Extreme crane upgrades

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The Panama Canal is being expanded. Jumbo-23 vessels are being constructed. This means larger ship-to-shore cranes will be needed at many terminals.

When a crane owner considers his options, he may be concerned that upgrading will not be feasible. However, extreme upgrades are often feasible. This article presents a recent crane upgrade study that included major modifications.

Background

A terminal operator is considering expanding his existing terminal to service larger vessels. The existing cranes are in good condition and can be productive for at least another 25 years, provided they are upgraded to service Jumbo-23 vessels. For operational reasons, the rail gage will be increased from 30 metres to 35 metres.

Liftech studied the modifications required to expand the existing cranes so that they may operate on the larger rail gage and service larger vessels.

Figure 1 shows the existing and proposed upgraded cranes – the existing crane in light green and the upgraded crane in dark green and red.

Approach

Several upgrade concepts were developed and evaluated to determine the most feasible upgrade solution considering cost and schedule. Cost and schedule estimates helped the owner decide whether to proceed with the upgrade or buy new cranes.

The owner also used the cost and schedule estimates to reexamine his original performance requirements. Some requirements were costly to implement with relatively little benefit and some were not costly but offered significant benefit. Consequently, the owner reduced or eliminated some desired features and increased others.

Significant upgrade considerations

The following section describes the significant issues considered for the upgrade options. An overview of the selected upgrade concept is shown in Figure 2 overleaf.

Quay – crane girder strength

Strength of the existing waterside crane girder was a concern. Initial upgrade concepts resulted in excessive waterside girder loads.

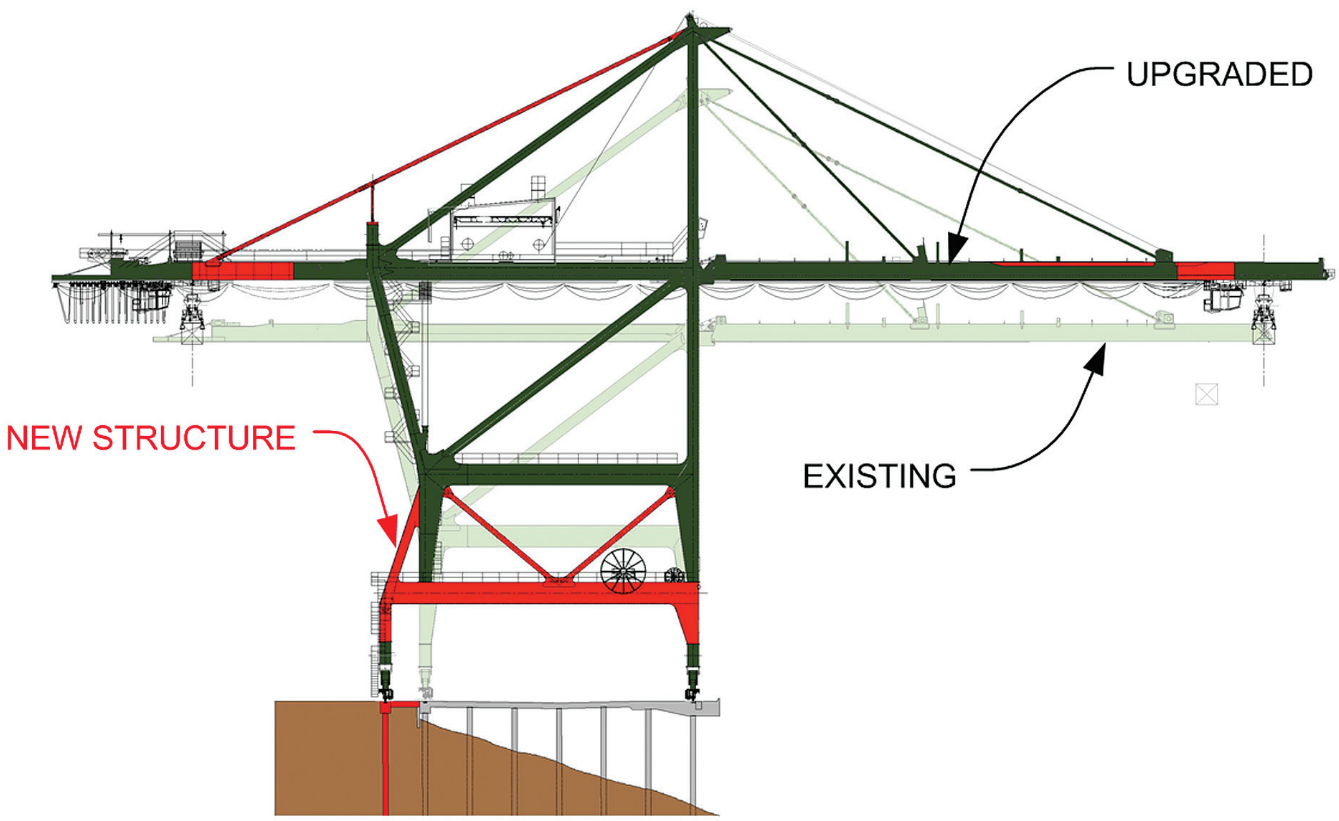

Figure 1. Existing and upgraded crane configurations.

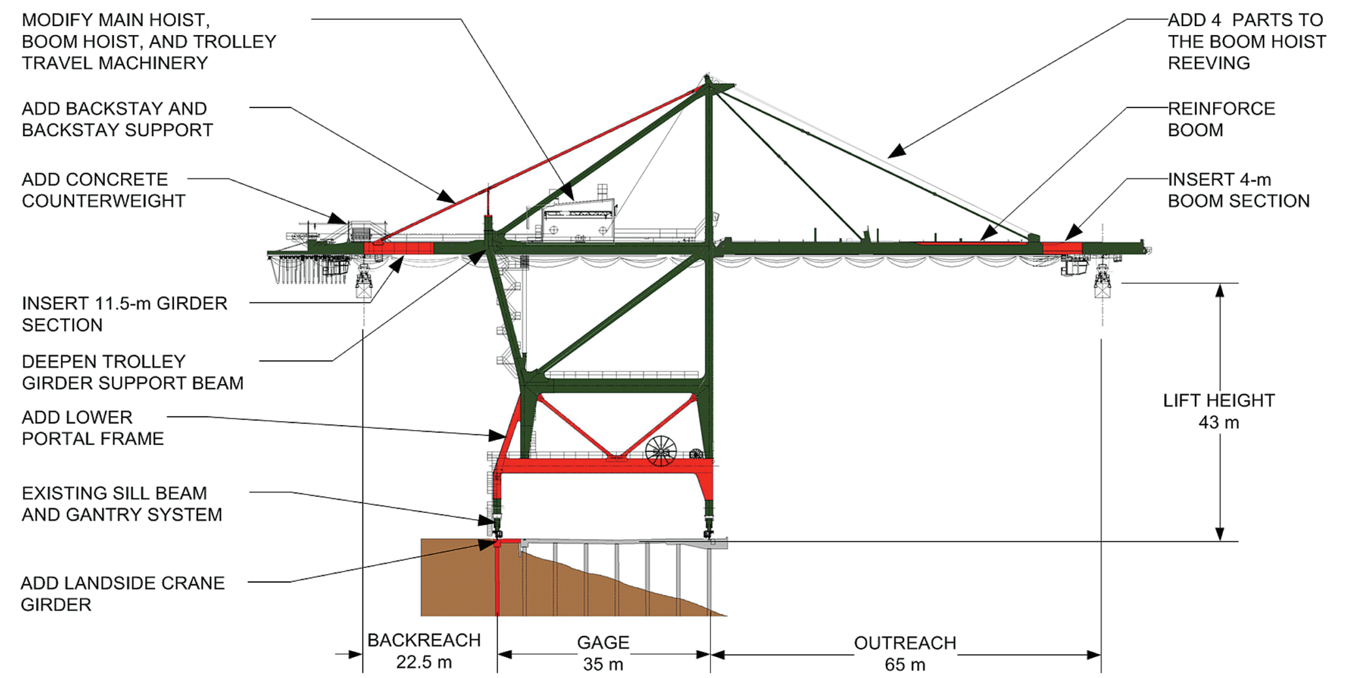

Figure 2. Selected upgrade concept.

The following options were investigated to reduce the waterside girder loads:

1. Placing the existing crane structure, the light green crane in Figure 1, toward the landside end of the lower portal frame
2. Relocating the machinery house farther landside
3. Reducing the outreach
4. Reducing the rated load at the full outreach
5. Adding a counterweight near the trolley girder end
6. Revaluating the existing crane girder strength
7. Strengthening the existing crane girder

Although the counterweight increases the landside girder loads and requires a new backstay, Option 5 is the most desirable, as the other options are more costly or do not meet the owner's needs.

Crane structure

Reinforcement of some fatigue sensitive components will be required, primarily due to the increased outreach. Cover plates will be added to portions of the existing boom, but some cover plates could be eliminated without reducing reliability by inspecting fracture critical details more often. The landside trolley girder support beam will need to be reinforced by deepening the existing beam.

A new backstay will be added to support the extended backreach and the new counterweight. Crane stiffness in both the gantry travel and trolley travel direction was considered during the design. For operation motions, the period of vibration in the trolley travel direction was limited to 1.5 seconds. The deflection in the gantry travel direction would increase, but still be acceptable according to the original design criteria. Therefore, it was not necessary to stiffen the O-frames or the boom.

Crane stability was found to be adequate for both operating and non-operating conditions. No additional ballast or tie-downs are required.

Boom hoist system

The longer, heavier boom increases the load on the boom hoist system. The existing crane used two sets of ropes, seven on each side, to lift the boom. Four hoist rope parts will be added to each set. The magnitude of this change is unusual. Typically, only two or three additional parts per side are added and, if necessary, a higher strength rope will be used. However, the existing boom hoist already uses high-strength wire ropes, so using a stronger wire rope was not an option.

The additional parts will increase the amount of rope wound on the drum. This extra rope could be accommodated in several ways: double wrapping the ropes, machining the existing drum for more grooves, relocating the rope dead end, or replacing the drum.

For this upgrade project the ropes will be double wrapped. This method involves a second layer of rope on top of the first layer. Double wrapping is usually avoided for heavily loaded, frequently wrapped and unwrapped ropes. Fortunately, the double wrapping occurs when the boom is nearly fully raised and the rope load is relatively light. Therefore, double wrapping is acceptable. This is a simple, common, and cost effective solution.

The additional rope length significantly increases the time to fully raise the boom. One method for mitigating the impact of the increased boom hoist time is to stow the boom at a partially raised position, such as 45 degrees from horizontal, to clear the vessel.

Main hoist and trolley travel systems

The greater lift height increases the length of the main hoist ropes. Unlike the boom hoist, the main hoist rope load is too large to double wrap. For this project, the additional rope length was accommodated by relocating the dead wraps to the ungrooved portion of the existing drum. A similar approach was used to adjust the trolley tow rope dead wraps for the longer trolley travel path.

Gantry travel and braking system

The gantry motors and brakes were evaluated for the increased vertical, wind, and inertial loads on the gantry travel system. Additional gantry motors and brakes will be provided for adequate performance. The equalizer system structure is adequate for the larger loads without reinforcement.

Summary

The project study indicates that even an extreme upgrade is feasible, and may be preferable to procuring new cranes.

ABOUT THE AUTHORS

Derrick Lind is a Liftech Structural Engineer and Associate, with 15 years of experience designing and evaluating various structural systems for commercial, industrial, and transportation facilities, including buildings, marine structures, wharves, bridges, and container cranes. His work includes structural analysis and design, supervising engineers, coordinating subconsultants' work, and managing project budgets and schedules.

Jonathan Hsieh is a Liftech Structural Engineer and Vice President, with 15 years of experience in design, review, analysis, and modification of container cranes, bulk handling cranes, and special structures. His expertise includes crane procurement, fatigue failure investigation and repair, and computer modeling and analysis. He has also worked on structural maintenance programs, seismic design of container cranes, crane instrumentation, and voyage bracing.

ABOUT THE COMPANY

Liftech Consultants Inc. is a consulting engineering firm, founded in 1964, with special expertise in the design of dockside container handling cranes and other complex structures. Our experience includes structural design for wharves and wharf structures, heavy lift structures, buildings, container yard structures, and container handling equipment. Our national and international clients include owners, engineers, operators, manufacturers, and riggers.

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