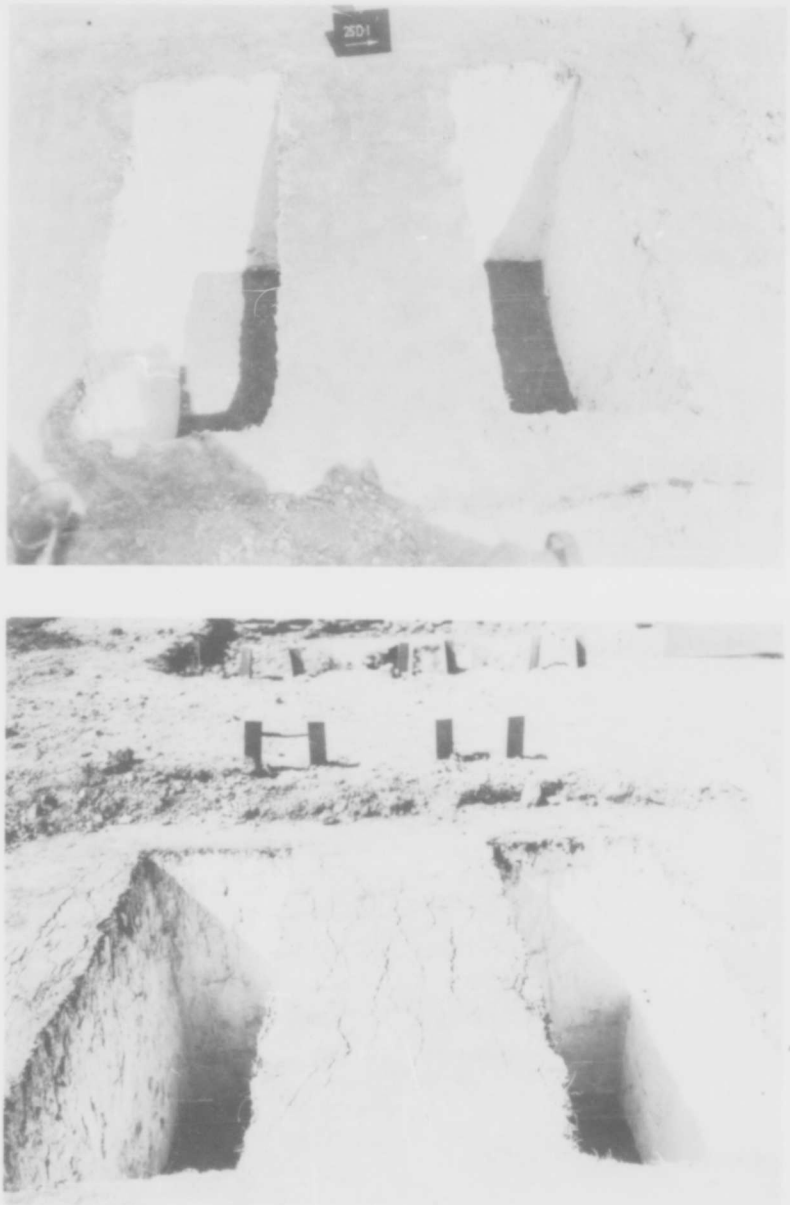


Fig. 14. Unit 25D. Top: pre-shot, ground zero indicated by arrow; bottom: post-shot, ground zero to left.

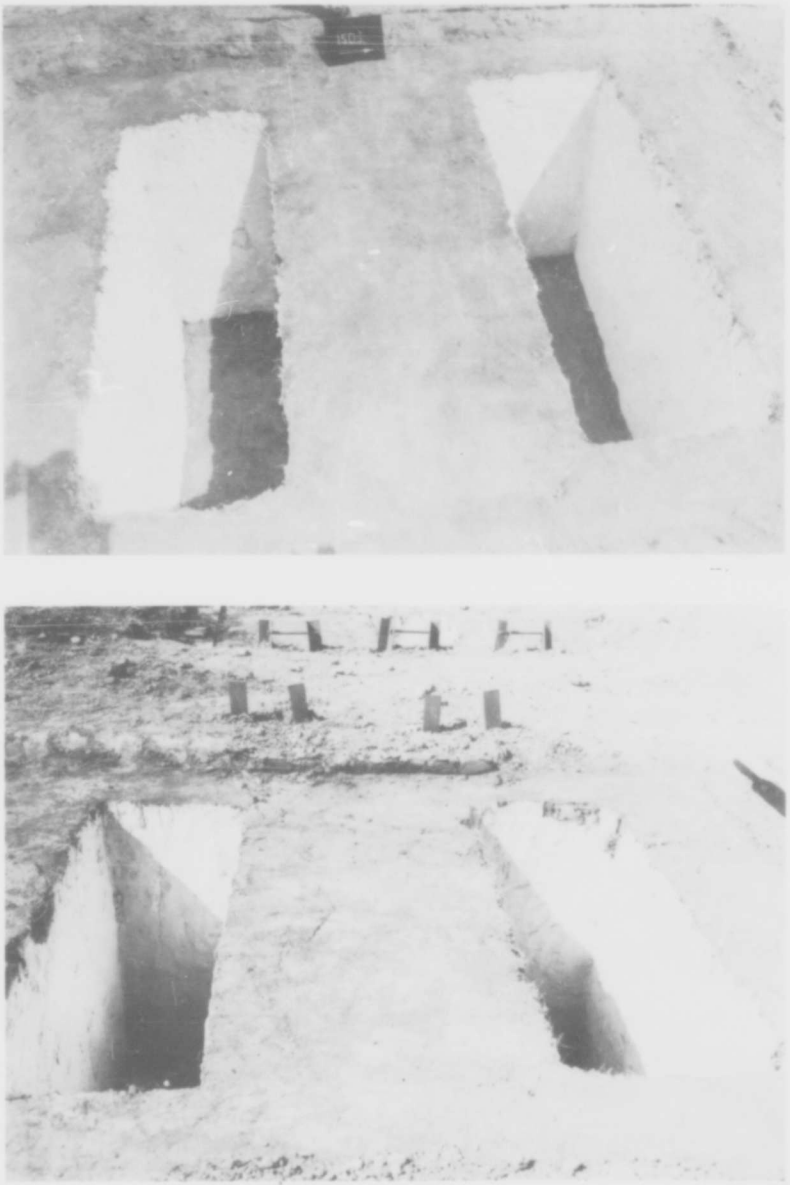


Fig. 15. Unit 15D. Top: pre-shot, ground zero indicated by arrow; bottom: post-shot, ground zero to left.

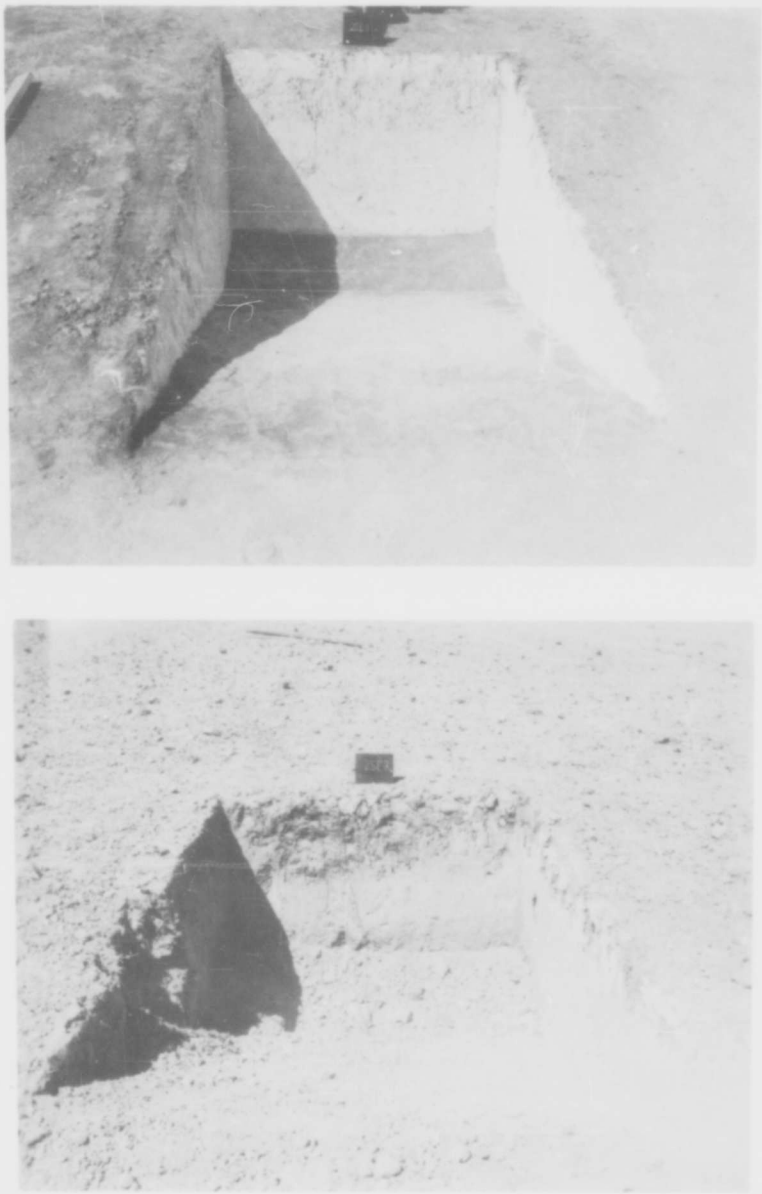


Fig. 16. Unit 25E. Top: pre-shot, ground zero toward bottom of photograph; bottom: post-shot (note sloughing of part of left side wall).

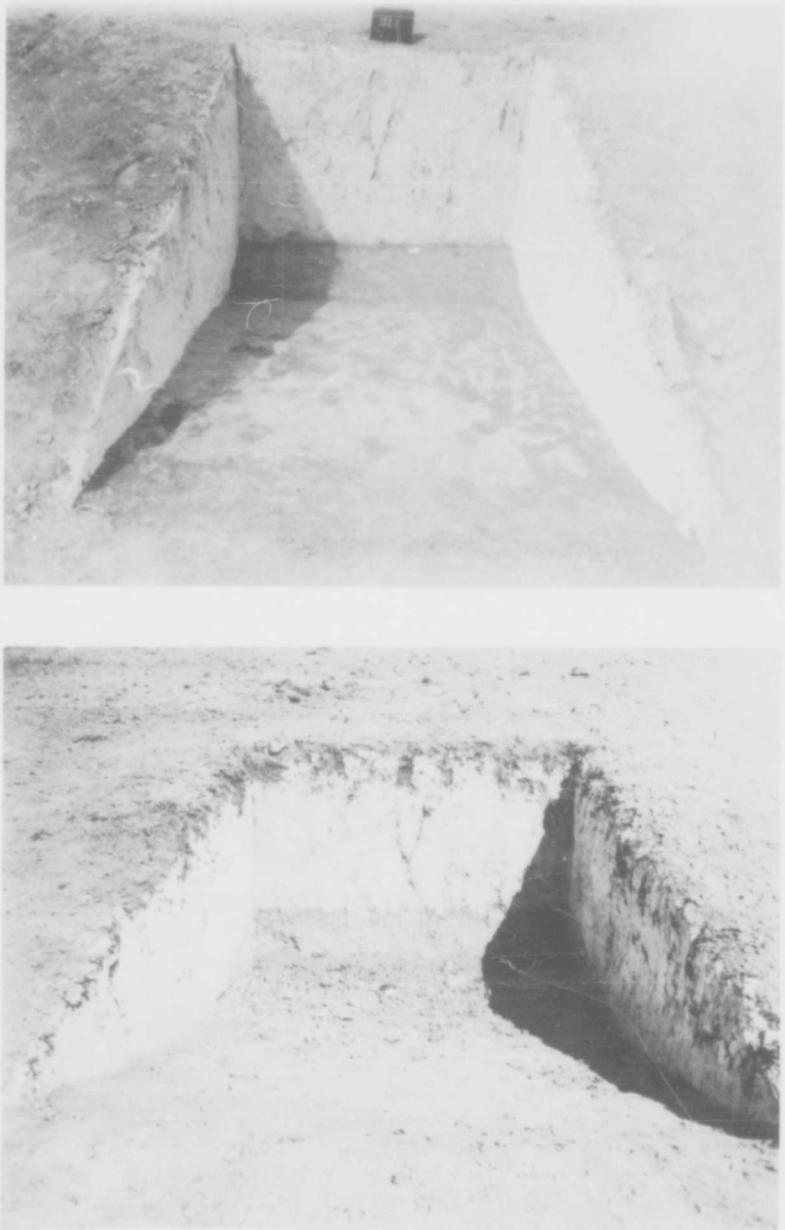


Fig. 17. Unit 15E. Top: pre-shot, ground zero toward bottom of photograph; bottom: post-shot (note cracks around side walls).

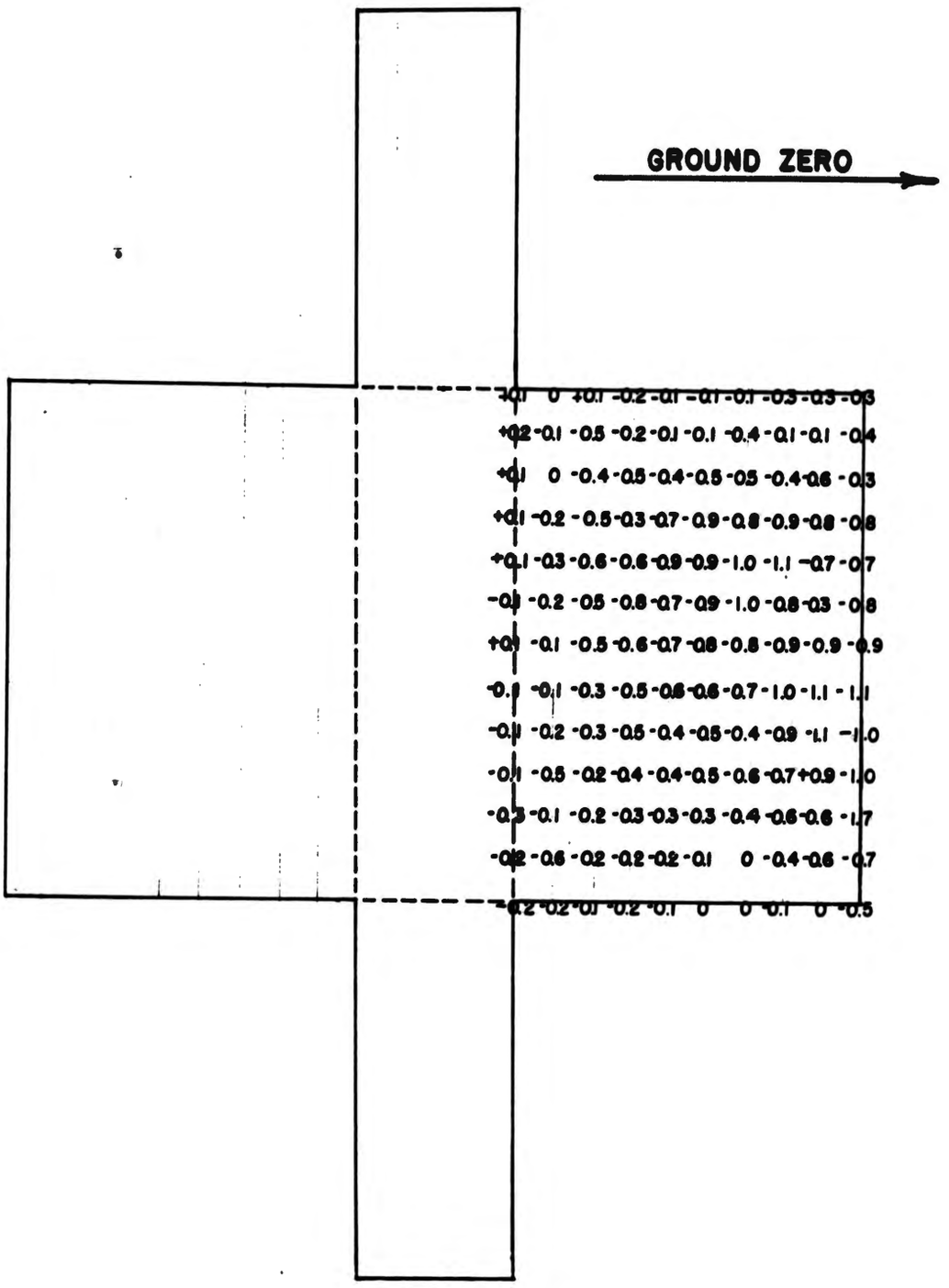


Fig. 18. Difference in pre-shot and post-shot wall measurements of unit 30A.

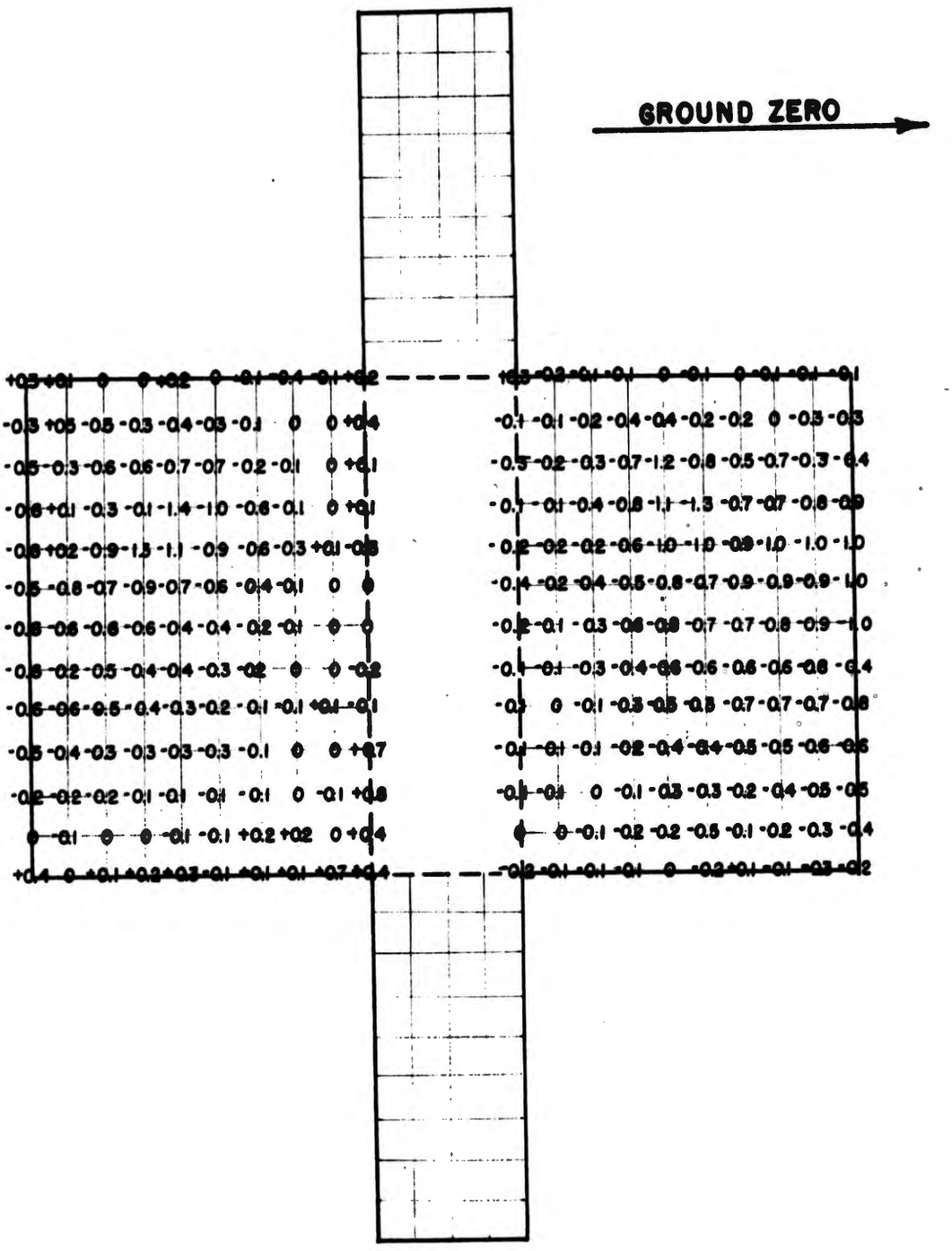


Fig. 19. Difference in pre-shot and post-shot wall measurements of unit 25A.

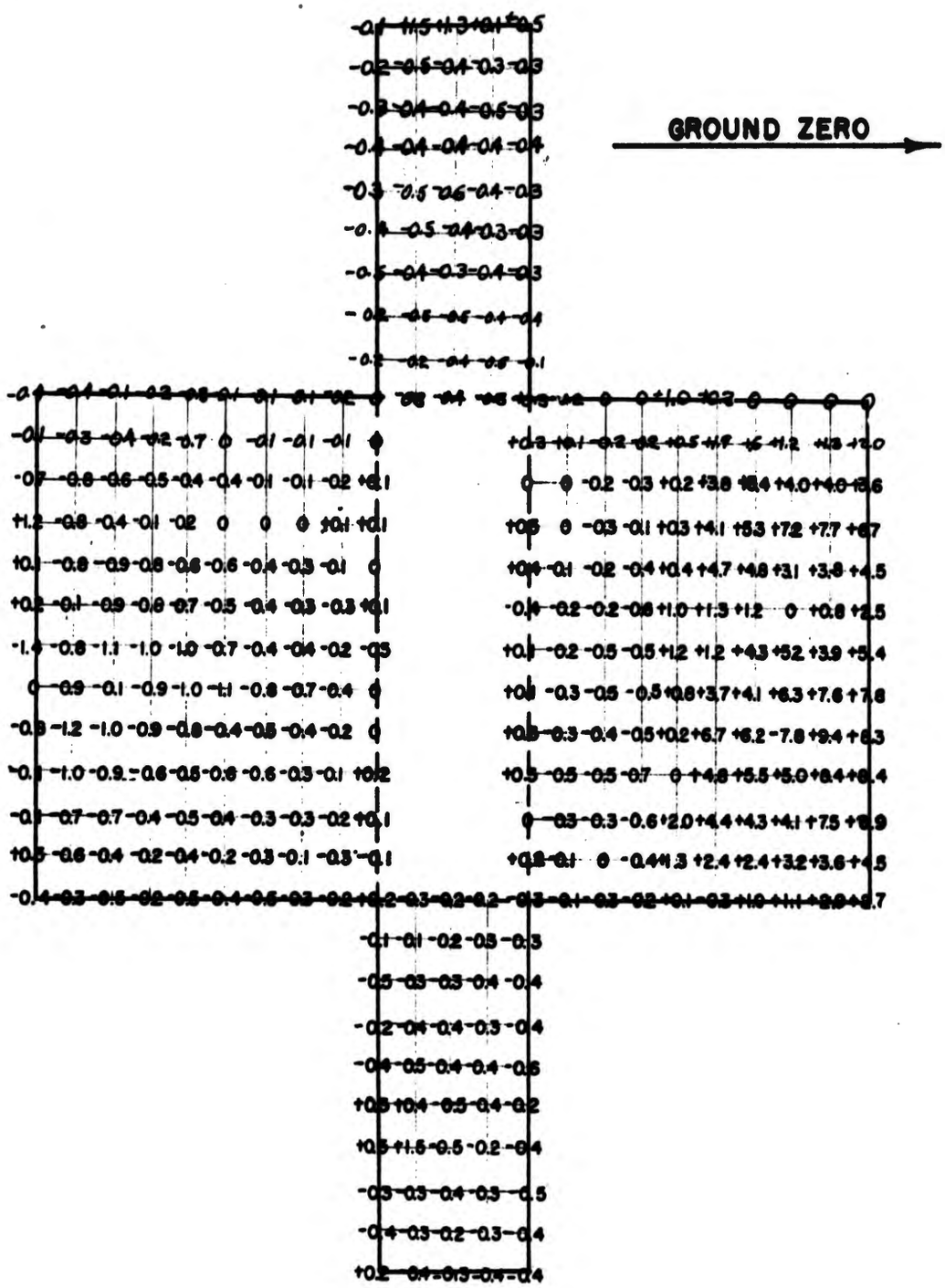


Fig. 20. Difference in pre-shot and post-shot measurements of unit 25C.

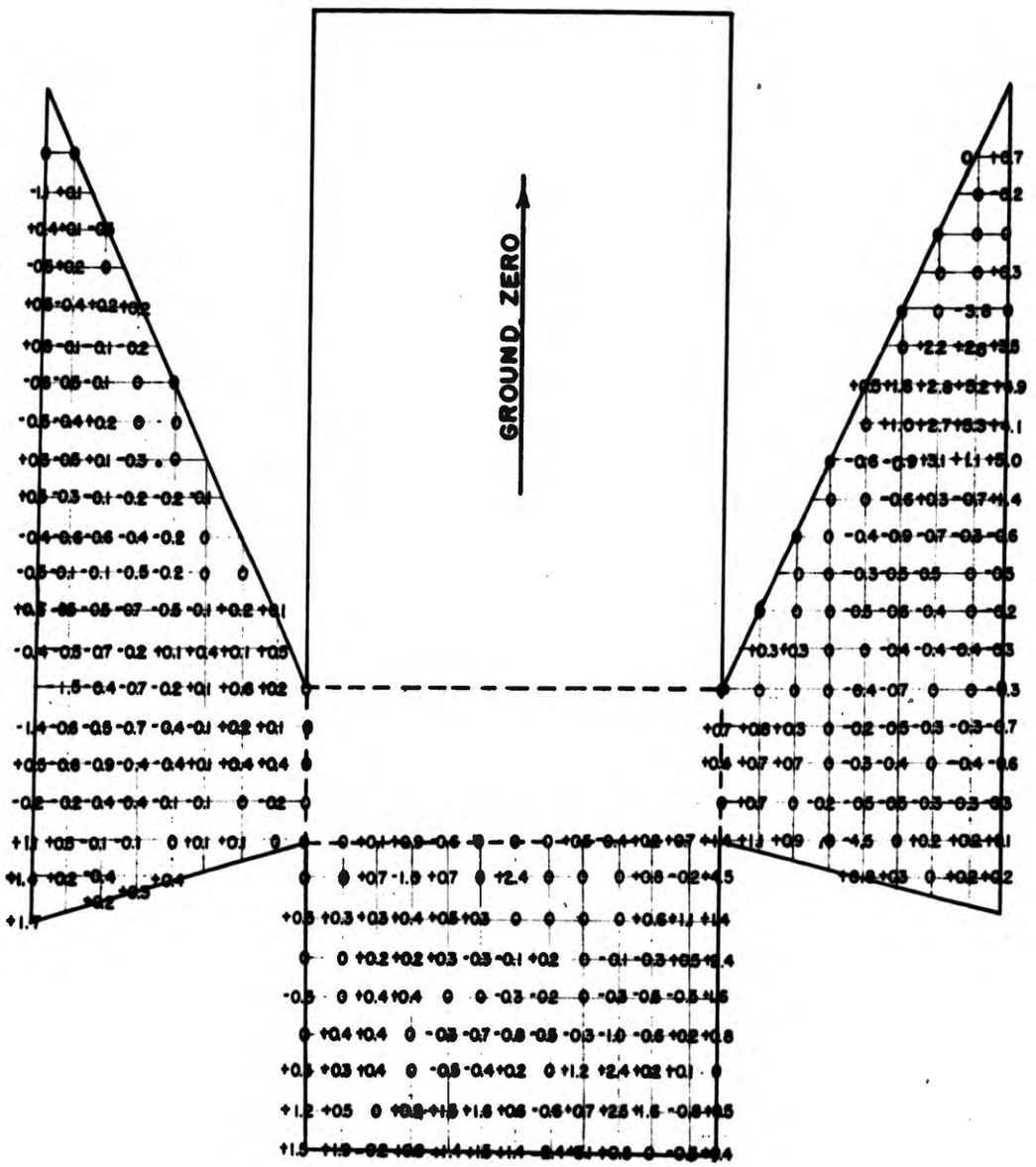


Fig. 21. Difference in pre-shot and post-shot measurements of unit 25E.

into the foxhole. Measurements of wall deformation were not made for some of the units because the magnitude of spalling was only slight; in the case of 25B, the walls bowed to a degree which prevented measurement.

III. DISCUSSION

7. Discussion. This test provided only some indication as to which blast phenomena contributed most to the failure of the walls of excavations. Additional units deployed at equal overpressures would be required to give more conclusive results. Also, the damage to the foxholes was not as severe as was expected.

This test did not evaluate blast damage to earth walls as a function of the variations of soil properties. The soil types and conditions were approximately the same at all of the 11 test units. Information about soil properties was available for the area in the vicinity of ground zero and is included in Appendices B and C.

At a distance of 450 feet from ground zero, the three covered excavations were unaffected, while the two open ones sustained cracks in the front and rear walls. This indicates that the incident air shock wave and its reflections in the cavity are primarily responsible for earth-wall damage.

At a distance of 360 feet from ground zero, the three covered excavations, as well as the two open ones, were cracked in the front and rear walls. Except for unit 25C, the damage to the covered excavations was less than that sustained by the open ones. The failure of unit 25C appears to have been caused by the cover timbers bending downward under the blast overpressure and striking the ground. This may have been due to settlement of the bearing timbers prior to the blast or to defective design of the cover itself. The front wall of the excavation was sloughed away, and the rear wall was severely weakened as shown in Fig. 12. The imprint of one of the 8- by 12-inch timbers can be seen where the cover struck the ground. It was noted that, of all the other test units 360 feet from ground zero which received noticeable damage, the wall nearer the blast was bowed in toward the center of the hole to a greater degree than was the opposite wall. This indicates that air-induced ground shock may be an important factor in earth-wall failure.

The front and rear walls of test unit 30A would have sloughed had it not been for the long roots of the prairie grass which retained the soil (Fig. 7).

IV. CONCLUSIONS

8. Conclusions. It is concluded:

a. Damage to the foxholes at the 15-psi overpressure level indicates that the incident blast wave and its reflections in the excavation are primarily responsible for earth-wall damage.

b. Damage to foxholes at the 25-psi overpressure level indicates that air-induced ground shock may be an important factor in earth-wall failure.

c. In the soil existing at the Canadian test site, the standard two-man foxhole showed, qualitatively, a high resistance to collapse from peak overpressures ranging up to 30 psi.

BIBLIOGRAPHY

DAVIS, NATHANIEL J., Jr., Protection Afforded by Field Fortifications Against Nuclear Weapons Effects, Exercise Desert Rock VII, Project 8-12-75-001, Report 1557-TR, U.S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia, 8 Dec 1958.

GRUM, ALLEN F., Field Fortifications, Operation Hardtack, Phase II (U), Project 8-12-95-400, Report 1576-TR, U.S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia, 10 Apr 1959. (CFRD)

APPENDICES

APPENDIX A

AUTHORITY

Item Nr 1904
CETC Mtg 323

RDT & E PROJECT CARD	1. TYPE OF REPORT ☐ NEW ☐ FINAL ☐ REPLACES (No. & Date) 8-12-95-400, 31 Dec 59	REPORT CONTROL SYMBOL CRCRD-1 (R2)
2. PROJECT TITLE: Techniques and Materiel for Engineer Operation in ABC Warfare (U)	3. SECURITY OF PROJECT: SECRET / 3.	4. PROJECT NO.: 8812-95-001 / 5. REPORT DATE: 15 May 1961
7. BASIC FIELD OR SUBJECT: Atomic Warfare	8. SUB FIELD OR SUBJECT SUB GROUP: Effects of Nuclear Weapons	9. CATEGORY: AR
10a. COGNIZANT AGENCY: Corps of Engineers b. DIRECTING AGENCY: Mil Sciences Div, R&D, OCE c. REQUESTING AGENCY: Office, Chief of Engineers	11a. CONTRACTOR AND/OR GOVERNMENT LABORATORY: U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia	b. CONTRACT NUMBER: -------
12. PARTICIPATION BY OTHER MILITARY DEPTS. AND OTHER GOVT. AGENCIES: N/A	14. SUPPORTING PROJECTS: None	16. EST. COMPLETION DATES: DEV. / ENGR TEST. / USER TEST / OPERATIONAL
13. COORDINATION ACTIONS W/OTHER MILITARY DEPTS. & OTHER GOVT. AGENCIES: DASA	15. DATE APPROVED 16. PRIORITY: 1A 17. BUDGET CODE: 5000	19. EST. SUPPORT LEVEL: ☐ UNDER $50,000 / ☐ $50,000 - $100,000 / ☒ $100,000 - $250,000 / ☐ $250,000 - $500,000 / ☐ $500,000 - $1,000,000 / ☐ OVER $1,000,000
20. CDOG; 610; 1110; 1122u	21. SPECIAL CODES	

22. REQUIREMENT AND/OR JUSTIFICATION

In any future conflict, Engineers will undoubtedly be required to operate in areas where nuclear weapons will be employed by both friendly and enemy forces. Thus, it is mandatory that a program of research and development be carried out to develop the techniques and material required to train and equip Engineer troops so that they may more effectively carry out their assigned missions. Some of the more important immediate requirements, as stated in CDOG, are as follows:

a. Par 610b "Engineer units will exploit the application of . . . nuclear energy . . . "

b. Par 610c(3) "Increased attention must be devoted to expedient and hasty type construction of field fortifications."

c. Par 610c(4)(a) Barriers: CONFIDENTIAL

d. Par 610c(4)(b) "Engineer troops or engineer equipment must assist . . in breaching barriers of all kinds . . . (and) . . . to assist in decontamination of critical areas."

DD FORM 613 PREVIOUS EDITIONS ARE OBSOLETE. PAGE 1 OF 3 PAGES

RDT & E PROJECT CARD CONTINUATION	REPORT DATE 15 May 1961	PROJECT NO. 8812-95-001

22. Requirement and/or Justification (cont'd):

e. Par 1110c(1)(c): SECRET

f. Par 1110c(2)(f) and (g): SECRET

g. Par 1122u: CDOG Study 61-1 Army Requirements for Nuclear Weapons Effects Research contains additional research requirements as follows: Annex B, par 2b(9); Annex D, par 3a(1); Annex D, par 3a(3).

23. Brief of Project and Objective:

a. Brief:

The capability of nuclear weapons to move land masses and to destroy huge targets so revolutionizes Engineer activities, both in kind and in magnitude, that it is essential that accurate data on weapons effects be available to the Engineer planner. It is the aim of this project to study these effects in light of Engineer responsibilities:

(1) Objectives:

The principal objectives are:

(a) Develop methods and techniques that will permit quick entry into, and effective operations in, areas devastated and contaminated by nuclear weapon detonations.

(b) Devise methods of utilizing atomic demolitions for engineering purposes.

(c) Develop means of protecting troops and materiel from nuclear weapons effects.

(2) Military Characteristics: Not applicable.

RDT & E PROJECT CARD CONTINUATION	REPORT DATE	PROJECT NO.
	15 May 1961	8S12-95-001

23. Brief of Project and Objective (Cont'd):

b. Approach:

It is planned to approach this problem along concurrent theoretical and empirical lines. This will be accomplished by theoretical studies in physical sciences, analysis of existing test data, testing with high explosives, testing with radioactive isotopes, and participation in full scale nuclear tests whenever possible. Specific avenues of approach, as indicated on the attached task cards, are taken depending on the requirement to be met.

c. Tasks:

The following tasks will be carried out under this project:

8S12-95-001-01	Engineer Studies and Investigations
8S12-95-001-02	Theory of Application of Atomic Demolition Munitions Effects
8S12-95-001-03	Radiation Shielding Studies of Engineer Equipment and Field Protective Works
8S12-95-001-04	Radioactive Barrier Breaching Methods and Equipment

d. Other Information: None

APPENDIX B

PROPERTIES OF SOIL AT GROUND ZERO. 100-TON TRIAL AT SUFFIELD EXPERIMENTAL STATION

Property	Result
Plastic Limit (%)	23.93
Liquid Limit (%)	45.95
Plasticity Index	22.02
Toughness Index	217.50
Shrinkage Limit (%)	14.05
Shrinkage Ratio	1.80
Shrinkage Index (%)	9.88
Specific Gravity	2.71
Percent Finer than No. 200 Sieve	98.86
Moisture Content (%)	13.32
Unified Soil Classification	CL

NOTE: Analysis run by Suffield Experimental Station personnel.

APPENDIX C

SOIL ANALYSES DATA FOR VARIOUS LOCATIONS OF TEST SITE

Distance From Ground Zero (ft)	Depth (ft)	Sample Description	Natural Water Content (%)
0	0	Clay (CL), very stiff, tan	12.1
0	1	Silty-clay (CH), very stiff, tan	13.4
0	2	Clay (CL), medium, tan	8.2
0	3	Clay (CL), medium, tan	7.7
0	4	Clay (CL), medium, tan	9.6
50	0	Silty-clay (CL), medium, tan	15.2
60	0	Silty-clay (CL), soft, tan	13.6
70	1	Silty-clay (CL), medium, tan	11.1
80	5	Silty-clay (CL), medium, tan	11.5

NOTE: Analysis run by Waterways Experiment Station.

Category 13 - Mine Warfare and Demolitions

DISTRIBUTION FOR USAERDL REPORT 1717-TR

TITLE An Attempt to Isolate the Blast Phenomena Which Contribute Most to the Earth-Wall Failure of Excavations

DATE OF REPORT 26 July 1962 PROJECT 8812-95-001 CLASSIFICATION U

ADDRESSEE	NO. OF COPIES
Department of Defense	
Chief, Defense Atomic Support Agency Washington 25, D. C.	2
Chief, Defense Atomic Support Agency Attn: Blast & Shock Division Washington 25, D. C.	10
Commander, Field Command, DASA Sandia Base Attn: FCWT Albuquerque, New Mexico	1
Department of the Army	
Chief of Research & Development Department of the Army Attn: Atomic Division Washington 25, D. C.	1
Chemical Corps	
U. S. Army Chemical Corps Nuclear Defense Laboratory Technical Library Army Chemical Center, Maryland	1
Corps of Engineers	
Chief of Engineers Attn: ENGTO-P ENGRD-SE ENGRD-MF ENGTO-O ENGMC-EB Department of the Army Washington 25, D. C.	 1 2 2 1 1

ADDRESSEE	NO. OF COPIES
Corps of Engineers (cont'd)	
Director Waterways Experiment Station Attn: Library P. O. Box 631 Vicksburg, Mississippi	2
Commanding General Army Map Service Attn: Documents Library 6500 Brooks Lane Washington 25, D. C.	2
The Engineer School Library Building 270 Fort Belvoir, Virginia	2
USAERDL	
Commanding Officer	1
Military Department	1
Demolitions & Fortifications Branch	8
R&D Project Case File	1
Technical Documents Center	2
Office of Counsel	1
Technical Reports Office	3
Mech, Elec, Mil, and TS Departments (Circulate)	1
British Liaison Officer	5
Canadian Liaison Officer	5
Ordnance Corps	
Chief of Ordnance Attn: ORDTX-AR Department of the Army Washington 25, D. C.	1

ADDRESSEE	NO. OF COPIES
Ordnance Corps (cont'd)	
Director Ballistic Research Laboratory Aberdeen Proving Ground, Maryland	1
Overseas Commands	
Office of the Engineer AFFE/8A (REAR) APO 343 San Francisco, California	1
The Engineer Headquarters, USAREUR Attn: I&M Branch APO 403 New York, New York	2
Engineer Section USARCARIB Fort Amador, Canal Zone	1
Engineer Headquarters 7th Army APO 46 New York, New York	1
Chief Engineer Support Control Office Attn: Chief, Cat. Branch, GED USAREUR Support Control Center APO 58 New York, New York	2
Senior Standardization Representative U. S. Army Standardization Group, UK USN 100, FPO Box 65 New York, New York	1
Quartermaster Corps	
Commander Quartermaster Field Evaluation Agency Quartermaster Research & Engineering Command Fort Lee, Virginia	1

ADDRESSEE	NO. OF COPIES
Quartermaster Corps (cont'd)	
Commander Quartermaster Research & Development Command Quartermaster Research & Development Center Attn: Technical Library Natick, Massachusetts	1
Office of Research & Development Office of The Quartermaster General Department of the Army Washington 25, D. C.	1
Transportation Corps	
Chief of Transportation Attn: TCACR-TC Washington 25, D. C.	1
USCONARC	
Commanding General Continental Army Command Attn: Engineer Section Fort Monroe, Virginia	2
Director Special Weapons Development Office HDQS, U. S. Continental Army Command Fort Bliss, Texas	1
Chairman Engineer Committee Tactical Department, Technical Information Service Fort Benning, Georgia	1
Combat Developments Office Attn: Engineer Advisor USA Infantry School Fort Benning, Georgia	1
President U. S. Army Armor Board Attn: Chief, Engineer Section Fort Knox, Kentucky	1

ADDRESSEE	NO. OF COPIES
Signal Corps	
Commanding General Signal Corps Engineering Laboratory Attn: Technical Documents Center Fort Monmouth, New Jersey	1
Department of the Navy	
Chief Bureau of Yards and Docks Department of the Navy Attn: Code D-400 Washington 25, D. C.	1
Officer in Charge (Code 200C8) U. S. Naval Civil Engineering Research and Evaluation Laboratory Port Hueneme, California	1
Chief of Naval Research Department of the Navy Attn: Reports Branch (Code 530) Washington 25, D. C.	1
Commandant of Marine Corps (Code A04E) Headquarters Marine Corps Washington 25, D. C.	1
Commanding Officer U. S. Naval Construction Battalion Center Port Hueneme, California	1
Director, Marine Corps Development Center Marine Corps Landing Force Development Center Marine Corps Schools Quantico, Virginia	1
Commander U. S. Naval Ordnance Laboratory White Oak Silver Spring 19, Maryland	1
Director U. S. Naval Research Laboratory Washington 25, D. C.	1

ADDRESSEE	NO. OF COPIES
Department of the Air Force	
Rome Air Development Center (RCVGE) Griffiss Air Force Base, New York	1
Wright Air Development Division (WCLEO) Wright-Patterson Air Force Base, Ohio	1
Director of Civil Engineering Attn: AFOCE Department of the Air Force Washington 25, D. C.	1
Washington ARDC Regional Office c/o Department of the Navy Room 4549, Munitions Building Washington 25, D. C.	1
Commander, Air Force Special Weapons Center Kirtland Air Force Base Attn: Library Albuquerque, New Mexico	1

UNCLASSIFIED