

# ARMORMAX Stabilizes Slopes in San Francisco Island Development



**Y**erba Buena Island (YBI) is a natural island located in the San Francisco Bay; neighboring Treasure Island is a man-made island built in the 1930s. The City of San Francisco and private developers have been planning a \$1.5 billion redevelopment of the two islands that span 405 acres. The Treasure Island/Yerba Buena Island Development Project embraces the quintessential California lifestyle and will create a new San Francisco neighborhood, including homes offered at below-market rates, multiple public-transportation connections, extensive parks and open space, public art, hotels, restaurants and more.

The first phase of the project included construction of The Bristol, a residential condominium, located on the northeast-central side of YBI between I-80 and Macalla Road. Construction of the multimillion-dollar complex required infrastructure improvements including water, stormwater, sewer and natural gas as well as upgrades to Macalla Road.

During a heavy precipitation event in fall 2021, stormwater runoff built up within the gravel encasement surrounding the stormwater piping beneath Macalla Road.

The buildup of stormwater resulted in an increase in pore pressure below the subsurface, resulting in slope failure on the north side of the road. The heavily eroded slope was 67 degrees, 120 feet long and consisted of silty, sandy soil. Adding complexity to the project, a sanitary sewer line and primary natural gas line were located within the slope face.

## The Team and Solution

ENGEO, a geotechnical engineering firm, contacted Propex to help engineer a solution that provided slope stability and erosion protection of the slope while also protecting the underground utilities. Incorporating the design factor of safety (FoS) for static and seismic conditions, ENGEO and Propex determined that the ARMORMAX® system using 6-foot B3 engineered earth anchors on a 5- by 4-foot spacing with 1,200 pounds of anchor pullout capacity was the best solution.

ARMORMAX is a solution for surficial slope stabilization that provides vegetated reinforcement, improves the factor of safety, and significantly reduces the probability of

failure. The system is composed of Engineered Earth Anchors designed and tested for compatibility and performance with PYRAMAT® 75 High Performance Turf Reinforcement Mat (HPTRM) to increase slope stability for up to 75 years. The anchors are designed to provide resistance to shear and lateral forces as well as embed beyond the predicted plane of failure.

Through various testing and field observations, the anchor component of the ARMORMAX System has shown to provide an immediate benefit from geotechnical and durability perspectives. Testing from Colorado State University not only found that use of Engineered Earth Anchors shows a reduction in erosion when compared to the bare soil, but also that soil accumulates near the anchors during testing. The buildup of soil around the anchors creates a “check dam” effect that will function to better retain the soil and increase the system’s overall performance.

Additionally, ARMORMAX can reduce the amount of space needed for a right-of-way and construction, because it provides improved surficial stability on steeper-than-normal slopes. This was an important factor for this project due to the proximity of Macalla Road to the slope repair.

## Completing the Project

Upon approval from all environmental agencies and the City of San Francisco, the slope was rebuilt, and ARMORMAX was installed in February 2022 by Selby’s Seed & Erosion Control. Due to the steepness of the slope, installers used harnesses and ropes tethered at the crest of slope for safety.

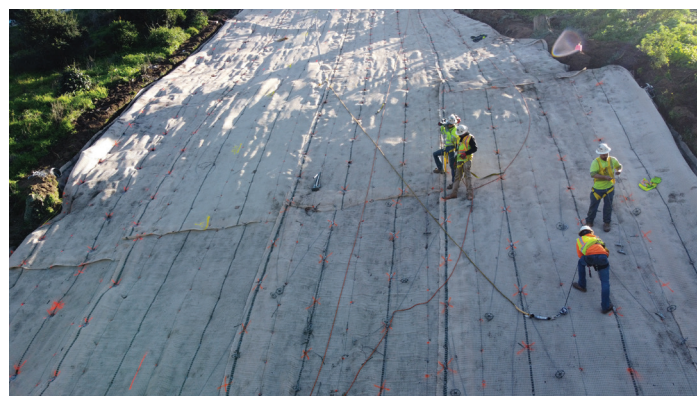
The construction technique used during the YBI install didn’t require additional construction equipment and didn’t require road closures or traffic-control measures. Upon completion, the FoS using ARMORMAX was improved to 1.51 compared to an FoS of 0.82 for the unprotected slope.

After installation, the HPTRM was sprayed with a bonded fiber matrix containing native seed to help establish vegetation. The ARMORMAX system is engineered with a patented trilobal design that locks seeds and soil in place to promote rapid root development for long-term vegetation. This helps decrease sedimentation and pollutants, and encourages infiltration of water back into the groundwater table. These are two reasons why the Environmental Protection Agency (EPA) identified systems that utilize HPTRMs such as ARMORMAX as a Best Management Practice (BMP) for improving water quality.

## Low Environmental Impact

Systems that utilize HPTRMs offer environmental benefits that other erosion control technologies such as rock riprap and concrete can’t offer. During design, it’s important to consider factors such as hydraulic performance, durability, economics and environmental impacts. Erosion control solutions should be designed to provide a low environmental impact to achieve long-term performance and overall project success.

The verified carbon footprint of 1 square meter of the HPTRM in the ARMORMAX system is 2.7 kgCO<sub>2</sub>e, cradle-to-grave. Comparatively, the carbon footprints of



The ARMORMAX® system of Engineered Earth Anchors with PYRAMAT® 75 High Performance Turf Reinforcement Mat (HPTRM) was able to reinforce a steep slope on Yerba Buena Island.

concrete-based alternatives are up to 10 times higher, and rock riprap is up to 30 times higher. While rock is a natural material, strip mining and crushing it for use in engineering projects often is done without regard for environmental impact. ARMORMAX is manufactured in a facility that is ISO 14001 certified, which recognizes companies that are actively measuring environmental impact and continuously looking for ways to reduce their carbon footprint.

Geotechnical slope failure and soil erosion can occur in any region. Steepened slopes often require stabilization and protection from surface erosion. In some cases, when the slope is stable, protection from surface erosion still is required. The incorporation of an Engineered Earth Armoring Solution such as ARMORMAX can help remediate geotechnical slope failure by passively resisting soil movement.

