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Maintenance and rehabilitation of sea walls and revetments between the Glencairn and Simonstown stations

The railway line between the Simonstown and Fish Hoek train stations is protected by sea walls which were constructed almost a century ago. In order to protect the railway line, concrete sleepers were placed in front of these walls during the 1970s. Over the last five years this intervention has been shown to be inadequate and an engineered solution was required over limited critical sections of the line. The November 2009 storms resulted in sections of the sea wall failing after being severely undermined. Passenger train operations were halted on the line in December 2009 due to public safety being compromised. After a design, procurement and stakeholder engagement process the necessary rehabilitation work was undertaken and completed in February 2011. Normal train operations were restored on 21 February 2011, the construction works having been completed within budget and within an acceptable time-frame

1 Site locations Long Beach and Marine Oil
2 Original sea wall with concrete sleeper revetment – Long Beach site
3 Sinkholes landwards of the sea wall necessitating the emergency repair – Long Beach site
4 Mass concrete wall protecting rail before November 2009 storms –Marine Oil Siding site

BACKGROUND

The railway line between Fish Hoek and Simonstown is both supported and protected from the sea by a stone and rock mason sea wall constructed in the early part of the 20th century. The seawall protects the railway line from normal and severe wave action during storms. During the 1970s old concrete sleepers were stacked against the walls acting as a rubble revetment, thereby protecting the walls from direct wave action. During the latter part of 2007 storms displaced the sleepers and caused damage to the sea walls. Repairs were carried out and additional sleepers were placed against the sea walls. At this stage, engineers at the Passenger Rail Agency of South Africa (PRASA) sought specialist coastal engineering advice and appointed Prestedge Retief Dresner Wijnberg (Pty) Ltd (PRDW) in July 2009. The first phase of the appointment was to carry out a status quo assessment of the sea walls, identify areas at risk and propose appropriate rehabilitation measures. PRDW made recommendations to PRASA in August 2009, which required, as a matter of priority, coastal protection works at two specific locations, namely Long Beach Site and Marine Oil Siding, near Simonstown (see Figure 1).

EMERGENCY MAINTENANCE REPAIRS

In November 2009 a series of 'black south-easters' caused significant displacement of the old concrete sleeper revetment. This led to the undermining of sea wall foundations and the development of sinkholes landwards of the sea wall at the Long Beach Site. The Marine Oil Siding rail line, which was protected by a combination of sand dunes, concrete sleepers and a short length of mass concrete wall, was also excessively scoured and eroded during the November storms.

The structural damage to the walls and track formation was assessed by PRDW and PRASA engineers and the line was closed for safety reasons on 4 December 2009.

PRASA requested PRDW to propose an emergency solution to prevent the potential total collapse and loss of a critical section

(50 m in length) of track infrastructure at Long Beach. Due to the time of year and the constraints at hand, PRDW proposed placing natural rock between 1 and 2 t in front of a 50 m section of sea wall to provide the necessary protection against waves.

Before commencing with the construction, environmental consultancy group ERM were engaged by PRDW to set up a meeting with the Department of Environmental Affairs and Development

5 Mass concrete wall protecting rail after November 2009 storms –Marine Oil Siding site
6 Unloading rock for the emergency repair section – south side of Long Beach site
7 Completed emergency repair section – south side of Long Beach site
8 Grouting the toe of the Long Beach sea wall

Planning (DEA&DP) Western Cape to seek approval to carry out the works. As the works were deemed as maintenance and within the existing footprint of the sea wall, an environmental impact assessment was not required and approval was subsequently granted.

The revetment rock was transported by PRASA with the assistance of Transnet Freight Rail (TFR) from a rail siding in Somerset West to the site at Simonstown Long Beach using railway wagons. The Contractor (Sea and Shore Projects) was responsible for sourcing the rock, transporting it to the siding and off-loading and placing the rock at Long Beach. The transportation of rock by rail expedited the maintenance work, which resulted in 900 t of armour rock being transported and placed within seven days.

DETAILED ENGINEERING DESIGN

In January 2010, PRASA made the decision to proceed with the necessary rehabilitation works to reinstate normal rail traffic at the Long Beach and Marine Oil sites, as previously recommended by PRDW. Three technical alternatives for the rehabilitation and maintenance works were considered:

1. The placement of additional concrete sleepers in front of the sea wall.
2. The construction of a new sea wall in front of the existing wall.
3. The construction of a rock revetment.

The placement of additional sleepers was discarded due to the ineffectiveness of the sleeper revetment to provide adequate protection to the ageing sea wall, and for aesthetic reasons. A new sea wall was not preferred, as the construction process would be slow, costly and could potentially destabilise the current wall. A rock revetment was considered to be the most robust, practical and aesthetically pleasing coastal engineering solution.

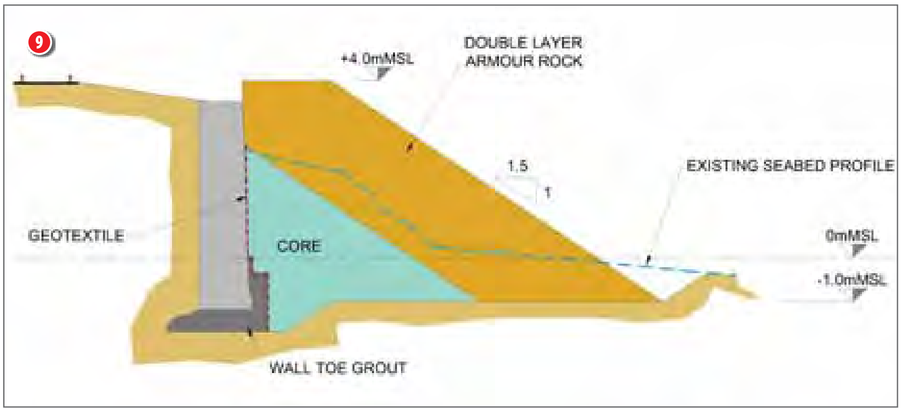
Long Beach revetment

A 415 m long rock revetment structure with a toe level at -1 m below mean sea level (MSL) was constructed to protect the existing Long Beach sea walls. The founding level was chosen to ensure that the revetment could accommodate future expected erosion. In order to prevent further leaching of fines beneath the sea wall, toe grouting was carried out before the revetment was constructed. A geotextile was placed along the face of the sea wall extending to the bottom of the newly constructed grout foundation. This would prevent further leaching of fines through the sea wall.

The core of the revetment was constructed using graded rock of 1 to 60 kg and recycled concrete sleepers broken down to size. This core was used as a bedding layer for the armour rock. The seaward slope of the revetment was specified as 1:1,5 with armour rock graded from 1,5 to 4,5 t.

Marine Oil Siding revetment

A 265 m long back of beach revetment with a founding level at MSL was constructed at the Marine Oil Siding site. This founding level was chosen to minimise any excavation below the water level which would require dewatering equipment. In this way the excavation work was kept semi-dry, thereby making construction considerably easier and more efficient.


9
+4.0mMSL
DOUBLE LAYER
ARMOUR ROCK
1.5
1
EXISTING SEABED PROFILE
GEOTEXTILE
CORE
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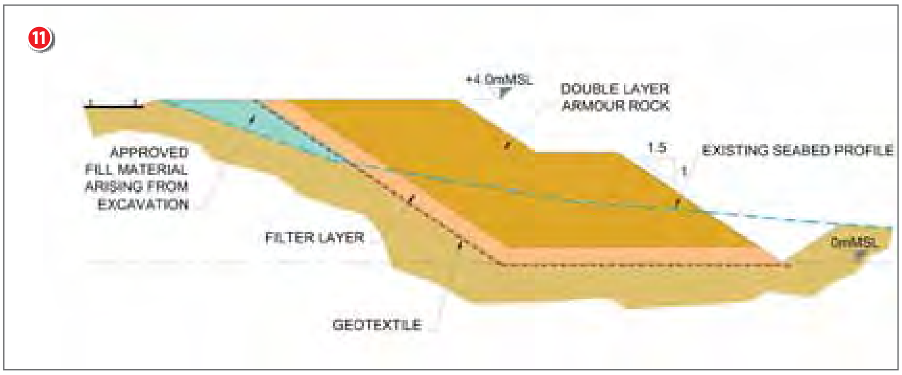
WALL TOE GROUT


10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APPROVED
FILL MATERIAL
ARISING FROM
EXCAVATION
FILTER LAYER
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GEOTEXTILE


12
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VOLVO


14

9 Typical Long Beach design section
10 Marine Oil Siding section under construction showing geotextile, filter layer and armour rock layer
11 Typical Marine Oil Siding design section
12 Offloading core rock at the Long Beach site
13 Constructing the Long Beach rock armour berm
14 Taking delivery, and loading armour rock at the Marine Oil Siding site

The revetment crest is situated 7,9 m away from the seaward rail of the railway line. This created an area 3 m wide between the seaward rail and inside the revetment structure, which was filled with approved backfill material. This was done to satisfy the Client requirement of a clearance of at least 3,2 m from the centre line of the railway to the edge of any structure.

A geotextile (Bidim A10) was placed beneath the revetment structure as a filter to prevent sand loss which could lead to revetment failure. A filter rock layer, with a grading of 5 to 25 kg, was designed as a base layer for the armour rock. The required armour rock grading was 1,5 to 4,5 t, placed in a double layer with a thickness of 2,3 m. The slope of the armour rock was specified as 1:1,5.

The revetment at the Marine Oil Siding originally had an extended sacrificial toe which was designed to accommodate future beach erosion due to storm events. During construction, excavations revealed that, over large portions of the revetment, bedrock was present above the design founding level. This led to a design variation of removing the sacrificial toe in areas where there was no risk of future erosion and settlement.

ENVIRONMENT AND HEALTH & SAFETY

A key component to completing the project as rapidly as possible was the engagement and appointment of an environmental consultant early in the design process. PRDW appointed ERM to assist with departmental liaison. This ensured that the proposed revetment activities along the sea wall were compliant with current environmental legislation and that sound environmental management procedures were followed during operations.

This helped PRASA to fulfil their obligations in terms of the National Environmental Management Act (NEMA). An Environmental Management Plan (EMP) was prepared and written into the tender document to ensure compliance during the duration of construction.

PRDW, acting as Engineer for the project, appointed Solid State Group to advise on health and safety aspects and act as Client's Agent in terms of the OSH Act and Construction Regulations. A Health and Safety specification was also prepared and included in the tender document.

Interested and affected parties (IAPs)

Due to the railway line's sensitive environmental location, numerous interested and affected parties (IAPS) were consulted. Meetings with IAPs, which included Marine and Coastal Management (MCM), City of Cape Town, SAN Parks, Simonstown Civic Association, SA Heritage and Resource Agency (SAHRA) and the local Trek Fishermen, were carried out in order to understand concerns and mitigate accordingly.

The construction period coincided with approval of an extensive seven-year long legal process which allowed local trek-net fishermen to continue with a fishing activity which has been passed down for generations. As an outcome of meetings held with the local fishermen and IAPs, a beach access design that accommodated the fishermen and local recreational beach users was implemented. In order to accommodate the fishermen's request for a wider beach section to handle their fishing nets, the toe over a 20 m section of the revetment was removed and founded on bedrock.

CONSTRUCTION

Logistics and timing

For the 14 months that the railway line was closed, PRASA provided bus transportation for commuters and tourists travelling to Simonstown. As a result of this inconvenience and cost the project required not only efficient liaison with all parties, but also a fast-tracked construction process.

The critical path for revetment construction was characteristically driven by the delivery of rock to the site. Fortunately, due to the Client's position as a passenger and commuter rail service with the support of Transnet Freight Rail, they had the necessary infrastructure and rolling stock to transport 14 500 t of heavy armour rock by rail wagon over a 15-week period.

This reduced the length of the construction duration, and the costs of transporting rock to the Long Beach site. The alternative would have been road transport with a haul distance of 60 km, using trucks equipped with modified rock skips.

The Long Beach and Marine Oil siding sites are 800 m apart and separated by the Simonstown Lower North Naval Battery. Both sites required different construction techniques and were managed independently while being constructed simultaneously. This was only possible by transporting rock to Long Beach by rail, and by road to the Marine Oil site.

Long Beach – armour rock berm

In order to provide a working area protected from wave attack, the Contractor created a berm out of the armour rock on the seaward side of the sea wall. The berm offered under most conditions a dry working platform from which excavators could off-load armour rock from the train wagons and place in front of the existing sea wall.

The berm was constructed by using approximately the same volume of rock per metre that would be required for the final design section of the revetment.

As the berm was constructed parallel to the sea wall, the old concrete sleepers could sequentially be removed for an on-land milling process. The milled material was later incorporated with 1 to 60 kg rock in the core layer. Once the toe grouting operation and core layer were in place, the excavators could retreat from the sea, repacking the berm to the correct profile and leaving a completed revetment section in place.

Marine Oil Siding rock moving

All rock transported to the Marine Oil site was tipped and stockpiled at the southern end of the beach. The rock was then moved along the beach by pushing it with a dozer. This method of moving the rock was not effective, and subsequently an articulated dump truck was used to transport the rock over the beach.

Weather-related downtime

The construction period began in September 2010 and ended during February 2011, coinciding with the summer months and the frequent gale force southeasterlies prevalent in False Bay. As the sites are situated on the shoreline on the western side of False Bay they were particularly vulnerable to the full force of the southeasterly storms. The strong onshore winds resulted in increased wave overtopping and spray, which rendered conditions unworkable. Eight working days were lost over the construction period, due to excessive sea spray and extreme water levels.

CONCLUSION

Train operations on the railway line between Fish Hoek and Simonstown station officially recommenced on 21 February 2011, ending a 14-month disruption period. The original contract was completed within the overall construction budget of R21 million and within an appropriate time-frame, considering the additional works and weather related delays.

The project has shown that the early appointment of environmental practitioners, and engagement of all IAPs, is paramount to the success of a project with a high public profile such as this. A healthy working relationship between the Client and Contractor contributed to the successful completion of the rehabilitation works for the Simonstown railway line.

ACKNOWLEDGEMENTS

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PROJECT TEAM

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Passenger Rail Agency of South Africa (PRASA)
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Environmental Sub-Consultant
Environmental Resource Management Group inc
Health and Safety Sub-Consultant
Solid State Group
Main Contractor
Sea and Shore Projects (Pty) Ltd
Sub-Contractor
Wezan Building & Civil Construction

15 Completed Long Beach revetment withstanding a moderate southeasterly

16 Completed Long Beach revetment with train operations continuing as normal – 25 February 2011

Source:
http://www.saice.org.za/downloads/monthly_publications/2011/2011-Civil-Engineering-may/files/res/downloads/book.pdf