



## Case Study

**application** | **Landslide Repair**  
**location** | **Trump National Golf Course, CA**  
**product** | **Mirafi® PET600, PET300, & PET200**

**job owner** | **Donald Trump**  
**contractor** | **Sukut Construction**

TenCate™ develops and produces materials that function to increase performance, reduce costs and deliver measurable results by working with our customers to provide advanced solutions.

### THE CHALLENGE

Trump National Golf Course, formerly named Ocean Trails Golf Course is a stunning, ocean-front golf course in Los Angeles County. The public course sits high atop jagged cliffs with the waves of the Pacific Ocean crashing below, offering spectacular ocean views from all of its 18 fairways.

On June 2, 1999 the approximate 17 acre area of an ancient landslide reactivated in a single rapid event. The slide saw downward movement of almost 3 m (10 ft) and horizontal (seaward) translation of about 15.2 m (50 ft). At the base of the slide was an almost horizontal thin layer of bentonite, only 0.32-7.62 cm (0.125 - 3 in) thick, that when exposed to water becomes extremely slippery (low friction). The slide mass had a 518 m (1700 ft) length, 122 m (400 ft) width and 21 m (70 ft) depth. The slide took with it most of the 18th hole (fairway and green), bluff edge, pedestrian trails, bike path, and a portion of a major Los Angeles County Sanitation District sewer line.

### THE DESIGN

Three repair alternatives were considered for the design:

1. Complete landslide removal and replacement.
2. Partial removal and rebuilding of the seaward portion of the landslide.
3. Partial removal and rebuilding of the landward portion of the landslide.

Partial removal and rebuilding of the landward portion of the landslide was found to be the best

alternative. This option would achieve the intended purposes, have the least alteration of landforms, and be the most feasible from a geotechnical engineering viewpoint.

Various earth retention options were analyzed for implementing the repair strategy. The MSE Wall option was considered the best solution, favorably meeting every parameter: construction time, expense, reliability, fill settlement, height & landform change.

The design required extremely high strength fabrics, over 600 kN/m (40,000 lbs/ft) tensile strength, combined with high soil interaction coefficients. Layers of geosynthetic reinforcement were to be placed at approximately 1.5 m (5 ft) vertical intervals with embedment lengths as much as 29 m (95 ft) in length. Mirafi® PET600, PET300, PET200 and HS4200 were used as the primary reinforcement to create a massive 30.5 m (100 ft) high fabric wrapped MSE wall/buttress. The face of the wall was designed with 46 cm (18 in) high welded wire

forms, with a nearly vertical batter of 4.6 degrees. As secondary reinforcement, Mirafi® FW404 was used to line the interior of the welded forms to contain soil at the face. The face of this massive MSE wall was to be butted up against another reinforced triangular backfill (also using Geolon® fabrics). This second reinforced fill mass was butted up against existing slide material/native soils of the seaward portion of the landslide, which was left in place to maintain the natural environment, hide the face of the wall, and protect the MSE structures from the Pacific Ocean. This composite of soil and high strength fabric serves as a giant stable soil block that will stop any future movement and protect the rest of the golf course from falling into the ocean.

### THE CONSTRUCTION

Construction had to occur in environmentally sensitive habitat areas along steep bluffs with often unstable soils and deep excavations while



Mirafi® PET high strength geotextiles met the design requirements of 600 kN/m (40,000 lb/ft) tensile strength and high soil interaction coefficients.

not disturbing any golfers (the golf course was actually open for business during construction).

The first step in repairing the slide area was to stabilize the main slide block with 116 shear pins. Each steel pin was 6 m (20 ft) long, 91 cm (36 in) wide, and filled with high density concrete. Shear pins were installed at 7.6 m (25 ft) intervals. Once the shear pins were installed, the construction of the MSE wall began by first excavating over 1.5 million cubic yards of soil of the slide area in sections to a 30.5 - 45.7 m (100-150 ft) depth below the failure plane. The ninth and twelfth fairways were used for stockpiling the soil from the first section, so that no impact would be made on the sensitive habitat adjacent to the site. Construction of the MSE wall began with placement of the first row of welded wire forms at the bottom of the excavation. Mirafi® FW404 was placed up the back of the steel forms, with a 1.5 m (5 ft) long flap of reinforcement draped over the face. Mirafi® PET high strength fabric was next placed up to the face of the basket. On-site fill materials were compacted into place over the reinforcement lengths, the flap was wrapped-back over the top of the soil. The construction process was repeated for each lift, every 45.7 cm (18 in), until the wall reached its full required design height.

A clay cap was placed over the entire filled area to keep water out. A layer of topsoil was placed over the clay cap so vegetation and landscaping could be planted. The entire reinforced fill structure is now covered by a beautiful grass fairway, putting green and sand traps.

**THE PERFORMANCE**

Costing over \$250 million dollars, Trump National is the most expensive golf course ever constructed. The cost of the landslide reconstruction totalled at \$61 million.

As golfers take in the breathtaking view from the 18th hole, few will realize that this hole is one of the safest coastal places to be standing as a result of the many layers of high strength geosynthetics sitting below their feet. "If I'm ever in California for an earthquake," says Donald Trump of his new 18th hole, "this is where I want to be standing."



Mirafi® FW404 was placed inside the welded wire basket forms to contain soil at the face. The Mirafi® HS geotextile was installed next to the basket face.



The 18th hole of the Trump National Golf Course is considered one of the safest coastal locations due to the high strength geosynthetics stabilizing the earth.

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