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MARRIOTT'S RENAISSANCE HOTEL AT SEAWORLD ORLANDO, FLORIDA

Introduction

Transfer Bridges: What are they?

Transfer Bridges are used to transfer automobiles, rail cars or pedestrians from land based to water based transportation systems or vice versa. For example a ferry ramp that acts as a bridge between land and the ferry is an example of a transfer bridge. Transfer bridges can also be used to transfer rail cars onto and off of car floats. A car float is a barge that has rails mounted on the deck so that rail cars can be pushed onto the barge for transport across a river or harbor.

Car floats rise and fall with the tide. Also the freeboard on the car float changes as the loading on the car float changes. The freeboard is the distance from the waterline to the top of deck.

A transfer bridge needs to accommodate the changes in tide as well as the changes in the car float freeboard due to loading and unloading the car float. Based on the location of the transfer bridge, the magnitude of tidal variations and size and loading of the car floats, the transfer bridge may

need to provide 10 foot or more of adjustment so that the car float can mate to the transfer bridge.

Transfer Bridge changes in inclination are accommodated by the use of movable (rotation) heel bearings with/or without pin (trunnion) hinges in the bridge girders. Having additional hinges provides additional adjustment capability, but this comes with additional cost and complexity.



Transfer Bridges at Greenville Yard (Prior to Super Storm Sandy)

Car Float History:

Transfer Bridges of New York Harbor Past, Present and Future by Schiano, Ciampi, and Lester was presented at the 15th Biennial Symposium; September 15- 18, 2014. This paper details the origins of transfer bridges. "The origins of rail transfer bridges date back to approximately 1838 in the mid-Atlantic States prior to the American Civil War." History of the Cross Harbor Freight Program (taken from the PA Greenville Yard Cross Harbor Freight Program-Basis of Design Report December 20, 2012)

Greenville Yard is the western terminus of the current rail car float (barge) system, which operates between Jersey City and 65th Street Facility on the Brooklyn waterfront. The barge rail car float system that moves goods across the New York Harbor has been in existence since before the growth of the national highway system and before the construction of vehicular bridges spanning the Hudson River. The Cross Harbor rail freight operation at Greenville Yard once encompassed six rail transfer bridges; as many as thirty-nine rail car floats barges, and upland rail support facilities. Today there is one transfer bridge (Bridge #11) is operational at Greenville

Yard. Transfer Bridges #9, #10 and half of #12 have been demolished. Transfer Bridge #11 is a temporary replacement.

The operator of the rail car float system is New York New Jersey Rail, LLC (NYNJ Rail), a switching and terminal railroad owned by the Port Authority of New York and New Jersey (PA) since November 2008. Since freight trains are not allowed in Amtrak's North River Tunnels, and the Poughkeepsie Bridge was closed in 1974, the ferry is the only freight crossing of the Hudson River south of the Alfred H. Smith Memorial Bridge, 140 miles to the north of New York City. The Cross Harbor Rail Freight Program (CHFP) operation is the last remaining rail car float operation in the Port of New York and New Jersey.

Ultimately, the Greenville Yard area will contain three distinct rail transfer sections: an Intermodal Container Transfer Facility (ICTF) to support the Global Terminal operations at Port Jersey Peninsula, a barge-to-rail container transfer facility, and an expanded Cross Harbor Rail Freight Program (CHFP).

65th Street Rail Yard is one of two possible receiving sites for the Cross Harbor Freight Program. 65th Street is on the Brooklyn, New York side, across New York Harbor from Greenville. The Bush Terminal, at 51st Street, was the sole connecting site for Greenville's rail cars until November 2012, when the NYNJ Rail transferred car float operations to the 65th Street Rail Yard Facility, to ship and receive rail cars to and from Greenville Yard. Up until November, 2012 the 65th Street Facility had not been, utilized by the Cross Harbor Freight Program on a steady basis. However, the 65th Street Facility, as of November, 2012 is the eastern terminus of the current rail car float (barge) system between Brooklyn and Greenville Yard.

The 65th Street Facility was rebuilt in 2001 to accommodate existing, three track wide car floats. As part of the Port Authority's plan for rail car float service expansion, replacement car floats which will be four tracks wide, with double the rail car capacity will be placed into service. Due to the wider car floats that will soon be calling the 65th Street Facility and service expansion, the facility will be upgraded along with Greenville Yard. The 65th Street Yard currently has (1) of its (2) bridges in service. This Yard will be expanded through the CHFP to utilize both Bridges #1 and #2, as service demand increases. Additionally, the fender system at the 65th Street Facility will be re-designed to allow for the simultaneous berthing of two, four-track wide car floats.

Under its CHFP, the Port Authority of New York and New Jersey, with funding from the Federal Highway Administration (FHWA), is redeveloping the Greenville Yard in Jersey City as required to increase the amount of freight moved by rail; thereby reducing the region's dependence on trucks. The major goal of the CHFP is to improve goods movement by rail across New York Harbor."

Super Storm Sandy

Hurricane Sandy made landfall in the United States about 8 p.m. EDT **Oct. 29**, 2012 striking near Atlantic City, N.J., with winds of 80 mph. A full moon made high tides 20 percent higher than normal and amplified Sandy's storm surge.

PA was planning to shore up the existing Transfer Bridge No. 11 until a new transfer bridge could be built at Greenville Yard when the winds and storm surge reached havoc on the dilapidated facilities.

The Greenville Yard facility was damaged beyond repair, and plans were put in place to immediately demolish the existing transfer bridges and install an emergency replacement bridge. HDR worked around the clock with the PA and Railroad Construction to demolish the existing facilities and install an emergency replacement bridge. Railroad Construction was mobilized on



Greenville Yard after Super Storm Sandy. Note Contractors barge embedded in Control Room for Transfer Bridge No. 11 Bridge

site to start shoring the existing Transfer Bridge No. 11when the storm struck. Progress meetings were held every morning to make sure that the project continued on track. An abandoned pontoon bridge was found, towed to Greenville Yard. The Bridge was inspected and steel repairs were made to the bridge. New pile supported foundations, trestle approach spans, and concrete abutment was installed. The pontoon bridge hinge bearings were rehabilitated and the bridge was installed at Greenville Yard. Rail Service was restored within 30 days.

Transfer Bridge Types

The above noted HMS paper details the evolution of the transfer bridges over time and the added mechanical improvements. At Greenville Yard in New Jersey and 65th Street in Brooklyn are the last three working examples of Transfer Bridges in the New York Harbor. The Greenville Yard and 65th Street Bridges had some of the remaining examples of the following design features:

Hinge Bearings:

The Bearings at the rear end of the Transfer Bridges were typically convex/concave bearings that accommodated the change in grade of the transfer bridges. Transfer Bridges would typically adjust to grades of plus or minus 4%. The bearings were often plain steal located in the splash zone near the waterline. These bearings would flood at high tide. Obviously corrosion was an issue.



Severe Rust and Scaling of Heel Bearings at Greenville Yard

Overhead Gantry Systems:

The existing transfer bridges at the 65th street facility in Brooklyn use overhead gantry systems.

The cantilever ends of the Transfer bridges at 65^{th} street are supported from Overhead Gantries

There were four Transfer Bridges at Greenville Yard prior to super Storm Sandy. These Transfer Bridges were all supported from overhead gantries.



South Transfer Bridge at 65th Street during deck reconstruction. Note Overhead Gantry System with Wire Rope, Sheaves and Counterweights.



Wire Rope and Counterweight at Greenville Yard

Sheaves, Wire Ropes and Counterweights:

The 65th Street Bridges use wire rope, sheaves and Counterweights to support the dead load of the span from the overhead gantry system.

The previous Transfer Bridges at Greenville Yard were also supported from overhead gantry systems using wire rope, sheaves and counterweights.

Hoist Motors:

The 65th Street Bridges use a hoist motor and wire rope to overcome the bridge imbalance and lift the transfer bridge into alignment with the car float. Once the transfer bridge is pinned to car float the transfer bridge will move up and down with the car float as the tide changes and the loading of the car float changes.

Screw Jacks:

The previous Transfer bridges at Greenville Yard used screw jacks to raise and lower the end of the transfer bridge.

Friction Cylinders:

At the previous Greenville Transfer Bridges friction Cylinders were installed between the end of the Bridge Girders and the Apron Span. The Friction cylinders consisted of nested pipe sections. Screws were tightened on the outer pipe section to the inner pipe section. The friction between the pipes kept the apron span in alignment. When an unbalance load was applied to the apron span that was



Screw Jack Operating System in the Old Gantry at Greenville Yard

large enough to overcome friction the friction cylinder would slip and the apron span would realign.



Friction Cylinder at Transfer Bridge No.10 Connects Bridge Girder to Apron Span

Single vs. Double Articulated:

The Transfer Bridges at 65th Street are single articulated transfer bridges. The bridges are supported at the abutment on a heel bearing that allows rotation. The cantilevered end of the bridge is supported by wire rope and counterweight. The Bridge is driven up or down by a winch motor that overcomes the bridge imbalance. Once the transfer bridge is pinned to the car float, the bridge spans simply between the car float and the heel bearing. The bridge is free to move up and down with the car float. The previous Greenville Yard Bridges were all double articulated transfer bridges. Once the apron span is pinned to the car float the apron would move up or down with the car float. The operator could control the end of the bridge span with the screw jacks to keep the bridge, the apron and car float in alignment while loading and unloading the car floats.

Buffers:

At the new Bridge No 10 at Greenville Yard hydraulic buffers were added to the end of the apron span. This was done to reduce the impact from the car float during mooring. A used Pontoon Bridge was found that could be used as a temporary bridge no. 9 at Greenville Yard. Inspection of the pontoon bridge revealed significant damage at the end from collision with car floats. HDR added two buffer cylinders to protect the end of the new apron span from contact with the car float.



Repairs being made to the end of the Temporary Transfer Bridge No.10 at Greenville Yard

Passive Transfer Bridges/ Pontoons:

A Pontoon Bridge is a passive floatation system. The Transfer Bridge has a hinge at the land side abutment and the bridge spans over the Pontoon. The track elevation at the free end of the bridge is set so that it is higher in elevation than the unloaded car float at high tide. As a car float is brought into alignment with the transfer bridge rail cars are pushed onto the transfer bridge which

lowers the pontoon in the water until the lock bars at the transfer bridge can be driven into receivers at the car float. Once the Car Float is secured to the Transfer Bridge, loading or unloading of the car float can proceed.

The Pontoon Bridge was brought to the Greenville Yard as temporary replacement to the damaged Bridge No. 9. Greenville Yard bridges were damaged beyond repair by Super Storm Sandy. At the time of the storm Bridge No. 9 was the only Transfer Bridge in



View of Temporary Pontoon at Transfer Bridge No. 9 from Greenville Yard

operation at Greenville Yard. The existing Transfer Bridge System was demolished, a new trestle bridge was designed and installed, the pontoon structure was installed and the service was restored at Greenville Yard within one month from the damage by Sandy.

Effect of Rail and Car Float Operation on Transfer Bridge Design

As the transfer bridges serve to allow the movement of rail cars between land and a car float, it is vital to understand the tidal elevation changes at this location. The difference in water level elevation between high and low tides can vary greatly depending on the location. The car float must be able to approach the transfer bridge without the danger of running aground.

The manner in which the car float reacts to different loading conditions must also be known. The distance from the waterline to the bottom of a marine vessel is known as draft; the distance from the waterline to the deck is known as freeboard. When the car float is loaded to its maximum, the draft distance is at its maximum and the freeboard is at a minimum. Similarly, the car float's draft is at its minimum and freeboard is at its maximum when the car float is completely unloaded. Therefore, the maximum elevation of the car float's deck occurs at high tide when fully unloaded and the minimum elevation occurs when fully loaded at low tide.

The characteristics of the rail cars can also play an important factor in determining the design constraints. Trains are formed by mechanically coupling rail cars to an engine. There are different types of rail cars featuring different types of couplings that can be used. The height from the top of rail to the bottom of a rail car is not a standard height for all rail cars. The types of cars utilized at the site must be known so that this height can be determined. The types of couplings the cars feature also need to be known. These factors are needed to determine the maximum and minimum grade changes the rail cars can withstand; if the grade change is too steep, the cars may bottom out (the bottom of the rail car could interfere with the rail) or decouple (if the angle exceeds the equipment's allowable range).

Based on the car float extreme elevations and the allowable operation angles, the length of the transfer bridge and the necessary angles for operation can be determined. The operation angles must be within the angles allowable by the rail cars. An option that can be employed in design to shorten the overall bridge length is to introduce an apron span. The apron span connects via a hinge to the bridge span, adding an additional articulation point. The additional articulation point allows for the necessary elevation changes to be made through two angles rather than one.

New Bridge Design

The design philosophy for the new bridge was to simulate the operation of the existing bridges. This would make the operator's transition to the new bridge easier. A double articulated girder system was selected to provide greater flexibility during operation. This is similar to the existing transfer bridge at Greenville Yard. It was determined that Hydraulic cylinders could be used without counterweighting. Unlike a normal movable bridge the bridge is operated with live load on the bridge. The design load for this transfer bridge is two tracks loaded with 286kip rail cars. Due to the magnitude of the live load it was decided that the additional dead load of the bridge was small compared to the live load. Therefore we could eliminate the wire ropes, sheaves, sockets and counterweight, and reduce the amount of maintenance required for these elements.



• Bridge Framing: Girder/Floor Beam/ Stringer

Bridge Hinges

Heel Bearings:

The heel bearings for the new Bridge No. 10 and Greenville Yard were designed using stainless steel for the Convex Hinge/ Masonry Plate. The concave sole plate is stainless steel as well with a Lubrite bronze bushing. The stainless and Lubrite Heel Bearing will provide a long service life even in a briny environment.

The heel bearing were designed to support the dead load and live load reactions at the land side of the bridge. The heel bearings were also designed to resist the moment on the bridge resulting from lateral loads applied to the car float. The moment is taken up as a longitudinal couple at the heel bearings. The heel bearings were not designed to resist the lateral loads on the bridge and the car float. These loads will be carried by the centering device.



Stainless Steel and Lubrite Heel Bearing



Stainless Steel and Lubrite Heel Bearing with Stainless Steel Sole Plate



Centering Devices:

The centering device is a centrally located bearing under floor beam FB0. The bearing mates up with two brackets mounted to the underside of floor beam FB0. The brackets have Lubrite bearings allowing the surface to slide as the bridge rotates. The brackets will be in full contact with the centering device at all times transmitting lateral loads from the bridge in to the centering device.

Hinge Joints:

The apron span is connected to the bridge span via hinges. These hinges utilize a pair of plain bearings featuring bronze bushings to the load from the apron to the bridge span. A keyed hinge pin was installed at each apron girder. A bronze thrust washer is installed on either side of the pin as a sacrificial component. A hinge bracket with a bronze bushing slides over the pin on either side, then bolt to the bridge girder to complete the hinge. To aid with lubricant retention, a cover plate is bolted to the bushing flange.



Installing Hinge Pin after Cooling in Liquid Nitrogen



Erection of the South Apron Girder. Note Clevis Connections for Hydraulic Cylinders at the top of both Apron and Bridge Girders. Also note Donut Fenders at Waterside approach to Transfer

Lock Bars:

The transfer bridge utilizes four lock bars to ensure alignment of the rail between the transfer bridge and car float. These lock bars are located as to match the placement of the existing structures/car floats to ensure interchangeability. The lock bars are restrained on the transfer bridge by front and rear guides, and when driven for aligning the car float. The receivers for the lock bars are mounted on the car float deck. For the new Bridge 10 at Greenville Yard, the lock bars are driven/pulled by hydraulic cylinders. However, the bars are provided with an additional pin and the plate supporting the lock bar features details similar to the



View at end of 65th Street North Bridge Showing Rail, Lock Bars and Bearing Girder

existing structure to facilitate manual operation in the event of lock cylinder failure. In providing a significantly sized clearance in the guides and receivers (approximately ¼"), a small amount of transverse and vertical misalignment of the car float is possible. The lock bars also transmit lateral loads from the carfloat to the transfer bridge, and ultimately to the hinge bearings and the centering device.

Bearing Girders:

The two Bearing Girders located at each transfer bridge serve to transfers live load from the cantilever end of the transfer bridge to the carfloat.

Bridge Buffers:

There are two hydraulic buffers that protrude through the end floor beam at the end of the transfer bridge. These buffers will absorb impact from car float during mooring.

Winch Motors:

There are two winch motors on platforms outside the apron girder at either side of the New Transfer Bridge No. 10. The four winches use Nylon rope to pull the carfloat tight to the end of the transfer bridge.

New Transfer Hydraulic Bridge Drive Systems



New Concrete Floor in Gantry House. Note: grid deck over Secondary Containment System.

The hydraulic power unit (HPU) pumps biodegradable hydraulic fluid through the system to enable the two bridge cylinders, two apron cylinders, and four lock cylinders to operate. Biodegradable fluid was selected to limit the impact on the environment in the event of a leak. The HPU utilizes two 150 HP motors and two 100 HP motors to drive the pumps, which push the fluid through a system of directional valves. The pumps used are pressure compensated variable displacement pumps which allow for control of the fluid flow without requiring the

motor to change its operation. The directional valves are used to determine if a cylinder will be pressurized and which side of the hydraulic cylinders will be pressurized, thereby controlling the direction of operation, to raise or lower.

As there are no counterweights to offset the system's dead load, the bridge and apron cylinders must take the dead and live loads seen by the system. The cylinders have a 26" bore and a 9" rod diameter with a 3000 psi maximum pressure on the rod end and 400 psi maximum pressure on the blind end. This allows the cylinders to drive with about 210 kips and retract with about 1,400 kips. To allow the necessary flexibility for the tidal elevations and the loaded/unloaded conditions, the cylinders have a 12'-2" stroke and feature spherical bearings at the end of the cylinder and rod. Four cylinders with a large stroke requires a large 1000 gallon reservoir to ensure there is enough fluid in the system for the necessary movements. To ensure relatively even operation of the bridge cylinders, a flow divider is used to control the flow to these cylinders. The flow divider provides a means of synchronizing the cylinder positions which helps to keep these cylinders operating together and prevents binding.

Important features of this system are the float and park modes. These modes allow for the system to support the loads while connected to a car float, yet make the adjustments necessary to compensate for loading/unloading the car float and/or tidal changes. In float and park modes, large changes in the bridge and apron cylinder position are not necessary; an additional pump and 10 HP motor are provided to allow for the system to make these minor adjustments without requiring the entire system to be energized. For more information regarding the float and park modes, see the Control Processes and Operation Modes section of this report.

The system features several filters and a strainer to ensure that contaminants do not damage the system. A reservoir heater is provided to keep the fluid warm in the reservoir during the cold weather. As the system works, the temperature of the fluid increases which can affect operation; an air cooler assembly is provided to bring the temperature of the fluid down during operation.

Temperature and fluid level switches monitor the fluid in the reservoir to alert personnel to adverse conditions. A secondary containment area is provided below the reservoir to capture fluid that may be spilled or leak.



Hydraulic Power Unit and 4 drive motors installed in gantry room over secondary containment.

Bridge Control System

The transfer bridge system is comprised of standard power distribution components, HPU system, and PLC system. All power distribution, HPU, and PLC system were located above the apron in a control house. The control desk was remotely located at the end of the apron. Field feedback devices were provided throughout the structure shown below.



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PLC System

The control system design comprised of a Hot Back up PCL. This was to ensure reliable operation of the system processing in the event of a processor failure. In addition to the redundant processors, redundant

processors, redundant power supplies were provided for the I/O racks to have an added level of reliability. The whole PLC system was placed in a single enclosure and located in the control house above the bridge/apron.



Control Desk



The control desk shown above was designed to have a similar feel to the previous desk with two separate joy sticks for operating the bridge and the apron, with some added user feedback for

monitoring. In addition controls for mooring barges was added to the control desk to increase the operator's control over the process. The control desk was located on the apron and designed to be outdoor rated. This was to provide the operator full view of the operation during system movements.

From this control desk the operator can control each winch motor individually, each lock bar individually, the bridge cylinders, and the apron cylinders. The control desk monitors bridge position providing feedback to notify operator of near end of travel limits as well as end of travel maximum limits. In addition to bridge movement monitoring the control desk provides the status of the HPU system and the PLC system.

Control Processes and Operation Modes

Bridge/Apron alignment, Mooring and Locking

The alignment process and mooring process relies heavily on the local crew. The operator will adjust the bridge and apron to prepare for an incoming barge from the control desk.

On the control desk are two separate joysticks which control the raising and lowering of the bridge an apron. Pulling on the joystick will raise the respective bridge/apron and pushing on the joysticks will lower the respective bridge/apron. The operator will adjust the bridge/ apron such that the apron is slightly above the incoming barge.

During this operation the operator will monitor the bridge position to avoid maximum limits of travel via indicator lights on the control desk. The system monitors the angle of the bridge, angle of apron, and angle between the bridge and apron. The system calculates all of the angles and ensures that they are within tolerance for train movements as well as protects from exceeding maximum limits and binding of the bridge/apron at the hinge. Should a max be reached, the system will restrict further operation to exceed these limits and only allow operation in the opposite direction to allow adjustments which enable proper alignment.

Once the barge is in position and the bridge/apron are in proper alignment the ground crew can connect mooring lines from winch motors to the barge. The 4 winch motors that pull in the moored barge are located at the ends of the apron. Each of the winch motors is provided with a local control station which allows operation of the winches. There is also options for controlling the winch motors from the control desk. These two control locations each report back to the PLC system to determine which location controls the winch motors and are interlocked in the program. A request/enable system was established to ensure that operation from the local stations and the Control station do not conflict. This also forces the operator and crew to coordinate during the operations.

Once the barge is moored against the apron the apron is lowered and the operator will drive the span locks into the barge to secure it. There are 4 span locks in total and it is at the operator's discretion to determine which of the 1 are driven first. This is determined by the list of the incoming barge. Once all 4 lock bars are driven the apron is placed into float mode.

Float Mode

Float mode requires no operator input and starts automatically once all 4 lock bars are driven. During this operation the apron cylinders are pressurized to apply a down force onto the barge. The user joystick which controls the apron movement at this time is disabled. The predetermined pressure in the cylinders required to apply this down force is monitored constantly by the control system. The pressure is mechanically released when the apron cylinder is contracted due to rising tides or unloading of the barge. In addition when the apron cylinder is extended due to receding tides or loading of the barge the control system will automatically re-pressurize the cylinder once it drops below 50% of the predetermined value.

Loading and Unloading Operation

During the loading and unloading operation the operator will monitor the location of the bridge and raise/lower it accordingly. No adjustments to the apron are required due to the float mode. The system will continue to monitor all positions during the operation.

Parking Mode

The "Park Mode" feature was a function added later during the construction phase at the request of the client. This feature was intended to operate the bridge automatically without a local operator when a barge remained coupled to the bridge. This event would occur at the end of the day, over the weekend, or during holidays. Keeping the barge coupled to the bridge in lieu of spud off in the water is desired for both cost and logistics. To move a barge tug boats are required and not available on demand as well increase operating costs.

To minimize the load on the electrical system during this mode main motors for the HPU are disable as they are significantly large. A smaller motor was added to the HPU unit to handle the small movements during tidal changed. By adding a smaller motor a local generator was able to be placed on the structure which would provide power in the event of a power failure.

The park mode feature is very similar to the Float mode, however in addition to automatically monitoring the apron position the bridge is monitored as well. The system will automatically monitor the angle between the bridge and apron and adjust the bridge accordingly to prevent binding of the bridge and the apron. This is achieved waiting to reach a max defined angle between the bridge and apron, both concave up and down as required. Once the max is approached, prior to exceeding the value, the system will adjust back to a predefined angle.

Field Feedback Devices

Limit switches are provided to monitor discrete position devices such as lock bar driven and bridge critical angles. For the environment and ease maintenance a limit switch without external moving parts were selected and provided with quick disconnect plugs. The limit switches are also submersible to accommodate for the wet/tidal environment.

To monitor the absolute position of the bridge inclinometers were utilized on both the bridge and the apron. These inclinometers provided absolute position/angle of the bridge with a high level of accuracy. A completely redundant inclinometer system was provided on each the bridge and the apron to provide a level of error checking in addition to minimizing downtime in the event of a failure.