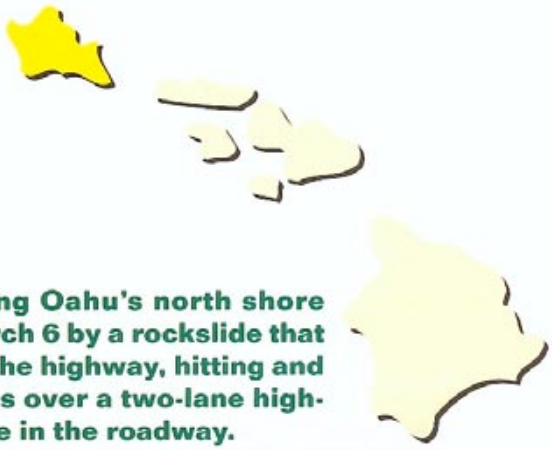
BYPASS ROAD CONSTRUCTED OF

Sand, Coral, and a Cellular System



The Kamehameha Highway at Waimea Bay along Oahu's north shore connecting Pupukea to Haleiwa was closed March 6 by a rockslide that caused several tons of rock to slide and fall on the highway, hitting and damaging two vehicles. The slide spread debris over a two-lane highway and caused an 18-in. deep by three-ft diameter hole in the roadway.

Panoramic view of the bypass road construction.

According to state geologists' assessments, the condition of the slope above the roadway was deemed unstable and unsafe for motorists to pass below, and therefore was closed indefinitely. In the meantime, residents were forced to make the long drive around the Koolau Mountains.

Further investigations of the slide site revealed other potential problems. The 100-ft high cliff is composed of unstable, badly weathered rock that hangs over the roadway. This brittle rock, called Koolau, is believed to be 2.5 million years old, the oldest rock above sea level.

Physically removing the rock was one option to prevent a possible landslide. Not only was the brittleness a factor to consider, but when the soil underneath became saturated with heavy rains, it pushed the rock forward.

The governor of Hawaii, Ben Cayetano, declared a state of emergency to facilitate the process, bypassing the usual, time-consuming construction procedures. During the closure of the only highway on the North Shore, traffic was rerouted from Waimea Bay northwards via Highway 3 to the windward coast, a venture that did not bode well with area residents, businesses, and tourists. The effects of the highway's long-term closure and loss of tourism revenue could cause an economic catastrophe, according to some local businesses.

After further evaluation, Kazu Hayashida, director of the Hawaii Department of Transportation (HDOT), reported a considerable

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Material sections 8 ft by 20 ft are placed three across to create the 24-ft wide, 1,000-ft long roadway.

amount of loose basalt rock, and met with the primary contractor, Kiewit Pacific, to discuss the safest and most expedient method to remove the unstable rock. A preliminary plan included using drills and demolition charges or water blasting to cut back the section of rock, removing the outer unstable 20 ft of rock overhang.

"We cannot just use drills because of the limited access to the rocks," stated Hayashida. "We will detonate small charges at some point, but they will not be strong enough to disturb the nearby church, heiau [temples], and homes. We're not trying to bring down the whole mountain. What we want to do is gradually cut away at the rocks until we get fresh rock that we know won't come tumbling down."

Native Hawaiians opposed any plan to blast the rock face, as it would harm the Puu O Mahuka Heiau and a sacred burial site above the highway.

The option selected for a long-term repair included moving the shoulder of Kamehameha Highway at the rockslide site some 20 to 30 ft away from the cliffside. The HDOT had recognized the site as unstable for over ten years, but opted not to repair due to budget constraints.

LOW-IMPACT SOLUTION

The HDOT officials, Kiewit Pacific, the Army Corp of Engineers, and general engineering contractor Structural Systems, Inc. (Honolulu), met immediately to determine construction of a bypass road. After surveying the proposed area and its proximity to Waimea Bay Beach Park, the design team recommended that the road meet four requirements: be able to withstand the North Shore's high surf conditions, especially critical during the rainy season where 30 in. of rain per week is not uncommon; have minimum impact on the environment, allowing the site to be easily returned to its original natural state once the highway reopens; support heavy vehicles over the soft sand subgrade; and be cost-effective.

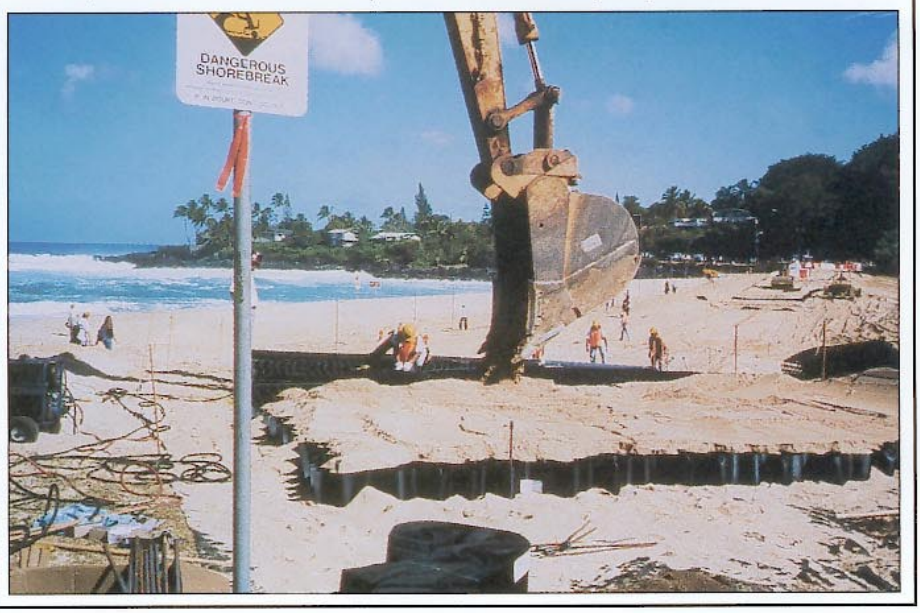
The U.S. Army Corps of Engineers and HDOT designed a temporary two-lane roadway approximately 24 ft wide by 1,000 ft long. The construction materials included geotextile fabric and the Geoweb™ (Presto Products Company, Appleton, Wisconsin) cellular confinement system filled with native beach sand and surfaced with a native crushed coral.

"Based on past challenges, we've experienced tremendous success with the cellular confinement system," said Joe Enright, president of Structural Systems, Inc. "Since turnaround time was key to this project, accessibility to a rapid load support system, along with onsite engineering support, were reasons why the system was selected."

Cellular confinement was originally developed by Presto and the U.S. Army Corps of Engineers as a means of constructing rubber-tired military vehicle access roads over beaches. The three-dimensional polyethylene, honeycomb-like structure confines and strengthens cohesionless materials in its cells, preventing shear failure and lateral movement of the infill material. The system produces a stiff base with high flexural strength, acting like a semi-rigid slab by distributing loads laterally and reducing subgrade contact pressures.

MATERIALS FLOWN IN

Within 30 hours of the design team's March 12 job site meeting, the Geoweb material was air-shipped from Wisconsin to Waimea Beach to expedite installation. Forty-three pallets were delivered in collapsed form; they were easily expanded to their full



Native beach sand is placed in the expanded cellular confinement sections with a backhoe.

The completed bypass road, topped with a compacted crushed coral, accepts traffic.

width and length (eight ft by 20 ft) and secured with Presto's ATRA™ anchors, plastic clips attached to 24-in. length rebar, before infilling.

"This is a classic example of job site partnering whereby various government agencies work with local businesses to design and build this type of engineering solution," said Enright.

In the initial stages of construction, HDOT personnel readied the beach for road construction by clearing trees and building a ramp at one end of Waimea Bay. In efforts to remain sensitive to local cultural and political concerns, Kahu Samuel Safrey, a Hawaiian priest, performed a ground blessing at the site.

The bypass road was constructed by placing a layer of geotextile directly onto the sand. The first course of eight-in. deep Geoweb sections was placed and infilled with the surrounding beach sand and compacted. A second course of cellular material was placed repeating the same procedure. The top three in. consisted of imported crushed coral that was placed on top of the two courses, saturated, and compacted. The eight-ft by 20-ft sections of material were placed three across to create the roadway. Two polyethylene drainage pipes were laid under the roadway to allow water from mountain runoff to pass under the road. Water-filled barriers were placed on both sides of the roadway to help delineate the two traffic lanes, protect the cells nearest the edges, and prevent cars from going off the secure road into the sand.

TRIAL BY STORM

Late winter storms creating flooding and surfs as high as 20 ft posed a threat to the integrity and foundation of the bypass road. The anchors provided adequate stability to the geotextile sections. The effectiveness of the anchors was further tested a few days later. High surfs ripped out the center portion of an adjacent walkway, washing it out to sea. Although the waves also emptied sand from some of the roadway cells, the anchors were credited with preventing the road sections from completely pulling out.

The bypass road was completed March 18 and has been open to traffic since. Currently, traffic is limited to a five-mph speed limit and a weight limit of four tons. Met with initial skepticism and opposition, the Waimea Bay Emergency Bypass Road is being accepted by residents and businesses and is functioning as planned. **PW**