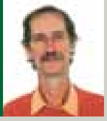

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Victoria & Alfred Waterfront canal boat lock

BACKGROUND

The first harbour basin in Cape Town was the Alfred basin, excavated out of the rock behind the shoreline between 1860 and 1870, under the direction of the British engineer Sir John Coode. Excavation of a second basin landwards of the Alfred started in 1877 and the rock was used to create the breakwaters for what was to become the outer Victoria Basin. However, by the time that the excavations were complete, ships had increased in size significantly and the second basin was considered to be too constrained and was therefore not flooded. It became an oil storage tank farm until the start of the Waterfront development, and was then decommissioned and rehabilitated by the oil companies.

Development of Cape Town's Victoria & Alfred Waterfront (V&AW) started in 1988, and from the beginning the concept of a new marina basin and a canal in the disused oil storage

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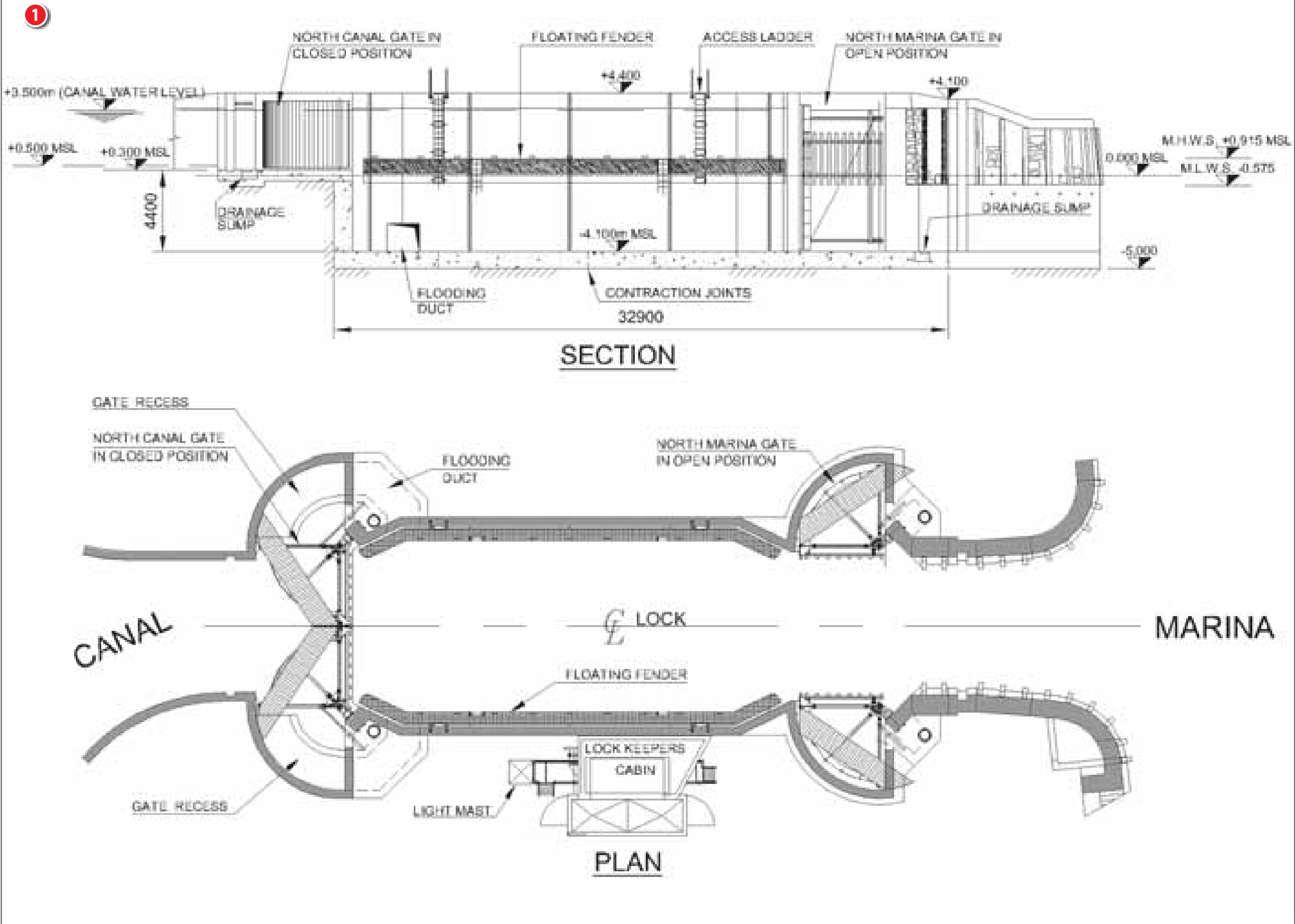


and harbour entrance areas was identified in the Master Plan. The basin and canal would provide attractive central nodes around which residential precincts could be developed. In addition the canal would establish a water link between the city and the harbour.

Prestedge Retief Dresner Wijnberg (PRDW) was commissioned by the Victoria & Alfred Waterfront company to investigate the marine engineering infrastructure that would be required to realise the Master Plan. A feasibility study was completed in May 1992. This included the scope of works that would be required to convert Sir John Coode's second basin into a tidal basin suitable for pleasure craft, and the construction of the canal. It was determined that a tidal canal would be costly and difficult to integrate into the surrounding precincts, due to the depth needed to provide sufficient water below low-tide level and the terracing that would be required for the adjacent landside developments. A perched canal was therefore decided on with a water level set at 600 mm below the typical surrounding ground levels.

It was envisaged that water taxis would be operated along the canal and that residents would be able to moor their private boats on the canal in front of their apartments. A means for the boats to be able to transfer between the tidal basin and the canal was therefore required and it was decided that a traditional boat lock would be the best method. The chosen location for the lock was at the northernmost end of the canal at the boundary of the residential precinct.

The first major component of the V&AW basin and canal marine infrastructure was the construction of a section of the canal in 1992 at the Waterfront entrance to enable building of the adjacent City Lodge Hotel. This was an isolated water body that was not connected to the sea and therefore not navigable.

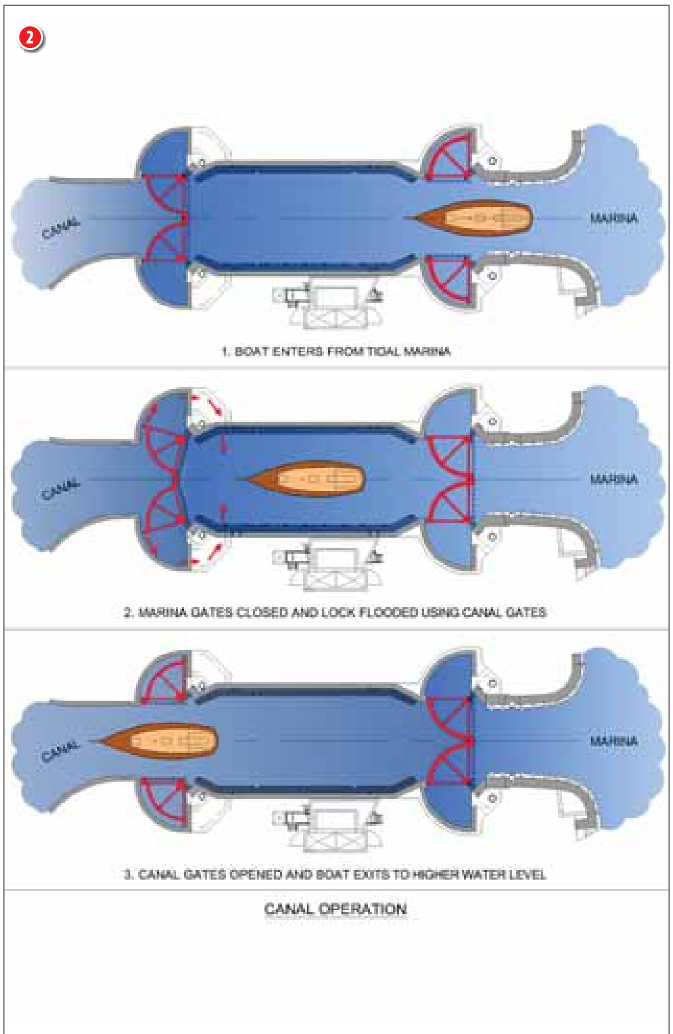
The next project was construction and flooding of the tidal Marina Basin. Fortunately it was possible to construct most of the works in the dry, which included the entrance structure for the future boat lock. Sufficient lock entrance was constructed to contain the recesses for the stoplogs so that a watertight barrier could be formed when the remainder of the lock would be constructed in the future. At that stage the design of the lock barrel and gates had not been undertaken.

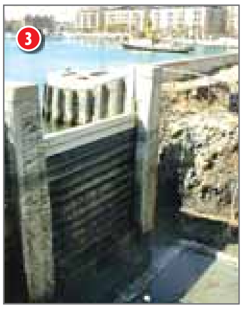
Canal construction carried on through a number of phases until completion in 2009. The northern canal section in the Waterfront residential marina was constructed and flooded in phases to match construction and occupation of the adjacent apartments and the One & Only Hotel.

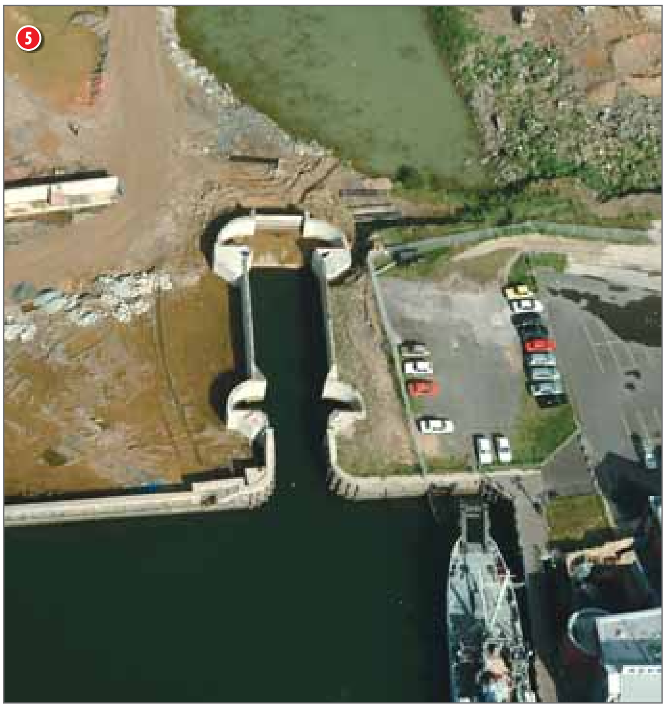
LOCK DESIGN

Design of the lock commenced in 2002. A review of current lock designs around the world was undertaken and it was found that contemporary small boat locks in the United Kingdom had curved sector gates rather than the more traditional flat mitre

1 Waterfront lock consideration
2 Sector gates lock operation
3 and 4 Construction of the lock barrel and gate recesses
5 Flooding of the lock barrel







gates. Unlike mitre gates, sector gates are able to move when the hydrostatic load is acting on them, and in a lock the gates themselves are used as sluices to fill and empty the lock barrel by cracking them open slightly in order to allow the water to flow past the seals. A sector gate lock was therefore selected for the Waterfront, and it is indeed a unique structure in South Africa. Figure 1 shows the configuration of the Waterfront lock, and Figure 2 illustrates the way in which a sector gate lock operates.

The lock and lower reaches of the canal are designed to take yachts with a maximum length of 15 metres and draught of 2,5 metres. Either one 15 metre yacht or a number of smaller size boats can be transferred by the lock at one time, and the lift between the basin and the canal is 3,5 metres on the mean tide. The canal has a fixed water depth of 3,0 metres. The lock barrel caters for the variable tide levels and therefore has a minimum of 3,0 metres water depth at the lowest astronomical tide. It is equipped with floating fenders that rise up and down with the water level and onto which boats tie up so that they do not have to adjust their mooring ropes during the change in level.

In order to verify the filling and emptying times for the lock the sluicing operation was tested with a 1:10 scale hydraulic model at the University of Stellenbosch laboratories. The sector gates at the canal end of the lock are half the height of the marina side gates, and the sluicing flow rate available for the filling operation is consequently less than the emptying rate. The obvious result of this is that the lock barrel takes longer to fill up than to empty. After some experimentation this was mitigated by reducing the radius of the canal gates so that there would be a wider gap for the water to flow through when sluicing.

When the gates at the canal end are sluiced to flood the lock barrel, the incoming water is captured into a pair of culverts that direct the flow transversely into the barrel from each side in opposing flows that dissipate the energy and minimise the water turbulence and the effect on the boats.

Each gate is fabricated from steel plate and hot-rolled sections, and comprises a curved hull plate strengthened with horizontal and vertical plate stiffeners. Each hull plate has three vertical spine beams that are strutted back to the hinges at the top and bottom of the gate. A vertical torque tube and additional bracing is provided to transmit and spread the drive loads to the full height of the gate. All steelwork, including the stainless steel components, are protected by sacrificial anodes.

Rubber music note seals are mounted along the vertical and lower edges of each gate and they bear onto stainless steel plates grouted into the lock barrel walls and base slab. Each length of seal is bolted onto a fabricated stainless steel channel that is adjustable so that the seal position can be fine-tuned to obtain the optimum pressure against the seal plate. All hydrostatic loads on the gate go directly to the hinges and there is no load transmitted through the seals. Sealing takes place by the water pressure on the leg of the music note seal itself, which deflects it and pushes it up against the steel plate.

Mounted on top of each sector gate is a pedestrian walkway to provide public access across the lock.

CONSTRUCTION

The lock design was first advanced sufficiently to enable construction of the concrete barrel and gate recesses. This was

6 Assembling of the lock gates

7 and 8 and 9 and 10 Views of the completed canal boat lock

undertaken in 2003 and 2004 by WBHO as part of a canal wall contract. Construction of the lock barrel and gate recesses took place with steel stoplogs in position in the entrance to hold back the waters of the tidal Marina Basin, and required working down to 5 metres below sea level for completion of the excavation and construction of the base slab (see Figures 3 and 4).

Fortunately the entire lock structure is founded on unweathered greywacke rock which, although highly jointed, restricted water ingress to manageable flows. The 39 metre long concrete structure was constructed in four panels and the contraction joints between the panels were sealed with hydrophilic rubber waterstops that swell and seal the gap. Once complete the lock barrel was opened up to the sea and allowed to flood until it became necessary to dewater it for the lock gate installation (see Figure 5).

In 2007 the design of the lock gates was completed and a tender issued for the construction of the steel sector gates. The canal gate contract had contractor designed components to it and used the FIDIC Conditions of Contract for Plant and Design-Build. PRDW was responsible for the design of all gate steelwork and the contractor was responsible for the design of all the mechanical, hydraulic, electrical and control components required to move and operate the gates. It was anticipated that the gates would be driven by hydraulic cylinders, but this was not prescribed in the tender documentation, as it was expected that electrical drive systems could also be offered.

Petrel Engineering was the successful tenderer and the contract was awarded in March 2008. They elected to use a hydraulic cylinder drive system and during the initial part of the contract PRDW worked closely with them to finalise the aspects of the gates affected by the drive system. This included the steelwork required to transmit the drive loads into the gates and the support plinths for the cylinders. Figure 6 shows one of the lock gates being assembled by Petrel on its side inside the lock barrel.

The power pack for the gate drive hydraulics is located in an underground plant room located beneath the control cabin at the side of the lock, and hydraulic fluid is pumped to each cylinder via steel pipelines located in ducts that run along the side of the barrel.

The lock is operated from the control cabin which is perched to give a view down into the barrel. All operations are automated and actioned by push-button controls. The sluicing sequence for each gate was set up and fixed during commissioning and there is an electronic interlock to prevent both gates being open at the same time. Feeding into the operating system are proximity detectors which verify the position of the gate and water level sensors located in the canal, lock barrel and downstream in the tidal area. The proximity detectors sense when the gate is at each pause or stop position during the opening or closing sequences and the signal from them triggers the operating system to stop the gate. On the other hand the water level sensors operate during the sluicing phase and detect when the difference in water levels across the gate is low enough to initiate the next phase of the opening.

Despite the reduction in gate radius that was implemented as a result of the model testing, it was felt during commissioning that the lock filling period could be reduced further. This was done by adding in a second sluice position to the canal gates, halfway through the filling cycle, in which the gates are opened further in order to increase the in-flow.

A 28-day trial period was stipulated as part of the lock commissioning and for this the contractor had to operate the lock every half-hour for eleven hours each day. This trial period verified the robustness of the lock structure, drive and control systems and highlighted those items that needed to be improved or modified. The lock was handed over to the client in May 2009 and has become a feature and attraction in its own right at the country's premier tourist destination.

ACKNOWLEDGEMENT

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PROJECT TEAM

Client Victoria & Alfred Waterfront (Pty) Ltd
Design Consultants Prestedge Retief Dresner Wijnberg (Pty) Ltd
Contractor (concrete works) WBHO Construction (Pty) Ltd
Contractor (sector gates) Petrel Engineering (Pty) Ltd
Contractor (floating fenders) Jarr Marine CC