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Excavation

Reference Details:

Owner Citytunnel Project, Malmö, Sweden +++ **Engineers** COWI A/S and SWECO AB, Malmö, Sweden +++ **Owner of Lot E101** NCC Construction Sverige AB, Malmö, Sweden +++ **Diaphragm wall and anchor Subcontractor** Brückner Grundbau, Essen, Germany



Permanent GEWI® Anchors prevent uplift of new underground railroad station

Citytunnel Project, Malmö, Sweden

The fixed road and railroad connection across the Öresund between Denmark and Sweden including the landmark Öresund bridge was opened in 2000 after a 5-year construction period.

Since then, rail traffic has significantly increased. Many forecasts project an additional increase of the traffic volume by 40%. Therefore, implementation of previously conducted intensive preliminary studies regarding the expansion of the rail infrastructure in the South of Sweden has become essential. These studies placed particular emphasis on environmental compatibility. After the

studies were approved, work on the City tunnel in Malmö, Sweden's third largest city, began in 2004.

The 1.3 billion EUR project essentially includes an 11 km long double-track section from the central railroad station to the Öresund fixed link, 6 km of which are in two parallel tunnels under central Malmö. In addition, the central station is being expanded to include a four-track underground station and changed from a terminus to a transit station. Additional track buildings as well as new railroad stations in Triangeln (subterranean) and Hyllie complete the project.

The new, approximately 1 km long underground station for the central station posed a particular challenge to engineers, since it is located up to 15 m below the ground surface and would »float« in a 12 m deep groundwater lake if the entire structure was not secured against uplift. Therefore, the construction of the station necessitated the building of a »dry excavation« with anchored diaphragm or slurry walls by the open-cut method. The permeability of the so-called bryozoa limestone, which is located at a depth of about 8 m underneath backfills, requires dewatering by means of wells to lower the water level to 1 m beneath the bottom of the excavation. In order to keep the changes of the hydrological conditions during the entire construction project as small as possible, the withdrawn water is redirected back into the soil via wells.

The bottom and the walls of the structure were concreted in one stage and the permanent uplift anchors are to be installed prior to the completion of the tunnel ceiling. According to the construction schedule, the entire area of 26,000 m² must be completely anchored by spring 2008.

The boreholes are drilled and encased to the final depth (on average 16 to 19 m below the upper surface of the base slab) using drilling equipment for a medium anchor grid of 2 x 3 m. The cleaned boreholes are then grouted with cement grout. After lifting the one-piece permanent GEWI® anchor in place, the external casing is removed and the anchor properly fixed in terms of position and height. As soon as the cement grout has cured, each anchor is subjected to an acceptance inspection using a maximum load of 1,580 kN, which is 1.5 times the service load. The bond length of the anchors is located in the bottom area of the bryozoa limestone, the so-called Limhamn formation, and was fixed at 4 to 5 m after preliminary tests. The anchors installed to date have all passed the acceptance testing with good success.

Before the lowering of the groundwater level is terminated, the anchor heads must be installed, the anchors prestressed to a service load of 1,050 kN, all

DSI Unit DSI Austria, Elsbethen / Salzburg, Austria and AAGE Christensen A/S, Valby, Denmark
DSI Scope Supply of 2,700 permanent GEWI® anchors, Ø63.5 mm, grade 555/700 with double corrosion protection in lengths varying from 16 to 22 m and anchor heads; extensive engineering consulting, ongoing acceptance inspections on the construction site; test anchors; installation instruction

cavities sealed and the anchor heads embedded in the bottom slab encased in concrete. The service life of the structure is designed for 120 years. Therefore, 20 test anchors are installed in certain accessible structural sections to allow inspection of the uplift anchors on a regular basis.

The opening of this landmark project including the expanded Malmö central station is scheduled for 2011.

As far as the anchors are concerned, this project is characterized by certain particularities:

- All double-corrosion protected anchors were manufactured by DSI Austria in Salzburg and transported in 22-24 ton shipments to Malmö, a distance of approximately 1,100 km.
- The anchors were manufactured in one piece up to a max. length of 22 m.
- The maximum deviation of straightness was + 10 mm for an anchor length of 22 m.
- Extensive quality certifications/certificates of compliance based on the Z-20.1-17 were required for every anchor batch delivered.
- 100% traceability of every anchor, i.e. every threadbar is consecutively numbered and provided with all supporting documents/certificates required.
- Supporting documents for all materials used, e.g. cement and anticorrosive agents, with a view to safeguarding drinking water quality.
- Compared to other steel rods or anchors with prestressed concrete strands, the GEWI[®] steel anchor has the advantage of relatively little bar strain, which in this project means minimal structural deflections in the event of load cases beyond the post-tensioning force.

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