HEAVY MOVABLE STRUCTURES, INC.
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Rehabilitation of LA 82: Vermillion River Vertical Lift Bridge at Perry, Louisiana

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INTRODUCTION

The Perry Vertical Lift Bridge is located on Hwy 82 in Vermillion Parish crossing the Vermillion River. The main span consists of a 75 foot lift span consisting of two main girders. The deck is an open steel grid deck supported on stringers and floorbeams. The approaches consist of concrete decks on steel stringers. The superstructure is supported by reinforced concrete piles. From abutment to abutment the bridge is approximately 383 feet long. The nearest detour route for this structure adds a length of approximately five miles to the route. (Figure 1)

In the down position the bridge provides 10 feet of clearance at high tide and 55 feet of clearance at high tide in the open position. The horizontal clearance between the fenders is 60 feet.

Figure 1 – Satellite Image of Perry Bridge

The Perry Lift Bridge was constructed in 1955 and is of riveted construction. The main lift span consists of two parallel girders connected by floorbeams which support stringers supporting an open grid deck. There was a single operator’s house located to the northwest of the channel and centerline of bridge. This bridge was built from LADOTD Standard Plans at the time of construction and there are numerous bridges with similar lift span details throughout the state. The approach spans were also constructed from standard plans, consisting of a concrete deck on simple span steel stringers supported on pile bents. (Figures 2 and 3)

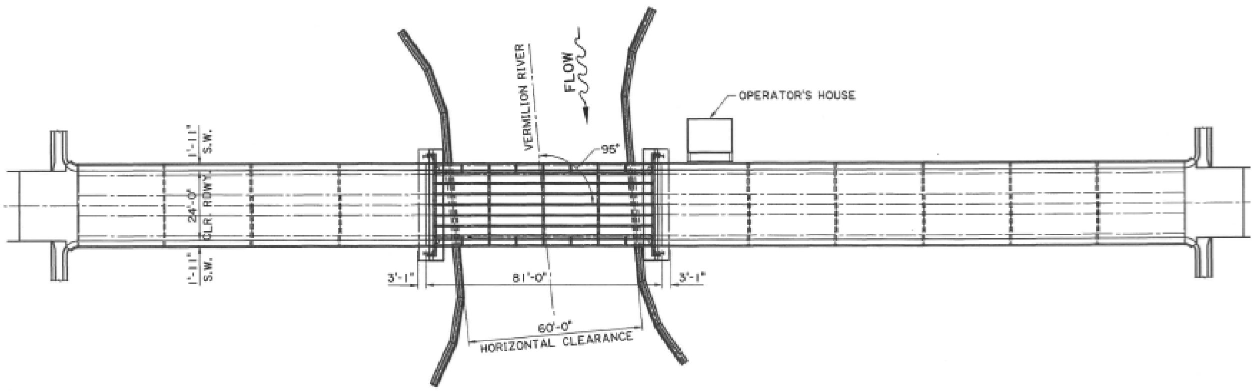

Figure 2 –Perry Bridge Existing Plan View

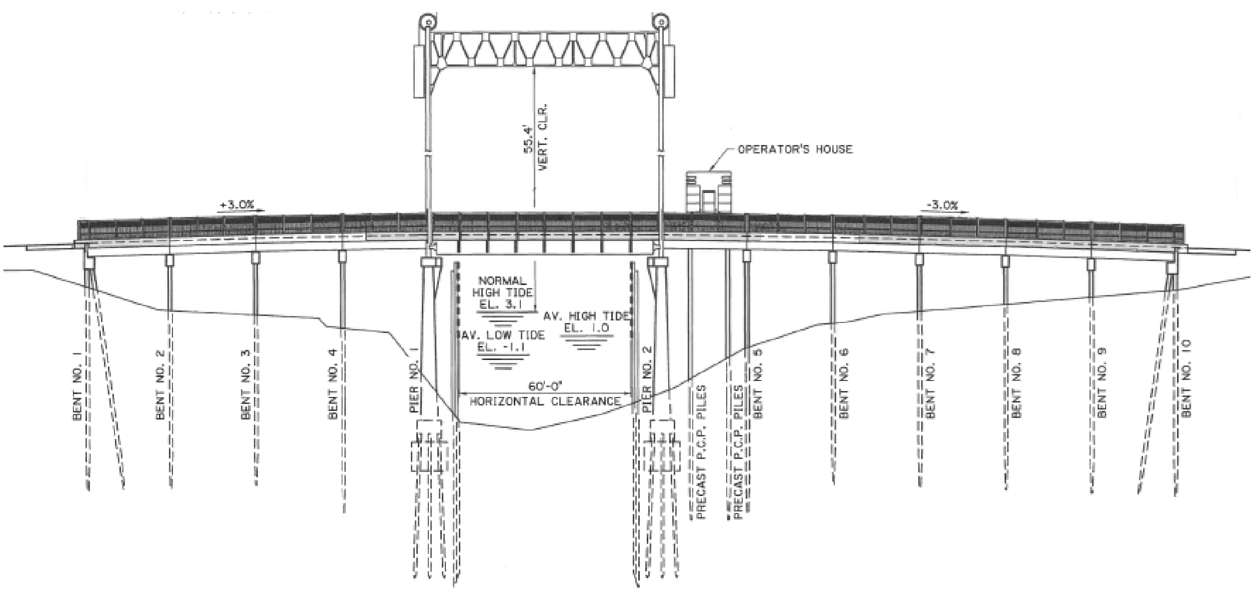

Figure 3 –Perry Bridge Existing Elevation View

THE BRIDGE'S ADVANCED AGE BEGAN TO SHOW

Generally, the bridge was in good condition, however there had been growing evidence of wear and tear from 60 plus years of continuous use, as well as changes to traffic and design codes which necessitated a multi-disciplinary comprehensive rehabilitation.

One of the main issues evident was the presence of low clearance tower portals which have been repeatedly hit by vehicular traffic, and as a likely result of these strikes, the district DOTD personnel suspected that the towers may also not be plumb. Tower portal struts exhibited permanent deformation of portal members, portal members were replaced several times, and most recently just prior to the final design phase for this rehab being presented.

While the Lift Span structure was in good condition, the lift span grid deck was found to be in poor condition, showing evidence of numerous and different repair types and needed to be replaced. Additionally, the lift span appears to have shifted to the north which required an extension of the south joint and the opening of the north joint.

And finally, the electrical and mechanical systems and components were also showing their age. The bridge is using the original wiring and grounding of the bridge was questionable as evidenced by the two prong outlets on the machinery deck. The bridge operates on the original motor and it needed to be rewound. The control console and switchboard are original and need to be replaced with current NEC clearances achieved. Machinery ranged from fair to poor condition. The span and counterweight guides are original and needed replacement. Span lock assemblies needed. Air buffers were functional but were in need of rehabilitation. Barrier gate machinery components were obsolete and needed replacement.

Similar to these deficiencies, there existed other deficiencies throughout all of the other bridge structures and components including approach span elements, access at the bridge, and the bridge fender which also needed replacement or rehabilitation.

Towers and Machinery Deck

The towers are in generally good condition though there is evidence that at least one tower leg may not be plumb as a result of vehicle accidents with the tower portal bracing. A survey was performed to determine the disposition of the tower legs, and this survey did confirm minimal out-of-plumbness to be corrected. Additionally, the low clearance of the tower portal struts (14 feet) has resulted in numerous impacts which necessitated the replacement of the tower portal struts. The feasibility of raising the portals was studied, and as part of the tower strengthening, the portals will be raised.

The machinery decks are open to the elements and can be slick when wet and need to be treated with a skid resistant coating. This issue can be compounded by several loose panels that needed to be replaced or reattached.

Machinery decks and tower access is substandard (railing is too low, clearances too small, and access dependent on opening bridge) and will be updated to current NEC and OSHA standards.

The tower metalwork also needed to be blast cleaned and painted.

Electrical

Electrical service to the bridge is a 240V/120V center tapped delta with a 208V high leg. The service disconnect is located on the service pole close to the parking area. A feeder runs from the disconnect switch along the bridge approach to the operator's house. Equipment in the switchboard is mostly original with additional circuits being added over time. All wiring and conduit are original. The control console components are original with some worn nameplates, hard to see lamps, and damaged indicators. The bridge is using the original wiring and the grounding of the bridge is questionable as evidence by the 2-prong outlets on the machinery deck. The motor appears to be the original motor and should be rewound. The control console and switchboard are original and should be replaced and NEC clearances achieved.

The control system is a manual control relay-based system with stepped resistance for speed control. The main motor is the original motor.

A rotary cam limit switch provides span position. Additional lever arm lever switches are used on the brakes and span locks. There are two plunger type span seated limit switches located on diagonally opposite corners of the span. The barrier gate rotary cam limit switches appear to be original.

Two channel floodlights are mounted on the operator's house. There is one maintenance light on the machinery deck by the drive motor and one mounted under the deck by the access ladder. Lighting in operator's house is by two ceiling lights. There are two navigation lights located on each fender fed from the barrier gate platform terminal box. The span navigation lights are fed through a cable reel on the nearside pier.

The operator's house is provided with telephone service. Communications between the bridge and approaching vessels is accomplished with a marine radio. A combination air horn and compressor, mounted above the front of the operator's house, is used as a backup to the marine radio.

The warning gates appear to be original. The traffic signal consists of four vertical red signal heads. There are advanced warning flashers on the draw bridge signs on both approaches.

Mechanical

The bridge is a tower drive vertical lift bridge with tied towers, with the main drive machinery located at the top of both towers and on the structural connection between the two towers. The two main drive motors, two thrustor-type motor brakes, primary gearbox, and auxiliary drive are located on the structural connection between the towers. The remainder of the operating machinery is located at the top of the two towers, with a line shaft connecting the output shafts of the primary gearbox with the input shafts of the secondary reducers. Each tower top contains a secondary reducer with two output shafts. Each output shaft is coupled to a line shaft which transmits the torque to an open gearset. The final pinions are coupled to these line shafts, and each pinion mates with a drive gear which is mounted on the inboard side of the sheave trunnion. There are two sheaves per tower, each carrying four counterweight ropes. The counterweight ropes are 1" diameter wire ropes which are connected to the lift span, run up the tower and over the sheaves, and connect to the counterweight.

The span and counterweight are both equipped with guide rollers that ride along tower mounted guide rails. The span has guide rollers on the fixed (west) end of the span, and guide plates on the expansion (east) end of the span. The counterweights have guide rollers on both the north and south sides.

The span guides serve to restrain the span during operation in the transverse and longitudinal direction, and the counterweight guides restrain the counterweight in the longitudinal direction.

The span is equipped at two corners with span locks. The span locks are located in the corners with oncoming traffic. The span lock assemblies are mounted on the pier near to the live load bearing strike plates, and consist of a spring-return latch which engages a span mounted catch. The span is also equipped at all four corners with air buffers. The air buffers are mounted on the span, and assist in slowing the span during seating.

Barrier gates are located at either end of the bridge, and serve to prevent cars from driving off the end of the approach or into the lift span when the span is in operation. The barrier gates are located after the approach traffic signal heads and warning gates.

The machinery is generally in fair to poor condition. The main counterweight ropes exhibit excessive wear and little to no lubrication, which is accelerating the wear. Several couplings are misaligned and/or exhibit excessive relative movement during operation, specifically at starting and stopping. This is evidenced by a ticking noise during operation at all of the couplings, which indicates broken coupling grids. Each open gearset exhibits excessive wear, especially on the opening faces. LADOTD personnel indicated that the couplings are opened every few months to re-index the machinery and seat the span correctly. This indicates rope slip and incorrect balance. A contract to replace the span drive machinery is currently in effect. This scope will pertain to those items not covered under the current contract.

GENERAL FEATURES OF THE REHABILITATION

General Features by Discipline

The goal of the rehabilitation is to provide a complete and comprehensive structural, mechanical, and electrical rehabilitation that will allow the bridge to operate reliably for an additional 30 to 40 years with regular maintenance as completed by targeted repairs or replacements of existing components.

Structural Rehabilitation

The lift span needed replacement of the grid deck, as well as member strengthening of floor system elements to remove the load posting restrictions. Also included were improved features such as addition of independent counterweight supports which the towers lacked, modification of the existing pedestrian walkway and repurposing it into a limited access maintenance walkway, and minor repairs of the lift span joints.

The lift span tower members needed strengthening to improve their capacity for modern design wind loading and to accommodate raising of the low portal members which frequently get hit, including straightening repairs, and replacement of the portal members.

In addition to these items, the structural rehabilitation also includes repairs to approaches, replacement of the fender system, access improvements, traffic improvements, addition of a new parking area, comprehensive cleaning and painting of the bridge, and a number of incidental miscellaneous repairs.

Electrical Rehabilitation

Due to the existing bridge usage, and minimal detour routes available, a consideration was as much as possible allow the existing electrical system and components to remain in operation during installation of the new electrical system and equipment to minimize the time the bridge is inoperable during the changeover. This required clearly defined installation steps within the specifications that the Contractor should follow during installation of the new electrical system to minimize the time that the structure will be closed to marine traffic.

The Operator’s House will be replaced, including, but not limited to installation of:

• New control desk.
• New switchboard.
• Integration of marine antenna, radio, and telephone circuits.
• Additional new circuit for new machinery deck jib crane.
• Add new circuits for new operator's house (HV AC, STP, water heater, microwave, water cooler, mini-fridge).
• New receptacles, conduit & conductors, and covers.
• New switches, conduit & conductors, and covers.
• New interior lights (both floors).
• New exterior lights (stairs, soffit and doors/porch area).

On the lift span, all limit switches were placed including span rotary limit switches, movable traffic barrier rotary limit switches, span seated plunger limit switches with snap action limit switches, and the addition of two (2) new span seated limit switches at comers without limit switches.

The existing lighting was improved including addition of new channel flood lights mounted on new operator's house soffit, addition of new maintenance lighting for new machinery deck access system, replacement of existing maintenance lighting at span drive machinery, additional new maintenance lighting at both tower machinery platforms, additional lighting to center walkway between both machinery towers, additional maintenance lighting at pier top platforms, replacement of span navigation lights and wiring/conduit, replacement of fender navigation lights and wiring/conduit, additional new movable span floodlight, additional new security lighting at new operator parking area, and additional new maintenance lighting at new generator platform.

Electrical system conduit and conductors were rehabilitated with the replacement of all conduit and conductors and with the new separation of control and power conductors, additional new standby generator and automatic transfer switch, the addition of new surge suppression device, replacement of cable reel and cable, replacement of all junction boxes and ensuring current NEC workspace clearances around each, addition of new local motor disconnects for the drive, barrier, and span lock motors, addition of new receptacles at drive motor, machinery towers, and pier top platforms, inclusion of new miscellaneous circuits, and replacement of the air horn, compressor, and other accessories.

Mechanical

Rehabilitation of the bridge’s mechanical systems was generally comprised of replacement of motors and their supports including an additional redundant second main drive motor, installation of new motor brakes, brakewheel, couplings and supports, replacement of new floating shaft and couplings, replacement of machinery brakes, machinery brakewheel and supports, replacement of dessicant breathers on all reducers, rehabilitation of existing secondary gearboxes to eliminate oil leaks around the clutch, addition of new lubrication fittings to all shaft bearings, replacement of new bull gears, installation of new sealing gaskets and hardware kits at the primary reducer output couplings and secondary reducer input couplings and all primary line shaft couplings.

All counterweight ropes and counterweight rope clevises will be replaced. While the rope replacement is performed, the sheaves and all sheave grooves for ropes will be cleaned to remove corrosion.

Additionally, machinery support systems will be replaced, including but not limited to replacement of span rollers and span guides, counterweight rollers and counterweight guides. The span locks will be replaced.

The existing movable traffic barrier, including its machinery, will also be replaced.

Consideration for the replacement of the span drive motor will be further detailed as one of the notable features of the rehabilitation.

NOTABLE FEATURES OF THE REHABILITATION

Rehabilitating the Main Drive Motor

As part of the rehabilitation design process, M&M investigated several options for replacing the bridge main drive motor, and the impacts of each option.

The first option explored was to leave the machinery as-is and to replace the 10hp motor with a set of redundant 10hp motors. Under the current existing span balance of 2900 lbs, the power requirement to operate the bridge was determined to be 9.1 hp. However, this current balance condition falls below AASHTO's minimum recommended imbalance. In order to meet AASHTO, the span balance will need to be raised to 4000, which then increased the required motor size to 10.2 hp, requiring a larger motor.

M&M performed lifecycle calculations for the open gear set consisting of the bull gear and pinion that drive the sheave, calculating the lifecycle for 10 years of prior operation plus 40 years of future operation. When driven by a 10 hp motor, the pinion and bull gear both rate for an additional 40 years of service. However, if driven by a 15 hp motor, the gear would not rate for service.

As an alternative to upsizing the drive motor, M&M also investigated the option of increasing the gear ratio at the bull gear and pinion that drive the sheaves. It was determined that if the number of teeth on the bull gear increased from 91 to 110, the horsepower required to operate the bridge then dropped from 10.2 to 8.4. The change in gear ratio also increase the time needed to complete an operation from 94 seconds to 112 seconds.

The alternative option was found to be the most desirable and economical for the owner.

DECISION MATRIX	No Changes	Increase the Motor Size	Installation of Larger Bull Gears
Motor	10 hp	15 hp	10 hp
Brakes	Will stay as currently sized	**Sizing will have to increase to accommodate additional torque**	Will stay as currently sized
Primary Reducer	Will stay as currently sized	**Will need to be replaced with a 15hp reducer**	Will stay as currently sized
Secondary Reducer	Will stay as currently sized	Will stay as currently sized	Will stay as currently sized
Motor Couplings	Will stay as currently sized	Will stay as currently sized	Will stay as currently sized
Primary Couplings	Will stay as currently sized	Will stay as currently sized	Will stay as currently sized
Secondary Couplings	Will stay as currently sized	Will stay as currently sized	Will stay as currently sized
Primary Shafts	Will stay as currently sized	Not analyzed	Will stay as currently sized
Secondary Shafts	Will stay as currently sized	Not analyzed	Will stay as currently sized
Pinion	Will stay as currently sized	**Will need to be replaced with a wider or stronger pinion**	Will stay as currently sized
Bull Gear	Will stay as currently sized	**Will need to be replaced with a wider or stronger gear**	**Will need to be replaced with a larger gear**
Sheave Assembly	Will stay as currently sized	Will stay as currently installed	**Will have to be raised approx 4.2" to accommodate larger bull gear**
Summary	**Motor does not rate for AASHTO loads at the recommended AASHTO balance (motor provides 97% of required horsepower)**	**Increased motor rates for AASHTO loading, at AASHTO recommended balance**	**Existing motor size rates for AASHTO loading, at AASHTO recommended balance**

Figure 4 – Motor Sizing Decision Matrix

Rehabilitating the Main Tower Legs

While tower leg metalwork was generally in good shape, several deficiencies with the tower and tower members were present that needed correcting. Both towers have been repeatedly struck by vehicles on against the low portal, necessitating replacement of portal members on multiple occasions. Additionally, some of these strikes have also deformed the tower legs out of vertical plumbness. Raising the portal above vehicular traffic, however, will increase the structural demand on the lower tower legs by increasing the unbraced length of the bottom panel.

The existing tower legs were also designed for circa 1950s wind load design criteria, and over the years, and under the current AASHTO LRFD Specification, the current wind design parameters have changed, increasing the demand on the tower legs and their anchorages.

A study of tower rehabilitation options were reviewed, including raising the tower on concrete pedestals to primarily resolve the low portal problem and raising the portals on the tower with strengthening.

While raising the tower would eliminate the low portal problem, it would not resolve by itself the need to increase tower capacity to resist current design wind loading.

For this reason, the rehabilitation alternative that was chosen was to raise the portal on the tower along with supplemental strengthening of the tower leg lower portion and its anchorage. The strengthening method was comprised of buttoning a new wide-flange section within the span-operating clearance zone of the tower leg that could strengthen the existing tower leg for both additional capacity to resist wind loading as well increase the capacity of the lower portion with a longer unbraced length due to the raise of the portal. (Figure 5)

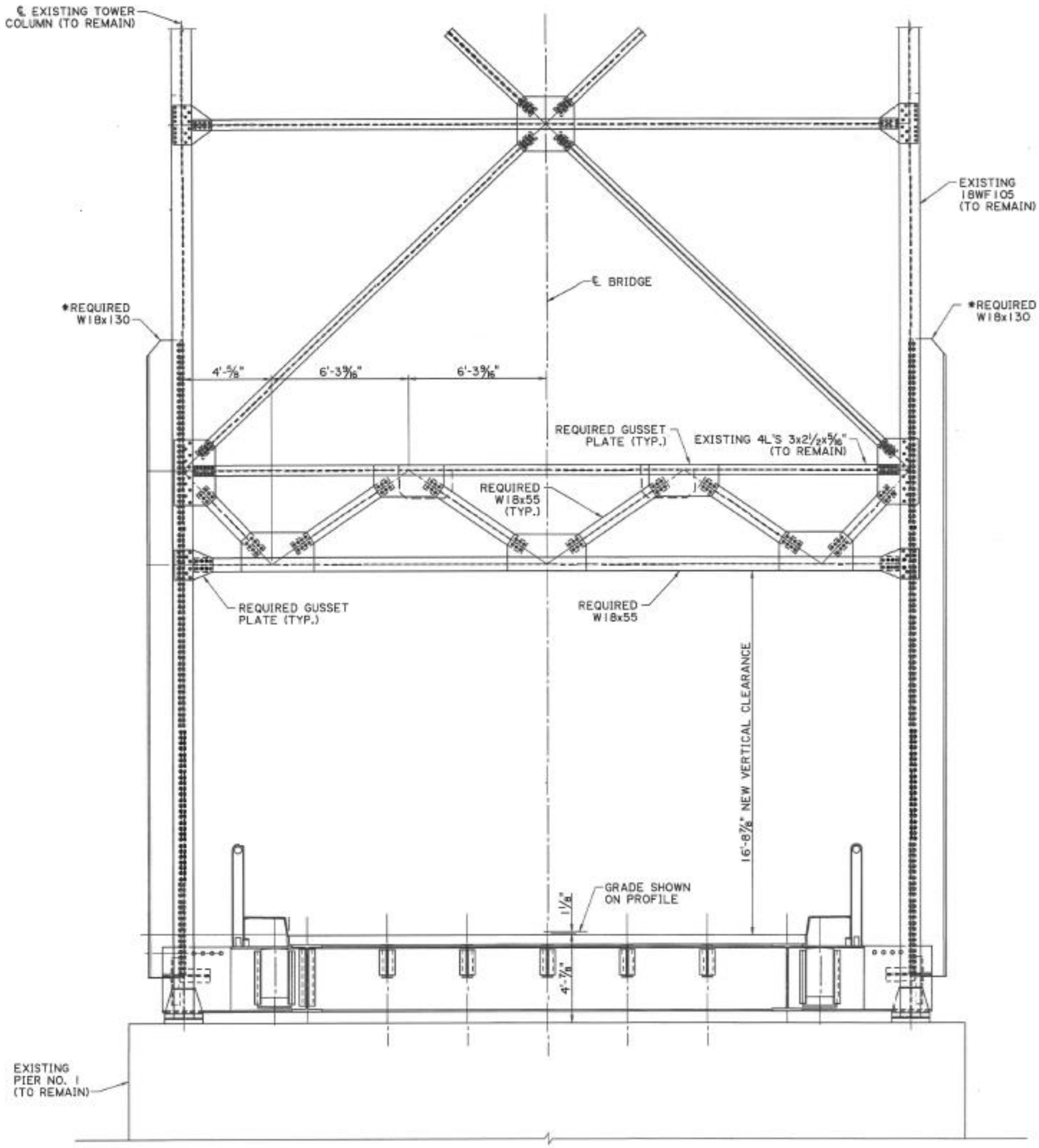

Figure 5 –Perry Bridge Tower Leg Rehabilitation

Photo 1 – LA 82 Vertical Lift Bridge of Perry, LA

Photo 2 – Tower Portal (replaced due to collision)

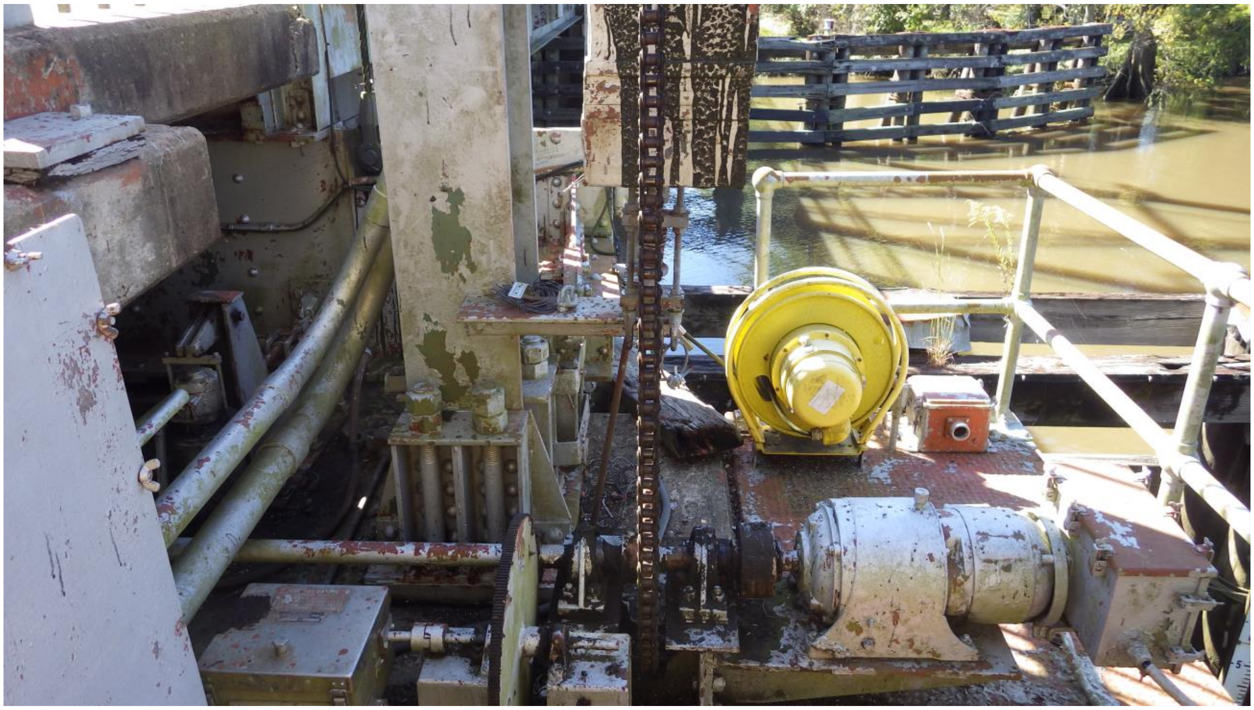

Photo 3 – Tower Pier (barrier motor, tower leg base anchorage, lower tower leg, and general accessibility)

Photo 4 – Lift Span Liveload Bearing

Photo 5 – Lift Cable Anchorage

Photo 6 – End Floorbeams Were Torch Cut & 1" Thick Repair Plate Was Welded to NW & SW Sides for Span Locks

Photo 7 – Air Buffer

Photo 8 – Tower Leg

Photo 9 – Northern Tower Legs Appeared to be Bowed Above Base

Photo 10 – Lift Span Machinery Deck Level

Photo 11 – Lift Span Machinery Deck Level – At Main Drive Motor looking towards Secondary Reducer and Sheaves

Photo 12 – Lift Span Secondary Reducer with Locking Clutch Assembly

Photo 13 – Main Sheave