MIT SEA GRANT
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Quarterly Report

3 copies

Letter from the Editor

The spring issue of the MIT Sea Grant Quarterly Report rounds out the first year for this new publication. Those of you who have been on our mailing lists for more than a year previously learned of program activities through publication abstracts, directories, and the annual report. However, many wanted even more in-depth information on research and education projects, particularly current ones. That interest sparked the Quarterly Report.

Now, after four issues, would you tell us if we're successfully anticipating and answering your questions in a form that is helpful to you. Please take a few moments to fill out the enclosed survey.

In appreciation for your time and effort, we would like to offer you a complimentary copy of any currently available MIT Sea Grant report. Many thanks for your assistance and continuing interest in MIT's Sea Grant College Program.

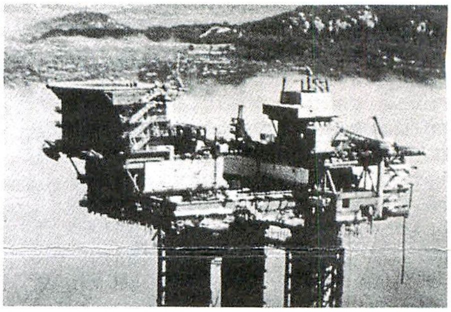
Predicting Foundation Performance for Offshore Platforms

Several years ago, Dutch engineers began designing a new flood defense network for the country's coast. In Oosterschelde Bay, south of Rotterdam, they chose concrete structures as barriers to protect the large inlet from sizeable tides and storm waves. In their original design they faced the uncertainty of how the foundation soils would behave with the continuous smashing of waves against the structure itself. They worried that in time, the cyclic attacks would soften and weaken the soil, causing the structures to move or to swing back and forth, much the way buildings act during earthquakes.

"Work on this project stimulated our interest in the whole subject of soil behavior in the sea bottom under cyclic loads that result from waves hitting offshore platforms," says Allen Marr of the MIT department of civil engineering, who participated in the Dutch project. Currently Dr. Marr, Professor T. William Lambe, and Mr. Alfredo Urzua, Lee Wooten, and George Bouklavas are completing a Sea Grant project to investigate the effects of cyclic loading on the foundations of gravity platforms. These massive structures rest directly on the sea bottom. While they are heavy enough in proportion to the wave forces to remain stable, the continuous, cyclic stresses cause changes, especially deformations, in the foundation soil.

Permanent deformations from an oscillating structure can have serious consequences. In the case of a large deformation, the structure may settle, leaving the platform's living and work quarters without freeboard and within dangerous striking distance of the sea. Settling can also rupture connections between the riser pipes that bring oil up into the platform, with consequential spills and shutdowns. A drilling or production operation may also have to temporarily close down if the workers are unable to abide the platform's oscillating motion.

"We're trying to develop techniques for predicting what these deformations will be so that we can design structures to minimize or tolerate their magnitude," says Marr. The team began with models of soil behavior that predicted stress for a particular wave load at different points in the foundation. Then they moved to the laboratory to duplicate the existing stresses on an element of soil from the sea bottom, and applied the



changes in stress which a wave would exert.

They cycled those stresses "just as a wave would in the field," asserts Marr, and extrapolated to a general set of conditions for stressing. The resulting mathematical model will allow them to predict the effect of waves of different heights on the cyclic and permanent deformation of the structure.

An earlier version of this model was used in the field tests on the Rotterdam flood defense plan. Before the actual test, the Dutch engineers asked several experts using various calculation methods and models to predict how much the structure would deform. While the predictions differed by orders of magnitude -- some engineers stated that the foundation would fail while others thought that the foundation would barely move -- Marr felt "very pleased" with his team's results.

"We know that our fundamental approach was very sound and based on a rational set of principles," he states. "Accurate predictions are difficult to make in the field of geotechnical engineering. If we can predict displacements for cyclic loads within a factor of two, I'll be very happy." Marr believes that his research team's analytical techniques will help in designing structures to withstand extreme loads.

Their task is complicated because soils behave unpredictably. Nature has not done an orderly job of laying them down. One small, weak layer, if undetected, can undermine the best efforts to build a stable structure. Soils are fairly inelastic and once deformed do not rebound to their original shape. Unlike man-made, "one phase" materials such as plastic and steel, soils are two or three phase materials that include other variable elements, water and sometimes air. "Each variable or 'phase' adds complexity," he explains.

Theoretical analysis and laboratory tests must also be run with necessary approximations of the ocean's behavior. The researchers must "pretend that the sea is a very nicely behaved system with waves like sine waves," Marr explains. A test which more closely represented the actual system would be very difficult to conceive, carry out, and interpret.

The resulting mathematical model extends work already developed by the geotechnical group at MIT "We're going into a new area in trying to define more completely the behavior of soil for cyclic loads. Our contribution has been to focus on how cyclic loads produce permanent deformations and displacement," Marr says. The nature of the stresses existing on the ground and those occurring due to the weight of the structure greatly influence both the magnitude and pattern of foundation deformation.

"It's a very complicated problem when you start putting a repeated load on something which substantially changes its properties due to that load," he adds. "We're trying to develop a technique to tell us that we're not getting up into the load range where the foundation suddenly collapses or fails, that we're designing in an area where deformations will remain small."

After the researchers finish their Sea Grant sponsored work on the finite element model that includes the stress/strain relationship, they will begin to study, with support from the Venezuelan government, a different type of offshore structure located on the continental shelf off Venezuela. They hope to start applying the theory and model to some real structures, "getting a feel for how accurate they are and where our shortcomings are. We've had to make a lot of simplifications, so we're sure there are some problems we haven't thought about and some simplifications that are too broad." For example, pore pressure builds up as the load starts to cycle. But as this pore pressure dissipates,the density of the soil changes and affects its behavior. "The question is predicting how these properties change and grinding that through some kind of analysis," says Marr.

"Some people say obtaining a representative method of analysis for this complex problem is impossible. But I think we're making sound incremental additions to our technology for designing safer and less expensive offshore structures."

Eel Grass Declines, Environmental Question

Fields of eel grass, an open water plant of immense ecological importance, line both the Atlantic and Pacific coasts. At different stages in the plant's life cycle it nourishes, protects and shelters fish, shellfish and birds, helps prevent erosion, and fertilizes the coastal ecosystem. Many organisms graze or grow on it, some creatures eat its leaves or seeds directly, while others digest the nutrients as it decays. Still others prey on neighbors living in the eel grass community.

Occasionally a serious plague attacks the eel grass fields, causing plants to brown and wither by the millions. The loss of a key source of plant detritus and of the microscopic organisms on the bottom of the food chain causes a devastating domino effect throughout populations of fish, shellfish, and birds. In short, the whole marine food chain is disrupted.

In the 1930s, researchers in Maryland and Europe blamed an international eel grass plague on Labyrinthula, a protozoan parasite which lives on the grass. Since the plant is a vital part of the coastal ecosystem, researchers at MIT are trying to learn whether Labyrinthula really is the cause. A Sea Grant sponsored project led by Eugene Bell, professor of biology, so far hasn't found any definitive evidence that the colonial protozoan is responsible. However, they have devised a more systematic way of studying a difficult environmental problem, and have also learned much about Labyrinthula's unusual means of locomotion.

The earlier field work on Labyrinthula and eel grass "was not of a very rigorous character," criticizes Professor Bell. Since eel grass is home to a large microscopic community, "When the researcher thought he was applying only Labyrinthula to eel grass to test its effects directly, we are not certain that the deleterious effects reported were not due to the action of some other organism."

To avoid such ambiguous results, Professor Bell's team did controlled experiments in the laboratory on clean eel grass to check the effects of Labyrinthula alone. Under these conditions they were unable to produce any browning effect or any increase in the rate of leaf turnover. Professor Bell's coworkers currently include Norio Nakatsuji, Stephanie Sher, Greg Famiglio, and Takako Nakatsuji.

Under normal conditions, Labyrinthula might be harmless. But in special cases Bell speculates that it might turn pathogenic and cause plant diseases. For instance, changes in salinity after hurricane-induced flooding might permit a pathogenic strain of Labyrinthula to flourish where it normally would be competitively controlled by the other

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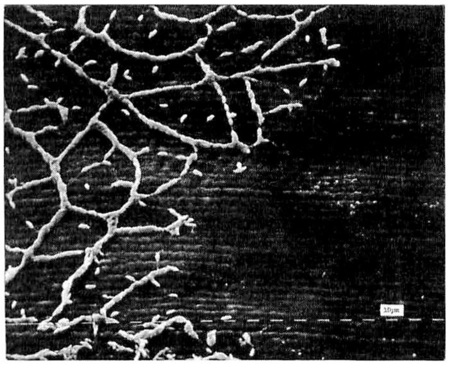
The MIT Sea Grant Quarterly Report reviews the Program's marine-related activities at the Massachusetts Institute of Technology. Free subscriptions are available on request from the MIT Sea Grant College Program, Building E38, Room 360, Cambridge, MA 02139. Telephone: (617) 253-4307.

strains present in the eel grass community.

Sound laboratory assays will be exceedingly useful in the future for looking at the plant and the materials that grow on it. Then, if an eel grass plague occurs, they can be used to test samples of the diseased plant in the laboratory where "we have the methods worked out to look for the causes of the disease."

"Environmental science is difficult; at times we can't call it science," Bell states. "It involves considerable guesswork, or rather, intelligent forays into a complex problem. The more that can be brought into the laboratory for precise analysis, the better." Therefore he emphasizes the importance of establishing well defined testing methods.



Labyrinthula cells move along eel grass within a substance they manufacture and secrete.

In the course of the Sea Grant research, the group developed what Professor Bell considers "a profound understanding" of the characteristics of Labyrinthula which permit it to move around on eel grass. The cells secrete a specialized substance which organizes into what Bell calls an external engine, surrounded by membrane. As the cells move within the substance that they manufacture and secrete, they interact with it in such a way that they are dragged along by the 'engine.' Other research work is underway to see how the engine is regulated.

Knowing how Labyrinthula moves could help clarify how (or if) it causes plant disease, explains Professor Bell. From their experiments his group realized that it can roam freely across the plant from root to leaf tips. Labyrinthula not only grazes on other microscopic eel grass inhabitants, but probably utilizes the leaf components directly by releasing little packets of enzymes. However, this process may occur only on those parts of the leaf which are already dead. Nobody knows yet whether this release can break down healthy plant tissues, or whether the enzymes work only on weakened plants. Perhaps special environmental conditions must also be present at the same time to cause disease. All these factors contribute to "why one has to look at the global environmental situation to understand what is going on," asserts Bell.

The group will continue to study how Labyrinthula relates to its environment and what stimuli it responds to, such as light or certain chemicals. They are also working on the environmental factors which might favor the growth of pathogenic strains of Labyrinthula or yeasts, and the internal factors which regulate cell motility.

Despite its profound importance to coastal ecology, very little is known about general fluctuations of the eel grass population. "It should be a considerable priority to conduct an overall eel grass census and look at ways of keeping track of the resource. Should declines be evident, something might then be done about reversing them."

Sea Grant Technology Skins Dogfish Shark

The MIT Sea Grant Program is charged by the federal government to give specialized assistance to local marine industries which cannot afford necessary but costly research and development investments. Most recently Sea Grant has worked with MIT researchers through the Massachusetts Marine Liaison Service (MML) to develop a prototype spiny dogfish skinning machine, which will make the processing of this species more economical for domestic food processors.

Currently the spiny dogfish or grayfish represents the largest unexploited fish resource in the Western North Atlantic. Although the exact stock size is not known, National Marine Fisheries Service trawl surveys indicate that there is a substantial yield of about 40,000 tons per year. This is very significant because historically haddock has only produced 50,000 tons annually, and yellowtail flounder rarely exceeds 40,000 tons annually. In the late spring and early fall, dogfish are most plentiful, outnumbering cod ten to one.

There are large markets for this fish throughout Europe and Asia. In Great Britain it is used in fish and chips,and in Germany the belly flaps are smoked and sold as delicacies. Much is to be gained for U.S. fishermen if either a U.S. market for dogfish or an export trade to Europe is developed on a larger scale. Fishermen would be able to sell a fish that they currently catch but throw back as worthless. Also, just as importantly, by decreasing the inflated stocks of dogfish, other important food fish like the cod, haddock, and mackerel -- that dogfish eat -- might be allowed to increase.

As for the marketability of this species in the United States, dogfish, which weigh between seven to ten pounds average, can produce a high protein fillet of about two to three pounds. This fillet can be cut into fish sticks, or used as fish steak in stews, but the technology to skin and process these sharks lags far behind that for other more popular species.

Dogfish processing is done almost exclusively by hand. Arthur B. Clifton, director of the Massachusetts Marine Liaison Service, reports that in one plant in Everett, Massachusetts, "a worker must secure the fish on a hook before he can make a few initial cuts with a knife. Then he takes a pair of pliers and grabs hold of the skin, pulling it off like he was trying to start an outboard motor." He adds that in many cases, "he really has to put his foot up on a bench to brace himself in order to remove the skin."

Hand skinning is difficult because of the hundreds of little dentals that comprise the dogfish's sandpaper-like skin. Like the feathers on a bird, which evolved from the scales of reptiles, the shark's skin is covered with *vestigal* teeth.

Machines exist for skinning fillets of fish such as cod, haddock, or flounder, but they have not been successful with dogfish for two major reasons.

The first is that the rotary blades which separate the meat from the skin require constant resharpening or replacement. The second and more important reason is that these machines are made to skin fish which are essentially flat.

Sharks are nearly round in cross section, as opposed to the thinner cross sections of cod or haddock. The top half of the dogfish is basically flesh and spine, while the bottom half is composed of the abdominal cavity and belly flap. This layout lends itself to cutting horizontally along the bottom of the backbone as opposed to cutting fillets from the sides of the fish.

When attempts have been made to skin the whole dogfish in existing machines, the blades tend to take off only a narrow strip of skin with each pass of the fish through the machine. The only part of the dogfish that can be skinned is the belly flap, but this is only after it has been pulled off the fish by a hand skinner.

For these reasons, Sea Grant approached Professor David Gordon Wilson of the department of mechanical engineering to design a cheaper, more mechanized processing method that would overcome these problems, and thereby greatly increase the success of an American dogfish industry.

The operation of the resulting prototype machine, designed by Professor Wilson and graduate students Michael Atlas and William Hoff, is simple. The fish is placed on a conveyor belt and moved to the wheel where it is impaled. Knives cut off the fins, tail, and belly flap, which are the easiest part of the fish to remove. The bulk of the skin is then removed by counter-rotating drums. A gripper drum pivots against the head of the fish and a rotary blade protruding from the wheel makes a nick on the back of the neck. When the blade retracts back into the drum, the drum rotates, driving a gripper blade into this nick, and clamping the skin to the gripper drum. The gripper drum and main wheel then move in opposite directions, peeling the skin off the fish in much the same way one peels a banana.

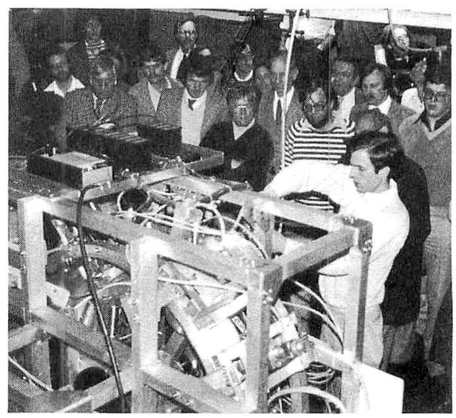
The drums are gear driven by electronic mo[illegible] rotary knives and actuators are air operated. The prototype is sequenced by a programmable digital relay logic controller. This type of controller, though unusual on a fish processing machine, is common in other areas of industrial processing.

Because the fish skin is peeled off by a machine rather than sliced or scraped, the quality of the flesh is comparable to that produced by hand skinning. After the machine skins the fish, the flesh and belly flap can be removed by hand.

This prototype machine can handle all marketable sizes of spiny dogfish or smooth dogfish without adjustment. Currently the MIT researchers are testing the machine's suitability for use on other round fish, in particular catfish.

The concept and hardware of the machine have been patented by MIT. The MIT Sea Grant Program's Massachusetts Marine Liaison Service is now striving to license a suitable manufacturer to undertake the necessary product engineering and marketing which will maximize the machine's impact and benefit to the fishing industry. They recently held a demonstration for more than 65 industry representatives at MIT.

If you are interested in knowing more, please contact either Arthur Clifton or Clifford Goudey at the MIT Sea Grant Office at (617) 253-7136. A brief video tape describing the machine and showing the skinning operation is available for viewing on a 3/4 inch cassette monitor.



In March, MIT Sea Grant demonstrated the prototype machine for the fishing industry.

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MIT Sea Grant
Quarterly Report Survey

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Many thanks for your help in answering this survey. We hope you will accept our appreciation and order a complimentary copy of one of our MIT Sea Grant reports. Please indicate the name and MITSG number: ______________________

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