FLANAGAN CONSULTING GROUP
Trusted Advisor to Northern Australia

Ports North

CAIRNS SHIPPING DEVELOPMENT PROJECT

Revised Draft Environmental Impact Statement

APPENDIX AE: Condition Assessment Report: Wharf 6, Wharf Street Cairns

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CONDITION ASSESSMENT REPORT

Wharf 6, Wharf Street, Cairns

Project No.	3527-02
Reference No.	R-DB0095A
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Table of Contents

1.0 EXECUTIVE SUMMARY

Ports North is seeking to undertake the 'Cairns Shipping Development Project' (CSDP) which includes widening and deepening of the existing channel into the Port of Cairns to improve access for large cruise ships, enable growth for HMAS Cairns Navy base and improve Port efficiencies. The project also involves the structural upgrade of wharfs and upgrade of services to the wharfs to accommodate the larger cruise ships.

Ports North has assessed the forecast ship visitations that will result from the channel upgrade and determined that the Trinity Wharfs (Wharfs 1 – 6) will need to have the ability to accommodate two cruise ships at berth at a time, potentially of sizes up to 290+ metres length. A drawing showing the potential cruise ship berthing arrangements is included in Appendix A. The berthing potential arrangements clearly identify that both berthing and mooring loads will be transferred to Wharf 6.

Therefore, as part of the CSDP, Ports North require a structural assessment of 'Wharf 6' to inform decision makers of the current condition and structural value of the existing structure and its appropriateness for continued use as a general purpose wharf, and as a cruise ship berth.

The structural assessment consisted of a visual inspection of the wharf in conjunction with a desktop review of the large body of technical information that has been accumulated over the past three decades.

Wharf 6 is currently in very poor structural condition due to the severe deterioration of the timber piles, headstocks, timber girders and concrete deck. Testing of these key structural components has confirmed that significant loss of strength and durability has occurred and is continuing to occur at an increasing rate. The failure of any of these structural elements could result in catastrophic collapse of the deck and could endanger users and equipment.

Wharf 6 does not comply with current Australian Standards and is not fit for purpose.

2.0 INTRODUCTION

Flanagan Consulting Group was commissioned to undertake a condition assessment of Wharf 6.

The commissioned scope of works includes the following tasks:

- Visual inspection of the wharf;
- Review of existing records, assessment, analysis and data;
- RPEQ endorsed report outlining:
    - Historic use, maintenance and repair;
    - Relevant Australian Standards and 'likely' compliance;
    - Issues affecting design life, operation and risk/safety;
    - General commentary on structural value.

A visual inspection of Wharf 6 was undertaken on 26 July 2016 by Mr Liam Kenny, Senior Structural Engineer and RPEQ.

Google Earth aerial view indicating the location of Wharf 6.

Google Earth aerial view indicating the location of Wharf 6.

3.0 EXISTING DOCUMENTATION

Flanagan Consulting Group was provided with the following documentation:

- Extract of engineering investigation report no. CET3653/C from Mr David Beal, dated June 1993;
- Report No. ITPL008-066 (*'Integrity testing of timber, concrete and steel piles at Cairns Port, Qld'*) from Integrity testing Pty Ltd dated 23 December 2008
- Timber support structure damage audit including wharf layout and defects register indicating damaged members of the wharf structure and planned repairs.
- General documentation, correspondence, photos and emails relating to operational issues, repairs and use of the wharf.

3.1 Engineering investigation report no. CET3653/C

The key points of the structural investigation from Mr David Beal, which was carried out through destructive testing of the concrete deck, are the followings:

- *'The visual inspections of the concrete cores and observation on site would indicate that there is severe deterioration of the lower section of the concrete slab including cracking up to mid height of the depth of the slab. The bottom layer of the reinforcement is corroding.'*
- *'The concrete was badly compacted and generally had a high voids content and had a large capacity to absorb water.'*
- *'The carbonation of the concrete is nil from the top surface but approximately 60mm from the soffit deck…As carbonation of the concrete is above the level of the reinforcement for the lower section of the deck slab, corrosion has occurred.'*
- *'The values of resistivity of the concrete are in the high to very high range. Therefore in this concrete deck, the tests would indicate a high corrosion rate for all reinforcement.'*
- *'From all the tests, the results indicated that the concrete is carbonated up to the bottom reinforcing level. The corrosion currents do exist at high levels and the lower reinforcement is corroding at a high rate.'*
- *'The cracking of the deck slab up to the middle of the slab from the soffit would indicate that this deck has had loads above its capacity.'*
- *'As this concrete deck slab is under-designed for the live loads that it is carrying and it would be very difficult to do concrete repairs to the soffit of the deck, the most appropriate method of reinstatement of this wharf would be replacement of the deck slab. This would be done only if the timber sub-structure is in a condition that would warrant the continued use of this structure.'*

3.2 Report No. ITPL008-066

Integrity Testing carried out Mod-Shock tests on 10 timber piles in 2008. According to information provided by *Integrity Testing,* the Mod-Shock test uses the broad-spectrum frequency response from a hammer blow to the element under test. The reflected signals are captured by a transducer placed on the element under test and recorded for later analysis. Through this test method *Integrity Testing* was able to provide information about pile diameter and length, pile defects, minimum pile diameter , depth of the pile where the greatest loss of section was found, pile head stiffness, total elastic load etc.

Based on the test information, the piles were categorised as per below:

- Category 1: a good pile, with no major defects;
- Category 2: generally assigned to piles which are serviceable, and with a normal load;
- Category 3: defective piles, with major defects but still capable of design loads as indicated in the "total load" results
- Category 4: Either structurally redundant or with sufficient defects to the pile to be replaced immediately.

1 pile (pile no. 103) was assessed as a Category 4 pile and therefore is needing replacement.

4 piles were assessed as Category 3 piles and therefore are needing replacement in the near future.

5 piles were assessed as Category 2 piles and therefore still serviceable piles.

The Mod-Shock test carried out in 2008 identified that 50% of the tested piles were defective piles with major defects, requiring either immediate replacement (category 4 piles) or replacement in the near future (category 3 piles).

3.3 Documentation of wharf layout and defect register

Based on the correspondence provided by the client we understand the following:

- A detailed inspection of Wharf 6 was carried out in 2010 where all members were assessed. After the inspection *Ports North* started to develop a repair strategy including restricted access to critical areas and targeted repairs to maintain reasonable access and functionality.
- In 2012 areas of significant damage were identified where the load limit of 20t posed a risk.
- *Ports North* has undertaken, over the years, an inspection and maintenance program for Wharf 6. Within this program load limits have been implemented over the wharf deck and, occasionally, access totally restricted to those areas requiring major repair.
- The current load limit to the wharf is 10t (max G.V.M.)

Current load limit to Wharf 6.

4.0 THE EXISTING STRUCTURE

Wharf 6 was constructed in 1942 and is therefore 74 years old and beyond it is original design life. The wharf structure consists of hardwood timber piles supporting hardwood timber headstock and girders. A concrete deck cast on galvanised iron steel is supported by the timber sub-structure. Three independent concrete structures, which previously provided support for a lifting crane, have been constructed in the southern portion of the wharf.

The wharf was constructed at a time when material costs were at a premium and a short design life was justified/anticipated. Due to the durability of some elements and past maintenance efforts by the Port Authority, the wharf has been usable well beyond what would be considered a reasonable lifespan, and has experienced an acceleration in deterioration over the past decade.

The wharf is approximately 135m in length at quayline and 27m in width.

Timber substructure of wharf and concrete structure.

Timber substructure of wharf.

Galvanised steel formwork over timber girders.

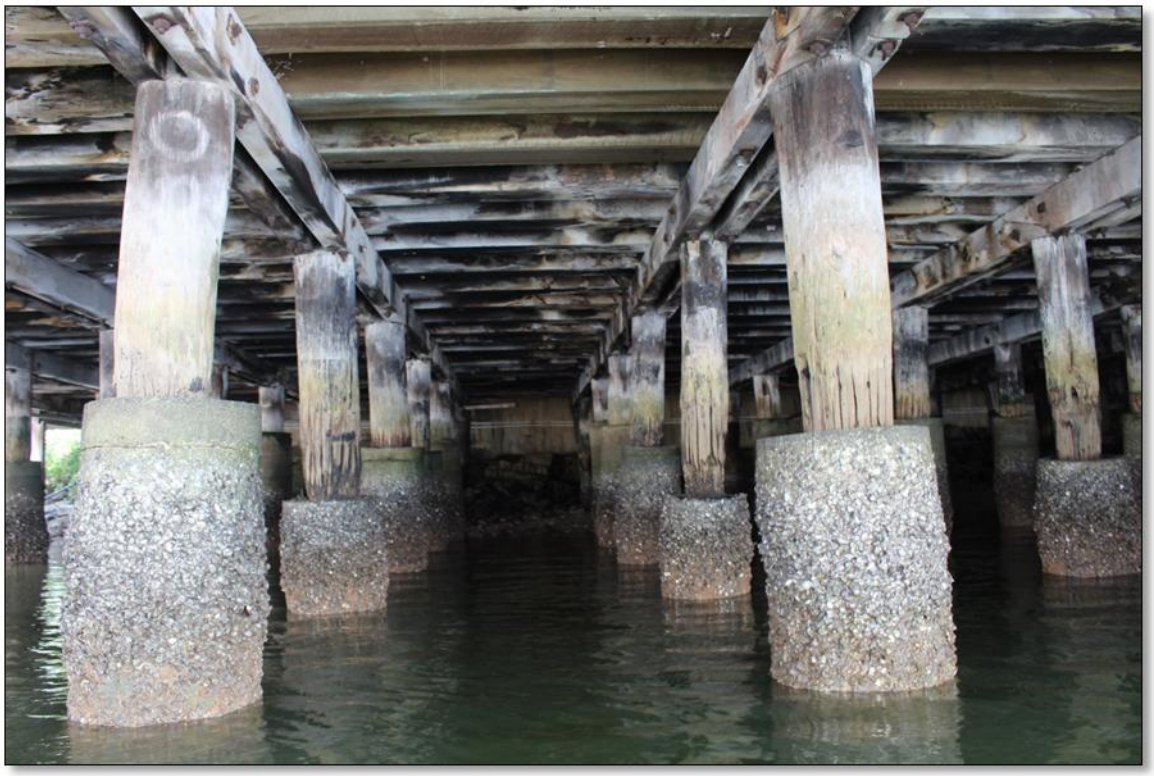
5.0 INSPECTION OBSERVATIONS

5.1 Timber piles

The timber piles are typically encased by backfilled concrete sleeves (reinforced concrete pipes) in order to provide the piles with a degree of protection against marine borers and to reduce the rate of deterioration within the tidal zone. The bases of the piles are typically in very poor condition with significant (and in places, complete) section loss. Severe degradation, decay and evidence of marine borer attack was observed within the tidal zone of the piles.

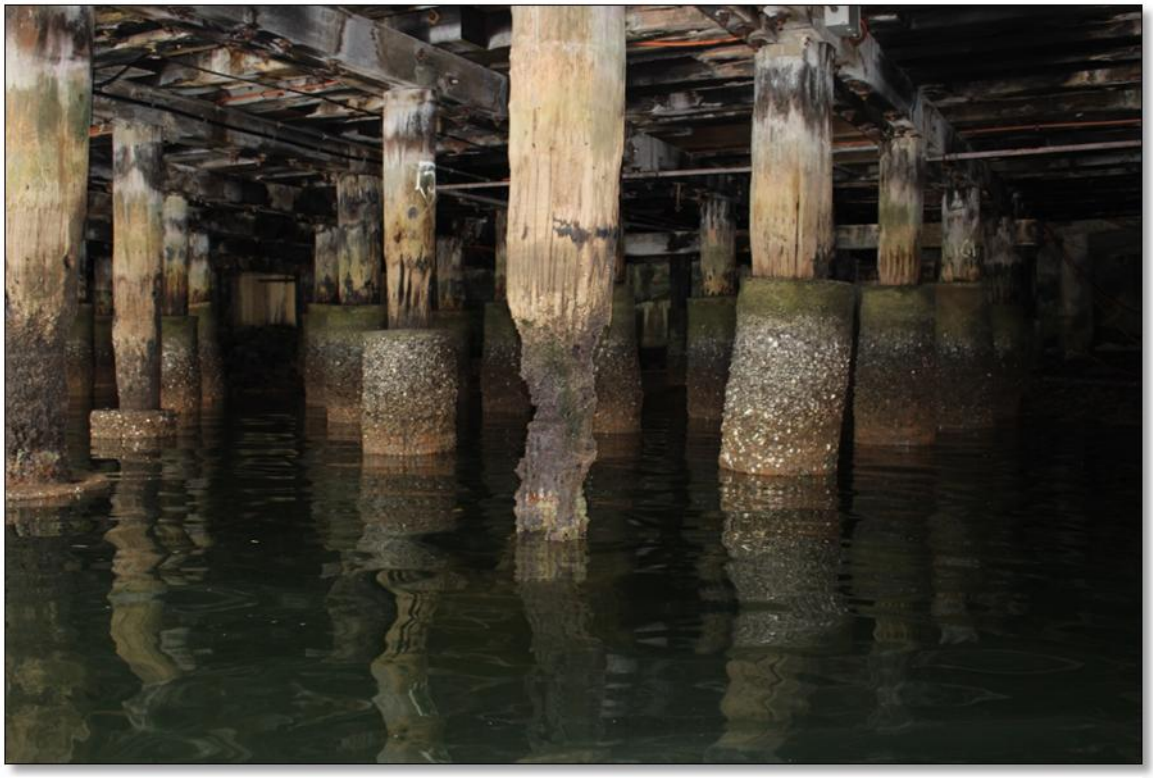
The height of the concrete sleeves was observed to vary in level. It is understood that progressive settlement into the soft underlying sediments, tidal or vessel generated scour, and potential effects of periodic dredging of the adjacent wharf berth pocket, has undermined the base of the sleeves (and potentially the piles) resulting in the sleeves dropping in level over time. The variability of the sleeve height is concerning as it indicates that the pile embedment level and the current support conditions are drastically different to that when the wharf was originally constructed and designed. The sleeve movement has reduced the durability of the piles and could be resulting in additional 'drawdown' forces on the piles reducing their capacity.

Various attempts have been made to fix and protect problem piles throughout the wharf. Several piles were observed to be wrapped, coated and in places spliced with varying degrees of success. It was observed that two piles were completely missing, leaving a section of the deck unsupported (this zone has been fenced off).

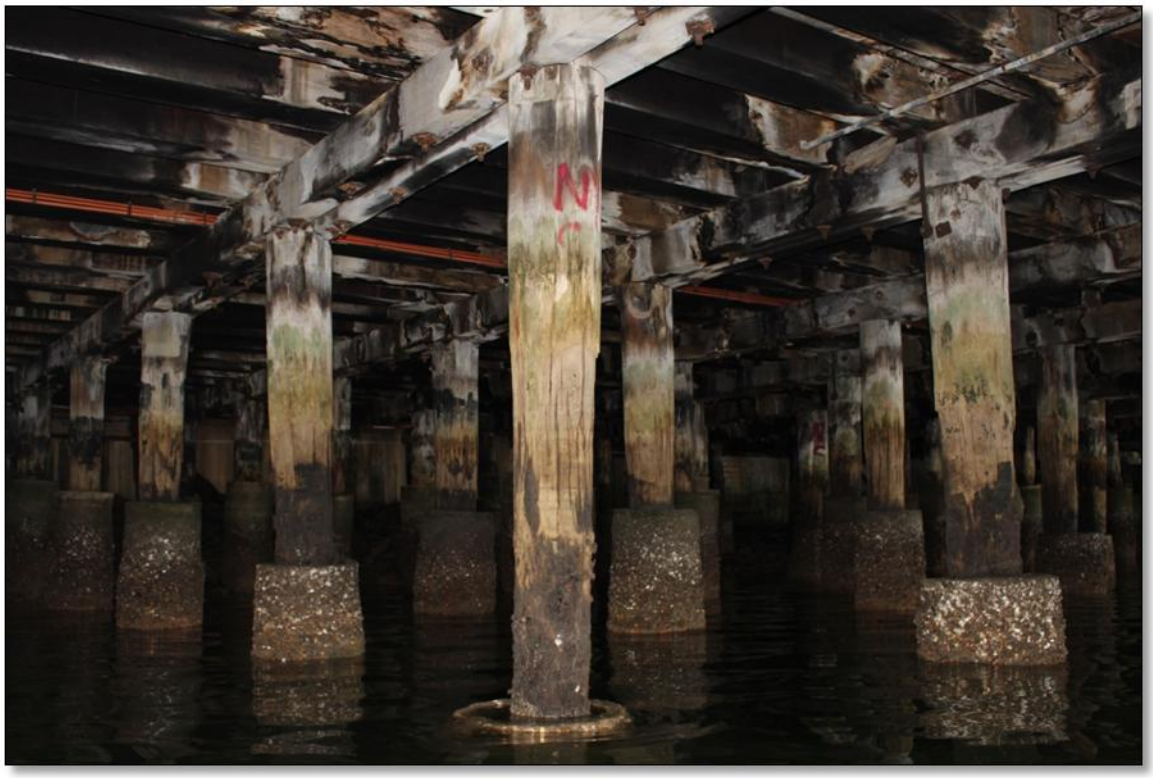


Degraded and decayed portion of piles visible above the concrete sleeves. Variable height of concrete sleeves.

Degraded and decayed portion of piles visible above the concrete sleeves. Variable height of concrete sleeves.

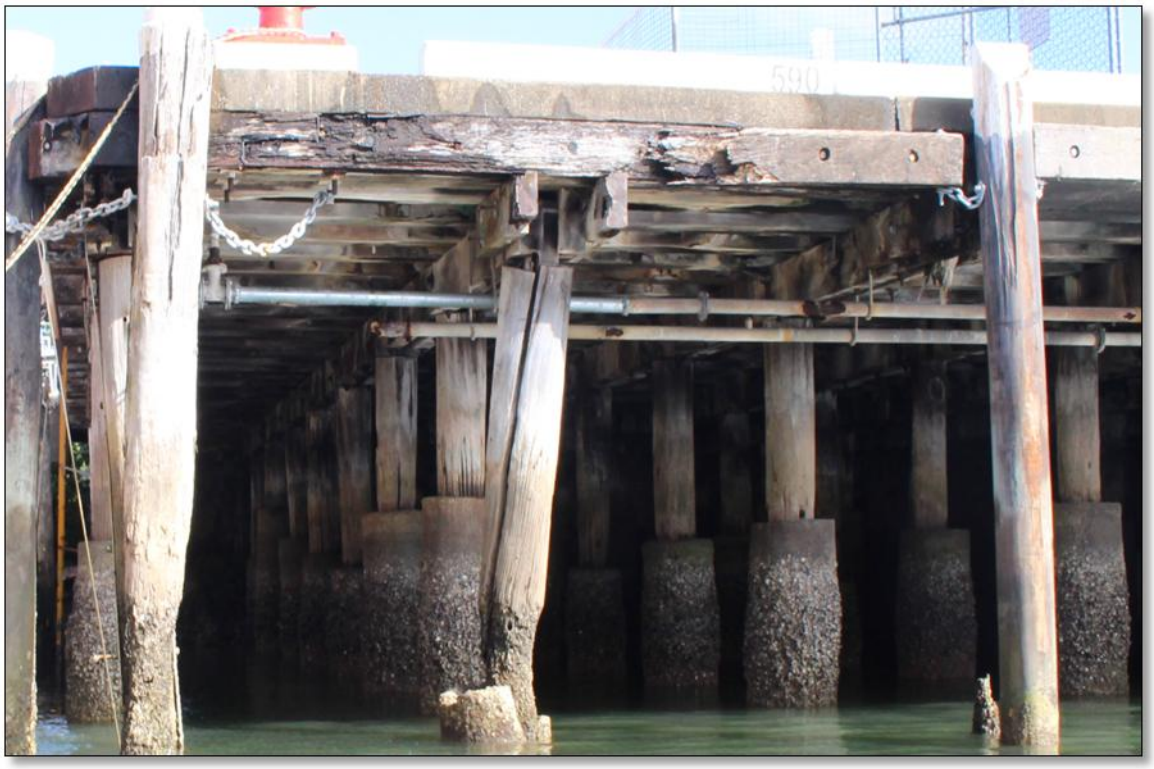


Advance degradation and decay of pile. Severe reduction in section dimension of pile.



Top portion of concrete sleeve at same height of water level.

Splitting of pile.

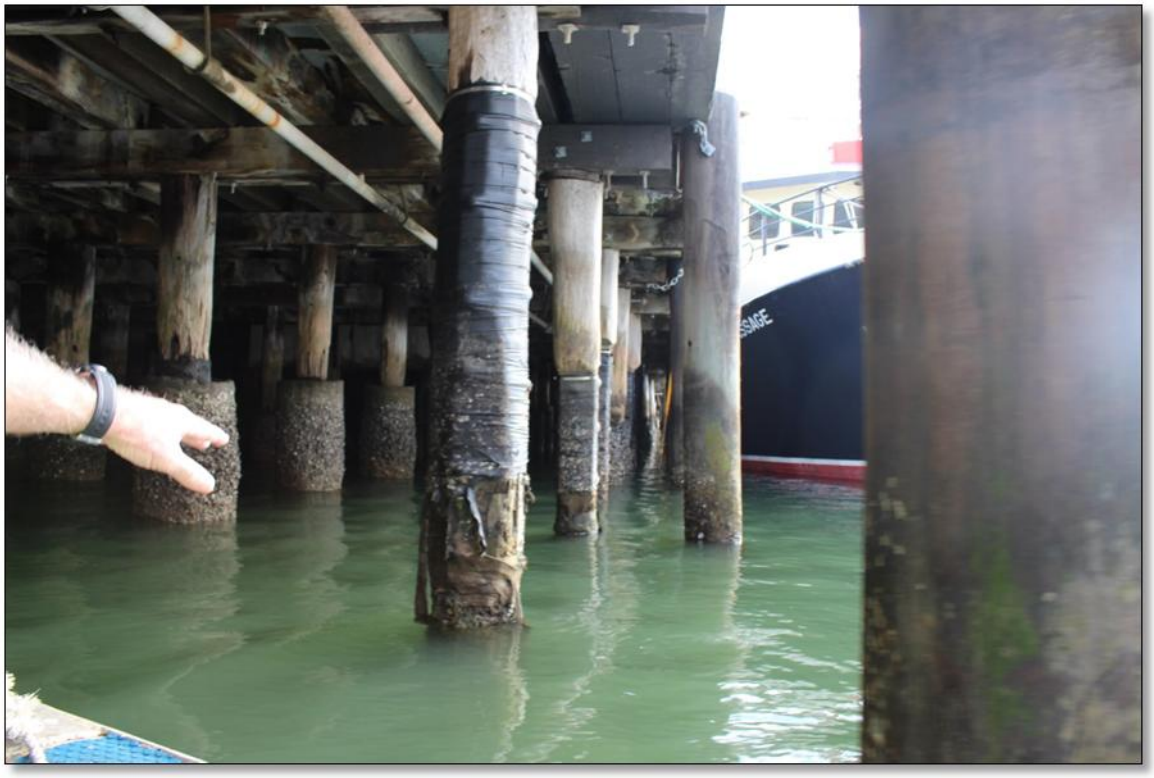


Splitting of pile and damage to concrete sleeve.

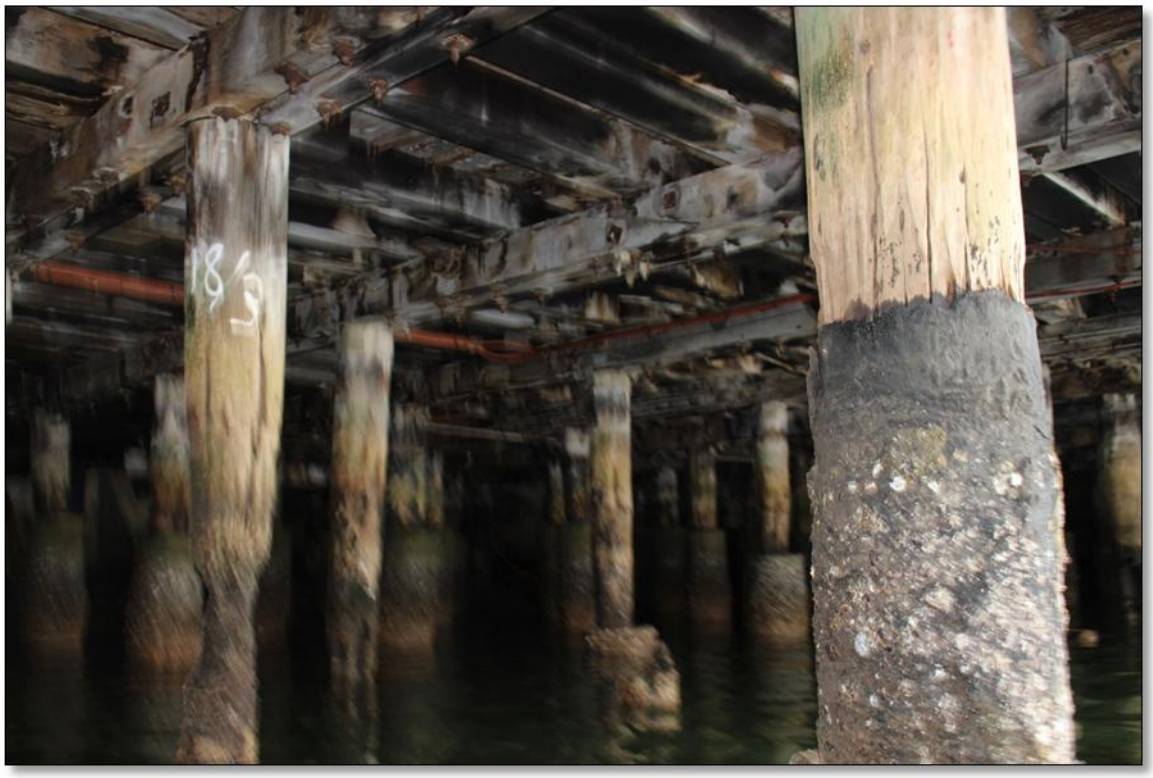
- Damage to the concrete sleeves was evident at different locations.

Damage to concrete sleeve.

Void between the pile and the concrete sleeve.



Wrapped pile with tape.



Pile wrapped with epoxy coating.

Spliced piles connected with steel plates bolted around the perimeter of the pile

Spliced piles connected with steel plates bolted around the perimeter of the pile

Missing piles

5.2 Timber headstocks & girders

Staining and fungal decay was evident in the timber headstocks and girders. Significant section loss has resulted from water leakage through cracks in the concrete deck.

All bolted connections have experienced a degree of corrosion and section loss.

Staining and damage to timber

Staining on headstock surface.

Localised damage to headstock.

Corrosion to steel rods, nuts and washers.

Corrosion to steel rods, nuts and washers.

Staining to timber girders.

Advance degradation and decay to timber girders.

Advance degradation and decay to timber girders.

5.3 Concrete Deck

The concrete deck is supported by the timber girders and only spans a short distance between these members. The concrete deck has been poured in various sections with (potentially) sacrificial soffit formwork. Where it still remains, this formwork is in very poor condition. Spalling of concrete (due to corroded reinforcing) is evident throughout the structural indicating an accelerating decline of the deck.

Corrosion to iron steel. Portions of the sheeting had completely rusted away.

Severe corrosion to bottom reinforcement. Steel sheeting to underside of deck has completely rusted away.

Severe corrosion of bottom reinforcement. Steel sheeting to underside of deck has completely rusted away.

6.0 ASSESSMENT

The following aspects of Wharf 6 have been considered:

- Current structural conditions based on our visual inspection and on tests carried out in the past;
- Potential Health and safety risks related to a structural failure event;
- Specification and requirements of '*AS4997-2005 Guidelines for the design of maritime structures';*
- Operational limitation/issues;

The consideration/evaluation of the economic viability of the Wharf 6 with consideration to the direct maintenance costs and indirect costs arising from the required operational limitations (load restrictions) has not been taken into account in this report.

6.1 Timber piles

6.1.1 Current structural condition

The timber piles are in poor condition with varying degrees of section loss and damage throughout the wharf. Several piles were completely missing and others were cracked, crooked and close to collapse. The condition of the piles within the concrete sleeves and below the water could not be observed, however loss of capacity could be inferred from the sleeve movements.

The Mod-Shock test carried out in 2008 identified that 50% of the tested piles were defective piles with major defects, requiring either immediate replacement (category 4 piles) or replacement in the near future (category 3 piles). It is unclear what repairs (if any) were undertaken to address these issues in the past but it is obvious that further deterioration has occurred since the time of the testing.

6.1.2 Potential Health and Safety Risks

The damaged piles represent a high risk to the safety of deck users, their equipment and adjacent boat users. Failure of a compression member of this nature would result in catastrophic failure of the section of deck supported by the pile. Structural failure of the pile would be sudden and could occur with little warning.

6.1.3 Specifications and Requirements of '*AS4997-2005 Guidelines for the design of maritime structures*'

AS4997-2005 specifies that *'generally timber would not be used as the principal structural medium for a facility with a design life greater than 25 years'.*

The Wharf 6 timber piles are 74 years old and are beyond their original design life. The timber piles do not comply with current Australian Standards.

6.2 Timber headstocks & girders

6.2.1 Current structural condition

The condition of the headstocks and girders varied across the wharf. Staining and fungal decay was evident and significant section loss has resulted from water leakage through cracks in the concrete deck. The connections between members (bolts) have corroded.

The size of the timber sections and the quality of the original timber has enabled these sections to remain largely intact in a number of areas.

6.2.2 Potential Health and Safety Risks

The damaged headstocks and girders represent a high risk to the safety of deck users, their equipment and adjacent boat users. The rot and section loss where water ingress has occurred could result in localised crushing or shear failure of these members and sudden deck collapse.

6.2.3 Specifications and Requirements of '*AS4997-2005 Guidelines for the design of maritime structures*'

AS4997-2005 specifies that *'generally timber would not be used as the principal structural medium for a facility with a design life greater than 25 years'.*

The Wharf 6 timber headstocks and girders are 74 years old and are beyond their original design life. The timber headstocks and girders do not comply with current Australian Standards.

6.3 Concrete deck

6.3.1 Current structural condition

The concrete deck was built approximately 74 years ago with engineering design knowledge, construction materials, construction techniques and quality control systems which are well below the current industry standard requirements.

Our observations and previous testing indicate that the Wharf 6 concrete deck:

- Varied in thickness and construction technique
- Is constructed from poorly compacted concrete with a high void content
- Has low concrete strength and density
- Is severely carbonated beyond the depth of the reinforcing
- Has a high rate of corrosion
- Has cracked as a result of prior overload

The concrete deck is in very poor structural condition.

6.3.2 Potential Health and Safety Risks

The concrete deck represents a high risk to the safety of deck users, their equipment and adjacent boat users. Given the short span between the timber girders it is probably that the concrete is working primarily in shear with little flexural action as a result of the deteriorated reinforcing. The limited concrete thickness of the deck indicated that punching shear from a wheel load or similar could easily occur. Punching shear is a brittle failure mode, with no visible signs prior to failure.

6.3.3 Specifications and Requirements of '*AS4997-2005 Guidelines for the design of maritime structures*'

Current requirements of '*AS4997-2005 Guidelines for the design of maritime structures*' in terms of structural durability are:

- Cementitious content should be not less than 400 kg/m^3;
- Minimum characteristic compressive strength of 40 MPa;
- Minimum cover to reinforcing steel of 70mm (considering a concrete characteristic compressive strength of 40 MPa) for an expected design life of 25 years;

AS4997-2005 specifies that, where these requirements are met, a design life of 25 years can be expected.

The investigation and tests carried out in 1993 identified the followings characteristics of the concrete deck:

- Cementitious content of approximately 320 kg/ m^3;
- Minimum characteristic compressive strength of 24 MPa(average compressive strength of concrete specimen was determined as approximately 27MPa);
- Minimum cover to reinforcing steel of 20mm;

The characteristics of the deck are well below the requirements of *AS4997-2005.*

6.4 Operational limitation/issues

Ports North have cordoned off the worst sections of the wharf (where piles are completely missing) and have attempted to put load restrictions on the remaining areas of the wharf. This approach is extremely difficult to monitor and maintain due to the variability in vehicle wheel loading, mass and configuration (particularly for frannas cranes) and operator awareness and knowledge. Given the structural defects and the nature of failure described in sections 6.1 – 6.3, consideration should be given to further restrictions or closure of the wharf.

7.0 CONCLUSION

Wharf 6 is in very poor structural condition and is beyond any practical repair. The deterioration of the structural members has resulted in a structure that could fail catastrophically and endanger users and equipment.

The wharf does not comply with current Australian Standards and has exceeded its design life.

Yours faithfully,

FLANAGAN CONSULTING GROUP

Liam Kenny

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