

Emergency Relief Program

Resilience Case Study – Florida

Articulating Concrete Block Revetment System for Flood Resilience: Hurricane Michael

Hurricane Michael made landfall in the Florida Panhandle on October 10, 2018. With 155 mile per hour winds and a 14-foot storm surge, it was the first Category 5 hurricane to hit the continental United States in over 25 years. Flooding and wave action damaged U.S. Highway 98 (US 98) in multiple locations in Bay, Franklin, and Gulf Counties, leaving the road impassable and affecting the cities of Mexico Beach, Port Saint Joe, Eastpoint, and Apalachicola. Both travel lanes, paved shoulders, and roadside slopes were damaged on several segments of the highway. Over five miles of roadway in 31 locations sustained damage along the 28-mile project area. The damage necessitated over \$22 million in repairs to reconstruct the roadway. US 98 is a coastal roadway that lies only five to ten feet above sea level. It had been repeatedly damaged by past hurricanes and tropical storms and was expected to face similar threats in the future. As a result, the Florida Department of Transportation (FDOT) decided to construct an Articulating Concrete Block (ACB) revetment system with funds from the Federal Highway Administration (FHWA) Emergency Relief (ER) Program to make the roadway more resilient to future storms.

Resilience Features

ACB revetment systems consist of a matrix of individual concrete blocks that form an erosion-resistant revetment with or without a geotextile underlay for subsoil retention. For this project, the blocks were placed on top of geotextile fabric and six-inch bedding stone.

FDOT decided to install an ACB system because of prior successes with the technique. In 2005, Hurricane Dennis damaged portions of US 98 in the Panhandle. FDOT installed an ACB system on the damaged segments as part of a FHWA ER-funded betterment in 2007. After Hurricane Michael in 2018, roadway portions that were protected by the ACB system only sustained minimal damage, while adjacent, unprotected portions were severely damaged. FDOT considered retaining walls, which had also successfully protected portions of the roadway in major storms. However, FDOT found the ACB system to be less expensive than and similarly effective as the other options when adequate right of way was available. When adequate right of way was not available, FDOT found additional retaining walls to be the most cost-effective solution.

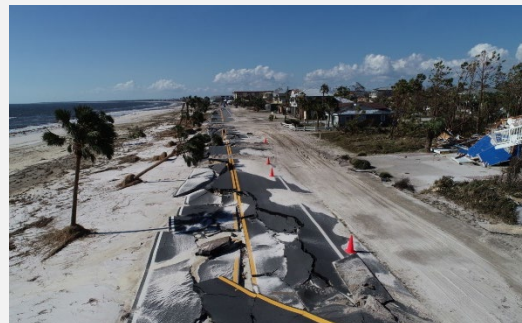


Figure 1. Damage to US 98 following Hurricane Michael. Source: FDOT

Project Snapshot

Location: Bay, Franklin, and Gulf Counties, Florida

Date of ER Event: October 2018

Nature of Event: Hurricane

Assets Impacted: US 98

Cost of Resilience Improvements: \$5.25 million

Economic Justification: Cost savings based on high probability of future hurricane damage

Type of Improvement: Betterment

Lead agency: Florida Department of Transportation

Other agencies involved: Federal Highway Administration, Florida Division



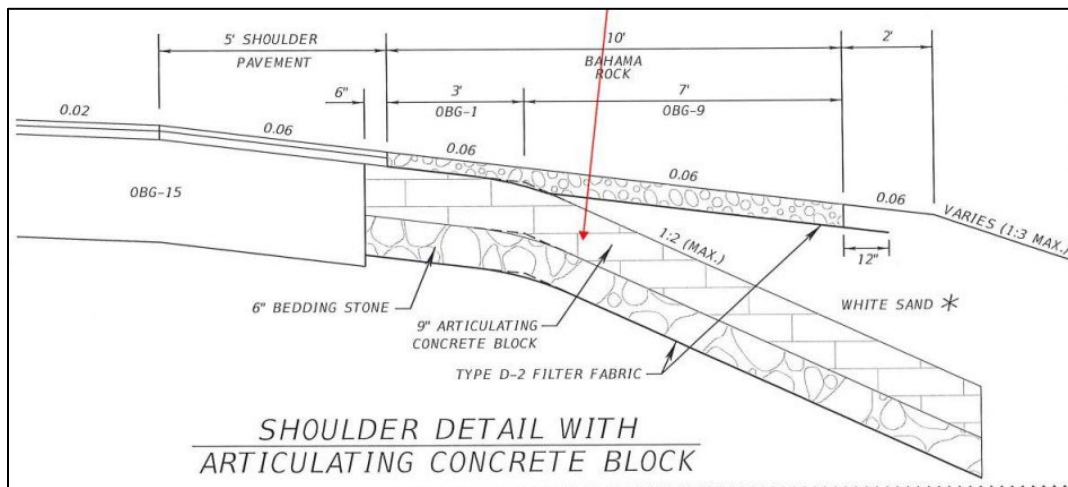


Figure 2: As-built plan of roadway shoulder with an articulating concrete block system. Source: FDOT

FDOT and FHWA found that installing the ACB system would result in a cost savings for the FHWA ER program after just one major storm. FDOT used information from previous bids to compare the cost of installing the ACB system versus reconstructing 1,000 linear feet of roadway. FDOT estimated the cost of reconstruction at \$724,000 and the cost of installing the ACB system at \$490,000. FDOT concluded that the additional cost of installing the ACB system would save the FHWA ER program money if the affected area experiences another strong storm in the next 50 years. According to the [National Hurricane Center Risk Analysis Program](#) (HURISK), a hurricane hits the region approximately once every nine to ten years, and climate change will make storms hitting the area even more intense. Past experience has demonstrated that even a tropical storm can wash out the roadway, so it is very likely the roadway would need to be reconstructed several times over the next 50 years without installing the betterment.

Challenges and Lessons Learned

Experience along the US 98 corridor has shown that ACB revetment systems are an effective flood resilience improvement. Other agencies could benefit from considering the system as a resilience improvement, especially for low-lying, coastal highways that are subject to frequent storms.

FDOT encountered several challenges in applying for FHWA ER funds and constructing the betterment:

- Locating an appropriate source for hurricane probabilities:** At first, FDOT was unsure of an appropriate source for hurricane probabilities to use in the cost justification. FDOT eventually identified HURISK as an appropriate source.
- Procuring enough material:** ACB systems use a significant amount of concrete. As a result, FDOT required concrete producers in the region to operate at maximum capacity to ensure there was enough. The system was manufactured in-state and shipped from Pinellas Park. There were no delays in the manufacturing or delivery of the ACB system.
- Designing drainage features:** The 2005 installation included gaps in the ACB system at cross drains. During Hurricane Michael, the roadway was damaged where there were gaps, necessitating reconstruction (Figure 4). Following the hurricane, the ACB system was installed around the existing cross drains, leaving no gaps within the area of reconstruction. FDOT found that it was more cost effective to install the ACB system during roadway



Figure 3: An Articulated Concrete Block (ACB) revetment system on US 98 in Florida. Source: FHWA



reconstruction to ensure that the block aligns properly with the edge of the pavement. Any gap between the ACB system and pavement could put the roadway at risk of damage in future events.

- **Addressing ecological concerns:** The proximity of the project to the coast brought up concerns related to endangered species and habitat conservation. FDOT consulted with the U.S. Fish and Wildlife Service regarding sea turtle nesting habitat, piping plover habitat, nighttime lighting, and other ecological concerns. Some consultations were performed after emergency repairs occurred. Additionally, the project had to be reviewed by the Florida Department of Environmental Protection Coastal Construction Control Line (CCCL), which manages all construction seaward of the designated CCCL to prevent erosion, conserve beach ecosystems, and maintain public access to the water.

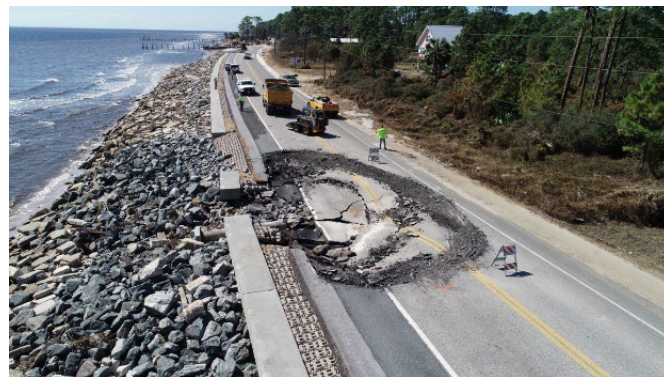


Figure 4: Following Hurricane Dennis in 2005, an ACB revetment system was installed along portions of US 98. The installation included gaps in the ACB system for cross drains. The ACB revetment system protected the roadway against Hurricane Michael in 2018, but unprotected areas near the cross drains suffered extensive damage. Source: FDOT

Key Takeaways

As a low-lying coastal highway, US 98 is vulnerable to damage from major storms. In the aftermath of Hurricane Michael, FDOT selected an ACB revetment system to make the roadway more resilient due to the ACB system's proven effectiveness along other parts of the corridor. FDOT found installing an ACB system to be much more cost effective than the frequent reconstructions that US 98 would otherwise likely require in the coming decades, based on the high frequency of storms and the expected effects of climate change.

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