

Dublin Port weighs anchors

A single bore multiple anchor system is being used to support massive sheet pile walls for a new berthing dock in Dublin Port. Dan Simpson reports.



A massive sheet piling operation has just been completed as part of a 23.5m contract from Dublin Port.

The 300m long Berth 51 is part of a new roll-on, roll-off docking facility. It is being excavated in fill and its sides formed by 850m of 23.5m long sheet piles and 54m of 32m long sheet piles, installed using a crane-mounted vibrating unit. These are being supported by 234 single bore multiple anchors (SBMAs) from UK geotechnical contractor Keller Ground Engineering.

The SBMA system consists of the number of unit anchors grouted over a short distance in a staggered formation along a single borehole. Each anchor is loaded individually but simultaneously with the others using hydraulically synchronised jacks. This ensures loads in each of the unit anchors are identical.

The SBMA system is designed to be used instead of conventional anchors with long fixed lengths.

“Anchors with a fixed length over about 3m start to become inefficient in mobilising the strength of the grouted ground,” explains Tony Barly, anchor consultant to Keller.



SBMA anchor tendons are double corrosion protected.

He says this is because of the non-uniform distribution of stresses along the longer fixed lengths. Initial stress concentrations at the proximal end leads to progressive debonding along the anchors' fixed length.

For example, an anchor tendon with a 10m fixed length in soil or weak rock will, at test load, need to extend 30mm at the proximal end of the fixed section before any load will be transferred to the distal end of the tendon. Barley says.

An anchor with a unit fixed length of 2-3m only requires a short amount of extension and so does not exhibit progressive debonding and non-uniform stress distribution.

Barley developed an efficiency factor based on an empirical

relationship from the results of anchor tests. This quantifies the efficiency and confirms that the efficiency of anchors falls greatly as the length increases.

“The efficiency factor” can now be applied to correct the traditional anchor design formulae which erroneously indicated that the ultimate anchor load is directly proportional to the fixed anchor length,” he says.

Not only are normal anchors inefficient in mobilising ground strength in 8-10m fixed length, but little or no increase in load capacity is achieved when fixed lengths are greater, Barley adds.

“SBMA systems double the efficiency in mobilising insitu ground strength over normal fixed anchor lengths of 8010m”, he says.

At Dublin most of the sheet piles were installed from a large barge, although some were placed from the dockside. Material was then excavated from the front of the wall to just below the proposed tie level, to allow access for installation of the SBMAs. For this project, anchors were typically installed at 30° and comprised four unit anchors with 3m



fixed lengths, giving a total fixed length of 12m and a total free length of 11.5m.

Most of the anchors were installed using a drill mast mounted on a specially developed 25t Hymac base, which could reach over the side of the dock and install the anchors from land.

Where access was difficult, anchors had to be installed from the waterside of the wall using a drill mast working from a platform mounted on the face of the sheet piles and powered by a diesel power pack on the land side of the berth.

Follow initial installation of the anchors, the structural capping beam was cast on the front of the wall.

Julie Ascoop, site agent for main contractor Ascon, says: "Initially the capping beam was going to be cast in an excavation behind the wall but the excavation works interfered with the neighbouring berth, so the design was evolved to prevent this."

After the capping beam was finished, the anchors were tensioned to tie back the top of the wall, allowing further excavation to take place in front of it. The wall retains more than 13m to fill, sand and gravel with up to 9.5m of the sheet piles embedded. The anchors support a working load of 1000kN at 1.2m spacing.

The anchors were founded by pressure grouting up to 7bar in the medium dense to dense sand and gravel. Where the material was loose and contained no fines the ground was pre-grouted with a sand and cement mixture without pressure. The pre-grout was redrilled two to three hours later, allowing normal anchor construction. Anchor tendons

have two continuous layers of plastic, which eliminates the risk of steel tendon corrosion.

The sheet pile wall runs along the quayside before turning 90° and heading inland. Anchor installation was difficult here, as Keller had to avoid hitting anchors that had already been placed. To overcome this, the firm varied the angle of the anchors between 27.5° and 37.5°.

The method was also used to avoid the piles of structures next to the quay wall. However, during installation it became clear that the existing pile locations were not precisely as recorded. This meant aborting some anchors or installing special short SBMA anchors. Some anchors had to be as steep as 50° and some were threaded between the piles. Where steepening of the anchors caused a problem because of limited thickness of sand and gravel above the underlying clay, short fixed length SBMAs were used.



Capping beam with anchor installation nearly complete.

Barley says, "Problems were solved by close co-operation between Keller, Ascon and the engineer. The anchor works were modified as required to find a sound practical solution where tight constraints existed."

Because each SBMA had four unit anchors, testing to failure would have required large loads. Instead, each pair of unit anchors was tested separately and their results added together to get the total load for the SBMA.

One pair of unit anchors was founded in the upper fixed anchor zone, between the top and 7m down the anchor, and the other in the lower fixed zone, between 7m and 14m down the anchor.

Tests revealed that the four unit anchor achieved a total load of more than 5000kN.

"This was probably the first ever soil anchor to demonstrate a capacity of 500t with the ability to sustain a permanent anchor working load of 200t," says Barley.

Two test anchors simulating production anchors were also cyclically loaded and subject to creep tests. Barley says tests confirmed that by using the SBMA system, permanent anchors with working loads in the 1800-2000kN range can be safely installed with a factor of safety of the order of 2.5 at the grout/ground bond.

"Using the SBMA system, Keller proposed alternative designs of 2000kN working load anchors at 2.4m spacings or 1500kN anchors at alternative 1.2m and 2.4m spacing for the sheet pile wall," he says.

"Unfortunately the test confirming the SBMA anchors could take a higher capacity were too late to allow the engineer to modify the capping beam for increased anchor spacings."

The project also involved installing 350kN to 1000kN working load anchors vertically through dolphin piles in the berth to resist uplift forces. These penetrated up to 8m into the underlying limestone.

Two berths and an approach channel were formed by dredging 97,000m² and part of the harbour was reclaimed using 48,000m² of granular material as part of the scheme.



Work on the sheet pile wall is now complete and the ramp for the berth arrived on a barge from Holland in September. The project started in July 2000 and is due to finish in July 2002.