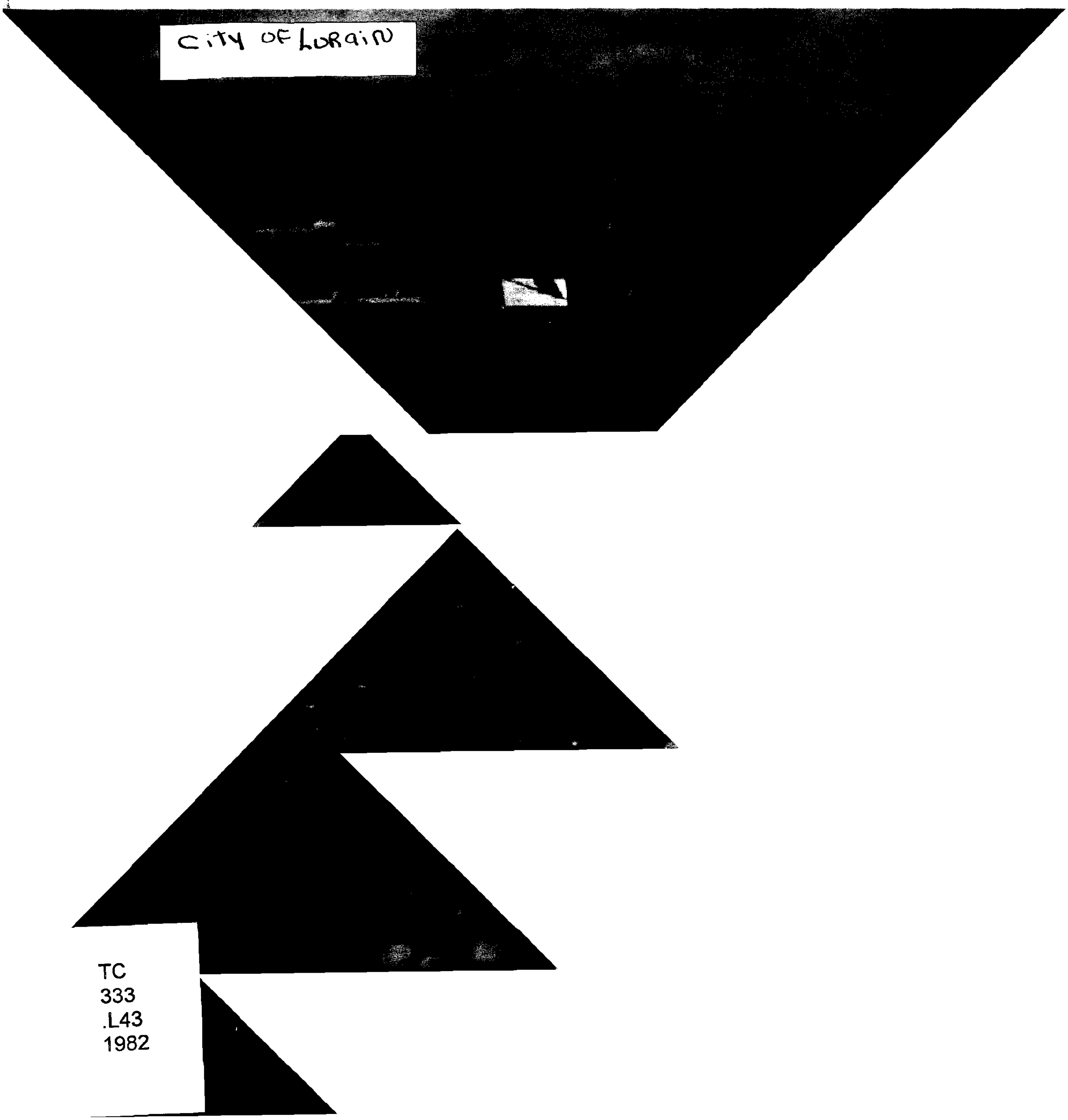
CONSTRUCTING A FLOATING TIRE BREAKWATER — THE LORAIN, OHIO EXPERIENCE —

— March, 1982 —

W.P.

City of Lorain



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— THE LORAIN, OHIO EXPERIENCE —

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PREFACE

In January, 1981 the Lorain Port Authority began the construction of a Floating Tire Breakwater, a relatively new technology in wave control, to expand recreational boating opportunities in the east harbor basin of the Port of Lorain, Ohio. The construction project represents the determination and perseverance of a small local agency trying to innovate solutions to local needs. Convinced that one must make the most of any situation and do it swiftly, the Lorain Port Authority pioneered the construction of the widest FTB built in the world.

Its experience with this Floating Tire Breakwater is shared in this paper. The project planning, pre-construction activities, and actual construction technique are unique, yet representative of what can be accomplished by other local leaders. In this context, this report is offered as encouragement to those leaders, and as a contribution to the present literature.

Little of the existing literature presents a thorough description of "how to build" a FTB. In this paper, the reader is presented a detailed case study with a concentration on construction procedure. We hope it will contribute to the advancement of the technology, more widespread practical application, and access to a bountiful resource, the waterfronts of America.

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LOCATION:

Lorain, Ohio, situated along the U.S. north coast, is in the middle of the industrial Midwest region of the country. Located approximately 30 miles west of Cleveland, it has its entire northern corporate boundary along the south shore of Lake Erie. Expanding inland from the banks of the Black River in the center of the city, Lorain has developed into a community of diverse cultural composition, a true "metropolitan" city. It relies heavily on industrial production, mainly ship building, steel making and auto-production as its economic backbone.

Lorain's harbor, at the mouth of the Black River, was the site of the original settlement of the town in 1811, and historically, it played a major role in the development of the town and its industry. Lorain's harbor now provides services to all of the Great Lakes region as a major bulk commodities port of call. Incoming, outgoing, and trans-shipments of coke breeze, iron ore, taconite, limestone, oil, sand and gravel cargoes move through its 30-foot-deep port facilities.

The focus has been on Lorain as a commercial port and its harbor area has only recently been viewed as a valuable recreational resource. While small privately owned boat yards and liveries had always existed along the banks of the Black River, it was not until the 1950s that local government began considering proposals for recreational boat harbors. In 1967, the first public marina with 70 berths was developed by the city as part of the public works project that also built the city's first major sewage treatment facility. With an increasing awareness of the Lorain harbor and its great potential as a major Great Lakes port, the city council, in 1964, voted to create a local port authority as prescribed under State statute. With the creation of the Lorain Port Authority, an advocacy body was now in place to carry forward harbor and port planning and development. *(Figure 1)*

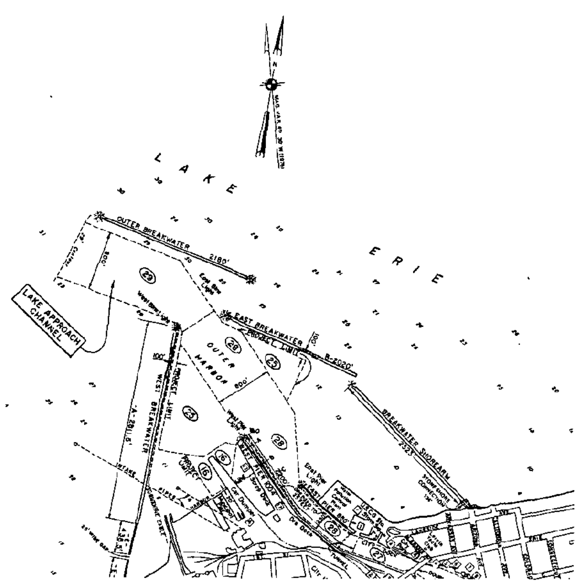


Figure 1

PLANNING

The commission of a study entitled *Recreational Boating and Commercial Docking Facilities for Lorain, Ohio* prepared by Stanley Consultants in 1970 for the Lorain Port Authority was the first documentation of the need for additional recreational docking and commercial marina facilities. This study proposed a development concept that combined the future commercial needs for port development with the future needs for recreational docking facilities. It proposed constructing additional commercial wharfage in the outer harbor and a 950 berth marina. For the most part, the plan was considered impractical because of the cost of the large landfill areas that were required. Two significant aspects should be noted. Firstly, the projected need for additional recreational docking facilities justified the development of 950 additional docks in Lorain harbor. Secondly, the proposed site of the development of the additional docking facilities was located in the east basin of the Lorain harbor. Interestingly, in every study since 1970, these same two conclusions have been reached. *(Figure 2)*

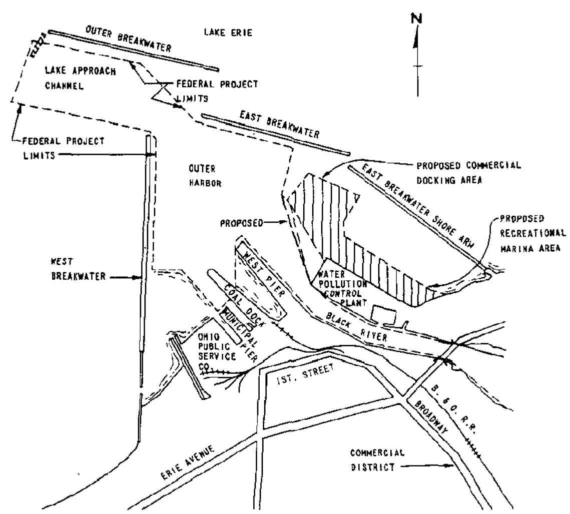


Figure 2

While nothing of a tangible nature happened during the 70s to further develop Lorain's harbor, developments in the area just outside the harbor to the east led to renewed interest in fostering recreational boating opportunities in the east basin. In 1973 the U.S. Army Corps of Engineers, as part of its Congressional mandate to contain contaminated dredge spoils as a water pollution control effort, determined that the area just east of Lorain harbor adjoining the east shore arm would be the site for a Diked Disposal Area for dredge spoils taken from the Black River in its annual maintenance efforts. The Diked Disposal Area for dredge material containment was completed in 1978. A rubblemound breakwater surrounds a 58 acre area which when completely filled, in 7 to 10 years by Corps estimates, will become reclaimed land and be given to the City of Lorain for public use.

Recognizing the unique opportunity this development offered to the City of Lorain, the Department of

Community Development authorized Stanley Consultants to re-examine the Lorain harbor under these new circumstances and focus their attention on recreational use. Stanley Consultants completed their Lorain Harbor Recreational Area Study in December, 1978. Their conclusion found that the east basin of Lorain harbor was the most ideal and economically practical area for marina development. With 58 acres of reclaimed land becoming available to support marina activities, it made the site even more desirable. *(Figure 3)* To quote some of their conclusions, "all marinas in the Lorain area are full and have waiting lists. Marinas in the Cleveland area are also full, and long waiting lists exist at several spots. Lorain, being only 25 miles from Cleveland, would be expected to attract boaters from the major metropolitan area if necessary. There seems little doubt that sufficient demand exists for small boat facilities in this area. Lorain Harbor has an added advantage over many other marinas, because it could offer an excellent modern protected facility with easy access to the lake." *(Figure 4)*

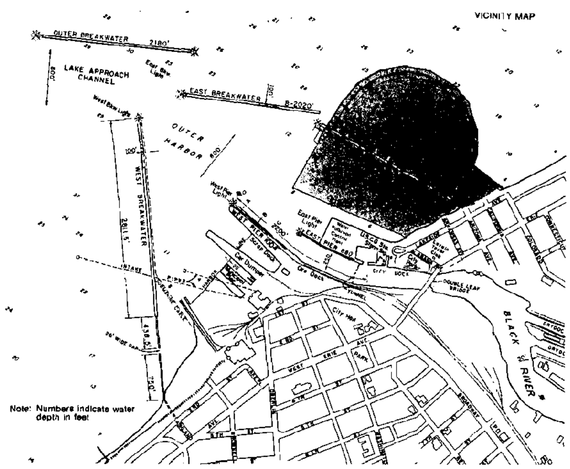


Figure 3

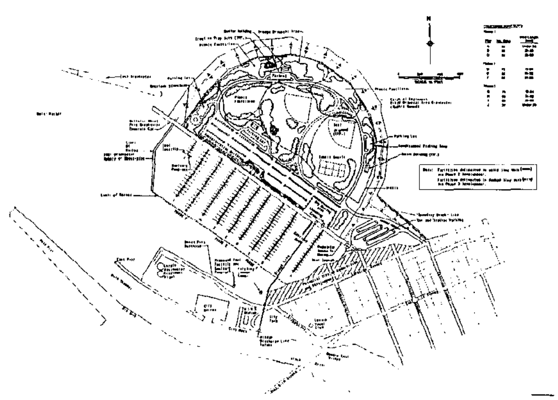


Figure 4

The 1978 report was concerned primarily with project feasibility and did not address detailed analyses of physical, environmental and economic conditions affecting development of such a plan. In an effort to evolve a viable development program for a marina in the east basin of Lorain harbor, the Lorain Port Authority retained Stanley Consultants to prepare a Lorain Marina Feasibility Study. This study looked specifically at developing "a program of site protection and marina implementation at Lorain harbor that would permit a marina to begin as early as 1980-1981." It should be noted here that the U.S. Army Corps of Engineers was simultaneously examining the Lorain harbor under a long-term study program for harbor improvements for commercial users and recreational users. The Corps' study also identified the east basin as the primary marina site. Federal assistance for permanent wave protection structures might become available to Lorain in 10 to 12 years after the completion of the Corps' study. This study is expected to be complete in late 1983.

Bearing in mind the Corps' lengthy planning process, the Stanley feasibility study was aimed at two specific concerns. The first item was the provision of a temporary breakwater for the site that could serve as adequate, economical wave protection until such time as permanent structures could be developed. The second item was a short-term marina development program. The results from this study recommended the construction and installation of a Floating Tire Breakwater in the east basin of Lorain harbor to provide adequate wave protection for the development of a marina.

FUNDING

Although committed to pursuing the recommendation of the feasibility study, the Lorain Port Authority found itself without the money to build a Floating Tire Breakwater. A search of State and Federal agencies that could fund the construction of a Floating Tire Breakwater began. The Ohio Department of Energy found the project to be unique and they entertained a grant application that could be funded under the Coastal Energy Impact Program. Funds were awarded.

The course was set for the Lorain Port Authority to build a Floating Tire Breakwater. Thus, the first step in the development of a new marina for the City of Lorain was to be a reality. *(Figure 5)*

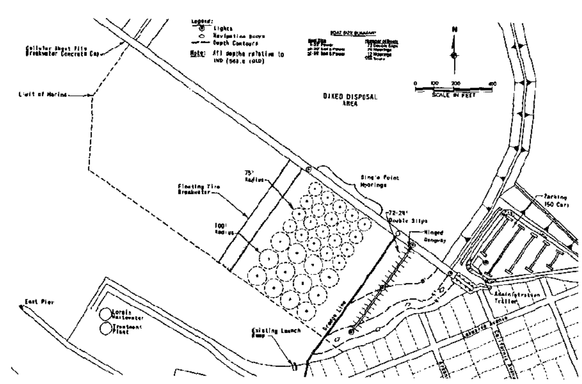


Figure 5

Floating Tire Breakwater Technology

EXISTING LITERATURE:

The idea of floating breakwaters is not new. Literature exists dating back to 1842, citing the possible usefulness of such devices, but to reiterate the words of another writer, "the theory of floating breakwaters has reflected an idea in search of a need." It now seems the need is at hand. Demand for coastal shoreline protection continues to grow as more leisure time is translated into increased participation in recreational boating activities throughout the country. Extremely high costs associated with fixed-bottom-resting breakwater structures coupled with the demand for increased shoreline wave protection have been major factors spurring initial technological advancement in the development of floating tire breakwaters.

Floating breakwater design utilizing scrap automobile tires got started in 1969 with the development of the "Wave Maze" by H. M. Noble. Major advances took place in 1972 when the Goodyear Tire and Rubber Company refined the design concept. The Goodyear-designed modular concept has since been, the most practical and most utilized design for FTBs.

It became apparent while researching the existing literature on FTBs that much of the research, testing, and field use of FTBs has been with those of the Goodyear design. It seemed clear that in selecting a FTB design for Lorain that the Goodyear design was the way to go—based on its history. All other design concepts seemed to be in the research and testing phase of development. Published research information on tying materials, flotation, mechanical connectors, permit considerations, wave energy transmission and measurement, and all other related topics relevant to FTBs is currently available. A bibliography of available reports can be obtained from the Northeast Regional Coastal Information Center at the University of Rhode Island and is referenced at the end of this report.

Two publications that were frequently used in the early research in the Lorain project and throughout the actual construction were: *Scrap Tire Shore Protection Structures,* 1977, R. D. Candle & W. J. Fischer and *Enhancing Wave Protection with Floating Tire Breakwaters,* 1978, Bruce DeYoung.

SITE VISITS:

The investigation into FTB technology was not strictly confined to researching the existing literature as the port authority prepared to undertake the FTB project. Site visits to Dunkirk and Barcelona, N. Y. were made to see FTBs in use at these harbors. Discussions were conducted with the agencies that were responsible for the construction and maintenance of these FTBs to uncover as much practical information as possible.

Technical assistance from Goodyear was also solicited. Lorain's close proximity to Akron, Ohio, Goodyear's headquarters, allowed for easy site visits to Lorain by Goodyear consultants who provided invaluable assistance in the early planning stages and throughout the actual construction. Goodyear's technical assistance and loaning of equipment considerbly eased the pre-construction planning process. The Goodyear staff had a broad awareness of what was happening in the field of FTB technology. When unable to answer a specific question, they would help to find an answer. This assistance was invaluable.

GOODYEAR DESIGN:

Through the process of reviewing the existing FTB literature, making site visits to existing installations with consultants, the port authority developed a basic understanding about FTB technology. Goodyear's design can best be described as a surface floating mat of interconnected modules of tires. The modules are actually 18 individual tires aligned in a specific pattern and bound together with rubber straps or chains. To visualize this pattern, imagine tires lying flat on the floor stacked on top of each other in a vertical fashion with a 3,2,3,2,3,2,3 layering pattern. As they are stacked, the binding material, (2 separate pieces) is woven through the tire pile, and connected together with nuts and bolts. *(Figure 6)*

Figure 6

To form the interconnected mat of modules, two additional tires are added to each module as "marrying" tires. These are interconnected to two tires on the edge of one module with two edge-tires of another module. The binding material is again woven through the tires and connected together with nuts and bolts. *(Figure 7)*

The binding material for the modules may vary from rope to chain to rubber belting. Belting is usually from scrap conveyor belt material. All of these binding materials had positive and negative characteristics and consensus was that rubber conveyor belting served as the best binding material.

The provision of supplemental flotation in the tires took on special significance. Early thinking in FTB development reflected the view that a tire, when placed in the water in a vertical position, would capture air in the crown or upper one-third of the tire sphere. Anyone who has been around a lake shore or river-

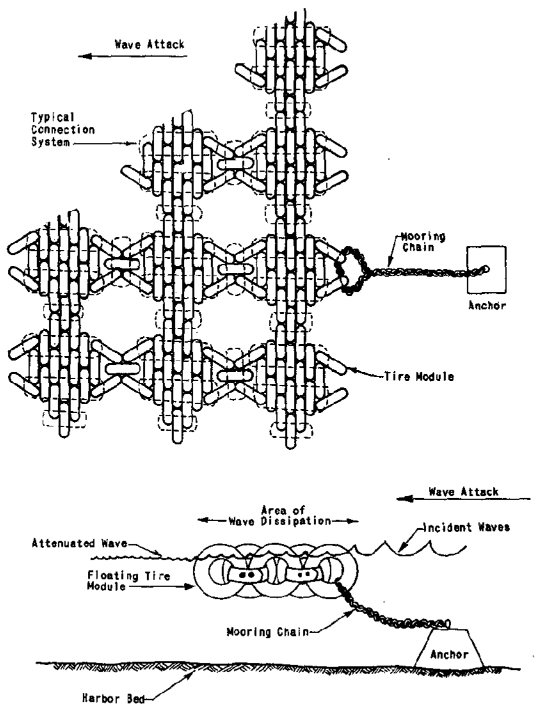


Figure 7

front area can attest to the accuracy of this theory. FTB thinkers logically concluded this same principle would apply to a FTB module. They postulated correctly. However, they also found that air is absorbed into the water causing the module to lose it buoyancy, if the module rested calmly for an extended period. This concern vanished quickly when it was realized that as soon as the wind starts to blow and cause wind waves to develop, the movement of the modules in the choppy water was sufficient to replenish any lost air. They reasoned that they had a reliable flotation system.

Well, not quite. They forgot to keep in mind that in almost every case when building an FTB, *scrap* tires are used to build the modules. Scrap tires are scrap tires for *one* reason. They will not hold air pressure. They have holes in them. In a FTB module, the tire will rotate in the binding until the area with the hole is above the waterline and the buoyancy is lost with the escaping air. If this happens to just a few tires in a module, it will swiftly sink the entire module. It follows that if there are a lot of modules tied together, it just takes the sinking of a few to pull an entire FTB down to the bottom.

This was exactly the case of the FTB at Barcelona, N.Y. It sank at its mooring from lost buoyancy. It had no supplemental flotation in the tires. The results of this bad experience was that the U.S. Army Corps of Engineers, in issuing the permit to build the Lorain FTB, required that supplemental flotation be installed in every tire used in the FTB. A further discussion of the application for permits will follow in the next section.

The most successfully used connector systems for attaching the binding material together has been standard machine bolts and nuts with washers top and bottom. In salt water installations, it was found that the metal nuts and bolts were unacceptable due to salt water corrosion. Nylon bolts and nuts in salt water has proved to work well. In fresh water, such as Lake Erie, it was recommended that all metal nuts, bolts, and washers be hot-dip galvanized to retard normal rusting.

The last aspect of concern was the anchoring system. Design criteria for this was available. The systems described were similar to those that are used to anchor boats at single mooring points. The main difference seemed to be that larger weights were used for the anchors. The consensus on positioning of anchors recommended spacing 50 feet on center for the leading edge, or side of wave attack, and 100 feet on center for the leeward side, or shore side.

APPLICATION TO LORAIN:

With a basic understanding of the current FTB technology, the port authority felt equipped to begin preparing for the actual design of its FTB. As the literature clearly points out, the first issue to be determined is the type of waves that are to be attenuated by the FTB. Wave analysis and FTB design work was left to Stanley Consultants in their marina feasibility study effort. Their study evaluated the problems of water level fluctuation, the physical constraints of the harbor geometry, wave conditions outside and inside the harbor, and ice conditions. Of principal concern in preparing to design a FTB is the wave data, specifically wave frequency, wave height, wave length, and wave steepness. From their study, Stanley Consultants concluded that:

> "From the analysis, waves in the 2 to 3 foot height range are possible throughout the development area. Waves of this height are unacceptable to a marina. Waves of this height with short periods are within the limits that can be reduced by 50-70 percent by temporary breakwaters. The resulting wave steepness is 3 percent. Temporary breakwaters are relatively ineffective against long period waves; a 9-second, 3-foot wave will have a wave steepness of approximately the same (3 percent) as the short period waves. From the wave analysis, it was found that all waves were within acceptable limits of safe marina operation, or could be adequately dissipated to within these limits."

Stanley Consultants designed the size of the FTB needed to meet suitable marina development standards. The design criteria and methodologies are set forth in the DeYoung publication mentioned earlier and *Preliminary Report On The Application Of Floating Tire Breakwater Design Data,* 1978 by V. W. Harms and T. J. Bender.

It is not within the scope of this study to report on design criteria and methodologies. It is recommended that the above-mentioned publication be studied before designing an FTB. Stanley's recommendation for Lorain was that a FTB 600 feet long (86 modules) by 80 feet wide (11 modules) would provide the necessary protection for a marina development in the east basin of Lorain harbor. It is noteworthy that the 80 foot width would prove to be the widest FTB ever built.

Preconstruction Planning

FUNDING:

Several months before Stanley Consultants' feasibility study was completed, it was evident to the port authority that a Floating Tire Breakwater would be the most economical and effective way to provide wave protection at the proposed marina site. This early awareness enabled them to research the FTB technology.

During this same period, the port authority learned of the availability of state funding through the Ohio Department of Energy and its Coastal Energy Impact Program. Armed with this information, the port authority forged ahead with an application to fund the Floating Tire Breakwater. It was determined that the Dunkirk site was similar to Lorain's site. Therefore, it decided to utilize Dunkirk's basic design and project the budget requirements by updating Dunkirk's costs to current dollars after inflation.

The port authority submitted an application to ODOE for $43,800 to construct the FTB at the proposed site. After a short period of grant application evaluations, the ODOE informed the port authority of its intent to fund its application to construct a Floating Tire Breakwater. With this good news, the port authority immediately set out to finalize the grant agreement with the ODOE and secure the necessary permits for building the FTB.

PERMITS:

An application for a construction permit was submitted to the U.S. Army Corps of Engineers District Office in Buffalo, N.Y., and to the City of Lorain Building Department. The Corps' application triggered a typical governmental review process by other agencies with possible jurisdiction, as well as, the public notice and comment period. This processing was completed without problem. The Corps issued a construction permit with two requirements for the construction, (1) that all tires used in the breakwater were to have foam flotation added to them, and (2) that each tire used in the breakwater be hot iron branded with 1½ inch or larger letters (LPA) prior to installation. The reason for the foam flotation was to avoid sinking. The reason for the tire branding was to limit the port authority's liability for retrieving stray floating tires washing up on private beaches along the lake shore. The Lorain Building Department determined that no permit would be required from its office because this type of construction was outside its area of responsibility.

BIDDING

The project took an unexpected turn. Stanley Consultants, after careful analysis of wave and bathometry data, recommended a FTB design of 80 feet (11 modules) wide by 600 feet (87 modules) long to reduce waves to an acceptable size to permit marina development. The estimated total cost for the recommended FTB design was $63,100. This size, and its attendant cost estimate, much to the surprise of the port authority, was almost twice as large as what was planned for in the ODOE grant application and exceeded the grant amount by one-third.

There was a glimmer of hope, however. In the preparation of their cost estimate, the consultants included the costs of paying for scrap tires and the cost of paying for conveyor belt material. The port authority had already made arrangements with the area tire dealers to have all the scrap tires donated to the project, and a local steel company was to donate its scrap conveyor belt material. The estimate for these two items totaled $18,000. With this sum subtracted from the total, the new estimated cost was placed at $45,100. This total estimated cost approximated the ODOE grant amount and the port authority felt reassured. With competitive bidding for the construction work, the final project costs were anticipated to be within the ODOE grant of $43,800.

Using the best available narrative of how to construct a FTB, *Constructing Floating Tire Breakwaters*, by Neil Ross, as the backbone, the port authority developed its bid documents. Included were all requirements from the Corps of Engineers, necessary legal instruments, and bonding requirements. With the documents completed, the port authority advertised for bids. Because the construction of a FTB was a new experience for local contractors, a pre-bid conference was scheduled to help builders familiarize themselves with the FTB technology. This conference was conducted by a consultant from Goodyear. A total of 13 contractors picked up the bidding documents, which was judged to be a reflection of the locally depressed construction economy rather than true interest in the project. Of those who obtained bid documents, only four firms attended the pre-bid conference. At the bid opening, only four contractors made submissions. The bids ranged in price from $89,247 to $269,307, and far exceeded the amount of the construction grant of $43,800 from the Ohio Department of Energy. Insufficient funds forced the port authority to reject all bids and re-evaluate the entire project.

IN-HOUSE CONSTRUCTION:

With the port authority's commitment to enhancing recreational opportunity, the decision was made to proceed with the FTB development as an "in-house" construction project. To do so would require a much greater involvement by the executive director in rounding up a workforce and coordinating the construction effort. A strategy was developed to garner a commitment from the Lorain City Government from the Comprehensive Training and Employment Act (CETA) Program for the labor force for building the FTB. After a period of negotiation with the city administration and local trade union representatives to resolve concerns about loss of union jobs, an agreement between the city and port authority was reached. The city would provide up to five job training positions to the port authority for the purpose of building the FTB.

The port authority decided to hire a construction manager to oversee the project. It would be the construction manager's job to set up and manage the day-to-day construction operations. The construction manager would also: (1) assist the port authority with cost evaluation and inventory of sources for material necessary for the FTB; (2) coordinate the timely procurement of required materials and subcontract work as necessary; (3) research and design all implementation strategies and special construction techniques and hardware necessary for the project; (4) provide daily coordination and supervision of the CETA employees during the project construction.

After solicitation for proposals to provide construction management, four proposals were received. The Board of Directors retained a manager based upon experience, commitment, interest, and price.

CONSTRUCTION SITE:

After resolving who would build the FTB, the next question became where would it be built. FTB reports suggested that the work site be at water's edge as near to the mooring site as possible. Work sites at water's edge were suggested so that the modules could easily be placed in the water so that "in the water" assembly of the mat could follow. This approach mandated favorable weather and water temperatures. For building a FTB in the winter months, as the port authority expected to do, building the modules on the ice at the mooring site posed a possibility. The FTB would be completely assembled with mooring lines and anchors all laid out on the ice. As the ice melted away everything settled into its proper position. This method offered real possibilities for the Lorain project. However, with a January start-up, there would not be sufficient time to get the 946 modules pre-assembled on safe ice at the mooring site.

The early planning for the project identified the Federal spending beach as the site best suited to construct the FTB. Permission was requested for use of the site and was granted by the U.S. Army Corps of Engineers who controlled it. However, with the prospect of constructing the FTB during the winter months, the suitability of this site diminished with its exposure to winter's bluster off the lake. A 26,000 square foot warehouse along the bank of the Black River approximately one mile upstream from the mouth was identified. The size of the warehouse perfectly suited the needs for constructing the FTB. It contained adequate floor space to receive and store all of the tires, and to house all of the operations of constructing the modules. The site along the Black River, with its 1200 foot bulkhead at the river's edge, offered the ideal conditions for launching the modules. Arrangements were made with the owner to lease the site for the construction of the FTB for a lump sum of $1,500. The rent was low and the arrangement constituted a contribution by the owner.

With a plan for building, management and staffing program, and an ideal site for constructing the Floating Tire Breakwater, the work was ready to begin.

The Construction Process

A thorough discussion of the construction process is the primary focus of this report. It is felt by many FTB experts that the experience of the Lorain Port Authority adds substantially to the existing construction technology with innovations in the areas of flotation, moorings, anchor systems, and construction techniques. For this reason, as much detail as possible will be included in this section to aid future FTB builders. It is, by no means, intended to be considered the final word in "how to do it." Further improvement in construction technology is surely needed and will come with more experience in the field.

The section is arranged into discussions of the individual components used in the construction, the processes involved in building the modules and assembling the mat, assembly and installation of the anchors and mooring system, transporting and attaching the mat to the mooring system, and installation of the marking device. Every effort is made to give the reader a feeling for the chronology of events to aid in understanding the over-all process.

In the beginning, little actual work with the tires took place. Passing the word to the tire dealers in the area and having them bring the tires to the construction site took much more time than had been expected. Many of the early days were spent preparing the warehouse for construction activity. The four-man CETA crew and construction manager revitalized the previously unused warehouse by installing new doors and locks, building a shelter area for use as an office and eating area, and constructing work tables that could be used for various tasks during the project. Simultaneously, telephone and electrical service for lighting, general use and equipment were being installed. During this period, the CETA employees, who were all unskilled workers with various backgrounds, gave the immediate impression of being an industrious group of good-natured individuals. For the most part this continued to be the case throughout the project.

TIRES:

Tires began arriving at the site during the second week of the project. Almost all of the scrap tires were stored outdoors before being delivered. This meant that nearly all the tires had large chunks of ice frozen inside the tire casing as one might expect during the middle of January. After unloading the tires, the ice was removed. By bouncing the tire on its tread and quickly flipping it over the ice fell out. This same method was used to remove the water in the tires in warmer weather.

The deicing and dewatering operations were wet and dirty activities. It necessitated wearing rubber gloves and water-proof boots to work. The worker would also closely inspect the tire to assure that it was the right size, 14 or 15 inch, and that it did not have any large holes, broken rim beads or large amounts of sharp metal belting protruding through the rubber. *(Figure 8)*

The elimination of tires with exposed and sharp metal belting became very important. Knowing that workers would have to swim around these tires while belting modules together made everyone aware of the danger of personal injury in the water. An area of the warehouse was designated to store the unusable tires,

Figure 8

and it became common for as much as 10 percent of each delivery to be discarded.

The tire branding operation, required in the Corps of Engineers' permit, was kept simple, but seemed a real nuisance due to its lack of utility to the overall construction of the FTB. To put the brand on the tires, a set of four metal branding irons with 1½ inch-long letters "LPA" on each iron was purchased. These irons were fabricated at a local sheet metal business. The irons were attached to a 24 inch-long metal handle with wood hand grip. To heat the branding irons, gas-fired plumbers lead pots were used, putting the iron directly over the flame until red hot, removing and immediately applying to the sidewall area of the tire. *(Figure 9)* There was usually enough heat stored in an iron to brand 3 or 4 tires per heating. With the use of two or three irons, using one while the others were reheating, a continuous branding operation was achieved. A system evolved whereby one man would pull tires from the pile, deice or dewater, inspect, and roll the tire to the branding station. Another man caught the incoming tires, laid them on their side for the branding, then quickly picked up the branded tire and rolled it into the

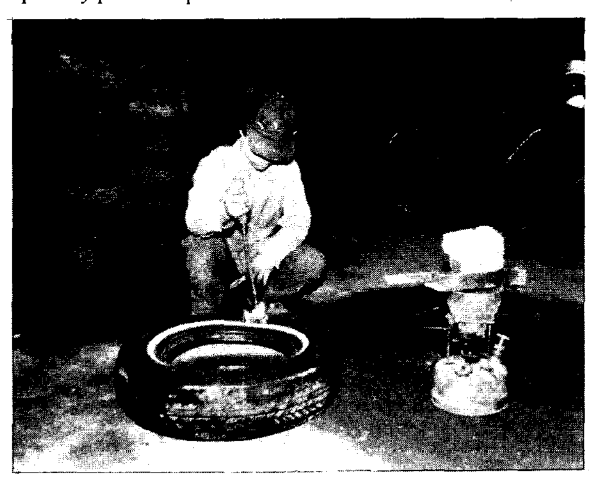


Figure 9

temporary storage area. Branding consumed the time of a third person. The fourth man stood in the temporary storage area and stacked the branded tire for later use. As the project progressed, the need for temporary storage was eliminated by moving the tire directly to the foam installation process that will be discussed later. *(Figure 10)*

An electric branding iron was tried, but without much success. The electric branding iron would not get hot enough to make a good brand. The idea of using electric branding irons in other projects should not be ruled out. They have been successfully used by others.

One positive feature of the branding operation was

Figure 10

its portability. As more tires were processed, floor space was quickly used up storing tires. With delivery trucks driving into the warehouse, it was possible to spot the unloading wherever convenient. The ability to relocate the branding operation kept handling of the tires down to the bare minimum.

Receiving an adequate supply of tires was a key aspect of the project. It became clear that the local tire dealers were not going to be able to provide enough tires, given the construction schedule. During the first three weeks of the project, a total of 1800 tires were delivered. At that rate, it would take over 33 weeks to gather the 18,920 tires needed to build the FTB. The construction schedule was projected at 20 to 25 weeks total. This reality triggered a concerted effort by the project manager to research, identify and contact other potential suppliers. Goodyear helped to find additional suppliers. Other tire manufacturers in the Akron area, all the area (a 75-mile radius) tire recappers, and used tire distributors were contacted. In the end, it was an area recapping firm and two Akron area used tire distributors that saved the day. The recap firm was able to make two or three deliveries per week with an average of 300 to 400 tires per delivery. The two used tire distributors brought their tires on 37′ or 45′ box trailers, holding an average of 900 to 1200 tires. *(Figure 11)* The only challenge was to get them unloaded as quickly as possible. During one five-day period, nearly 3000 tires were delivered. At the end of the 15th week of the project, all tires necessary to build the FTB

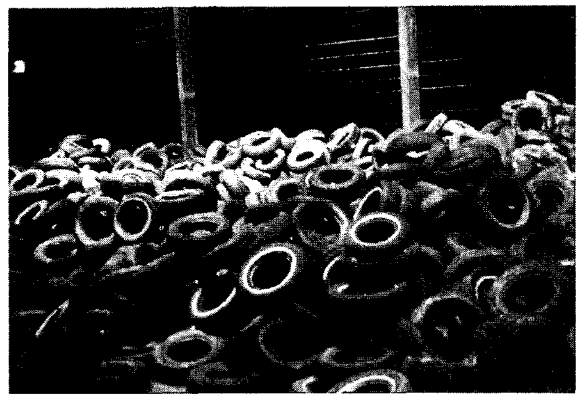


Figure 11

—18,920 — plus about 2500 rejects had been delivered to the construction site. A total of 21 different firms made deliveries of tires during that 15-week period.

THE BELTING:

The port authority, in its planning for building the FTB, asked local steel plant officials at the U.S. Steel Corporation to donate any scrap conveyor belt material that might be available in the mill. Fortunately, this request received a favorable response, and U.S. Steel agreed to provide the scrap belting, as long as the port authority made the arrangements to have it hauled out of the plant. This agreement was made several months before the project actually started.

Except for a van that was loaned to the port authority by the City of Lorain Park and Recreation Department and a fork lift that was rented for use during the project, all other equipment for the project had to be rented or borrowed. Without the exceptional cooperation from the various divisions of city government and benevolent volunteers who assisted by loaning equipment and time, the project would have been more costly.

Using a large dump truck from the Park and Recreation Department and a volunteer's dump truck, the first load of belting was transported from the steel plant to the construction site. Due to the weight of the material, three trips into the steel mill were necessary to get all of the belt that was needed for the project. The last trip necessitated the use of a large 15-ton dump truck from the City Street Department to pick up a 5,000 square foot roll of belting.

The conveyor belt material donated by U.S. Steel had been used in its coke plant. The rolls varied in width from 3′ to 5′ and in thickness from ½″ to ¾″ and had 5 or 7 plies of nylon reinforcement. After rolling a small roll out on the floor, it was realized that the material was much heavier and stiffer than expected. A few strips, 3″ wide by about 15′ long, of belt were cut using utility knives for prototype testing. It was found by assembling of a module, that the narrow 3″ wide strips of belt were not very flexible and fairly difficult to bend into the over-lapped position required for bolting together. After consultation with Goodyear, it was decided that the module binding straps would be 11′-6″ long. The connecting straps for attaching the module together to form the mat would be 7′-0″ long. It was decided that all the straps would be 4″ wide.

The next challenge was to efficiently cut the wide rolls of conveyor belt material into the strapping. Thinking on the subject started with the identification of alternatives. These included using a heavy duty industrial vertical bandsaw, portable circular saws, a self-propelled concrete cutting saw, or sharp bladed knives.

Checking with a few companies who specialized in cutting the belting, the bandsaw method was recommended as the best and most efficient way to get the job done. The cost of buying or leasing a new or used vertical bandsaw far exceeded what the project could afford. The circular saw and concrete saw method were tested on the material. Both of these methods proved unsuccessful due to the high speed rotation of the cutting blades. This caused tremendous heat buildups on the blade and subsequent burning and smoking of the material. Cutting small sections with these saws led to filling the entire building with a dense smelly smoke, making these approaches totally unacceptable. Hand cutting with knives, originally thought as too difficult and time consuming to seriously consider, was the only alternative left. The work of cutting the conveyor belting to size began.

This process began with the building of two 11 foot, 6 inch long and two 7 foot long wood jigs. These jigs, with parallel straight edges were laid on top of the belt, which had been rolled out on the floor. Squarely cutting the wide belts to the right lengths eliminated the need to measure each piece before cutting. *(Figure 12)* With the large warehouse floor, it was possible to roll out as much as 200 lineal feet of belt at one time. Because the rolls of belting were so heavy, the only way to roll it was to push it with the fork lift. *(Figure 13)* After the belt was cut into the required length, it was stacked into small piles and moved with the fork lift to the cutting area for slitting the 3, 4 and 5 foot wide pieces into 4 inch wide strips. *Figures 14, 15)*

The 24-foot long slitting table was able to hold two

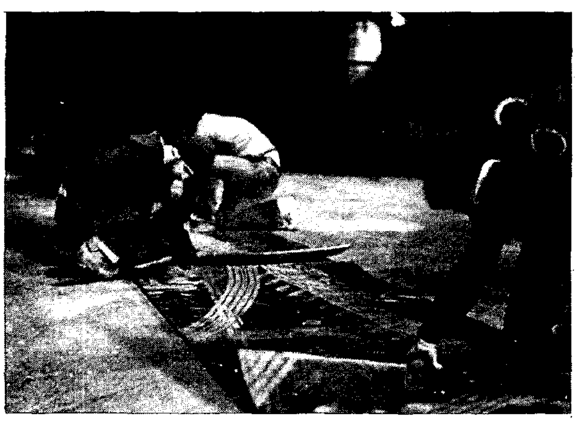


Figure 12

of the 11 foot, 6 inch long pieces of belt, and the entire crew working in two-man teams was able to work at the slitting table at one time. To cut the belt into strips, the men would position each large piece on the table and place cutting lines at 4″ centers across the entire width of the belt using a standard construction chalk line. *(Figures 16, 17)* Working together, one man pulled the knife blade through the material, while the

Figure 13

Figure 14

Figure 15

second man was stripping away the piece being cut. The cutting and stripping had to be performed in unison to prevent the knife from binding in the rubber. This method of cutting proved to be vigorous work for the men and was the cause for grumbling until they became accustomed to it. *(Figure 18)* As each strip of belting was cut, it was placed in a storage pile near the pneumatic air punch that punched the holes in the belt. This pile of belting grew to a size of 30 feet in diameter by 6 feet tall. *(Figure 19)* A total of 2050 long strips and 1820 short strips, which was equivalent to 36,315 lineal

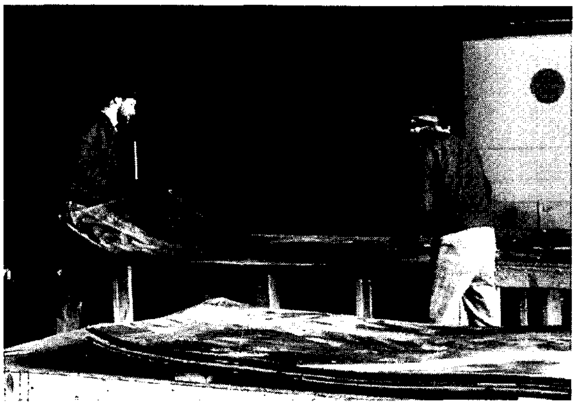


Figure 16

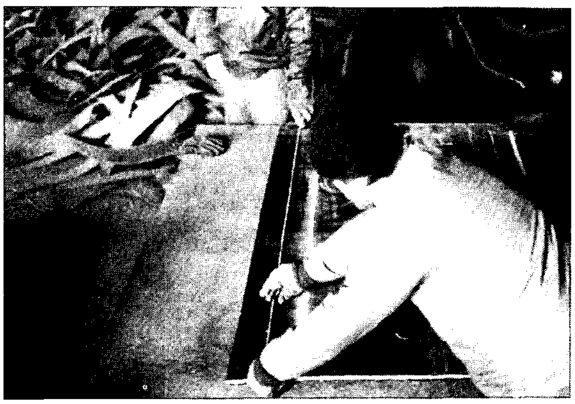


Figure 17

Figure 18

Figure 19

feet or 6.88 miles of 4" wide belt, were cut over a five-week period. Other work was performed during this period and very few full days were spent working on belt cutting. Most days were broken up by unloading tires, deicing and/or dewatering, branding, or other tasks.

The use of a compressor and pneumatic punch needed for punching the bolt holes in the belting material was pre-arranged with Goodyear. As the project start-up date approached, Goodyear was notified and the necessary arrangements were made to have the equipment shipped to the construction site. The equipment was to be shipped by truck from a Goodyear manufacturing facility in the Brownsville, Texas area to Lorain. The delivery of the equipment was delayed and did not arrive at the construction site until the sixth week of the project. Ted Woodhall, a retired Goodyear engineer, came to Lorain to assist in setting up the equipment for operation. A highly qualified engineer, Woodhall had been involved in FTB development work and brought with him a wealth of practical information that was invaluable throughout the project.

Goodyear, through Woodhall, had the punch and die sets machined for use on the pneumatic punch. It was quickly discovered however, that the punch and die set that had been made up was not going to work. The die was to punch two holes with one motion by the pneumatic ram, each properly spaced. The belting was so tough, (i.e., the composition of the rubber, the nylon ply reinforcement, and the age of belt) it resisted the punch from penetrating through the belt when maximum pressure was applied. This forced the machining of a new set of dies that would punch a single hole. Woodhall redesigned the new die and had it machined in Akron. Upon his return a week later, he had the new punch and die sets. With a spacing index it was possible to punch the two holes individually on each end of the belt with exactly the right spacing to allow for proper alignment when lapping the ends together for bolting. With only slight adjustment to the system, everything worked well. The only maintenance in the operation was resharpening or replacing the punch about once a week, as it dulled enough to ineffectively cut the rubber and push the plug out. *(Figure 20)*

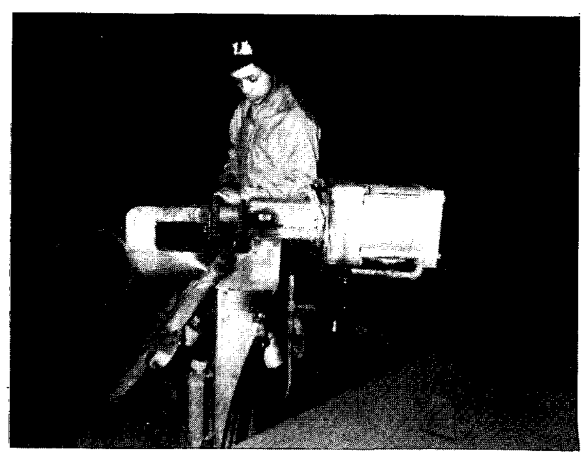


Figure 20

A four wheel cart, typically used in lumber yards, and built with a 4 foot wide by 12 foot long deck, was used to transport a large supply of the belts to the area next to the pneumatic punch. This permitted the punch operator to increase his efficiency by eliminating frequent trips to the belt pile. The cart continued to be useful for moving other material and equipment throughout the project. The help provided by Goodyear and Woodhall in this operation was extremely beneficial.

THE FLOTATION:

Research on flotation began very early. The focus was upon urethane foam flotation as recommended in the most recent FTB literature. Cost estimates from Stanley Consultants and the unsuccessful bidding suggested that as much as 25 percent of the budget could be devoted to the flotation material. It was important to know exactly what we were going to get for our money. Since urethane foam for marine flotation was basically alike from all manufacturers, the key in selecting a supplier was the price. Knowing that 9,460 pounds was needed, the quantity of 10,000 pounds was a convenient figure to use for cost comparisons. After comparing four quotes, the best price was offered by the General Latex Company in Ashland, Ohio. Ashland is only about 40 miles from Lorain and the construction manager made a visit to the General Latex plant to learn more about the product. New information surfaced about the product and led to a search for alternatives to urethane. Urethane foam is a two-part chemical product. The chemicals used in the system are highly volatile. Extreme care and safety are necessary in handling. In hand mixing, as was proposed, it was necessary to maintain a warm air temperature (60° to 70° Fahrenheit) to get the proper chemical reaction and the proper flotation quality. The work area had to be properly ventilated for the health and safety of the workers. The chemicals would be rendered useless if exposed to freezing temperatures. Curing time was 24 hours in warm air for achieving the desired quality.

Construction was planned within an unheated 26,000 square foot A-frame warehouse with a maximum ceiling height of 40 feet. Had the project been scheduled in the summer months, the site would have been ideal, but the project's starting date was in January. Although the construction and heating of a small work space for foaming and curing was considered, the total expense for such exceeded the budget. Subcontracting the urethane installation off-site was also too expensive. The search for alternatives really did not go too far. There was sufficient documentation in the FTB literature to indicate what had failed in previous experiences. Styrofoam or expanded polystyrene had been tried and successfully provided the necessary flotation quality. Nonetheless, it had certain undesirable qualities. The material was susceptible to physical degradation when exposed to chaffing, to chemical degradation with exposure to petroleum distillates, and to water permeability. If the skin of the styrofoam could be coated with a protective cover, these problems could be eliminated.

This notion led to discussion with floating dock builders who used styrofoam for dock flotation. Most of the companies molded their own polystyrene and used a special raw material called G.R. (gas resistant) material. This material was resistant to chemical degradation from gasoline or other petroleum base materials. This is important in marinas where there is the possibility of gasoline spills and other types of cleaning solvents being flushed into the water.

Most manufacturers applied a protective coating over their flotation blocks or installed them inside waterproof aluminum or plastic containers. One manufacturer recommended replacing the material when it wears out because it is so inexpensive.

Styrofoam was, in fact, a viable flotation device for an FTB. With research into purchasing G.R.-type styrofoam, it was discovered that it was a highly specialized product manufactured only by special order. Use in the FTB would require a special design of size and shape for the foam blocks. The cost estimate for the engineering and subsequent production of G.R. styrofoam flotation was far too high for the program budget.

Research continued leading to a solution. An affordable design was finally evolved. This idea called for using standard styrofoam shaped in a triangular volume. The dimensions were to be based upon a right-angled triangle with an A chord dimension of 6 inches, a B chord dimension of 11 inches, a C chord or hypotenuse dimension of 12½ inches and a volume depth of 6 inches. To protect this triangular "block" from chemical and physical degradation, it would be bagged in a 10 mil extruded polyethylene bag and heat sealed. Two of these bagged blocks would be installed into the crown of each tire.

With this approach, the need for special engineering, manufacture of special molds, and molded production were eliminated. Using standard styrofoam cutting tools and cutting the blocks out of large standard sized billets, the unit cost per block came in at $.27. Total cost per tire, which included two blocks sealed in two bags, was $.78 per tire. The $.78 per tire cost was 60 percent higher than the material cost for the urethane foam estimate. After adding labor, and utilities to the urethane foam cost, a much smaller difference between the two systems existed. Coupled with a concern for the health and safety hazards of working with toxic chemicals, the decision to go with the styrofoam flotation was made.

Tuscarora Plastics, Inc., of New Brighton, Penn., a company specializing in molded styrofoam provided technical assistance during the evolution of this design. Even though their specialty was molding styrofoam, rather than cutting and shaping from billets, Tuscarora was the lowest bidder for 38,000 triangular blocks of styrofoam.

Three manufacturers of plastic bags were consulted in the Cleveland area. A consensus emerged on the type of product and its specification calling for a 10 inch x 16 inch, 10 mil extruded tubular polyethylene bag. Price quotations for this material led to Aabaco, Inc, of Cleveland, being selected to supply the bags. Aabaco also supplied the heat sealing equipment for sealing the bags. *(Figure 21)*

The order for the styrofoam blocks was placed during the second week of the project. The first shipment of material was to be delivered four weeks from date of

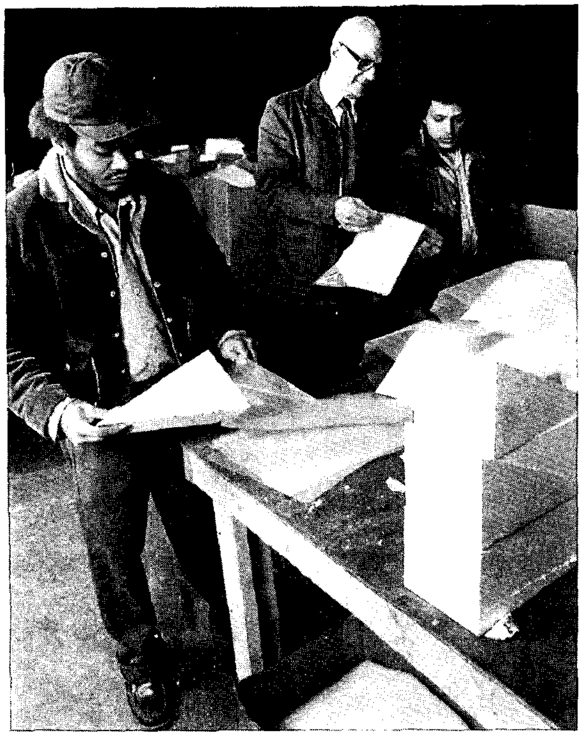


Figure 21

order. An earlier delivery would have been preferred, but the manufacturer insisted upon making full truck load deliveries for reasons of economy. Delivery of the plastic bags coincided with this timetable. There was plenty of work with the tires and belts, so time was not wasted waiting for the styrofoam blocks.

The blocks and bags arrived at the construction site during the seventh week of the project, one week later than expected. The heat sealing equipment was assembled and a work area for the bag sealing operation established. The heat sealer was a simple piece of equipment. It was manually operated by a foot pedal that closed a spring-hinged, 14-inch jaw and opened automatically when foot pressure was released. Electric heat in the upper and lower jaws was thermostatically controlled. It took some practice to learn how long to keep the jaws closed on the bag to avoid a faulty seal. *(Figure 22)*

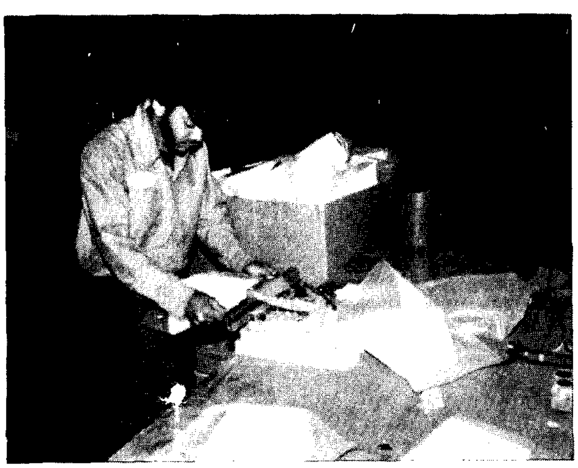


Figure 22

To get the most efficiency from the operation required two men. One man operated the heat sealer and another man placed the styrofoam blocks in the bags, maintaining a constant supply for the heat sealer. There were 225 blocks of foam in each carton and 180 cartons in the whole job. Maximum production in one 8 hour day was 2,000 blocks, but that was the exception rather than the rule. The monotony of the operation led to more "creative" scheduling of the workers' time to avoid boredom.

Time soon came to insert the styrofoam blocks into the tires. Thought a minor task, it quickly became a major problem. The styrofoam blocks, to be stuffed into the crown of the tires, were specifically designed with a width of 6″ to ensure that they would be firmly clamped by the beading of the tire. The dimension between the rim beads is about 3″ to 4″ on a 14″ or 15″ tire. This required the spreading of the rim beads sufficiently to stuff the 6″ wide block between the beads. It was difficult to spread the rim bead, hold it open, and stuff two blocks with only two hands. When two men tried to do it, arms got in the way, and fingers got pinched. A standard tire spreader, used in gas stations, was tried without much success. Although it did spread the tire enough to insert the blocks, it was very slow to operate, requiring precise alignment of the tire in the spreader. After the blocks were inserted, it was difficult to remove the tire because the spreader's hooks would be pinched between the block and the bead.

The construction manager designed a more simple system from heavy gauge sheet metal. A flat hook, bolted upright to a table, had a bend at its top. When the tire was set vertically on the table with the sidewalls facing the worker, he could easily catch the outside rim bead in the hook and spread the tire open by pulling on the inside bead. This freed his other hand to stuff the foam block into the tire and easily unclip the tire from the hook by tipping the tire and sliding it out. With a little practice, a worker was able to pick up a tire, set it in position in the hook, stuff both blocks of foam, unhook the tire, and roll it into temporary storage in less than 10 seconds. *(Figure 23)*

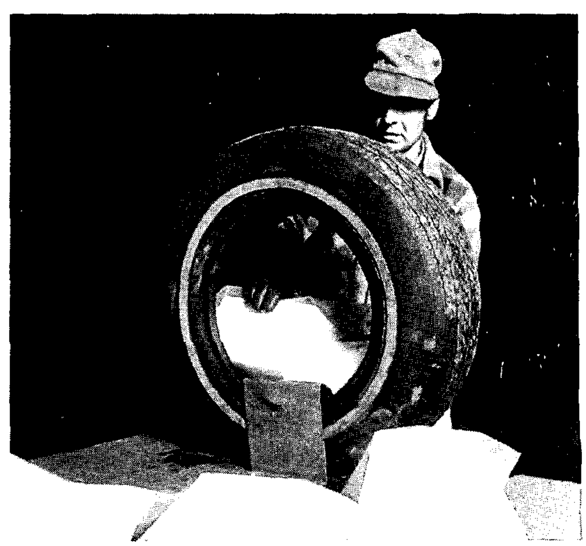


Figure 23

Three of these flat hooks were bolted to a 4′ by 8′ table allowing three men to work at this operation. With the hooks bolted near the edge of the table, ample surface remained to stockpile the foam blocks within easy reach. Mounted on a table, the operation was portable, allowing it to be moved. This eliminated additional steps to move the tires to the work area. Work at this operation was also tedious. *(Figure 24)*

Figure 24

NUTS AND BOLTS:

Nylon nuts and bolts were originally planned for use in the FTB project. In the research to identify suppliers and costs, it was learned that they were much more expensive than comparable metal nuts and bolts. It was determined that there was not a critical need to use nylon rather than metal fasteners. The metal would rust in the fresh water, but not to a point of causing the bolt to fail. In fact, the rust was thought to be a positive factor. Nylon nuts and bolts came loose from the constant motion of the FTB in the water. Deforming the threads curtailed this occurrence but required an additional step in construction. The expected rust formations on the metal nuts and bolts were expected to lock the nut tightly and prevent any possible dethreading. This would serve to minimize annual maintenance.

After pricing suppliers, an order for the bolts, nuts and washers was placed with the Freedom Fastener Company of Lorain. The order contained 8,500 ⅜″-16″ bolt and nut sets and 17,000 one inch diameter washers. They would all be American made. It was recommended that all of the connectors be hot dip galvanized to prevent the excessive rust buildup. With the galvanizing, the bolts and nuts were expected to rust enough to prevent dethreading.

BUILDING MODULES:

Existing literature addresses itself to building modules. As that literature suggests, two tire stacking racks were built according to recommended specifications. The experience with using the racks was not very successful. After the module was assembled on the rack, and the binding straps bolted tightly together, the module was tipped over on its side to remove the rack. But the rack would not move. It had become tightly bound to the tires. The entire crew pulling on it could not remove it. The heavier binding material was exceeding the very small tolerance allowed in the rack design. Had the rack been fabricated with removable posts, it would have worked. An alternative for assembling the modules of having two workers holding the belts and weaving them through the tires was tried. This system worked very well, and its use continued throughout the project. Two men would hold the belts in front of them and two men would stack the tires. The men stacking the tires took care to drop the tire onto the stack so that the foam flotation was positioned opposite them. *(Figure 25)*

Figure 25

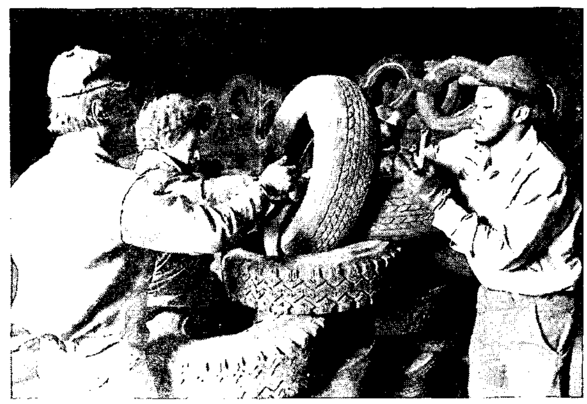


Figure 26

Figure 27

When all 18 tires were in place, the belt holders would pull out any slack in the belt and compress the stack of tires by pressing down on the top layer. Simultaneously, two workers were getting the nuts, bolts and washers ready for bolting the belting together. Each would work with one of the belt holders to get the bolt holes to align and push the bolts through the belting. *(Figure 26)* Large one-inch diameter washers were always installed on both sides of the belt to prevent the bolts from pulling through the holes in the belt. The nuts were finger tightened and both workers using hand wrenches would pull down on the nut until the washer started to cup the rubber belt surface. Four men working in this manner were also able to build a module in 4½ to 5 minutes. *(Figure 27)*

After assembling a module, the workers would allow it to fall on the floor with the flotation side of the module on the bottom, move to another location, and start assembling another module. The fifth man in the crew using the fork lift, picked up the module and moved it to a storage area. A number of ways of stacking and placing the modules in storage was tried. The best was to stand the modules vertically on end, the same way as when built, leaning them against each other, starting from a wall and working out. One layer of modules would be placed horizontally on top of those standing on end. Two modules standing on end,

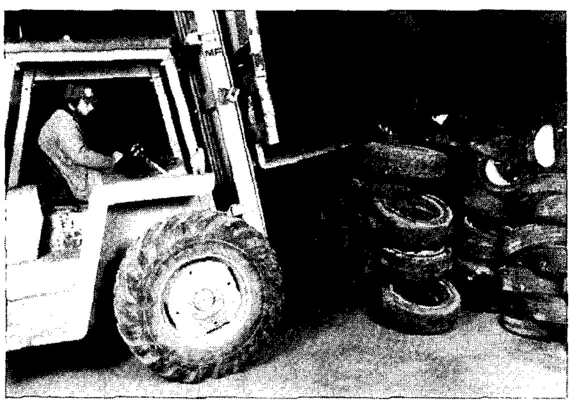


Figure 28

leaning against each other, provided just enough area to place the horizontal module on top, and the foam blocks in the tires made the modules standing on end rigid enough to support the weight of the top module.

To pick up the completed modules with the fork lift, the operator would lift the module by hooking the forks under belting. The operator could carry the module to the desired storage area and place it in position. When the full weight of the module was resting on the floor again, it would automatically

Figure 29

release itself from the forks and settle into its upright position. To set the modules on the horizontal layer the lift operator would pick up the module by sliding the forks underneath and lifting the module in its horizontal position. He would move the module into its storage position, lower the forks, and slide them out by backing up. *(Figure 28)*

It was important to employ an efficient method of storing the completed modules inside the warehouse. It was undesirable to store them outside because of possible vandalism, especially to the flotation blocks.

Keeping the modules dry until they were launched into the water eases their handling. Inside storage required that sufficient floor space be left available for the continuing production of modules and for receiving and unloading additional shipments of tires. The storage system employed helped to maintain the room needed for working, although toward the end nearly all the available floor space became covered with tires. *(Figure 29)*

It became clear that the production of modules could not be accomplished by completing all of the sub-assembly operations first and then proceeding with a continuous module building process. Since it was unknown when all of the tires needed to construct the 946 modules would finally be delivered, combining the operations in a day's work seemed to be more effective.

To complete the project in a 20 to 25 week period, module production had to be completed by the 19th week of the overall project. With starting the construction of the modules during the 10th week, completion would be necessary over the next nine week period, requiring building approximately 100 modules per week. A goal of 30 modules per day was established.

Building 30 modules required 540 "prepared" tires and 60 belts punched. To have the 540 "prepared" tires and the belting available each day meant operating the sub-assembly operations during the first part of the day, usually until noon, leaving the afternoon to build modules. To meet the daily goal for the module production, at least 1,080 blocks of foam had to be bagged and sealed each day. Utilizing the men most efficient at this operation enabled it to keep pace. However, it was usually necessary to keep the operation running while trucks were being unloaded, deicing/dewatering or tire branding was being performed by the other workers.

The tires used in these early stuffing operations were drawn off from tires already branded and stored within the work area. It quickly became apparent that the way in which the tires were stacked after the foam was installed affected the efficiency in the module building process. After different stacking arrangements were tried, the one that contributed most to the module building process was a system where tires were stacked horizontally — six tires high and six rows wide. When the modules were built, the tire stacking took place right in front of the "prepared" tire stacks, eliminating a lot of unnecessary steps. *(Figure 30)*

The completion of the last of the 946 modules came on the second day of the 19th week of the project. The concept of having daily and weekly production goals paid off. Module production averaged construction of

10 modules per hour, utilizing a four-man crew. The largest number of modules produced on a continuous basis in one day was 50 modules and that was limited only by running out of "prepared" tires and belts.

The completion of the last module really marked the end of the first phase of the project.

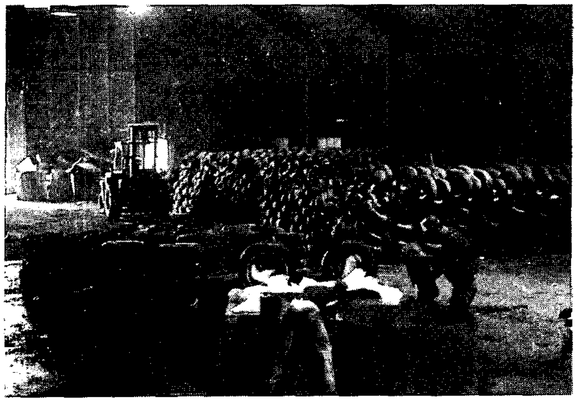


Figure 30

ASSEMBLING THE MAT:

Assembling the modules into the mat and launching was the next phase of construction. Assembling the mat was thought an "in-the-water" operation. It seemed undesirable based on two concerns: the CETA workers had no training for working in the water, creating liability, and the lake temperature was expected to be too cold for extended periods of exposure. There had to be a more efficient way to accomplish the work. The process to be used to assemble the mat was to attach all of the modules together at the river's edge and push or pull them into the river. After considering the spectrum from manually pushing to using bulldozers, it was decided that the fork lift was able to push the mat.

Work began to prepare the site for the assembly operation. The work area was a 150′ stretch of sheet-piled river bank with a 4 foot drop to the water. The area was very rough and required grading to allow a flat and level working surface to hook the modules together. The finished grade was elevated slightly above the top of the sheet pile to prevent the modules from hanging up as they were pushed over the edge into the water.

With the plan to push the modules and slide them into the water, a slippery surface was needed. Bear in mind that the plan called for sliding full width (80′ wide, 11 modules sections) into the water at one time which posed considerable friction. Some of the unusable rolls of conveyor belt material were rolled out over the area where the modules would be hooked together and slid into the water to form a rubber launching pad. *(Figure 31)* The rubber belting as a pad to slide the modules into the water worked extremely well.

To move as many modules as possible at one time, a 28′ long dual axle open frame trailer was borrowed. A 24′ long by 8′ wide plywood deck was built on the trailer, and proved to be a perfect module carrier. After a day of practice at stacking the modules on the trailer and hauling them out to the assembly and launch area,

Figure 31

it was possible to haul nine modules on the trailer. By carrying two additional modules out with the fork lift after the trailer was loaded, the 11 modules needed to make a complete row were at river's edge. *(Figure 32)*

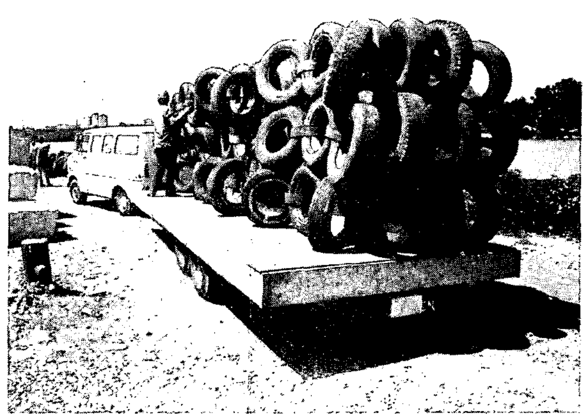


Figure 32

To begin building the first mat, the first three rows of modules were married together. A perimeter bridle, a continuous length of belting, (actually short belts bolted together) was laced through the tires of the modules forming the edges of the mat. When the first three rows were assembled and the perimeter belt in place, the launching of the first row into the water began. *(Figure 33)*

Figure 33

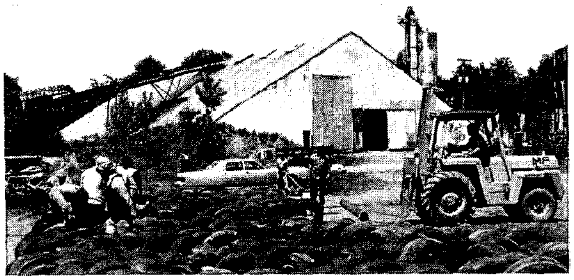


Figure 34

To push the modules more effectively using the fork lift, a 16′ long 6″ diameter steel pipe was used as a push bar. The pipe had two slots cut into it that allowed it to fit onto the forks. This made it possible to apply pressure along 16 feet of the landside edge of the mat. *(Figure 34)* The plan for launching the first three-row section dictated pushing it far enough to have the first row of modules floated in the water completely. The second row hung over the edge of the bulkhead and the third row sat completely on the land near the edge of the bulkhead. (*Figure 35)* With the third row in this position, the fourth row would be married. The plan worked perfectly, and not one person had to enter the water to hook up a module.

Figure 35

The assembly process quickly became very efficient. As soon as the trailer carrying the nine modules was loaded, it left the warehouse followed by the fork lift carrying two modules hung vertically from the forks. While the driver of the truck pulling the trailer waited near the assembly area, the fork lift would drop off the two modules it was carrying, then move away to pick up the push bar. The push bar was located so that the fork lift driver did not require any assistance in attaching it to the forks. By the time the fork lift driver had the push bar ready, the crew working on connecting the modules had completed its work. The pushing of the next row into the water would quickly follow. It generally took three pushes — one in the middle and one on each end — to slide the whole row into the water and keep the entire mat in a straight line position. *(Figures 36, 37)*

Figure 36

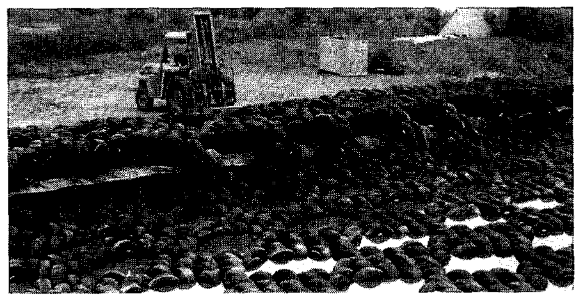


Figure 37

As soon as the row was launched, the fork lift returned to the warehouse. The driver pulling the module trailer would move into position. The workers would push the modules from the trailer, spotting them in position as the trailer moved down the row. When the trailer was completely unloaded, the truck would turn around and return to the warehouse for another load of modules. Workers at the launch area aligned the modules and made the required hookups and continued installing the bridle around the perimeter. Using this system, eight to nine complete rows of the FTB mat were completed each day. *(Figure 38)*

Figure 38

It was not possible to build all 86 rows of the FTB in one long piece because it would project into the Federal channel of the river and would interfere with the commercial traffic. This made it necessary to build four sections of mat, each 150′ in length. *(Figure 39)* Each section took three days to complete. As each

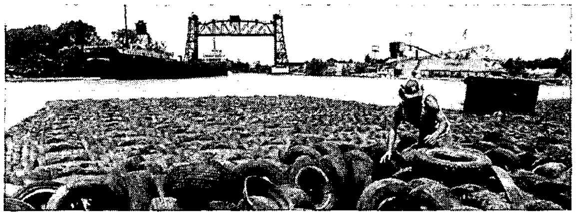


Figure 39

Figure 40

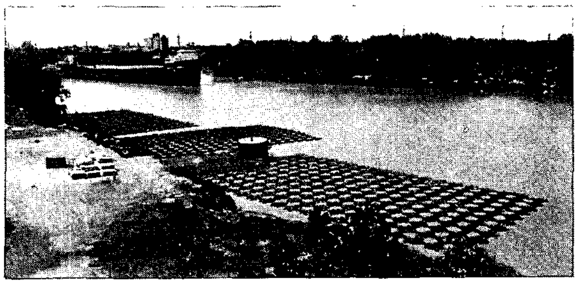


Figure 41

section was completed, it was pushed completely off the dock and towed to a temporary mooring site along the river. A small 14′ fiberglass runabout with a 25 H.P. motor that was loaned to the project was used to move the sections of the FTB. Everybody was surprised at how easily the section could be moved. Nonetheless, it was difficult to maneuver or steer the large mats into an exact position with the small boat. Construction of the entire 86 row, 600′ length FTB was completed in 13 working days without the need of one person doing any work in the water. The FTB was ready for installation at its permanent mooring site, pending the placement of anchors and mooring lines, by the 22nd week of the project. *(Figures 40, 41)*

ANCHORS, MOORING LINES, AND THEIR INSTALLATION

The selection of the weight of the anchors and size of mooring lines was a topic of considerable research. Recommendations were carefully considered and evaluated.

The one great fear that preoccupied the construction manager throughout the planning and building of the FTB was the possibility of the FTB breaking away or dragging its mooring. Such was the case in previous installations. The data on mooring forces in FTBs was probably the least documented.

To provide some additional confidence about the anchors and mooring lines, a naval architect from the local shipyard was consulted. Every piece of available data on mooring forces in FTBs, Stanley's recommendations, a complete description of the FTB, and a site visit were made available to the naval architect. It was

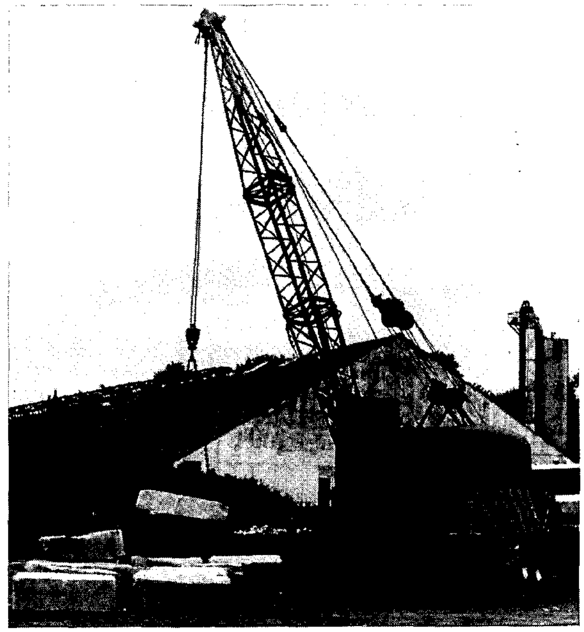


Figure 42

hoped that he could confirm what to use and add quantifiable recommendations before materials were ordered.

It was determined that the anchors and mooring lines were undersized for heavy storm conditions. It was decided to use five-ton anchors and mooring lines with a 18,000 pound working load limit. Arrangement for the anchors called for 18 anchors to be employed, 12 placed along the windward side with 50′ spacing and six anchors placed along the leeward side with 100′ spacing. To help prevent anchor-dragging in storm conditions, it was also planned to place the anchors into holes dug in the lake bed.

A search was then made for materials meeting the required specifications. Materials had to be cost conscious and easy to handle. A decision was made to use 5-ton sandstone blocks based on their cost which equalled the material costs involved in making the concrete blocks. This eliminated the time and effort required in manufacturing the concrete blocks at the construction site. *(Figure 42)*

Selecting the material for the mooring lines was a little more difficult. Three alternatives were considered; galvanized wire rope, chain, and nylon web belting. All three offered the required strength. In looking at chain, it was realized that it would be unacceptable in terms of weight and cost. Weight per linear foot for an 18,000 pound working load, was very high. In the 60′ lengths for each mooring, line, it would be impractical, if not impossible, to handle from a small work boat. The cost per foot was also higher than the other two materials considered.

The nylon web belting was the least expensive of the three materials. Further research showed it had been unsuccessfully tried as an underwater binding material. Experience had shown that sand and sand drifts occurring in wave conditions, acted on the nylon belt like a cutting abrasive. In as little as seven days time, it could cut through a nylon belt. The knowledge of this

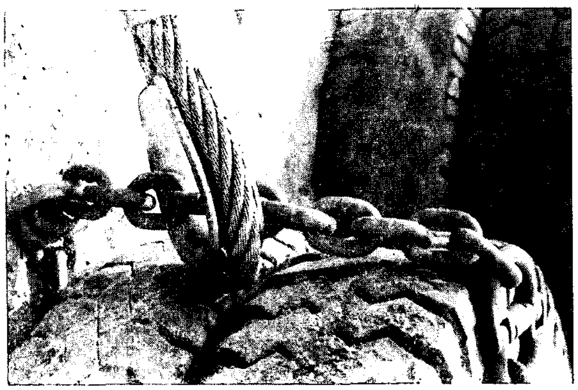


Figure 43

Figure 44

effect was enough to decide against nylon belting.

Galvanized wire rope, commonly referred to as cable, was the material selected for the mooring lines. Sized to meet working load requirement of 18,000 pounds meant using an 1 1/8″ diameter material. The weight of the cable was not light by any means, but compared to about one-fourth the weight of comparable strength chain. The cost of the cable was about one-half the cost of the chain. However, with the additional cost for specialized fittings on the ends of the cable to facilitate connection to the anchors and the FTB added, the cost of the cable was only slightly less than the chain.

In planning the use of the wire rope, shock to the cables during storm conditions could be expected. The shock to the cables was expected to be the major contributor to cable fatigue and breakdown. As a means to limit the shock and prolong the cable life, it was decided to install a shock absorber into each mooring line. Two truck tires were selected for the shock absorber in each mooring line. The two truck tires attached together were placed in the mooring line about 10′ from the anchor. In this manner, they would usually rest on the lake bottom and would rise off the bottom only when forces on the FTB became severe. The tires were connected into the mooring line using thimbled eyes in the cables and continuous loops of chain laced through the tires. *(Figures 43, 44)*

The connection of the mooring line to the anchor stones and to the modules required special consideration. Installing 1½″ solid steel bar stock through a pre-drilled hole in the sandstone with steel plates welded to the top and bottom of the bar provided the needed connecting point on the anchor. An open-swaged socket on the end of each mooring cable could be connected to the 1½″ bar in the anchor stone by pulling the pin in the socket, sliding the jaws of the socket around the bar, and reinstalling the pin. *(Figure 45)* To connect the mooring line to the modules, a separate ¾″ diameter piece of cable was used. This cable was woven through the entire module to better distribute the weight and load. Woven through the module, the ends of this cable which had swaged thimble eyes, would be connected to the mooring cable which also had a swaged thimble eye, using a 12-ton working load galvanized safety shackle. *(Figure 46).* Using this connecting method allowed for the mooring line with shock absorber to be attached to the anchor stone and placed as one unit on the lake bottom. A floating marker was attached to the loose end of the mooring line with a ¼″ "reach line" for retrieval. The cables attached to the modules were installed before the FTB sections were towed to the site for installation. Final attachment required pulling up the loose end of the mooring line from the bottom and connecting it to

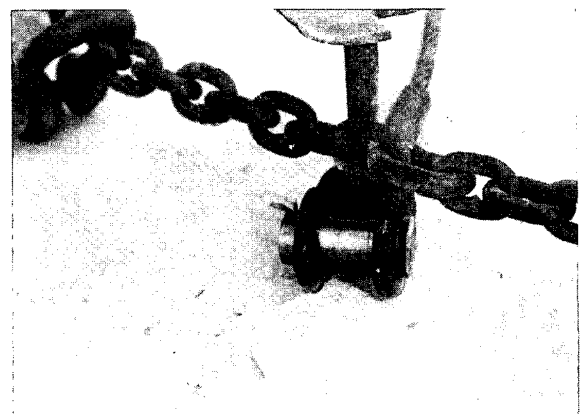


Figure 45

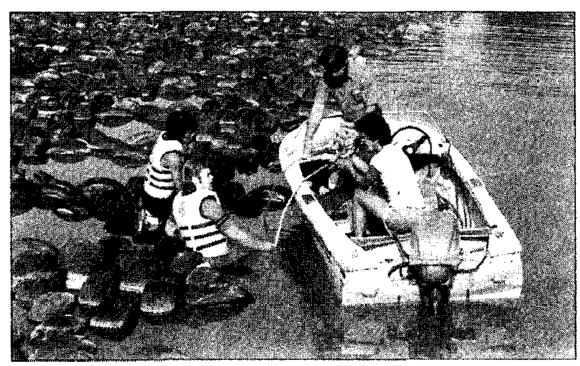


Figure 46

the ends of the cable woven through the module. This system worked very well during the final installation and required only three men working from the small work boat.

The installation of the anchors and mooring lines on the lake bottom was the only work in the project that required using subcontract labor and equipment. A local marine contractor with a 50-ton derrick barge, tug and work scow was contracted to complete this work. After the 18 mooring lines with their shock absorbers had been assembled on the dock at the construction site, the subcontractor moved his equipment to the site and loaded all 18 anchor stones and the mooring lines onto a work scow alongside the derrick barge. *(Figures 47, 48)* When loaded, the equipment was towed to the east basin site for installation. At the site, the first chore was to lay-out the locations for the anchors. Using a measuring chain in a skiff and a transit located on the government pier, floating markers were dropped for the locations of the anchors. *(Figure 49)* When this was completed, the derrick barge and scow were moved into place.

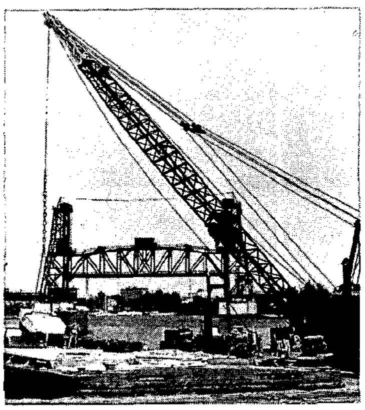


Figure 47

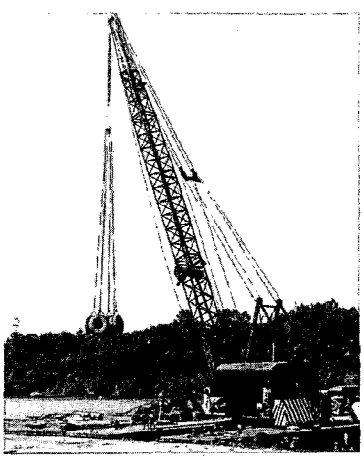


Figure 48

Using a clam bucket, a hole was excavated in the lake bottom for the anchor stone. The clam bucket was removed and stone hooks for picking up the sandstone anchor were attached to the derrick's crane. The anchor stone was lifted from the scow with the mooring line attached to it and placed into the hole in the lake bottom. The mooring line was stretched out and dropped into the water as the anchor was lowered to

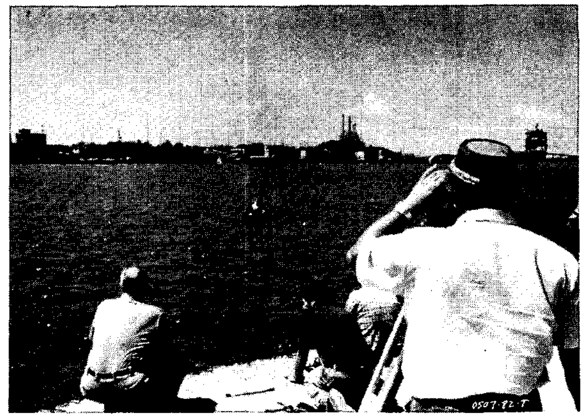


Figure 49

help prevent the shock absorber tires from getting fouled on the anchor. Having the scow loaded with the anchors on the inside of the derrick barge, (i.e., the side where the FTB would be positioned) allowed the workers to stretch the mooring lines to the approximate position of the final connection. *(Figure 50)* This greatly aided the final connection to the FTB by reducing the amount of stretching needed to raise the end of the mooring line to the surface.

While the anchors were being placed, pad eyes were being welded to the government pier. Because of the proximity to the water, the welding was performed from a boat moored alongside the pier.

To set the 18 stones required two full days of work. With the completion of setting the anchors and pad eyes, everything was ready for towing the FTB sections from their temporary mooring up the Black River to the permanent installation site.

Figure 50

TOWING AND CONNECTING:

With the services of the harbormaster, the port authority harbor patrol boat, and a volunteer, the first section of the FTB was towed 1½ miles from the construction site to the east basin. On this first tow the harbormaster's tug was positioned at the front of the FTB section (80′ x 150′) pulling and the other two craft were tied off to either side of the section near the rear. This method of towing, while easy when going in a straight line, was awkward to maneuver in the Black River. The towing consumed approximately 1¾ hours.

The positioning of the first FTB section required the towing crafts to be particularly careful. The section was positioned by sliding the mat over the floating markers tied to the ends of the mooring lines. The towing craft had to be careful not to run over the floating markers to avoid fouling in the propellers, to prevent sinking or cutting and thereby, losing the location of the mooring lines. *(Figure 51)* Performed successfully the workers in the small work boat were able to connect the mat to the anchors at the shackles. After the initial two connections were made the tow craft was able to move away and the balance of the connections were made. *(Figure 52)* All of the tow boats were radio-equipped to prevent confusion. If a connection was difficult to make because the section had drifted out of position, a tow craft standing by would push the section by running its bow against the tires. All connection on the first section required three hours.

Figure 51

Figure 52

A temporary marking light required by the U.S. Coast Guard had to be installed. The light had to flash from dusk to dawn to mark the end of the FTB. A standard street barricade, used for marking roadway hazards, was borrowed from the city utility department. Typical of these barricades, it had an amber-colored battery-operated flasher. To satisfy the Coast Guard requirements, the amber flasher was changed to a green-colored flasher. The barricade and flasher were mounted to the seats of a 14′ aluminum open fishing boat. The boat was pulled on top of the modules, chained, and padlocked to the modules to prevent theft. *(Figure 53)* The boat made it easy to relocate as each additional section of the FTB was added. Installation of the other three sections followed the same procedure with minor adjustments. To gain additional control and maneuverability of the FTB section, the harbormaster's tug pushed, rather than pulled, the mat. The other two boats were positioned along the sides of the mat at the front. This permitted greater steering ability at the front of the section by having the boats increase or decrease their individual speed. Towing proceeded more confidently in the river. *(Figure 54)*

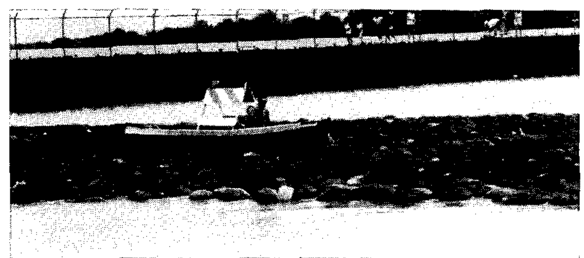


Figure 53

Figure 54

Installation of the last three sections required men working in the water for the first time. These three sections required hookup to the previously installed section and to the mooring lines. As the section was moved into position, the workers prepared to enter the water, wearing life jackets and carrying the necessary tools, extra nuts, and bolts. Working in two man teams, they connected the mats together at outside corners to prevent the section from drifting. The marrying tires and belts were attached to the end of one of the sections. The team opened the belt, properly positioned the marrying tire and belting, and bolted the belting back together. *(Figure 55)* The crew in the work boat began connecting the mooring lines, using the tow boats to shift the position of the FTB section as required to relieve strain. The workers in the water finished connecting the nine remaining modules together, a task that really did not require more than one hour for each of the three sections. Connecting the

Figure 55

mooring lines required more time because of the need to reposition the mat due to wind drift. Nearly a full day's work was required to tow and connect each section to its permanent mooring. *(Figure 56)* After each section was anchored, the temporary marking light would be relocated to the end of the new section.

While this system worked well, it was not without problems. First, the sinking of two markers did occur, requiring a diver to locate the lost end of the mooring line and reattach a new marker and line. Locating the mooring cables was not difficult, but entailed patience since the visibility was poor and the diver searched by feel. Second, two leeward side anchors had been positioned incorrectly causing the mooring line to be short. It was easier to add cable to the mooring line for the connection. Extra cable for these two anchors, and for two other mooring lines that were too tight, were ordered. With the extra cable installed in the mooring system, the entire 600′ length of the FTB fell into an eye-pleasing straight line.

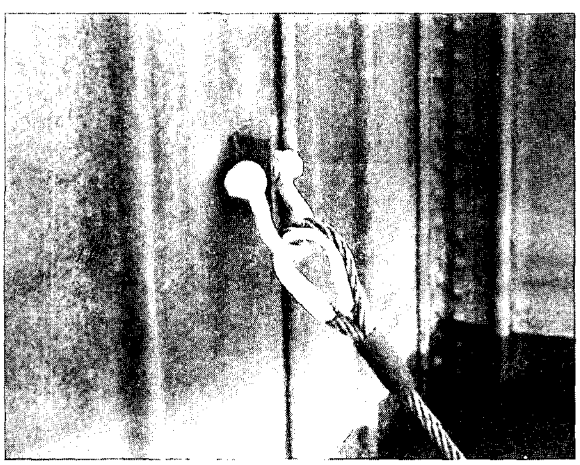


Figure 56

The completion of the construction and installation of the FTB took about six weeks longer than originally planned, due to the delayed receipt of some of the mooring lines. Actual work weeks amounted to a total of 24 and reflected favorably on the planning for the project.

Special assistance was provided by Goodyear, assisting the port authority with publicity about the FTB and its final installation. Through this effort, a positive image of the technology and the Lorain Port Authority commitment to development in the Port of Lorain was shared with many.

NAVIGATIONAL LIGHTING:

A permanent navigational light had to be installed at the end of the structure. The specification of U.S. Coast Guard called for a structure a minimum of 10′ above the water level. The light had to be green and display at 15, but not more than 30 flashes, per minute. The light source was to be a tungsten incandescent type light with independent power source, to be operated from sunset to sunrise and visible for one mile on a clear dark night. These specific requirements led to working with Penwalt Automatic Power, Inc. of Houston, Texas, a manufacturer of navigational aids.

Other factors about the light and its structure had to be considered. These included the need for a buoy-type since the tire modules would not support a structure required to be 10′ above the water. Furthermore, cost was a concern and it needed to be virtually maintenance free.

Automatic Power's solution to these requirements was a light mounted atop a tension-anchored buoyant mast. The mast would stand upright from its anchor by the use of 1500 pounds of buoyancy mounted to the mast and held submerged below the surface. The design called for a 1¼-ton anchor attached directly to the bottom end of the mast. The mast would elevate the light to a minimum of 10′ above the water level during high water, and even higher as water levels dropped. The lamp atop the mast would be a standard off-the-shelf type lamp with a solid state six volt flasher system, with a .5 seconds on, 3.5 seconds off flashing sequence, controlled by an electronic photo sensitive eye, have a six place automatic bulb changer to reduce required maintenance, and powered by a solar charged battery system with five-year battery life expectancy. The mast structure was designed and constructed of steel pipe and bracing for permanent installation for summer and winter conditions. *(Figure 57)*

The total cost for the marking light, anchor and installation was $3,446.37. The least expensive marking light considered, it was thought the best alternative.

The installation of the marking light proved to be easy. Two divers using a float bag eliminated the need for heavy lifting equipment and a higher cost. *(Figure 58).* With the float bag, the anchor and mast could be attached at the surface of the water and towed to its permanent location. Deflating the float bag, allowed the anchor and mast to sink into position. *(Figure 59)* With the mast placed in the water *(Figure 60)*, the marking light unit was then attached to the top of the mast from a work boat. *(Figures 61, 62).* This entire operation required four hours.

With the marking light in place and operational, the entire FTB project was complete. *(Figure 63)*

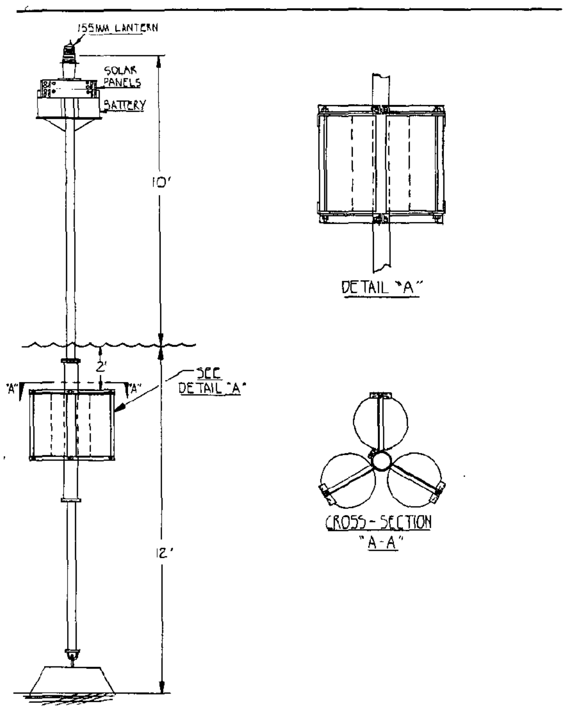


Figure 57

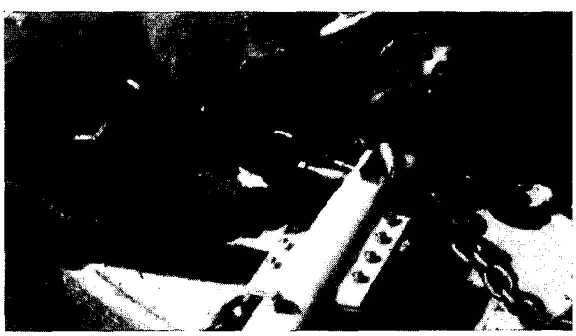


Figure 58

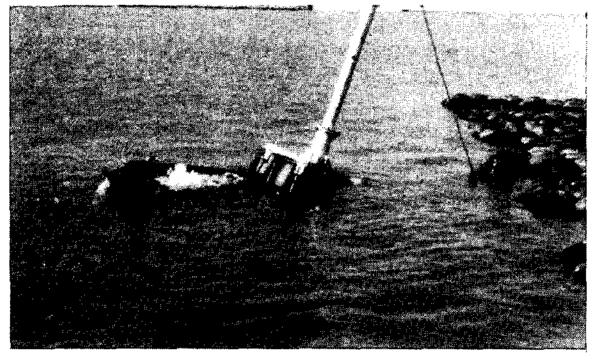
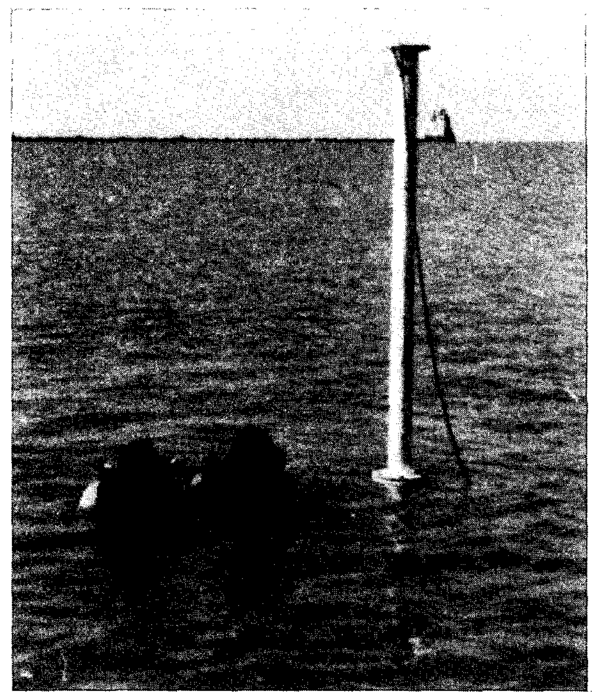


Figure 59



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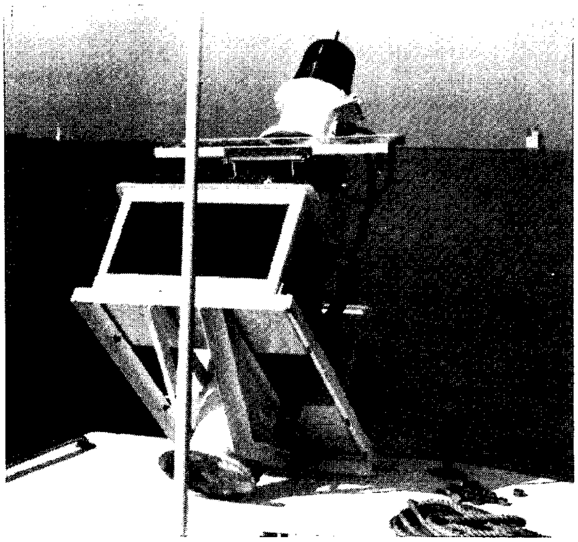

Figure 61

Figure 62

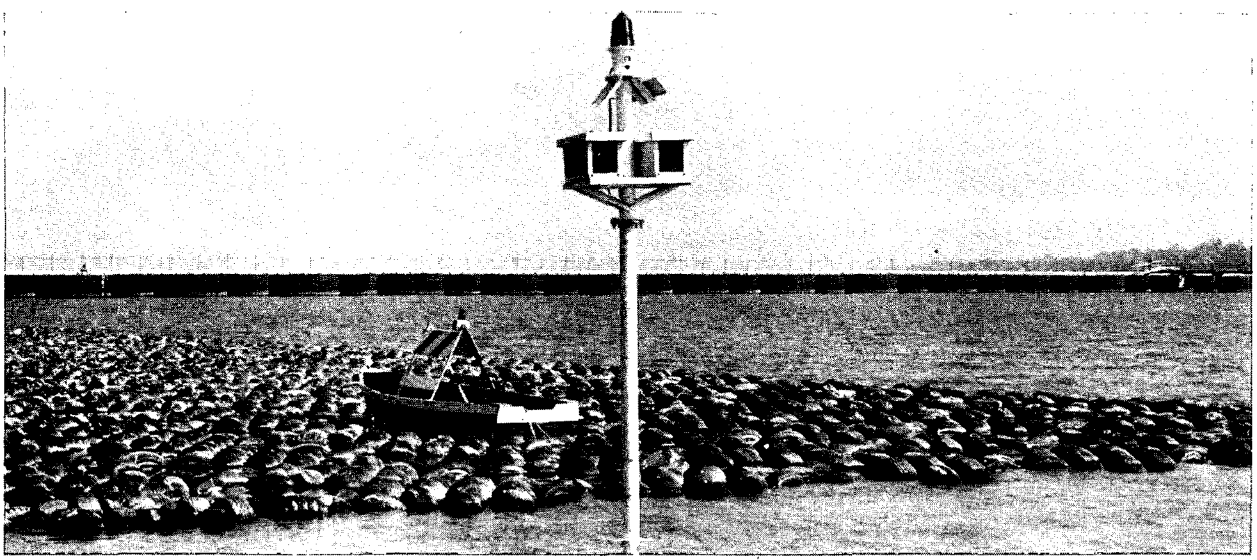

Figure 63

Cost Analysis

BUDGET ESTIMATES:

Two early cost estimates evolved. First, the costs included in the application for funds from the Ohio Department of Energy. This budget was computed using existing literature (adjusted for inflation) and the design of a 28 foot by 1000 foot FTB as observed in Dunkirk, N.Y.

FLOATING TIRE BREAKWATER

1980 Cost Estimate

570 Modules x 20 Tires/Mod = 11,400 Tires

Item	Quantity	Unit Cost	Total Cost
1. Scrap Tires	11,400	.20	$ 2,280.
2. Urethane Foam	6,600 lbs.	.95	6,270.
3. Chain	20,000 ft.	.95	19,000.
4. Anchors (handmade) 500 lb.	30	40.00	1,200.
5. Anchors (250 lb)	15	20.00	300.
6. Mooring Chain	3,000 ft.	.95	2,850.
7. Labor estimate — 2 hrs/bundle-build & install	1,136 hrs.	9.00	7,950.
			39,850.
8. Administration	@ 5%		1,950.
		Total:	$41,800.
9. Contingencies			2,000.
			$43,800.

Later, after Stanley Consultants had finished their wave analyses, a second budget evolved based upon a 80 foot by 600 foot FTB and adjusted unit costs.

REPRESENTATIVE COSTS FOR FTB CONSTRUCTION AT LORAIN

Item	Quantity	Unit Cost	Total Cost
Scrap Tires	18,920 tires	$ 0.20	$ 3,800
Foam Flotation	9,460 lbs.	0.95	9,000
Scrap Conveyor (Belt Strips)	28,400 ft.	0.50	14,200
Seaward Concrete Anchors 1,800 lbs	13 anchors	105.00	1,400
Leeward Concrete Anchors 900 lbs.	14 anchors	70.00	1,000
Anchor Mooring Chain One-Half Inch Open Link	1,600 ft.	1.05	1,700
Labor			
Construct (1 hr/module)	946 hrs.	15.00	14,200
Install (1.25 hr/module)	1,183 hrs.	15.00	17,800
			$63,100

The port authority, having received a commitment for belting and scrap tires, still believed the project was feasible. Excluding these costs, the consultants' total estimate was $45,100, a figure very close to the $43,800 grant award. Surely, it was thought, competitive bidding would close the gap.

The competitive bidding process proved otherwise. The four bids varied from $89,247 to $269,307. All bids were rejected and the port authority decided to build the FTB in-house. With a labor commitment from the CETA program, a third budget was developed. This budget took into consideration the donation of labor, tires, and belting, but retained a category for supervision to cover the expense of a construction manager.

LORAIN PORT AUTHORITY

Floating Tire Breakwater

Work Budget

General Fund	Estimated Cost
1. Supervision	$12,000
2. Insurance	500
3. Site Lease	1,500
4. Utilities	1,000
5. Leased Equipment	3,000
6. Hand Tools	500
7. Lumber	1,000
8. Chains, Bolting, Anchors	3,000
9. Foam	12,000
10. Other Sub-contract	2,000
11. Marking Buoys	5,000
12. Contingencies	2,300
	$43,800

As an aid to understanding the work budget, an explanation of each item follows:

1. Supervision: The expected cost of the construction manager for the project under a professional service contract entered into between the port authority and the construction manager. Unexpectedly and fortunately for the project, the salary for the construction manager was eligible under the CETA program which freed money for expenses.

2. Insurance: Special insurance possibly required for employees working in the water. The need for insurance for employees was eliminated totally in the project. The State Workman's Compensation insurance handled through the CETA payroll provided adequate protection and no additional insurance was required.

3. Site Lease: This cost was based on an agreement with the landlord that fixed the lease cost, regardless of duration.

4. Utilities: Electric and telephone. Also included were charges by the electric utility company for installing a three-phase, 440-volt electrical service to the warehouse and the cost of an electrician's time and material for installing the electrical panel, lighting and utility plugs inside the warehouse.

5. Leased Equipment: Monthly rental costs of the fork lift and portable field toilet.

6. Hand Tools: For the purchase of necessary hand tools, including special tools or equipment such as the branding irons, tire spreader brackets, and life jackets.

7. Lumber: The cost of lumber and other material necessary to repair the warehouse for the project and materials needed for tables and other equipment used in the construction of the FTB.

8. Chains, Bolting, Anchors: This category is self-explanatory. The original cost estimate was based on some early price quotes for chain and anchors. This, of course, changed drastically when the anchor and mooring line design was changed and the cost of the sandstone anchors and galvanized wire rope was used.

9. Foam: The cost of urethane changed, but from the urethane foam system to the styrofoam block and polyethylene bag system.

10. Other sub-contract: Costs for specialized help. The marine contractor hired for setting the mooring and anchor system was the main expense. The original estimate reflected the cost of a lighter system. Costs for grading and site preparation at launch area were also included.

11. Marking Buoys: All of the costs of acquiring the buoy, anchor and installation.

12. Contingencies: Fuel costs for fork lift, boats, branding iron, mooring rope, safety, and first aid material, and other unexpected costs.

ACTUAL COSTS:

In the final analysis, the project exceeded the ODOE grant by $7,622. This shortfall was offset by the port authority adding $6,000 from its general fund and selling off some of the accumulated equipment at the end of the project. The primary cause for the higher than expected project cost was the increased expense of the mooring and anchoring system. These extra expenses in the mooring system were viewed as a good investment in light of the potential hazard of under-designing.

Final distribution of expenses appeared as follows at close-out:

FLOATING TIRE BREAKWATER
Work Budget
October 31, 1981

	Estimated Cost	Expense To Date	Balance Budget
1. Supervision	$12,000.00	$ —	$12,000.00
2. Insurance	500.00	—	500.00
3. Site Lease	1,500.00	1,500.00	—
4. Utilities	1,000.00	3,904.98	-2,904.98
5. Leased Equipment	3,000.00	4,203.27	-1,203.27
6. Hand Tools	500.00	496.03	3.97
7. Lumber	1,000.00	789.87	210.13
8. Chains/Bolting	3,000.00	12,826.95	-9,826.95
9. Foam	12,000.00	14,738.63	-2,738.63
10. Other Sub-contract	2,000.00	5,754.00	-3,754.00
11. Marking Buoys	5,000.00	3,446.37	1,553.63
12. Contingencies*	8,300.00	3,762.52	4,537.48
	$49,800.00	$51,422.62	($1,622.62)**

Gross CETA Wages at Close-out — October 31, 1981 $51,652.00 (with fringes)
*The sum of $6,000 appropriated by port authority, 7-14-81
**Recaptured by selling reuseables

UNIT COSTS:

FOAM

Two styrofoam blocks sealed in 10 mil polyethylene were required for each tire — 18,920 total tires.

Foam — 38,000 block x $.274	=	$10,411.67
Bags — 38,000 bags x .1139	=	4,326.96
Total Cost:		$14,738.63

Unit Cost per tire = **$.78**

MOORING SYSTEM

The mooring system was made of 18, 5-ton sandstone anchors, 20 mooring lines, each 60 feet long, and two intermediate connecting lines from the government pier. The mooring lines connected to each anchor, consisted of one ¾″ galvanized wire rope section as the connector at the modules, two 1⅛″ galvanized wire rope sections, the two truck tires as shock absorber, two sections of ⅝″ chain and two hammerlocs for connectors of the tire shock absorbers, and one 12-ton safety shackle. The two 60′ lines attached to the government pier were 1⅛″ galvanized wire rope, ¾″ wire rope module connectors, and 12-ton safety shackles. The last part of the mooring system was two 25′ long ⅝″ chain sections attached to the government pier at intermediate points on pier end of the FTB. These were connected to ¾″ galvanized wire rope module connector with 12-ton safety shackles.

Anchors	• 18 @ $125. freight inc.	$ 2,250.00
Mooring Line Components	• 18 pcs. ¾" x 30 ft. 6x19 IWRC galvanized wire rope 2/gal. thimble swaged both ends @ $68.62 ea.	1,235.16
	• 18 pcs. 1⅛" x 35 ft. 6x25 IWRC galvanized wire rope w/gal. thimble swaged both ends @ $173.04 ea.	3,114.72
	• 18 pcs. 1⅛" x 11 ft. 6x25 IWRC galvanized wire rope w/open swaged socket one end and galvanized thimble swaged other end @ $118.76 ea.	2,137.68
	• 2 pcs. 1⅛" x 60 ft. 6x25 IWRC galvanized wire rope w/gal. thimble swaged both ends @ $258.84 ea.	517.68
	• 4 pcs. ¾" x 20 ft. 6x19 IWRC galvanized wire rope w/gal. thimble swaged both ends @ $51.26 ea.	205.04
	• 36 pcs. ⅝" x 5 ft. herc-alloy chain @ $36.40 ea.	1,310.40
	• 42 pcs. ⅝" hammerlocs @ $12.78 ea.	536.76
	• 26 pcs. 12-ton safety shackles @ $23.56 ea.	612.56
	• 54 ft. ⅝" used chain @ $2.50/ft.	135.00
	Total, less discount	$11,956.95

Unit cost per mooring line/anchor combination 18 @	$ 607.34
Unit cost per mooring line to pier connection 4 @	$ 280.72

NUTS AND BOLTS

Hot-dipped galvanized plated nuts, bolts, and washers were used as the belt connector for the modules. The sizes of bolts and nuts used was ⅜" — 16 x 1¾" capscrew and ⅜" — 16 hex nut. The washers were ⅜" flat washer, 1" O.D. Each bolt, nut and two washer set cost $.1024 each. While approximately 8,000 sets were needed for the project — 8,500 sets were purchased.
8,500 connector sets @ $.1024 each = $870.00

TOTAL PROJECT COSTS:

Material and Project Support:				$ 51,422.62
Labor Cost:				
CETA Labor — $5.37/hr. x 5.78 men x 960 total hours		=	$29,814.00	
Fringe Benefits $1.10/hr. x 5.78 men x 960 total hours		=	6,104.00	
Total CETA Labor			$35,918.00	
Supervision — $15.00/hr. x	960 total hrs	=	$14,400.00	
Fringe Benefits $ 1.39/hr. x	960 total hrs	=	1,334.00	
Total Supervision			$15,734.00	
Total Labor Cost				$ 51,652.00
Total Project Cost				$103,074.62

UNIT COST — TOTAL PROJECT

Material and Project Support per Module (946)	$ 54.36
Total Labor Cost per Module (946)	54.60
Total Project Cost per Module (946)	$ 108.96
Total Project Cost per Square Foot (11 modules — 80 ft. x 86 modules — 600 ft. = 48,000 sq. ft.)	$ 2.15
Total Project Cost per Lineal Foot (i.e. 600 ft.)	$ 171.79

In summary, early budgets were based on existing literature, which contained limited costing data about relatively few installations. The bidding experience evidenced: 1. limited general contracting knowledge of FTB construction, and 2. a diversity of opinion on construction methodology.

The reader is cautioned and reminded that many hours of time, and valuable equipment were loaned and donated to the project. Furthermore, the labor rates paid to the CETA employees may be lower than what might be expected in other locales. It is fair to conclude that anyone preparing to bid on FTB to a general contractor can expect these factors to increase the total costs above those experienced by the Lorain Port Authority.

Short Term Observations

The FTB installation in the east basin of Lorain Harbor was completed on July 23, 1981. In the six-month period since the installation, constant observation and monitoring of the FTB has taken place, with visual inspections from a boat, observation from shore during storm conditions, and under-water inspections by divers checking the mooring system. From these observations the following findings are offered:

THE MOORING SYSTEM:

An inspection of the mooring system by a diver was performed six weeks after the installation. During that six-week period, the FTB was exposed to two storms. Although no specific data on the storm conditions was collected, both storms exposed the FTB to very rough lake conditions.

The diver checked the condition of cables, the shock absorber truck tires, and the anchors. The inspection of the cables was performed by running a piece of cloth over the cables by hand to feel for any strand breakdown. None was detected.

The inspection of the shock absorber tires did reveal altered conditions. At the time of installation, a diver inspected the shock absorber tires and they were lying flat on the bottom. The later inspection revealed the shock absorber tires had repositioned themselves so that they were standing in a vertical position on the bottom. This had to be caused by the storm forces on the cables which lifted the shock absorbers and repositioned them.

Inspection of the anchor stones indicated that there had been no movement. All connectors (i.e. safety shackles, chains, and hammerlocks) were in good condition.

BINDING MATERIAL:

Inspections of the binding material showed no visible breakdown or deterioration of any of the bindings. Nearly all of the galvanized nut and bolt connectors in the belts evidenced rusting, as expected.

FLOTATION:

The flotation has worked effectively. A few of the foam blocks have been dislodged by the storm action. These were retrieved from the shore to be saved for reinstallation in the spring. The total loss amounts to 25 pieces. It is believed that these blocks may not have been snugly fitted in the tires as a result of the launching or dislodged by swimmers attracted to the installation. The loss of these blocks of foam does not seem to present a problem. The level of freeboard of the modules has remained the same since launched.

DEBRIS COLLECTION:

The FTB has proved to be a good collector for debris and flotsam. This has not proved to be much of a problem and storms seem to flush most of the debris from the modules.

SEAWEED AND SEDIMENT:

Growth of seaweed on the tires below the water line has been tremendous. Growth has been observed to be as much as three feet long on some tires. *(Figure 64)* Storm action seems to trim some of the seaweed as the tires work against each other. Icing throughout the winter is expected to strip away all algae.

Accumulation of sediment inside the tires has been non-existent. Previous study of the area showed very little movement of bottom sediment. For this reason, no holes were punched in the tires to allow sediment to filter out. Current opinion is that these holes are not effective unless they are large enough to prevent plugging by sea life (i.e. 4-inch square or larger).

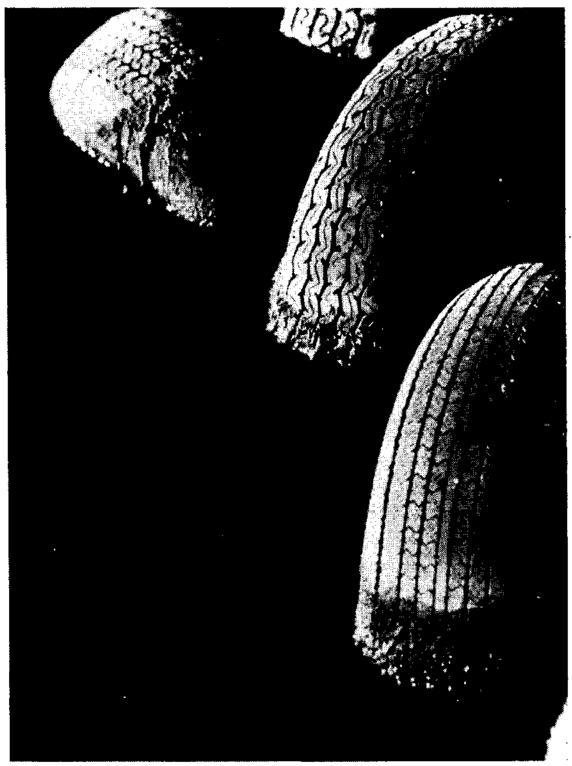

Figure 64

FISH POPULATION:

No evidence of an increase in fish population was detected in the area by local fishermen. No measurements of fish-life near the FTB were recorded, and therefore an accurate picture of the situation is impossible. Other experience with FTBs has shown increases in fish populations nearby. The Lorain installation presents a real opportunity for further study in this area.

EFFECTIVENESS:

The six-month observation period has provided opportunity to see the effectiveness of the FTB at work. The breakwater works effectively in reducing the short period (3′ to 4′ waves). Under the storm conditions observed, the water along the leeward side of the FTB was reduced to calm water. *(Figures 65,66,67)* No wave measuring devices were placed in the area to accurately record wave heights, thus the amount of the

Figure 65

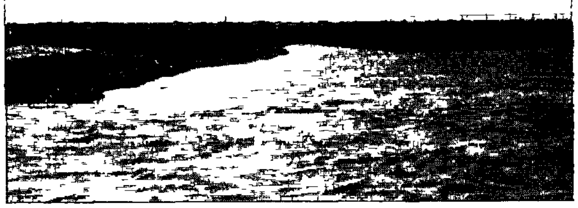

Figure 66

Figure 67

attenuation cannot be quantified These devices will be installed in the spring

The observation period has evidenced a wave action that the FTB has been ineffective in attenuating With the configuration of the fixed breakwaters in the east basin area long period waves are occurring along the government sheet-pile pier to which the FTB is attached These longer period waves roll beneath the FTB as if the FTB was riding the wave Apparently, there is a multiplication of wave energy With the installation of the FTB the short period waves are reduced and the existence of the long period waves rolling through the FTB is evermore evident *(Figures 68, 69)*

These long period waves will pose little problem to installing single point moorings behind the FTB, however, further study of a floating dock system is required Amendments to the installation are being evaluated to counteract this site specific problem

Figure 68

Figure 69

ICE CONDITIONS

The breakwater was exposed to floating ice-packs during the month of December, 1981 without any visible problem Since January, 1982 the FTB has been completely frozen in the ice with the entire east basin area ice-covered *(Figure 70)* No signs of problems are evident as of March, 1982 Further observation during the spring thaw will be conducted to evaluate the effects of the ice on the FTB It is anticipated that no problems will be experienced

Figure 70

THE PUBLIC RESPONSE:

Local public response to the breakwater installation was very favorable and was probably the result of the joint public relations effort of Goodyear and the Lorain Port Authority. As the result of media coverage about the installation, many inquiries have been received about available dockage, which will soon be installed.

Another unexpected number of inquiries about the FTB and its construction have been received from around the country, as the result of the national wire services, leading to inquiries from as far away as Southhampton, England. This interest from around the world bodes well for the future of FTB development.

Conclusions and Recommendations

The experience of constructing and installing the FTB in the east basin of Lorain harbor has to be considered a success. Although the basic goal of building a breakwater durable enough to remain in place year-around for 10 years with a minimum of annual maintenance is believed achieved, the test of time will be a better judge.

The goal of minimizing work in the water was accomplished. The need for assuring the permanence of the breakwater was fulfilled with the redesign and installation of a stronger, heavy-duty mooring line/-anchor system. And finally, the overall project was considered to have been performed in a timely and cost-effective manner.

The nature of the project as a one time, public agency undertaking, had a direct bearing on how the construction activities evolved. Investment in tools and machinery which could have greatly expedited many of the operations in the project were unaffordable. Implementation of such equipment would have greatly improved production and efficiency in building modules. However, the budget of the project did not allow it. Nonetheless, building systems and procedures described earlier were employed with success.

From the Lorain experience, further suggestions to facilitate a similar project are offered:

1. Because of delays in getting tires, delays in receiving the conveyor belt, and other factors that caused delay in getting into module production, it is recommended that a pre-construction period be expected. At least a one-month period before construction should be expected. One paid staff person can arrange details for stockpiling tires, getting material ordered, making the necessary improvements required at the construction site, and the making of other necessary arrangements.

2. If the styrofoam block and bag system is used as a flotation device, it is suggested that a glue, adhesive, or other fastening device, be tried to more permanently secure the flotation blocks to the inside of the tire. This was not tried and effectiveness is yet undetermined. Loss of the flotation blocks has not proven to be a serious problem, but a cost-effective means of gluing or fastening would add another degree of security to the overall system.

3. Utilizing the procedures employed in this project, a doubling of the production rate could be attained with the employment of four additional workers. This would allow the sub-assembly operations to run simultaneously with the building of the modules and provide a continuous flow of "prepared" tires to that operation. Workers trading tasks during each day is recommended to overcome the repetitious and boring nature of the tasks.

4. The ease of the second method of towing (two boats forward) the breakwater sections suggested that it would have been far more practical to have towed and installed larger sections of the FTB than in this project. It is suggested that sections up to 50 modules long can be easily towed and installed, assuming good weather conditions. This can save a lot of time.

FOR THE FUTURE:

This first hand experience with scrap tires as wave energy absorbers, has proven their effectiveness in attenuating waves. This fact encourages further use of scrap tires as a solution to other hydraulic problems. The need for protected water space for recreational boating opportunities has been documented. An even greater demand for shoreline protection is evident throughout the country. With the high costs for conventional breakwaters solutions to erosion problems, utilizing scrap tires is becoming economically practical.

Existing FTB literature cites that research and development have been conducted to examine the effectiveness of utilizing scrap tires for shore erosion control, but much more is needed. Scrap tires, with their proven ability to absorb wave energy, non-degradable quality, low cost and relative abundance, make them an ideal material for solutions to hydraulics problems. Their use for shoreline erosion control, lake and river bank protection, beach replenishment, beach retention, and other applications are waiting to be explored.

The prevalent perception of scrap tires as a waste material needs to be changed so that a valuable raw material resource fulfills a new usefulness.

ABOUT PEOPLE

THE AUTHOR:

David Thomas Lee, called Tom by his friends, was the construction manager for the Lorain FTB. With that experience he served as the principal author for this report. It was Tom's innovative, yet practical, approaches that guided the project to completion. After study at Mount Union College, Alliance, Ohio, Tom received his Bachelor of Architecture degree from the State University of New York at Buffalo in 1973. Tom has a multi-dimensional background having served as a field engineer, prototype engineer, graphic designer, construction supervisor, rehabilitation administrator, and construction manager. His work has been with the private and public sectors. Tom is self-employed as a consultant offering multi-functional services. Tom is 33 years old. He and his wife, Carol, are the parents of Amy and Joshua. They are avid sailors, and Tom has served as the business manager and commodore of the Lorain Sailing Club and commodore of the Lorain Yacht Club.

THE EDITOR:

John G. Sulpizio is the Executive Director of the Lorain Port Authority, an agency which concentrates upon economic, industrial, and recreational development on the waterfront. His commitment to improving that waterfront where he grew up, led to the decision to build and funding of the FTB. John is a 1969 graduate of Cornell University, Ithaca, N.Y. and holds a Bachelor of Arts degree. John has held various positions in the field of community development. Prior to joining the Lorain Port Authority in 1978, he was the chief planner for the City of Lorain. John is the president of the Council of Lake Erie Ports, a director of the Chamber of Commerce, and active in professional and civic affairs. Recently, he served as a panelist at the Second Annual Conference on Floating Breakwaters in Seattle, Washington. John is 35 years old and is spending his spare time completely rebuilding a 90-year-old homestead in the center city for his wife, Patricia, and himself. They are expecting their first-born.

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BIBLIOGRAPHY

This list of publications represents reference information used in planning and constructing the Floating Tire Breakwater in Lorain and research sources for this report.

Bishop, C.F. 1980. *Design and Construction Manual for Floating Tire Breakwaters.* National Water Research Institute of Canada for Inland Waters, Burlington, Ontario, Canada.

Candle, R.D. & Fischer, W.J. 1977. *Scrap Tire Shore Protection Structures.* Goodyear Tire and Rubber Company, Akron, Ohio.

Davis, A.P., Jr. 1977. *Evaluation of Tying Materials for Floating Tire Breakwaters.* University of Rhode Island Marine Technical Report #54, Kingston, Rhode Island.

De Young, B. 1978. *Enhancing Wave Protection With Floating Tire Breakwaters.* Cornell University Sea Grant Extension Program Information Bulletin #139, Ithaca, New York.

Giles, M.L. & Sorensen, R.M. 1978. *Prototype Scale Mooring Loads and Wave Transmission for a Floating Tire Breakwater.* Army Corps of Engineers Coastal Engineering Research Center, Fort Belvoir, Virginia.

Harms, V.W. 1979. *Data and Procedure for the Design of Floating Tire Breakwaters.* New York Sea Grant Institute, Albany, New York.

Kowalski, T. & Ross, N.W. 1975. *How to Build a Floating Tire Breakwater.* University of Rhode Island Marine Bulletin #21, Kingston, Rhode Island.

Penny, B.C. 1981. *Performance Analysis of Test Section Floating Tyre Breakwaters.* Lyttelton Harbor Board, Christchurch, New Zealand.

Ross, N.W. 1977. *Constructing Floating Tire Breakwaters.* American Chemical Society Symposium: Conservation in the Rubber Industry.

Shaw, G. & Ross, N.W. 1977. *How to Build a Floating Tire Breakwater.* University of Maine/University of New Hampshire Cooperative Institute Sea Grant Program.

Stanley Consultants, 1970. *Recreational Boating and Commercial Dock Facilities, Lorain, Ohio.* Lorain Port Authority, Lorain, Ohio.

Stanley Consultants, 1978. *Lorain Harbor Recreational Area Study.* Coastal Zone Management Program and the City of Lorain Department of Community Development, Lorain, Ohio.

Stanley Consultants, 1980. *Lorain Marina Feasibility Study.* Coastal Zone Management Program and the Lorain Port Authority, Lorain, Ohio.

Woodhall, E.S. 1980. *Breakwaters as an Aid to Marinas, Shore Erosion Control and Marine Life.* Presentation Paper, Ohio Sea Grant, Floating Tire Breakwater Conference. February, 1980, Firelands College, Huron, Ohio.

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