AUCKLAND DOWNTOWN FERRY TERMINAL UPGRADE

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SUMMARY

The Auckland Downtown Ferry Terminal is the hub of Auckland's ferry network, a network that began in 1905 and which connects Auckland's CBD with the wider Auckland area. After one hundred years of service, the historic piers that make up the Downtown Ferry Terminal required repairs to the structural fabric beneath the deck to maintain them in a safe condition for the ongoing use of Auckland's ferry commuters.

The ferry terminal is extremely busy with frequent vessel movements related to commuters and harbour tourism. In addition to this, the attractive central city location means the terminal is also a hub for restaurants, cafes and tourism operators – all nestled around the busy piers.

Concrete repair work commenced on Piers 1 and 2 adjacent to the historic Ferry Building in mid 2008 and continued through into 2010. The concrete piles, deck beams, cross bracing and deck soffit were badly deteriorated and the repairs were designed to reinstate the damaged areas and restore the integrity of the elements. Much of the existing sub-structure had to be temporarily supported due to the degree of deterioration and this added further logistical issues to the maintenance of existing business operations on the top of the wharf.

The repair techniques employed included dry-sprayed guniting and forming and pouring using high performance self compacting concretes. All defective concrete was removed using hydro-demolition to minimise the noise associated with traditional concrete breakout – the only option for this busy public space.

The paper will discuss the repair and strengthening work that was required and the techniques employed. It will also discuss the unique and sensitive operating environment and the importance of how to operate such a potentially disruptive project within a fully operational public space with a large number of stakeholders.

BBR Contech has worked closely with Auckland Regional Transport Authority, structural engineers URS and a large number of ferry terminal tenants to complete the work with minimal disruption to existing operations.

Figure 1 – Piers 1 and 2 of Auckland Downtown Ferry Terminal

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HISTORY

Wedged between the Tasman Sea and the Pacific Ocean, Auckland City has always had strong maritime tradition, and in mid to late 19th century in an era before the proliferation of the motor vehicle, a network of work boats and ferries were still an important mode of transport throughout the region

By the mid 19th century ferries where already plying between downtown Auckland city and many of the small settlements like Devonport scattered around the harbour fringe. Ferry connections (now long since disappeared) such as that between Auckland City and Clevedon existed and regular services provided the locals with the only practical way to come to the city and conduct their trade. By the end of the 19th century with a growing demand for services it would appear that the small old timber ferry tee on Quay Street and the Queen Street Wharf could no longer cope with the numbers of ferries and passengers.

Accounts of the time record that the appointment of a Mr. M.H Hamer in 1903 to the position of Harbour Board Engineer as the person responsible for a plan in 1904 for the ports future that included the replacement of these older timber structures using the new building method of Ferro Cement.

Figure 2 – Ferry Tee and Queens Wharf circa 1912

Records suggest that among the first of these new Ferro Cement wharves constructed was the Ferry Tee around 1906 and completed in 1907, with the Queens Wharf starting in 1907 and completed in 1913 (Figure 2 shows the two wharves at completion). It is known that The Ferro Cement Company of Australasia was the constructor of these wharves and that they later went on to build Auckland's landmark Grafton Bridge. Grafton Bridge however would appear to have been their undoing as the company was wound up by creditors in 1909 although it does seem that they were allowed to complete the wharf contracts they currently had in progress.

The use of reinforced concrete construction in New Zealand in the early 1900s was in its infancy, and many of the design principles and construction methods would have been very foreign to the builders, the clients and the population at large. Photos of the time suggest that the driving of these new reinforced concrete piles would actually draw crowds of people to watch.

This new technology was also not without its detractors and the "Observer" newspaper of the time expressed fierce opposition to this new method of construction, its durability and it questioned also the way in which all the contracts were let to the Ferro Cement Company even when they had higher tender prices than other local contractors.

This early foray into reinforced concrete construction has also revealed what may be the first reported case of rebar corrosion in concrete in New Zealand. A small note in the Wanganui Herald of August 1908 describes rust spots and splitting on the braces on the Ferry Tee, Queens and Birkenhead Wharves. Obviously seriously concerned, the Auckland Harbour Board of the time cabled Mr. Hamer who was on holiday in England at the time and told him cut his holiday short and to return to New Zealand to sort out a remedy.

PRESENT DAY USE

Owned and operated by the Auckland Regional Transport Authority (ARTA) the Downtown Ferry Terminal (DTFT) serves as the important hub of the Auckland regions ferry services that make up part of the increasingly important public transport network for the region.

DTFT comprises two main piers - Pier 1 occupies part of the eastern side of the much larger Queens Wharf, with Pier 2 comprising the whole of what was previously called the Ferry Tee. Refer Figure 3 for general wharf layout.

The Downtown Ferry Terminal currently provides facilities for the 4.5 million passengers, and approximately 100,000 vessel movements per year.

In 2003, a major upgrade of the Downtown Ferry Terminal was undertaken by ARTNL (the predecessor to ARTA) to upgrade the facilities to cater for the ever increasing numbers of passengers and the increase in services to the many new ferry destinations throughout the region. In what was the first major upgrade to the superstructure since the wharves where constructed 100 years ago, the new terminal now provides modern covered passenger areas, complete with new ticketing and services facilities for the ferry operators.

Once this topside work was complete, attention then turned to the condition of the sub-structure of these historic wharves which were known to be showing signs of distress.

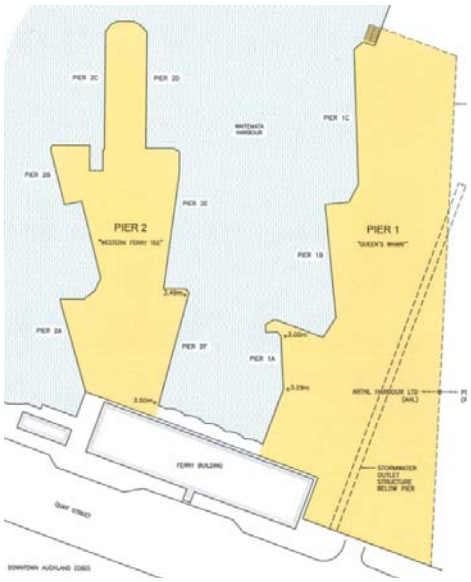

Figure 3 – General layout of Piers 1 and 2

EXISTING WHARF STRUCTURE

The two piers of DTFT cover a deck area of approximately 6000m^2. Both structures have quite similar construction with haunched primary beams sitting atop piles on an approximate 6 meter grid. Secondary beams, and in some areas smaller tertiary beams make up the grid which is topped with a one way reinforced slab of between 150-180mm thick.

Samples of the reinforcing steel taken from the structures were tested and found to be 270 MPa UTS and a selection of concrete test cores indicated the compressive strength of concrete to be in the order of 30MPa.

Of course many of the normally accepted practices found in the construction of a reinforced structure we would expect to see today such as increased cover to steel are absent, however both wharves have proven to be extremely durable and given their 100 year age have probably performed beyond designer expectations. In addition, the original design loading for the wharf has changed over the years with current loading far more demanding than what might have been contemplated some 100 years ago.

Given the location, service environment and level of technical knowledge available for the first 75 years of the structure life, it is commendable that the structure was still performing and able to be upgraded in a way that would see it continue to be of valuable service for many years to come.

CONDITION ASSESSMENT

To enable the remedial program for the Piers to be properly developed, a comprehensive condition survey of both structures was undertaken by URS in 2007.This included a structural assessment of the current loading requirements.

This report identified significant defects to many of the structural elements caused by chloride induced corrosion of the reinforcing bars and the subsequent splitting and spalling of the cover concrete, along with reduction in rebar cross section

As is almost always the case in marine structures, the most significant defects were found to be in the upper tide region and in the splash zone. The deterioration had affected the majority of the piles and cross braces on both wharves. Figure 4 illustrates typical deterioration of wharf elements.

Figure 4 – Typical deterioration of beam, pile and cross brace elements requiring remedial work.

Another area where a high number of defects where found was the structural elements of the lower ramps. These lower ramps where constructed on the original ferry berths to presumably allow easier loading and unloading during various tide heights. At some time after the original construction they where levelled off with new deck slabs supported on walls to the lower ramp. Both the new slab above and these lower decks were severely affected by rebar corrosion and these areas were among the worst affected zones on the wharves. Another construction defect that has caused most of the of the deterioration in the slab underside was sagging of bars towards middle of bays resulting in low cover and consequently elevated levels of corrosion on these parts of the rebars.

The conclusion of the report was that in order to maintain the wharf in a serviceable condition for a further 20 years, an extensive partial rebuild of many of the primary structural elements would be required.

REMEDIAL WORKS

Tenders were called in early 2008 and the contract awarded to BBR Contech. This unique site required that a number of considerable challenges needed to be overcome to undertake remedial works.

Not only is the Downtown Ferry Terminal a fully operational wharf with some 12,000 passengers using it per day, but there are a number of tenants including restaurant, cafes and tourism operators in the immediate vicinity that in summer attract many hundreds of patrons per day. It was identified at tender time that all these parties would be adversely affected by the re-construction activities, and more specifically the noise created when removing the defective concrete was a major concern.

To this end hydro demolition was the preferred method for removal of the spalling concrete, as it was not only to be the most technically appropriate method, but the one which would be the least disruptive to the terminal users, nearby tenants and the ferry operators.

Whilst the noise levels at the source of the hydro-demolition lance can reach 110dB it does not produce the vibration that is created when pneumatic breakers are used for concrete removal and it was this characteristic that makes hydro-demolition the most suitable method of concrete removal. The ultra-high pressure water blasting technique requires special attention to safety and there were close controls on the proximity of hydro-demolition operations to the public and other remedial activities. Protection screens were installed to isolate blast debris and keep the ferry users and general public protected from the potentially harmful activity. This was a particular requirement where the concrete removal was required at the edge of the wharf and when the direction of blasting was towards the water. In some instances, conventional hand breakout was used at the wharf edge to further minimise any potential harm to the public or property in close proximity. Figure 5 illustrates the hydro-demolition operation on a typical support beam.

Figure 5 – Typical hydro-demolition of deteriorated concrete on a deck support beam.

With relatively high sound levels to manage within close proximity to the wharf users, a number of other measures were put in place to mitigate the effects of the noise. These included extensive use of panels of 2 layers of plywood with a barium sulphate filled sound attenuating mat sandwiched in between. These were placed locally around the hydro demolition operators and along the sides of the piers. During summer it was decided by mutual agreement between the client and contractor that hydro-demolition and other noisy activities would be stopped for lunch hours to enable diners at the nearby restaurants and cafes to enjoy have a peaceful dining experience. If this was not agreed upon, it is likely that the retail tenancies would have simply protested about the noise and disruption resulting in complaints to the council and imminent stop work notices. By constant communications and close collaboration with tenants, the disruption was minimised.

The other major challenge was that while carrying out the major remediation to important structural members, there was still a requirement to keep the topside spaces open to ferry operators and their passengers with the minimum of disruption.

For some elements such as the piles, the temporary support during reconstruction was provided below deck level with large steel props. For the secondary beams and the roof soffits it could be seen that the large temporary supporting steel beams required to provide the support would have been extremely difficult to install under the wharf. A myriad of services and the potential health and safety issues arising when positioning such large steel beams ruled out this option.

A new technique was developed using a number of steel beams with ramps over them. These where constructed to both act as support for the beams below using hangers through the deck, and provide unimpeded pedestrian and vehicle access across those areas under repair.

These ramps allowed the thousands of ferry passengers to continue using the normal ferry departure points. They also permitted fuel and waste management trucks to access the end of Pier 2 where there was an established refuelling facility and the main unloading point for general freight and waste materials.

Figure 6 – Temporary ramp and structural support

Access Systems

As the piers have been in constant use for over 100 years it was inevitable that a multitude of old services, both redundant and currently in use would lie beneath the deck. This fact and the construction of the old low level ramps meant that modular access systems could not be used for much of Pier 2 and a portion of Pier 1. In these areas a heavy duty clip and tube scaffold supported from the deck was installed to provide the required solid work platform for the substantial remedial works. Figure 7 shows a typical section of this scaffold.

Figure 7 – Scaffold access platform

In the more open areas of Pier 1 where bays were more consistent a series of large movable steel frames were used that could be moved easily to cover a larger area with less remedial works.

Reinforcing steel

The required cleaning to remove all corrosion material from the exposed reinforcement was achieved by using the hydro demolition equipment and a special rotating head. This produced reinforcing completely free of the corrosion products without the need to use abrasive blasting. The cleaned reinforcing was then treated with 2 coats of Sika MonoTop Primer anti-corrosion treatment prior to any repairs.

A large percentage of the reinforcing bars in the various elements repaired required either full replacement or supplementary bars to be added to restore their full structural capacity. These were welded, lapped or where this was not possible epoxy grouted and lapped starter bars were used. A total of 25 tonnes of replacement and supplementary reinforcing was used in the project.

Three methods of reconstruction of the concrete were used for the remedial works, each with its own special characteristics suited to the location and configuration of elements requiring the rebuild.

Formed and poured SCC

As the repairs to the braces and piles extended deep into the tidal zone it was decided that the only practical way of rebuild was to recast them back to profile using formwork. A ready mixed self compacting concrete (SCC) was developed in conjunction with Allied Concrete in Auckland. Prior to the first remedial work being started, a number of trials were conducted and tests where undertaken to check that the proposed mix complied with the strength specifications for the contract and that workability would be suited to the various types of repairs required. This same mix was also used for the rebuilding of the primary and secondary beams and proved to be highly flowable allowing filling of the forms from only 2 or 3 positions on a shallow 6 metre beam. Figure 8 shows typical reinstatement on a number of beam and cross brace elements.

Figure 8 – Repairs using self compacting concrete.

Inspection of these elements cast in SCC some two years after casting show they have little to no signs of drying shrinkage. Some 256 piles, 185 braces and 200 beams where repaired using this technique.

Dry sprayed gunite

Sikacrete-Gunite 103, a proprietary dry spray gunite was used for the rebuilding of 250 square metres of the slab soffits and for small edges of beams or piles above the high tide mark. Gunite had the advantage in this situation of being able to be conveyed to the work face down hoses over 150 metres allowing a gunite base station to be setup within the work compound so as not to disrupt any existing wharf operations. Figure 9 illustrates a typical gunite operation on the deck soffit.

Figure 9 – Guniting of deck soffit.

Ready mixed concrete

Ready mixed 50 MPa silica fume modified concrete was used where whole new top slabs where required over the tops of the old ramps. It was decided that these top slabs were more economically cut out and replaced than repaired because of the difficulty in gaining access to them from the underside.

CONCLUSION

The project took 28 months to complete with a peak work force of 28 men completing demolition and rebuilding of over 230 cubic metres of concrete on the structures in a highly used and extremely visible part of Central Auckland. The project was always scheduled in such a way that repair was carried out in prioritized areas and with close attention to available budgets. The busy ferry operations, retail tenancies and close proximity to the public on a very restricted site makes this one of the most demanding concrete repair environments ever experienced. The work to reinstate the integrity of the wharf was undertaken without interference to existing operations and demonstrates that essential concrete infrastructure can endure a lengthy service life – in this case in excess of 100 years. Repair and upgrading can be configured in such a way to further extend the service life at a fraction of the overall cost to demolish, plan, relocate businesses, obtain consent and rebuild a new structure.

This important restoration work to extend the useful life of this valuable asset was made possible by a committed team of Client, Engineer and Contractor, and the understanding of the passengers, the ferry operators, and the numerous tenants on and around the terminal.

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