PORT TECHNOLOGY INTERNATIONAL

FEATURED

- Thermal imaging technology
- Brake-ing boundaries
- Terminal tank mixing
- Ship-to-ship LNG transfer

www.porttechnology.org

Edition 61

ADVANCED AUTOMATION

Embracing efficiency

FAR EAST FOCUS

China – Rise of the dragon

CYBER SECURITY

The internet's dark side

VTS, Navigation, Mooring and Berthing

"The coastal section of Fujairah subsoil comprises of calcareous sandstone strata overlain by a layer of calcareous beach sand. This sandstone can occasionally be very hard and potentially lead to early refusal of the driving process. To overcome this issue, an extensive driveability assessment was carried out in combination with a testing program to evaluate the performance of various types of steel sections and MV pile heads."

'MV Pile anchors in the Port of Fujairah', page 80.

MV Pile anchors in the Port of Fujairah

Gert-Jan Roelevink, *maritime project manager, MUC Engineering, Fujairah, UAE*

While traditionally in the Middle East quay walls are designed as gravity type structures, a trend can be observed that more and more quay wall projects are being realised as steel driven retaining wall systems. This has proven to be attractive for various technical and commercial reasons, especially at relatively large retaining heights.

For large retaining heights, the anchored combi-wall system has become a common solution which is regularly applied in new quay projects. These combi-wall systems are generally anchored with a tie-back anchor system, or 'dead-man' placed in the soil at a distance behind the face of the wall. Although regularly used in Europe, and particularly in the Netherlands and Germany, where the combi-wall found its origin, the Müller Verpress (MV) anchoring system has not been used in the Middle East. However, at the moment the last MV piles are being driven in the Port of Fujairah OT2 project where they are part of a new 835-metre long quay wall with a retaining height of 23.6 metres.

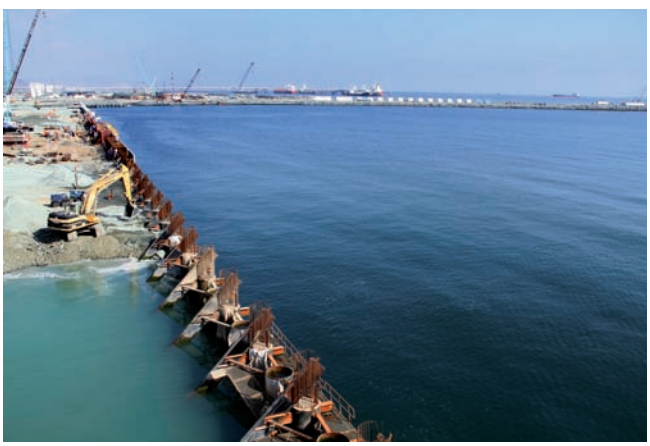
Project background

In 2010 the Port of Fujairah decided to expand its marine Oil Terminal 2 (OT2) by realising two new berths capable of receiving VLCC size tankers. The facility was to be built as a continuous quay wall in order to allow flexible berth usage. For space constraint reasons and a fast track schedule, there was a preference to adopt a combi-wall retaining system. This imposed a practical challenge on the execution because the harbour basin had already been dredged to -18 metres and is being used for tanker maneuvers to the already operational oil terminal. Hence, reclaiming a temporary working platform was not feasible and all construction work needed to be done using floating equipment. For this practical reason the feasibility was investigated for alternative anchor systems that allowed backfilling after installation of the quay wall system. A traditional tie-back anchor system is placed in the backfill of the quay wall and can only be mobilised after filling has progressed up to the anchor level. Consequently the MV pile anchor was proposed in combination with a rock backfill.

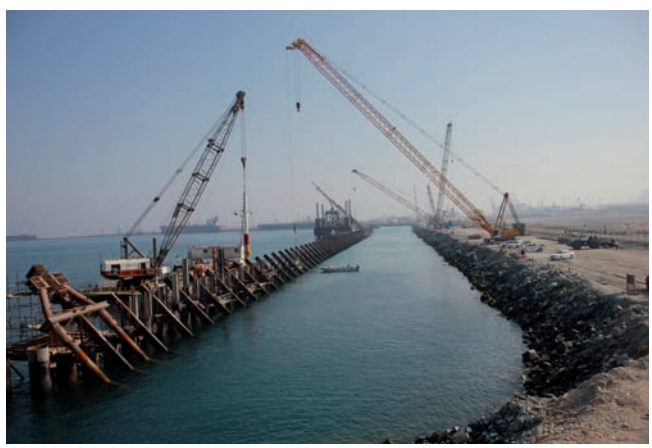
The Müller Verpress pile

MV piles are steel tubular pipe or H sections that are driven into the soil. Grout is injected through pipes attached to the pile while it is being driven into the ground, creating a grout body along the entire embedded length of the pile. A steel container is attached to the base of the pile to push aside the soil and provide a space for the grout body to develop. The grout injection pipes are led along the steel section into the container.

The grout body around the pile adheres to the steel section and substantially increases shaft friction capacity between the pile and the soil. Additionally the grout provides a protection against corrosion and serves to lubricate the pile during the driving process. The MV piles are driven into the ground at about a 45 degree angle, serving as a tension element which can be activated prior to completion of the backfill.

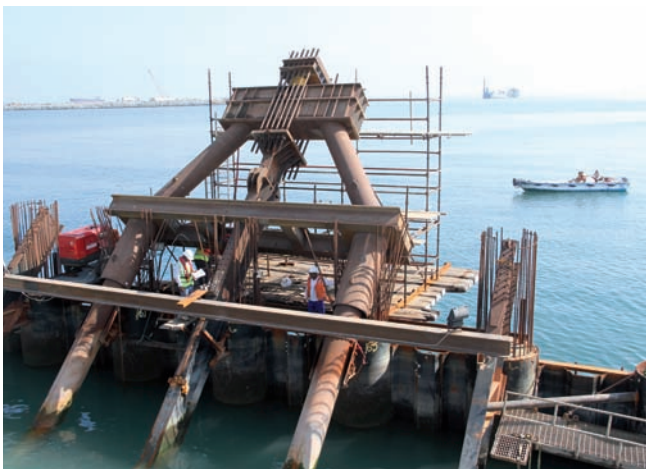


Port of Fujairah OT2, MV piles installed.



Fujairah's MV piling project under construction and one of the test installations on the left.

MV Pile head design.


MV Pile test installation for 1,000-tonne tensile test.

MV pile and grout container design

One of the main challenges was to assure the driveability of the MV piles. Similar to large parts of this region, the coastal section of Fujairah subsoil comprises of calcareous sandstone strata overlain by a layer of calcareous beach sand. This sandstone can occasionally be very hard and potentially lead to early refusal of the driving process. To overcome this issue, an extensive driveability assessment was carried out in combination with a testing program to evaluate the performance of various types of steel sections and MV pile heads.

The grout injection system comprised of a grout container at the pile head, the grout hoses and the injection plant. Several grout container designs and grout hoses were tested. Finally a design with a container on both sides of the flange and a bypass system along the beam's web proved to be most reliable for creating a grout body covering the entire circumference of the pile.

Testing programme

The testing programme comprised of a number of suitability tests on preliminary piles and acceptance tests on working piles up to an axial tensile load of 10,000 kN. The results from the suitability tests were used to optimise the pile design and conclude the feasibility of the anchor system.

The design bonded length of the anchor has been defined using friction values generally adopted for sandy soils. However, during all tests it was observed that the MV pile behaves very well in the calcareous sandstone and is rigidly fixed in the ground. Further analysis of the test results showed that the friction at the soil grout interface appears to be significantly higher than assumed in the design. This leaves room for optimisation in the bonded length of the MV pile in future projects. Several tests were also performed on cement mixes to assess their fluidity and strength development in marine environment.

Rig requirements

The rig used to drive the piles was a custom modified leader crane operating from a self-elevating platform. Modifications were made to the leader to allow driving in a 45 degree rake, providing proper support and alignment of the pile and hammer during the driving process and to provide sufficient pull down force for the hydraulic hammer.

In conclusion

Although the quay wall construction project has not yet been fully completed, it can be concluded that the MV Pile system has been a success in the OT2 quay wall project in the Port of Fujairah. The installation process was generally fast and without problems related to driveability in the calcareous sandstone.

The performance of the MV piles has also exceeded expectations. Tensile tests showed excellent friction properties at the grout-soil interface in the bedrock layers. Accordingly, for this new quay wall project, built at relatively large water depth, the MV pile anchoring system has proven to be a good alternative to the traditional tie back anchoring systems with several practical advantages related to speed of working and backfilling works.

About the author

Gert-Jan Roelevink is Maritime Project Manager at MUC Engineering. His background is hydraulic engineering, where he specialised in the design of coastal protection and port infrastructure and port master planning. As maritime project manager his responsibilities are the management of port infrastructure design projects as well as the design engineering division at MUC office which consists of structural, geotechnical and hydraulic engineers, master planners and project managers totaling about 30.

About the organisation

MUC Engineering is an independent advisory engineering and consultancy company based in the Middle East. MUC Engineering has supported the Port of Fujairah with the development of the Fujairah OT2 master plan and has carried out the design and project supervision for the OT2 infrastructure. Furthermore, MUC acts as project management consultant for a number of the commercial oil storage terminals in the FOIZ.

Enquiries

Capt. Mousa Building, Ground Floor, Hamad Bin Abdulla Rd Fujairah
P.O. Box 7718 F ujairah, UAE
Website: www.muc.ae
Phone: +971 92239954
Fax: +971 92232006
Email : roelevink@muc.ae