It's safe to say that marina tenants appreciate placid moorages, but many of them have little or no idea how much science and engineering goes into planning and designing them. As a structural engineer specializing in marina design for the last 20 years, I can tell you that designing a tranquil marina is no easy task.

A smooth ride in a marina delivers more than just a higher level of comfort to tenants and a less stressful berth for their boats. It can also turn a parking lot for boats into a revenue-producing machine. As the saying goes, “The more tranquil the marina basin, the more likely the tenants will come to the marina and use its services.”

A good example of this saying can be found at Elliott Bay Marina, nestled in the harbor in Seattle, Wash., with its panoramic views of the cityscape, Mt. Rainier, and the Olympic Mountains range. The marina is so pleasant that businessmen leave their office buildings to lunch with clients and have a drink on their boats. What most of these businessmen don’t know is that it takes a combination of wave attenuator, wave wall, and rubble mound to protect the marina and provide this tranquil setting.

In addition to sheltering the marina basin, wave attenuators provide other revenue benefits. Many marinas use them for fuel docks and visitor moorage, as well as floating platforms for bait shops, groceries, and harbor-master on-dock service booths. Marinas can even use the offshore side of many

Floating wave attenuators provide peace, protection, and tranquility on an affordable budget

By Craig Funston, P.E.

terms of costs and benefits, marinas typically depend on the knowledge and expertise of consultants and manufacturers. Everett Babbitt, president of Bellingham Marine, Bellingham, Wash. offers a manufacturer’s perspective. “Wave attenuators are generally less expensive than fixed structures such as rubble mound breakwaters,” said Babbitt. “Like all components of a marina, we design them to be site specific. Fetch distances, wind speeds, water depths and an array of other factors will affect the cost.”

When determining the most cost-effective attenuator, Babbitt stressed the importance of having a skilled professional analyze the marina site. “If a floating attenuator looks like a possibility, then budgets can be formulated with the preliminary engineering,” he said. “This is well worth the effort. Attenuators have proven durable and successful for decades, often with very little maintenance.”

This marina in Oak Harbor, Wash. uses a castellated concrete floating wave attenuator developed especially for the site by Bellingham Marine.
"A great example of this formulation is the city marina in Oak Harbor, Wash.,” Babbitt continued. “Their attenuator creates wonderful public access and picnic areas and hosts one of the region's most popular sailboat racing venues.”

Reflection vs. attenuation
Taking the rock and roll out of a wave has only two solutions. First, one can reflect the wave off of an impervious, immovable object. A rubble-mound breakwater or a solid wall are the most obvious examples of this method.

A floating concrete wave attenuator performs the same function for that part of the structure that fronts the wave. Today's concrete wave attenuators typically have so much mass and inertia that they appear solid to an incoming wave. In practice, the floating concrete wave attenuator will reflect most of the wave energy in the same manner as a fixed breakwater or wall.

A unique option for keeping the marina placid is to install a recreational island. The city of Ft. Pierce, Fla. is considering such a solution after its battle with Hurricane Frances. It's a sure solution to the problem of long fetches in the Intracoastal Waterway. (See “Ft. Pierce Marina Tells a Story of Hurricane Fury and Destruction,” Marina Dock Age, May/June 2005).

The second method is to let the wave pass—but dampen or suppress its energy as much as possible as it passes. Some fixed wave walls are open at the bottom for ecological purposes, and essentially act as wave attenuators. These walls have openings designed to prevent “dead” areas that interrupt current and tide flow, and where the water can become anoxic (lacking in oxygen), which is obviously unhealthy to life.

Marinas considering rubble-mound breakwaters and fixed walls (whether vented or not) will find that they are often much more expensive than attenuators; can't be easily moved in future remodeling projects; are potentially harmful to the harbor's ecology; and require the harbor to be reasonably shallow at the installation point. For many marinas, any one of these issues would point them toward a floating wave attenuator.

Concrete attenuator
It is important to note that the modern concrete floating wave attenuator is not a wave eliminator.

The modern floating wave attenuator design works as both a reflector and an energy attenuator (Fig. 1). For the part of the wave energy from the top of the wave to the bottom of the wave attenuator, the wave is reflected. The energy below that point is dampened by the mass and breadth of the wave attenuator.

But there are limits. In the final
analysis, wave attenuators can only reduce the energy in a wave and act as a shock absorber to dampen its movement. In extreme conditions, which are rare except for open water situations, the wave length can be so long the wave attenuator moves in synch with the wave and there is no dampening at all. Given the semi-protected waters that are most common for U.S. marinas, this extreme-case phenomenon is very unlikely.

Attenuator design
So how does one design wave attenuators for marinas? The first step is to determine the worst-case storm event that can be expected in 15, 25, or 50 years. Marinas can and should hire consultants to collect and analyze meteorological and topological data to determine a worst-case event. This will be an educated guess and will never be perfect, because we’re dealing with nature.

But don’t lose sight of the value of site-specific engineering. For 99.9% of the time, a well-engineered solution will help most marinas survive storms and protect the marina investment and its tenants.

To complete the engineering and design, the marina must address several questions. What are the expected winds, and from where will they come? How long is the fetch? Do topographical or structural obstructions create reflections and multiply the effects of the waves? How shall the wave attenuator be situated relative to the threat? What are the height and period of the waves?

With this wave information, engineers and scientists can apply a statistical approach to provide a useful prediction of the conditions the new wave attenuator will perform against. From this analysis one can build a wave attenuator best suited to the site.

Energy below the sea
Most marina managers tend to think of a wave as extending from the trough to the crest, but much of its energy extends down into the sea—especially when the bottom is closer than half the length of the wave. For the purposes of this article, the wave begins to interact with the bottom at about 30 to 40 feet of depth.

Once the wave reaches shallow water, the motion within the wave is elongated from circular to elliptical. The water below the surface becomes more agitated and the wave energy is more continuous from the surface to the bottom. Figs. 2 and 3 show this effect.

How they work
Wave attenuators work by reflecting the part of the wave that fronts the wave attenuator. Therefore, the deeper the wave attenuator, the more effective it will be. But there are limitations.

Installing very deep wave attenuators creates tremendous forces on the marina’s mooring systems. Thus, engineers compromise between depth and function so that wave energy is allowed to flow beneath the wave attenuator.

So what happens to the energy beneath the wave attenuator? Wave energy is dampened by the mass and inertia of the attenuator as the wave passes under it. The wider the attenu-
Wave energy diminishes with depth in a deep water wave.

For waves with a period greater than four seconds, the width of wave attenuator that would be needed becomes impractical for most applications.

Note: To get the desired effect it isn’t necessary to have a solid bottom. Marinas can get the same results by placing flanges or skirts front and back that extend the depth facing the wave to create a “box” open at the bottom (see Fig. 1). Tests have shown that an open-bottom box works about as well as a closed one, but is less expensive to manufacture.

**Six things to remember**

When it comes to installing wave attenuators, marinas should remember six things:

- Performance of a wave attenuator is determined first by depth, then width. Deeper wave attenuators do a better job of reflecting waves, but they also create powerful forces on the mooring system. Wider wave attenuators create friction that takes energy from the wave, but require less rugged pilings or moorings.
- For waves with periods longer than about four seconds, a floating wave attenuator may be impractical.
- In designing and constructing wave attenuators, marinas should avoid “hinged” connections, and note that continuously-joined longer structures work best.
- Be very selective about putting permanent moorage slips on floating wave attenuators because they do move in storms. Using the outside of a wave attenuator for transient moorage is fine, but not recommended during storms.
- Wave attenuators typically cost less than the cost of a rubble-mound breakwater or sea wall, and can be used in deep water.
- Wave attenuators are ecologically friendly and can actually stimulate additional sea life in the marina because...
they attract vegetation and bivalves, which attract fish.

**Beneficial results**
The floating wave attenuator has made an important contribution to the marina industry. Here are two examples of the benefits attained from wave attenuators at marinas.

Barb Herzog of Sunset Marina, Key West, Fla. credits the marina’s wave attenuator with saving the facility from extensive damages during Hurricane Wilma (October 24, 2005).

The marina is situated in a protected basin, with the western opening exposed to the Gulf of Mexico. Two wave attenuators are located on each side of the entrance channel to protect the west side. The section closest to the marina also serves as the home base for a 115-ft. charter fishing boat that provides both mooring revenue and protection and wave attenuation for the basin.

“Wilma could have caused extensive damage to the marina and all the boats inside, but it didn’t,” Herzog said. “The two wave attenuators did their jobs. The winds reached 135 mph, the storm surge lifted the marina-side wave attenuator to within a foot of the top of the pilings. When the surge subsided, it came back down and everything was fine.”

The wave attenuator on the other side of entrance was severely damaged, but it also did its job, according to Herzog. “The wave attenuator was lifted above the piling and is a mess,” she said, “But it saved the marina. We only had one boat with cosmetic damage and the docks were fine.”

In Sausalito, Calif. Ken Pedersen, president of Clipper Yacht Co., which manages a marina here, said the oldest part of the marina (Basin Two) wouldn’t be standing today without a properly designed and installed wave attenuator.

Pedersen said that Basin Two at the marina is a fixed wooden dock moorage decked with one-by-six planks. In 1997, an El Nino caused extensive damages at the marina. The insurance money allowed the marina to put in a 480-ft. wave attenuator. “Without it [the wave attenuator], we wouldn’t be able to keep the marina open in Basin Two,” said Pedersen. “The wave attenuator has protected those old wooden docks all this time as we continue to press for approval of our remodeling project.”

So, wave attenuators continue to improve the lives of boaters everywhere and is clearly winning the recognition it deserves.

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