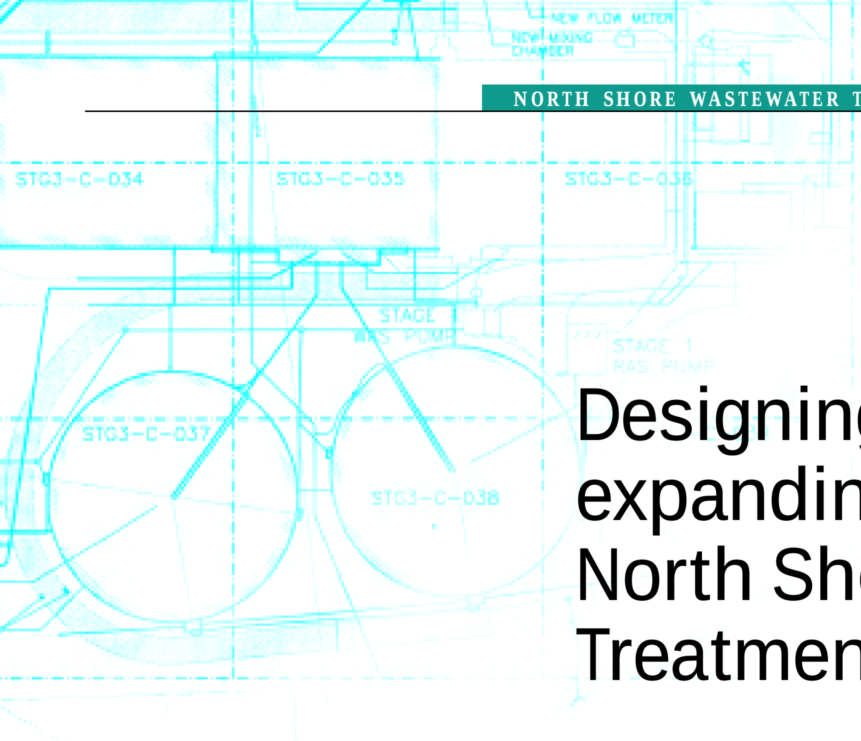

Designing for growth – expanding Auckland's North Shore Wastewater Treatment Plant

North Shore City's population is expected to reach more than 200,000 in the next few years. Designing for the upgrading of infrastructure systems for growth of this kind is a specialised business.

The first stage of a major upgrading of the city's wastewater treatment plant was carried out between 1993 and 1995 by Downer Construction Ltd. This included the first aeration tank and clarifier together with ancillary works.

Downer won the tender to begin Stage 3 of the project in March last year with Auckland engineering design company Woodward-Clyde. The knowledge gained from the Stage 1 experience gave them a valuable advantage in tackling the third and final stage.

Due for completion in May 2001, the project is currently running some seven months ahead of schedule, due mainly to the considerable time savings mainly achieved through the concrete design and construction choices made.

Woodward-Clyde's design largely conformed to the North Shore City Council's concept plan for the expansion, and included a further two aeration tanks and two clarifiers identical to those included in Stage 1.

Construction of the $14 million project began on 1 March 1999 with a scheduled completion date for the building component of 8 May 2001. The revised completion date is currently October of this year.

Designing for 'clean' technology

The two 7000 m^3 aeration tanks are at the heart of the MLE (Modified Ludzack Ettinger) process adopted for this expansion. This nitrogen reduction process is designed to remove ammonia and reduce nitrates to produce effluent that is more suitable for discharge into the Hauraki Gulf. The MLE process uses bacterial action to convert ammonia to nitrates, followed by further bacterial action in which bacteria strip the nitrates of oxygen, harmlessly releasing nitrogen gas to the atmosphere.

The size of the structures meant that some floor slab pours had to be large to minimise the number of construction joints and facilitate the speed of construction. The floor of the MLE tanks was poured in three sections. The central section of the clarifier floors was poured first followed by two pours of half of the annulus.

Concrete design specs

Mixes for the concrete used for this project were designed by the supplier, Atlas Concrete. Specification requirements included:

Minimum Concrete Strength at 28 days:
Site concrete – 10 MPa.

Tank structures – 40 MPa, to provide a dense concrete with resistance to the corrosive constituents of sewage.

Concrete Modulus E: 29.7 GPa (theoretical value)

Minimum cement content:340 kg/m^3
Maximum aggregate size and nominated slumps were also specified to suit the concrete that was to be provided for the various elements of the project.

Concrete strengths and concrete cover were selected in accordance with the

Above: The second ofthree main concrete pours at dawn for the floor of the MLE Tank.

Right: View ofMLE tanks (foreground) partlyfinished with two clarifiers behind (nearing completion) and effluents polishing pond in the background. Note the existing Stage 1 clarifier can be seen operating in the background left ofthe photo.

requirements of NZS3106 and NZS3101 to provide adequate protection to the reinforcing for durability purposes. This was to ensure that the structures have a 50-year design life.

Structural form

MLE tanks 2 and 3 took the same general form as tank 1 constructed in Stage 1 of the upgrade. The main areas of difference in the design philosophy were that:

Precast external wall panels with an in situ infill were used where practical.

Precast wall panels were used for non-structural internal walls.

The MLE tanks are a reinforced concrete structure with a slab on ground, typically precast perimeter walls,and in situ infill. The inlet and outlet pipes are reinforced precast concrete with rubber ring joints.

The 300 mm thick perimeter precast wall panels are typically joined together with an approximately 600 mm wide in situ strip. Structural internal walls are 300 mm thick in situ concrete. Non load-bearing internal walls are 120 mm thick precast concrete panels connected to the main load-bearing walls using a pair of stainless steel angles bolted to the supporting element.

Loading specs

Seismic actions for water-retaining structures were derived in accordance with the "Study Group on Seismic Design of Storage Tanks – Progress Report". Elastic acceleration spectra were developed by Engineering Geology specifically for the site. These values were adopted as a minimum, and a seismic risk factor of 1.3 was used for this project.

The precast 120 mm internal wall panels to the MLE tanks have been designed so that in a severe seismic event

they could either be repaired or replaced if they become damaged. Main internal and external walls typically cantilever from their base. Additional support is provided by the propping action of the concrete walkways and return walls.

The walkways transfer loads that are generated by propping the top of the internal and external walls to the main structural walls. The external concrete walkway is 1700 mm wide x 300 mm deep. Main internal walkways are 200 mm deep in situ concrete.

Typically, intermediate walkways are formed from precast Tee sections. These can act either in tension or compression to transfer loads across the tanks. Infill concrete at the columns provides continuity to these elements.

Design analysis

The existing tank (Tank 1) could not be emptied until Tanks 2 and 3 were operational. In evaluating the design, it was assumed that Tank 1 and/or Tank 2 and/or Tank 3 could be empty or full at any one time. The walkways have been designed to support pipework, plant and service personnel to a total of 5kPa.

Slab on ground

A 300 mm thick slab was adopted, with a site screed under the slab.

The slab analysis was carried out using a combination of Plaxis (a 2D finite element soil analysis programme) and hand calculations to model the effect of imposed loading on the slab.

The slab is conventionally reinforced to provide crack control and redistribution of peak stresses. Additional reinforcing is provided in the slab adjacent to walls to provide adequate bending capacity to transfer forces generated by the lateral loads on the walls. To reduce the number of construction joints and to minimise shrinkage effects,an expansive additive was used, enabling the entire floor slab to be poured in three pours of about 340 m^3 each.

Two layers of polythene were used between the slab and the site concrete to reduce interface friction and provide a suitable slip layer. This allows movement of the slab when the concrete is in the expansive phase.

Under-slab drainage system

To control uplift water pressure applied to the underside of the slab on ground, a subsoil drainage system was provided consisting of a 150 mm thick layer of sand material. This was placed on the excavated surface and protected by a layer of site concrete. 150 x 30 mm geotextile covered strip drains were placed in the drainage layer to drain out water to the drainage system.

The permeability of the foundation soil is low, therefore the 150 mm-thick drainage layer has sufficient capacity to act as a collection media for any moisture that migrates up from the subsoil. In this way it will permanently depress the water table in the area of the MLE tanks.

Settlement

Settlement affects on the slab were analysed. Settlement is to be monitored during construction and immediately after the filling of the tanks. Allowance was made for the permanent lowering of the water table by the underfloor drains. Due to the drainage system to be provided, the settlements will not be significantly affected by either seasonal changes in ground water levels or operating levels of the pond.

Secondary clarifiers

The clarifiers are reinforced concrete circular structures with a cast in situ central mushroom (rotating bridge support) with a slab on ground, and precast perimeter wall, effluent launder and walkways. The perimeter wall panels are stressed circumferentially with a sliding base that is pinned after stressing. The inlet and outlet pipes located under the slab are reinforced precast concrete with rubber ring joints.

Left: Attachmentof a precast walkway unit to the clarifier.

Middle: Preparation of clarifier wall panels for joining with in situ infills 200 mm wide.

Right: Craning an 11 tonne precast wall panelinto place for the MLE tank.

Inside view ofthe clarifier showing concrete mushroom, sloping floor, outside wall with precast concrete weir units attached, and clarifier outlet structure.

The walls were provided with 12, 55 mm diameter hot dip galvanised metal ducts.Each duct contained seven No 12.9 mm seven wire low relaxation strand which was tensioned and grouted after curing a 200 mm wide in situ joint.

The clarifiers are 48 m diameter to the inner face of the perimeter walls, which are 5.5 m high. The 200 mm thick floor slab on ground slopes down towards the centre from the perimeter wall with a dual floor slope, dropping 1.88 m to the central well. At the centre is the mushroom with a head diameter of 9.6 m set 4.38 m above the inner edge of slab. The edge of the slab runs into a 1.0 m deep 6 m diameter sludge well around the base of the mushroom.

The precast units for the perimeter effluent launder and walkway are linked through the perimeter wall with deformed bars. These are to be grouted into ducts that are cast into the precast units. One outlet chamber and two scum chambers are provided in each clarifier. The outlet chamber and scum chambers are constructed from reinforced cast in situ concrete.

The base joint of the perimeter wall is sealed to the slab with a flexible sealant after completion of stressing and casting of the exterior base key. Slab construction joints are sealed with Duroseal.

The project is being commissioned in stages with the first DAF (dissolved air flotation) sludge thickener commissioned in February 2000. The first new clarifier will be commissioned in March 2000 and MLE Tanks 2 and 3 are scheduled for completion by July/August 2000. The full process is anticipated to be running by October 2000.C

Project Team

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