ROLLING GATES FOR THE PANAMA CANAL – PIANC WG 173

by

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1. INTRODUCTION

The guidelines presented in the WG 173 report included the experience of the rolling gates for the Panama Canal Third Set of Locks for its design, fabrication and construction. This paper further adds the recent experience on their operation and maintenance. The Third Set of Locks project was envisioned to increase Canal capacity in terms of more transits and tonnage, and also sought to add value to its customers by offering locks to handle Neopanamax vessels of up to 170,000 tons. An early decision was to build three steps of contiguous lock chambers to reduce water usage and preserve water quality. Additionally, the requirement of high reliable locks operations specified double rolling gates at each location for a total of eight rolling gates for each of the Agua Clara locks in the Atlantic and the Cocoli locks at the Pacific end. The result are the largest and heaviest rolling gates in operation up to 4,200 tons.

2. ROLLING GATE DESIGN

The new Panama Canal locks have a unique configuration starting first with the three step lift locks on each end of the canal. Each Neopanamax lock chamber has a dimension of 55 meters wide, 458 meters operational length and 18.3 meters minimum water depth. The design also incorporated three water saving basins (WSB) per lift for a total of nine WSBs. The filling and emptying system has two longitudinal culverts with side ports to the lock chambers which have been designed, modeled and tested to meet efficiency criteria.

A particularity of multiple lift locks is that the intermediate gates are subject to higher loads before water equalization which results in the rolling gates subjected to differential heads of up to 22 meters. The operations require high reliability and minimized outage times, so operational lock availability above 99.6% was required in its design. Double set of gates in each of the four lockheads at each lock was also a requirement for operational safety, redundancy, reliability and maintainability, resulting in a total of sixteen rolling gates with the sea gates in the Pacific end the heaviest.

The Panama Canal required the new rolling gates to be of wheelbarrow design mainly to reduce the submersible parts and maintenance. Reduced parts replacement times were required particularly to replace the front submerged gate undercarriage. Extensive modeling and testing was required to fine tune the buoyancy tanks for the different operational conditions, stability, reduced wear and to meet the operational requirements. The use of bulkheads to isolate the gate for dry docking for inspection and maintenance was also required and special supports included to support the dry weight of the gate in its recess.

The use of double gates ahead of the vessels entering the lock chamber is an operational requirement for safety. Once the ship is secured to the lock walls with its own lines, the inner gate is opened for additional space for the vessel and the operational tugs that assist the vessel in its transit through the Panama Canal. Rolling gates are also designed to withstand the eventuality of ship collision, with requirements such as its operability and minimized disruption to vessel transits. Fatigue, stress, wear, wave, wind, tidal conditions were all considered and modeled in the gate design.

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3. ROLLING GATE MANUFACTURING AND TRANSPORT

Rolling gates were manufactured in blocks in the shops and assembled and painted vertically in a yard, requiring a total of over 50,000 tons of steel. The gates were transported from Europe to Panama and were shipped upright four at a time using a floating carry deck vessel. Thus, a total of four trips were required to transport all 16 rolling gates which were unloaded on the Atlantic site. The eight Pacific gates were transported one at a time by barges transiting the original Panamax locks. The Panama Canal had onsite presence at gate manufacturing facilities of its Engineers and third party inspectors at all times to assure compliance with the contract specifications for performance and durability.

The contractor decided to install the rolling gates in the dry on the basis of ease and timeline. The rolling gates were moved upright all the time by means of self-propelled motorized wheel transporters (SPMT), which allowed precise positioning of gates in its recess. Testing of the gates was done after flooding the locks a year before opening.

The rolling gates are opened and closed with mechanical drives using steel wire ropes and drums, two drums per gate, each drum driven by a variable speed electric motor and a gear box. The wire ropes are double wrapped for opening and closing the gates in a very standard fashion. The drums are coupled by a center steel shaft. For reliability and redundancy, one motor is capable of moving both drums, although in normal operations both motors are running. A brake keeps the drum from moving when not in operation. An automatic wire rope hydraulic tensioning system picks up the slack on the cable and eventual stretching. A small auxiliary motor is added for fine positioning of gate during maintenance work.

The rolling gates are remotely operated from a central control house by means of PLCs and fiber optic cables. All electrical feed and communications have two loops for increased reliability and backup operations.

4. ROLLING GATE OPERATION AND MAINTENANCE

Operating speed to open/close the rolling gate across the 55 meters chamber width in no more than 5 minutes results in an average speed of 0.18 meters per second. Variable speed motors allow for acceleration and deceleration of the gate to maintain stability and smooth operation. All lock operators of the Panama Canal are carefully selected from the different crafts and are therefore very knowledgeable in lock operations and maintenance. For the new locks, the Panama Canal control house operators were selected among the senior operators of the original locks and have greatly contributed in fine tuning, improving and establishing the new lock operating procedures.

The new locks are designed for high reliability of operations, thus requiring a fault tree analysis to incorporate a combination of redundancy, reliable parts and components, ease of maintenance and minimize shutdown times and frequency. The design-build contract includes three years of initial maintenance. It is a good practice to gradually incorporate owner's operations and maintenance staff, as early as practically possible, in the installation, testing, troubleshooting of locks equipment and controls for proper knowledge transfer.

The expanded Panama Canal has transited over 3,000 Neopanamax vessels since its inauguration on June 2016. The users have responded enthusiastically, exceeding market estimates, particularly for 13,000+ TEUs containerships and large LNG carriers.

REFERENCES

PIANC. (2017). Report of Working Group 173: Movable Bridges and Rolling Gates, Design, Maintenance and Operation Lessons Learned, PIANC, Brussels