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Structural Inspection
North Terminal, New Bedford, MA
Report of Findings

Prepared for:

New Bedford Harbor Development Commission
52 Fisherman's Wharf, New Bedford, MA

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List of Attachments

Engineer/Firm Assigned

CLE Engineering, Inc. (CLE) was contracted by the New Bedford Harbor Development Commission (HDC) to perform an underwater and topside structural inspection of the marine infrastructure of North Terminal. CLE teamed with Fathom Diving (Fathom) to perform the underwater portion of the inspection. The scope of work included the piers and bulkheads of five leased parcels (including the terminus of Antonio Costa Ave). The piers at North Terminal were constructed using three different designs and are of varying ages. This report reflects the conditions of the property which were present and visible at the time of the inspection. Questions regarding this report, its scope and/or content should be addressed to Susan Nilson, P.E. at (508) 748-0937.

1. Introduction

The structures which were within the scope of this inspection are those along parcels 1, 2, 5, 7, and 10 as labeled on the figure below. Three separate designs exist at the North Terminal site;

Parcel 1 - Concrete encased timber piles supporting a concrete deck
Parcel 2 - Steel sheet pile cells supporting a concrete deck
Parcels 5, 7, and 10 - Steel H-Piles supporting concrete deck

Historic aerial photographs indicate that all of North Terminal's waterfront infrastructure was constructed before 1971 with the exception of Parcel 2. Given the design and condition of the bulkhead along Parcel 2 it is likely that the structure was constructed before 1985. No construction plans were located of the pier and bulkheads along any of the parcels within North Terminal. These sites do not have previous inspection reports to serve as a comparison or to determine rate of corrosion/deterioration.

All of the subject parcels are heavily used for both vessel berthing and maintenance in addition to serving as loading and unloading areas for the parcel tenants. In the years following construction, some of the buildings on site have encroached over the pier deck.

Figure 1: North Terminal Layout

Figure 2: Aerial photograph dated 1961

Figure 3: Aerial photograph dated 1971

2. Summary of Findings

2.1 Maritime International Terminal (Parcel 1)

2.1.1 Description of Structure

The Maritime International Terminal (Pier) is approximately 478 linear feet and is used for access to fishing vessel berths, for support of the buildings on site, and general storage. No record plans or plans indicating date of construction where located (aerials indicated pre-1971 construction date). The structure consists of a large concrete deck supported by concrete encased timber piles. The piles are driven along a grid line only along the seaward face, piles behind the face are located in an almost random arrangement. Due to the non linear arrangement of the piles and the very close spacing (only 18 to 24 inches clear space is typical), inspection of this site was not possible. The few piles inspected exhibited signs of reduced section area due to marine borer damage.

Photograph 1: Typical pile layout along fender line

Photograph 2: Typical close spacing of piles

2.1.2 Structural Assessment /Recommendations

The pier along Parcel 1 likely contains hundreds of piles supporting both the concrete cap and the terminal buildings above. These piles comprised of concrete encased timber are susceptible at or near the mudline to marine borer attack. Assuming this condition has existed for nearly 50-years an inspection focused just on this Parcel should be completed immediately.

An inspection of this site should begin with the preparation of a pile plan indicating the location (approximate) of each pile and assigning a pile designation. This designation could then be used by the dive team to reference pile condition in a format which is directly transferable to its location on the concrete deck.

Given that the concrete jackets at this site extend almost the full length of the piles it may be possible to extend the service life of the structure significantly by extending the jackets into the mudline. The efficacy of this repair cannot be determined until an inspection is completed.

Parcel 1: Short Term Recommendations 0-2 Years

- Underwater and topside structural inspection

Parcel 1: 3-5 Year Recommendations

- TBD following inspection report

2.2 Cape Cod Aggregates (Parcel 2)

2.2.1 Description of Structure

Parcel 2 is a 250 linear foot steel cellular bulkhead with a reinforced concrete cap. The bulkhead provides support for vessel berthing and for the offloading and bulk storage of sand and aggregates. The fender system consists of timber piles and a continuous timber wale which are supplemented by large diameter tires hung from the back side of the concrete cap. Photograph 3 below provides a view of the critical components.

Photograph 3: Typical bulkhead/fender construction

2.2.2 Observed Conditions

The steel sheet pile cells are of varying diameters and extend from the mud line directly into the concrete cap. The flat steel sheets which comprise the cells exhibit signs of heavy corrosion with pitting of the steel and no evidence of a previous coating. However, relatively few holes were located during the underwater inspection (two - 24 in^2 at Cell 3, and one 300 in^2 at Cell 8). Conduit located at various locations along the steel cells may indicate that an impressed current system was once installed at the site but no such system is currently in operation.

The timber fender system is in fair condition with the piles still showing evidence of their preservative treatment. The bolting hardware retains a crisp profile with minor deterioration and the bolting holes have not been expanded beyond their original size (through friction or marine borers). The tire fenders are typical for an industrial site of this type and although not an engineered solution, they appear to perform adequately as contact of the timber system with a vessel appears to be infrequent. A galvanized channel protects the concrete cap from friction damage from the tire anchor cables.

2.2.3 Structural Assessment/Recommendations

Overall the bulkhead is in *Fair* condition with no load restrictions but significant deterioration. The presence of heavy deterioration and holes in the sheet pile cells indicate that the bulkhead is approaching the end of its service life. However in the near term (beyond the next inspection interval) should the parcel's use remain as it is today, patching of the three located holes is the only structural repair which is recommended at this time. It may be possible to extend the life of the system with the installation of a cathodic protection system. An analysis of the current condition and connectivity of the structure should be performed to assess the cost/benefit.

Parcel 2: Short Term Recommendations 0-2 Years

- Cathodic protection analysis
- Design of bulkhead patching repairs

Parcel 2: 3-5 Year Recommendations

- Perform bulkhead patching repairs
- Routine inspection in 2021

2.3 North Terminal Pier (Parcels 5, 7, and 10)

2.3.1 Description of Structure

The North Terminal Pier along Parcels 5, 7, and 10 extends 1,000 linear feet from the northern end of Parcel 2. This structure is 55 feet in width and is comprised of concrete encased steel H-piles supporting cast in place concrete pile caps and precast concrete deck panels. A steel sheet pile AZ-sheet bulkhead extends along the entire length supported by steel H-pile batter piles. A timber fender system extends along the entire length.

The pier serves as an offloading area for product, vessel maintenance area, as well as to provide access for deliveries to the parcel tenants. Vehicular traffic has access to the entire site via Antonio Costa Ave and Hervey Tichon Ave. Navigational charts of the area indicate depths of 24-30 ft (MLLW) immediately along the fender line.

Figure 4: Navigational Chart

Photograph 4: Replaced timber fender along Seawatch parcel

Photograph 5: Typical below deck view of pier construction/condition

2.3.2 Observed Conditions

Inspection of the piles found that the concrete jackets do not extend far below Mean Low Water (MLW) leaving the H-piles exposed for 20-30ft. CLE inspected approximately 45% of the steel piles to a Level II condition by removing the growth on at least a portion of the steel faces. The flanges were found to be extremely thin as shown in Photograph 6. UTM measurements indicate that the original flanges would have been near 0.5 inches thick. Current readings found many piles under 0.2 inches in thickness; observations of the flanges appear consistent these readings throughout the site. Several piles were found to be completely failed with total loss of the flanges.

The concrete deck and pile caps have localized areas of spalling and corrosion of the steel reinforcement consistent with the age of the structure. Spalling or loss of concrete was not extensive enough to determine reinforcement diameter or spacing.

The steel bulkhead was found to be deteriorated especially at the northern end of the project site (see Photograph 11). Large holes (6 ft x 2 ft and 6 ft x 4 ft) were observed at the northern end of Parcel 10. Evidence of a tie back anchor system were found intermittently along the entire length (see Photograph 12). It is not clear if these anchor systems are original or were retrofitted at a later date.

Photograph 6: Pile 18.3.2 (typical)

Photograph 7: Bent 16 Pile C2 - Bottom of concrete jacket visible

Photograph 8: Bent 15 Pile C2 - complete loss of flanges

Photograph 9: Bent 16 Pile 16.3 2 - flange edge

Photograph 10: Typical batter pile construction against bulkhead

Photograph 11: Typical Sheet Pile Condition

Photograph 12: Tieback bolts through bulkhead

Table 1.1 – Underwater Readings

Pile Location	Elevation	UT *East Flange*	UT *Web*	UT *West Flange*
1-A	Mud	0.425	0.425	0.420
	Mid	0.330	0.460	0.355
	MLW	0.305	0.395	0.335
10-A	Mud	0.370	0.435	0.135
	Mid	0.320	0.200	0.355
	MLW	0.410	0.435	0.380
13-A	Mud			
	Mid			
	MLW	0.435	0.435	0.435
13-C	Mud			
	Mid			
	MLW	0.25	0.230	0.130
36.4	Mud	0.245	0.325	0.120
	Mid	0.215	0.180	0.135
	MLW	0.140	0.280	0.210
Bent 4	Mud	0.295	0.255	0.290
	Mid	0.300	0.295	0.280
	MLW	0.300	0.215	0.245
Bent 27	Mud	0.280	0.285	0.275
	Mid	0.270	0.275	0.290
	MLW	0.325	0.265	0.245

Figure 5: Ultrasonic Thickness Measurements

2.3.3 Structural Assessment/Recommendations

CLE performed structural calculations using estimates of original pile thicknesses and lengths to determine the approximate capacity of the structure at the time of construction. As shown in Attachment B it is estimated that the pier began its service life with an approximately 400 psf deck load capacity. Given that some piles were observed to be completely deteriorated and most were found to have only 50% or less of their original section remaining, the structure is considered to be in *Poor* condition. In its current condition the allowable loading must be significantly reduced from the original 400 psf. Based on a structural analysis of the piles, all piles which are below 0.217 inches in web/flange thickness have an allowable capacity less than 100 psf. Piles with thickness less than 0.153 may fail due to overstressing and have no remaining live load capacity. The pile condition plan provided in Attachment A indicates that the vast majority of the piles in which the marine growth was removed were found to be in severe condition with significant section loss. Those piles not assigned a color were not cleaned of marine growth, and can be assumed to be of similar condition to those which were cleaned. Until further inspections can be conducted, the capacity of the pier must be limited to 100 psf.

It is recommended that an inspection of 100% of the plumb piles be performed as soon as possible to determine if areas of pier may have additional or less capacity than 100 psf.

The large holes in the bulkhead at the northern end of the project site are permitting loss of fill through the bulkhead possibly undermining the area immediately landward of the pier. Continued loss of fill presents the possibility of a collapse due to loading by vehicles, product, etc.

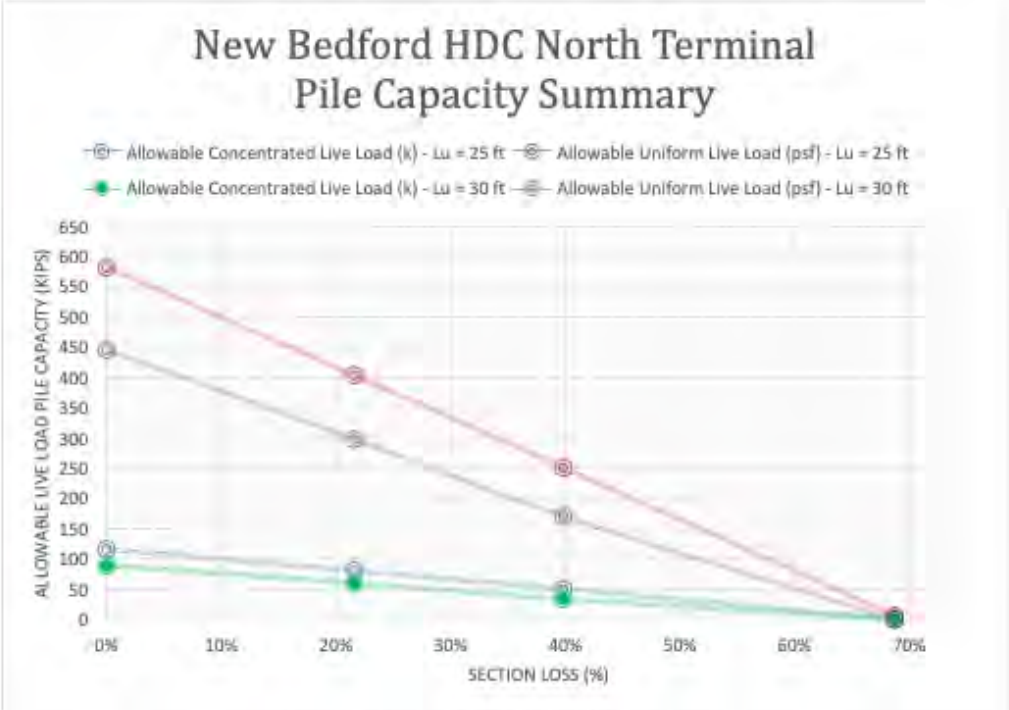

Figure 6: Section loss vs. Allowable Live Load

Parcel 5, 7, and 10: Short Term Recommendations 0-2 Years

- (Immediately) Limit pier capacity to 100 psf
- Perform underwater inspection cleaning 100% of the piles to determine section loss
- Prepare allowable deck loading diagram
- Design pile repairs/repair completely failed piles

Parcel 5, 7, and 10: 3-5 Year Recommendations

- TBD following 100% pile inspection

3. Cost Estimates

Table 1 below provides a cost summary of the short term recommendations which are known at this time. Following the additional inspections of Parcels 1, 5, 7, and 10 actual repair costs will be to be added to these.

Table 1 - Short Term Recommendation Cost Estimates

Short Term Recommendations 0-2 Years	Estimated Cost
Parcel 1	
Full Inspection UW/Topside	$60,000
Parcel 2	
Cathodic Protection Analysis	$10,000
Design of Patching Repairs	$5,000
Parcels 5, 7, and 10	
100% Underwater Inspection (axial piles)	$50,000
Structural Analysis of Deck Loading	$8,000
Design Pile Repairs	$10,000
Subtotal	$143,000