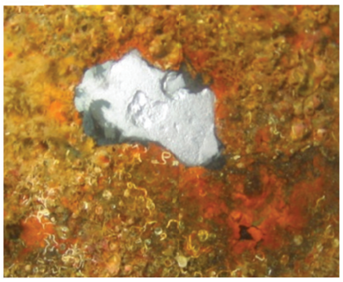
Case Study: Corrosion of Sheet Piling at Northport – Marsden Point, New Zealand

Introduction



Corrosion seen at Northport Ltd

Located in the Whangarei Harbour is a three berth deep water port, constructed using a combination of sheet piling and tube piling, to support 60Ha of reclamation for port storage, as well as 570 metres of concrete deck structure for general cargo shipping. The construction of the port has been carried out in two stages, with Stage One construction building two berths at 390m, while Stage Two added a further 180m giving the port its third berth and a combined berth length of 570m. Although there are two slightly different designs in the two stages, the issues with corrosion remain the same.

The port has been designed for a 50 year design life, with additional thickness based on a calculated loss of steel over that time being the main means of allowing for corrosion. After 10 years, we are now in the process of assessing the structure, its anticipated design life based on the evidence we can gather onsite, and hopefully coming to a conclusion whether further corrosion protection is required to extend the structures life beyond the engineering design life of 50 years.

Northport – The Design

Stage One

The main reinforced concrete deck structure is supported by two rows of steel pipe piles that are concrete filled above the design dredge level. As part of the design, the steel casing in the upper layer is designed to be sacrificial. The rear support structure is sheet piling, consisting of AZ piles, which doubles as a retaining wall for the reclamation in behind it. This reclamation is hydraulically placed sand that was placed during the construction phase as the turning basin was dredged to its designed level. There is also a deadman structure on the landward side of the sheet piling wall, also constructed of sheet piling (see Figure 1).

During the design phase, corrosion protection was discussed, and some measures were put in place to counter corrosion. The main allowance for corrosion is steel thickness over and above the structural requirements, allowing for losses over the design life period. It was envisaged that management of the port would get to a point, approximately 20 – 30 years after the construction of the port, where they would reassess the life expectancy of the structure and make further provisions by way of corrosion protection.

To enable such work to be carried out, allowance for a future impressed current cathodic protection (CP) system was designed into the construction. The sheet piling wall and steel reinforcing in the concrete deck has been tested at construction to determine that it is all electrically connective, thus allowing it to be retrofitted with a CP system.

Other measures that were designed into the structure were to have a concrete lining on the inside face of the sheet piling in the intertidal zone. This zone was determined to be one of the high risk zones that would suffer greatest loss of sheet thickness, and might also be susceptible to Accelerated Low Water Corrosion (ALWC). Pitting in this zone was also a concern and past experience with some of the port engineers involved meant that stopping potential loss of material being retained by the piling was a key design parameter.

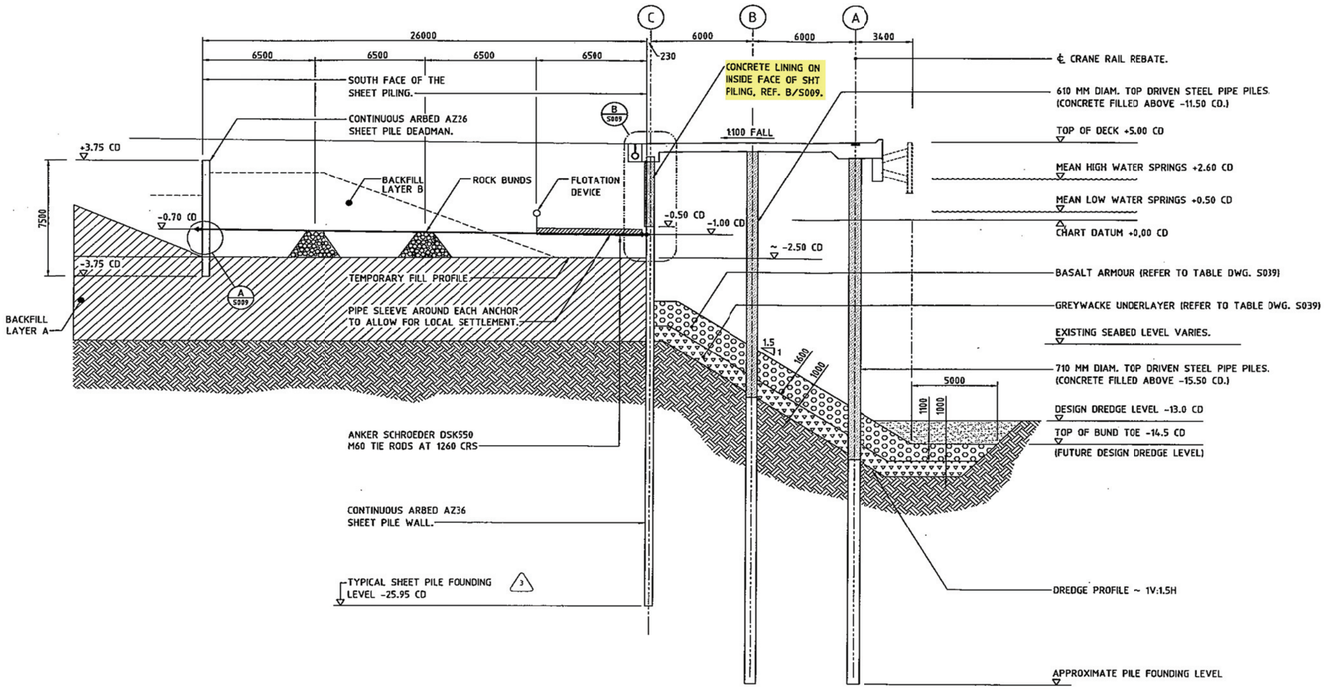


Figure 1 - Typical Cross Section (Stage One)

Stage Two

The second stage was a slightly different design due in large to the additional depth of water the construction plant were having to work in. It was therefore designed so that there are two rows of sheet piling, both supporting the concrete deck. These were tied together with large tie rods, and instead of a third row of sheet piling for a deadman, passive ladders were used. The other main difference in this structure is that the sheet piling is now at the front face of the deck structure, instead of using tube piles such as in the previous design. This design now also means that the full depth of piling is accessible to divers for inspection, whereas the previous design has a rock bund covering the lower extents.
(see Figure 2)

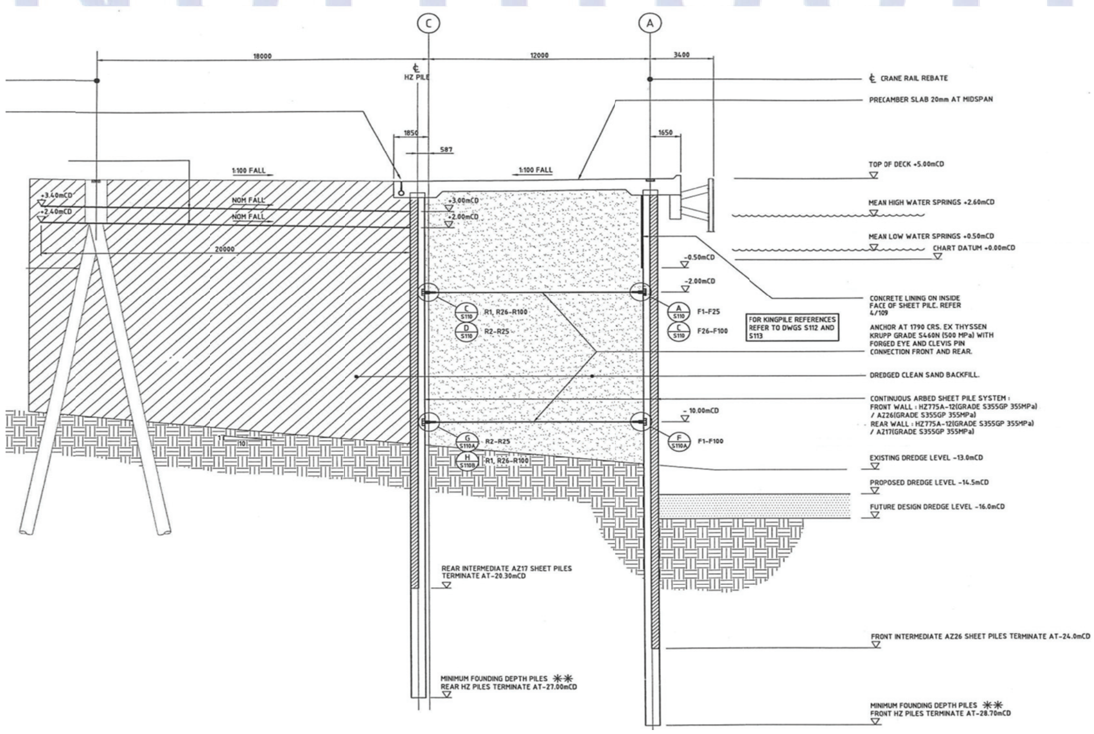


Figure 2 - Typical Cross Section (Stage 2)

The Current Situation

Northport is in a position where we have identified that there is an issue that needs to be looked into further. We are in the process of talking with suppliers and consultants alike, trying to understand the severity of the corrosion, as well as the types of corrosion that we are faced with.

Photos are being taken of the intertidal zone from time to time for comparison. Divers are also making visual inspections of the structure underwater, photographing and using small tools to better understand the amount and rate of corrosion taking place.

We have purchased an underwater steel thickness gauge to help record loss of steel thickness over time, as well as a pit gauge to determine the severity of pits and the impact that they may have.

It appears we have multiple types of corrosion, including general corrosion, pitting, ALWC, MIC. There may also be stray currents from ships impressed current system while berthed alongside, which needs to be looked into further.

ALWC – Accelerated Low Water Corrosion

During the construction of the port, ALWC was discussed as a potential threat to the piling. It was therefore designed to have additional steel thickness added to the design of the piling. There was also a paint system consisting of 350 microns of epoxy applied to the area just below the intertidal zone (i.e. from +1.0mCD to -2.0mCD). In addition to that, in case the piling was breached, a layer of concrete was poured in behind the piling to act as a solid barrier between the fill material behind the wall and the potentially breached sheet piling layer. During recent inspection dives, evidence of ALWC seems to be taking place. The rate at which this piling seems to be pitting looks to be high, as can be seen in Figure 3.

Figure 4 shows the typical orange patches at low water. Below this orange film is bright steel, with the film easily removed by hand.

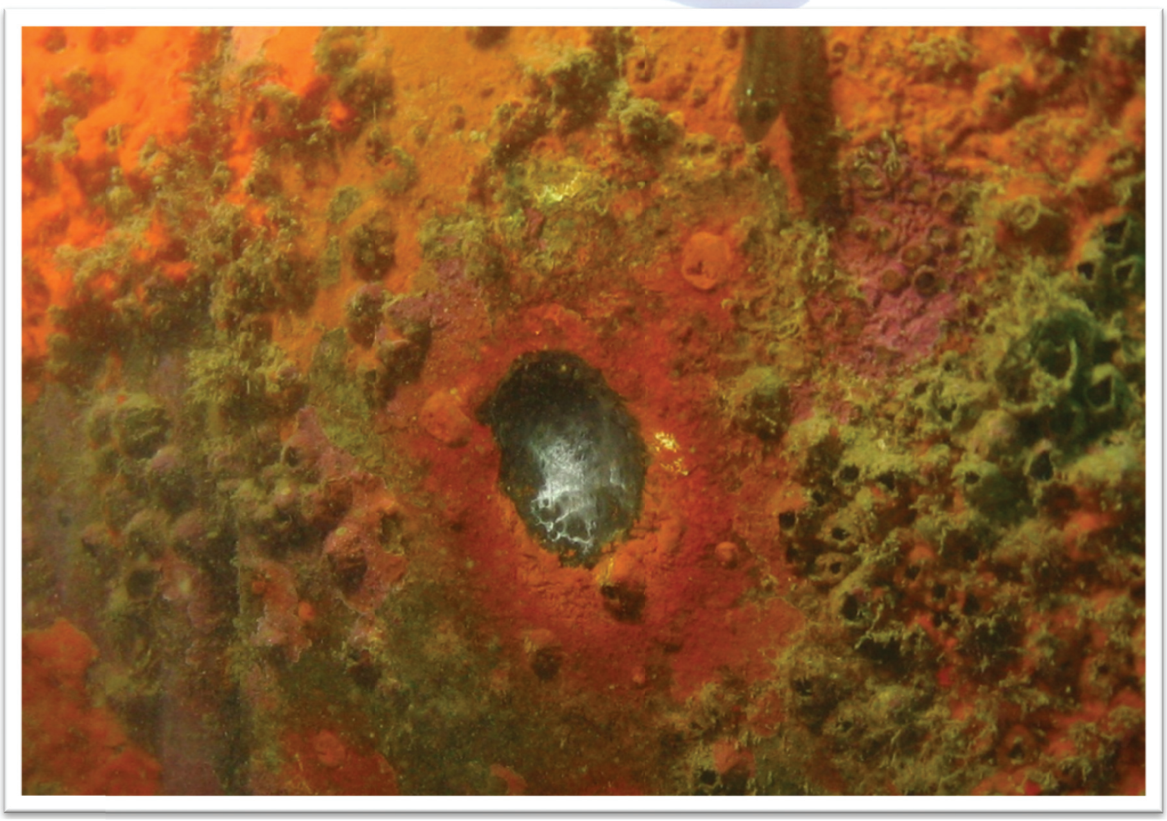


Figure 3 - ALWC pitting of sheet piling, 4 - 5mm deep

Figure 4 - Typical corrosion seen on Stage 2 piling at low water

MIC - Microbiologically Influenced Corrosion

During diving inspections of the piling, the divers have noted that there is a reasonably consistent amount of corrosion on the lower portion of the wall (-11mCD to -13mCD) on Berth 3. Due to its depth it has been suggested that it would not be ALWC, however this does not appear to be general corrosion. The divers have reported that there are large patches of corrosion that have an orange appearance at first, but with a light rub bright steel can be easily seen. During the rubbing of this surface, black silt is also noted, which appears to be a layer between the external orange appearance and the shiny steel surface. The steel surface is also noted to have localised and sometimes deep pits, up to 5 – 6mm deep. Further sampling and testing may confirm the presence of MIC.

Figures 5 & 6 show corrosion and pitting noted during diving at the toe of Stage 2. Bright steel is easily exposed by divers rubbing their hand over the surface.

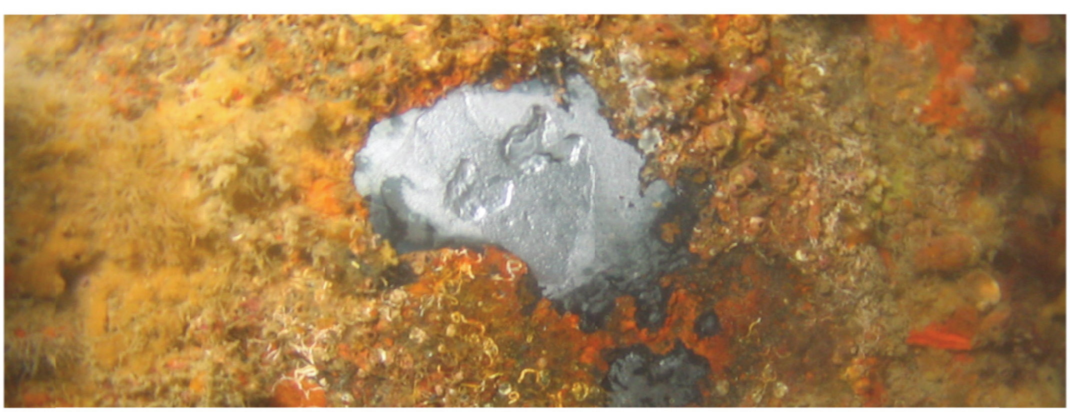


Figure 5 - Pitting occurring at depth, possibly MIC?

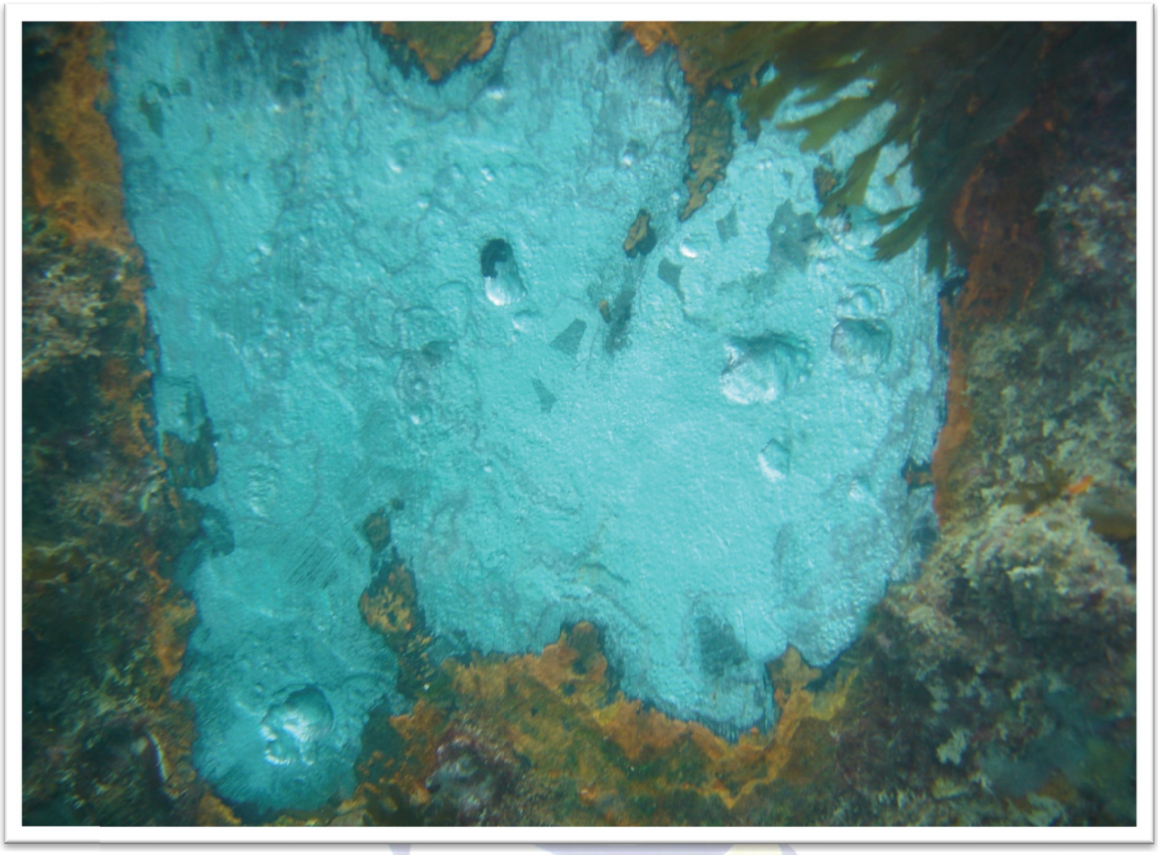


Figure 6 - Corrosion over a large area, with multiple large pits

Monitoring

Internally Northport have been looking at implementing an ongoing monitoring program. At this stage there is a structured plan on how we anticipate to carry this out, however Northport would like to obtain advice from people that have carried out similar work previously, or professional advice on what intensity we should be undertaking and under what conditions.

Monitoring is to be conducted using a Cygnus 1 ultrasonic underwater steel thickness tester, a pit depth gauge and underwater photography. Sites for monitoring are to be recorded and retested each time for comparison.

The layout of the testing can be seen in Figure 7. This has not been field tested yet, but will be based around previous dive work.

The linear spacing between monitoring sites is set at 25m, based on a dive program of two days. To increase the number of sites beyond that may mean that additional dive time will be required, which due to berthage requirements by ships, may mean that there are significant time delays between dives.

Over time we are looking to build a picture of the entire sheet piling face. We hope to understand the causes of the corrosion, if there are measures already available to counter them, as well as understand what we need to do to plan for maintenance over time. If a large scale protection system is required, then we hope to understand the trigger point for that as well.

Sheet Piling Test Programme

Depth (- CD)	Berth 3								B 2/3
	600	575	550	525	500	475	450	425	RTN
0.0			Dive 6				Dive 6		
0.5		Dive 6		Dive 6		Dive 6		Dive 6	
1.0	Dive 6				Dive 6				Dive 6
1.5									
2.0									
2.5									
3.0									
3.5									
4.0			Dive 6				Dive 5		
4.5		Dive 6		Dive 6		Dive 5		Dive 5	
5.0	Dive 6				Dive 5				Dive 5
5.5									
6.0									
6.5									
7.0									
7.5			Dive 3				Dive 3		
8.0		Dive 3		Dive 3		Dive 3		Dive 3	
8.5	Dive 3				Dive 3				Dive 3
9.0									
9.5									
10.0									
10.5			Dive 2				Dive 2		
11.0		Dive 2		Dive 2		Dive 2		Dive 2	
11.5	Dive 2				Dive 2				Dive 2
12.0			Dive 1				Dive 1		
12.5		Dive 1		Dive 1		Dive 1		Dive 1	
13.0	Dive 1				Dive 1				Dive 1

Depth (- CD)	Berth 2								Berth 1								
	400	375	350	325	300	275	250	225	200	175	150	125	100	75	50	25	0
0.0		Dive 6				Dive 7				Dive 7				Dive 7			
0.5	Dive 6		Dive 7		Dive 7		Dive 7		Dive 7		Dive 7		Dive 7		Dive 7		Dive 7
1.0				Dive 7				Dive 7				Dive 7				Dive 7	
1.5																	
2.0																	
2.5																	
3.0																	
3.5																	
4.0		Dive 5				Dive 5				Dive 5				Dive 4			
4.5	Dive 5		Dive 5		Dive 5		Dive 5		Dive 5		Dive 5		Dive 4		Dive 4		Dive 4
5.0				Dive 5				Dive 5				Dive 4				Dive 4	
5.5																	
6.0																	
6.5																	
7.0																	
7.5		Dive 3				Dive 3				Dive 4				Dive 4			
8.0	Dive 3		Dive 3		Dive 3		Dive 4		Dive 4		Dive 4		Dive 4		Dive 4		Dive 4
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13.0																	

Figure 7 - Test point location plan for monitoring

Contact Details

If you would like to know more about where this project is going, or how you may be able to help out, please contact Northport staff. This structure is relatively young, with multiple issues involved. It may suit you as a test site or test case for your products, which we would be more than happy to discus with you.

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