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Unique geomebrane lining design

and installtion at effluent treatment plant

MONDI BUSINESS PAPER'S Richards Bay mill required a secondary treatment process facility to be able to treat effluent for the purposes of re-use or for discharging back into the natural environment, improving the environmental performance for the mill in line with European Union (EU) 'paper profile' parameters. These parameters comply with the best available technology in the pulp and paper industry and compliance is essential for paper products marketed in the EU.

This project was unique by virtue of the size and capacity of the tank required to meet the client's needs. It was undertaken by a design construct consortium comprising Grinaker-LTA Civil Engineering (GLTA) and a construction team made up of the following:

- Aquatan (Pty) Ltd – design and installation of the membrane liner to the floor and wall/floor joint
- PDNA – structural engineers on the main tank, measuring well and cooling tower supporting structure
- Semane – structural engineers on the surrounding infrastructure and technical building
- ARQ – geotechnical investigation and design of the secondary tank founding structure

NEW SECONDARY EFFLUENT TREATMENT TANK

The 123,3 m diameter outer tank and 72 m diameter inner tank with support infrastructure directing flow in and out of the secondary treatment tank were designed and constructed in only 12 months. Construction started on 1 September 2004 with completion on 15 September 2005. This is one of the largest plants in the world for the treatment of pulp and paper wastewater.

Secondary effluent treatment tank details

As stated above, the effluent tank consists of two concrete circular tanks, the outer tank wall of 123,3 m diameter and 10,5 m high (the aeration basin) and the inner tank wall of 72 m diameter and 6,5 m high (the clarifier) with a central integral concrete core of 12 m diameter.

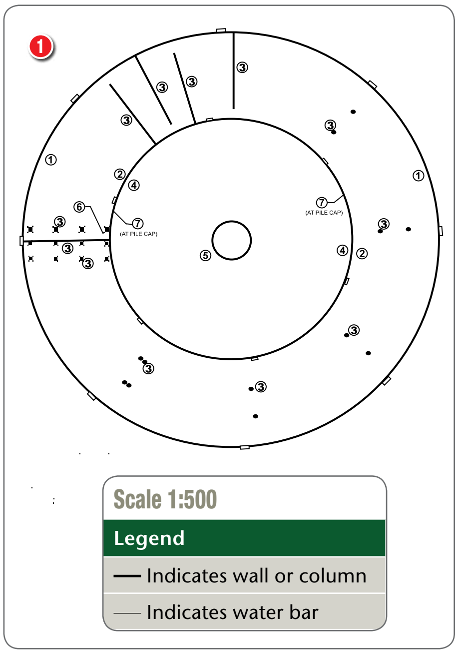
Requirement for a geomembrane liner

A conventional concrete floor would not have been feasible because of the following constraints:

- The walls and internal core were supported on a pile and pile cap arrangement where various vertical settlements were expected (outer wall 8 mm, inner wall 22 mm and central core 16 mm)
- The floors of the tanks were expected to have substantial differential settlements of 20 mm to the outer aeration tank and 26 mm to the inner clarifier tank
- The walls were designed for various movements both inwards and outwards due to wall cable tensioning (elastic shortening), creep, shrinkage and temperature change. The net result was that the outer wall could move a total distance of 120 mm horizontally and the inner wall a total distance of 80 mm horizontally! These movements could not be ignored in a water-retaining structure and bearing in mind that these movements would occur at various phases both during the construction stage and the service life of the effluent tank
- In the aeration basin (the outer tank) there was a requirement for five division walls, which spanned between the two circular walls. These walls were stationary and therefore had to accommodate and not impede the circular wall designed movements

Challenges to find a suitable geomembrane liner

Considering the above complications, it was evident that the customary dam lining materials would not be suitable. It was decided to use Hyperliner, an ethylene vinyl acetate material, as a geomembrane liner. This material accommodates differential and multiaxial movements and has an extensive elongation characteristic prior to yield and break stresses. As a result of construction activities over the installed liner,



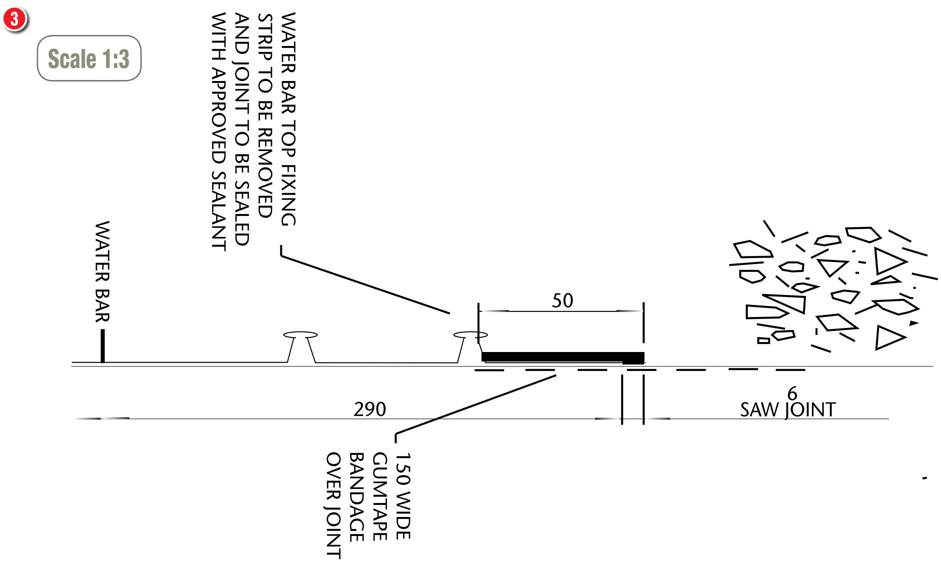


Figure 1 *Plan showing division walls and columns*
Figure 2 *Section through wall showing cast-in water bar*
Figure 3 *Joint detail at the top of the horizontal water bar*

a 2,0 mm thickness was proposed. Owing to the concrete overlay (described later), the lack of UV resistance of this material was not an inhibiting factor.

An additional advantage with EVA is that it is possible to manufacture an extruded water bar out of exactly the same formulated material. (This advantage will be described below.)

Basic design

The floor substrate generally consisted of a substantially thick compacted sand backfill layer (±4 m) between the walls. This was followed by an 80 mm no fines layer and leakage detection system with a 20 mm thick mortar topping to provide a smooth surface for the 2,0 mm Hyperliner membrane. An 80 mm thick reinforced concrete slab was then cast on top of the Hyperliner as a protective layer to prevent future operational damage from pedestrian traffic or mechanical scraper arms, etc. A specially manufactured continuous

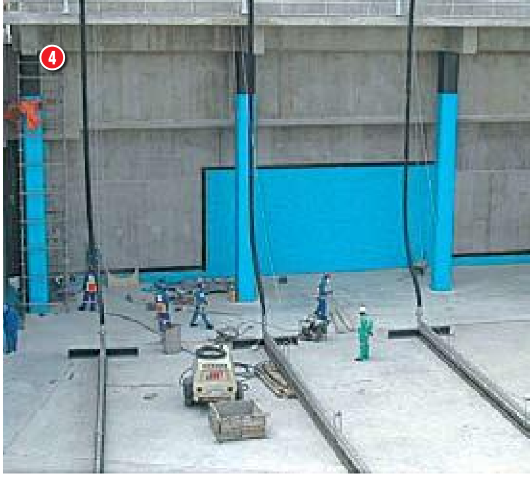


Figure 4 *Geomembrane liner to division wall and columns*
Figure 5 *Central core make-off detail*
Figure 6 *Pipe support column and tie beam geomembrane lining*

The entire waterproofing of the lining system relied on the homogenous casting in of the water bar into the walls. Special attention was provided to ensure continuity around the protruding pre-stressing buttresses. This necessitated meticulous on site hot knife jointing methods

Hyperliner rearguard water bar strip with four protrusions was supplied to and cast into the walls by Grinaker-LTA approximately 600 mm above the floor level.

Detailed design and solution

Water bar

The entire waterproofing of the lining system relied on the homogenous casting in of the water bar into the walls. Special attention was provided to ensure continuity around the protruding pre-stressing buttresses. This necessitated meticulous on site hot knife jointing methods.

As an added precaution an innovatively designed seal was extruded between the top of the water bar and the concrete and then a gum tape bandage was adhered between the top of the water bar and the concrete wall.

The floor membrane was then later extrusion welded to the horizontal water bar. This extruded weld was quality checked using the spark testing method.

Differential vertical settlement between wall and floor

In order to prevent any shearing of the liner at the wall/floor joint, a system of 180 mm thick circumferential jockey slabs (1,5 m wide x 3,0 m long) were cast onto the circumferential ring beam which supported the wall bearings. When floor settlement occurred, the jockey slabs merely tilted, thereby eliminating the vertical shearing action on the liner.

The joints between each jockey slab had an aluminium strip nailed one side, which accommodated any differential movement (both horizontal and vertical) between adjacent slabs.

Horizontal wall movements

It is felt that this particular detailed design ensured the complete integrity and success of the water proofing system and hence the entire project!

In order to accommodate the substantial and varying wall movements, a 300 x 325 mm triangular corner fillet was cast at the wall/floor joint on top of the jockey slabs. This fillet was tied to the wall with hoop iron ties and a sliding joint was provided on top of the jockey slab with the incorporation of two HDPE sheets. This ensured that when wall movement occurred, the entire fillet moved with the wall by sliding on top of the jockey slab. Special consideration had to be taken of what movements occurred first to ensure that the liner was not stressed (or 'stretched') at any stage. In addition, one had to consider that the inward movement did not 'pinch' or 'squeeze' the liner against the 80 mm concrete slab overlay. A gap was therefore left between the slab overlay and the concrete fillet. These gap widths varied according to the predicted movements. The slab overlay bottom edge was also chamfered to accommodate the folding of the liner at this point.

Stationary internal division walls and columns

As there was no horizontal movement to these internal walls and columns, it was not necessary to make any provision for a movement joint.

Where these walls joined the circular moving walls, they were supported vertically with a corbel on each side and a sufficient gap was left between the dividing wall and the circular walls to ensure free movement.

To accommodate the liner and the above differential movements at the floor area, a 1,0 m x 1,0 m box out was provided in the wall and the water bar and liner were simply taken through this box out. This ensured that there was no threedimensional stresses placed on the liner.

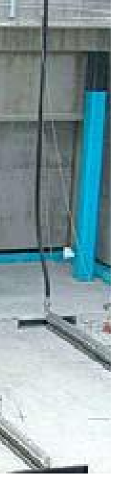
Central core

At the central core, in the clarifier, a system of jockey slabs was once again used to accommodate the vertical settlement. A 150 mm wide bridging strip of 2 000 µ HDPE was placed over the jockey slab/central core joint to prevent the liner being compressed into the joint when hydraulically loaded.

The liner was mechanically fixed to the central core using a radiused 50 x 50 x 5 mm stainless steel angle, gasketting and bolts.

Pipe support columns

In order to eliminate any possible leakage at these structures, it was decided to line the entire columns. This operation incorporated some intricate welding work around some of the interconnecting column tie beams and the subsequent prevention of air entrapment had to be considered.



Site installation and quality control

Casting of 80 mm concrete overlay on top of liner

Stringent conditions and controls were in place to minimise pedestrian traffic over the exposed liner. Full cooperation of the Grinaker-LTA and Aquatan site teams was required with regard to the planning and programming of the geomembrane laying and the concrete casting operations. One welding operator was in full attendance during all concreting operations, both day and night, to inspect and repair any accidental damage to the liner.

Water bar installation and sealing

As steel shutters were used for the walls, Grinaker-LTA had to design a special fixing system to hold the water bar in place and to form a recess for the sealant at the top of the water bar. The system worked well and the sealant and gum tape bandage ensured an additional positive waterproofing system (see figure 5 above).

Quality assurance and control

Owing to the vulnerability of the membrane on an active construction site, a stringent system of checking and rechecking was carried out. The subsurface was carefully checked by both parties, signed off and all welds were checked using air pressure testing, spark testing and vacuum testing. The use of a clear Hyperliner welding rod had the added advantage in that a visual check for off centre welding could be carried out.

Specially fabricated rubber tipped shovels were used for the concreting operations to prevent any mechanical damage to the geomembrane liner.

CONCLUSION

Considering all of the above implications and difficulties and fast-track programme, and that no leakage occurred, the client may consider the geomembrane lining a complete success.

This was a truly phenomenal project, demanding the highest level of design ingenuity and careful supervision while continuously challenging conventional geomembrane installation and construction methods. ☐