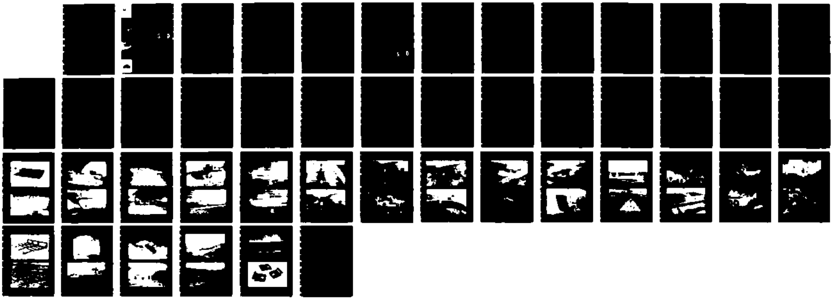
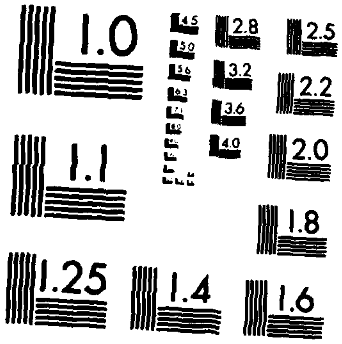
AD-A171 511 EVALUATION OF WATERWAYS EXPERIMENT STATION DEVELOPED ALUMINUM ACCESS/EGRE..(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS GEOTE.. 1/1

UNCLASSIFIED S D TRIPLETT ET AL. MAY 86 WES/TR/GL-86-5 F/G 13/2 NL




1.0
2.8
2.5
3.2
2.2
3.6
4.0
1.1
2.0
1.8
1.25
1.4
1.6

(12)

US Army Corps of Engineers

TECHNICAL REPORT GL-86-5

AD-A171 511

EVALUATION OF WATERWAYS EXPERIMENT STATION DEVELOPED ALUMINUM ACCESS/EGRESS MODULES

by

Shirley D. Triplett, Dewey W. White, Jr.

Geotechnical Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39180-0631

May 1986

Final Report

GEOTECHNICAL LABORATORY

Prepared for DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

Under Project No. 4A162719AT40 and 4A762719AT40
Task BO, Work Unit 08

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Technical Report GL-86-5

2. GOVT ACCESSION NO.: ADA171511

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): EVALUATION OF WATERWAYS EXPERIMENT STATION DEVELOPED ALUMINUM ACCESS/EGRESS MODULES

5. TYPE OF REPORT & PERIOD COVERED: Final report

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):

Shirley D. Triplett
Dewey W. White, Jr.

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:

US Army Engineer Waterways Experiment Station
Geotechnical Laboratory
PO Box 631, Vicksburg, Mississippi 39180-0631

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Project No. 4A162719AT40 and 4A762719AT40, Task BO, Work Unit 08

11. CONTROLLING OFFICE NAME AND ADDRESS:

DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

12. REPORT DATE: May 1986

13. NUMBER OF PAGES: 41

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report):

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):

18. SUPPLEMENTARY NOTES:

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number):

Access-egress surfacing modules (WES)
Stream crossing, Military (LC)
Transportation, Military (LC)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

This investigation was conducted to determine if a hinged-aluminum panel system, extruded aluminum access/egress surfacing module, would provide exit roadways out of rivers for fording/swimming vehicles, access lanes for bridge or raft launching equipment, and roadways to and from a bridgehead. Studies were also conducted to determine module placement procedures and the compatibility of the modules with the access/egress roadway system dispenser. The

(Continued)

DD FORM 1473, 1 JAN 73 — EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued).

surfacing modules were placed on a low-strength soil test section, and military vehicles were trafficked on the modules to determine if they would support 3,000 passes of mixed military vehicle traffic. The surfacing was then placed on a 25 percent slope and trafficked with wheeled and tracked vehicles during dry, wet, and muddy conditions to determine the traction characteristics of the modules. Twenty-five passes of an M113 Armored Personnel Carrier were applied to a lake bank test site surfaced with the modules to determine if they would satisfy the assault egress vehicle role. Two widths of the surfacing modules were investigated to fulfill the requirements of the Letter of Agreement (LOA), each with its own method of dispensing.

As a result of this investigation, the surfacing modules met the requirements for trafficking and dispensing as stated in the LOA. However, several recommendations to further improve the system are included based on the findings reported herein.

PREFACE

This report describes studies that were part of the work sponsored by the Office, Chief of Engineers, US Army, under Project No. 4A162719AT40 and 4A762719AT40, Task BO, Work Unit 08, entitled "Access/Egress System for Improved Mobility in Soft Soils."

The investigations were conducted by personnel of the Geotechnical Laboratory (GL), US Army Engineer Waterways Experiment Station (WES) during the period May 1984 through July 1985. Credit should also be given to Belvoir Research, Development, and Engineering Center for the use of their dispenser during the investigation. Engineers actively engaged in the planning, analyzing, and reporting of this study were Messrs. H. L. Green, R. H. Grau, D. W. White, Jr., and Ms. S. D. Triplett, Pavement Systems Division (PSD), GL. Also, Mr. Keith Glaza was contracted by WES to design the aluminum modules. Engineering technicians for the project were Messrs. T. Williams, S. Alford, PSD, and D. A. Ellison (retired). General supervision was provided by Dr. W. F. Marcuson III, Chief, GL, and Mr. H. H. Ulery, Jr., Chief, PSD. This report was prepared by Ms. Triplett and Mr. White, and edited by Ms. Odell F. Allen, Publications and Graphic Arts Division.

Director of WES during the preparation and publication of this report was COL Allen F. Grum, USA. Dr. Robert W. Whalin was the Technical Director.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
feet	0.3048	metres
inches	2.54	centimetres
pounds (force) per square inch	6.894757	kilopascals
pounds (mass)	0.4535924	kilograms
tons (2,000 pounds, mass)	907.1847	kilograms

EVALUATION OF WATERWAYS EXPERIMENT STATION DEVELOPED ALUMINUM ACCESS/EGRESS MODULES

PART I: INTRODUCTION

Background

1. With the advent of modern military assault vehicles and more rapidly emplaced bridging, the need for the US Army to gain an equivalent capability to reach a gap crossing and maintain subsequent flow has become essential. The current methods used to provide access/egress routes to temporary bridge sites and the inability of fording and swimming vehicles to egress some water obstacles will delay the movement of combat and support forces, thereby presenting crucial personnel and equipment targets at crossing sites. Poor soil conditions and/or steep slopes along river and streambanks must be overcome to allow movement by tactical assault vehicles at the most tactically advantageous locations.

2. The Office, Chief of Engineers, US Army provided initial funding for this program during FY 80. The broad purpose of the program was to investigate, develop, and test concepts and techniques for rapid construction and use of materials that provide access/egress routes over extremely soft soils that are inaccessible for sustained military operations. The program was envisioned as a 6-year research effort which included the following major elements:

a. Research and problem analysis.

b. Development of new capability.

c. Evaluation and selection of potential systems.

d. Adaptation of new construction concepts, techniques, and systems to the problem areas.

e. Preparation of technical reports.

3. A Letter of Agreement (LOA) for a Tactical Bridge Access/Egress System between Headquarters, US Army Materiel Development and Readiness Command (DARCOM) now US Army Materiel Command (AMC), and Headquarters, US Army Training and Doctrine Command (TRADOC) (Walker 1979) was used as the guideline

for this program. A summary of the major requirements of the LOA is as follows:

a. The assault vehicle egress role must allow swimming and fording combat vehicles to exit streams that have slopes within their normal climbing capabilities (maximum 25 percent). The egress points must be capable of withstanding 25 passes by vehicles up to and including Military Load Class (MLC) 70. The system will enable one squad of an Engineer Combat Company, using current organic equipment, to simultaneously install two egress points, 16.4 ft* wide and 49 to 66 ft long, within 15 min after arriving at the exit bank.

b. The bridge equipment access role must provide access lanes for use by gap crossing equipment to reach bridge launch sites. The access lanes must be capable of withstanding 50 passes by vehicles up to and including MLC 25. The system will enable 10 people from the Engineer Assault Float Bridge Company (ribbon), using current organic equipment, to install single lanes 13.1 ft wide, at the rate of 328 to 410 ft in 30 min.

c. The bridge traffic access/egress role must provide roadways capable of withstanding 2,000 to 3,000 vehicle passes (10 percent rated at MLC 70). The system will enable one platoon of the Engineer Combat Company (Corps), using current organic equipment, to install single 13.1 ft lanes at the rate of 820 to 984 ft in 45 min.

4. Studies that included literature searches and field evaluations of promising materials were conducted to determine if any inventory depot items or "off-the-shelf" commercial items would meet all the requirements of the LOA. Eight separate studies conducted at Waterways Experiment Station (WES) were designed to address major requirements of the LOA for a tactical bridge access/egress system and were consolidated into one report (Carr, Green, and Taylor 1980). Each of the studies was described previously either in a WES Memorandum for Record, a draft report, or a draft user's manual. That report summarizes the early test results and documents the work in chronological order. Each in-house report was presented as an appendix. Another study evaluated two commercial products used as tactical access/egress systems (Ellison 1982). Results of these studies revealed that no military inventory item or commercial item tested would satisfy all the requirements of the LOA.

5. Another study was conducted in 1980 to determine if any inventory items would meet the assault vehicle egress requirements for riverine crossings as listed in the LOA (Carr and Willoughby 1980). Test results indicated

---

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

that none of the materials tested would meet all the requirements, but a neoprene-coated nylon membrane used in conjunction with mats or other materials might satisfy the assault vehicle egress role as stated in Part A of the LOA. Subsequent to the results of this study, materials that included combinations of neoprene-coated nylon fabric, steel wire fabric, and oak planks, aluminum rectangular tubes, or aluminum channels were designed, fabricated, and tested (Triplett 1986). Results of these tests concluded that a test item fabricated from a neoprene-coated nylon fabric, galvanized steel wire fabric, and aluminum channels will satisfy all of the requirements of the assault role as stated in Part A of the LOA. A patent is pending on the design of this item which has been designated Flexmat.

6. During the conduct of this study, the US Army Mobility Equipment Research and Development Command (MERADCOM), now Belvoir Research, Development, and Engineering Center (BRDEC), Fort Belvoir, Va., was developing a system that would meet all of the requirements of the LOA. They funded a contractor to develop a surfacing material and a dispenser that would place and retrieve the surfacing. WES was funded to provide technical expertise during the development of the system and conduct Engineer Design Tests (EDT) on the system. After the design for the system was finalized, two dispensers/retrievers and three 100-ft-long sections of roadway surfacing were fabricated and shipped to WES. Development Tests 1 (DT1) were conducted at WES on this system to determine if it met the requirements of the LOA. As the BRDEC program proceeded, it became evident that one system would not satisfy all of the requirements of the LOA. Therefore, a Letter Requirement (LR) for the Access/Egress Roadway System (AERS) (Headquarters, Department of the Army, US Army Engineer School, 1985) was drafted which essentially eliminated the assault vehicle egress role from the requirements for the system BRDEC was developing.

7. Results of the DT1 of BRDEC's system indicated it would satisfy the requirements of the draft LR, and the system was shipped to Fort Knox, Ky., to undergo an Operational Test 1 (OT1) The US Army Armor and Engineer Board was the test agency for the OT1. Although the system looked promising, the roadway surfacing, which was developed by an independent contractor, was a proprietary item. The contractor indicated it would be very expensive for the Government to obtain the surfacing or the design rights for the surfacing. With this in mind, BRDEC requested WES to modify the surfacing material

designed and developed at WES so it could be included as a test item at the OT1 conducted at Fort Knox, Ky.

Purpose

8. This investigation was conducted to determine if a WES developed hinged-aluminum panel system, extruded aluminum access/egress surfacing module, whose design was Government owned would provide exit roadways out of rivers for fording/swimming vehicles, access lanes for bridge or raft launching equipment, and roadways to and from a bridgehead. Studies were also conducted to determine module placement procedures and the compatibility of the modules with the AERS dispenser.

Scope

9. The surfacing modules were placed on a low-strength soil test section, and military vehicles were trafficked on the modules to determine if they would support 3,000 passes of mixed military vehicle traffic. The surfacing was then placed on a 25 percent slope and trafficked with wheeled and tracked vehicles during dry, wet, and muddy conditions to determine the traction characteristics of the top surface of the modules. Twenty-five passes of an M113 Armored Personnel Carrier (APC) were applied to a lake bank test site surfaced with the modules to determine if they would satisfy the assault egress vehicle role as stated in the LOA. The width of one surfacing module was reduced from 16.4 ft to 13.1 ft before tests were conducted to determine the compatibility of the module with BRDEC's dispenser/retriever. A full 16.4 ft-wide module was used to determine the feasibility of dispensing and retrieving the modules from a wooden crate. Tests were conducted on flat and 25 percent sloped areas.

Definitions of Terms

10. For information and clarity, certain items used in this report are defined as follows:

California Bearing Ratio (CBR)--A measure of the bearing capacity of the soil based upon its shearing resistance. CBR is calculated by dividing the unit load required to force a 1.95-in.-diam piston into the soil to a depth of 0.1 in. by the unit load required to force the same piston the same depth into a standard sample of crushed stone, and then multiplying by 100.

Pass--One trip of the test vehicle across the test section.

Module--One extruded aluminum panel, 2 in. thick, 25.5 in. long and 16.4 ft wide.

PART II: DESCRIPTION OF ALUMINUM ACCESS/EGRESS SURFACING MODULES

11. WES contracted Mr. Keith Glaza to design the extruded aluminum access/egress surfacing modules. ALFAB, Inc., Enterprise, Ala., was contracted to fabricate a test quantity of the modules. From a Government-owned design the panels, hinge links, and hinge pins were fabricated from 6061-T6 extruded aluminum alloy. Each individual module is 2 in. thick, 25.5 in. long, 16.4 ft wide, and weighs approximately 240 lb. The panel's cross section is made up of 13 tunnel-like openings separated by aluminum walls. Protrusions 1/4 in. high are located on each side of the module to provide traction on the top surface for wheeled or tracked vehicles and an anchoring system on the bottom surface. Adjacent extruded modules are connected with an aluminum hinge pin and 16 hinge links. The hinge connections were also designed to allow each module to be rotated 360 deg with respect to the adjacent panel. Thus, the modules can be folded into a compact bundle. Since the modules can be rotated a full 360 deg and they are symmetrical, they can be folded from either end, and there is no "top" or "bottom" to the module. The pins are anodized with a black film to reduce the friction between the rubbing metals. The connected modules are shown in Photo 1.

PART III: TEST VEHICLES

12. During this investigation, four test vehicles were used to simulate military vehicular traffic. The vehicles used were required to operate at their respective highway loadings and tire pressures, which in each case was the maximum capacity. The M48A1 tank was modified by removing the turret and gun, and adding weights to simulate a MLC 70. The test vehicles, gross weight, and tire pressures when applicable were as follows:

- a. Five-ton M54 cargo truck (40,000 lb gross weight, 70 psi tire pressure) (Photo 2).
- b. Five-ton ribbon bridge transporter (RBT) truck (47,400 lb gross weight, 50 psi tire pressure) (Photo 3).
- c. M48A1 tank (140,000 lb gross weight) (Photo 4).
- d. M113 APC (24,000 lb gross weight) (Photo 5).

PART IV: TRAFFIC TESTS

Unsurfaced Area

13. Traffic tests were conducted over an unsurfaced low-strength soil test section to determine the need for an access/egress surfacing. The test section was 2 ft deep, 24 ft wide, and 44 ft long with approach areas at each end. A 40,000 lb M54 truck with a tire pressure of 70 psi became immobilized during the seventh pass over the 1.5 CBR soil (Photo 6). Following the truck passes, without leveling or reprocessing the soil, an M48A1 tank loaded to 140,000 lb attempted to traffic the test section. During the tenth pass, the tank became immobilized (Photo 7). The results of this test indicated that without any surfacing, the weak soil material will rut causing the underbody of the vehicle to drag and eventually will immobilize the vehicle.

Surfaced Area

14. Traffic tests were conducted over a weak soil test section to determine if the extruded aluminum modules would meet the requirements stated in the LOA for a tactical bridge access/egress system. The test area filled with 1.3 CBR soil had the same dimensions as the unsurfaced test. A bundle of modules was placed at one end of the prepared area and deployed across the section by cables attached to a RBT. The time required to install the 16.4 by 55 ft section of surfacing using two men was approximately 5 min.

15. An empty RBT made several passes over the modules to seat them before the traffic tests began. Traffic was applied as shown in Table 1 for a total of 3,000 passes. Photos 8, 9, and 10 show the surfacing as it was trafficked. During the first few passes of loaded trafficking, there was some vertical movement in the hinge joints measuring 1 to 2 in. As traffic continued and the panels became embedded in the soil, the joint movement decreased to 0.5 in.

16. There were no problems in the placement procedure and no structural damage to the modules during trafficking. Some of the soil was forced up through the hinge joints, but it caused no traction problems and was considered minor (Photo 11). The modules were removed from the area with a crane, and the underlying soil was examined. A CBR reading of 1.9 was

measured after the trafficking, giving an average value of 1.6 CBR for the test. Cross-section and profile measurements taken at various intervals showed a maximum elevation change of 1 in., which was considered low for these circumstances.

PART V: SLOPE TESTS

17. Before transporting to the slope testing site, the modules were cleaned and folded into two adjacent stacks hinged at the bottom panel. A forklift then placed the stacked modules near the toe of the 25 percent slope. A crane was used to unfold the two stacks in opposite directions, up and down the slope, leaving approximately 5 ft of surfacing on the level area above the slope, 44 ft on the incline, and 6 ft on the flat area at the bottom of the slope. Three 2-ft-long "tack type" anchors made from 3/4-in.-diam reinforcing bars welded to 8-in.-diam plates were used to secure the surfacing. The anchors were driven into the ground (CBR 20) as shown in Photo 12 between the first two panels at the top of the slope. Refer to Table 2 for a summary of the traffic applied during the slope tests.

Dry Slope Test

18. With the clean, dry surfacing in place over the slope, 10 passes were applied with the M54 truck, 15 passes with the RBT, and 10 passes with the M48A1 tank. To determine the traction characteristics of the modules, each vehicle was stopped several times during its ascent and then allowed to continue. After trafficking was completed, the surfacing had moved down the slope 5/8 in. Soil and gravel tracked onto the surface caused minor abrasions to the modules. Otherwise, no damage occurred. Photo 13 shows a view of the surfacing after the dry slope test.

Wet Slope Test

19. During the second series of tests, the surface was continually sprayed with water during trafficking (Photo 14). Traffic was applied in the same manner as the dry slope test (see paragraph 18) with no loss of traction due to the water. After trafficking was completed, the modules had moved only 1/4 in. further down the slope. Additional soil and gravel were tracked onto the surfacing resulting in only minor abrasion to the modules (Photo 15). However, the water draining off the surfacing at the bottom of the slope had flowed onto the approach area and caused rutting due to the traffic of the vehicles. The resulting 15 to 18 in. difference in the elevations of the soil

and the surfacing at the approach area caused the vehicles to have difficulty maneuvering onto the modules.

Muddy Slope Test

20. Before trafficking the area again, the ruts in the soil at the toe of the slope were smoothed and 12 module panels (approximately 26 ft) were added to increase the length of the surfacing extending over the approached area. A processed weak-strength (less than 1 CBR) 12 in. layer of clay soil was deposited on the modules as shown in Photo 16 at the approach end to simulate a muddy river crossing. The M48A1 tank made 10 passes up the slope without any difficulty (Photo 17). The M54 and RBT traffic was intermixed with the M54 making 15 passes and the RBT 10 passes over the surfacing. Each of these vehicles had some trouble during their first few passes, but the tires eventually spun through the mud to the surface of the modules and gained traction. The performance of the RBT improved when it operated in a higher gear. After the trafficking was completed, the modules were cleaned and inspected for damage. Several indentations and some abrasions occurred due to gravel that was tracked onto the modules during the test. Also, one small hole was caused by a piece of gravel penetrating through the top surface of a module (see Photo 18). No additional movement of the modules down the slope occurred.

Lake Site Egress Test

21. Several unsuccessful attempts to egress the bare slope at the lake site were made by the APC (Photo 19). This indicated a need for a surfacing to provide traction on the slope. For relocation to the lake site, the panels were again folded in two adjacent stacks as described in paragraph 17 and transported with a forklift to the 25 percent lakeside slope. The stacked panels were placed near the water's edge and deployed using a crane (Photo 20) to pull 10 panels into the water and the remaining 15 panels up onto the slope. Although a commercial crane was used during this test, military equipment such as a 20-ton wheel-mounted crane which is organic to ribbon bridge companies and other bridge construction units is capable of placing the module surfacing on the bank of a water obstacle. However, we recommend the

placement procedure described in paragraph 30. The strength of the soil on the slope was rated at 7 CBR above the waterline but less than 1 CBR below the water's edge. Initially, the module surfacing was not anchored, but as traffic began, the panels started to slide down into the water. As a result, traffic was stopped, and the surfacing was pulled back to its original position and anchored as described in paragraph 17. Twenty-five lake egress passes were made with the APC causing the slope at the waterline to increase to 55 percent and the panels to slide 4 in. into the water. The three anchors were then removed and two more passes made with the APC. Each pass caused the surfacing to slide approximately 3 in. further down the slope indicating that the anchors were still required. The surfacing was then removed from the lake site, cleaned, and inspected. Only minor damage in the form of abrasions to the surface caused by the tracks of the APC was detected.

PART VI: DISPENSING TESTS

22. To meet the requirements for installation as stated in the LOA, two systems were tested. The previously developed Pacific Car and Foundry Co. dispenser was tested for use in the bridge equipment role with the 13.1-ft-wide modules. To satisfy the assault vehicle egress role, a wooden crate was designed for shipping and deploying the 16.4-ft-wide modules. Each system is capable of completely deploying the surfacing using only one vehicle. In the case of the Pacific Car and Foundry Co. dispenser, the RBT is used and for the wooden crate, the APC is used.

BRDEC Dispenser

23. The Pacific Car and Foundry Co. of Renton, Wash., designed a dispenser for use with the RBT for BRDEC (Photos 21 and 22). Since the extruded aluminum modules being tested at WES were similar in design to the surfacing the dispenser was developed for, dispensing tests were conducted to determine if the BRDEC dispenser and the aluminum modules were compatible.

24. The cable and boom of the RBT can lift a bundle of modules onto the dispenser and then load the entire package onto the bed of the truck for transporting. Photo 23 shows a RBT loading an empty dispenser. For deployment, the panels are fitted under the rubber bumpers on the dispenser, and one end of a loose cable is connected to the end module panel while the other end is wrapped around the shaft connecting the triangular-shaped sprockets (Photo 24). The shaft is then turned several times by the operator using the hand-held mechanism until the first panel is over the sprockets. The cable is then disconnected. As the operator continues to rotate the sprockets, the truck backs onto the dispensed modules as they reach the ground (Photo 25). Careful attention must be given to the rate at which the operator turns the sprockets. Too fast or uneven movement will cause the panels to pile up. The entire process of dispensing took three men approximately 5 min to lay a 95 ft length of the aluminum modules.

25. To retrieve the modules, the RBT backed over the surfacing to the last panel. Winch-controlled cables connected at the inside snatch blocks pass through grooves on the triangular-shaped sprockets and down to the first panel where they are hooked to cable loops as shown in Photo 26. The winch

operator then reels the cables in until the first panel is near the front of the dispenser. The cables are then unhooked and moved to the outside snatch blocks located on the retrieval arms. The cables are then hooked to the rotation fixtures, and the retrieval process resumes. As the truck drives forward, the winch operator continues to pull the panels onto the truck by tightening the cables and turning the sprockets to push the panels into place under the rubber bumpers. The rotation fixtures must be manually moved and fitted into every other panel (Photo 27) as the cables are reeled in and out. The retrieval process takes four men approximately 25 min to complete on a flat area. That time increases to 35 min when working on a 25 percent slope.

26. The 16.4-ft-wide modules were dispensed and retrieved three times on a flat area. However, since the dispenser was designed for a 13.1-ft-wide panel, the 16.4 ft modules caught on the cables and eventually had to be cut down to a 13.1 ft width. For cutting, the modules were placed flat on the ground with one end propped up with a board to provide clearance for the saw blade. One meter was measured and marked at one end of each panel. A straight edge was then clamped along the marking to provide a cutting guide. The pins were pushed flush with the opposite end of the module so that after the cutting was completed, sufficient slack would remain in the pin to thread the bolt. A heavy duty Black and Decker skill saw with a carbon tip blade was used to saw through the panel, hinge, and pin while following along the guide. The modules were then replaced on the dispenser and 2 in. cut off the outside hinge on either end of the panel so that the bolts connecting the pins were recessed inside the outer edge of the modules.

27. The narrower modified modules were then dispensed and retrieved once on a flat area and twice on a 25 percent slope. The panels were not damaged during the deployment or recovery process. But the cable loops used to begin retrieving the modules peeled back the aluminum hinge links housing the cables as the force on the cables increased. Photo 28 shows the damage to the hinge links.

Wooden Crate

28. For the 16.4-ft-wide modules, a different method of dispensing had to be developed. A wooden crate (Photo 29) was designed with a dual purpose,

to ship and dispense the modules. In the event that the surfacing would be transported with the RBT, the weight of the loaded crate was kept under the maximum allowable for the RBT (10,000 lb).

29. The crate was designed so one APC acting alone could completely deploy the surfacing. Attachments for cables are located on the front (Photo 30) and rear of the crate so it may be pulled in either direction. The back is slanted so the panels will lean at an angle and therefore be less likely to fall forward. The trailing skids are pinned so they may be removed when the crate is in the transport mode or they can be used as a ramp for deploying and retrieving the modules. Thirty-seven panels could be loaded onto the crate without exceeding the 10,000-lb weight limit.

30. During transport, the panels were encircled with steel bands to hold them securely to the crate. For dispensing onto a flat area, the first panel may be anchored and the crate pulled with the APC out from under the modules or the crate may remain stationary while the APC pulls the panels out (Photos 31 and 32). Either method requires approximately 5 min using three men. The panels were dispensed and retrieved three times without incurring any problems. Retrieval was performed in a similar manner as described in paragraph 25. The RBT backed up to the rear of the crate and used the winch-controlled cables and rotation fixtures to reload the modules onto the crate.

31. To dispense the surfacing onto the 25 percent slope, the crate was placed once at the top of the slope (Photo 33) and once at the toe (Photo 34). The APC then connected to the panels as before and pulled them into position over the desired area. Both the deployment and recovery went smoothly and caused no damage to the surface of the modules. But at the cable hook-ups, the hinge links peeled back again due to the force on the cables.

32. For transporting to the far shore, the banded crate and modules could be lifted by a CH-47 Chinook helicopter and flown across the water obstacle. An APC could then swim across, connect to the modules and pull them into the water, thereby providing an egress route. For the test at the lake site, the crate was positioned approximately 11.5 ft above the water's edge. The APC entered the lake, drove up onto the bank and connected to the first panel. As the APC reentered the lake, it pulled the modules in behind it (Photo 35). A rope was tied to the cable connection that enabled a passenger in the APC to disconnect the surfacing from the APC after it was extended as far as was needed into the water. The APC then had enough traction to egress

the bank and drive around the crate, connect to it, and pull it out from under the panels as they unfolded on the slope. The modules had a tendency to stack up in places (Photo 36) rather than fold out in a single layer. Therefore, the APC had to be connected to the modules again to pull them into a flat, single layer of surfacing. The entire process took four men 13 min to complete. The APC returned to the water and made several egresses without any difficulty. To recover the modules, the APC simply connected a cable to the panels and pulled them onto a flat area and then loaded them onto a crate as before (see paragraph 29).

33. During the first few tests, several needs for modification to the crate were noted. The rear ends of the main skids were beveled like the front end so that when the crate was dragged from the back side, less embedment in the soil would occur. The back of the crate was reinforced with steel plates to prevent leaning, and the height was reduced by 6 in. so the modules could be stacked easier. The corners of the trailing skids were rounded to prevent the extrusions on the modules from snagging. After the modifications were finished, the dispensing tests were completed with no further damage to the crate. The modified crate is shown in Photo 37.

PART VII: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

34. As a result of this investigation, the following conclusions are made:

- a. The surfacing modules have adequate strength to support more than 3,000 passes of mixed military vehicle traffic with 10 percent rated at MLC 70.
- b. The modules will provide adequate traction for 25 passes of both wheeled and tracked vehicles up to MLC 70 on a 25 percent slope under dry, wet, and muddy conditions.
- c. The 13.1-ft-wide surfacing is compatible with the BRDEC dispenser and can be dispensed at the rate of 95 lin ft in 5 min by three men.
- d. The 16.4-ft-wide surfacing can be dispensed from the wooden crate onto a flat or sloped area using the APC at the rate of 82 lin ft in 5 min using three men.
- e. The 16.4-ft-wide surfacing can be dispensed at a lake site from the wooden crate using the APC at the rate of 82 lin ft in 13 min using four men.
- f. The 16.4-ft-wide surfacing can readily be modified to the 13.1-ft-wide size by any reasonably equipped shop.
- g. It is conceptually possible to airlift the 16.4 ft or the 13.1-ft surfacing to cover 95 lin ft and 82 lin ft, respectively, with the CH-47 helicopter, although it was not actually demonstrated.

Recommendations

35. To improve the system, the following recommendations are offered:

- a. A camouflage system should be developed.
- b. A new attachment for the cable connection (Photo 38) should be fully evaluated.
- c. Tightening the joints between the modules and reducing the weight of the modules should be investigated.
- d. An anchoring system for use with the extruded aluminum modules when placed on a steep slope should be developed.

REFERENCES

Carr, G. L., Green, H. L., and Taylor, H. M. 1980. "Tactical Bridge Access/Egress Preliminary Investigation," US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Carr, G. L., and Willoughby, W. E. 1980. "Traffic Slope Tests of Military Inventory Items and Their Effectiveness in Riverine Egress Tests," Miscellaneous Paper GL-80-17, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Ellison, D. A. 1982. "Evaluation of Sod Saver Blocks and M. C. Gill Panels for Tactical Bridge Access/Egress Applications," Miscellaneous Paper GL-82-17, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Headquarters, Department of the Army, US Army Engineer School. 1985. "Letter Requirement Access/Egress Roadway System TRADOC ACN 028690," Fort Belvoir, Va.

Triplett, S. D. 1986. "Evaluation of Flexmat as an Assault Egress Surfacing," US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Walker, R. W. 1979. "Letter of Agreement for a Tactical Bridge Access/Egress System, USATRADOC ACN 38653," Headquarters, US Army Training and Doctrine Command, Fort Monroe, Va.

Table 1

Order of Traffic Applied in Traffic Tests

Vehicle	No. of Passes
M54	600
RBT	600
M54	600
M48A1	200
M54	150
RBT	150
M54	150
M48A1	50
M54	150
RBT	150
M54	150
M48A1	50
	3,000

Table 2

Order of Traffic Applied in Slope Tests

Slope Condition	Vehicle	No. of Passes
Dry	M54	10
	RBT	15
	M48A1	10
Wet	M54	10
	RBT	15
	M48A1	10
Muddy	M54	15
	RBT	10
	M48A1	10
Lake Site	M113	27

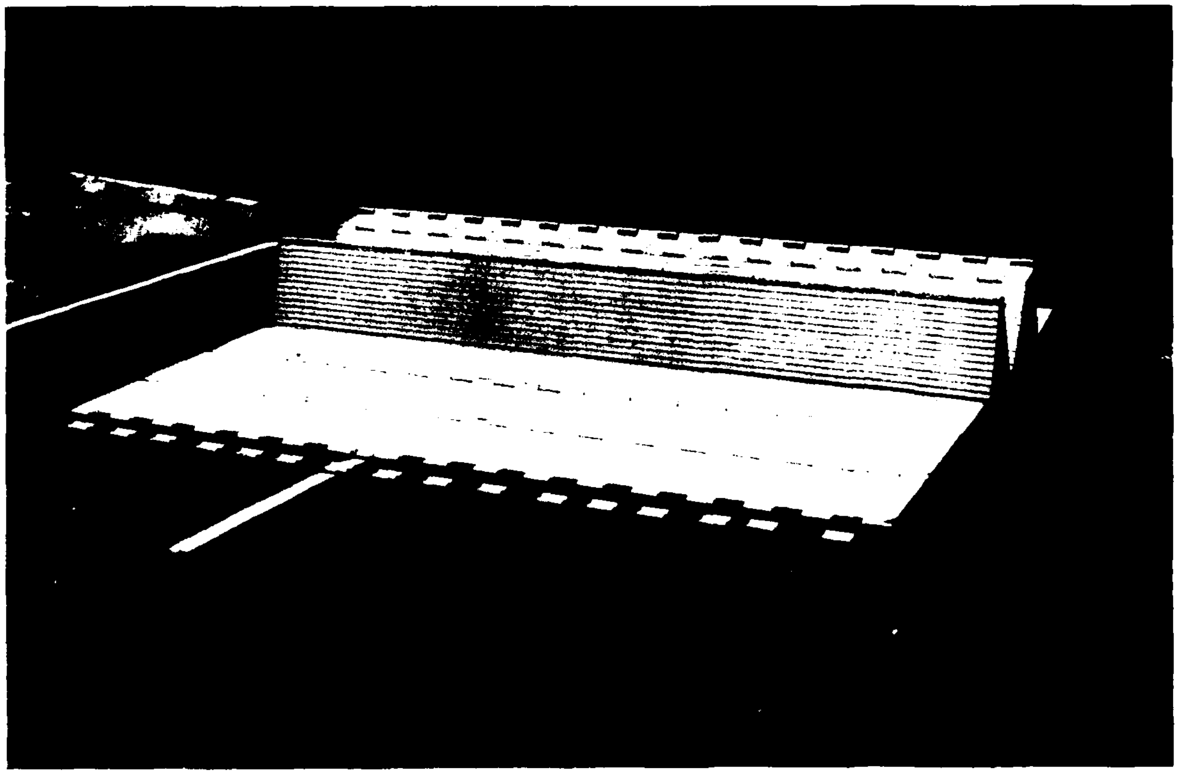


Photo 1. Extruded aluminum access/egress surfacing modules

Photo 2. Five-ton M54 cargo truck

Photo 3. Five-ton RBT

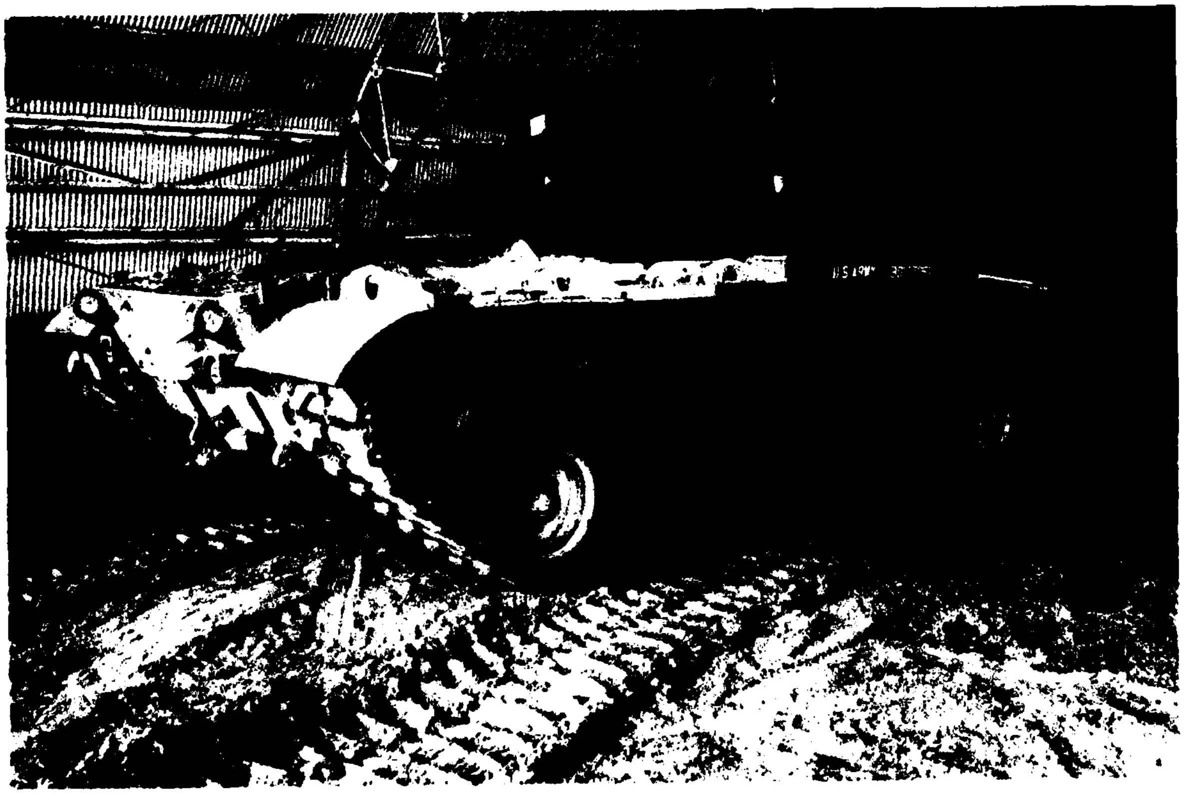


Photo 4. M48A1 tank

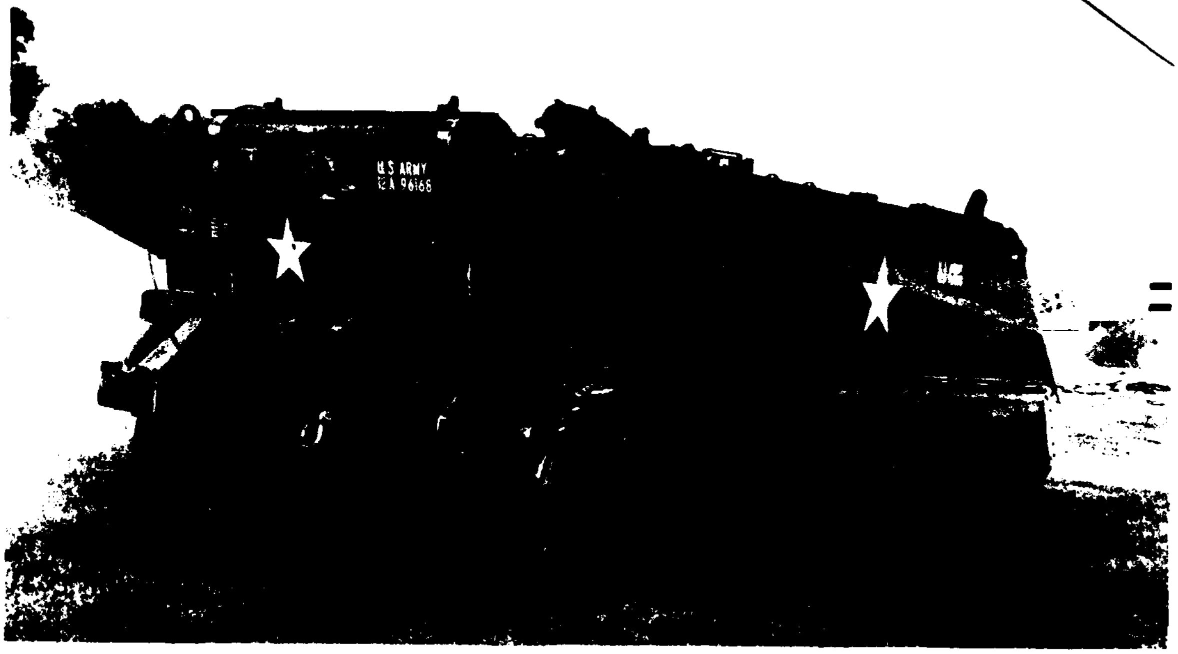


Photo 5. M113 APC

Photo 6. M54 cargo truck immobilized in 1.5 CBR soil

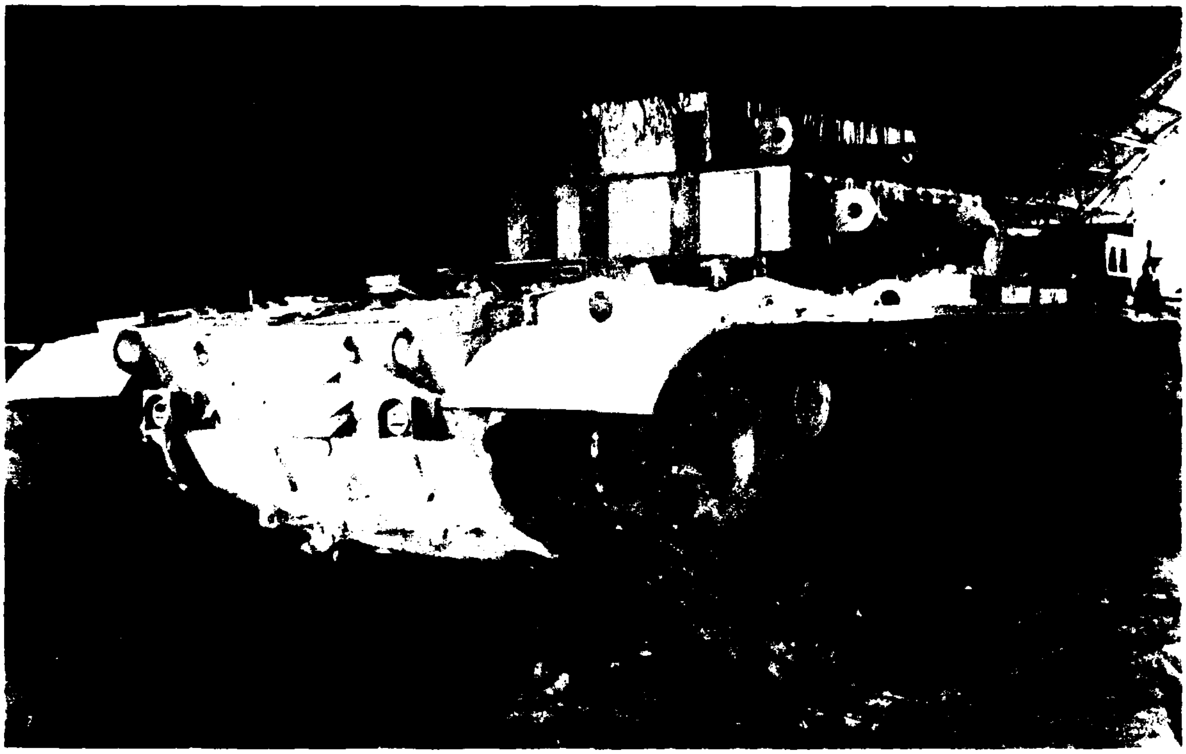


Photo 7. M48A1 tank immobilized in 1.5 CBR soil

Photo 8. M54 cargo truck trafficking modules

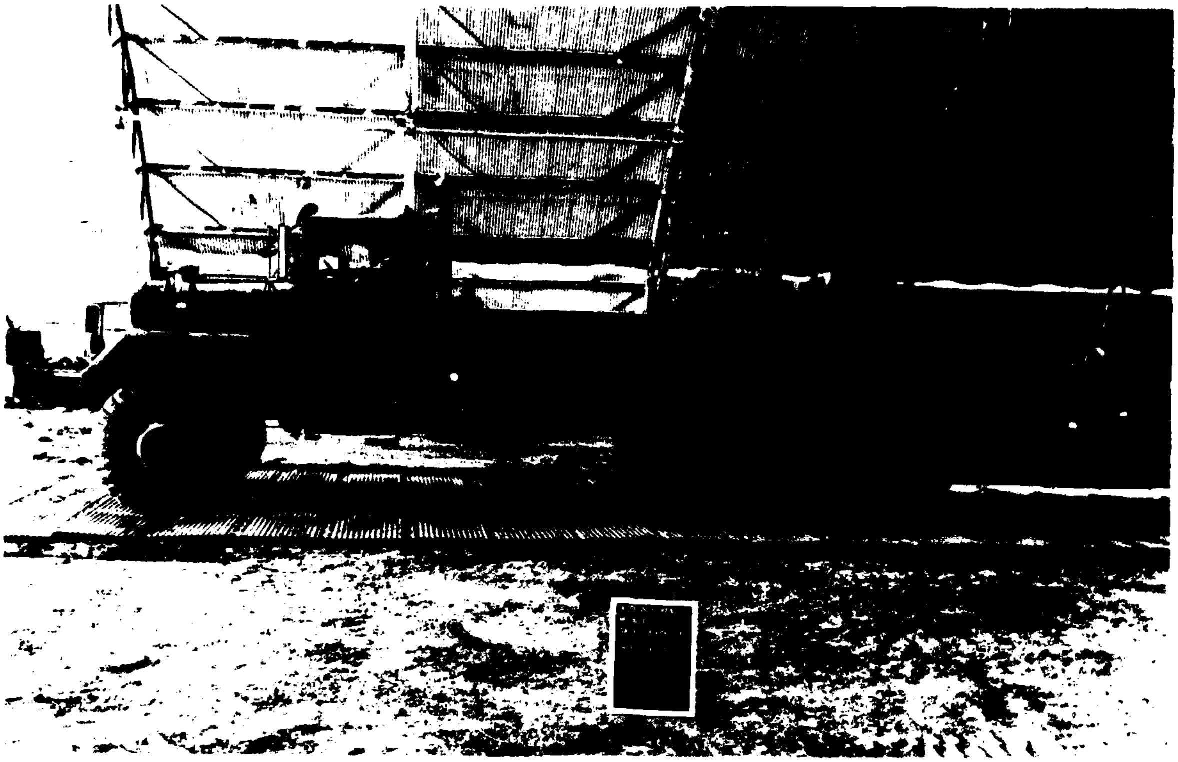


Photo 9. RBT trafficking modules

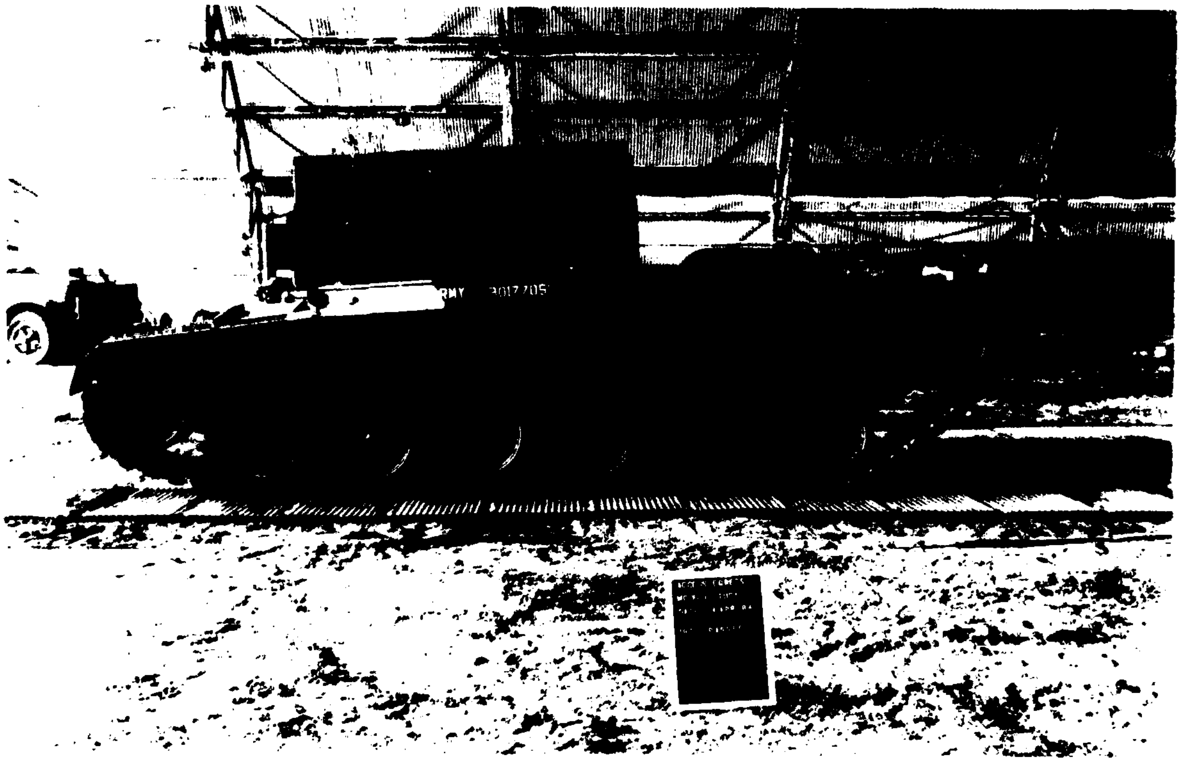


Photo 10. M48A1 tank trafficking modules

Photo 11. Overall view of the test section after 3,000 passes of mixed traffic

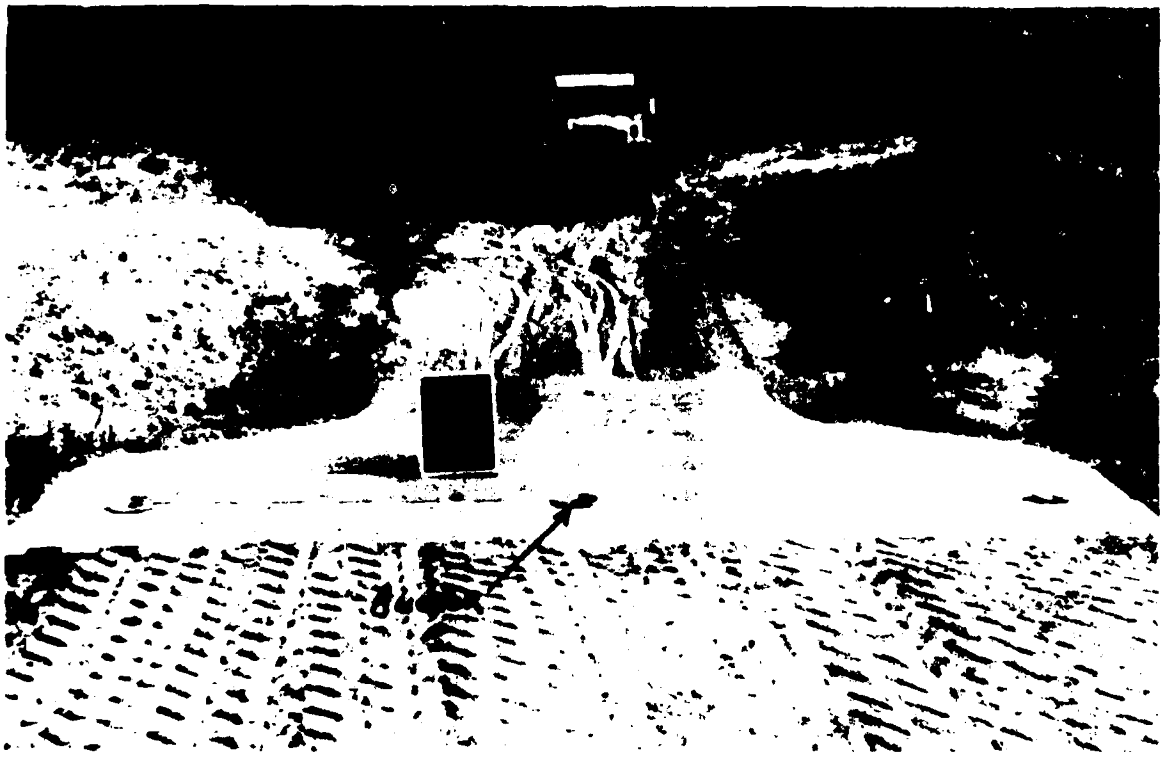


Photo 12. Modules installed on 25 percent slope prior to trafficking

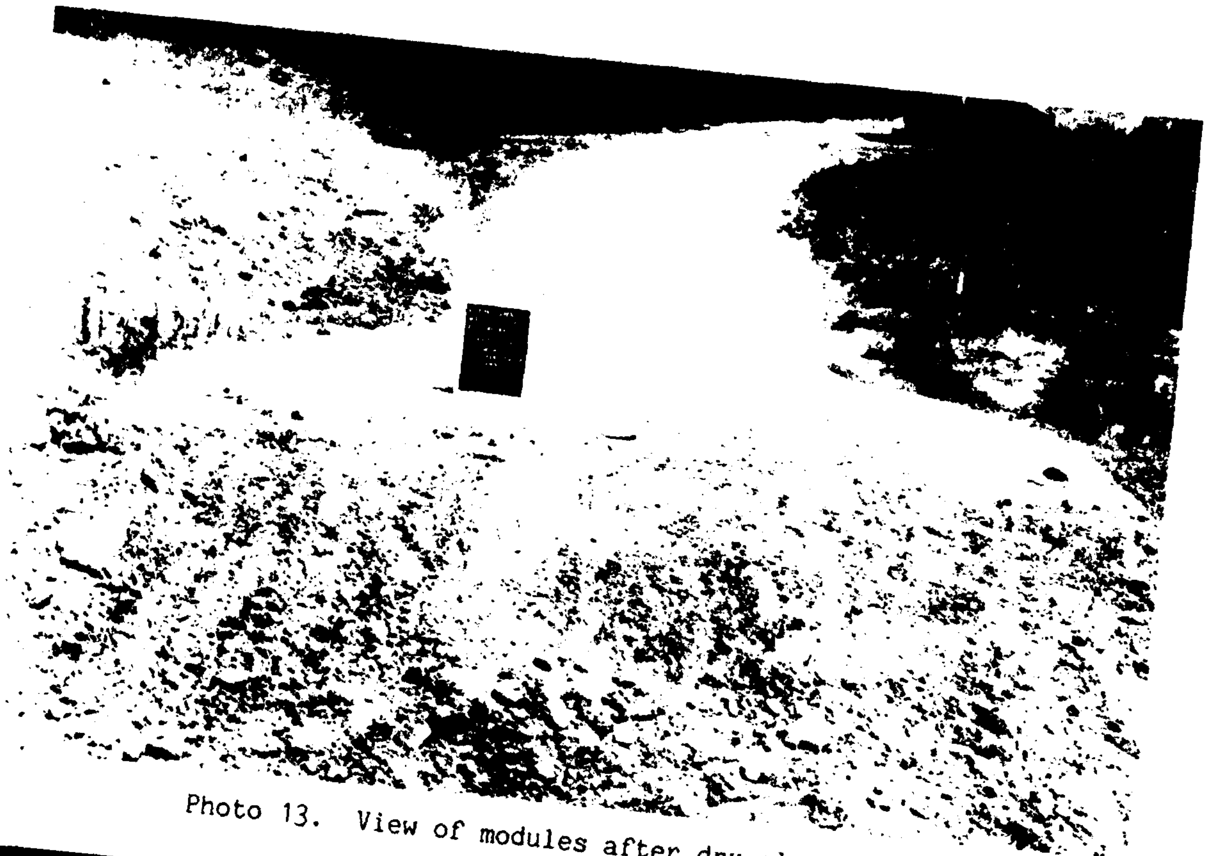


Photo 13. View of modules after dry slope test

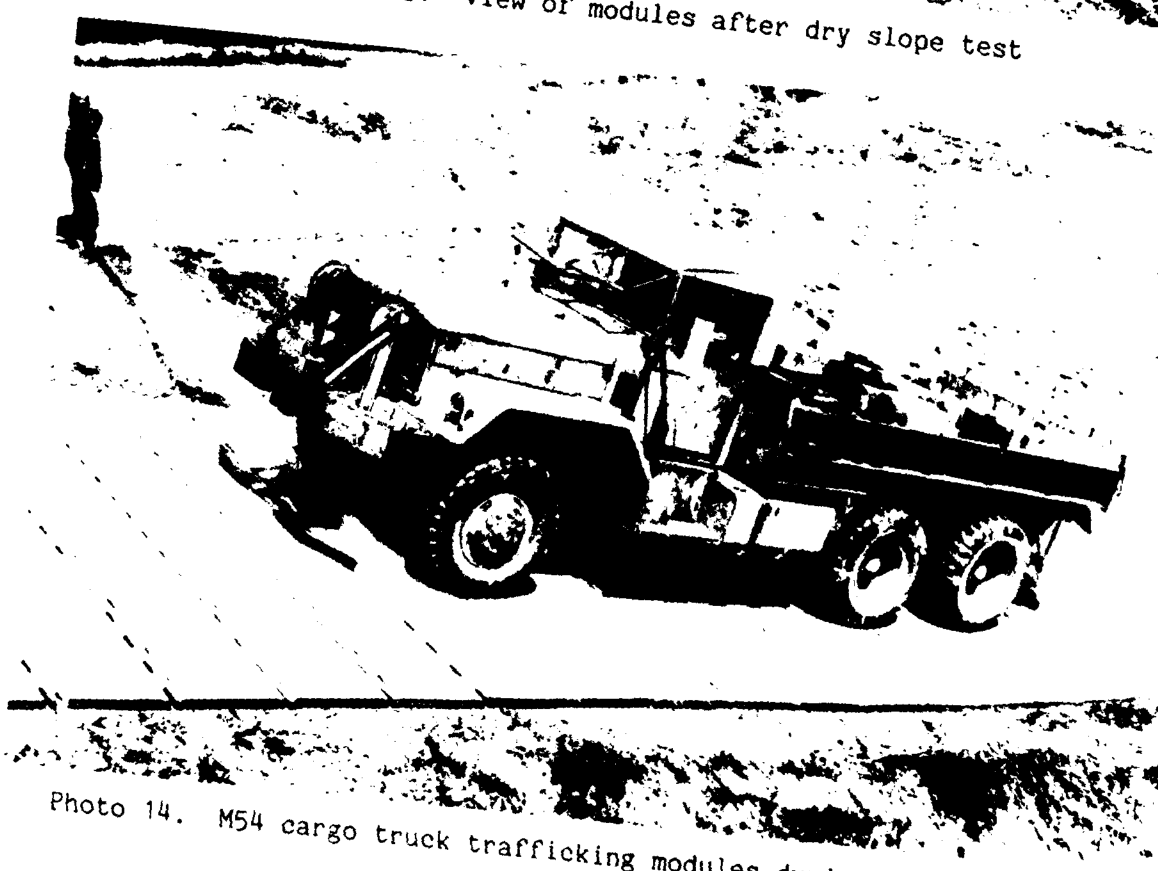


Photo 14. M54 cargo truck trafficking modules during wet slope test

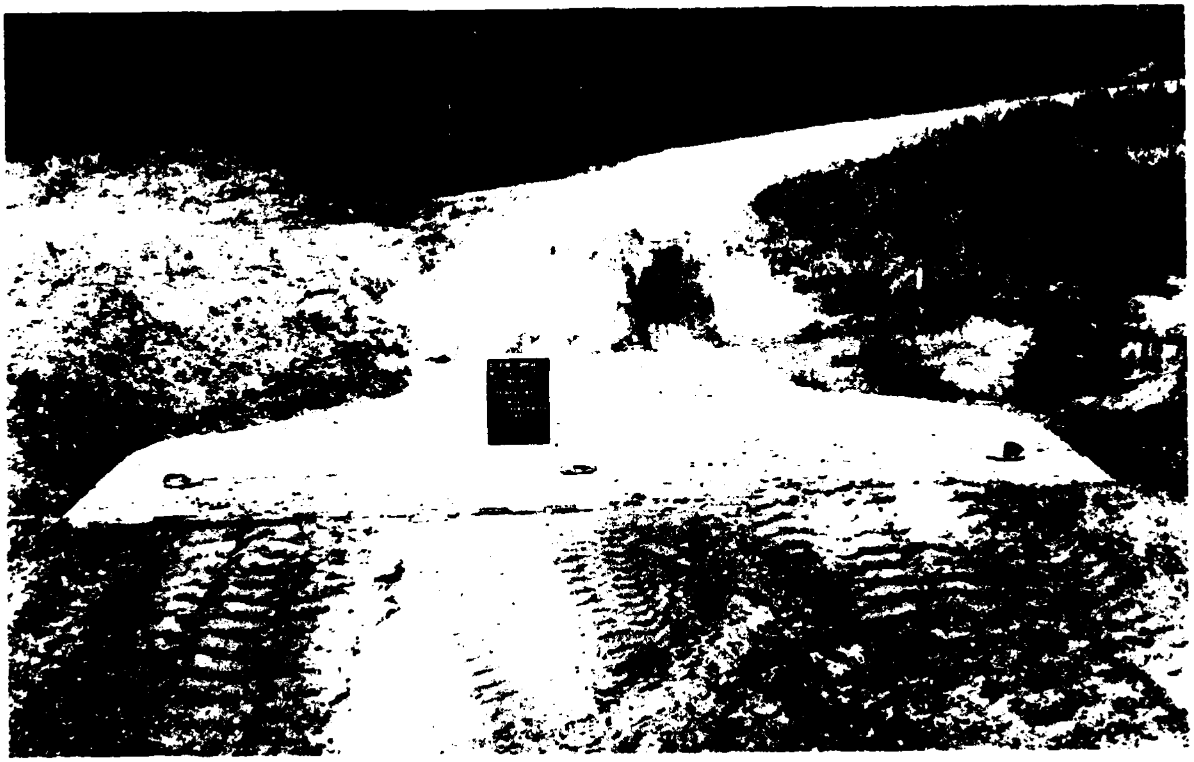


Photo 15. View of modules after wet slope test

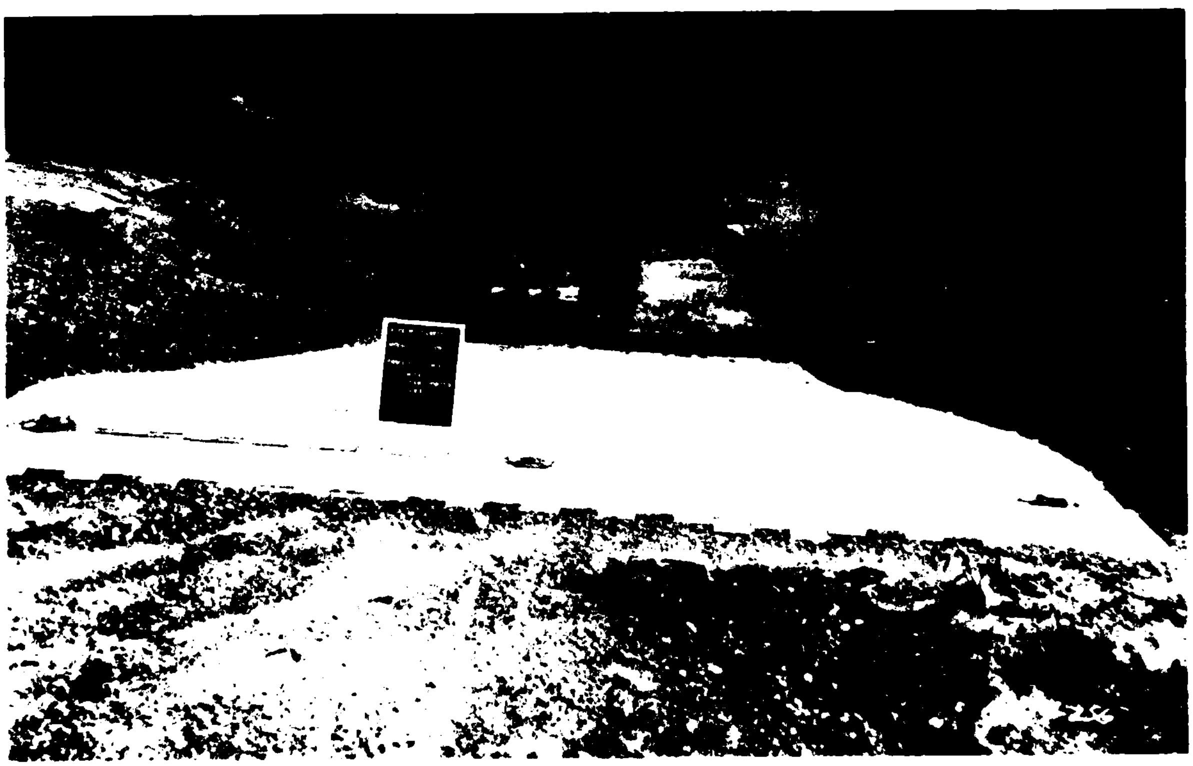


Photo 16. Modules prepared for muddy slope test

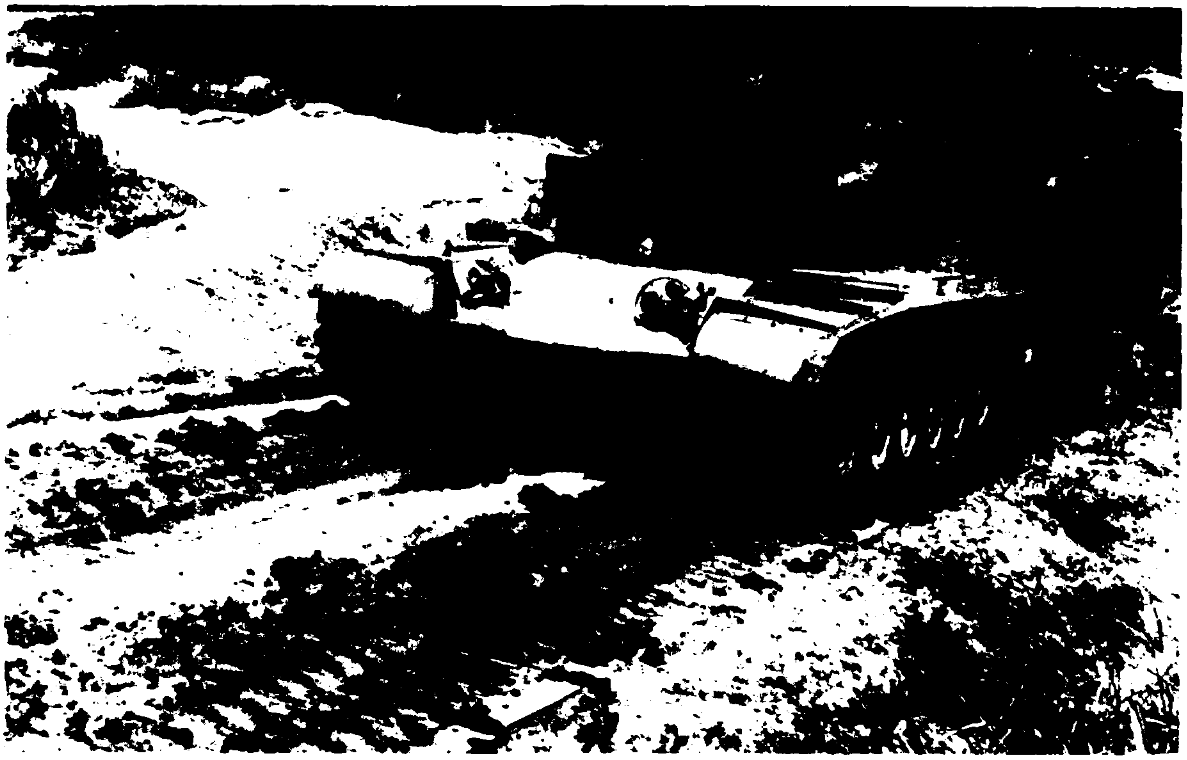


Photo 17. M48A1 tank trafficking modules during muddy slope test

Photo 18. Damaged module following muddy slope test

Photo 19. APC attempting to egress unsurfaced lake bank

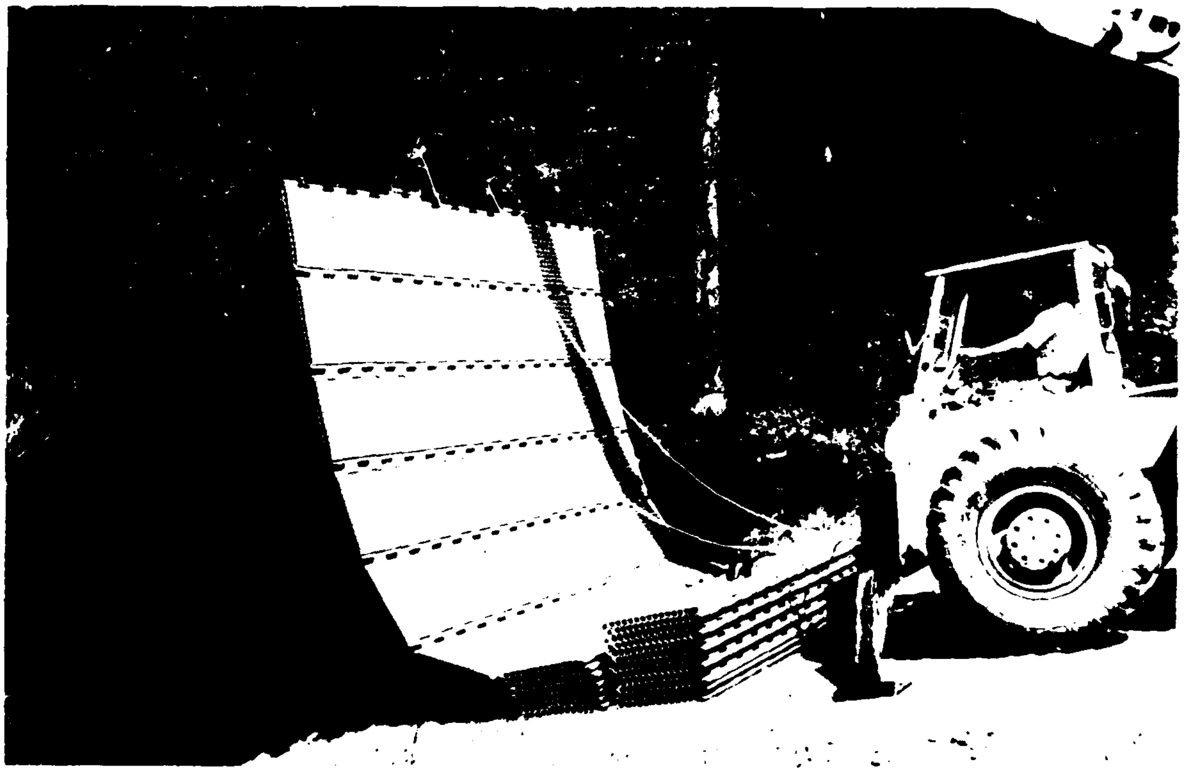


Photo 20. Modules being deployed at lake site

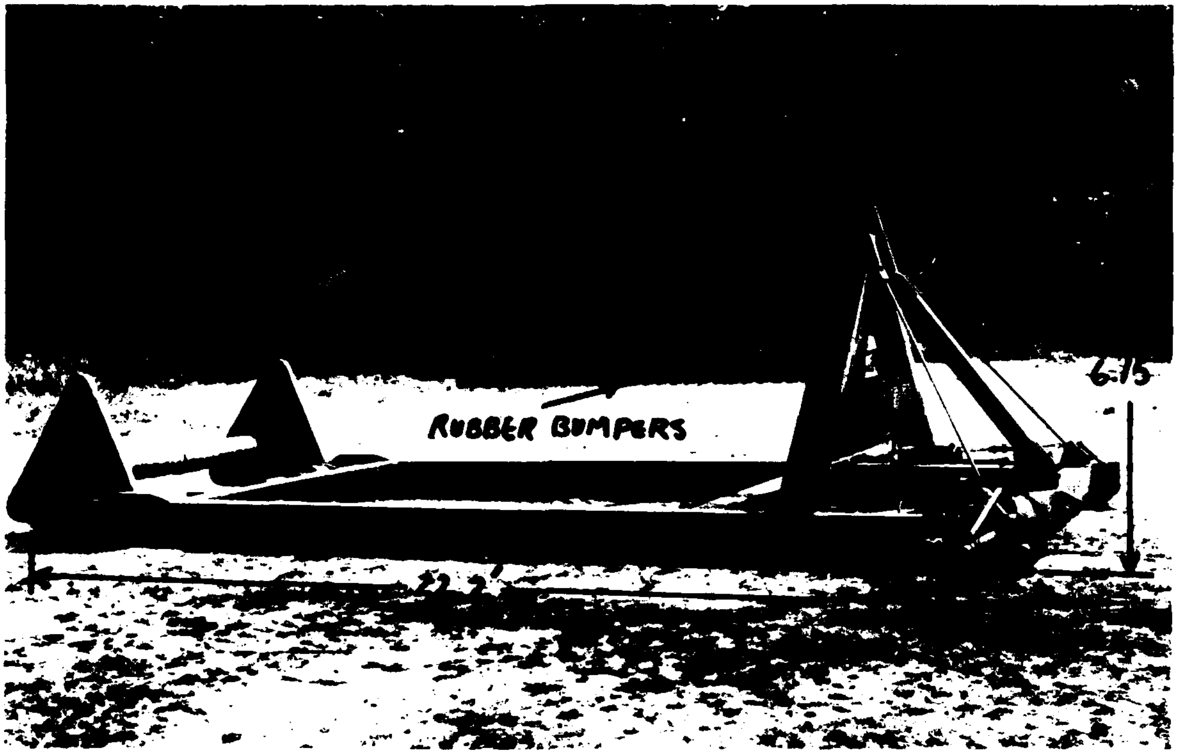


Photo 21. Pacific Car and Foundry Co. dispenser (6.15 by 22.2 ft)

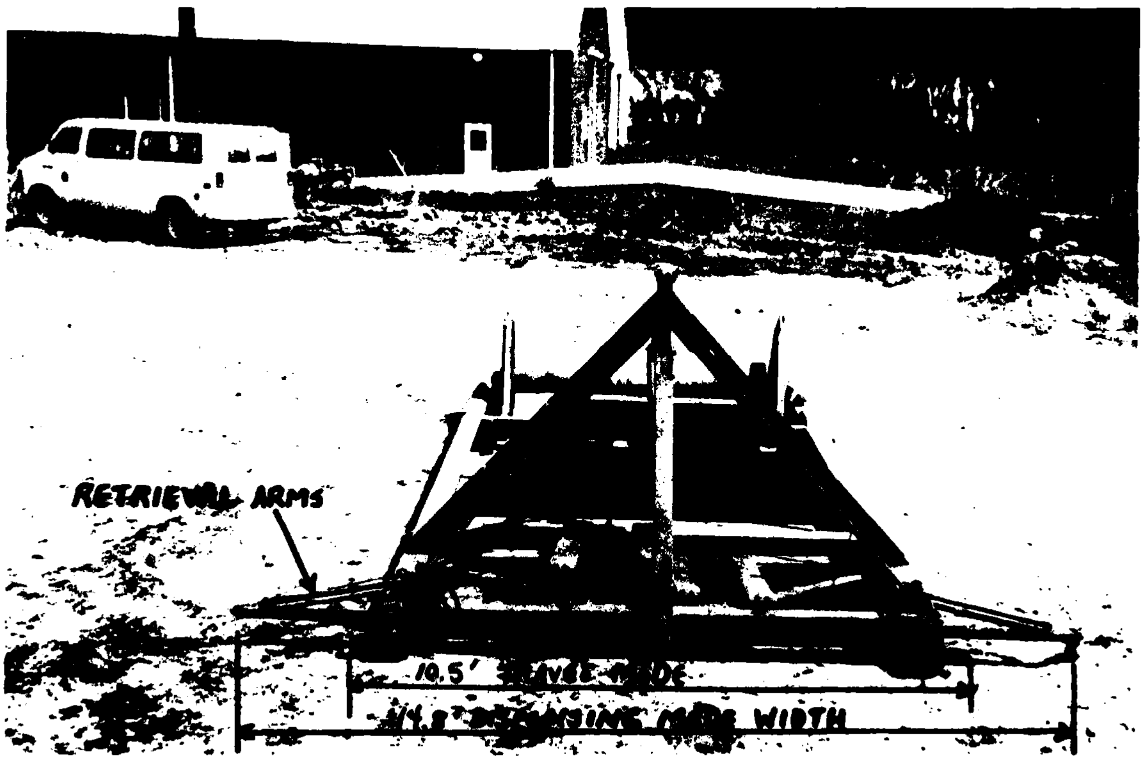


Photo 22. Pacific Car and Foundry Co. dispenser (10.5 by 14.8 ft)

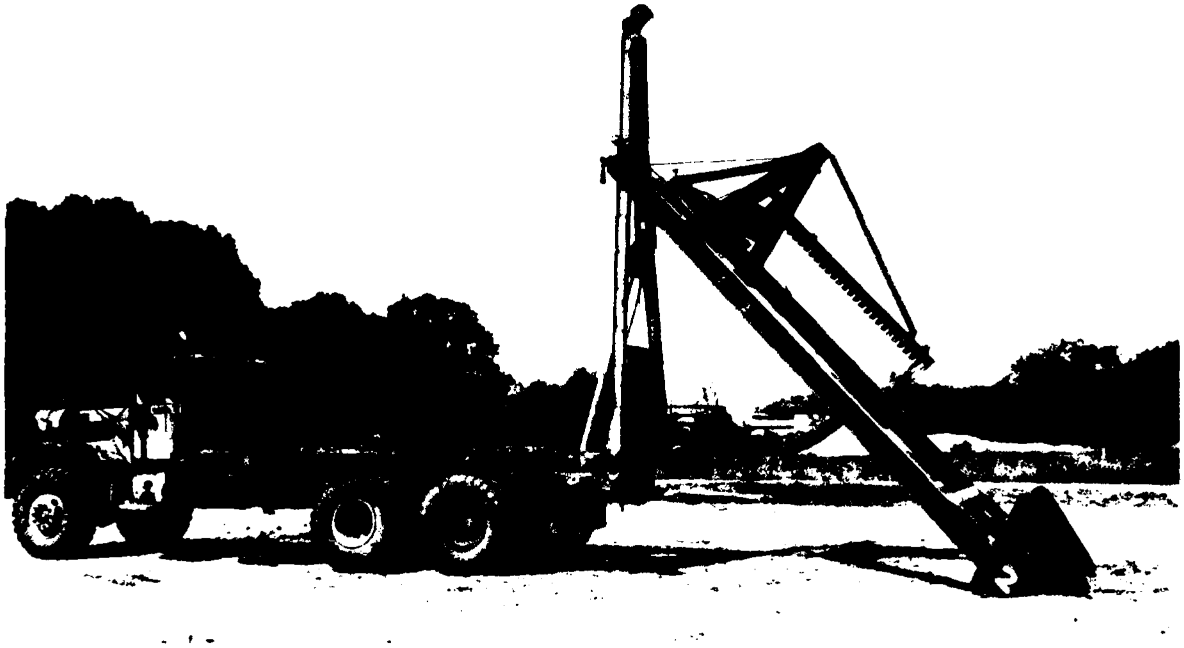


Photo 23. RBT loading dispenser onto truck

Photo 24. Modules fitted into dispenser and ready for deployment

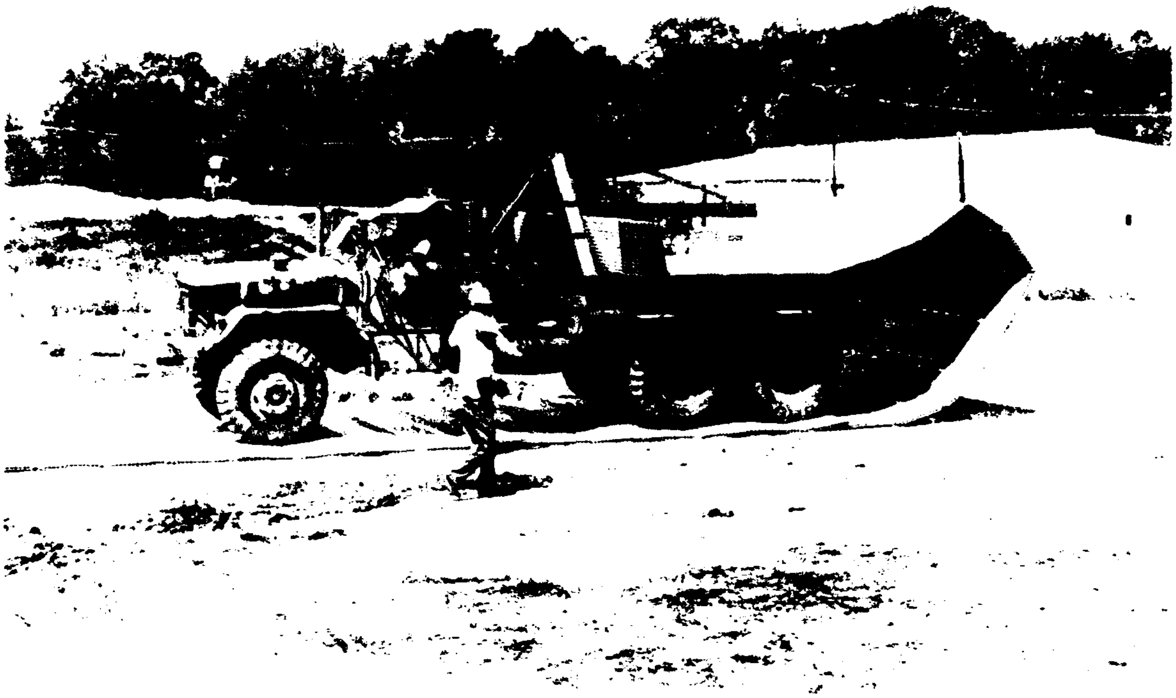


Photo 25. Modules being deployed from dispenser

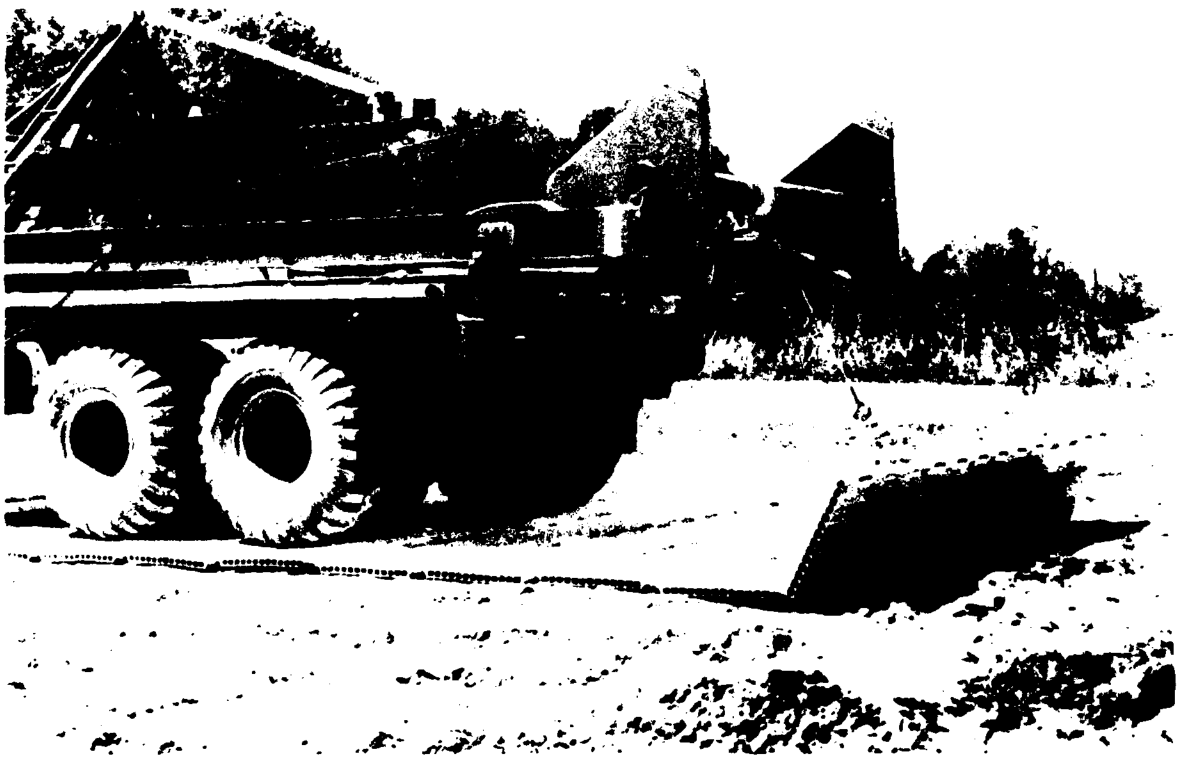


Photo 26. Beginning the retrieval process

Photo 27. Using the rotation fixtures to retrieve the modules

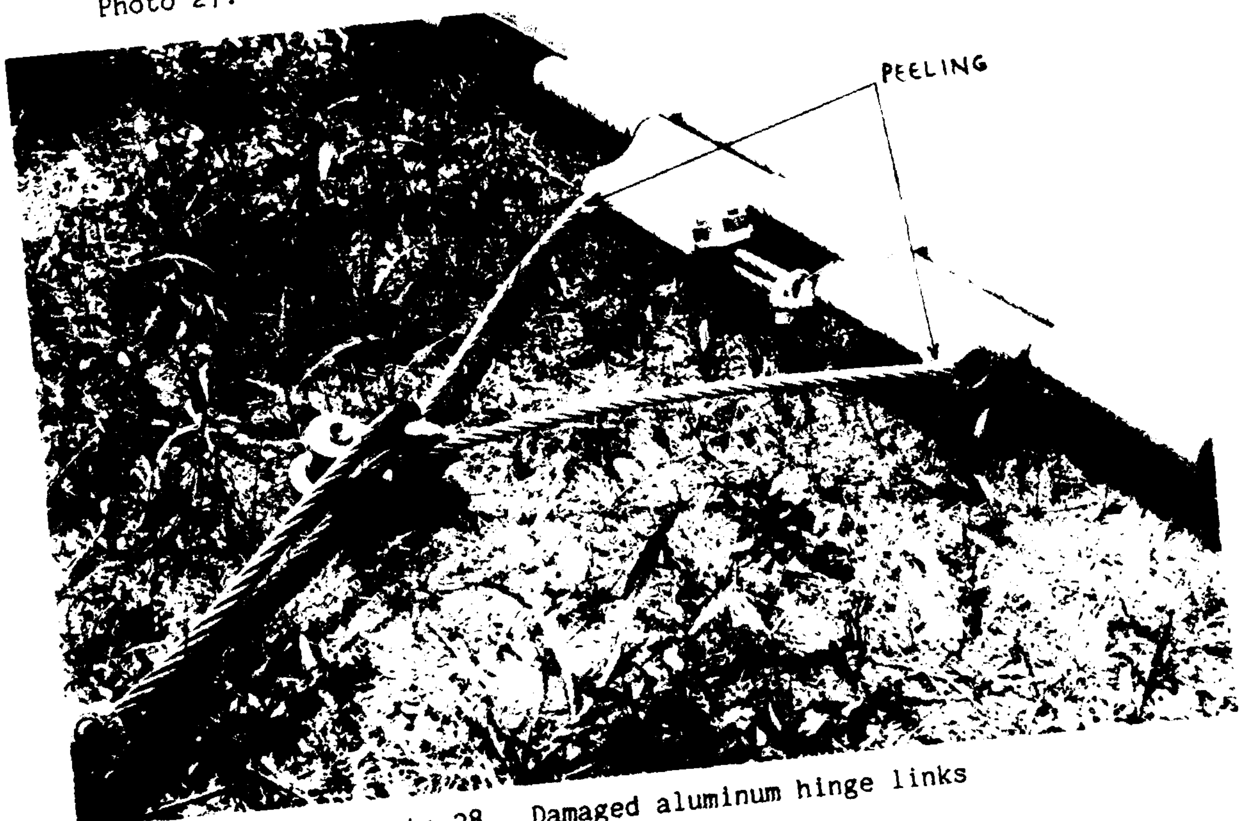


Photo 28. Damaged aluminum hinge links

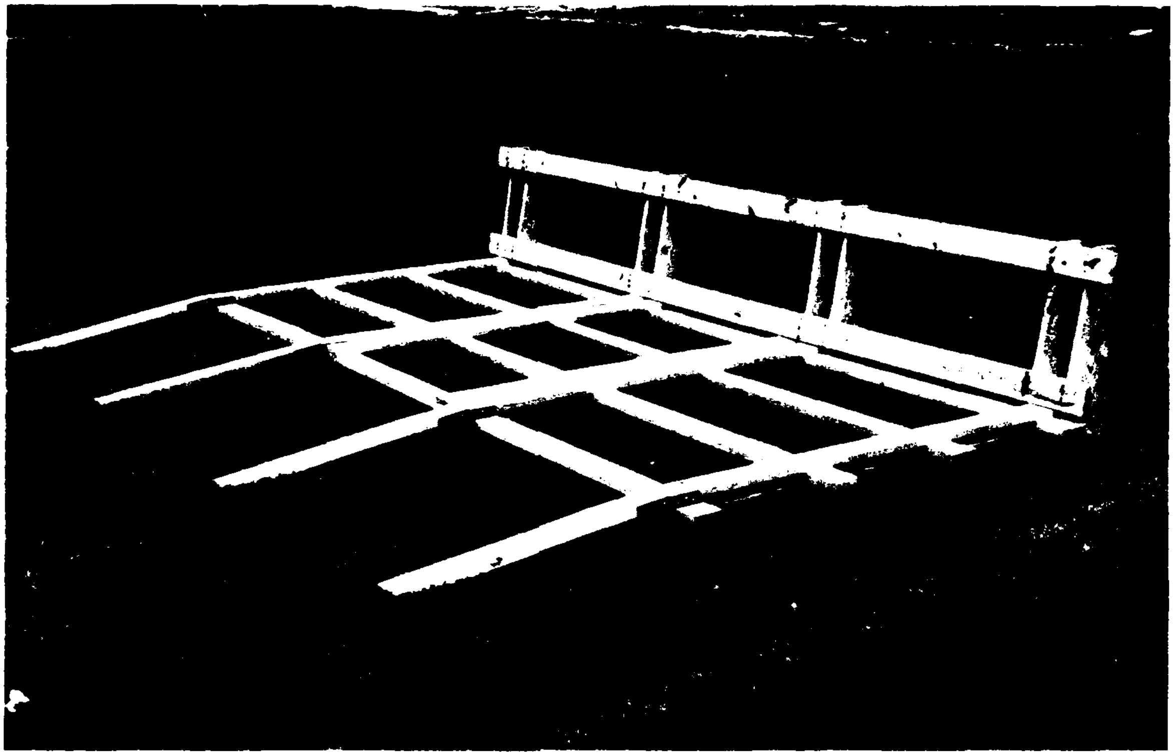


Photo 29. Wooden crate designed for 16.4-ft-wide modules

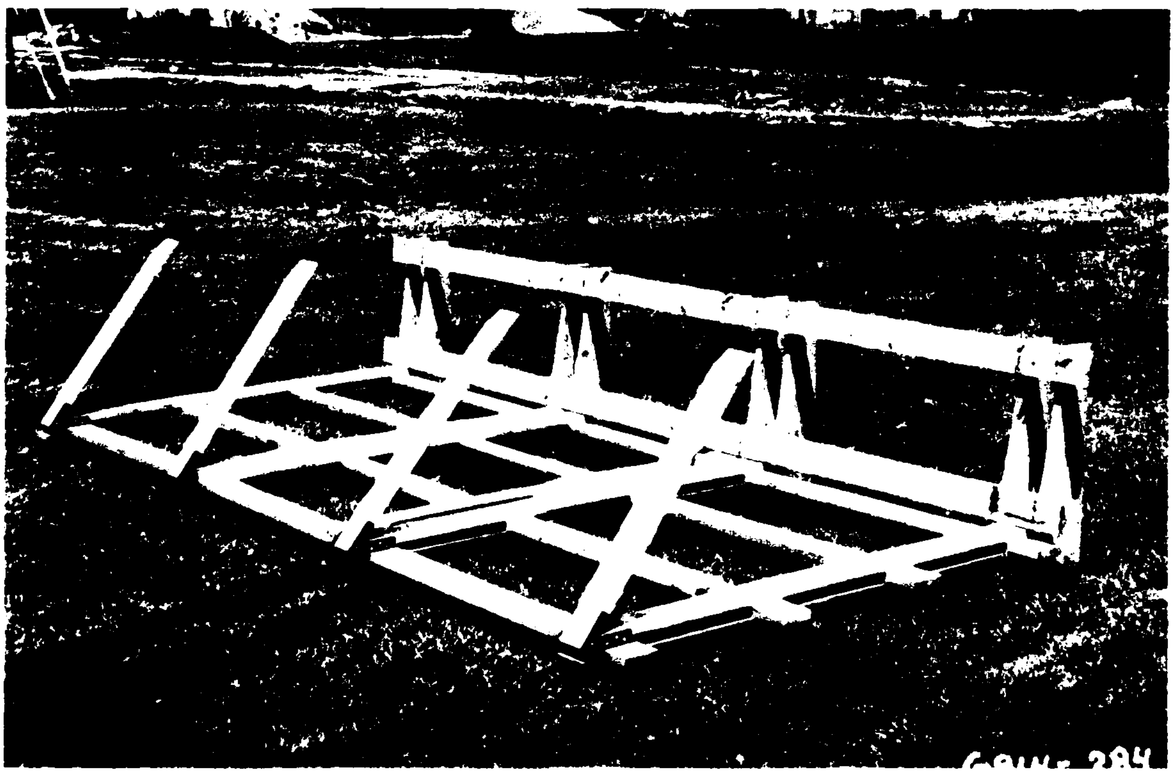


Photo 30. View of wooden crate showing front cable hook-ups

Photo 31. APC pulling modules out of the wooden crate

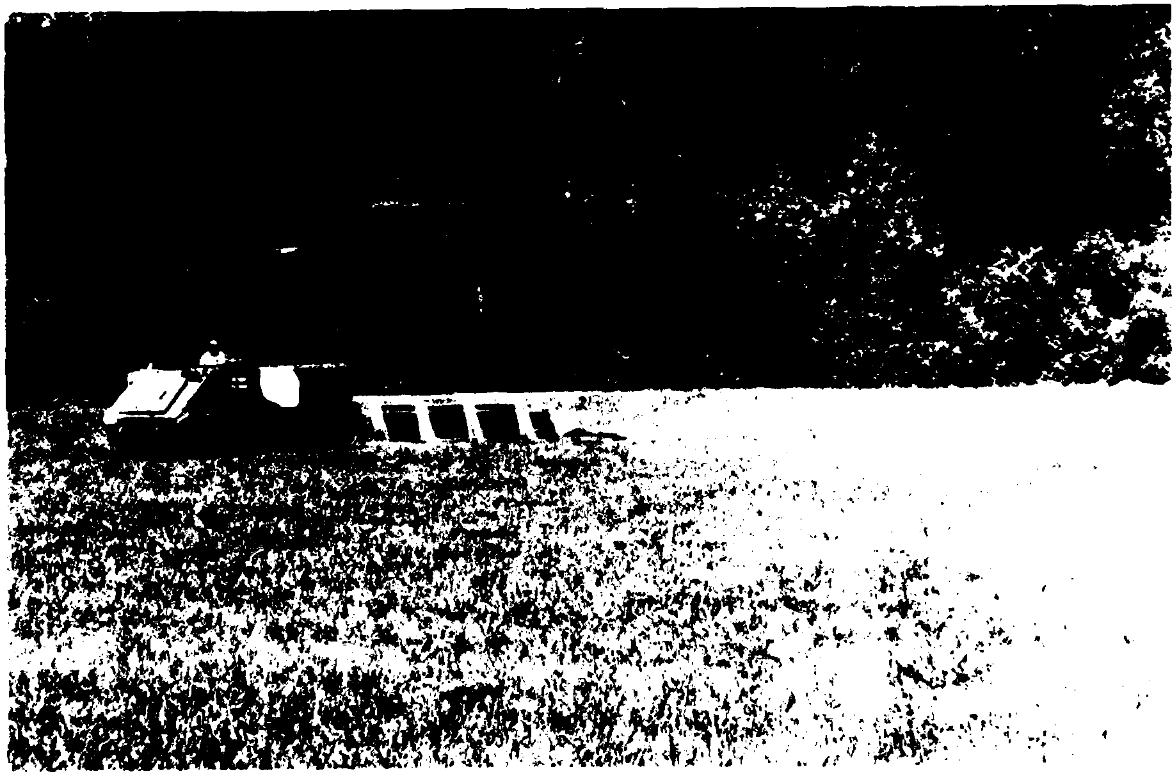


Photo 32. APC pulling the crate out from under the anchored modules

Photo 33. APC dispensing modules from wooden crate onto 25 percent slope

Photo 34. APC dispensing modules from wooden crate onto 25 percent slope

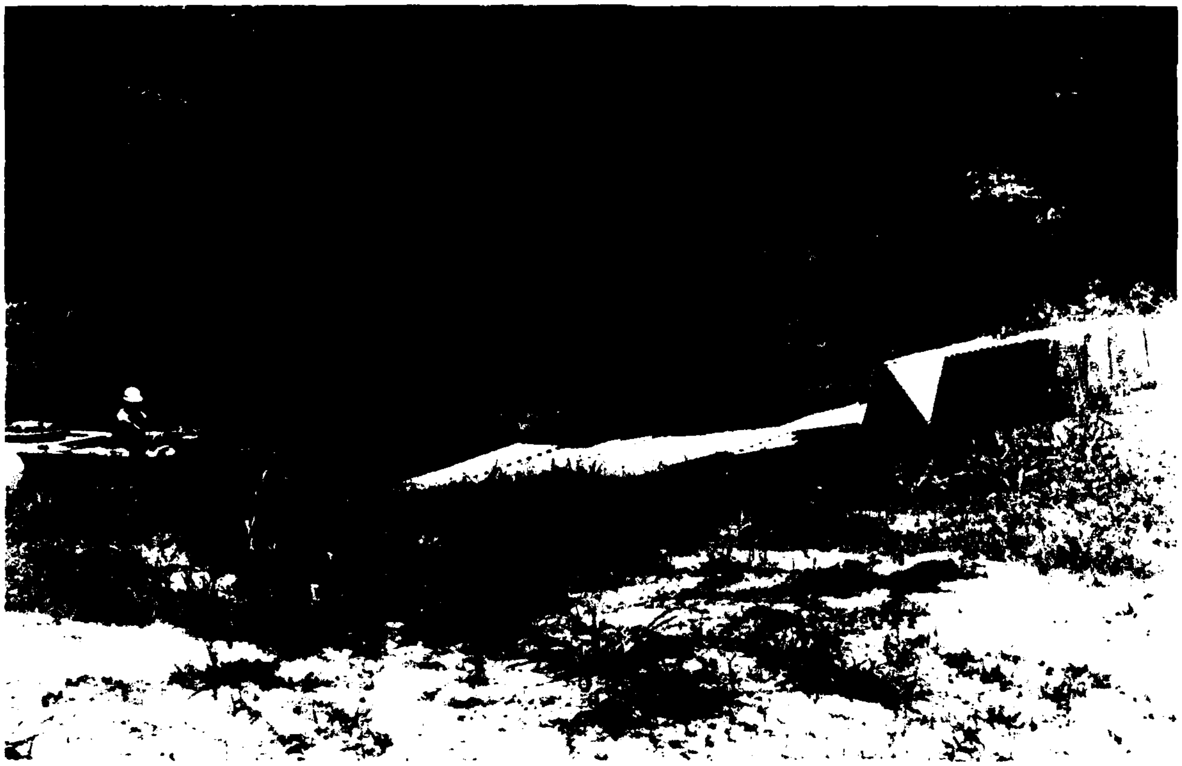


Photo 35. APC dispensing modules from wooden crate at lake site

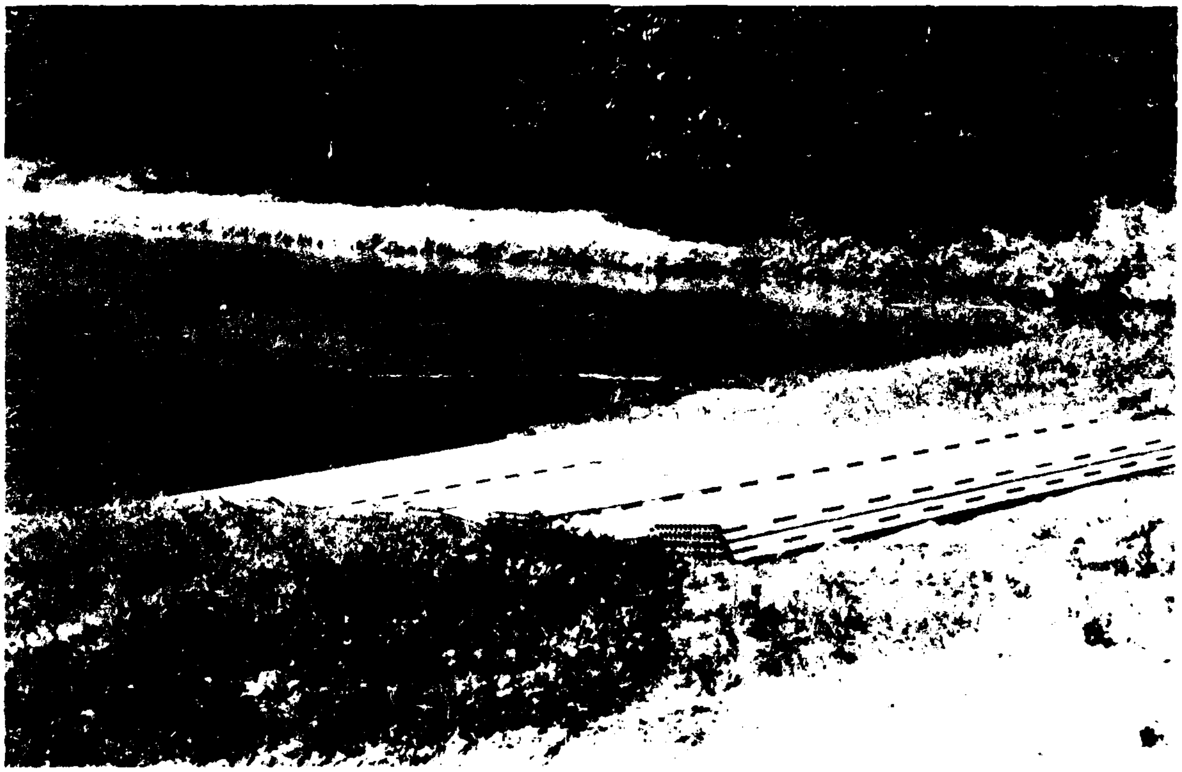


Photo 36. Modules in piles before straightening

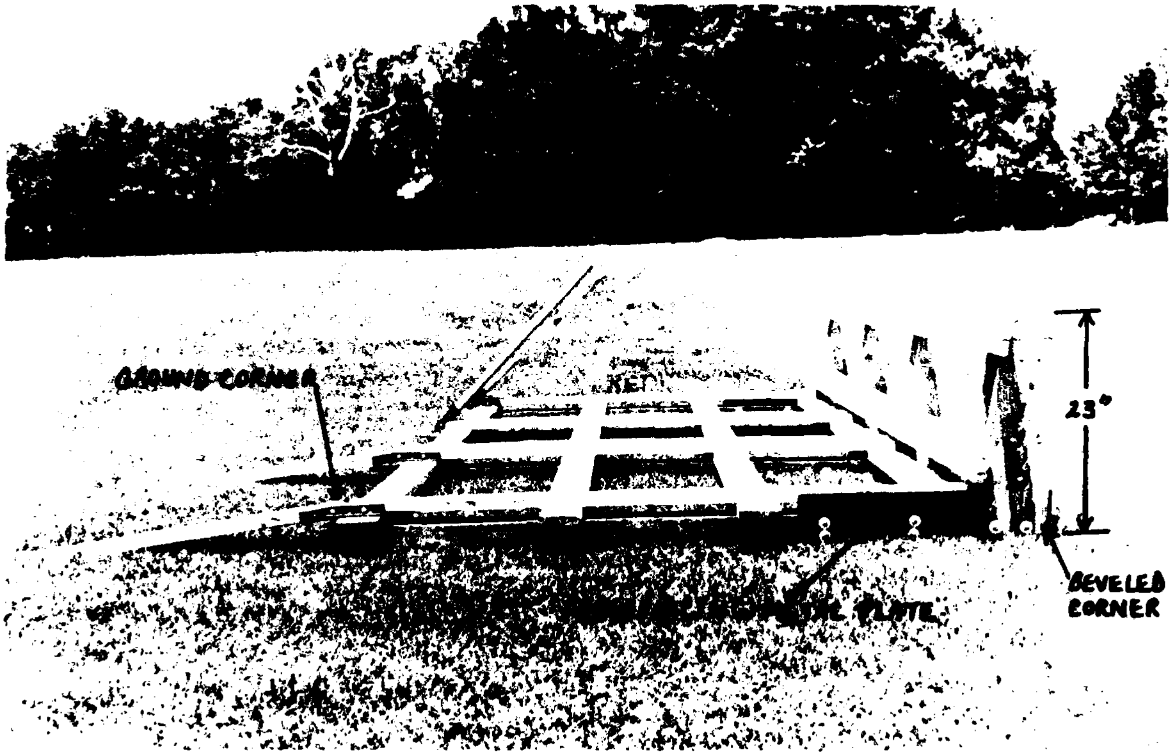


Photo 37. Modified wooden crate

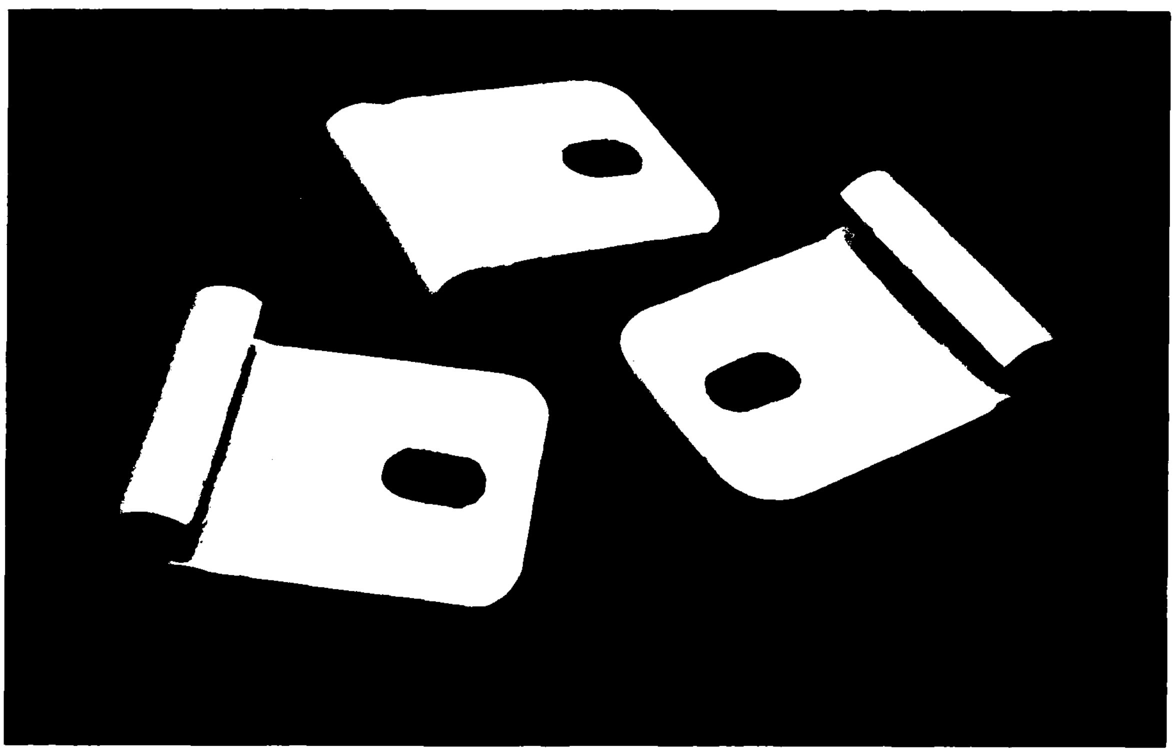


Photo 38. Recommended replacement for hinge links used as cable connectors

END

10-86

DTIC