

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

Owner Babcock Rosyth Defence Ltd. +++
Structural Design Schal Project Management +++
General Contractor Kvaerner Construction Ltd. +++
Anchor Installation Kvaerner Cementation Foundations Ltd.

DSI Services Supply of DYWIDAG strand anchors, stressing equipment rental, technical assistance.

Owner Devonport Management Ltd. (DML) +++
Structural Design Babbie & Partners +++
General Contractor Kier Construction Ltd. +++
Anchor Installation Amec Civil Engineering Ltd., Piling Division

DSI Services Supply of DYWIDAG strand anchors, stressing equipment rental, technical assistance.

**DYWIDAG strand tendons upgrade historic dry docks****Fife, Scotland; Plymouth, England: Royal Dockyards at Rosyth and Devonport**

Several dry docks within historic UK dockyards are presently being rehabilitated; they will serve as contingency docking facilities for nuclear submarines of the British Navy. In 1691 William of Orange commissioned the royal dockyard at Devonport in Plymouth, Devon. Scottish Rosyth at Fife, in Scotland, originally Her Majesty's Naval Base, opened in 1916. In both cases the side walls of the dry docks were strengthened with DYWIDAG rock anchors to comply with modern seismic design requirements.

Rosyth's entrance lock, as well as forming the vital link between the safe harbour and the tidal estuary, was also able to be utilised as a dry dock facility, for undertaking repair and refitting work, and was one of the Navy's greatest assets in its day.

The entrance lock is 259 m long by 34 m wide by 20 m deep and is large enough to accommodate a "Vanguard" class submarine. The lock was constructed from a dolerite island in the Forth called Dhu Crag. A channel was blasted through the rock island to form the lock, with the rock from the blasting operations used as aggregate in the mass concrete lock walls.

As a strengthening scheme, a rock anchor system was designed to pin the existing mass concrete walls to the bedrock below and behind the walls in order to increase its mass and to prevent sliding and over turning from occurring under seismic activity. 1,024 No 15 x 0.6" DYWIDAG strand anchors (DYFORM strand) with a guaranteed ultimate capacity of 4,500 kN were installed. The longest anchor measured 31.5 m with a bond length of 6 m. Another 222 No 3 x 0.6" DYWIDAG strand anchors were used. All anchors were prefabricated and pregrouted with double corrosion protection under DSI supervision at the contractor's works. Stressing was conducted using DYWIDAG HOZ 4000/250 jacks with RI 1.2 hydraulic pumps.

Dock 10 at Devonport is 254 m long, 43 m wide and 15 m deep. It was built of granite blocks sitting directly on bedrock. Seismic evaluation showed that the west wall needed strengthening.

A trench was excavated along the entire west side of the dock and a large concrete beam was cast within it. 250 mm Ø vertical holes were accurately drilled and closely monitored at one metre centres along the beam to depths of up to 65m. The 147 No 21 x 0.6" DYWIDAG anchors, each with an ultimate capacity of 6,300 kN, were installed into these holes and stressed to tie the dock wall directly into the deep bedrock to prevent collapse in the event of an earthquake. The dock owners required that anchors conform to a very high quality specification and it was necessary to satisfy their stringent demands before the anchors were approved. This entailed a sophisticated gun-barrel test to prove bond efficiency under laboratory conditions and comprehensive corrosion protection for all aspects of the anchor.

Because of their very long and bulky lengths, special handling methods were devised to assemble the anchors, factory pre-grout the 8m bond length, coil the free lengths and transport them to the project site. Lifting and installation of 65 m long anchors to avoid damage was a considerable challenge solved by use of a specially developed "magic wheel" technique in conjunction with a high jib crane and winch. The anchors were stressed by DSI personnel using 500 tonne jacks (400 mm stroke) specially imported from DSI USA and hydraulic equipment from DSI Munich. This proved to be a very effective combination.

