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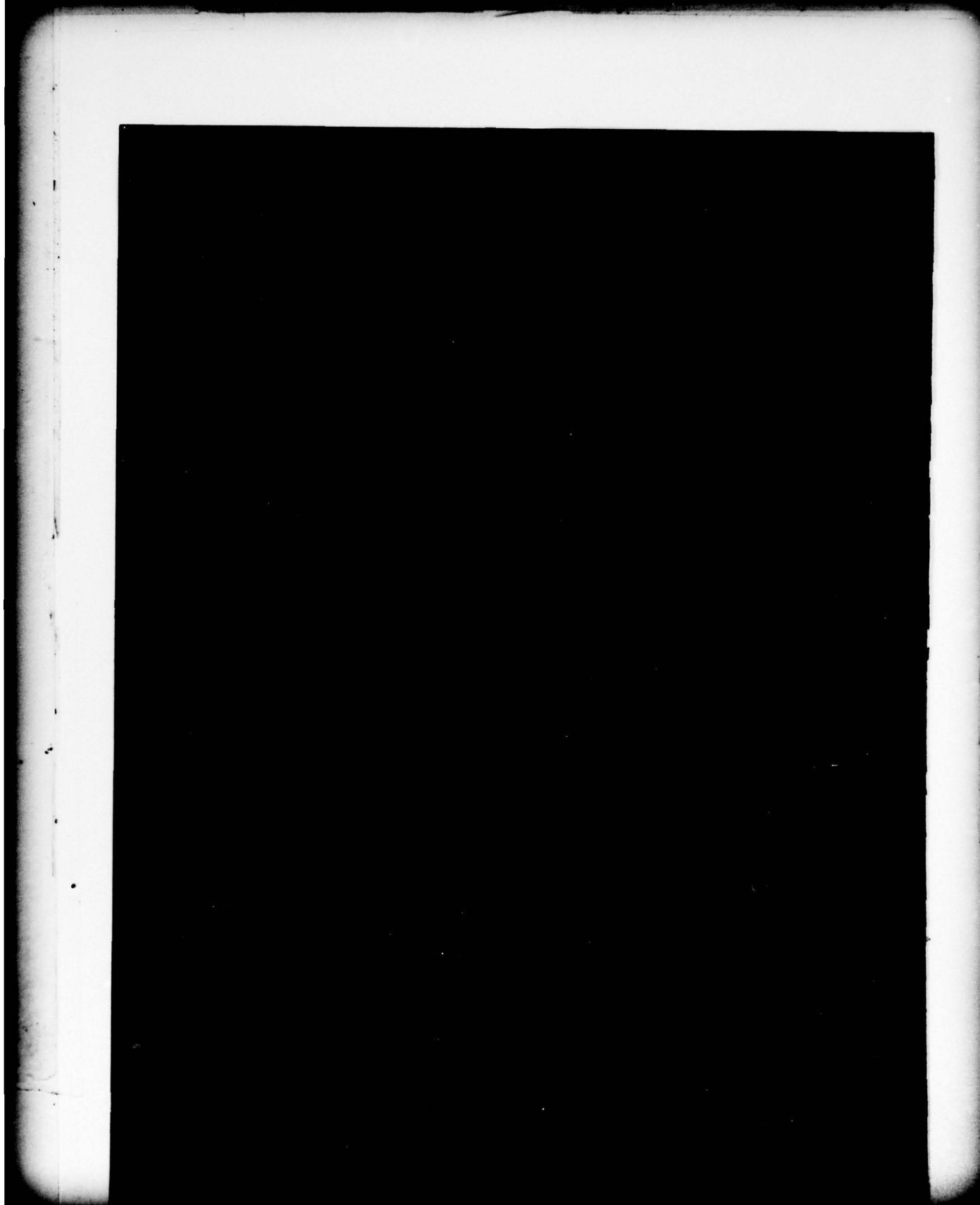
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CONTRACT REPORT S-74-1

RESEARCH STUDY FOR THE DESIGN,
DEVELOPMENT, FABRICATION, AND
DELIVERY OF TRUSS WEB HEAVY DUTY
LANDING MAT WITH INTEGRAL
WATERPROOFING

by

G. K. Glaza

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May 1974

Sponsored by U. S. Army Materiel Command
Project No. IT162112A131



Conducted for U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

Under Contract No. DACA39-72-C-0003 (Neg)

By The Dow Chemical Company, Midland, Michigan

ARMY-MRC VICKSBURG, MISS.

FOREWORD

The work reported herein was performed by the Dow Chemical Company, Midland, Mich., for the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., under Contract No. DACA39-72-C-0003 (Neg) during the period March 1972 to March 1974. The study was conducted as part of the landing mat program under "Environmental Constraints on Materiel," Project No. 1T162112A131, under the sponsorship of the Research Division, Research, Development, and Engineering Directorate, U. S. Army Materiel Command. The principal investigator for Dow was Mr. G. K. Glaza, Program Manager.

WES personnel directly concerned with this project were Messrs. D. W. White, Jr., and G. L. Carr, project engineers, H. L. Green, Chief, Landing Mat Branch, W. L. McInnis, Chief, Materiel Development Division, R. G. Ahlvin, Assistant Chief, Soils and Pavements Laboratory, and J. P. Sale, Chief, Soils and Pavements Laboratory.

BG E. D. Peixotto, CE, and COL G. H. Hilt, CE, were Directors of WES and Mr. F. R. Brown was Technical Director during the project.

The contract under which this report was prepared was monitored by Messrs. Green and White. The Contracting Officer was Mr. J. J. Kirschenbaum, Jr.

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CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

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

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
square inches	6.4516	square centimeters
square feet	0.092903	square meters
pounds (mass)	0.45359237	kilograms
pounds (force)	4.448222	newtons
kips	453.59237	kilograms
pounds per square inch	0.6894757	newtons per square centimeter
pounds per square foot	4.88243	kilograms per square meter
pounds per cubic foot	16.0185	kilograms per cubic meter
feet per second	0.3048	meters per second
miles per hour	1.609344	kilometers per hour
knots (international)	0.5144444	meters per second
Fahrenheit degrees	5/9	Celsius or Kelvin degrees*

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

SUMMARY

An integral waterproofing system was developed for the extruded aluminum truss web heavy duty mat and a roll test quantity of mat equipped with the system delivered to the U. S. Army Engineer Waterways Experiment Station at Vicksburg, Mississippi.

The male-female side joint is sealed by an extruded neoprene, multi-cavity, hollow, compression type seal. The hinged lever closing action of this joint is used to compress the seal.

An enlarged "dog bone" type of locking bar, with identical cavities for containing seals extruded into each of its two horizontal sides, provides the means for conveniently and quickly sealing the joints between adjacent end connectors.

Locking bar seals are extruded neoprene, in a multi-cavity, hollow, compression type of design.

Locking bars are "loaded" with compressed seals prior to delivery to the field. After locking bars are installed, seals are permitted to expand by removing the retaining strips that have confined the seals in a compressed condition.

Mat female corners are sealed by direct abutment of locking bar seal ends against the continuous side seal of the adjacent mat.

Mat male corners are sealed by installing a molded neoprene combination cap and plug over the protruding end of the installed locking bar.

The most advantageous features of the sealing system are believed to be laying speed and economy.

The system can be readily adapted to other types of mats such as XM-18, XM-19, AM-2, and the new 48" x 55-1/2" truss web C-5A mat.

Reproducible original drawings adequate for the procurement of additional mats identical to the roll test mats have been prepared and delivered to the WES.

RESEARCH STUDY FOR THE DESIGN, DEVELOPMENT, FABRICATION,
AND DELIVERY OF TRUSS WEB HEAVY DUTY
LANDING MAT WITH INTEGRAL WATERPROOFING

PART I: INTRODUCTION

The Problem to be Solved

1. This report covers a research and development program that was undertaken to add an integral waterproofing system to the heavy duty truss web landing mat that was developed under Contract No. DACA39-69-C-0014(Neg)*.

2. Roll and other engineer design tests conducted by the U. S. Army Engineer Waterways Experiment Station at Vicksburg, Mississippi had established the ability of that mat to provide the physical and performance characteristics of a heavy duty mat as defined by the "Revised Department of the Army Approved Qualitative Materiel Requirement for Prefabricated Airfield Surfacing" issued 2 April 1968.

3. Maximum mat weight and minimum structural performance levels required by the QMR for heavy duty mat are:

Weight	5.0 to 6.5 lbs./ sq. ft.
Single Wheel Load	50,000 lbs.
Tire Pressure	250 psi
Nominal Contact Area	200 sq. in.
Coverage Level	1,000
Subgrade CBR	4
F4 Tailhook Impacts at 80 Knots	5
Roll-over Landings (1" dia. cable)	20

*Contract Report S-71-1

4. In common with all earlier production mat, field use of the truss web heavy duty mat, developed under the noted prior research contract, requires a separate means of protecting the subgrade against water infiltration from above. This is accomplished by completely covering the entire subgrade with a highly tear-resistant waterproof membrane, usually elastomer coated nylon sheet material, before laying the aluminum mats.

5. Obvious disadvantages of this dual system include greater time spent by mat laying crews and the additional original and maintenance costs of the membrane. Less obvious, but perhaps of significance, are the limitations that the use of a membrane places on possible improvements in field anchoring that may be required to accommodate horizontal braking loads imposed by very heavy aircraft such as the C-5A.

The Approach to the Problem

6. The approach pursued during the execution of the work reported herein was to develop and apply to the already proven truss web heavy duty mat midsection geometry new male side connector, end connector and locking bar configurations that will accommodate and permit effective functioning of a system of waterproofing seals.

7. The integral waterproofing system developed by the work described in this report, while specifically directed toward improvement of the truss web heavy duty mat, can be readily adapted to other types of mats such as XM-18, XM-19, AM-2, and the new 48" x 55-1/2" truss web C-5A mat.

PART II: PROCEDURE

Separating the Problem into Components

8. Sealing the complete perimeter of each mat was perceived as requiring solutions to three uniquely different sealing problems:

- a. Male-female side connector joint.
- b. End connector joint.
- c. Mat corners.

9. Of the three, the end connector joint appeared to present the greatest challenge as well as opportunity for invention.

Side Connector Seal

10. It was readily recognized that, with minor modification, the hinged lever characteristic of the previously developed male-female side connector geometry could be used to compress a suitable seal and accomplish watertightness in this area.

11. A decision was made to attach an extruded neoprene side connector seal to the male side of the mat extrusion (fig. 1).

End Connector Seal

Candidates studied

12. A study was made of possibilities for compressing an end connector seal by using a force that is generated during normal mat laying procedure. The space limitation imposed by the mat thickness defeated attempts to accommodate a seal in a lap joint in which the seal compression force would be applied by the weight of a mat supplemented by the standing weight of one or more of the mat laying crew.

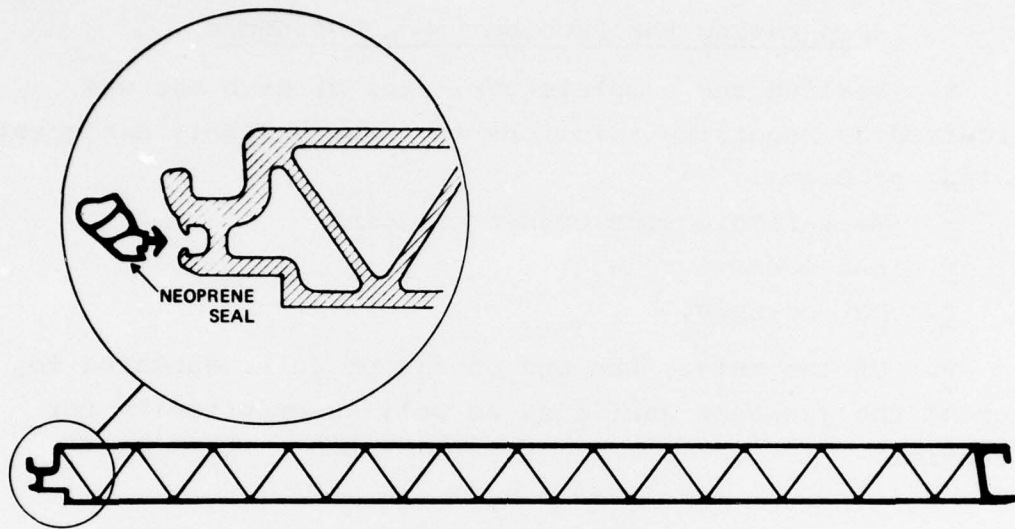


Fig. 1. Waterproof truss web mat extrusion.

13. Using a wedge shaped locking bar end to compress a preformed seal was given considerable attention. A possibility that was not developed but which is judged to have merit is shown in Appendix A (fig. A1) and (fig. A2).

14. Brief investigations were made of possibilities for using a two-component rapid curing urethane, a water-swallowable acrilamide (mine sealer), vacuum collapsed pre-cured seals and inflatable seals.

Laying speed emphasized

15. Primarily to maximize mat laying speed, a decision was made to develop a design that would permit pre-loading the locking bars with compressed preformed neoprene seals prior to being delivered to the mat laying site.

16. The principle employed involves spot bonding compression seals into cavities extruded into each side of the locking bar (fig. 2), retaining the seals in a compressed condition to permit easy entry of the locking bar

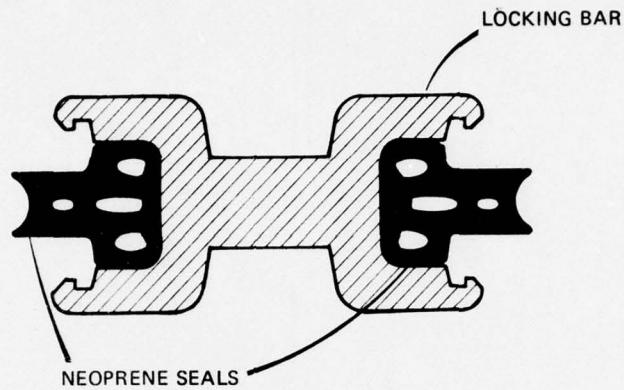


Fig. 2. Locking bar and seals.

into the cavities formed by two adjacent end connectors (fig. 3) and, after the bar is in place, permitting the seals to expand by withdrawing and discarding the seal retaining strips (fig. 4).

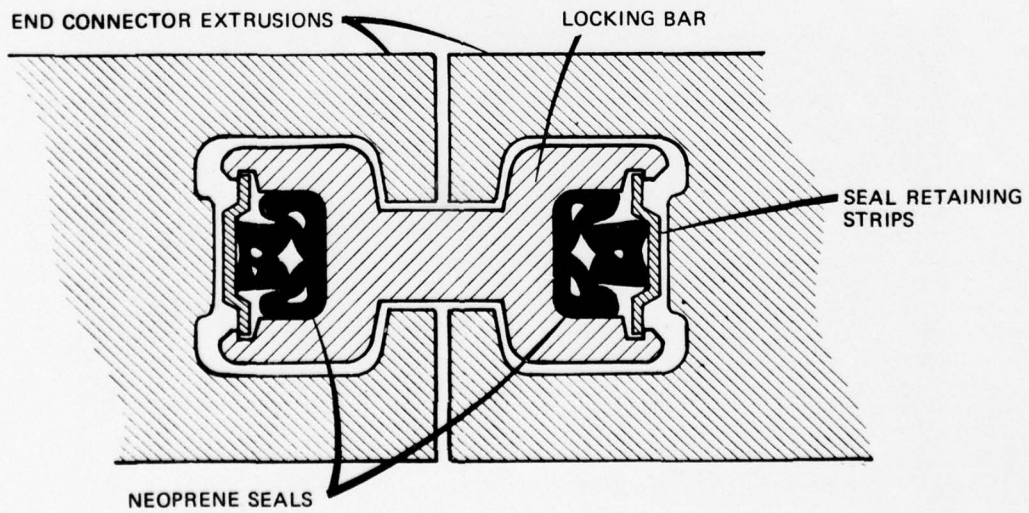


Fig. 3. End connectors joined by locking bar prior to removal of seal retaining strips.

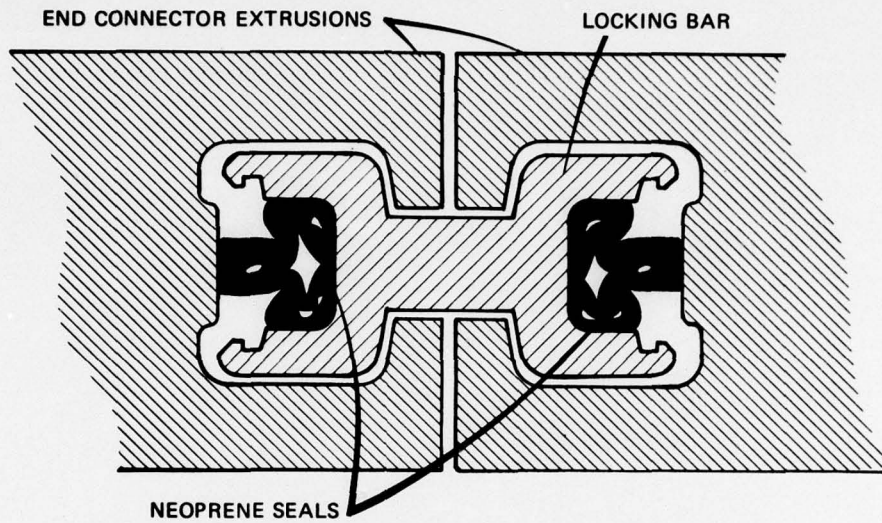


Fig. 4. End connectors joined by locking bar after removal of seal retaining strips.

Installing compressed locking bar seal retaining strips

17. A fixture was devised for mechanically compressing full length locking bar seals (fig. 5).

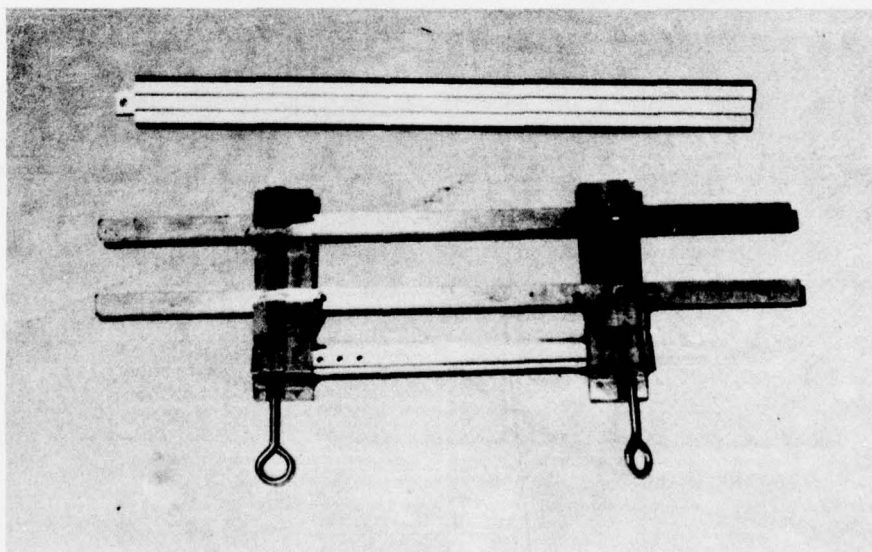


Fig. 5. Tool for pre-loading locking bars with compressed seals.

18. Procedure developed for installing seal retaining strips involves immersing the fixture and compressed neoprene seals in a mixture of dry ice and alcohol for five seconds, removing frozen compressed seals from the fixture, positioning seals in a locking bar, lubricating the seal side of two rigid vinyl retaining strips, and sliding such strips into position before the seals thaw.

Positioning locking bar in end connectors

19. Despite the restriction to such movement provided by expanded seals, it is believed that under repeated rolling loads a locking bar will creep lengthwise, if such movement is required to equalize sealing forces applied to opposite ends.

20. To aid in initially locating bars to approximately equalize such forces, a small mechanical tool (fig. 6) was made and delivered that quickly and precisely locates a locking bar in adjacent end connectors and holds it there while retaining strips are being removed.

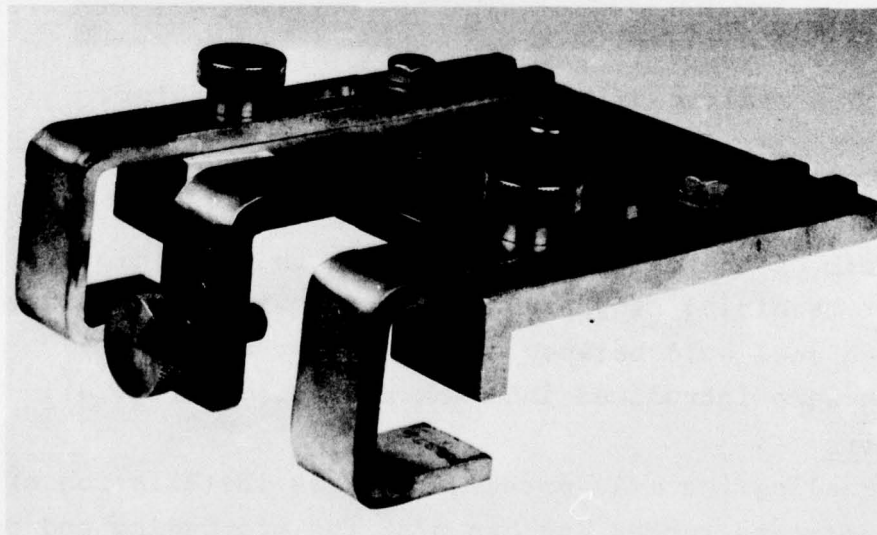


Fig. 6. Tool for positioning locking bar while seal retaining strips are being withdrawn.

Corner Seals

Female corners

21. Female corners are effectively sealed by direct contact between end connector and side connector seals (fig. 7).

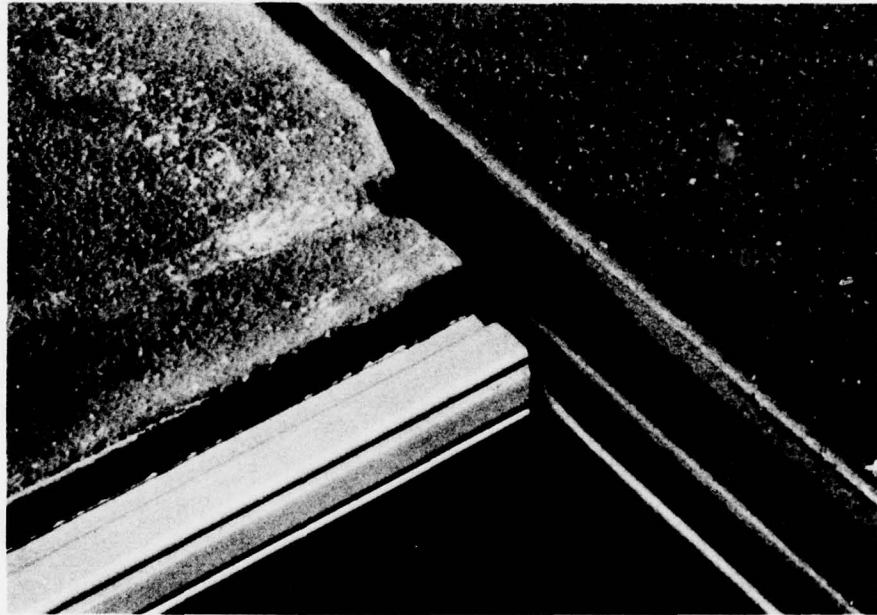


Fig. 7. Sealing of female end of end connector.

22. Consistent sealing requires that the end of the end connector and the outside surface of the slanted "C-rail" rib of the mat extrusion lie in the same plane. Additional machining steps required to provide accommodation for a flush seal weld between end connector and mat extrusions were introduced into the new design (fig. 8).

Male corners

23. Sealing the male corners requires installation of a molded neoprene rubber end cap over the protruding end of the locking bar (fig. 9). This cap is deformed sufficiently

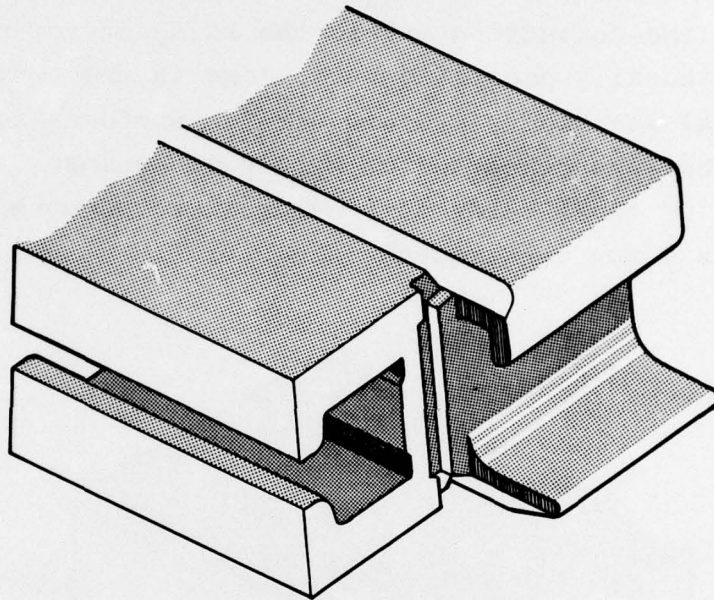


Fig. 8. Joint preparation prior to welding flush female side seal weld.

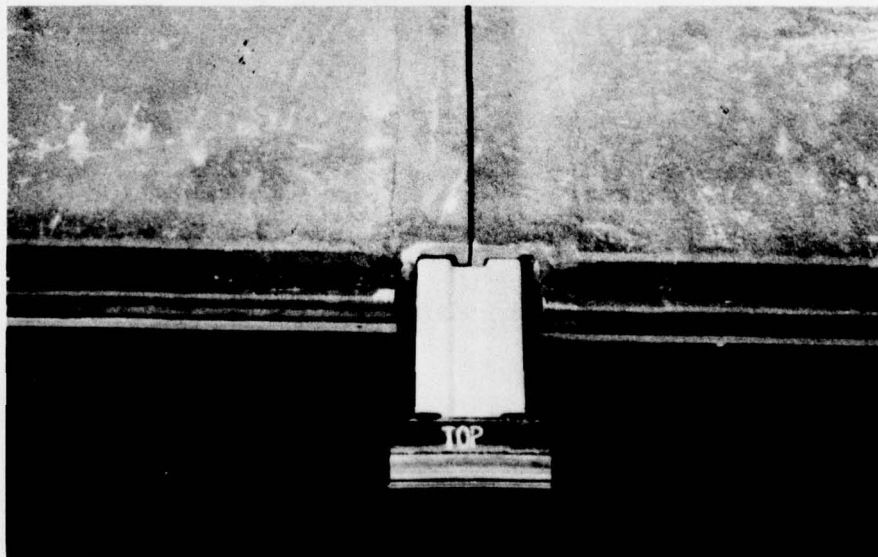


Fig. 9. Molded neoprene cap that seals male end of end connector.

to effect a tight seal when force is applied to the end of the cap by the contacting mat in the adjacent row of mats.

24. Naturally occurring variations in the contours of the vertical seal welds produce erratic surfaces for the molded rubber end connector caps to seal against. Machine contouring of these welds to provide improved consistency of shape is a new requirement (fig. 10).

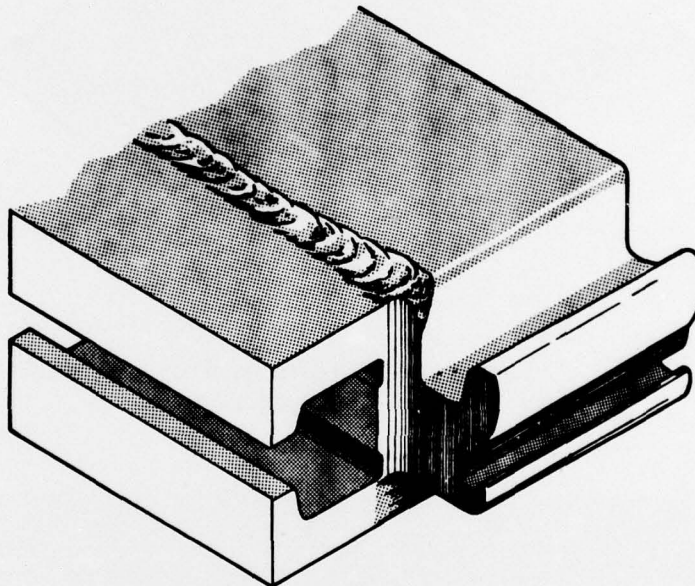


Fig. 10. Machine contouring of male side seal welds.

End Connector to Mat Extrusion Joint

25. To provide the strength required to qualify as a heavy duty mat, the same method for reinforcing end connector-to-mat extrusion welds that was used on the original truss web heavy duty mat was used in the new waterproof mat design (fig. 11) and (fig. 12).

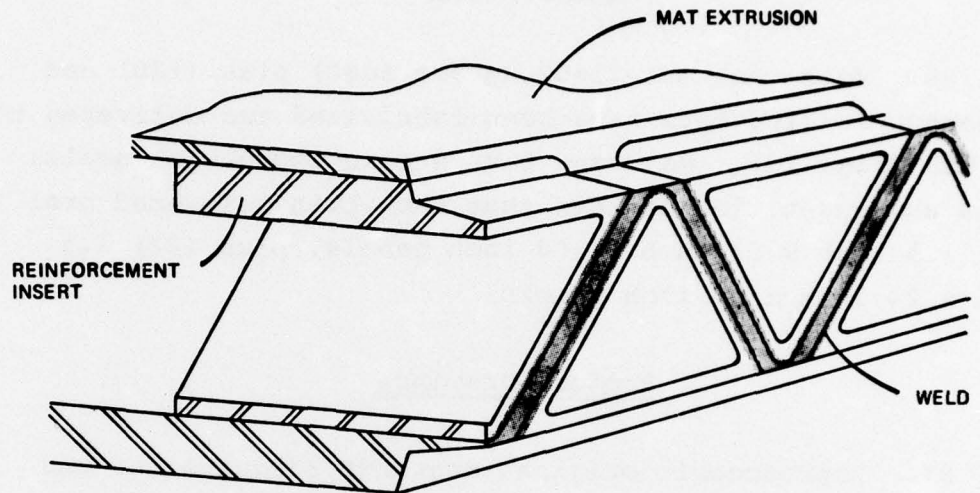


Fig. 11. End connector to mat extrusion reinforcement inserts.

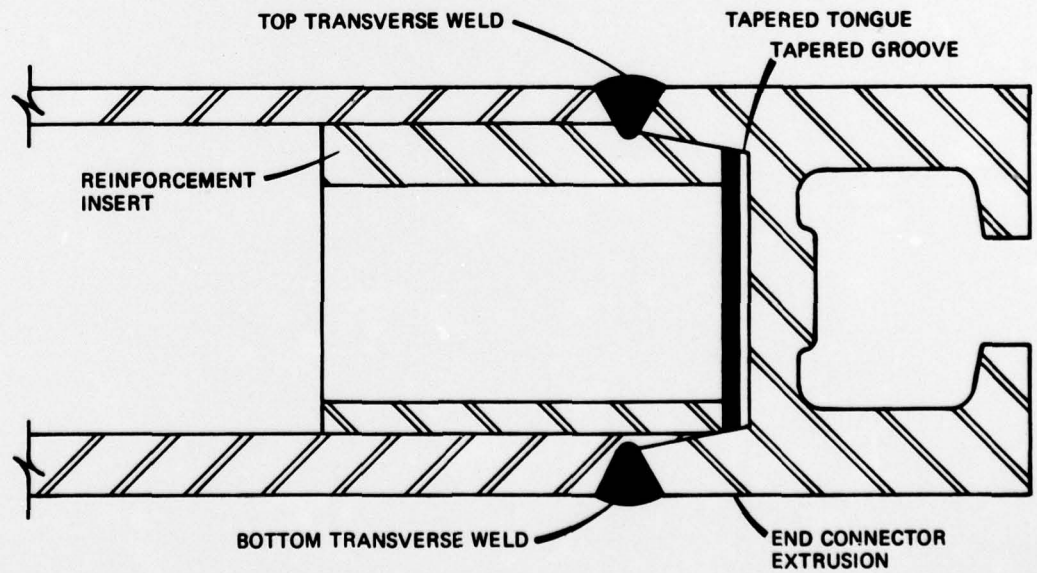


Fig. 12. Attachment of end connector to mat extrusion.

Roll Test Mat

26. Roll test mat (1602 square feet) plus (120) end connector locking bars have been fabricated and delivered to the WES (fig. 13). Mats and bars are equipped with seals. Sizes and quantities of mats that have been delivered are: (78) 1.5 inch x 24 inch x 108 inch panels, plus (22) 1.5 inch x 24 inch x 54 inch panels.

Product Drawings

27. Reproducible original drawings adequate for the procurement of additional mats identical to the roll test mats have been prepared and delivered to the WES.

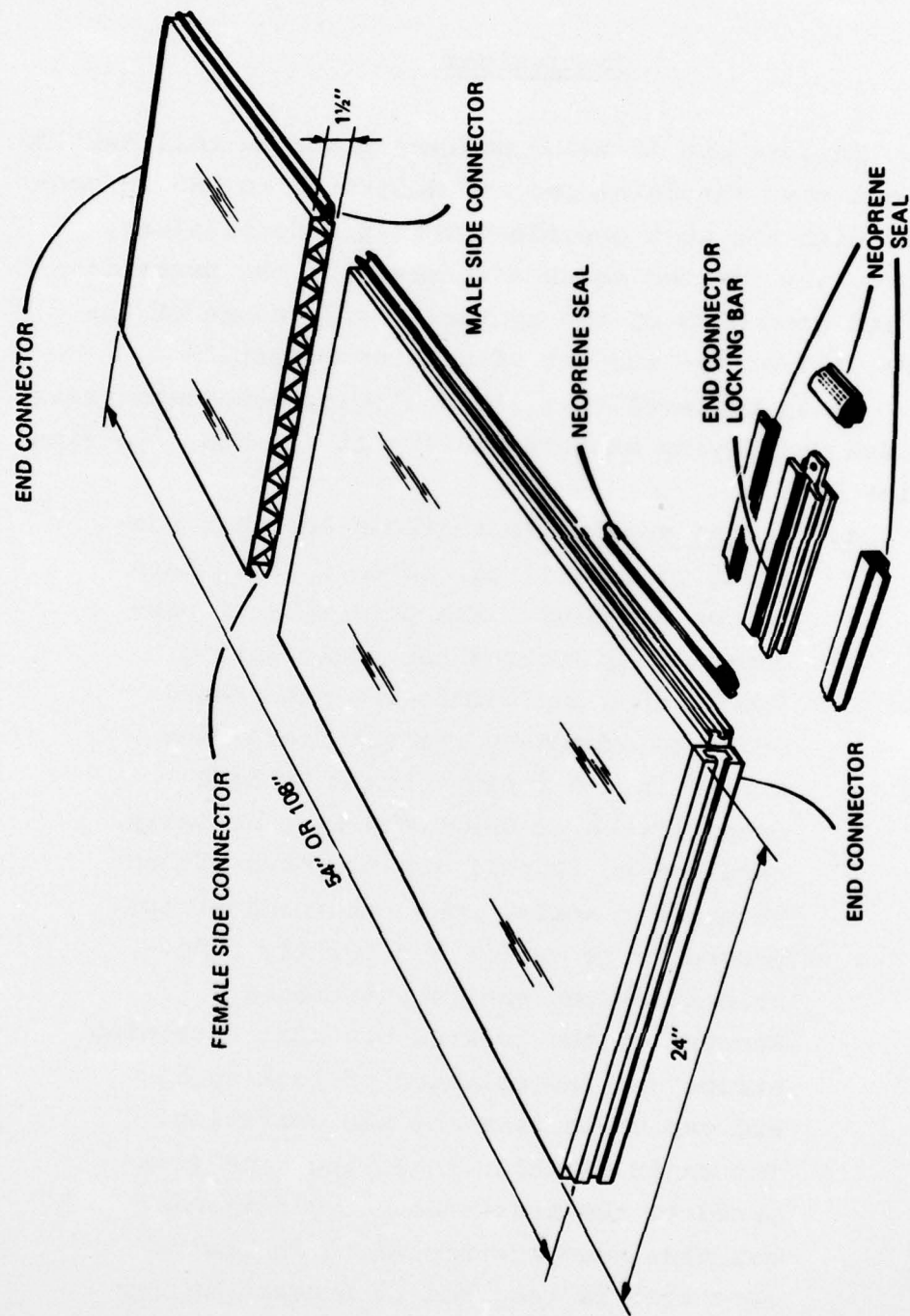


Fig. 13. Waterproof truss web heavy duty landing mat.

PART III: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

28. This report is being written prior to roll testing of the mat that was developed and delivered to WES in conjunction with the work described herein. Conclusions, therefore, are limited to an assessment of the practicality and economics of the system. Performance of the hardware will be the subject of a later report.

29. It is believed that the following was demonstrated by limited mat laying experimentation at the WES involving full size mats.

- a. Laying speed. Indications are that contract goals will be proven to have been met or exceeded. The principle of pre-compressing locking bar seals during fabrication and permitting compressed seals to expand by removing retaining strips in the field appears to have added little to the field time normally required to install locking bars without waterproof seals. The retaining strips proved to be easily and swiftly removable after the bar is positioned. Removal of the locking bar seal retaining strips and installation of locking bar end cap seals is a one man operation. The major addition to laying time (compared to the truss-web heavy-duty mat) has thus been restricted to the extra care that is required to prevent injury

to, or dislocation of, the side connector seals as adjacent rows of mats are joined.

- b. Economics. Compared to the truss-web heavy-duty mat, the only extra cost that has been added to the metal portion of the waterproof mat is the additional fabrication required to machine the male corner notches (fig. 10) and to assure flush female corner welds (fig. 8). The side connector seal, the locking bar seal, the locking bar seal retaining strip and the locking bar end cap molded seal are all easily produced, competitively priced shapes and materials.

Recommendations

30. Based on limited mat laying experimentation and observations, it is believed that some improvement in the functioning of the seals may be obtained by:

- a. Rearranging the internal geometry of the hollow side connector seal to make it more resistant to peeling dislocations during mat laying.
- b. Changing the design of the locking bar end cap seal to include a softer rubber insert inside of a harder rubber shell.
- c. Providing for a locking engagement of the side connector seal with the locking bar end cap seal.

31. An alternate method for pre-loading locking bars with compressed seals that does not require freezing of the compressed seals should be developed. This will probably require a metal rather than a plastic retaining strip.

32. It is believed that the waterproofing system as developed by this contract and with the modifications recommended in paragraph 30 and paragraph 31, has enough merit to warrant its addition to the 48" x 55-1/2" truss web C-5A mat.

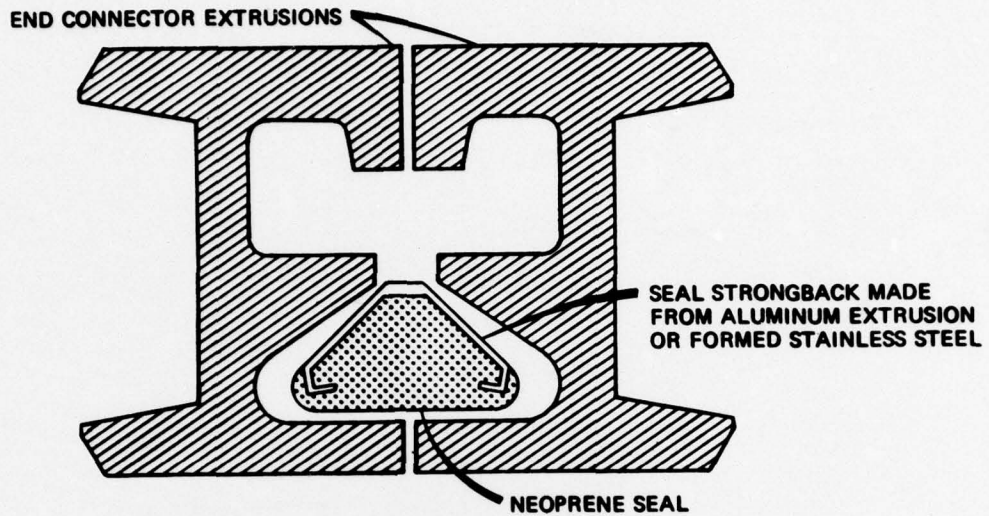


Fig. A1. Alternate (not developed) method for sealing joint between end connectors-- before installation of locking bar.

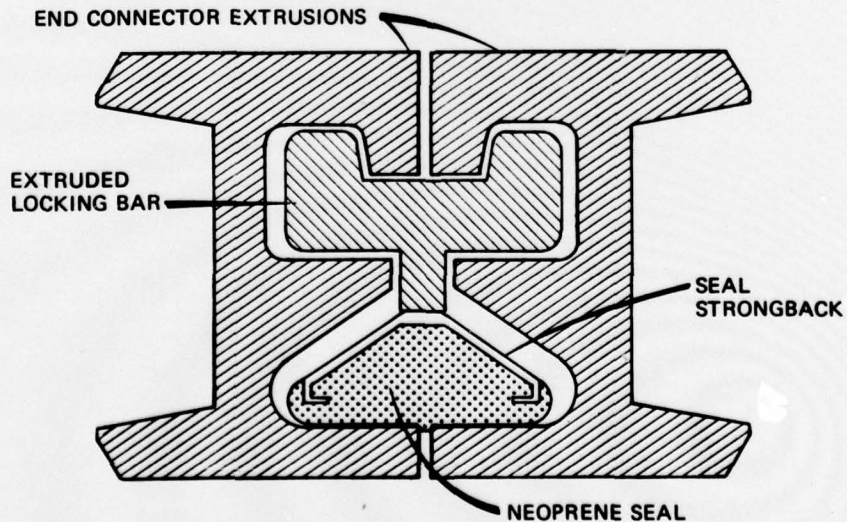


Fig. A2. Alternate (not developed) method for sealing joint between end connectors-- after installation of locking bar.

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