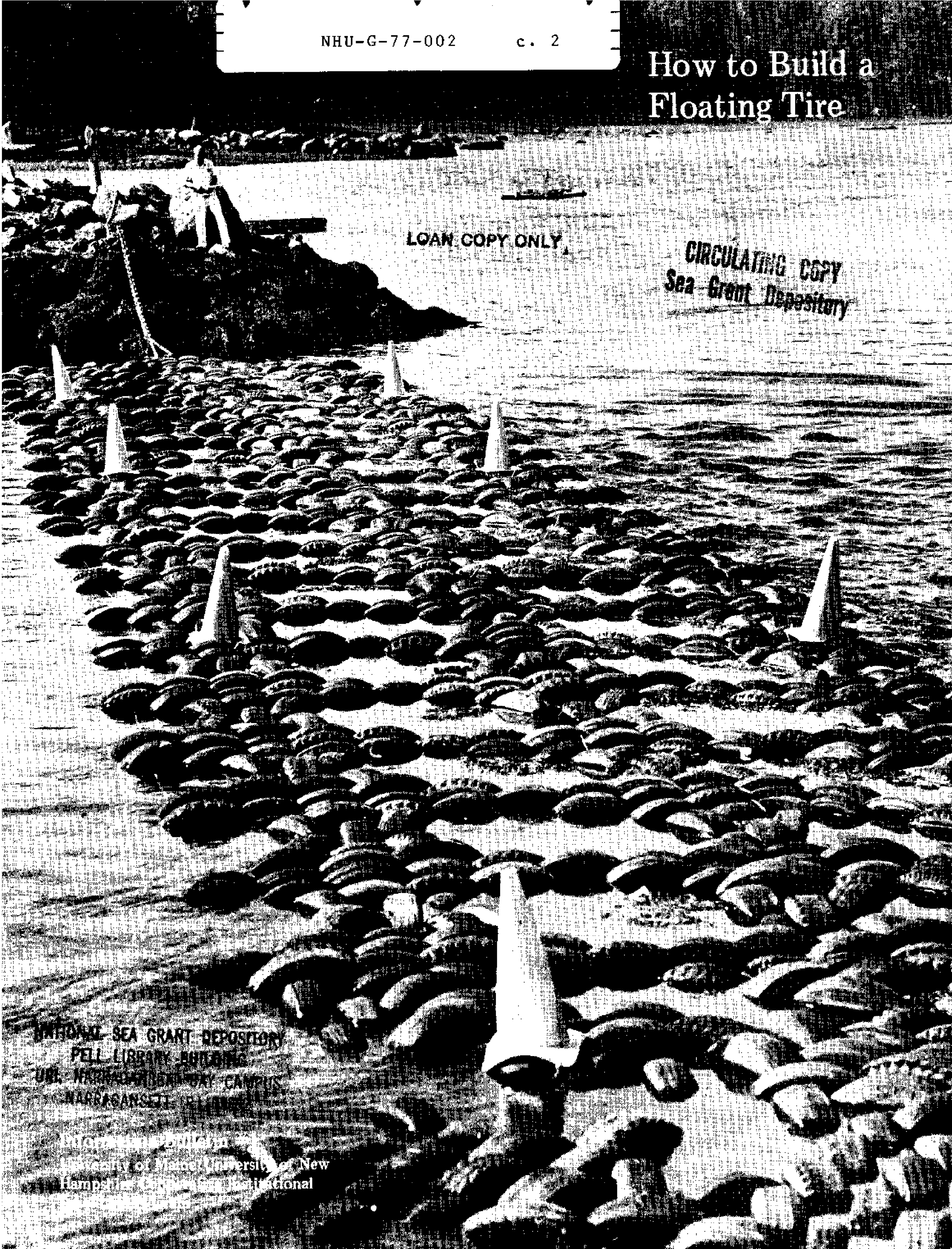
How to Build a Floating Tire ...



Information Bulletin
University of Maine/University of New
Hampshire Cooperative Institutional

Published by the University of Maine/University of New Hampshire Cooperative Institutional Sea Grant Program, September 1977, using published and unpublished material based on research conducted by the University of Rhode Island Marine Advisory Service and Goodyear Tire and Rubber, Inc. Contributors to this publication include Neil Ross , Tadeusz Kowalski and Al Davis of the University of Rhode Island; Paul Ring and Phyllis Coggins of the University of Maine; George Shaw and Louise Eklund of the University of New Hampshire; John K. Hutchinson of the New England Marine Advisory Service and Goodyear Tire and Rubber, Inc. Photos courtesy of Goodyear Tire and Rubber, Inc., and the UNH Marine Advisory Program.

Additional copies of this publication are available from the UNH Marine Advisory Program, 222 Kingsbury Hall, Durham, NH 03824, or from Sea Grant Publications, Ira C. Darling Center, Walpole, Maine 04573.

HOW TO BUILD A FLOATING TIRE BREAKWATER

George Shaw
Neil Ross

September, 1977

Information Bulletin # 1

University of Maine/University of New Hampshire
Cooperative Institutional Sea Grant Program

This publication is a result of Marine Advisory Services sponsored by NOAA Office of Sea Grant, Department of Commerce, under Grant #04-6-158-44056.

Introduction

The floating tire breakwater (FTB) concept was developed as more people realized the need for an environmentally acceptable, low cost breakwater. Many public boat mooring sites, marinas and yacht clubs are situated in exposed areas and need protection from wind waves and boat wakes. Obtaining permits to construct bulkheads, rock groins, jetties and other conventional breakwaters is becoming increasingly difficult. Furthermore, the high cost of constructing such breakwaters is usually prohibitive. Recent cost estimates range from $500 per linear foot for wooden bulkheads to $1000 or more per linear foot for rock groins, depending on exposure, depth of water, tidal currents and other environmental factors.

A properly constructed and maintained FTB, however, should cost under $50 per linear foot, at today's costs, and should have a lifespan of ten years.

The original research on construction of an environmentally acceptable, low cost breakwater was begun in 1972 by the Marine Advisory Service at the University of Rhode Island. At that time, Goodyear Tire and Rubber Company was seeking potential uses for scrap tires. URI and Goodyear researchers cooperated in research efforts, which resulted in an 18-tire modular construction design, conceived by a Goodyear research engineer. This modular design has become the accepted way to construct FTBs.

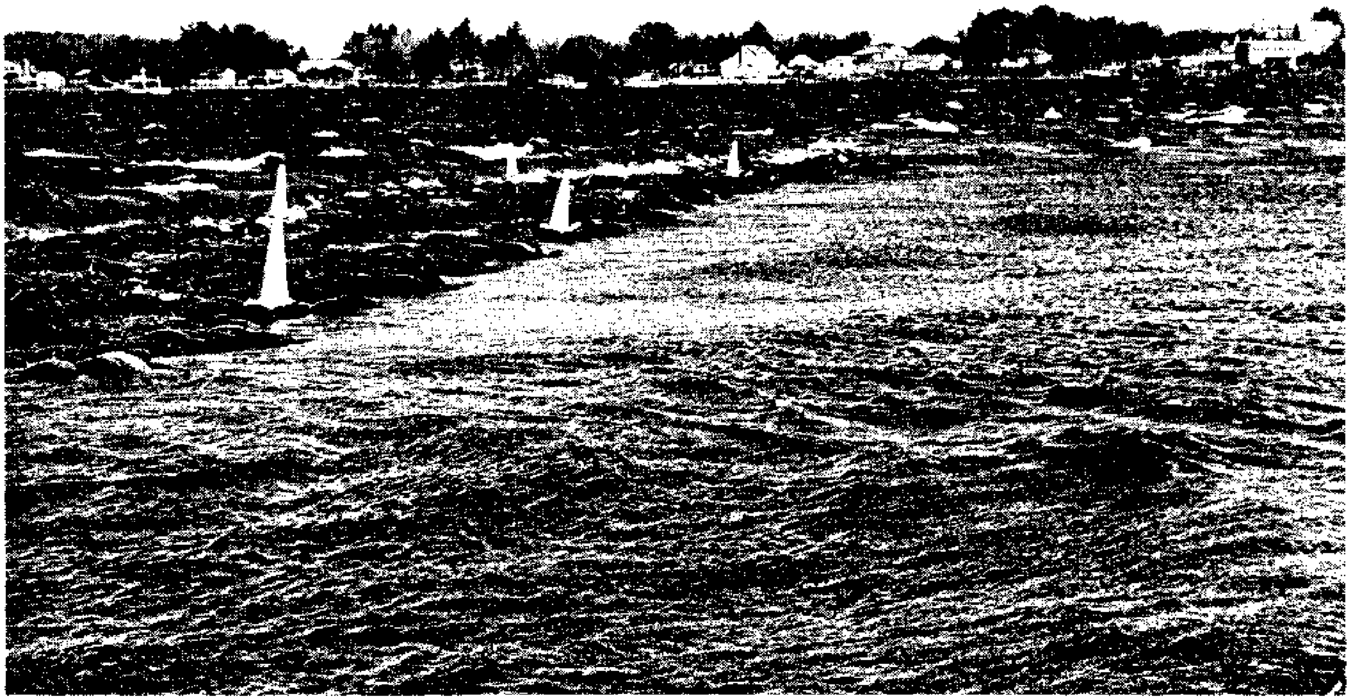
Modular Design

The modular design of the breakwater calls for a vertical arrangement of tires into connected units, or bundles.

Construction of the breakwater is very simple and requires a minimum of binding material. Its design depends on the three dimensions of a unit: length, beam and draft.

Length: The dimension parallel to the oncoming waves, is determined by the size of the area to be protected. The best arrangement in a cove is two overlapping breakwater sections that extend outward from opposite shores to form an "entrance" where the two sections overlap. If the pre-

Mast-hauling operations at the Great Bay Marina in Newington, New Hampshire, have benefitted from the installation of a 21' x 150' floating tire breakwater.



The Great Bay Marina floating tire breakwater in action on a brisk and breezy November day.

dominant direction of the waves is known, a shorter breakwater facing the waves might be sufficient. Its length and shape would then depend on the physical characteristics of the area to be protected as well as wave refraction around the ends of the unit. To control refracted waves, a longer breakwater or an L-shaped one may be needed.

<u>Beam</u>: Width is determined by the predominant wave length in the area to be protected. Increasing the width increases the wave length that will be suppressed. The general rule is that the beam must be greater than half of the significant wave length.

To determine the significant wave length, first determine the period (T) of the oncoming waves by measuring the average time in seconds between successive wave crests passing a given point (such as a piling or buoy) in the space of about five minutes. Then, calculate the significant wave length (L) using this formula:

$$L = 5T^2$$

This formula applies to deep-water waves or those where the depth of water is greater than half of the wave length (L).

Most of the early FTBs were three bundles wide, or about 20 feet. Many full-scale field tests have been performed by Sea Grant at the University of Rhode Island to substantiate the performance of the breakwater. Automobile tire structure widths of 20 and 26 feet were found to be 80 percent effective in suppressing three-to-four-foot waves. Therefore, it is recommended that a structure 26 feet, or four bundles, wide by one unit deep be considered for suppressing three-foot high waves.

Draft: Immersed depth is determined by the height of significant waves occurring in the area. Again, a general rule: draft should be greater than one-half the height of the significant wave. Breakwaters built of standard automobile tires are effective in seas up to five feet. Such breakwaters will suppress about 70 to 85 percent of the incoming wave height. Larger truck or tractor tires will increase the depth of the breakwater and control higher waves.

First Steps

The breakwater should be situated with its leading edge parallel to the oncoming waves. It should be moored as close as possible to the area to be protected so that the wind will not have sufficient fetch to rebuild the waves behind the breakwater.

Since the breakwater is very mobile, the best location can be found by experimentation. In fact, the FTB can be shifted with the seasonal variations in wave direction. The breakwater should be placed in water of sufficient depth to prevent it from touching bottom at low tide or in low water. Doing this will also prevent it from sinking. The returning tide might fill the tires with sand and sink them. For this reason, this type of breakwater should not be installed without supplemental flotation in highly silted rivers. In high silt transport areas, the breakwater might continue to float if 2" x 3" holes were cut in the bottom of each tire to allow the sediment to wash through. This has not yet been tested.

Permits must be obtained from the appropriate agencies before a floating breakwater can be installed in the navigable waters of New Hampshire, Maine and most other states. Briefly stated, approval or acceptance must be received from local abutters, planning and zoning boards, State Fish and Game Departments, and all other state regulatory agencies involved in matters such as these. In addition, the U.S. Army Corps of Engineers must give its approval. Anyone planning a breakwater should allow six to eight months for the permit procedure. To speed up the process all local, state and federal permit requests should be filed at the same time.

Materials

Tires: With an estimated existing stockpile of more than two billion scrap tires in the United States, marinas should not have much difficulty obtaining them. Large quantities are usually available from tire dealers, recapping centers, truck stops, highway departments and town dumps. Most of these places are eager to dispose of them and many will even deliver them to the marina free of charge.

Air trapped in the tire crowns will provide sufficient buoyancy to keep the FTB afloat a while. The tires float approximately six inches above the water level and two feet below the surface, providing about ten pounds of reserve buoyancy per tire, or 200 pounds per unit of 20 standard (14-15 inch) tires.

It is recommended, however, that supplemental flotation be provided in every tire. Any one of several types of closed cell rigid urethane foam, set into the tops of the tires, is suitable for this purpose.

Binding Materials: The binding material can represent as much as one-third of the total cost of the breakwater, with labor and the mooring system accounting for the remainder. The temptation is to economize on binding materials as much as possible, but this kind of economizing should be avoided.

The ideal binding material must be able to hold together for ten years in an aerated-seawater condition where it is subject to corrosion, crevassing, fatiguing and abrasion. To be ideal, it must do this at a reasonable cost. In fresh water, corrosion and crevassing will be less of a problem.

In situ salt water tests were conducted at URI's Narragansett Bay Campus from January through November, 1976 to evaluate the reliability of 12 different materials that were thought suitable for connecting FTB units.* The binding material recommended above all others tested is conveyor belt edging material, a scrap product resulting from the trimming of new conveyor belts. Because of its fabric plies, this material demonstrates ultimate tensile strength on the order of 9,500 p.s.i. when no stress risers, such as bolt holes or cuts are present. The belt material is available from several tire manufacturers in this country, including Goodyear.

Minimum recommended belt dimensions are 2" wide by .375" thick with three or more nylon plies. Dimensions of this scrap material can vary widely, so prior arrangements should be made with the rubber company supplying the belting to avoid shipment of unuseable sized material.

Conveyor belt edging demonstrates several other desirable characteristics. It can be easily cut on a band saw or with a hand hack saw or axe. Holes for bolts can be punched singly or with a multiple gang punch. The material is virtually inert in the marine environment. It is pliable enough to be handled easily by one man during its fabrication and assembly into the tire modules.

As a means of fastening the belting together, the use of nylon bolts, nuts and washers was conceived. This makes a binding system that is totally inert in the marine environment. The nylon fasteners should be dyed black before they are used. Doing this will provide a screen to prevent ultra-violet rays from degrading the nylon over a long period of time. Several minutes of immersion in household dye in boiling water is sufficient for this purpose.

*Complete test results are available upon request from the University of Rhode Island Marine Advisory Service.

The size and number of fasteners that are employed on each belt section is important for overall strength and fatigue considerations. Two basic systems that have been employed to date are:

1. The use of three (3), 3/8-16 bolts per belt fastening. (See photo on this page.) The belt width used with this pattern should be no less than two inches wide in the bolt zone to prevent the belting from being torn through to the edges. This pattern can support an average load of 2,100 pounds before the bolts fail. Washers must be employed under the bolt head and nut to prevent the head or nut from pulling through the rubber.

The floating tire breakwater installed at the Great Bay Marina in Newington, New Hampshire, in September, 1976, was bound together with conveyor belt edging material. Three 3/8-16 bolts per fastening were used to secure the bonds.

Voids in the center of these 3/8-16 injection molded bolts cause the strength of these bolts to vary substantially, by several hundred pounds. For this reason, the second system, explained below, is recommended over the 3/8-16 bolts. Several breakwaters which employ this system are in use at present and have been in the water for more than six months. One of these, at the Great Bay Marina in Newington, New Hampshire, is 150 feet in length and is positioned perpendicular to a daily tidal flow in excess of three knots. It has also withstood the onslaught of winter ice movement with no damage to the binding system to date.

2. The use of two (2), 1/2-13 bolts per belt fastening. The belt used with this pattern should be no less than two inches, and preferably three inches wide to prevent belt tearing. An average strength of this pattern is 2,150 pounds. In this system, the bolts do not fail. Either the bolts pull through the rubber belting or the belting tears.

These bolts differ from the 3/8-16 bolts in that they are manufactured from cast nylon bar stock on a screw machine and do not have the voids that are present in the 3/8-16 bolts. This system tends to be more predictable as far as repeatable strength limits.

Hints for Use of Nylon Fasteners:

(a) When tightening the nuts, torque limitations should be maintained. These will vary with the size of the bolt being used. Watch the nylon washer (only flat washers are recommended, i.e., no lock washers) for cupping as the nut is tightened. A very slight cupping indicates that the nut is tight enough.

(b) Bolts should be long enough to permit a minimum of ¼" of threads to protrude through the nut. Allowance for varying belt thicknesses and two flat washers should be made accordingly. This ¼" of threads allows a propane soldering tip to melt and distort a sufficient number of threads to prevent the nut from "backing off." Also the growth of marine plants in the exposed threads severely hampers the nut from working loose.

The following information is a result of the <u>in situ</u> test employing rubber conveyor belting and nylon fasteners as the binding system for a floating tire breakwater:

1. The belting and nylon fasteners are inert in the sea water environment.

2. The belting has excellent abrasion resistance to chafing against tire casings, other binding materials and marine growth, such as barnacles and mussels.

3. The belting shows no signs of delamination (separation along fabric plies) after nine months of immersion.

4. A slight increase in tensile strength of the belting (approximately 2-3%) was noticed after six months of immersion. This could be due to a better dissipation of heat, generated by the internal tensile straining, through the wet fiber plies.

5. The material is easily handled by one or two persons during fabrication and assembly.

6. The system allows localized loads to be distributed readily throughout the tire matrix.

7. The system can withstand low water temperatures including ice, high loading conditions caused by currents, wave action and cyclic fatigue loading. It can be towed without undergoing excessive strain.

8. The materials do not pollute the environment.

9. The system has a negligible negative buoyancy effect upon the breakwater modules.

10. The system can be unfastened readily for addition of tires, repairs or for other purposes.

At this time, these materials and fastening methods are the most economical and, probably, the most dependable. Estimated life is ten years.

Second to this system would be chain with a minimum wire diameter of ½", preferably galvanized. In third position relative to reliability would be polypropylene, either braided (for use in splicing) or regular lay. If polypropylene is employed in this capacity it should have an ultra-violet screen shield to retard degradation. All other materials are not recommended as binding material for floating breakwater applications.

Materials not recommended for FTB use are:

1. Nylon lines. They demonstrate poor abrasion resistance, knot loosening and ultra-violet degradation.

2. "Kevlar" line. Internal fiber friction during flexing of rope severely impairs strength characteristics of this material.

3. Any metallic wire rope, such as plain steel, galvanized steel or stainless steel because of inherent corrosive problems (particularly around the clamped or swedged ends), metal fatigue, caused by constant flexing, and the cutting action of the rope on the tire bodies.

Construction

The design of the breakwater is based on a modular concept, in which relatively few tires are secured together to form an easily assembled, portable building unit. This unit then serves as the basic building block for large structures.

The construction procedure is very simple. First, assemble the modular unit. This is done by securing 18 tires together to form a 7' x 6½' x 2½' bundle. The basic method used to construct the bundles is to stack the tires flat in a 3-2-3-2-3-2-3 configuration, as shown in Figure 1 and in the photo on page 8. Weave the binding material through as the tires are stacked. The increasing weight of the tire stack and compression of the

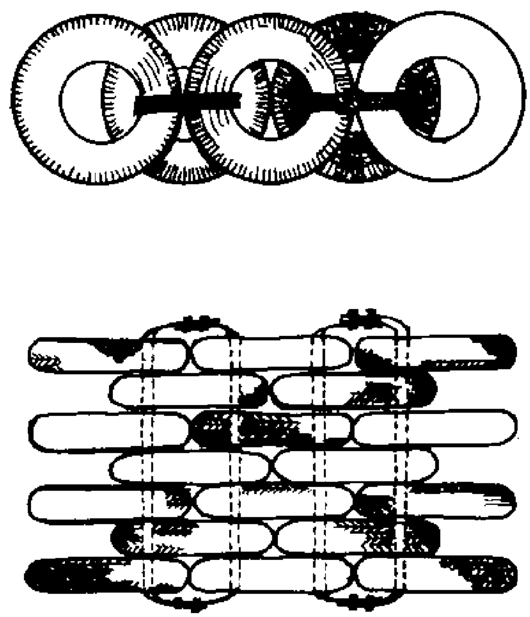


FIGURE 1

Modular Building Unit Shown as Constructed tires by hand will allow easy fastening of the binding material, and will form a tightly secured bundle.

The bundles should be constructed near the installation site, if practical. However, they are relatively easy to transport from the assembly site to where the breakwater will be installed. Be sure to install supplemental flotation in each tire before assembling the tires into bundles.

Connecting the tire units into a long chain to form the breakwater requires only a slight alteration of tire position and the addition of two tires per bundle.

Tire bundles are constructed by stacking the tires flat in a 3-2-3-2-3-2-3 configuration. Binding material--in this case, conveyor belt edging--is woven through the tires as they are stacked to secure the bundle.

First, the four corner tires of each bundle are rotated about 100°, as shown in Figures 2 and 3. Next, the two additional tires are inserted at each end of the module to serve as connectors, interlocking to form the desired shape of the protective structure. (See Figure 3)

The resulting mat, shown in Figure 4, has excellent strength characteristics (as high as 55,000 lbs. breaking strength on a 6½' spaced longitudinal and transverse grid). It also has the ability to absorb great amounts of enery by yielding and deforming when over-loaded. Elongation of more than 30 percent is possible in both directions.

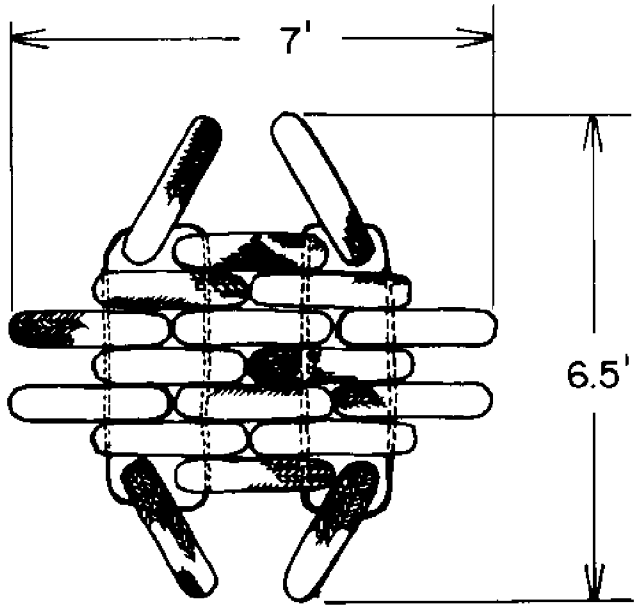


FIGURE 2

Modular Building Unit Shown as Installed

These elongations occur only under extremely high loading conditions, and the tire bundles return to their normal shape under no-load conditions without permanent deformation resulting.

The Bridle. To prevent any individual bundles from separating and drifting away, a bridle line should be threaded through the outside tires around the perimeter of the breakwater. (See Figure 4.) Secure the line to the two outside tires in each bundle to prevent chafing. The material can be one or more lines of synthetic rope or chain (providing the weight is not excessive).

Moorings. The size of the moorings and anchoring system will vary depending on the type of bottom (sand, rock or mud) and local tides and currents as well as the amount of exposure to wind and waves. Anchors, mushroom moorings, concrete and/or granite blocks heavy enough to resist drag are satisfactory.

Design the mooring system as you would for boats over 30 feet long. Local experience with moorings will be the best guide. Wooden pilings with the breakwater built around them may be used in place of moorings. It is recommended that moorings be placed a maximum of 50 feet apart on the wave side and every 100 feet on the lee side. Mooring lines should be attached to the breakwater in such a way that the load is distributed between two or more bundles.

Marking. The FTB could be a navigational hazard unless properly marked and lighted.

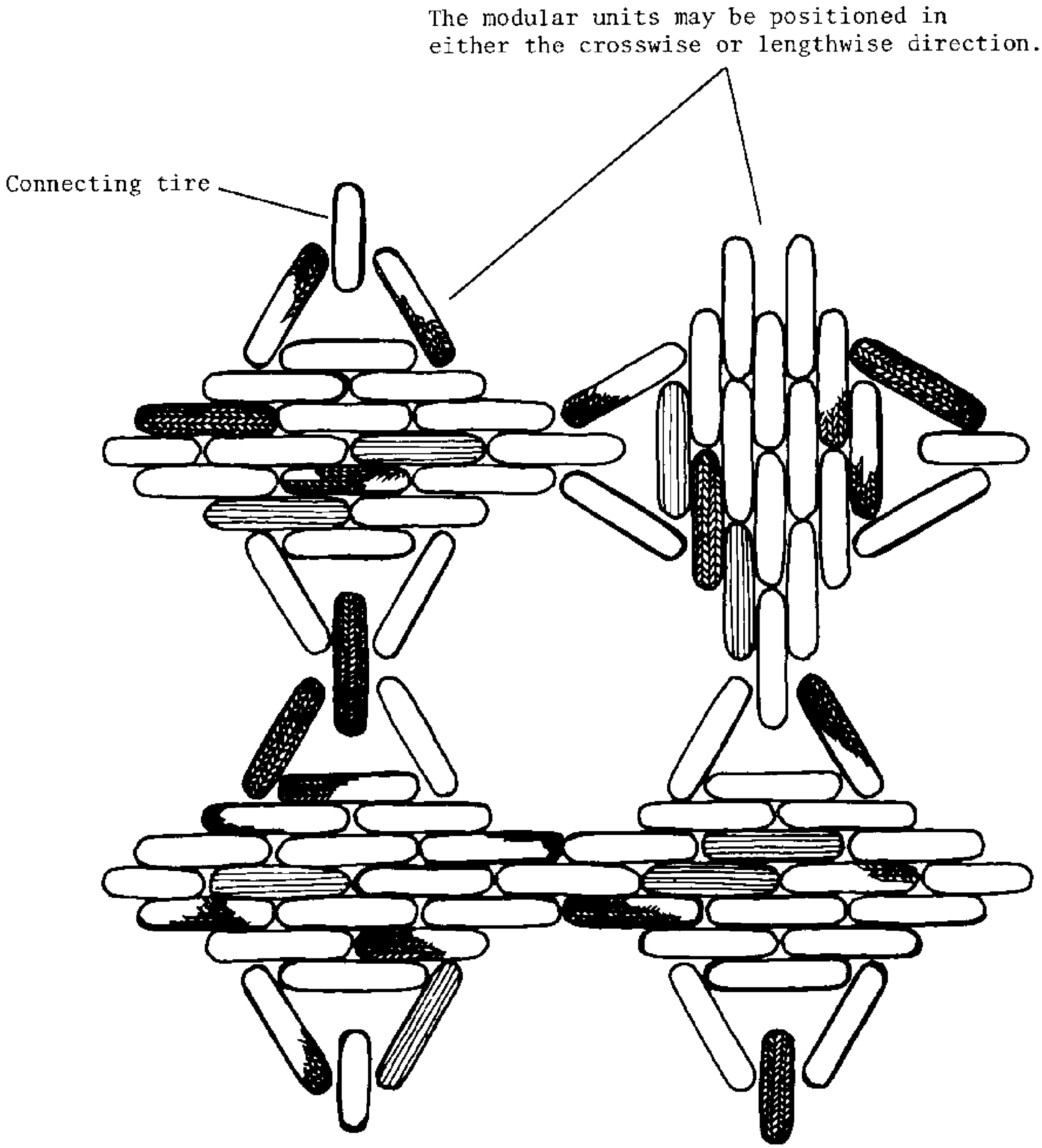


FIGURE 3

Modular Units Connected to Form Mat

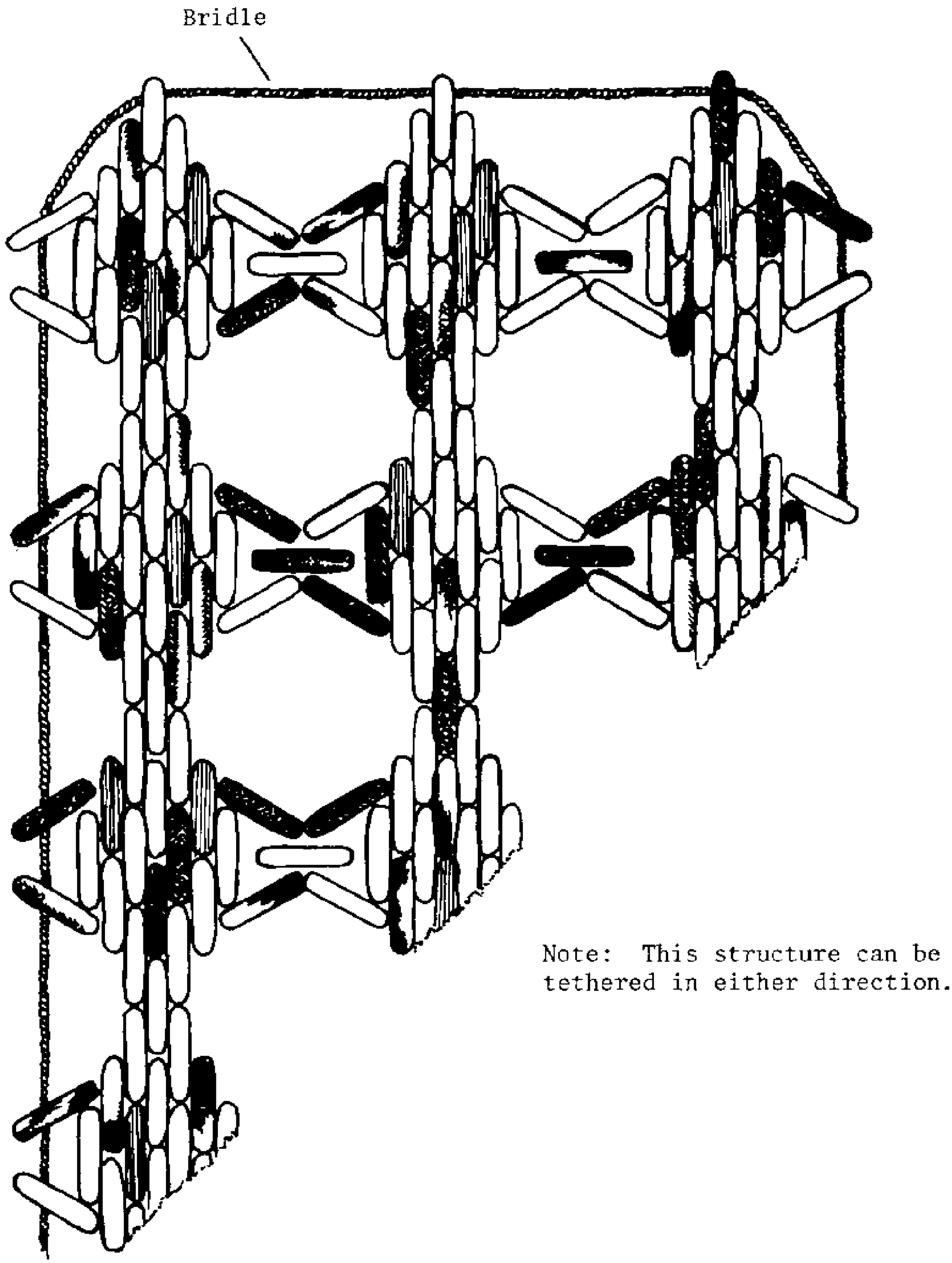


FIGURE 4

Shore Protection Mat and Connecting Bridle

Maintenance. Being a dynamic structure, the breakwater system will be subject to wear and deterioration. Therefore, it should be inspected regularly and after each storm, especially during the first few months after installation. When breaks in the binding material occur, they should be repaired promptly. Binding materials and mooring lines should be watched for chafing and corrosion. Moorings should be checked annually.

Repairs and clean-up can be made easily in the water. One bundle will support the weight of an average man, and most inspections and repair can be made without moving the breakwater.

The tire mat is a very efficient collector of floating bottles, bags, boards and other debris. Though it is an ecologically sound structure in itself, the breakwater can become an eyesore if it is not frequently policed.

In areas where winter icing conditions are heavy and where currents or strong winds may affect ice floes, it is wise to remove the FTB during the time of possible ice damage.

An Ecological Plus

Floating tire breakwaters become floating fishing reefs, too. Tires provide an excellent substratum for marine growth which, in turn, provides both food and habitat for game fish. It is thought that, as an artificial reef, this floating structure will be more effective than a structure placed on the bottom. This is so because of its location in the upper three feet of the water, where there are higher light intensities, warmer temperatures and higher oxygen levels. Tires are non-toxic and quite stable in the marine environment. Sea Grant researchers believe FTBs have aquacultural potential.