

# Innovative Hygroscopic Flood and Debris Resistant Material

By Stewart Kriegstein

## Sustainability Through Innovation

This article is part of Environmental Connection's mission to help grow the industry by promoting innovative research, products and technology that meet industry needs through more sustainable approaches. Articles in future issues will continue to provide multiple perspectives to promote ongoing efforts to protect natural resources.

Innovations result from solving problems big and small, and some work, others don't. However, all ideas can lead to more and better innovations. In the flood and erosion control industry, there are many new ideas that incorporate the concepts of sustainability, durability, resilience and of course economy.

Professionals in the construction industry are regularly challenged to solve or improve the solution for problems. How those problems are addressed helps contractors work more efficiently, provide higher quality services and, hopefully, make a profit.

Hygroscopic flood and debris-resistant material was conceptualized and created to solve construction-related challenges. When building a new concrete seawall under an existing building on a beach in California, Warstone Innovations preemptively tried to protect the site from tidal flooding, so that a deep large mass concrete footing could be installed. There was limited use of heavy equipment to excavate beach sand for the seawall. It was decided to install a perimeter sandbag wall on the site, parallel to the ocean. The sandbags were manually filled and placed 6 feet (2 m) in depth and 6 feet (2 m) high, tying into existing seawalls adjacent to the project. There were 3,000 sandbags in total. It took a full crew of workmen five days to fill and stack the sandbag wall. Work was performed in mid-August with normal summer weather and normal tidal conditions.



**Figure 1. Absorbcrete® FIB bags used for ocean tidal site protection – foundation repair, Malibu, California.**

Since the new concrete footing was large and workspace limited, the concrete was placed in slots, with a total of four slots for the project. The concrete pour for the two end slots was complete when the weather began to change, and an unusual small summer storm formed and quickly approached the location. This storm caused some beach erosion allowing the tide to reach the sandbag wall. The sandbag wall held fast at first, and concrete for the third slot was poured. The storm intensified in the afternoon and the rain and tide brought flotsam from damaged structures and tree branches. Upon arrival the next morning to pour the last concrete slot, workers found virtually all of the 3,000 sandbags had been washed away. Workmen scoured the beach collecting empty sandbags and found many that had been impaled by the flotsam debris. The consensus was that

if the sandbags had not been punctured by the debris, which allowed sand to leach out and dislodge the remaining bags, the sandbag wall would have held and protected the site. Needless to say, completing the last concrete footing slot took many days of hand excavating and became very costly. This experience proved that a different, better, more resilient protective device was needed.

Innovations are almost never just a single idea. They are concepts that require maturation, running mental scenarios and asking the "what if" and "what about." Eventually, a solid idea becomes an innovation. In this case, the theory was that the sandbag wall would have remained in place to protect the project site if the bags were filled with a solidified material that would not leach out when breached.

The resulting product is a hybrid material that is a reusable, lighter dry weight, sand-filled bag alternative (Figure 1). The hygroscopic material is composed of proportionately mixed natural hollow fibers with cement, sand and aggregate to provide an extended service life and durable matrix for an array of purposes. This innovation brings resiliency and efficiency as a new tool to economically manage the dynamics of the evolving climate-changing world.

There are several sandbag alternatives currently available, however, most are used for larger flood control scenarios, while the Warstone innovation dramatically improves the use of sand for protection. Studies have been performed comparing costs of sandbags versus sandbag alternatives, with the overall conclusion that sandbags are cost effective for a single use, but sandbag alternatives are more economical and more sustainable for multiple uses.<sup>1</sup>

The natural fiber and cementitious material mix is super absorbent and retains a volumetric weight gain when exposed to water. The dry mix will increase in weight by approximately 60% per volume. When the flooding waters recede, the retained water in the bag will slowly evaporate back to almost its original dry weight, and when exposed to water again, it will re-absorb the water and return to its hydrated weight. Initially, the hydrated mix will harden and become somewhat fixed, thereby becoming cohesive and greatly resistant to impact forces that generally debilitate traditional sand-filled bags.

This lighter dry material is sustainable, reducing overall transportation costs per coverage area of protection. The hybrid material uses less equipment and labor for deployment and removal and can be reused at least five times, including in extreme temperature conditions. This material can be used in a wide variety of containers from sandbags, interlocking bags and bulk geotextile containers.

The natural fibers are from coir, a byproduct of coconut production. Coir is naturally more resilient to saltwater than other natural fibers, making this mix universal for flood protection in fresh and saltwater conditions. When the protection use for this material has been exhausted it

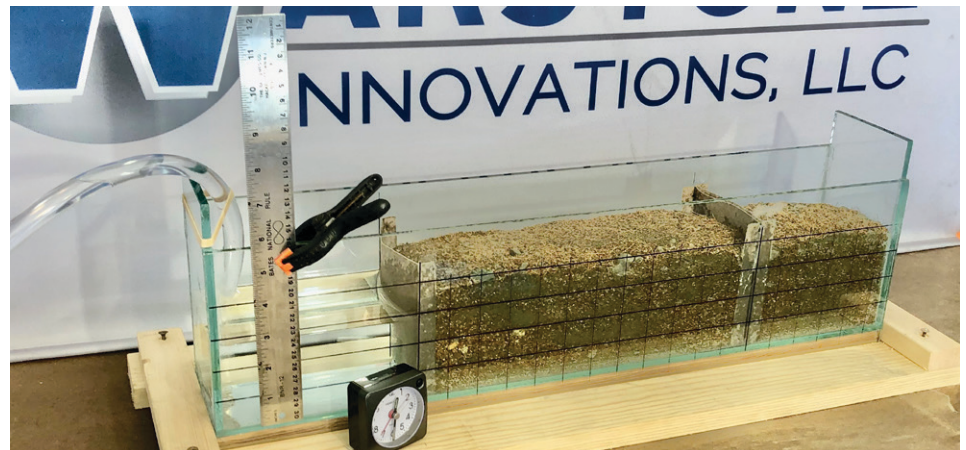


Figure 2. Aquarium test of hygroscopic fiber/cement material recorded the absorption speed of water that correlated to the increase in hybrid material weight.

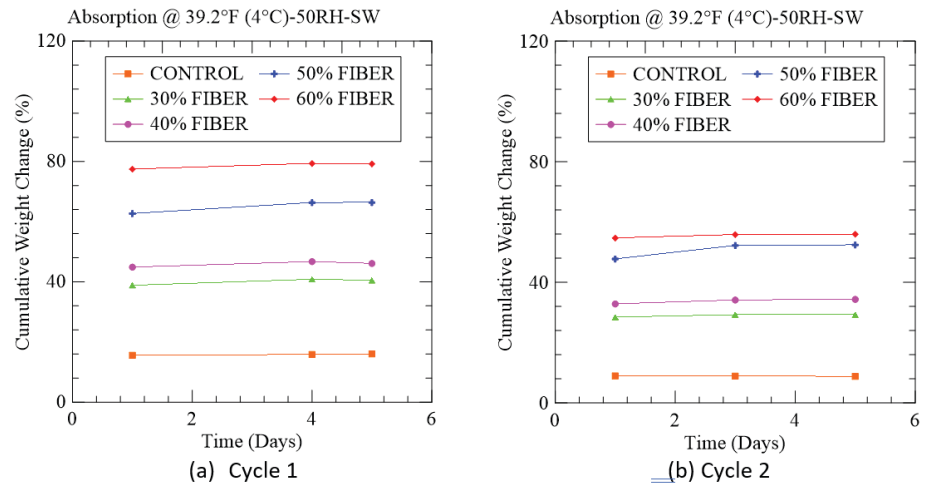



Figure 3. Graphs indicating volumetric weight change vs time of hygroscopic fiber/cement materials at various percentages of fiber.<sup>2</sup> Performed using saltwater during two hydration cycles.

can be repurposed as a filter layer of a rock revetment or scour blanket among other uses.

The hygroscopic natural fiber and cementitious material mix has been extensively tested at Texas A & M University, Zachry Department of Civil and Environmental Engineering, through the Center for the Integration of Composites in Infrastructure, a National Science Foundation program.<sup>2</sup> Laboratory testing included the proportionality of the fibers with respect to absorption and dehydration results at various temperatures for potable and saltwater (Figures 2 and 3). Strength characteristics have been studied and an academic research paper with final results will be presented in September 2024. 

#### References:

1. Lankenau L, Massolle C, Koppe B, et al. Sandbag replacement systems - a nonsensical and costly alternative to sandbagging? *Natural Hazards and Earth System Sciences* 2020, 20(1), 197 - 220. <https://doi.org/10.5194/nhess-20-197-2020>.
2. Ramineni K, Congress SSC, Biswas N, Puppala AJ, & Kriegstein S (Accepted). "An Experimental Study to Evaluate the Performance of Fiber-Based Cement Mixture Bags as Alternative Flood and Erosion Barriers." ASCE GeoEnvironMeet 2024, Portland, OR.

#### About the Expert

Stewart Kriegstein is founder and inventor at Warstone Innovations LLC. A retired, seasoned general engineering contractor with 40 years of expertise in coastal engineering construction, he provides consulting services and is actively involved in entrepreneurial ventures related to multiple patents.