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Saving Lives with Precast

Newly developed precast concrete emergency shelter has the potential to save thousands of lives.

By Shari Held

Image courtesy of Brahman Industries


Image courtesy of Brahman Industries

STATIM (Storm, Tornado, and Tsunami Interconnected Module) shelters are designed to provide protection from natural disasters for 50 people.

Natural disasters can have devastating consequences. One of the deadliest, the 2004 Indian Ocean earthquake and tsunami, claimed more than 200,000 lives.

"I remember being shocked by those images," said Miguel Serrano, principal of Brahman Developments, a company based near Fort Lauderdale, Fla., that specializes in upscale residential construction projects.

Inspired by the event, Serrano pooled his resources and connections – including structural engineers, naval engineers and others – to develop a precast concrete shelter that would protect those affected by natural disasters.

STATIM IS BORN

The result of that collaboration is the STATIM (Storm, Tornado, and Tsunami Interconnected Module) shelter. Each module provides protection for 50 people and contains two weeks of emergency supplies, batteries, solar power and communication technology for tracking purposes.

Speaking with Serrano reveals his passion for and dedication to the shelters. He relocated Brahman Developments from Puerto Rico to south Florida, founding Brahman Industries to handle development.

"I moved to Florida specifically because it has the casting plants and a robust maritime industry infrastructure and resources such as high-capacity gantry cranes, which are needed to handle completed shelter units for water trials and destructive testing," he said.

Though still in development, STATIM has already received a U.S. patent and has 14 other patents pending from other countries. Worldwide, big hopes and expectations are riding on STATIM shelters.

Many shelter concepts have been advanced prior to STATIM, but none are of the size and scale appropriate for community and government applications.

"If they are strategically fielded and implemented, they could save tens of thousands of lives, if not hundreds of thousands," said Dr. George Pararas-Carayannis, president of Tsunami Society International.

Each of the shelter's four precast concrete modules will be 13 feet in diameter and 10 to 12 feet long.

PRECAST IS THE ANSWER

Serrano knew his concept for the STATIM shelter had to be simple, durable and affordable. It needed to rely on readily available materials and unskilled labor to be easily manufactured worldwide. And it had to be strong enough to survive the impact of the initial tsunami wave while providing occupants with a minimum of two weeks of supplies.

Initially, Serrano and his collaborators considered constructing the STATIM from aluminum. That idea was nixed because it was too expensive and required special skills to produce. The same went for steel, which also had corrosion issues. Fiberglass and carbon fiber were also discussed, but both were too lightweight to survive the acceleration of the first wave of a tsunami.

While the team continued working on development, Serrano happened to watch a documentary about the manufacture of large-diameter, precast concrete sewer pipes. The film served as the catalyst for his aha moment.

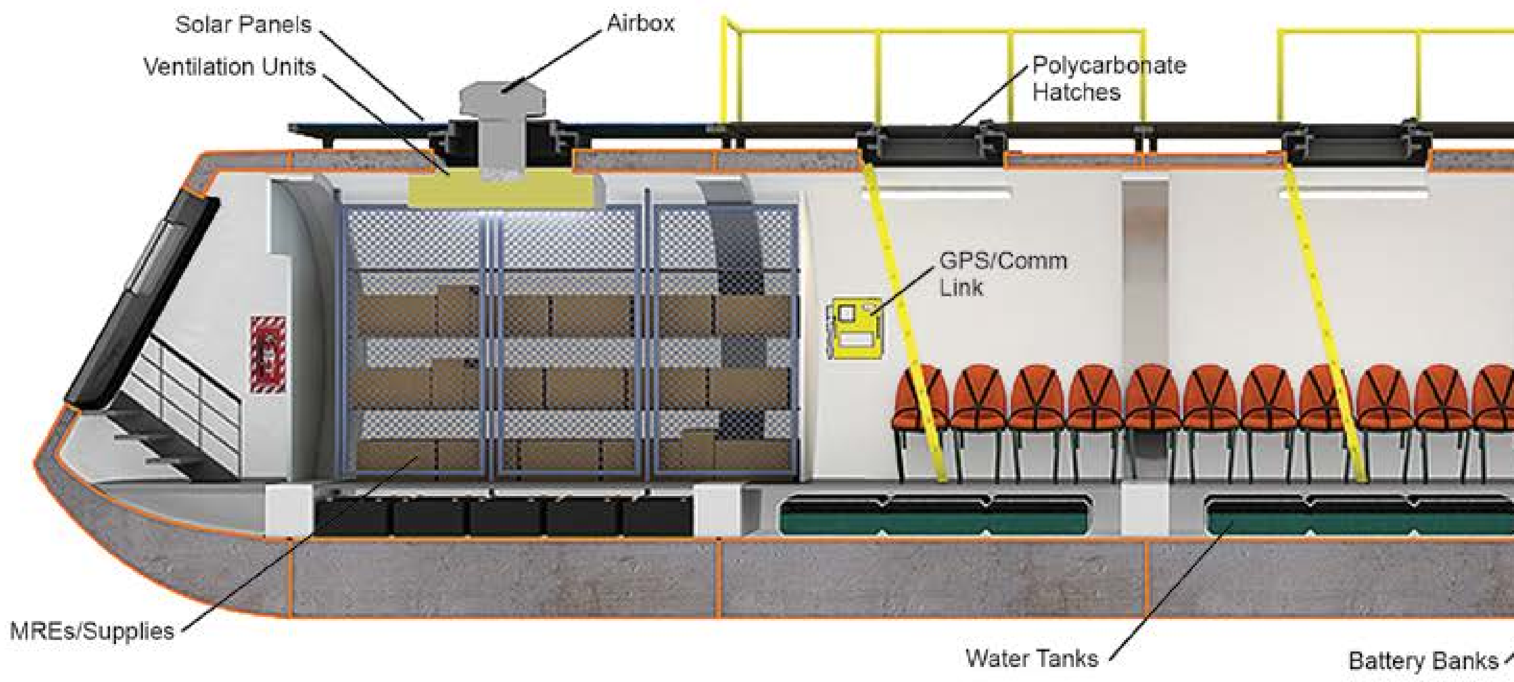
"That's when I said, 'Hey, rebar and concrete is the way to do it – it's inexpensive, there's no highly skilled labor needed and materials are available everywhere,'" Serrano said. "It's got to be concrete!"

BUT WILL IT FLOAT?

On paper, concrete was the best material for the job, but would it float? To find the answer, Serrano consulted with Anthony Martinez, P.E., of Martinez Marine Design, a Houston-based naval architecture and marine engineering firm.

"In the beginning, I suggested Miguel use a material other than concrete," Martinez said. "Large ships are almost exclusively built from steel. Concrete vessels are certainly contrary to a lot of traditional thinking."

Martinez worked with Serrano to review the design of the module's cylindrical shape and stability. He calculated not only whether the proposed precast structure would float, but whether it would remain in an upright position and be able to maintain that level of buoyancy.



This cross-sectional view depicts the many resources available inside a STATIM shelter.

The dimensions were instrumental in making the precast modules float. Once constructed, each module will be 13 feet in diameter and 10 to 12 feet in length. A typical, fully assembled hull unit – which includes four center modules and two end caps – will weigh approximately 227,000 pounds.

"Since they are made from concrete, they have to be of sufficient size so they displace more water than they actually weigh," Martinez said. "The distribution of the precast concrete within the construction of the hull itself is what allows it to remain upright."

Concrete's mass solved the STATIM's controlled buoyancy issue while enabling it to protect occupants from life-threatening tsunami waves.

"If it were made of steel, the force of the acceleration in the initial wave could shake the occupants to the point of injury or even death," Serrano said. "Concrete has a lot of positive factors."

NO MARGIN FOR ERROR

The main difference between the STATIM shelter and the concrete sewer pipe which inspired Serrano's design is that the STATIM is engineered with internal ring beams for added structural reinforcement. Modules are joined by watertight gaskets.

"With the current design, we can join up to five modules, plus two end caps," Serrano said.

The more rounded end cap will be positioned toward the expected direction of the wave. The other end cap functions as a watertight door that enables ground-level boarding for passengers with disabilities.

In 2012, Serrano approached Toronto, Ontario-based Hamilton Kent to help design a robust, watertight joint and produce a gasket for the project.

"To accommodate the required pressure of 5 psi and the type of overlap on the sections, we had to come up with a unique solution," said Jason Maristanez, product development manager with Hamilton Kent. "Lives will be depending on the watertight seal."

Hamilton Kent typically manufactures gaskets for square precast structures and round concrete pipes, so they were well prepared to provide appropriate assistance. The company ended up modifying an O-ring joint to work with the STATIM's cylindrical shape.

"We provided a certain amount of gap in between the spigot and the bell of the joint," Maristanez said. "From there, we were able to calculate the proper diameter of O-ring to meet the pressure requirements Miguel required."

SIMPLE AND EFFICIENT

Serrano's production model is to create the steel forms and ship them to precasters that will produce the modules and transport them to installation sites. He plans to build a global network of precasters he can train and rely on for this part of the job.

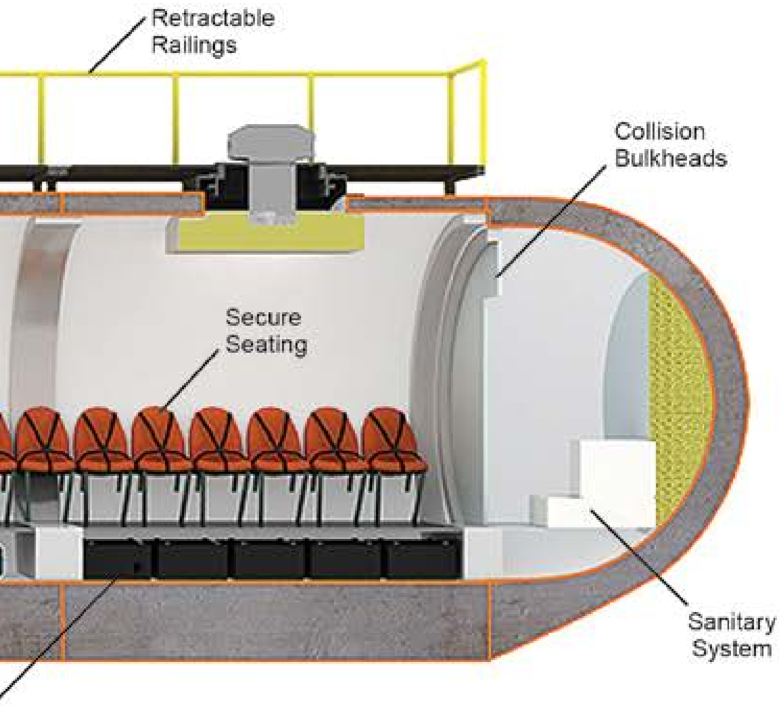


Image courtesy of Brahman Industries

Since the project is still in the development stage, the precast specifications remain fluid. But one thing's for sure: The STATIM units won't be manufactured using any complicated mixes or compounds.

"Keep it simple is our goal," Serrano said. "We want the design to be easily duplicated in remote locations like Indonesia that may not have access to the same materials at the same cost as we have here."

Current specifications call for:

- Minimum concrete unconfined strength of 5,000 psi at 28 days
- Concrete specific weight equal to 150 pcf (a conservative assumption that may be reduced to 110 pcf)
- One-inch diameter, high-strength threaded bars
- Mild reinforcement to meet ASTM A615 Grade 60
- 0.6-inch diameter strand, Low-Relaxation to meet ASTM A416 Grade 270 ksi

Completed modules can be transported via standard low-bed trailers, railways or barges. STATIMs can be surface-mounted, partially buried or, if being used as a storm/tornado shelter, completely buried.

Installation is a breeze. First the site is prepped. Then the modules are joined and the gasket joints sealed. Finally, the elements are secured via post-tensioning. This enhances the flexibility and movement of the structures, allowing bigger shelters to be created.

MOVING FORWARD

Collaborative projects – especially when those involved are volunteering their time and resources – don't often move quickly. It took two years to develop the STATIM concept. In 2011, a month after Serrano received his first U.S. patent, a tsunami killed 18,000 people in Japan, precipitating the meltdown of the Fukushima Daiichi nuclear plant.

"It was painful to watch while we were working on something that really could have made a difference," Serrano said.

Because forms of this size are so expensive to make, Brahman Industries will initially use small-scale computer models to study the STATIM behavior, buoyancy and recovery times. Serrano anticipates producing a full-scale prototype later this year.

"We are striving to keep the cost around $2,000 per occupant," Serrano said. "That would make it exponentially more cost-effective than other alternatives."

At $2,000 per occupant, he estimates the STATIM system will cost 1/10 the price of a traditional search and rescue operation. Additionally, STATIM is an improvement over alternative solutions because the units will be able to accommodate more people.

"Our idea is to spread shelters for 50 people throughout the region, so everyone is ensured they can reach their designated shelter," he said.

Serrano has already received a letter of interest from Japan for 250 units and strong interest from the Netherlands and Chile. Resorts, hotels and coastal communities are also inquiring about STATIMs.

"Miguel is a very capable and resourceful inventor and entrepreneur," Pararas-Carayannis said. "I'm confident it will come to fruition."

The success of STATIMs, Martinez noted, will also do much to promote the use of precast to deliver safe, easily constructed vessels to places without well-developed infrastructure systems.

"That would be extraordinarily significant," he said. PS

Shari Held is an Indianapolis, Ind.-based freelance writer who has covered the construction industry for more than 10 years.