MWP

Structural Assessment

Skerries Pier

Fingal County Council

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Contents

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1. Introduction

MWP have been commissioned by Fingal County Council to assess the sheet piled section of the pier at Skerries. There are concerns with regard to the condition of the pier based on the condition of the sheet piles.

This report has been prepared by Micheál Fenton and Pat Parle of MWP. MWP are a multi-disciplinary engineering and environmental consultancy with offices in Cork, Tralee, Limerick and London. One of the disciplines is harbour and coastal engineering. Recent projects include:

- The design of a new container terminal jetty at Ringaskiddy. The project was design and build and MWP undertook the design of the jetty and underlying revetment for the contractor BAM.
- The design, PSDP, preparation of tender documents, tendering and administration of contract to upgrade the middle pier in Howth FHC.
- The design of numerous quay wall upgrade works in Dublin Port as part of the Alexandra Basin Redevelopment Project.
- Ongoing civil and marine design for a new RORO facility at Dublin Port.

Micheal Fenton BE, C Eng, MIEI is an Associate Director of MWP and is the Project Manager and design team lead for the Dublin Port Masterplan 2 project, involving the construction of a new RORO facility including the design of combined wall structures, suspended jetties, double tier linkspan with associated approach bridges and a circa 300m long piled dolphin structure.
Pat Parle BE, MSc, C Eng is an Associate of MWP and was project manager of the Howth FHC middle pier upgrade. Pat is presently project manager in relation to a dredging project for DAFM in Howth Harbour.

2. Background Information

The assessment is informed by:

- A visual inspection of the pier undertaken by MWP personnel in 2008 As part of an options study for the pier.
- A visual inspection of the pier undertaken in 2019 In relation to engineering aspects of a study, undertaken by MWP and Raymond Burke Consulting into potential use of the piers at Balbriggan, Skerries, Rush and Loughshinny.
- A health and safety inspection of Skerries pier undertaken by MWP in 2020 Following on from the use study.
- Dive survey inspection of the sheet piled section of pier undertaken by Irish Sea Contractors in 2020 (Report Reference No. 20201320). This includes records of voids in the sheet pile out-pans along the southern side of the pier.
- An underwater dive survey inspection of the sheet piled section of the pier undertaken by Norfolk Marine in 2021 (Document No. 21-018/UI01). During this survey measurements were taken of the steel thickness of the sheet pile out-pans at various elevations.
- Core Hole Investigation Report completed by Norfolk Marine in 2021 (Document No. 21-018/UI02). This includes details of five cores through the pier deck slab.
- OPW drawings in relation to a proposal to extend the then masonry section of the pier with a sheet piled wall section. It is not clear if the pier was constructed in line with these drawings but from the visual appearance of the pier construction it would look like this was the case.

- Historic Site investigation data obtained from the GSI archives relating to an investigation works undertaken between circa 1964 to 1967.

3. Description of the Structure

It would appear from the drawings and the date of the historic site investigation report that the sheet piled section of pier was constructed at the earliest in the late 1960's or early 1970s. It is therefore in the order of 50 years old.

The pier comprises a plan area of approximately 10m wide and 50m long. The pier deck elevation is approximately 3.2mODM. Seabed levels in the immediate vicinity are approximately -4 to -5mODM (-4.4mODM best estimate). The pier is oriented east west with the lee berthing side to the south.

There is a concrete seawall on the north/ seawards face. This wall is directly exposed to waves from the northeast.

Based on the inspections carried out and the OPW drawings available, a typical cross section indicating the principal components of the structure is included on Figure 1 below. The key features are as summarised as follows.

- A double wall consisting of Frodingham 3N sheet piles, driven into the seabed to an elevation of circa -8.6 to -9mODM.
- 62mm diameter steel solid bar tie rods at 2.85m c/c, providing a tie back support to the sheet piles at an elevation of circa +2.0mODM.
- 2no. 225mm back to back walings positioned at the rear face of the sheet pile wall, to distribute the sheet pile forces to the tie rods.
- Stone fill between the sheet pile walls
- Reinforced concrete capping beam encapsulating the top of the sheet piles around the full perimeter of the wall.
- Mooring bollards along the south face, cast into the RC capping beam. Mooring bollards are tied back to the stone fill via 4no. 22mm diameter bars connected to a 1050mm square x 400mm thick deadman anchor.
- 175mm to 200mm thick mesh reinforced deck slab, supported on the stone fill material and resting on a corbel in the RC capping beam at each end.

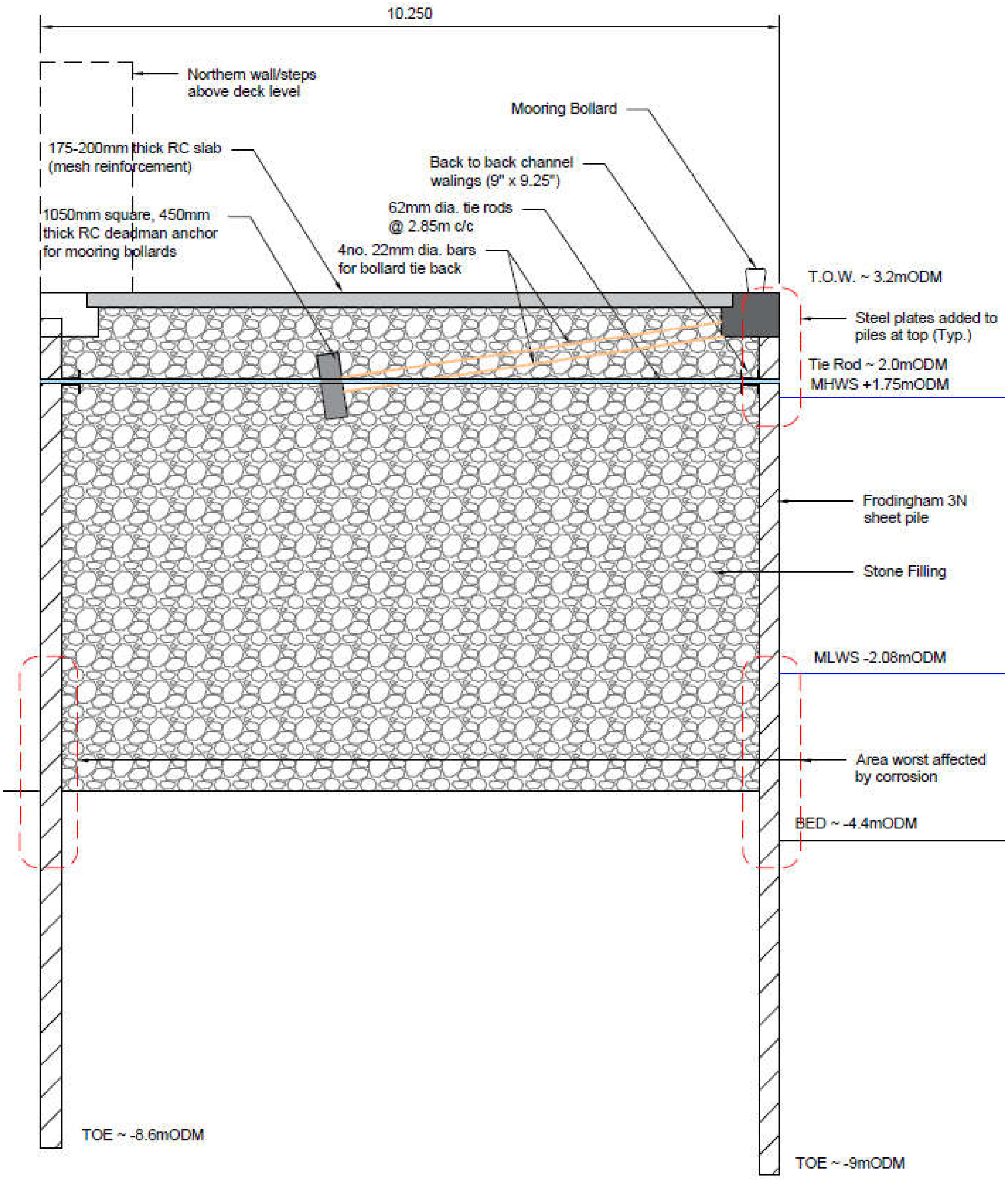

Figure 1 Typical Cross Section Through Existing Pier – Based on OPW Drawing

4. Loading

The principal loads on the structure are due to:

- Earth and water pressures, arising from the stone backfill material between the sheet piles;
- Waves from the Irish sea impacting on the seawall and sheet piling on the east side of the pier;
- Bollard pull forces arising from vessels mooring at the pier. The largest craft is assumed to have a length of approximately 20m;
- Berthing and impact forces from the fishing craft;
- Wind loads from the east acting on the seawall and on craft berthing on the west side of the pier deck level. These would be combined with wave forces.

5. Comments on Overall Condition of the Structure

Inspections and surveys of the structure date as far back as the 2008 and before this – a Royal Haskoning report on the structure is dated 2005 . These identified that the upper section of sheet piled wall had suffered considerable corrosion damage and that some sections of out-pan had been completely removed exposing the coarse fill behind. Repairs to the out-pans are evident from photos of the piles.

The Norfolk Marine inspection report in December 2021 included a photographic record and visual inspection of the piles and thickness measurements of the out-pans. The thickness measurements showed that the remaining thickness of the sheet pile out-pans are generally between 6 to 10mm in the upper zones. Between bed level and MLWS, the thickness of steel remaining is often significantly less and full loss of section has occurred across the out-pan at numerous locations. This is attributed to Microbial Induced Corrosion (MIC). Notably, MIC appears to be more prominently along the south face of the pier.

During the visual inspections of the deck and capping, no significant signs of deterioration, settlement or distress were observed. The Core Hole investigation carried out by Norfolk Marine in 2021 indicates that the deck slab is supported directly by the stone fill material between the sheet piles. This suggests that settlement of the fill material, which could occur due to (1) poor compaction, (2) horizontal wall displacement, or (3) washout of material from pile voids, has not occurred. It is noted however that the deck slab is also supported on a corbel n the sheet pile capping beam. According to Norfolk Marine Report section 4.5 states "there was localised voiding within some of the holes where the fill material has escaped to the surrounding seabed". It appears that the localised voiding has not caused voiding under the deck slab. The deck slab support could to some degree disguise voiding.

6. Expected Normal Corrosion Rates on Steel Elements (Ignoring Microbial Induced Corrosion)

The expected normal corrosion of the steel components of the structure can be estimated in accordance with IS EN 1993-5 on the basis that the structure is approximately 50 years old. These corrosions rates ignore Microbial Induced Corrosion (MIC).

The predicted corrosion rates were applied to the key structural components of the pier in order to provide a better understanding of the causes of the damage observed and to estimate the residual strength of structural elements not affected by MIC.

Predicted sheet pile corrosion rates are summarised as follows:

1. Steel Sheet Piles – Exposed Face: 1.75mm in the permanent immersion and intertidal zones. 3.75mm is the low water and splash zones.
2. Steel Sheet Piles – Buried Face: 1.2mm adjacent to the stone fill, 0.6mm below seabed level.

Frodingham 3N sheet piles have a flange/out-pan thickness of 11.7mm and a web thickness of 8.9mm. Based on the above normal corrosion allowances, the expected remaining thickness of the sheet pile is summarised on Table 1.

The corrosion rates measured by Norfolk Marine are broadly consistent with these predictions with the exception of the zone from MLWS to bed level where much higher corrosion is evident. This is attributed to Microbial Induced Corrosion (MIC).

Table 1 Expected Remaining Thickness of Sheet Piles based on IS EN 1933-5 Allowances

Zone of Attack	Predicted Remaining Thickness from IS EN 1993-5 (mm)	
	Flange/Out-pans	Web
Low Water & Splash Zones	6.75	3.95
Permanent Immersion & Intertidal Zones	8.75	5.95
Below Seabed	10.5	7.7

The tie rods are located within the stone fill where IS EN 1993-5 indicates 1.2mm corrosion would occur around the perimeter of the bar in uncompacted fill. However, the stone fill at Skerries Pier is likely to be highly permeable with potential flow paths along the line of the tie rod. Therefore, it is considered that higher corrosion rates more akin to the splash zone could occur. On this basis the remaining tie rod diameter is expected to be approximately 55mm.

Using the same approach, the mooring bollard tie bars would each have a corroded diameter of approximately 14-15mm.

7. MWP Analysis & Predicted Failure Mechanisms

A soil-structure interaction (SSI) analysis was carried out using a plane strain model in Plaxis 2D geotechnical modelling software. The arrangement of the model is indicated on Figure 2 below. The analysis considers earth and water pressure only, which are the predominant loads acting on the structure during calm conditions.

The analysis carried out indicates that the maximum stresses in the sheet pile wall, ignoring axial effects which are be relatively small, would be approximately 40% of the original uncorroded sheet pile yield stress. When the 50 year corrosion allowance suggested in IS EN 1993-5 is considered, the analysis indicates that the wall would be approaching its yield stress. The extensive voids in the outpan of the sheet piles near bed level would significantly reduce the capacity of the piling, and the analysis indicates that the piles would yield due to this loss of section.

The analysis indicates that the tie rods would be working well below yield stress, even considering normal corrosion rates over 50 years. Therefore, it is expected that a failure of the structure would be due to yielding and rotation of the sheet piles at some point above bed level, most likely near MLWS. It is anticipated that there is a degree of redundancy in the structure and some bending moments can be re-distributed away from severely corroded zones to other less corroded areas before a collapse would occur. As such a structure approaches failure, additional deformation, settlement, tilting and distress would usually be apparent. Although the sheet pile corrosion near bed level would cause the piles to be stressed beyond their yield stress, there does not currently appear to be any significant signs of distress which may otherwise suggest the structure is approaching collapse.

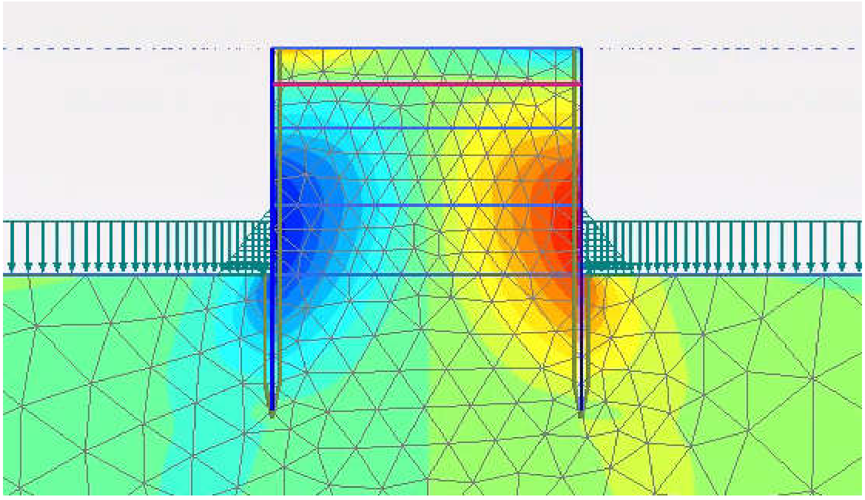

Figure 2 Plaxis 2D Plane Strain Model of Pier

8. Findings of Analysis

The findings of the above analyses are:

- It is apparent from the inspections carried out that the sheet piles have reached their end of life. Notwithstanding this, there is currently no significant evidence to suggest that the structure is approaching failure. The structure has experienced loading from waves and wind during storm events in the recent past. Under calm conditions the structure supports predominantly earth and water pressures which, with the exception of tidal variations, are mainly permanent in nature and the structure appears to be catering for such loads without showing signs of significant distress. Failure of the structure due to permanent earth and water pressures is expected to occur progressively as the overstressed zones of sheet piling distribute loads to other less corroded areas.
- A sudden failure without warning is more likely to occur due to externally applied loading, such as wave/wind forces or mooring forces. Wave and wind loads acting on the structure during a storm would induce additional axial forces and moments in the piles. Whilst the structure appears to have withstood such loading during recent north easterly storms, there is less certainty if this can be sustained in the near future, considering the variable nature of the loading and the likelihood of ongoing degradation of the sheet piles.
- The residual cross section of the mooring bollard tie bars suggests that a mooring force of around 30T could still be maintained by these bars. However, the tie bars transfer the mooring forces back to the deadman which in turn induces an undesirable lateral pressure on the active soil wedge behind the sheet piles. Such pressures, which could be dynamic in nature and may not necessarily have been experienced in the recent past, have potential to induce a sudden failure of the structure.
- As noted, the investigations carried out by Norfolk Marine indicate that the deck slab is still supported directly on the stone fill material. There are no signs of significant distress at deck level. Vertical loading etc from fishing operations in terms of localised loadings due to fish boxes and small vans during calm conditions are unlikely to overstress the present structure considering the condition of the concrete deck and the ability of the structure to withstand recent storm conditions.
- Impact loads from fishing vessels berthing alongside the pier is understood to occur via fenders or tyres suspended from the deck. The resulting loads would be relatively small if careful berthing at low velocities occurs in calm conditions. This is not expected to result in a sudden global failure of the structure. Higher impact velocities impart higher energies which would need to be absorbed by the structure and the current fender arrangement would not be suitable to minimise the resulting concentrated forces.

9. Options

9.1 General

There are three main options regarding the future use of the sheet piled section of Skerries Pier.

They are:

1. Unrestricted use;
2. Restricted use
3. Close the pier

9.2 Unrestricted use

Unrestricted use would mean that any sized vessel, vehicle or loading could use or impact upon the pier and could cause overloading of the structure, given its existing state. The condition of the sheet piles and the possibility of sudden failure due to such use and the consequences of such a failure precludes this as a feasible option. It is not recommended that there be unrestricted use of the pier.

9.3 Restricted Use

There may be a possibility of restricting use to calm conditions and berthing only to load/ unload craft with small trucks/ vans servicing the boats. However, given the significantly deteriorated condition of the sheet piles such an operational approach would require considerable monitoring and control of activities on the pier and monitoring of environmental conditions and the further deterioration that may occur.

Such monitoring and controls should include in outline:

1. Fishing vessels should only be allowed to berth alongside the pier to load/unload the vessel. Once this operation is complete, vessels should move away from the pier.
2. Mooring is not permitted, except in calm conditions and only for the duration of loading/unloading operations.
3. The pier should be closed to general traffic and members of the public.
4. Traffic on the pier should be limited to one van or light truck at a time, for use associated with the fishing vessels.
5. Access to the pier should not be permitted when the predicted wind speed exceeds say 10 knots.
6. Regular visual and geometrical monitoring. This would involve positioning survey targets at key locations on the structure so that the position, elevation and verticality of the structure can be determined.

9.4 Close the Pier

This option relates to the closure of the sheet piled section of the pier to vessels loading/ unloading and berthing/ mooring against it, to vehicular traffic on the pier, to loading of the pier with catch or equipment or other materials. While limited pedestrian access will not cause significant loading of the pier it should be discouraged. This option is the most prudent and practical of the three.

10. Conclusion

Based on an assessment of available data and outline analyses detailed above it is concluded that given the condition of the pier and the large uncertainties with regard to the analysis undertaken for this report and in the absence of monitoring and controls as detailed under restricted access above which may be considered impractical it is recommended that the sheet piled section of the pier be closed.