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Plastic grids may replace sandbags

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Waterways Experiment Station

"The flash flood hit this morning after two days of heavy rainfall. As local streams and rivers erupted from their banks, the floodwaters completely inundated the municipal water treatment plant and forced evacuation of the hospital, overwhelming sandbagging operations. Damages will be in the millions of dollars and repairs could take months..."

News stories like that may soon be history in many instances thanks to a cooperative research partnership involving a small business, the U.S. Army Corps of Engineers, and a new flood fighting material originally developed for military roads.

For decades, the main tool in fighting floods has been the sandbag — simple to operate, but labor intensive and slow to emplace. The Corps has a long history of fighting floods with sandbags. Al Arellanes has been involved in flood fighting for more than 20 years as both a contractor and as a government official, and he knew there had to be something better than sandbags.

In 1984, Arellanes became involved as a contractor with research at the Waterways Experiment Station (WES) site of the Engineer Research and Development Center to build field fortifications using a unique expandable plastic grid system.

The expandable "sand grids" were invented a few years earlier by Steve Webster at WES to stabilize expedient military roads across beaches and similar soft soils. The Corps later patented the grid cells.

To build roads, the plastic sand grids are expanded and filled with sand, soil, and other local materials to form a stable roadway base. Other WES researchers thought the grids could be used to build expedient field fortifications by stacking them on top of each other to form protective walls and bunkers.

"I started working on the field fortification effort with Capt. Andy Hamlin at WES," said Arellanes. "But early on, we saw limitations in the commercially manufactured sand grids used at that time for roads."

Arellanes altered the existing roadway grids until he developed his improved version, the Rapid Deployment Fortification Wall (RDFW). He sold his first RDFW to WES in 1985. Limited research continued on the grids for fortifications, but they never saw widespread use.

Through the years, Arellanes kept tinkering with the grids and improving them by using different plastics (including recyclable), different grid cell sizes and configurations, and different collapse-expand designs.

The early1990s saw Arellanes working for the Federal Emergency Management Agency (FEMA) as a disaster assistance manager at flood events. Working a static flood in northern California, it hit Arellanes that stacked grids, similar to the concept for field fortifications, could be used as an alternative to sandbag walls for flood protection. He left FEMA to work on the grids as a new effective flood-fighting tool.

The grid wall took more than 72,000 waves up to three feet high in the L-shaped wave flume at WES with minimal damage.

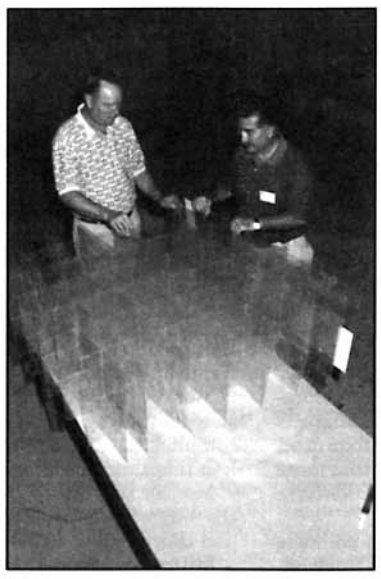
"We did more than 20 site demos of RDFW for flood fighting throughout California to various agencies," said Arellanes. "Each time, the officials liked it, but said 'We need more data.'"

In 1996 Arellanes contacted Phil Stewart at WES about getting a license to use the Corps-patented grids. Stewart runs the Office of Research and Technology Applications. Working with Stewart, Arellanes eventually established a Cooperative Research and Development Agreement (CRADA) with WES. A CRADA is a research partnership between a federal laboratory and private industry.

"CRADAs benefit our research program by providing extra funding, they help private industry develop better products by using our unique facilities and expertise, and it helps the nation by providing better and safer construction materials, techniques, and methods," said Stewart. "We've done more than 100 CRADAs in the past seven years. In FY 99 we leveraged almost $1 million in extra research funding. CRADAs are a win-win situation."

The CRADA between WES and Arellanes and his joint venture partners, Ron Brewer (a Native American 8-A small business contractor) and Rey Rodriguez, allows joint research and development tests of Arellanes' RDFW grid system. WES supplied unique research facilities and equipment, technicians, and an engineer, while Arellanes and his partners provided their time, laborers, materials, and built the wall.

The research product will be a written report that can be used by both the Corps and Arellanes. "When he goes before FEMA or other federal or state agencies, Arllanes can say, 'This has been tested by the Corps and here are the results,'" said Stewart.



Steve Webster and Al Arellanes examine a section of the Rapid Deployment Fortification Wall.

They used the L-shaped wave flume at WES to conduct the tests. This unique research facility is 250 feet long, up to 80 feet wide, and seven feet deep. Designed for coastal research, the flume was perfect to put real water loadings on the grid wall, including wave action.

Research hydraulic engineer George Turk headed up the WES support. Turk brought a lot of hydraulics research experience to the test, and he has worked on a variety of CRADAs, mostly on coastal breakwater design. Most importantly, Turk served on a research team that conducted field surveys of expedient flood fighting techniques immediately following the 1993 Upper Mississippi River Flood.

"During the '93 flood, we saw an awful lot of examples of bad sandbagging," said Turk. "I don't want to take anything away from the efforts of the flood-fight volunteers but, in truth, it is very difficult to build a proper sandbag levee without extensive training and experience."

The RDFW grids tested at WES have a collapsed size of four feet by four feet by half an inch, but expand to four feet long, four feet wide, and eight inches high. The grids are stacked and interlock at the top, bottom, and sides to form a continuous cell wall structure. The stacked grids are quickly filled with sand by a front-end loader. The test wall at WES was four feet high and 50 feet long in the flume.

"It's interesting to see this concept become a reality," said Arellanes. "It was amazing to see 40 inches of static water against the wall with only eight inches of freeboard. When we started making waves hit the wall, I was impressed by the wave energy and the consistency the wave machine developed. Each time we ran a test, we raised the bar on the wall's capabilities."

The wall held up incredibly well throughout the testing. The static water load simulating a normal flood event putting little stress on the grid wall. Even under the pounding of more than 72,000 cycles of waves up to three feet in height, the wall showed little evidence of wear and tear.

According to Arellanes, a seven-man crew can build a 100-foot-long, 48-inch-high wall of RDFW in one hour. It would take a 35-man crew up to eight hours to build the same length and as stable a wall with sandbags. RDFW is also reusable for up to six flood events, whereas sandbags cannot be reused and often must be disposed at designated landfills.

With Turk's past flood fighting insight, he is also enthusiastic about the potential for RDFW. "This grid is so simple to use, even volunteer labor could quickly build protective structures that meet construction standards. It could easily protect high-value assets. You could ring such structures quickly with a grid wall. In flood fights, you could use grids to quickly and efficiently close gaps in levees for railroad crossings, roads, and such."

The grid also has great potential in raising levees, according to Turk. "Levees are narrow on top, usually only the width of a road. If you're going to raise a levee elevation with sandbags, say four feet, then the base must be at least 12 feet wide. You flat run out of room to work. A grid wall may only require one or two sections."

Arellanes is very enthusiastic about RDFW and the joint research effort. "With the documentation from these tests, we can show people that we have the product to satisfy their emergency flood fighting needs. By eliminating the labor to emplace sandbags, you can greatly improve the levels and amount of protection during a flood event."

Arellanes' biggest problem in the future may be in determining all the potential applications for RDFW — raising levee crowns, sheet flows on roads, static rises, protecting vital assets, diverting storm water, wind-driven wave flooding, hurricane storm surges. The RDFW may lead to increased flood protection for people and property across the country.