FIXED STRUCTURES

An alternative consisting of all fixed mooring structures (traditional dolphins or monopiles) was originally proposed; however, the cost still exceeded the available budget for the client. Moreover, to meet the schedule requirements of the contract, additional floating equipment would be required to drive the additional piles and support lengthy overwater cast-in-place concrete work.

The solution was to eliminate fixed mooring structures and replace them with flexible moorings. Plate anchors were less costly than monopiles and could be installed in a fraction of the time utilizing smaller equipment than it would take to construct typical mooring dolphins. Fabrication of the anchors was performed simultaneously with installation of the pier piles to reduce the overall construction schedule.

Two (2) pile-supported access piers (designated North Pier and South Pier) serve the Ro-Ro operations of the layberth facility, with each pier accommodating two (2) berths. The piers were designed and constructed making maximum use of precast elements to reduce the amount of cast-in-place concrete required at the fairly remote project site, as well as to decrease the overall construction schedule. The lateral load demand on the piers was greatly reduced, and the construction simplified, by setting the fixed piers back from the fender line and removing all breasting and mooring loads from these structures.

Given the geometry of the site, differing requirements of the various design vessels, and the need to be as efficient as possible with the structures, the piers were not alike and had unique layouts. The south pier (Figure 1) was dedicated to serving the LMSR vessels and was able to be sized and located such that it could accommodate an articulating stern ramp from each ship.

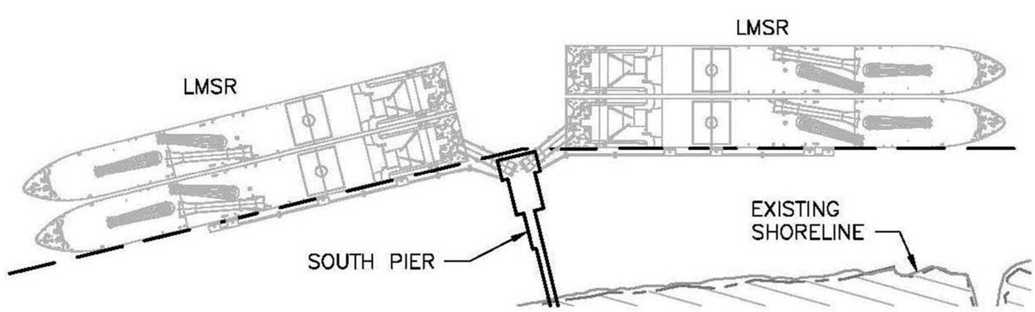

Figure 1. South Pier (Berths 1 and 2)

The north pier (Figure 2) was thus required to accommodate FSS and Cape K vessels. Due to specific vessel requirements, the Cape K was required to berth starboard side to the access pier. Additionally, the Cape K vessels have a shallower draft than the FSS vessels. Thus, placing the Cape K vessels in the furthest north position allowed the utilization of their stern ramps and permitted the team to minimize the required dredge volume by reducing the dredge depth in the northernmost berth.

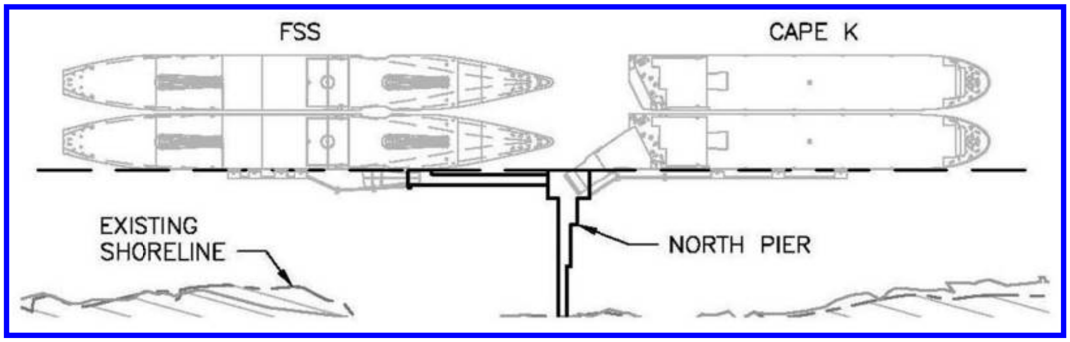

Figure 2. North Pier (Berths 3 and 4)

For each berth, the vessel berthing position accommodates ramps, trucks, and other operational requirements. Specifically, the vessel berthing position allows operational use of one ramp system and accommodation ladder for each vessel without interference from mooring fixtures, mooring lines, or the ramp of another vessel. The vessels are positioned such that the neighboring vessel ramp does not prevent truck (AASHTO HS20-44) access and the piers were sized to accommodate turning radii of multiple vehicles. Trucks are able to access at least one ramp on all vessels located on the inside mooring location of nested vessel pairs, without repositioning the vessel.

Each vessel berthing position allows both Operational and Heavy Weather mooring without repositioning the vessel, though additional lines and minimal line rearrangement are required to transition from Operational to Heavy Weather mooring configurations. Allowable maximum vessel movements (see Table 3) were based on vessel motion criteria recommended by the International Navigation Associate (PIANC 1995) for the safe loading and unloading of comparably sized vessels.

Table 3. Allowable Maximum Vessel Movements

Surge (*ft*)	*Sway* (*ft*)	*Yaw* (*degrees*)
1.3	1.97	3

A significant challenge in developing a workable solution was determining optimal locations for breasting and mooring structures. This required balancing vessel movements under Operational conditions with individual line loads and reaction forces on the breasting structures and anchors under Heavy Weather conditions. Dozens of iterations of the mooring analysis were analyzed with multiple locations and configurations of the anchors and breasting structures. The controlling loads for design of the breasting structures were derived from the wind load cases rather than the berthing scenarios, with a maximum thrust of 747 kips.

Breasting structures (see Figure 3) are comprised of a cast-in-place concrete cap supported by three (3) 66-inch diameter precast prestressed concrete cylinder piles (tension) and three (3) 24-inch square precast prestressed concrete battered piles (compression). Large diameter cylinder piles were utilized for their efficiency in order to minimize the structure footprint of the dolphins while accommodating the large tension demand induced under Heavy Weather conditions. The maximum service tension load on an individual cylinder pile was 583 kips.

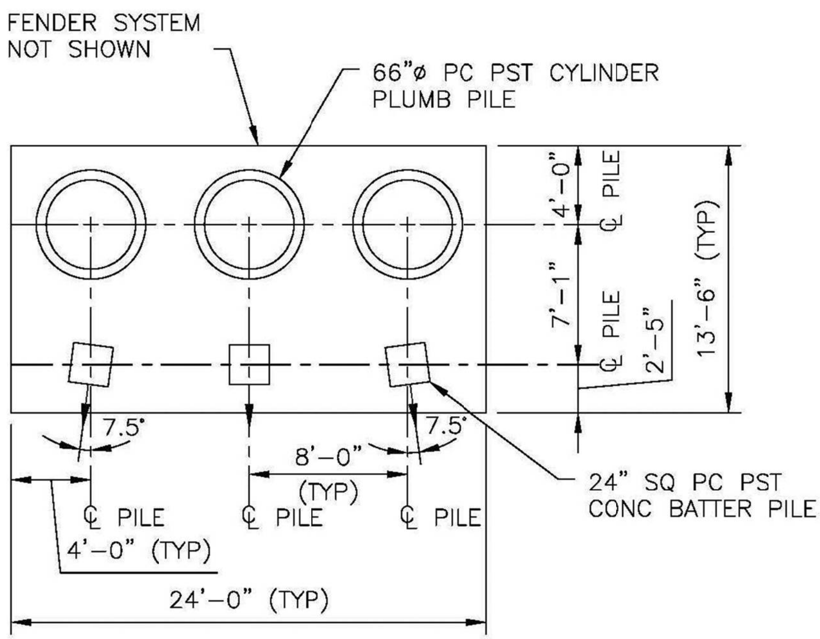

Figure 3. Breasting Dolphin Layout

Each breasting structure is outfitted with a fender system consisting of three (3) cone fenders and a 24'-0" by 8'-0" UHMW-PE faced steel box panel. Additionally, each breasting structure has a 125MT bollard, for accommodating spring lines.

FLEXIBLE MOORINGS

A total of 29 flexible mooring anchors were used in lieu of fixed structures to accommodate the large forces imparted on the mooring lines during weather events. The anchors were fabricated simultaneously with construction of the piers and installed in less than three weeks, saving approximately eight (8) weeks on the overall schedule compared to construction of fixed mooring dolphins. Anchorage for twenty five (25) of the moorings was provided via plate anchors (see Figure 4, Photo 1) and four (4) moorings consisted of pipe pile anchors. The anchor plates ranged in size from 6’x12’ to 8’x16’ and were driven to depths up to 100 feet below mudline. In several locations, the proximity of anchors to one another or to a fixed structure precluded the use of plate anchors due to the influence zone of the anchors and potential for soil failure. Here, steel pipe pile anchors (see Figure 5) were used in lieu of the plate anchors. The pipe pile anchors, ranging in size from 4’-0” to 8’-0” in diameter, behaved similarly to the plate anchors from an overall vessel response perspective. While effective, the use of pipe piles was limited to the extent necessary as the cost of pipe piles for this project was deemed more expensive than the use of plate anchors.

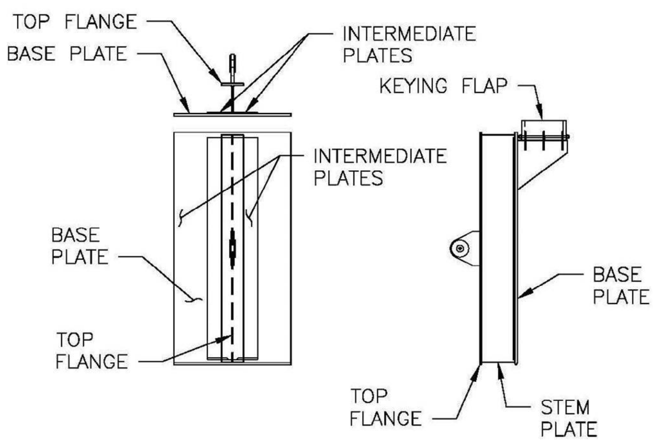

Figure 4. Plate Anchor

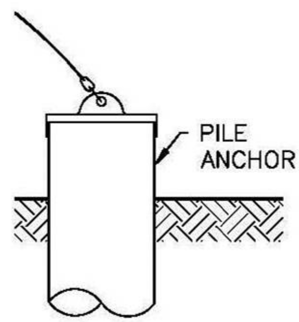

Figure 5. Pipe Pile Anchor

Photo 1. Fabricated Plate Anchor

Design loads for the anchors ranged from 250 kips to 485 kips. Anchor and chain sizes (nominal 3”, 3.5”, and 4”, see Photo 2) were optimized to balance cost and functionality. Plate anchors were driven with a vibratory hammer and follower, and then set and proof loaded. During the proof testing, the tension on the chain was continuously monitored and recorded and the amount of chain pulled from the ground before the anchor fully set was measured.

Photo 2. Fabricated Buoy and Anchor Chain Ready for Installation

The riser chain is held at the waterline via a hawser type buoy. Buoys range in size from 8’-4” to 11’-0” in diameter, with a maximum overall height of 8’-0”. Due to an overlap in mooring arrangements between berths and the importance of attaching each mooring line to its correct anchor, the buoys were color coded and numbered to reduce confusion and make it easier to identify the correct buoy to which a given line should be attached. A typical mooring arrangement is shown in Figure 6.

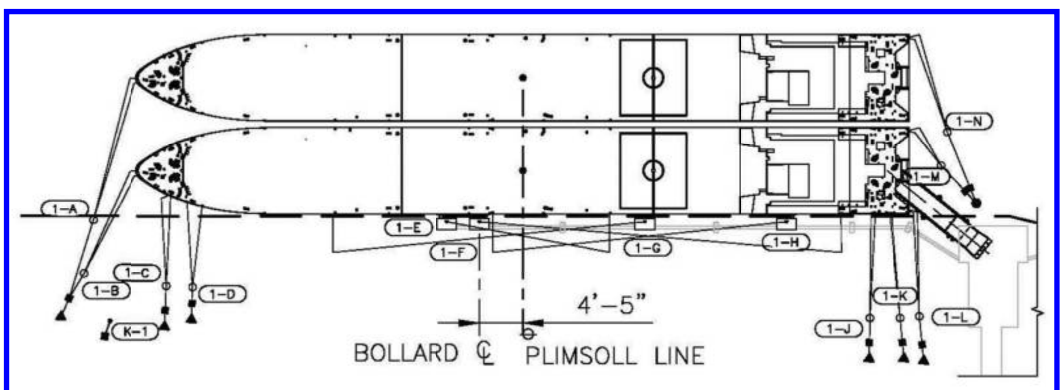

Figure 6. Typical Mooring Line Arrangement

VESSEL ACCESS AND MANEUVERABILITY

Most important to the owner was ship access to the berth and the ability for ships to enter or exit the basin in all weather conditions. The original scope of the dredge prism was limited in allowing access for the vessel, tugboats, pilots, etc. During design of the facility, the design-build team consulted with all of the local officials including the Sabine Pilots Association, the US Coast Guard, the Sabine Neches Navigation District, as well as local tugboat operators, etc. for input on the necessary requirements for entry and exit operations of the facility. During these meetings, it became apparent to the client that the ability to safely navigate the facility with the current dredge prism was inadequate. The design-build team worked with the client and associated parties to redesign the channel to allow safe vessel entry, exit, and maneuvering operations inside the facility while minimizing the overall additional dredging required.

The overall size of the dredge prism was lengthened by 25 percent, doubled in width, and increased 3’-6’ in depth, resulting in an increase in dredge volume from 570,000 cubic yards to 1,200,000 cubic yards. This significant increase in volume created additional issues beyond costs to the owner. Nearby disposal sites permitted for use on the project did not have sufficient capacity to hold the additional volume of hydraulically dredged material. In order to make room in the local disposal facilities, the design-build team worked with the Sabine Neches Navigation District (SNND) to strategize schedules that would allow SNND time to remediate a local dredge placement area to handle the additional volume of spoils. All of this was accomplished without impacting the overall project schedule and delaying delivery of the facility to the client.

Due to the significant additional volume of material to be dredged, the dredger would be required to stay on site an additional 63 work days beyond what was originally anticipated. This significant impact to the schedule required a modification to the work sequence such that dredging operations at the interior of the dredge prism would be completed first to allow pile driving and follow-on construction activities to commence. Once the available placement area was full, the dredger demobilized from the site until SNND was able to provide an additional placement area. Approximately five months later, the dredger remobilized to the site and completed the dredging operations. All of this was accomplished without delay to construction activities.

PERSONNEL ACCESS

In order to meet the available budget, primary access to mooring buoys and breasting structures for line handling operations would be provided via boat access during line handling operations. During construction, the client asked the design-build team to provide continuous access to all breasting structures of the facility in order to improve line handling access during storm situations. Providing additional catwalks to all structures was the easiest and most cost effective option.

Crew access to the vessels continued to be a vexing problem. During normal Operational conditions, access to the vessels via the deployed Ro-Ro ramps is possible and was always considered to be the primary means of personnel access/egress to the ships. However, the ramps are not always deployed, especially during Heavy Weather conditions when the vessels are battened down and are expected to experience significant movement. The use of the on ship gangways was limited to ships whose gangway was located at the same position as the dedicated vessel. Ships with fixed position gangways or gangways in alternate locations on the ship different than the dedicated vessel configurations would not land properly on the proposed access platforms.

The client requested that the design-build team provide access via a gangway that could lower over the side of the ship and accommodate multiple classes of ships, both within and outside of the client's current fleet. The design-build team provided a modular stair tower in each berth that could withstand the wind requirements of the overall facility design and provide flexibility for all ship types. The finished stair towers (see Photo 3) are interchangeable to any mooring structure on the project and can be raised or lowered as necessary (due to the modular nature of their design) to meet the access requirements for any ship in the fleet. The completed facility is depicted in Photo 4.

Photo 3. Catwalk and Stair Tower in Berth 1 (South Pier)

Photo 4. Completed Facility

WETLAND MITIGATION

As this marine facility is located on the banks of the Neches River, numerous wetlands were present within the construction footprint and a small portion of wetlands were impacted during construction of the facility. Through interaction between the design-build team and the United States Army Corps of Engineers, the design-build team employed a strategy to build around and leave as many wetlands undisturbed as possible. As designed and permitted, the required mitigation for disturbed wetlands included construction of four (4) acres of new wetland habitat, strategically located within the project limits to allow proper water retention and the best possible long term viability. Once the site was selected, the government acquired approval from the landowner to locate a permanent wetland that would be left undisturbed in perpetuity.

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Port of New Orleans: Mississippi River Intermodal Terminal

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Abstract

The Mississippi River Intermodal Terminal at the Port of New Orleans (Port) is a new on-dock intermodal railyard providing the Port's Napoleon Avenue Container Terminal with access to the six Class I railroad yards located in New Orleans. This facility, opened in March 2016, replaced an older railyard that previously provided rail connectivity for the Port's container terminal. The new intermodal terminal provides 10,000 linear feet of rail track along with five acres of heavy duty concrete paving for container marshaling. Two electric rubber tire gantry cranes with 60-ton twin pick capability transfer the containers to and from the rail cars. The railyard is capable of handling 160,000 TEUs (twenty-foot equivalent units) per year with one track turnover per day. Not only does this project provide the Port with a more efficient intermodal railyard, but because the new yard is shifted away from the waterfront, valuable container marshaling space is freed up. This optimization paves the way for the planned expansion of the Napoleon Avenue Container Terminal.

PORT OF NEW ORLEANS

The City of New Orleans was founded in 1718 and has operated a port since that time. In 1896, the Board of Commissioners of the Port of New Orleans (Board) was created by the Louisiana legislature to administer public wharves and regulate trade and traffic. Located near the mouth of the Mississippi River, the Port serves as the gateway from the Gulf of Mexico to 14,500 miles of inland waterway. This waterway system provides barge access to 33 states. The Port is the only U.S. port served by all six Class I railroads, providing direct access to 133,000 miles of rail network that serves 30 states and six Canadian provinces. All Port facilities are conveniently connected to the interstate highway network via Interstate 10 and U. S. Highway 90 (future Interstate 49 South). This unique convergence of ship, barge, rail and truck brands the Port of New Orleans as the America's most intermodal port.

While the Port's position on the Mississippi River provides easy access for the transport of breakbulk cargo by barge, the Port also has world-class container and cruise facilities. Facilities include 20 million square feet of cargo handling area, more than 3.1 million square feet of covered storage area, and 1.7 million square feet of cruise and parking facilities. The modern container facilities have a capacity of 640,000 TEUs per year, six ship-to-shore gantry cranes, 3,000 linear feet of berth space capable of accommodating vessels with 45 feet of draft, and an on-dock intermodal railyard.

The top commodities handled at the Port include steel, plywood, rubber, London Metal Exchange goods, frozen poultry, chemicals, and coffee. In 2014, the Port handled over 3.7 million short tons of breakbulk cargo and accommodated more than one million cruise ship passengers. Containerized cargo volumes exceeded 500,000 TEUs from July 2014 through June 2015 for the first time in the Port's history.

CONTAINER EXPANSION

Most of the Port's facilities are located in a narrow section of land between the Mississippi River and the adjacent neighborhood, and the Napoleon Avenue Container Terminal is no exception. With no room available for terminal expansion, in 2002, the Board purchased from the Illinois Central Railroad (ICRR) 26 acres located adjacent to the container terminal. This property was bisected by a railyard that was used for the Port's intermodal containers and included other under-developed lands ready for improvement to serve as a modern container marshaling area.

Redevelopment of this area into a modern container handling facility is the centerpiece of the Port's 2020 Master Plan and will expand the Port's container capacity to 1.2 million TEUs per year and provide a total of 12 ship-to-shore gantry cranes at a cost of $770 million (see Figure 1). The relocation and modernization of the intermodal railyard is the first step to achieving this plan by expanding the amount of waterside property to be developed into container marshaling yard adjacent to the future berths.

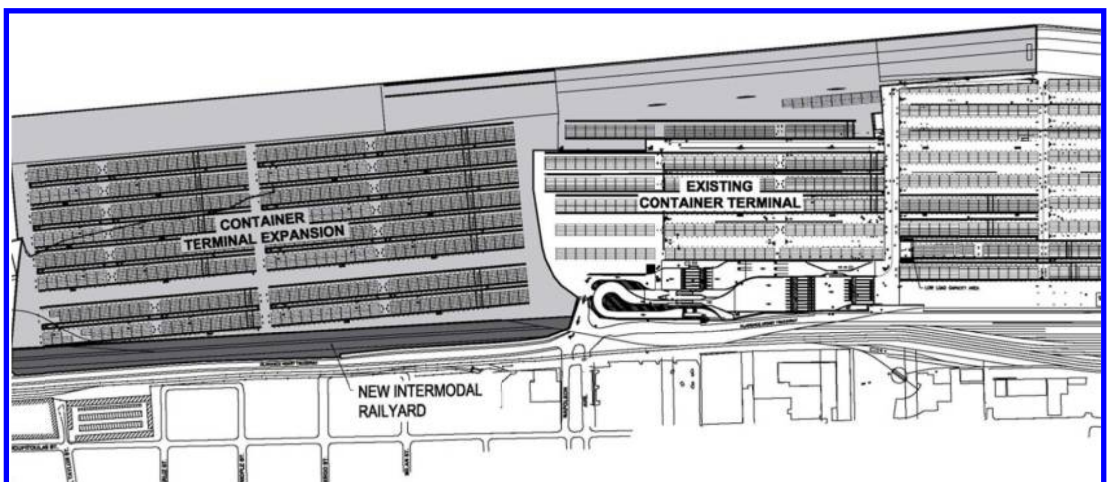

Figure 1. Container Terminal Expansion