Existing General Maintenance and Rock Quays, Port of Saldanha

Design of two quay upgrades, Port of Saldanha

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SUMMARY

The Saldanha–Northern Cape development corridor has been targeted for investment as one of the strategic integrated projects (SIP 5) identified in the National Infrastructure Plan of 2012. The area has an inherent competitive advantage due to its location in relation to the West African gas fields, and this has led to the establishment of the Saldanha Bay IDZ focusing on the development of an oil and gas services and marine repair cluster. To support this, the Transnet National Ports Authority (TNPA) has undertaken to lengthen the existing General Maintenance Quay (GMQ) by 40 m, increasing the length of the quay from 107 m to 147 m, and to upgrade the existing Rock Quay located approximately 80 m to the north of the GMQ. The upgrades to the Rock Quay will include extending the quay southwards to close the gap between the two existing quays to create one continuous length of quay.

With the proposed extensions the usable quay length will increase from the current 107 m to approximately 300 m, which complements and is in line with TNPA's Port Development Framework Plan and its Land Use Plan. It also gives effect to the provisions of the Ports Act, namely to improve the productive use of port infrastructure, and to obtain optimum value from existing infrastructure.

The upgrade design is described in this article.

BACKGROUND

Upgrade of the General Maintenance Quay (GMQ)

The existing GMQ was constructed with I-shaped precast block elements stacked on top of one another in columns and tied together with a cast in-situ concrete capping. The top of the concrete capping is at +3.80 m CD, and the founding level of the block wall is at -11.7 m CD, resulting in the overall wall height being 15.5 m.

Currently the capping on the existing quay is approximately 107 m long. However, the precast blocks extend a further 20 m beyond the end of the capping as tapered wing walls on either end of the structure. The intention was to extend the GMQ by building up off these tapered wing walls using precast I-shaped blocks, thereby extending the concrete capping by 20 m on each end. This would increase the overall length of the quay by 40 m to 147 m.

Upgrade and extension of the Rock Quay

The existing Rock Quay is approximately 90 m long and was constructed with steel sheet piles. Limited information was available on the structure and, based on visual inspections, it was evident that the structure was in a state of disrepair. In addition, sediment accretion and debris from a scrapped vessel located in the berth pocket prevented vessels from mooring up against the quay. In conjunction with TNPA, it was therefore decided that the existing sheet pile wall should be replaced and the berth pocket reinstated as part of this project.

The gap between the existing GMQ and Rock Quay will be approximately 55 m after the upgrades to the GMQ have been completed. TNPA requested that this gap be closed to join the two existing quays to create one continuous length of quay approximately 300 m long.

For the upgraded and extended Rock Quay a combined wall system, consisting of an HZ king pile as the primary element and an AZ sheet pile as the intermediary secondary element, was selected as the preferred solution. A design dredge depth of -8.5 m CD was specified by TNPA. However, the dredging undertaken during construction would be limited to -6.5 m CD, in line with the requirements specified in the Environmental ROD.

Pile driving across the gap between the General Maintenance and Rock Quays

BLOCK WALL DESIGN DESCRIPTION (GMQ)

The existing block wall was constructed in the late 1970s and is over 35 years old. Limited information was available on the structure and the design approach adopted. The prevailing design approach used in the '70s was the traditional factor-of-safety (FOS) design approach, and it was therefore decided to follow the same design approach for the verification checks required on the existing block wall.

The design approach adopted for the southern and northern extensions differed slightly, as the southern extension was designed as a free-standing wall and the northern extension as a backfilled wall. Larger units, similar to those on the existing structure, were required for the southern extension to provide additional mass to the block wall, as it acted as a free-standing wall. For the northern extension, units identical to the existing structure were used, as this section of the wall will be backfilled.

Precast blocks weighing 60 t

COMBINED WALL DESIGN DESCRIPTION (ROCK QUAY)

The combined wall comprises approximately 145 m of piling extending from the GMQ block wall quay in the south to the

New combi wall installed ahead of existing sheet pile rock quay

Closing the gap between the general maintenance and rock quays

Placing of precast anchor walls

H-piles with profiled driving toe to assist with pile penetration through the hard calcrete layers

northern end of the existing rock quay sheet pile wall. The new combi wall will be installed directly ahead of the existing sheet pile wall with a return wall constructed at the northern end.

The sheet pile quay wall structure has been designed according to EN 1997 (Design Approach 1 Combinations 1 and 2), using recommendations from BS6349-2. The pile, anchor wall and tie rod sections have been verified against structural failure according to the provisions in EN 1993.

The embedded wall design package D-Sheet Piling v9.1, supplied by Deltares of Delft in the Netherlands, was used to conduct the limit mode verification checks on the sheet pile wall. D-Sheet Piling models the embedded wall as an elasto-plastic beam on a foundation of uncoupled elasto-plastic springs (representing the soil). The C, phi, delta soil model module, based on Culmann's formulae, was used along with the Eurocode 7 design verification module. The staged construction tool was used to develop a realistic step-by-step loading sequence from the initial stage, through the various construction and loading stages, to the final stage.

Combined wall design section

The design section consists of a single anchor combination pile wall comprising an HZ880M A-12/AZ26-700 Grade S430 sheet pile and an M90 Grade ASDO 500 MPa tie rod, anchored to a precast reinforced concrete inverted 'T' anchor wall.

The precast inverted 'T' anchor wall was preferred to a simpler sheet pile anchor wall in order to increase the local material and labour content of the project. In order to achieve the maximum passive response to meet the applied tie loads the inverted 'T' anchor wall will be installed with an inclined angle on the tie rod.

The selection of a combination wall section was governed by the installation requirements due to the hard calcrete layers present in the soil profile. The use of a high-modulus HZ king pile, profiled with a driving toe, ensures that required penetration depths can be reached, while the AZ profile infill sheets can be installed to -11.5 m CD with minimum embedment into the harder layers. In addition, the high-modulus section allows for reduced embedment depths, enabling the toe of the HZ sections to sit at the -16.0 m CD level just above the main identified hard calcrete layer. The reduction in toe depth also ensures

Piling materials stock yard

that the section is working efficiently and guarantees that, although the section sizing is governed by installation, there is no unnecessary overdesign at final design loading.

Seismic design considerations

Saldanha Bay is an area of low seismicity with low accelerations. A simplified pseudo-static design approach, based on Monobe-Okbe's classic method including hydrodynamic pressure fluctuation, was used to verify the combination wall against seismic hazards.

Corrosion protection

The combined wall has been designed for maximum durability in the marine environment, with minimum requirements for major in-service maintenance. In terms of corrosion protection the following system was proposed in order to meet the 50-year design life:

- The concrete cope beam will extend down to -0.5 m CD to provide at least 50 years of protection to the steel combined wall in the tidal and splash zones.
- Sacrificial galvanic anodes will give a 10-year service life (single anode deployment) to the exposed steel wall below the concrete cope. Sacrificial steel will provide the remaining 40 years of service life. A dual corrosion protection system was selected as there was uncertainty regarding the corrosion rate. Adopting a dual system allows for additional anode developments if the rate of corrosion is higher than anticipated.

Pile driving


Dredging the rock quay

- Sacrificial steel will provide the 50-year service life for the embedded pile sections.
- Tie rods have been oversized with > 50-year sacrificial steel allowance. The critical nature and complexities of replacement of the tie-back system require a conservative approach to corrosion protection.

SHEET PILE WALL INSTALLATION

The geotechnical investigation undertaken as part of this study indicated the following generalised soil profile:

Starting at ground level (+3.8 m CD):

0.00–3.00	Medium-dense to dense gravelly, SANDY fill
3.00–12.00	Medium-dense to dense SAND/SILT with random pedocrete (calcrete) zones
12.00–25.00	Very dense, variably developed PEDOCRETE/CALCRETE in a silty or sandy matrix
25+	Very stiff residual granite CLAY

SPTs that were taken down the profile, returned N-values ranging from 12 to refusal. In addition, UCS test results taken from the more competent calcrete zones found in the core sample, returned values of between 14 and 24 MPa, consistent with medium-hard rock.

The concern at design stage was that the dense sediment layers and the harder calcrete zones would make driving conditions difficult. However, this risk was mitigated by increasing the steel grade to 430 MPa, profiling and reinforcing the toe of the piles and driving with a large impact hammer in hard areas if required. Pre-drilling and pre-auguring to assist with installation were also viable options for the contractor in the hard calcrete areas, although installation without additional means was preferred.

ENVIRONMENTAL PROCESS

An application to conduct a Basic Assessment (BA) EIA was submitted to the Department of Environmental Affairs (DEA), and authorisation to proceed with the BA was granted in late November 2012.

The prescribed comment periods and public meetings were held and, on completion of the stakeholder consultation period, the Basic Assessment Report (BAR) and the Environmental Management Plan (EMP) were issued to the Department of Environmental Affairs (DEA). The approval and Record of Decision (ROD) were received in August 2013.

Environmental impacts

There are only minor environmental concerns arising from this quay wall extension project. The potential activities triggering environmental concerns and the associated mitigation measures are the following:

Dredging impacts: The preferred quay structures require minimal dredging outside of the deepening of the berth pocket to -6.5 m CD. A low total dredge volume of 15 000 m³ has been estimated. The potential impact from dredging activities would be increased turbidity in the water column. A background turbidity level for the site is to be established prior to the commencement of dredging activities. Real-time monitoring of turbidity levels in relation to the background level established for the site during dredging activities, restrictions on dredging during high winds and the use of hydraulic dredging methods would mitigate potential turbidity impacts.

Quay construction impacts: The preferred quay wall construction methods, utilising precast blocks and prefabricated steel sheet piles, have minimal negative environmental impact. However, the potential environmental impacts would be the standard impacts arising from marine construction activities, including but not limited to oil spills, construction waste, hazardous waste, noise pollution. The contractor's EMP will cover the handling of all potential construction-related environmental concerns. Proper monitoring of construction activities will ensure compliance with all EMP requirements.

Social benefits

The direct social benefits due to construction activities related to the extensions will come through the creation of construction jobs and local material market stimulation. The success and sustainability of the Saldanha IDZ depends on stakeholder access to quay facilities. The upgrades and extensions to the GMQ and Rock Quay will enable the Port of Saldanha to provide quay access without compromising other port activities.

CONCLUSION

Projects that involve design integration with existing structures require a high level of design flexibility to allow for modifications and changes as more information becomes available during construction. Often geometric constraints will govern structure selection, and careful consideration of constructability is required to ensure that construction risks remain acceptable. These types of projects are common in ports, as existing infrastructure is continuously upgraded and improved to meet increasing and changing demands.

ACKNOWLEDGEMENT

PRDW would like to acknowledge TNPA for supporting this article. ◻

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Marine Sub-contractor: Subtech (Pty) Ltd