Unique tie back solution for quay wall with DYWIDAG strand tendons

Reference Details:

Owner City of Antwerp in co-operation with the Flemish Community +++ **Structural Design** Preliminary design by owner (technical department) final design: JV of Ingenieurbureau Gyselynck G.c.v. and Studiebureau S.B.E., N.V. +++ **General Contractor** A.K.C. (Antwerpen Kaaimuren Combinatie) JV of Franki, Herbosch-Kiere, Antwerpen Bouwwerken AB

DSI Services Supply of 1858 DYWIDAG Strand Tendons 7-, 12-, 15- and 19-0.62"; Consulting at final design stage.

Antwerpen, Belgium: North Sea Container Terminal
Thanks to its favourable geographical position and its modern technical facilities, Antwerpen has become one of the most important seaports in Europe. More and more of the 108 million tons of goods per year are handled with containers. The "Europe Terminal" was the first container terminal built in 1987 on the River Scheldt. River terminals are, compared to traditional docks, more attractive as they eliminate the time consuming locking of ships from the docks to the Scheldt and vice versa, thus saving a vessel up to 4 hours per call. In order to meet the increasing demand for container traffic, the port authority of Antwerpen together with the Flemish Community decided to build a second terminal, the so-called "North Sea Terminal". DSI with its Belgian and Dutch subsidiaries was involved in the construction of the quay wall and of the inland navigation terminal. DSI's profound experience was decisive for this contract, where traditional anchoring methods were replaced by post-tensioning techniques.

The North Sea Terminal is located north of Zandvliet and Berendrecht sealocks, on the right bank of the Scheldt River. The principal structures of this project were the 1,1 60 m long quay wall, a roll-on-roll-off facility on the upstream side, and the 300 m long inland terminal in the Canal Dock.

The quay wall consists of a concrete main wall dug from level +9 to -31.5 m tied back on two levels to an anchoring wall. The lower part of the main wall is a 1.5 m thick diaphragm wall composed of 7.2 m sections built by the slurry trench method. The upper part is traditional cast in place concrete. At both ends of the quay wall the original river bed needed to be raised prior to construction. Combi-walls (steel tubes with infill sheeting) were placed at these locations to avoid excavation of slurry trenches in a fresh refill.

The tie back wall is composed of a series of steel tubes driven into the ground about 30 m behind the front wall. These piles also serve as the foundation of the rear crane rail. The strand anchors in PE ducts were cement grouted for corrosion protection.

12 strand tendons were placed at 1.2 m centers in the lower level at -6.5 m, whereas 1 5 strand anchors are at 2.4 m centers in the top level at +3.3 m.

The original design specified massive 120 mm Ø lowgrade steel bars. The rigid connections on both ends could be a problem especially as the soil settles. A hinged solution was proposed - however, only a double hinge solution would have accounted for the shear forces, but was uneconomical and also unreliable and inaccessible, considering the depth of the anchor.

The DSI strand alternative offered many advantages:

- Strand anchors were relatively flexible and could follow soil settlements without expensive hinge details. The use of smooth transitions at the connections provided a good support of the deflected tendon.
- Continuous double corrosion protection (DCP) from end to end with HDPE ducts and cement grout provides a long service life for the anchor and quay wall.
- Strands were delivered in coils and cut to lengths making installation in the deep excavation easy. In this case no cranes were necessary to install the anchors.
- The tendon length could easily be adapted for this site requirement.

- With high accuracy the tendon anchor force could be introduced into both anchoring levels.
- Deformations of the quay wall could be monitored and even adjusted by regressing, if necessary.

A total of 1,858 tendons were replaced (7-, 12-, 15- and 19-0.62") in the finished quay wall which was successfully completed in early 1997. This along with similar projects expands the basis of DSI for future projects in the port and maritime technology market.

Following anchoring solutions were used to meet the design requirements:

- The tendon layout consisted of a combination of U- and L-shaped anchors.
- U- and L-shaped secondary PE pipes were cast into the front wall concrete in order to provide a duct for inserting the primary PE sheathing and the strands.
- DYWIDAG MA anchorages as well as SD anchorages were installed at the live end and cast into the steel piles. The same type anchor was positioned and cast in the front wall concrete serving as the dead end of the L-shaped tendons.
- In the end sections of the quay wall DYWIDAG type Z bond head anchorages were installed as dead ends in the steel piles.

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