

**Marine Structures****Reference Details:**

Owner British Government +++
Main Contractor Costain Civil Engineering +++
Consultant Golder Associates +++
Installation CAN Geotechnical

DSI Services Supply of permanent DYWIDAG strand anchors and rock bolts, delivery from DSI United Kingdom.



Rock of Gibraltar secured with DYWIDAG anchors - Slope stabilization Gibraltar, British Crown Colony

Contrary to newspaper reports two years ago, the 452m high Rock of Gibraltar is not falling into the sea off Spain's southern tip.

However, heavy rainfall in early 1997 caused cliff instability at Camp Bay, on the south west of the 3km x 2km British Crown Colony, resulting in a rock slip which required remedial works to the collapsed section and to adjacent cliffs.

The landslide affected a 45m wide section of the cliff and contained about 15,000m³ of debris. A military building at the cliff top, left in a precarious position, had to be demolished and both the coast road and beach access were blocked. Following removal of the landslide debris, the engineer's solution was to use controlled blasting to form a pre-split face, secured with permanent ground anchors, and to construct a stone block-wall against the new slope.

In a most aggressive warm marine environment where efficient corrosion protection was considered to be vital, 135 DYWIDAG multistrand anchors with double protection against corrosion were specified for installation into the cliff face.

Each anchor comprised 4-0.6" strands with a total ultimate capacity of 1,200 kN to satisfy the design working load of 500 kN. This was achieved with a bond length of 4m.

With an irregular rock face up to 70m high, and with considerable overhangs, the ground anchor installation was extremely demanding and an experienced UK roped access specialist, CAN Geotechnical, was selected for the work.

All drilling and anchor installation was done with drilling rigs and operators suspended on ropes from the cliff top. Safety was paramount and all equipment and men were actually attached to two firmly anchored and capacity tested ropes at all times.

As the required overall anchor lengths could not be determined until the actual holes had been drilled, long anchors were delivered to site and shortened to meet the varying ground conditions before installation.

Some of the ground anchors were 32m long and the degree of difficulty to drill the holes, lower the tendons down the overhanging rock face and to install them whilst suspended from ropes cannot be overstated. Fully protected anchor head assemblies were fitted to each anchor prior to testing and applying the working load with DYWIDAG hydraulic stressing jacks. DYWIDAG rock bolts 25mm dia. were also installed further along the cliff as part of additional stabilization work on the same contract to increase stability and reduce the risk of further landslides.