COPENHAGEN MALMÖ PORT

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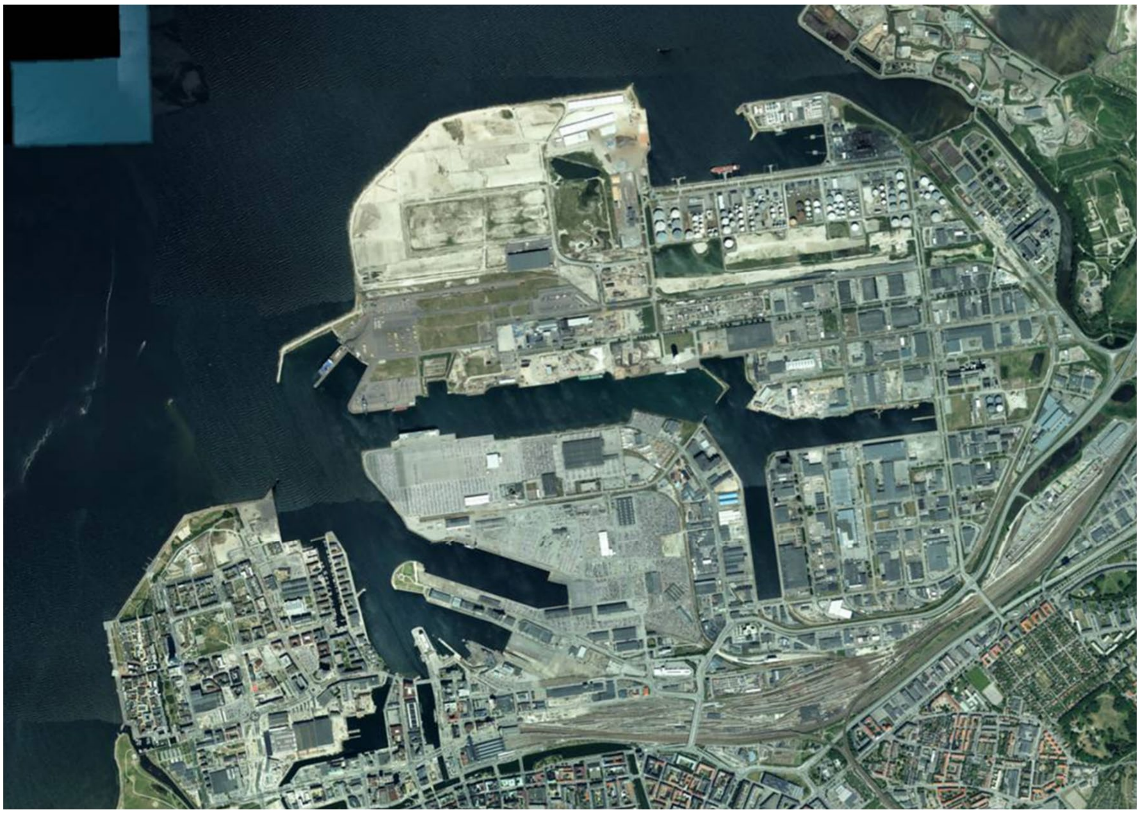
RISK ANALYSIS FOR WORKS IN CONJUNCTION WITH THE REBUILDING, ALTERATION OR CONSTRUCTION OF PORT FACILITIES IN THE PORT OF MALMÖ



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This document is a translation made by SHK of the original response in Swedish to the safety recommendation. In case of discrepancies between this translation and the Swedish original text, the Swedish text shall prevail in the interpretation of the response.

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1 INTRODUCTION

On the morning of Sunday 17/12/2023, the Finnlines vessel Finnpartner collided with the pierhead of berth M0702. For reasons unknown the bulb of the vessel hit the western corner of the pierhead, which caused extensive damage to both the structure of the quay and to the underlying tarmacked surface of the quay with the foundation of a storm bollard. As a consequence of this incident, the Swedish Accident Investigation Authority (SHK) conducted an investigation into the accident, which came to be regarded as a very serious marine casualty, which also gave rise to an incident in the form of a workplace accident with an evident threat to live. SHK's report concerning the accident was published on 17/12/2024 and is available for the public to download from SHK's website (SHK 2024:18 R1).

The following recommendation was made to the City of Malmö and Copenhagen Malmö Port in the final report:

- 'include a damage consequence risk analysis whenever port constructions are constructed, rebuilt or changed.'

This risk analysis has been produced for general use within the whole of CMP's area of operations with respect to backwards-anchored sheet-pile quays and their quay equipment, and in order simultaneously fulfil the requests in SHK's recommendation, but not solely for that reason.

1.1 Background

The construction works in conjunction with repairs and rebuilding and new construction of quays and other port facilities include many high-risk work elements. In order to minimise and, in those cases where it is possible to eliminate any risks associated with these types of works, a risk inventory with accompanying risk and impact assessment shall be conducted before the works commence. When planning new facilities or rebuilding the construction work environment coordinator for design/planning (BAS-P) is responsible for both ensuring that the construction works are possible to accomplish in a safe manner and that future maintenance of the facility can be conducted in just as safe a manner with regard to work environment.

When it comes to repair works after damage has occurred to, for example, a quay structure due to a collision, it is also the case here that the planner who produces the documentation for the repair works shall ensure that these are possible to execute in a manner that is safe when it comes to the work environment. In this case as well the repair measures worked out must be preceded by a risk inventory with accompanying risk and impact assessment.

1.2 Aim

The aim of this risk inventory with accompanying risk and impact assessment is to minimise and, in the best case scenario, eliminate the risks that may arise in the event of rebuilding, alteration or construction of port facilities, with a focus on backwards-anchored sheet-pile quays.

1.3 Scope

The analysis encompasses an assessment of what risks there are in conjunction with construction works involving the rebuilding, alteration and construction or quay structures of the type backwards-anchored sheet-pile quays. The analysis also takes into consideration adjacent port structures such as bollard foundations.

The analysis also addresses risks such as collisions with vessels, overloading of quay surfaces caused by variable loads such as supporting trestle pressure from mobile cranes or beneficial overloading of other types.

1.4 Limitations

As the majority of Copenhagen Malmö Port's quays in Malmö are backwards-anchored sheet-pile quays, only this type of quay structure with accompanying quay accessories such as bollard foundations and associated Moorex system is addressed in this risk analysis. Quays of the pile-deck type are not discussed in this analysis but this material can also be used a guidance when conducting a risk inventory for this type of quay.

1.5 Methodology

A risk inventory with potential risks has been conducted. The risks have then been assessed qualitatively with respect to the likelihood and consequences of each. These have then been weighed together in a risk matrix. For risks that have been deemed medium-high or high, proposals for measures to reduce the likelihood or consequences of the risk in question have been produced.

2 EXISTING CIRCUMSTANCES

As mentioned previously, essentially all of Copenhagen Malmö Port's quays are built as backwards-anchored sheet-pile quays. The tensile braces, which are made of steel, in the quays can be either horizontal, with bracing plates or bracing sheet piles in its rear part or anchored into the underlying limestone with a bracing angle typically of 45° between the horizontal and vertical planes. Figure 1 shows a typical example a backwards-anchored sheet-pile quay with horizontal braces.

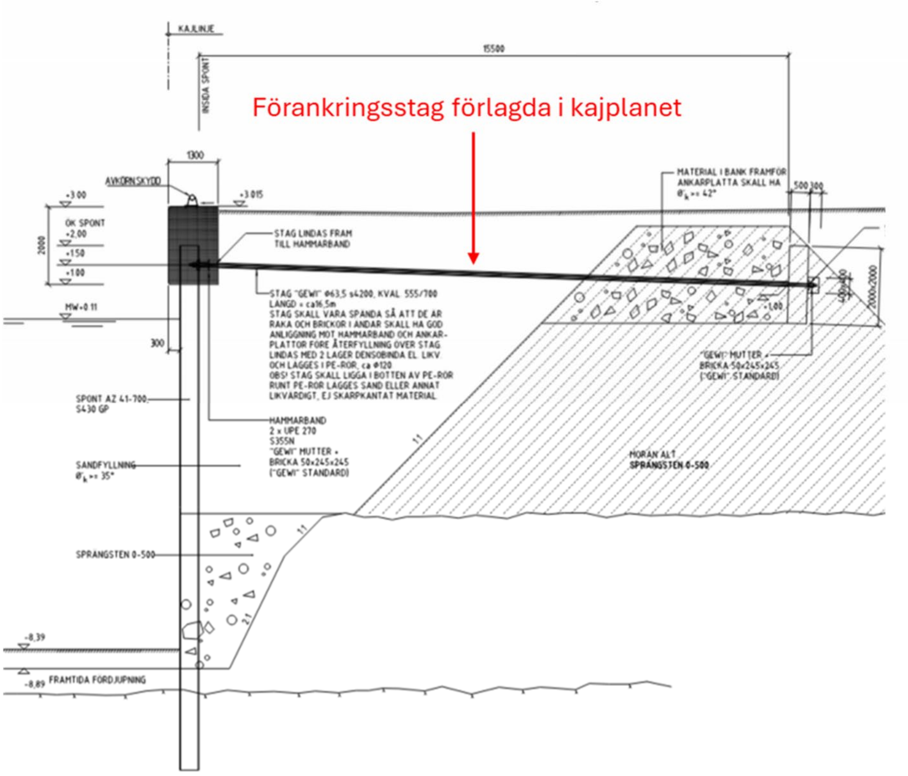

Figure 1: Example showing the structure of a backwards-anchored sheet-pile quay with horizontal tensile braces.

Sheet-pile quays are designed for bollard loads, loads from the quay's fenders and for overload on the underlying quay surface. Where relevant, the quays are also designed for the impact of ice loads. The design overload on the underlying quay surface is normally 20 kPa (2 tonnes/m^2), but there is some variation. It can be mentioned by way of an example that the pier quay making up ferry berths 702 and 703 is only designed for an overload of 10 kPa, while the container quays 705 and 706 are designed for an overload of 30 kPa.

The quays at ferry berths 702 and 703 have subsequently been equipped with erosion protection made of reinforced concrete. This is because it was discovered during a dive inspection that there was a tendency for parts of the base of the sheet piles to become undermined and thus also risked losing their support. The installation of this erosion protection was carried out in 2019; see also Figure 2, which shows examples of sheet-pile quays equipped with erosion protection made of reinforced concrete.

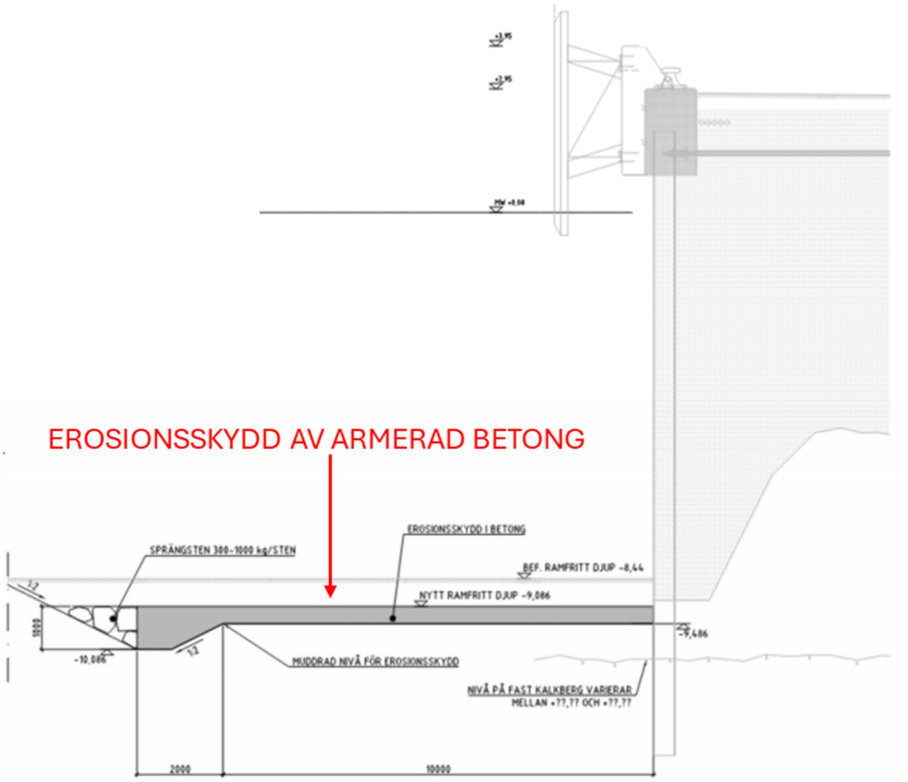

Figure 2: Examples of sheet-pile quays with reinforced concrete erosion protection.

2.1 Wind, current and wave conditions

The outer parts of the northern harbour in Malmö are exposed in the northwest to wind and waves, primarily from the west and northwest. This is especially true for the ferry berths 702, 703 and 704. Other quays and the ferry berths within Copenhagen Malmö Port's area in Malmö are relatively protected from the impact of wind and waves.

3 RISK IDENTIFICATION

The following risks have been identified with regard to alteration, construction and extension of quays and adjoining structures in the Port of Malmö:

1) The bulbs of vessels colliding with sheet-pile quays.
2) Erosion damage caused by, for example, propeller wash alongside sheet-pile quays that are not equipped with erosion protection.
3) Overloading of quay surfaces alongside the quay edge caused by mobile payloads such as vehicles, mobile cranes, containers or similar.
4) Unintentional cutting of bracing stays for sheet-pile quays when excavating quay surfaces behind the quay edge.
5) Unclear signage with regard to which loading criteria apply within different areas in the northern harbour. This applies for both quay surfaces and vehicle ramps.
6) Overloading of bollards.
7) Risk of increased loading in excess of the quay's original loadbearing capacity in the event of a change to the loading conditions for an existing quay or a change in how the quay is used.
8) Loss of ability to manoeuvre caused by strong winds and simultaneous unfavourable wind direction. Applies especially to quays 702, 703 and 704 in the northern harbour.

A complete description of risks 1–8 above, with a description of the consequences/damage, proposed measures in the event of damage, proposed measures to prevent or minimise damage to existing quays, and proposed measures for preventing or minimising damage when planning new facilities are set out in Appendix 1.

3.1 Illustration of selected identified risks where damage has occurred

Risk #1

Figure 3 illustrates two cases of undermining of underlying quay surfaces following a collision between a vessel and the quay, where holes have arisen in the sheet-pile wall.

Figure 3: Material falling out through a hole in a sheet-pile wall following a collision with a vessel (risk no. 1).

Risk #2

Figure 4 shows undermining of the underlying quay surface caused by supporting material at the base of the sheet pile having gradually been washed away by propeller wash.

Figure 4: Undermining of the base of sheet pile caused by propeller wash (risk no. 2).

Risk #5

Figure 5 shows signage at a ferry berth. The signs refer to permitted loads on the adjacent vehicle ramp for the main deck, but can just as easily be interpreted as referring to the surrounding quay surface.

Figure 5: Unclear signage (risk no. 5) (photo taken by Qace Asadi, CMP).

Risk #6

Figure 6 shows the top of a bollard cut-off in conjunction with its use when mooring.

Figure 6: Top of a bollard that has broken when mooring a vessel (risk no. 6).

4 QUALITATIVE RISK ASSESSMENT AND RISK EVALUATION

The likelihood and consequences of the risks identified in chapter 0 have been marked in the risk matrix below (see Figure 7).

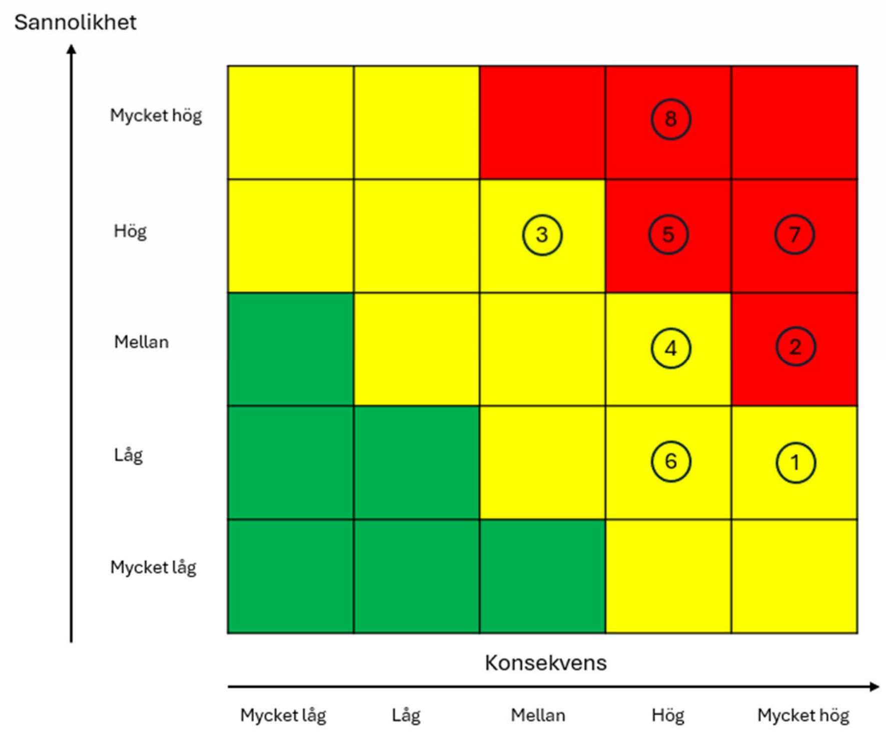

Figure 7: Risk matrix with evaluation of identified risks.

As shown in Figure 7, risks nos. 2, 5, 7 and 8 end up within the area marked in red, which means that measures must be put in place in order for acceptable levels of risk to be achieved. Risks 1, 3, 4 and 6 end up within the area marked in yellow, which means that measures should be considered.

5 RISK-MITIGATION MEASURES

Risk-mitigation measures for the identified risks nos. 1 to 8 are described in detail in Appendix 1 to this document.

What is generally the case is that CMP's requirements in respect of the use of protective equipment such as lifejackets must be complied with in order to minimise the risk of workplace accidents.

6 CONCLUSIONS AND RECOMMENDATIONS

CMP is recommended to establish a risk inventory council with representatives from CMP's senior management group, production line and trade union safety representatives. The aim of the risk inventory council is to capture at an early stage the risks that may arise in conjunction with the alteration, construction and expansion of quay structures and in conjunction with changes in how existing quay structures are used. It is suggested that recurring meetings be held quarterly and that additional meetings be held in advance of planned construction activities within the port area.

7 APPENDICES

Appendix 1: Risk inventory table for identified risks 1–8, with a description of consequences and proposed measures.

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Appendix 1

RISK ANALYSIS FOR WORKS IN CONJUNCTION WITH THE REBUILDING, ALTERATION OR CONSTRUCTION OF PORT FACILITIES IN THE PORT OF MALMÖ

		EXISTING QUAY	EXISTING QUAY	WHEN PLANNING NEW FACILITIES
RISK	**CONSEQUENCE/DAMAGE**	***Measures in the event of damage***	***Measures to prevent or minimise damage***	***Measures to prevent or minimise damage***
1) The bulbs of vessels colliding with sheet-pile quays.	Holes in sheet-pile walls. Infill material from the quay falling out. Undermining of underlying quay surface. Undermining of structures on the quay surface that do not have pile foundations.	Affected quay area is immediately cordoned off and access to the quay surface is prohibited. Vessel traffic close to the quay is stopped. UV inspection is conducted using divers or an ROV if the work environment risks are deemed too high to use human divers. The aim of the UV inspection is to check for any holes in the sheet-pile wall and any infill material that may have fallen out onto the seabed. If no holes can be detected in the sheet pile and no infill material is found on the seabed, the cordon can be removed and vessel traffic can be restarted. If the damage described under point two above can be detected, a proposed measure involving repair and stabilisation of the quay and any structures on the quay surface that do not have pile foundations shall be worked out as soon as possible. The section of quay remains cordoned off and may not be accessed or used for vessel traffic before repair measures have been completed and approved.	Installation of dolphins or other barriers to prevent a direct collision (not possible everywhere). Strict requirements that clarify the highest windspeeds and simultaneous wind directions that apply when calling at the quay in question.	A detailed vessel simulation with the vessels in question for the wave, wind and weather conditions that apply in the area shall be conducted in order to find the most optimal design for new quays and ferry berths with the aim of preventing accidents and incidents. Planning of dolphins or other barriers to prevent a direct collision (not possible everywhere). Divide up the sheet-pile structure into cells, i.e. section this so that it is only possible for infill material from the affected section/cell to fall out and undermine a small area of the quay surface. Infill material closest to the backside of the sheet-pile wall can be made of a coarser fraction such as broken rock in order to reduce the likelihood of it falling out if holes were to arise in the sheet-pile wall. Gravity foundations shall not be used. All structures on the quay surface alongside the edge of the quay such as storm bollard bases, automated mooring systems etc. shall have pile foundations. Directly anchoring storm bollard bases that are located past the bracings of the sheet-pile quay is still permitted if this is possible, depending on the properties of the ground.
2) Erosion damage caused by, for example, propeller wash alongside sheet-pile quays that are not equipped with erosion protection.	Undermining of the base of sheet pile Infill material from the quay falling out Undermining of underlying quay surface The sheet-pile wall moves horizontally out from the edge of the quay, which can result in the wall of the quay collapsing locally	Ongoing damage is usually possible to detect through subsidence on the quay surface just behind the edge of the quay. This is also valid when sheet pile has rusted through, in which case infill material falls out into the dock. Affected quay area is immediately cordoned off and access to the quay surface is	Continual inspection of the quay surfaces just behind the edge of the quay. Note subsidence and similar non-conformities in the quay surface. Performed at intervals set out in the maintenance plan. Continual inspection/hydrography/dive inspections in order to detect on-going erosion	All new sheet-pile quays are equipped with concrete erosion protection that is designed for the propeller wash that may conceivably arise.

Appendix 1

		EXISTING QUAY	EXISTING QUAY	WHEN PLANNING NEW FACILITIES
RISK	**CONSEQUENCE/DAMAGE**	***Measures in the event of damage***	***Measures to prevent or minimise damage***	***Measures to prevent or minimise damage***
		prohibited. Vessel traffic close to the quay is stopped. • UV inspection is conducted using divers or an ROV if the work environment risks are deemed too high to use human divers. The aim of the UV inspection is to check the base of the sheet pile along the section of quay and any infill material that may have fallen out onto the seabed. • The base of the sheet pile can be temporarily prevented from moving further using bracing infill made of, for example, broken rock on the outside of the sheet-pile wall. • Repair measures are worked out. • Repair measures are implemented. • The cordon can be removed after approved repair measures.	in good time. Performed at intervals set out in the maintenance plan. • The quay sections that do not have erosion protection are equipped with this.	
3) Overloading of quay surfaces alongside the quay edge caused by mobile payloads such as vehicles, mobile cranes, containers or similar.	• In the mildest case, local damage occurs to the paving on the quay surface in the form of vertical deformation. • Overloading leads to stay damage in existing bracing stays. The quay loses its design loadbearing capacity locally. Continued increased loading can lead to 'progressive collapse' when more and more bracing stays collapse and the sheet-pile wall loses its support. • When there are larger deformations in the structure of the quay, instability can arise in, for example, mobile cranes positioned alongside the edge of the quay, which can in turn lead to the mobile crane falling into the dock.	• The section of quay in question is cordoned off to both passenger traffic and other traffic. • The surface of the quay is visually inspected in the position of the suspected overloading. • Note any cracks in the asphalt and horizontal movements in the front of the quay. • When broken stays are suspected, the affected bracing stays are carefully dug out in their entirety, including the bracing points on the front and rear edges. • If the stay or its attachments are damaged, repair measures shall be implemented. An engineer determines which repair measures are required. • When the repair measures are complete and approved, the cordon can be removed and the section of quay can again be used as intended.	• Clear signage that indicates what permitted load on the quay surface applies for each section of quay shall be put up. • When any use of a mobile crane etc. for which the quay has not originally been inspected is required, a new construction calculation for the mobile crane in question shall be produced by a geotechnical engineer. The calculation shall show how the specific equipment may be used on the quay surface with stated measurements and safe distances.	• Stipulate in the documents that clear signage which shows the permitted load on the quay surface in question shall be put up by each section of quay.
4) Unintentional cutting of bracing stays for sheet-pile quays when excavating quay surfaces behind the quay edge	• The quay loses its design loadbearing capacity locally. • If no action is taken there is a risk of broken stays in adjacent stays by	• The section of quay in question is cordoned off to both passenger traffic and other traffic. • The affected bracing stays are carefully	• Before (careful) excavation takes place in the quay surface behind the edge of the quay, existing stays shall be clearly labelled with	• In the final stage of the projects, record drawings produced shall clearly show where in the ground the stays have been positioned.

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Appendix 1

		EXISTING QUAY	EXISTING QUAY	WHEN PLANNING NEW FACILITIES
RISK	**CONSEQUENCE/DAMAGE**	***Measures in the event of damage***	***Measures to prevent or minimise damage***	***Measures to prevent or minimise damage***
	continued loading on the quay surface. This can in turn lead to ‘progressive collapse’ when more and more bracing stays collapse and the sheet-pile wall loses its support.	dug out in their entirety, including its bracing points on the front and rear edges. • An engineer determines which repair measures are required. Most frequently the stay needs to be replaced in its entirety. • When the repair measures are complete and approved, the cordon can be removed and the section of quay can again be used as intended.	marking spray on the paving on the quay surface.	The ends of the stays shall be feed in coordinates that are reported in a table on record drawings.
5) Unclear signage with regard to which loading criteria apply within different areas in the northern harbour. This applies for both quay surfaces and vehicle ramps.	• Overloading of quay surface, see risk point 3).	• See risk point 3).	• See risk point 3).	• See risk point 3).
6) Overloading of bollards	• The top of a bollard breaks off. • Risk of personal injuries for staff present on the quay surface.	• The concrete for the attachment of affected bollard is inspected by an expert. • If the concrete for the attachment is deemed to be fine, the defective bollard is replaced with an identical new one. • If there is a suspicion that concrete for the attachment is damaged, repair measures are worked out by an engineer. • After repair measures with a replaced bollard are completed and approved this can be used as intended once again.	• Existing bollards shall be clearly marked with the maximum value for the bollard load. This can be done both using colour marking and by writing on the bollard its maximum capacity in tonnes.	• Clear marking of the maximum capacity of the bollard in tonnes is a requirement set in the planning stage.
7) Risk of increased loading in excess of the quay’s original loadbearing capacity in the event of a change to the loading conditions for an existing quay or a change in how the quay is used.	• Overloading of quay surface, see risk point 3).	• See risk point 3).	• Before the quay is brought into use for new/altered activities a status assessment of the quay shall be conducted. The status assessment shall encompass the entire structure both above and below the waterline. The following elements should be included in the status assessment. - Dive inspection with measurement of the remaining thickness of the material in the sheet pile. - Inspection of the concrete in the capping beam - Inspection of a selection of the bracing stays to which the sheet pile is anchored. Is done by carefully .	• Ensure that material is accurate and clear with regard to the set of record drawings such as plans and calculations are saved and archived in a structured manner for future requirements.

Appendix 1

		EXISTING QUAY	EXISTING QUAY	WHEN PLANNING NEW
RISK	**CONSEQUENCE/DAMAGE**	***Measures in the event of damage***	***Measures to prevent or minimise damage***	***Measures to prevent or minimise damage***
			excavating the underlying quay surface. drawings for the quay in question - Verification calculation of the quay structure for the new/altered conditions.	
8) Loss of ability to manoeuvre caused by strong winds and simultaneous unfavourable wind direction. Applies especially to quays 702, 703 and 704 in the northern harbour.	The vessel is at risk of approaching the quay at too high a speed and damaging the quay structure and/or the fenders.	Inspection of any damage and development of repair proposals. Repair measures, which can consist of replacement of fenders, concrete repairs etc. See also risk point 1).	Restrictions for each ferry berth with guideline values for maximum windspeed for a given wind direction for when vessels are able to call and depart under their own steam. If these limits are exceeded, a tugboat shall be used when calling and departing.	When planning new quays or new ferry berths, a detailed vessel simulation for the intended vessels shall be performed. The results from the vessel simulations shall form the basis on which to find optimal designs for new quays and ferry berths taking into account safety and manoeuvrability.