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Size matters

With its inauguration on 26 June 2016, the Third Set of Locks Project on the Panama Canal was officially completed. MARCO VAN DAAL reports

Construction of the Panama Canal started in 1881 but it ran into challenges that delayed completion and the official opening until 15 August 1914. Vessels with a maximum length of 965 feet (294 metres) and a width of 106 feet (32.3 m) could make the 48 mile (77 km) short cut between the Atlantic and the Pacific Ocean. Vessels of this size are called Panamax to indicate that they can pass through the Panama Canal.

To accommodate larger ships the Third Set of Locks Project commenced in 2007. Inauguration of the US$ 5.25 billion scheme was in June 2016. So-called New-Panamax or Post-Panamax vessels can be accommodated with a length of 1,200 feet (365 m) and up to 160 feet (48.8 m) wide. Panamax container vessels can carry around 5,000 units of 20 foot containers whereas Post-Panamax vessels can carry around 13,000. See Figure 1.

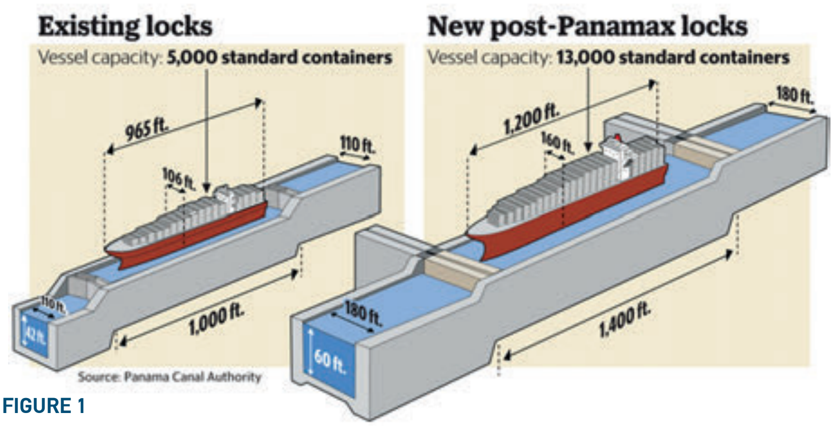

FIGURE 1

How it works

The Panama Canal connects the Atlantic Ocean to the Pacific Ocean via three lock systems; The Gatun Locks, the Pedro Miguel Locks and the Miraflores Locks. The location of the Miraflores locks close to Panama City and a spectator bay means these are the most famous. Ships are raised and lowered between sea level and the Gatun Lake level, 85 feet (26 m) above sea level. In 1914 Gatun Lake was the largest manmade lake in the world. See Figure 2.

All Panama Canal locks, including the new Third Set, operate on gravity. It means that there are no pumps as water from the Gatun Lake and from the higher locks flows into the lower locks and then the ocean by opening a set of valves. This is cost effective, efficient and virtually maintenance free.

All water to raise and lower the vessels comes from Gatun Lake. Gatun Lake in turn receives its water from rainfall, 1.5 billion cubic metres a year. With the completion of the third set of locks the water supply and the level of Gatun Lake became a concern. Droughts can jeopardise operation of the Panama Canal with major consequences for the world economy.

To reduce the amount of water that flows into each of the oceans with each passage, the Third Set of Locks was constructed with water-saving basins. Instead of the water from Gatun Lake flowing into the ocean, some 60 % flows into a basin and is reused for the next vessel passage. Figure 3 shows one of the existing locks on the right and the new Third Set, including the water saving basins, on the left of the picture.

Power delivery

In its 100 years the Panama Canal has seen upgrades. The original lock door gears have been replaced by hydraulic cylinders. In 2002 a new power plant was built near the Miraflores locks. Though not a recent project, the challenges faced are typical for projects in remote areas. The plant extension was 2 km from the locks. A 300 tonne diesel genset was to be delivered to the Miraflores power station.

The most obvious route (see Figure 4) was from the nearby Port of Balboa, 4 miles (6.4 km) away. Even though the canal was designed to accommodate immense vessels carrying 5,000 containers, >

ABOUT THE AUTHOR

Marco van Daal has been in the heavy lift and transport industry since 1993. He started at Mammoet Transport from the Netherlands and later with Fagioli PSC from Italy, both leading companies in the industry. His 20-year-plus experience extends to five continents and more than 55 countries. It resulted in a book *The Art of Heavy Transport*, available at: www.khl-infostore.com/books Van Daal has a real passion for sharing knowledge and experience and holds training seminars around the world.

FIGURE 2

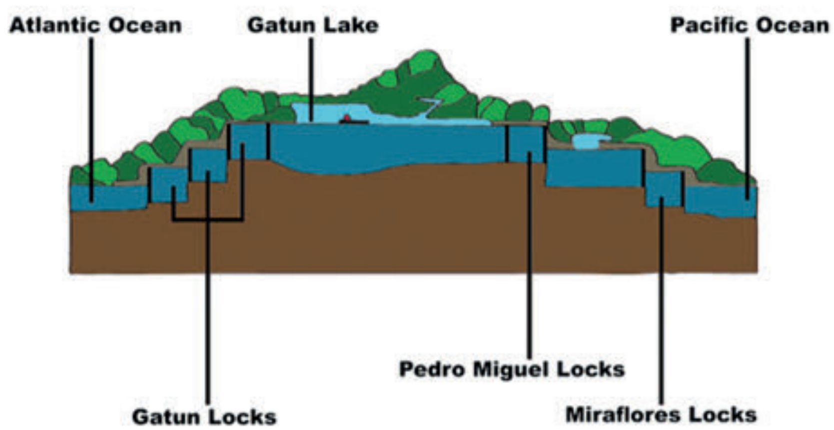


FIGURE 3

the infrastructure around the locks was nowhere near suitable for transporting heavy loads like a diesel genset. The other, less obvious, route was to discharge the genset while the heavy lift vessel was in one of the lock chambers, and shut down the Panama Canal in one direction during this discharge operation. The Panama Canal Authorities ACP (Autoridad del Canal de Panama) was not in favour of this option as a shutdown of the canal means a shutdown of the revenue stream. In addition, the discharge operation would be in front of the spectator bay and block the view for visitors. This, however, turned out not to be an issue as the audience was interested to see the discharge of the genset from close by.

Even though the total route was less than a mile it had its challenges:

- crossing a public parking lot
- a 180 degree hairpin turn
- a 15 degree downward slope
- a bridge crossing (built in 1901).

The crossing of the riveted bridge that was used as the supply route when the canal was under construction, was the most critical aspect in this route. We had to work our way back to a transport combination that would work for the bridge and then cope with the remainder of the route.

There were no reliable bridge drawings, at least none that we could get hold of. The next best thing was to visit the bridge and take on-site measurements and steel samples for analysis of the steel grade. Once this was known we could estimate the maximum allowable load that the bridge could handle and choose transport equipment accordingly.

From a stability and capacity point of view a 12-axle line SPMT would suffice to carry out the transport. The combined centre of gravity (CoG) height of the genset and SPMT was as follows:

$$CoGcomb = (M1*h1 + M2*h2)/(M1 + M2)$$

Where;
M1 = genset weight = 300 tonne
M2 = SPMT weight = 42 tonne
(PPU weight omitted)

FIGURE 4


h1 = CoG genset = 2,800 mm (above grade)
h2 = CoG SPMT = 1,200 mm

$$CoGcomb = (300*2{,}800 + 42*1{,}200) / (300 + 42) = 2{,}604 \text{ mm}$$

Hydraulic stability angle = arctan 483 / 2,604 = 10.5 degrees.

NOTE: the distance 483 mm in the formula is the allowable transverse distance that the combined CoG may travel to either side before it moves outside of the stability area. This distance is based on a three point suspension set-up of 8 axles each and the CoG of the genset positioned in the centre of the transporter. See Figures 5 and 5A.

With a recommended minimum stability angle of 8 degrees, the 10.5 degrees is well within the margins. Spreading out the load, however, over just 12 axles lines, would over stress the bridge construction. A minimum of 14 axles was required to stay within the bridge capacity. A 14-axle line SPMT weighs 49 tonnes.

FIGURE 5

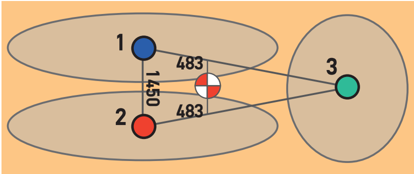

FIGURE 5A

This resulted in a new combined CoG of 2,575 mm. It did not have much influence on the new hydraulic stability angle of 10.6 degrees but had a much larger impact on the axle loads. These went down from 28.5 to 25 tonnes per axle line.

In reality a 16-axle line combination would have been preferable but would be too long to make the 180 degree hairpin turn. The option of changing configuration from 12 to 16 axle lines or from 14 to 16 axle lines at the bottom of the slope, just before entering the bridge, was reviewed but this would block the bridge access. As this bridge is still the only access road to the Miraflores locks for all supplies as well as all tourist traffic, this option was not approved by the Panama Canal Authorities.

While travelling down the 15 degree slope the transporter was hydraulically lowered in the rear and raised in the front. This gave the transporter deck an angle of 5.6 degrees so that the genset only leaned forward 9.4 degrees instead of 15 degrees. Dunnage and additional chains were used to prevent the genset from moving under the influence of this slope.

Transporter angle = arctan (13*axle distance / max deck height) =
= arctan (13*1.4 / 1.8)
= 5.6 degrees

Figure 6 shows the most critical part of the transport - the bridge crossing. Even though all engineering was properly carried out, it still was a critical transport. Transport restrictions in place included maintaining a constant speed without any stopping or acceleration. All other traffic was restricted from entering the bridge during the operation. Prior to the crossing spray paint was used to mark the transporter travel path to ensure that it would remain on the main bridge girders.

After the crossing the bridge was inspected and no damage or deformation was found. It did, however, make some sounds that are not normally made by a bridge. ■

FIGURE 6