



Fraser Grain Terminal

VFPA Project and Environmental Review - Marine Structures Supplemental Information

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1. Project Description

Fraser Grain Terminal (FGT) is proposing to develop a grain export terminal at Fraser Surrey Docks (FSD) Berth No. 3/4, on the Fraser River. FSD Berth No. 3/4 is already used for the export of agricultural products such as canola, malt and lentils; mobile equipment on rubber tires is currently used to load the vessels. In contrast, FGT is proposing to use a more automated, remote controlled shiploader system consisting of three fixed towers each with a loading boom and spout. The loading boom on each tower slews and luffs, which, together with the spout which tilts, provides full hatch coverage of the design vessel without warping.

The FGT operation will reuse much of the existing FSD Berth No. 3/4 infrastructure including the existing concrete pile and deck, the fender system, and the bollards. Existing FSD services will be reused; based on the reference drawings, it is not expected that any modification or relocation of existing services will be required to facilitate the installation of the new foundations for the shiploader towers.

Three new foundations will be provided for the shiploader towers; each foundation is completely independent of the existing wharf structure for both vertical and lateral loads. Each of the foundations will consist of steel pipe piles with a cast-in-place concrete pile cap. Ground improvements (GI), designed by others, will be installed on the shore side of the existing bulkhead below the tie-rods in the vicinity of the tower foundations. Care will have to be taken during the installation of the GI to prevent damage to existing structures and services. Any structures or services damaged during GI installation will be required to be repaired by the GI contractor. The purpose of the GI is to improve the seismic performance of the soils behind the existing wharf structure in the vicinity of the tower foundations. The new foundations will be designed for life safety protection (no collapse) in the design seismic event. Notwithstanding the installation of the GI, the existing wharf structure and the bulkhead behind it are expected to move toward the river in a seismic event and to potentially collapse. Sections of the existing wharf deck will be removed at the tower foundation locations such that the expected movement of the existing wharf and bulkhead wall in a design seismic event will not lead to collapse of the new towers and foundations.

This report is provided at the request of FGT to supplement the revision to the Vancouver Fraser Port Authority (VFPA) Project and Environmental Review (PER) application. The previous application was based on a different shiploader type. This document, which describes the project with particular emphasis on the in-water portion of the work, should be read in conjunction with the following Advisian drawings:

- 307071-01159-00-MA-DSK-1500 - Cover Sheet and Drawing List
- 307071-01159-00-MA-DSK-1501 - General Notes and Design Criteria
- 307071-01159-00-MA-DSK-1502 - Existing Site Plan
- 307071-01159-00-MA-DSK-1503 - Demolition Plan
- 307071-01159-00-MA-DSK-1504 - General Arrangement
- 307071-01159-00-MA-DSK-1505 - Pile Plan and List
- 307071-01159-00-MA-DSK-1506 - Sections and Details

2. Reuse of Existing FSD Structures and Services

2.1 Fenders

The existing Berth No. 3/4 fenders will continue to be used in the FGT operation.

The existing fenders are Sumitomo Lambda 600H x 1500L CL2 rubber units spaced at 7.6 m (25 ft.) centres. Berthing analysis was completed based on the maximum design vessel berthing in ballast (maximum berthing displacement of 36,000 tonnes) at a berthing velocity of 0.10 m/s. The maximum design vessel is a Panamax vessel with an overall length limited to 225 m, with a draft limited to a maximum of 11.5 m (partial load). The analysis found that the existing fender units are satisfactory for the berthing of ballasted maximum design vessel.

For the assessment of the existing fenders, the abnormal energy factor first introduced in the document titled "PIANC 2002 Guideline for the Design of Fender Systems" has been assumed to be 1.0 in accordance with the accepted design practice at the time of the fender system design (before the widespread adoption of the PIANC guideline). If the fender system was being designed today, the abnormal energy factor used would be 1.5 and the fenders would be larger; however, Advisian considers that existing fender systems are not required to be upgraded to meet newer fender design guidelines (i.e. the new guideline should not be applied retroactively to the existing fender systems). This approach is similar to that used for existing wharf structures which are not required to be upgraded to meet newer seismic code provisions.

2.2 Bollards

The existing bollards at Berth No. 3/4 are typically of the following casting types:

- Elliot Steel A-19 bollard casting secured to the concrete deck with six anchor bolts.
- Liverpool 555# cleat casting secured to the concrete deck with four or five anchor bolts.

In addition, there is a "one off" single bitt bollard casting at Bent No. 23.

FSD has indicated that the safe working load (SWL) of these bollards (excluding the single bitt bollard at Bent No. 23, for which the SWL is unknown) is 60 tonnes or 80 tonnes depending on the location. Refer to Advisian Drawing No. 307071-01159-00-MA-DSK-1504 for the bollard ratings and locations.

A simplified mooring analysis was undertaken for the maximum design vessel moored under various conditions of wind and current. The "one off" single bitt bollard casting at Bent No. 23 was not included in the analysis. Design criteria for wind and current are shown on Advisian Drawing No. 307071-01159-00-MA-DSK-1501.

The analysis found that the existing 60 tonne and 80 tonne bollards are considered satisfactory for the mooring of the design vessels based on the existing bollard SWLs provided by FSD. It is noted that some of the existing bollards were an upgrade following the original construction of the concrete dock. At this time, the design drawings for the bollard upgrade installation have not been located. During detailed design, it is recommended that further efforts be made by FSD/VFPA to locate these bollard installation drawings to provide documented verification of the current SWL ratings of the existing bollards.

2.3 Concrete Pile and Deck Structure

The existing Berth No. 3/4 structure, constructed in 1968/1969, consists of the following elements:

- Precast pre-stressed 610 mm (24 in.) octagonal concrete piles, both vertical and battered.
- Cast-in-place concrete pile caps at 7.62 m (25 ft.) centres running perpendicular to the berth face.
- Pre-stressed and post-tensioned (PT) solid concrete haunched deck slabs; slabs are 1.83 m wide and 385 mm thick at midspan and 610 mm thick at the ends. There are two PT ducts per slab and the layout of the ducts changes at Bent No. 8 located near the east end of the Berth No. 3/4 structure.
- Deck overlay (610 mm thick) supported on the concrete deck slabs; the overlay consists of 75 mm of asphalt, over a 150 mm base course, over 385 mm of crushed rock.

A steel sheet pile bulkhead with horizontal tie-backs, located behind the concrete wharf structure, retains the fill at the back of the wharf. The sheet pile wall was installed after the original wharf construction to replace a previous timber bulkhead. Remnants of the original timber bulkhead remain in place on the river side of the sheet pile wall.

Most of the existing Berth No. 3/4 concrete pile and deck will remain in place. As described in Section 3.1, it will be necessary to remove portions of the existing deck to isolate the new tower foundations from the existing wharf structure and bulkhead in the case of a seismic event. The wharf structure and the sheet pile bulkhead behind it were designed long before modern seismic design requirements came into effect and these structures are expected to move towards the river and potentially collapse in the design seismic event, largely as a result of soil liquefaction. The GI to be installed behind the existing sheet pile wall is expected to significantly reduce, but not to eliminate, the lateral movement of the existing structures. Even with the GI, the expected lateral movement of the wharf deck/bulkhead in the design seismic event is such that drilling holes through the wharf deck between the post-tensioning ducts would not provide sufficient clearance around the new piles to prevent them from being damaged by the movement of the existing wharf. The removal of the existing deck slabs will increase the clearance around the new piles and will also greatly facilitate the installation of the new piles that will support the waterside of the new shiploader tower foundations. It will be necessary to provide barriers around the spans of the existing FSD deck which remain in place immediately upstream and downstream of the areas where existing deck slabs will be removed (see Drawing Nos. 307071-01159-00-MA-DSK-1501 and 307071-01159-00-MA-DSK-1503).

2.4 Services

Existing services in the Berth No. 3/4 area include:

- Storm sewer.
- Underground electrical.
- Underground fibre optics.
- Gas line.
- Sanitary sewer.
- Water main.

These existing services, which are shown on Advisian Drawing No. 307071-01159-00-MA-DSK-1502, will be reused in the FGT operation. According to the reference drawings, the locations of the new shiploader towers are such that it should not be necessary to modify or relocate any of the existing services. However, there is always the risk that the reference drawings are inaccurate or incorrect, and the contractor will be advised to take care when removing the asphalt, base course, and crushed rock in areas where deck slabs are to be removed and when removing fill over the existing tie-rods for landside pile installation in case undocumented services are located in these areas (Drawing No. 307071-01159-00-MA-DSK-1503).



3. New Structures

3.1 General

Shiploader Tower Nos. ST01 and ST02 will each be supported on a foundation consisting of 10 steel pipe piles (three piles on each waterside corner and two piles on each land side corner) and a cast-in-place concrete cap. Shiploader Tower No. ST03 has an additional waterside pile. Hence, a total of 31 piles will be required. The layout of the new shiploader towers is such that the towers straddle the existing sheet pile bulkhead behind the existing wharf structure. The new tower foundations will be structurally independent of the existing structures.

The new concrete pile caps for the tower foundations, to be located just above the existing wharf deck and fill level, will be 10.5 m by 10.5 m by 1.5 m. The existing wharf pile caps are left in place beneath the new tower locations as they are still required to provide their contribution to the support of berthing and mooring loads for the existing wharf. Some variation in pile spacing is required because the spacing of the shiploader towers (58.75 m) is not an even multiple of the wharf bent spacing (7.62 m) and it is necessary to avoid conflict between the new piles and the existing wharf pile caps which remain in place. Drawing No. 307071-01159-00-MA-DSK-1505 shows the pile layout at the three tower locations.

As discussed in Section 2, the existing concrete deck slabs will be removed to isolate the new tower foundations from the movement of the existing wharf structure and bulkhead in the case of a seismic event. Slab removal will also facilitate pile installation of the waterside tower foundation piles.

Slab removal will be carefully controlled because it will be necessary to cut through existing bonded post-tensioning in the slabs to facilitate their removal. The steps for slab removal will follow standard procedures for safely cutting through bonded post-tensioning as summarized below:

- Remove asphalt, base course, and crushed rock as required to expose the upper surfaces of the slabs to be removed and the immediately adjacent areas to remain. Care shall be taken in case there are undocumented services in this overlay.
- Verify the location of the post-tensioning ducts and then remove the concrete around the ducts at the areas to be cut. According to the reference drawings and construction photographs, there are two 75 mm internal diameter ducts in each slab.
- Open the ducts to confirm the soundness of the grout on each side of the proposed cut. According to the reference drawings, there are twelve 12.7 mm strands per duct.
- If the existing grout is not sound, grout the strands on each side of the proposed cut. At locations where the cut ends of the post-tensioning strands will remain in place, wedge the ends of the strands apart and install epoxy to replace the concrete which has been removed to create a new anchorage zone around the ends of the post-tensioning strands that will remain in place after slab removal.



- Saw-cut through the haunched slabs (including all rebar and pre-stressing and post-tensioning strands) and remove the slab to create the openings required for the shiploader towers. Exposed strand and rebar at the cut face will be burned back from the exposed surface, followed by cleaning and patching with a dry pack grout.
- Construct a new curb and handrail on the perimeter of the wharf deck area to remain and then reinstate the crushed rock, base course, and asphalt. Install no-post barriers around the perimeter of the slabs immediately upstream and downstream of the slabs which were removed to prevent vehicle access to these areas.

Alternative methods for safely cutting the post-tensioning to facilitate slab removal, if proposed by specialty contractors experienced in this work, will be considered.

3.2 Waterside Piles for Shiploader Tower Foundations

New steel pipe piles (914 mm diameter, three per corner with one additional pile in the foundation for Tower No. ST03) will support the waterside corners of the shiploader tower foundations. The piles will be installed at a slight batter (4V:1H) to reduce horizontal deflections under wind loads and seismic loads.

The expected work plan for the installation of the waterside piles is shown below:

- The contractor will have previously removed the existing wharf deck slabs in the relevant areas as described in Section 3.1.
- The contractor will verify that the existing structures which remain are as shown on the reference drawings. Any existing timber pile stubs or other remnants of the former timber bulkhead (locations vary) which will conflict with the installation of the new piles will be extracted/removed. Locations and batters of the existing concrete piles will be verified to confirm that there will be no conflict with the proposed location of new piles. If necessary, minor adjustments to the locations of the new piles can be made as required prior to the start of pile driving.
- The contractor will prepare the existing riverbed slope for pile driving. The slope protection below the existing deck structure generally comprises a combination of coarse rock and containment wire mesh. The rock is too coarse to drive piles through without significant risk of damage to the piles. Therefore, the contractor will use divers to mark the limits of the areas to be cleared, using the existing piles and main bulkhead wall for reference, and cut the wire mesh. The mesh will be folded back, on the slope, and secured. A long-reach excavator will be used to locally remove the coarse rock on the slope. The excavator may use a conventional bucket with thumb or a small hydraulic clamshell. Rock will be temporarily stored until reinstalled. Divers will inspect the slope immediately before pile driving to confirm that no rocks have fallen into the pile window.
- Once the slope has been prepared, a crane with pile driving equipment will install piles. The pile driving would be undertaken by land-based equipment working from the upland behind the wharf or from the wharf deck on the river side of the deck opening. The contractor may start pile installation with a vibratory (vibro) hammer, but will be required to finish driving with a diesel or similar impact hammer to prove the capacity for each pile. Pile Driving Analyser (PDA) testing of a representative number of piles, as recommended by the geotechnical consultant, will be provided.

- Following installation of the waterside piles, the rock slope protection will be reinstated, using the assistance of divers to confirm correct installation. Galvanized corrugated or HDPE sleeves may be installed around each pile to protect the pile coating from damage during reinstatement of the rock. Once the rock is confirmed to be installed correctly, the divers will reinstate the wire mesh, trimming to suit the new piles, and adding lap splices to strengthen the cut joints.

Pre-installation and post-installation surveys will determine if any rock was spilled over the edge of the offshore containment sheet pile wall, in which case that accumulated material will be removed. Pre-installation and post-installation surveys will also be used to confirm final grade of the slope protection.

It is understood that full access will be given to the contractor completing the installation of in-water works. On this basis, it is expected that the total duration for in-water works associated with waterside piles is approximately five weeks depending on the work program (days and hours worked per week) proposed by the contractor.

The relevant areas for environmental considerations related to the in-water works are provided below:

- The total plan area (plan footprint) of riverbed that will be disturbed to allow the waterside piles to be installed is estimated to be 310 square metres.
- The total plan area (plan footprint) of the 19 waterside piles is 12.5 square metres.

3.3 Land Side Piles for Shiploader Tower Foundations

New steel pipe piles (914 mm diameter, two per corner) will be installed behind the existing Berth No. 3/4 dock structure to support the shiploader tower foundations. All land side piles will be vertical. These piles involve land-based construction only and will be fully embedded into the existing upland portion of the site. It is recommended by the geotechnical consultant that the land side piles would be installed prior to the installation of the GI.

For the installation of the land side piles, localized excavation will be undertaken to expose the existing tie-rods (which support the sheet pile retaining wall located at the back of the existing Berth No. 3/4 dock structure) to prevent conflict or damage during construction. As for the waterside piles, the contractor may start pile installation with a vibro-hammer, but will be required to finish driving with a diesel or similar impact hammer to prove the capacity for each pile. PDA testing of a representative number of piles, as recommended by the geotechnical consultant, will be provided.

3.4 Seismic Design

The overall design of the tower foundations will be in accordance with the National Building Code of Canada 2015. However, the VFPA has advised FGT that the seismic design of the marine structures for the project shall meet the intent of ASCE 61-14 (Seismic Design of Pile-Supported Piers and Wharves). Within the ASCE 61-14 standard, the VFPA has specified that the marine structures fall under the 'Low Design Classification', meaning that the only required seismic performance criteria is the provision of life safety protection in the design earthquake. The design earthquake is a 2,475 year event with modifications to the 2,475 year design spectra as allowed in ASCE 61-14.



The shiploader tower foundations will be designed to withstand the inertia forces and the effects of soil liquefaction (lateral soil flows, loss of soil strength, and post liquefaction settlement) associated with ASCE 61-14 - Design Earthquake for a wharf of "Low" design classification; i.e. life safety protection will be provided in the design earthquake.

The existing FSD Berth No. 3/4 marine structures will not be modified or upgraded to comply with ASCE 61-14 seismic provisions.



4. Closing

This report has been prepared to supplement the Advisian drawings prepared in support of the FGT PER application. It provides a summary of the marine structural requirements for the project and also gives additional information about the assessments undertaken regarding the reuse of existing FSD structures and services and about possible construction methodologies.