Mondi effluent treatment a massive project

RICHARDS BAY in KwaZulu-Natal is situated along a stretch of coastline that is home to some of the most sensitive wetland systems in the world. Mondi Business Paper, a world-class producer of paper products, makes extensive use of water and wood-based products in the production of its paper. The control of effluent, recycling and disposal of water used in the paper production process is a matter of concern to Mondi, who are conscious of the environmental responsibilities inherent in its positioning on this coast, near the industrial hub and harbour facilities of Richards Bay.

This, among other reasons, led Mondi in 2005 to commission the building of a secondary effluent treatment plant to ensure the safety of water recycled for use and water that was destined to be returned to the ocean.

In awarding the contract for this immense project, the construction of a tank with a diameter of 123 m, Mondi catapulted the companies involved in the contract into the construction of what would be Africa's largest effluent treatment tank.

A design and construct consortium led by Grinaker-LTA Civil Engineering (GLTA) undertook the project. Semane structural engineers undertook the surrounding infrastructure and technical building, and ARQ undertook the geotechnical investigation and task of designing the secondary tank founding structure. PDNA was commissioned to act as structural engineers on the main tank.

Because of its large diameter and depth, radial movement due to temperature change and elastic shortening is a lot greater than smaller-radius tanks. This large movement meant that the joint at the wall and floor interface were to be designed carefully and in consultation with Aquatan, waterproof-lining suppliers.

THE PROJECT

Despite the massive size of the project, which required the construction of a 123,2 m diameter outer tank and 72 m diameter inner tank with support infrastructure directing flow in and out of the secondary treatment tank, the plant was designed and constructed in only 12 months. Construction began on 1 September 2004 and was completed on 15 September 2005.

The siting of the plant on a significant thickness of soft and loose estuarine deposits within the Richards Bay industrial area presented many challenges, including the question of how to accommodate an imposed load of 1 200 MN generated by the tank, which was 10 m high, on a sub-grade of approximately 16 m of loose to medium density sands and soft to firm silts and clays. Conventional foundations were precluded, as excessive settlement would have been problematic.

Another complicating factor was calculating permutations of forces that would be present when the tank was in use by Mondi. In some cases the outer tank could be dry and the inner full. At other times, the opposite would be true, creating different ring pressures and more compression.

The floor detail of the tank also had to be carefully considered. The normal construction would have been totally rigid. By using the unique founding system adopted by PDNA costs for this facet of the development were approximately 20% below the industry norm.

Because of the expense required to use piling and foundations to cope with forces of about 250 kNm, a solution in the form of a partially piled structure was decided on.

THE SOLUTION

In the solution adopted, portions of the structure are piled out on piles that do not extend to bedrock. The rest of the structure 'floats' on the sub-grade.

A pile and pile-cap arrangement supports a 10,5 m high circular post-tensioned retaining inner and outer wall. The core structure comprises a 12 m diameter integral concrete structure, also supported on piles. The pilecapping beam along the circular walls was designed to carry the 10,5 m high walls. Sand with a mortar capping was placed on top of and along the pile cap to form temporary support to the wall during construction.

Bearings were placed at pile positions that transferred vertical loads directly into the ground. Twelve radially guided bearings were placed along the outer circular wall and eight radially guided bearings along the inner circular wall. In total, 60 steel-bearings were provided beneath the outer wall and 42 beneath the inner wall.

Wall movement occurs due to tensioning, temperature change, shrinkage and creep. The aeration basin wall (123,2 m diameter) was designed for a water depth of 9,5 m and the secondary clarifier wall (72 m diameter) for a water depth of 4,4 m with a saturated soil depth of 4,0 m below the raised surface bed. The post-tensioning was designed so that with full water pressure, a minimum of 1 MPa compression is retained in the circumferential direction. Reinforcement was provided to allow for early shrinkage with a maximum crack width of 0,2 mm, additional vertical reinforcement on the outside face was provided to resist tensile stresses due to 'moments' induced during sequential stressing. Also, additional horizontal reinforcement was provided at the top of the wall to withstand tension forces created during initial stressing of the lower parts.

Partial construction joints with continuity of reinforcement to control early shrinkage cracks were provided at not more than 5,8 m c/c. The installation of piles commenced as soon as a suitable working platform was formed. These were installed following the perimeter of the structure in both directions, thus completing the installation of the 107 piles in a short time. Pile trimming, subsurface drainage and leak detection system, underground piping and pile-cap construction was completed thereafter. The installation of bearings and the construction of the tank walls followed the construction of the pile-cap.

The inner and outer walls were constructed in three lifts. The first lift was completed utilising a conventional gang-form system. The second and third lifts were completed through a 'DOKA' bracket arrangement that was supported by the already constructed first lift.

Sleeves with a diameter of 85 mm were cast into the walls.

Cable strands were later installed through the sleeves, which, after tensioning, would provide sufficient circumferential strength to withstand 6200 KN per metre height of load at the tank bottom. Similar magnitudes of resistance were provided for in the 12 m diameter inner tank.

Before the inner and outer tank could be completed, a large volume of fill, 4,0 m deep, which formed the inner-tank raised platform, had to be brought inside. This eliminated the tedious task of having to cart fill material over two 10,5 m high walls.

plant

As a world-class producer of paper products, Mondi Business Paper makes extensive use of water. When their operations are situated on a sensitive coastline, effluent treatment becomes a major business focus

Other plant and equipment was also brought inside before complete wall closure could take place. Backfilling to the inside face of the inner wall could only commence after this wall was tensioned.

The construction of the launder/overflow channel to the inside face of the inner wall continued as this wall was being built. All ancillary structures such as walkways and dividing walls were constructed simultaneously with the circular walls. Transverse design loading for all dividing walls was fortunately limited to those imposed by wind. There was no resultant transverse load imposed by water, as there would always be water on both sides of the dividing walls.

The cable-tensioning sequence was chosen to limit unbalanced stresses occurring within the walls to a minimum, particularly at buttresses, hence cables were stressed in stages before reaching its full design stress (75% of ultimate).

All cables at the same elevation (set of cables) were stressed simultaneously. The outer wall consisted of 18 sets of cables and the inner tank of 13 sets.

Large (800 mm diameter) and small (150 mm diameter) pipes were required to pass through the post-tensioned walls at certain locations in the tank, because radial movement of the walls was expected to be large, compensators were designed to accommodate this movement at these pipe positions.

The leak detection system restricts ground water seepage into the 100 mm thick no-fines concrete layer, which was prepared to drain only leakages that occurred from the tank, 110 mm slotted PVC geo-pipes drain into manholes positioned on the outside along the circumference of the outer wall. These pipes drain demarcated areas; hence, detection of leakages is made easier.

CLOSING REMARK

A complex project of enormous importance to the participating engineers, the plant demanded high levels of design ingenuity and careful supervision. It continually challenged conventional design theories and construction technology.

SECONDARY EFFLUENT TREATMENT PLANT, MONDI BUSINESS PAPER, RICHARDS BAY

Commendation in the category Technical Excellence in 2006

Submitted by Witwatersrand Branch

KEY PLAYERS

Client Mondi Business Paper
Consulting engineers PD Naidoo and Associates
Main contractor Grinaker-LTA

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