Heavy Movable Structures, Inc.

SIXTH BIENNIAL SYMPOSIUM

October 30 - November 1, 1996

Doubletree Resort Surfside
Clearwater Beach, Florida

Drive System Replacement of the Tarpon Docks Bridge

by

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ABSTRACT

Fluid Power Systems

Title: Drive System Replacement of the Tarpon Docks Bridge

Topic: This presentation will discuss the replacement of the bridge drive system on the Tarpon Docks Bridge, a single leaf bascule bridge located in Panama City, Florida, with a hydraulic cylinder drive system. Points of interest will focus on the requirements of the system in terms of power and safety, development of the design, control techniques employed on this particular system and the unique use of cylinder trunnions for mounting. Also, installation and start-up, along with lessons learned, will be examined.

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INTRODUCTION

In 1994, the City of Panama City, Florida contracted to perform an in-depth inspection of the Tarpon Docks Bridge, owned by Panama City. The investigation resulted in recommendations for a variety of repairs. The outcome of this report lead to a set of plans and specifications outlining the renovations to be executed. This paper will examine the process of development and implementation of the rehabilitation of The Tarpon Docks Bridge.

EXISTING STRUCTURE

The Tarpon Docks Bridge, originally built in 1950, is located near downtown Panama City, Florida. The bascule portion consist of a single leaf, 61 feet in length, which provides two lanes of bi-directional traffic. Before rehabilitation, the drive system consisted of a 15 HP Hopkins frame drive. Span control was developed by a single drum switch controller located on the main control panel with the entire system being energized with 240 VAC, 3 phase power. The span lock drive system had a one way cycle time of 35 seconds, rendering it impractical.

Primary concern of the existing structure and components was in the span drive system. Inspection revealed extensive deterioration of the existing Hopkins frame and drive machinery establishing that it would have to be replaced. Lack of automatic acceleration and deceleration control from the main control desk would also need to be addressed. Finally, a new span lock drive unit and actuator would be required.

DRIVE SYSTEM SELECTION

Many drive systems have been employed throughout the existence of the movable bridge industry. One common type of drive is the direct electric motor drive system containing an electromechanical prime mover, gear box, and rack and pinion gears. The hydraulic drive system, using hydraulic cylinders, is another common drive type used for span motion. Also, hybrid systems can be found using hydraulically driven low speed, high torque (LSHT) motors and mechanical gearing. All of the these systems achieve the same goal of driving heavy bridge spans, However, for various reasons, one type of system may become more appealing when economic and other practical factors are considered. These factors, along with space availability in the bridge machinery area, were considered for the Tarpon Docks Bridge project in determining a final drive arrangement.

The field was narrowed down to two alternatives drive systems being considered for this rehabilitation. One option would replace the old Hopkins drive with an identical used drive from the Newport Bridge, a similar bascule scheduled for demolition in the near future. Although this alternative would result in a lower initial cost, it was concluded that required redundancy and reduction of single points of failure would not be properly addressed. Furthermore, drive control (speed, acceleration, and deceleration) would remain at the discretion of the bridge tender. This was not a desired control technique.

The second alternative would be a new hydraulic cylinder drive system. This option, as with the Hopkins replacement option, would require demolition of the existing drive components. Furthermore, the cylinder drive would require the addition of structural stiffening members and cylinders trunnions for attachment of the main drive cylinders to the bascule span. It was, however, determined that this system would provide the desired redundancy and automated control for safe motion control of the leaf.

After review of the proposed alternatives, the cylinder drive system was selected. Although the initial cost of this systems was more than that of the Hopkins drive alternative, the lower long term cost associated with maintenance and the compliance with current AASHTO codes offered by this design made the cylinder option the definitive choice.

OPERATIONAL REQUIREMENTS AND DESIGN DEVELOPMENT

MAIN DRIVE

After the drive selection was concluded, a set of drive parameters had to be established. These variables primarily included opening/ closing time and acceleration/ deceleration time. Figure #1 indicates the resulting operational profile. Requirements for power were derived based on AASHTO wind conditions, span weight, span unbalance, and bearing friction. Consideration for span holding in AASHTO condition "E" winds of 20 pounds per square foot on the vertically projected span area were addressed which dictated cylinder size and geometry.

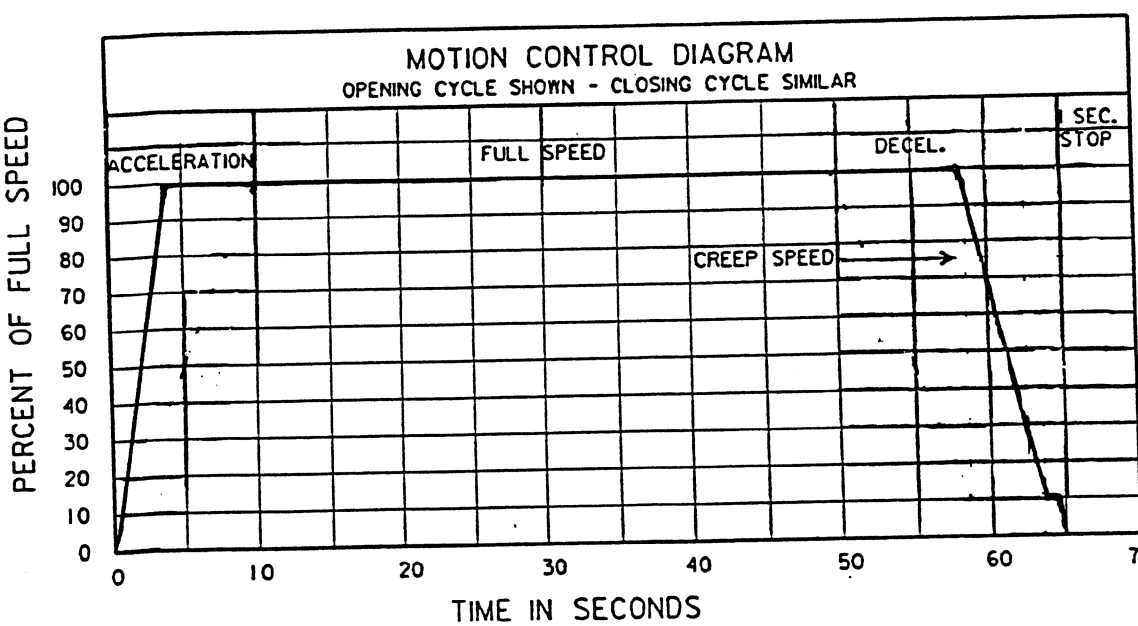


Figure #1

Calculations were performed to determine required flow to raise or lower the bridge and pressure to overcome wind and other resistance. The resulting loads indicated that needed HPU power, after taking considerations for drive efficiency, would be 20 HP in order to provide necessary flow and pressure at the pair of cylinders for proper bridge operation. See Table #1.

------------OPENING------------		------------DRIVE SYSTEM------------		
TIME	**ANGLE**	**POWER**	**MAX FLOW**	**MAX PRESSURE**
65 seconds	75 degrees	20 hp	34 gpm	2500 psi

TABLE #1

The hydraulic schematic, as shown in Figure #2, is of a basic design. Major components include a pair of prime movers at 10 HP each, a proportional directional control valve, and a pair of counterbalance valves for span control and dynamic braking. The use of a cylinder manifold blocks mounted and hard piped directly to each cylinder provided span locking capability in the event of a hose rupture through the use of pilot operated check valves. Also incorporated into each manifold are needle valves for emergency lowering of the span, relief valves set to protect the cylinders and manifolds in the event of an over pressure situation generated at the cylinder, and anticavitation valving for "idling" one cylinder during single cylinder operation.

Careful consideration is taken in providing gauges, test ports, and flow meters. Although these items may not be exercised on a regular basis, they always prove invaluable during system start up and testing (as was the case in this project).

Excellent control of the single leaf is another benefit for using the hydraulic alternative. This control would be initiated by the bridge tender through the use of a variable resistance joystick. A zero to 10 DVC proportional signal is sent from this joystick to the valve amplifier card which is programmable and provides linear ramping along with a current loop output with amplitude proportional to the input signal. This current loop then drives the hydraulic proportional pilot and control valves for bridge speed control.

Further safety is accomplished with the use of proximity type limit switches. Within the nearly closed (when lowering) and the nearly open (when raising) limits of span travel, the valve amplifier cards scale output signals down to a programmed 10% of full value. With this control technique, the bridge tender is not responsible for manual acceleration or deceleration and, consequently, the possibility of "slamming" the leaf is nearly eliminated.

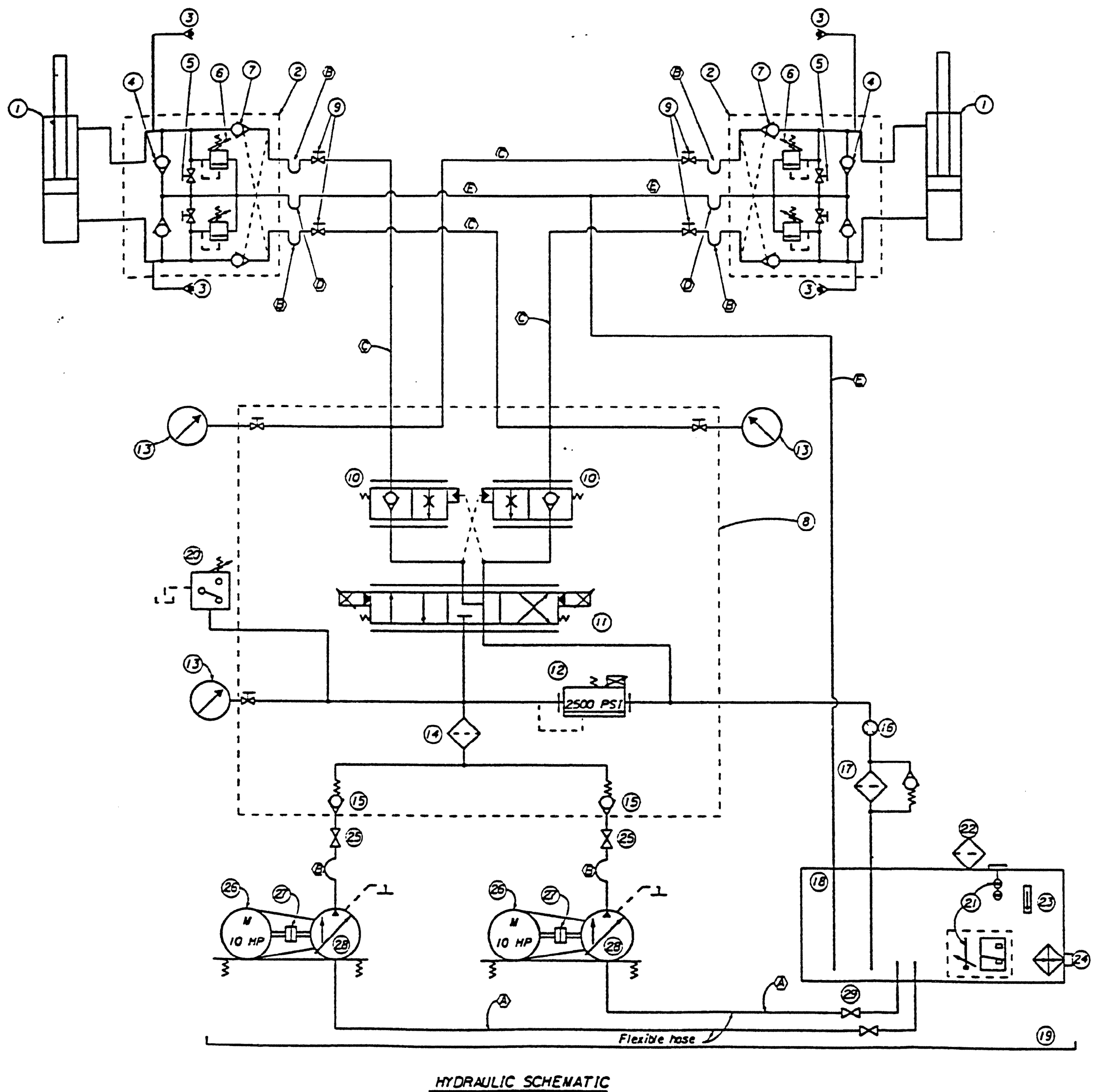
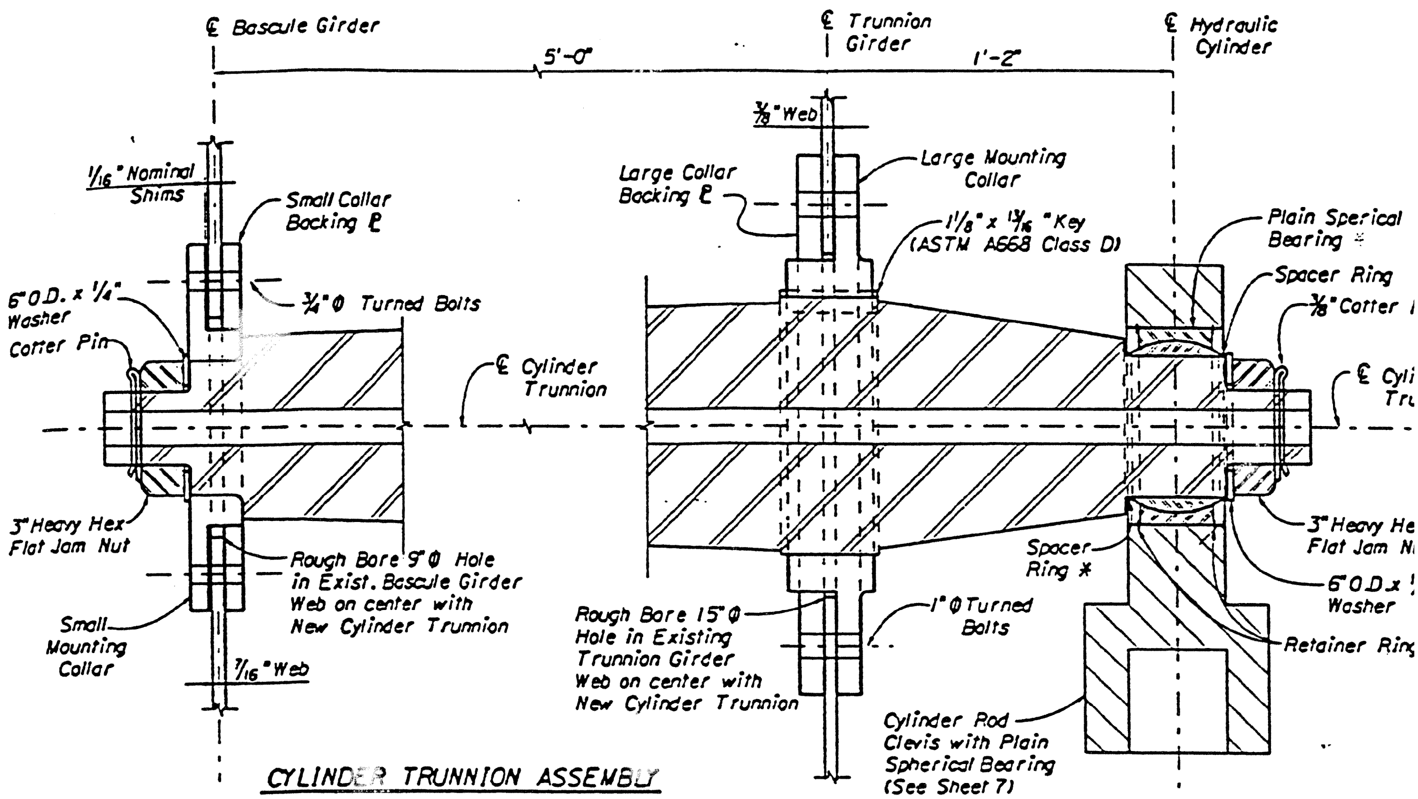


Figure #2

Further HPU controls include proportional ramping of system pressure from near zero PSI to full operational pressure allowing motors and pumps to start in an "unloaded" condition. Also, the use of these power compensated pump controls results in reduced heat generation and a more efficient system.

DRIVE CYLINDERS AND CYLINDER MOUNTING

As discussed earlier, cylinder dimensions and geometry were determined in the initial stages of design based on AASHTO span holding requirements. These calculations resulted in the use of two cylinders, each with a bore of 9.8 inches, a rod diameter of 5.5 inches, and a working stroke of 51 inches. Mil duty cylinders were specified for reliability and the cylinder supplied would furnish the specified bolted heads for serviceability, test ports at both ends, and a nickel-chrome plated rods conducive for the marine environment application. Mounting incorporated spherical bearing in the rod eye and rear, single blade clevis as shown in Figure # 3a and 3b, respectively. The use of these bearings will allow for any slight misalignment of the bascule span or cylinders.



Figrue #3a

The existing design of the bascule leaf and machinery floor prevented vertical attachment of cylinders to the bascule girders, a technique often employed in hydraulic cylinder retrofit applications. Several methods have been employed in mounting hydraulic drive cylinders on existing trunnion bascule bridges. Typically, the cylinders are attached to the underside of the existing main girders or trunnion girders or to the underside of new "cylinder girders" which span between the first counterweight girder and the last floorbeam. At Tarpon Dock none of each of these alternatives presented major drawbacks. The Tarpon Dock bridge is narrow (26'-7" between main girders) and working space between the machinery platform and centerline of trunnions is limited (8'-1½"). This provides insufficient height for mounting the cylinders below the main girders. Additionally, because of the limited width, any cylinder girders would need to be located in the area occupied by the existing Hopkins Frame, requiring extensive demolition and reconstruction of the rack girders. This lead to the development of a new mounting method for cylinder retrofits.

The solution derived was to mount the cylinder to the end of a "cylinder trunnion" installed through the webs of the existing main girder and trunnion girder. See Figure #3a. This positioned the two cylinders to either side of the existing Hopkins Frame and allowed the attachment point to the leaf to be only 9 inches below the centerline of trunnions. Positioned as such, the cylinder stroke was adequate for full leaf rotation with only minor modification of the machinery platform. This positioning also allowed for much of the work to be performed prior to removal of the existing machinery.

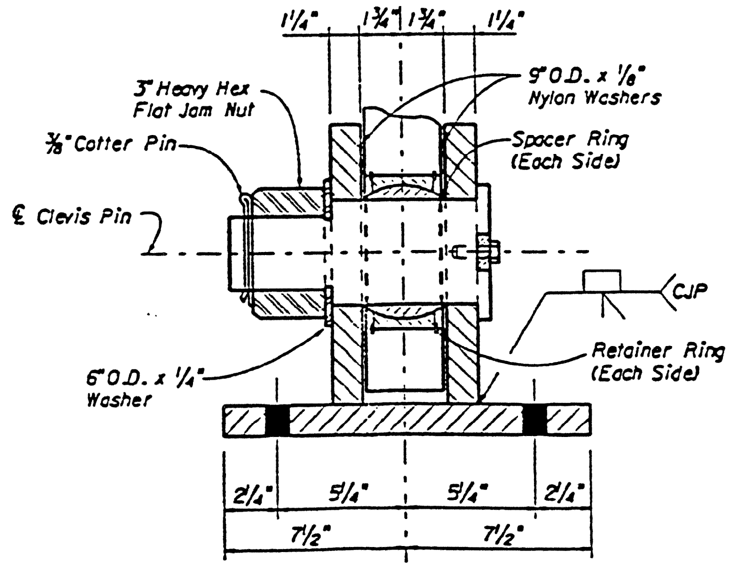


Figure #3b

SPAN LOCKS

Span lock one-way cycle time was brought into the specified 6 seconds by replacing the existing self contained HPU with a new unit. This 1.5 HP unit would use the same directional control style of motor reversing as the existing equipment which made for a simple retrofit. A new NFPA type cylinder, hoses with quick-disconnects, and an emergency hand pump for manual backup completed the lock design which would compliment the overall rehabilitation project.

SYSTEM INSTALLATION AND STARTUP

Great care was taken during installation of the HPU and cylinders. All work would be performe by certified fluid power mechanics with experience in this or similar applications. The HPU and cylinders were shop inspected and tested before delivery. After installation, with cylinders bypassed, all conducting lines were throughly flushed at high flow and filters were monitored for indication of clogging. The system was then pressurized to operating pressure and lines were inspected for leakage.

With the cylinders back on line, the hydraulic system was ready for functional testing. Ramp times and output values for control valve operation and limit switch positions would have to be adjusted for smooth performance. Required adjustments were then made for the relief valve settings and power limiting for both pumps to assure prime movers were drawing current for their designed power rating. Further testing was performed to determine all port pressures for counterbalance and P.O. check valves at all modes of operation. Restricted or incorrectly designed drain routes could result in undesired power oscillations at the drive cylinders.

Adjusting the drive system to specified values is an important part of finalizing a project of this nature. Power requirements, structural integrity, and other functions are all determined based on a comprehensive working system. To allow acceleration, creep-speed, or other parameters to fall out of allowable specified ranges could jeopardize other areas of the overall design. Because of this, it was important to obtain values as shown in the plans and specifications, record these values, and have these recordings signed off by the Engineer of Record. This would become the functional test report to be delivered to the bridge Owner.

CONCLUSION

The Tarpon Docks Bridge became another of many bridges incorporating a hydraulic system for the development of reliable, smooth bascule span motion. The final product provided evidence that a properly designed, fabricated, installed, and tuned hydraulic system will result in reliable and economical bridge operation.