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New STS crane design is ABC

US crane consultancy Liftech Consultants Inc. has launched a new STS crane concept called the Articulated Balance Crane (ABC) as an alternative to traditional A-frame STS crane structures for terminals where wheel loads, tie-down loads or excessive maintenance at the boom hinge point are issues for crane owners.

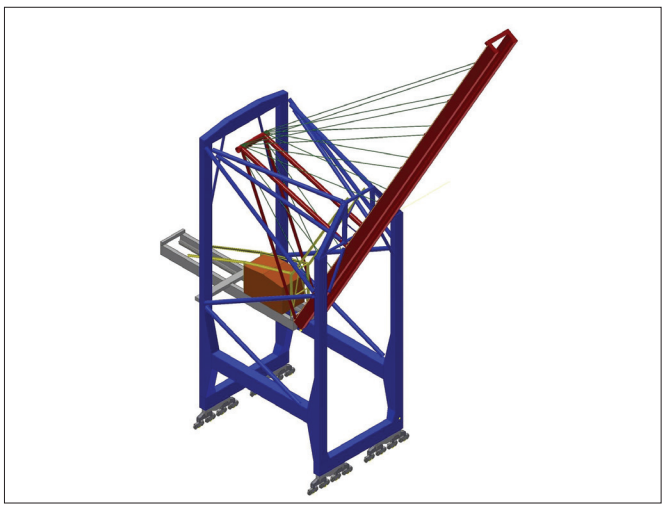
STS cranes have increased in size dramatically since the first A-frame crane structure was developed by Liftech's founder in 1959. However, despite outreach requirements growing to 68m+ and lift height requirements extending to 48m+, terminal operators still require cranes that are no wider than 27m between the buffers, with a 100ft rail gauge for existing terminals. Putting more and more crane structure on the same footprint increases wind and wheel loads significantly, particularly when the boom is in the stowed position, beyond what older wharf structures can accommodate in many cases.

With its ABC concept, Liftech has come up with a way to lower crane weight by approximately 8% within existing footprint restrictions, and reduce wheel loads on the crane rails when the crane is in the operating and stowed positions by as much as 15% – without radically changing the whole crane structure and mechanical systems.

The ABC features an elongated boom that extends back to the landside legs of the crane, with a shorter crane girder section that remains horizontal as it is lowered, as the boom rotates into the raised position for vessel clearance and stowage.

There are different options for the raising and lowering mechanism, including a machinery system that uses the same main components as a conventional boom hoist, but with a different rope reeving pattern, fleet angles, and sheave arrangement. On the waterside leg, Liftech envisages that the boom pivot point at the waterside shoulder beam would be similar to boom hangar connections used by some crane manufacturers in the industry today, which can be inspected and replaced if needed.

Other design features include a system for securing the crane girder at the raised and lowered positions. Liftech was involved in the design of the elevating girder crane in Virginia, which has an upper section that can be raised and lowered, and was built by ZPMC. Liftech expects that a similar pin insertion method could be used on the ABC to secure the girder to the landside leg for stowage.



Liftech's Articulated Balance Crane in the stowed position

Some design details, such as how the electrical cabling and personnel access would be managed need to be worked out with a crane manufacturer, but Liftech believes they can be met using existing components and without overly complicating the crane design.

Where the ABC design is a departure from standard crane design today is its use of 10 cable stays instead of two H-beam steel sections for the boom forestays. Liftech believes it is possible to use technology from cable-stayed bridges to incorporate lighter cable stays into the ABC design, without creating a potential corrosion problem, and without compromising the stiffness and deflection characteristics of a conventional forestay support system.

Liftech has not patented the new design, and is willing to work with users and manufacturers to put it into practice. See page 17 for full details.

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Reducing weight and wheel loads

Liftech's new concept for an Articulated Balance Crane can reduce the weight and wheel loads of very large STS cranes*

Ship-to-shore (STS) container cranes have increased in height and outreach to accommodate ever-increasing ship sizes, but the crane footprint has not changed much, especially in the crane gantry travel direction, parallel to the wharf. Consequently, wharf vertical loads due to crane lateral loads have increased significantly, resulting in large operating and stowed wheel loads and large stowed wind tie-down loads for stowed crane stability. The problem is more pronounced in typhoon wind regions and when a terminal wants to place larger cranes on an older wharf with limited crane girder wheel load capacity.

For many crane operators, maintenance of the rail joint between the crane trolley girder and the boom is a source of significant maintenance and cost.

Concept solution

To address these issues, Liftech is presenting a new crane concept, the Articulated Balance Crane (ABC). For operations, the ABC would function similarly to a conventional STS crane. For stowage, an elongated crane boom and upper works would rotate as a unit about hinges near the waterside legs, providing clearance for the vessel, while the machinery house and shortened trolley girder landside of the landside leg would remain horizontal but would translate in a downward arc. The net effect would be a stowed crane with a lower centre of gravity and reduced overturning moment due to stowed wind loads.

To evaluate the concept, Liftech redesigned a recent rope-towed trolley (RTT) STS crane model for the ABC concept and compared the crane weight, wheel loads, and stability of the two cranes. Liftech has only performed an initial evaluation of one RTT crane design, but the ABC concept could be applied to RTT or machinery-on-trolley (MOT) crane designs.

On a standard STS crane, the fixed trolley 'girder' extends from the landside of the crane to near the wharf edge and is supported under the landside and the waterside cross beams (trolley girder support beams). The 'boom' is supported by hinges at the trolley girder and by forestays that extend to the fixed apex supported by A-frame pylons over the waterside cross beam. This layout allows the boom to be raised, to provide clearance when ships arrive and when the crane must gantry past the ship bridge alongside the wharf.

The key to the new ABC concept is that the boom is continuous, extending from the boom tip to the landside cross beam, instead of the waterside cross beam. In the design concept, a shorter landside trolley girder, supporting the machinery house, is connected to the boom at the landside cross beam, and supported by a parallel linkage connected to the waterside cross beam.

In the ABC concept, raising the boom lowers the trolley girder, the machinery house, and the parked trolley. The boom is hinged to the frame at the waterside cross beam. The parallel linkage support of the trolley girder keeps the machinery house and trolley horizontal during the boom raising and lowering motions.

Depending on the crane geometry, the landside girder, machinery house, and trolley could be stowed near the height of the portal beam, with the boom raised near 60 degrees. In the stowed position, the trolley girder would be locked to the frame, either at the landside leg or at the portal beam.

In the ABC concept, raising of the boom and associated lowering of the trolley girder are controlled by standard boom hoist machinery with modified reeving between the machinery house, the main girder, and the landside cross beam. With the RTT ABC, proven trolley and main hoist designs that are used on standard STS cranes today could be used.

Aside from the parallel linkage support of the landside girder, the design of the longer boom is a key part of the concept. In the ABC concept design, 'A-frame' pylons rise from near the waterside pivot points on the twin boom girders and are slightly inclined to the landside so that the pylons clear the frame waterside cross beam. On a standard STS crane, these A-frame towers are stationary and are supported on the frame cross beam itself.

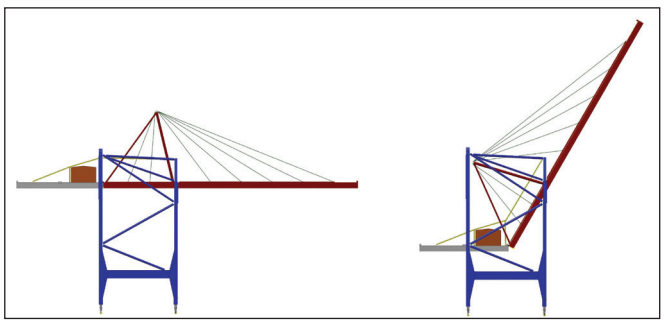
High lateral loads come from the main girder linkage into the waterside cross girder, and are transmitted by fixed struts that connect near the crane frame main pipe braces. To resist high bending moments, the ABC waterside cross girder is designed as a deep truss instead of a typical box girder. A side benefit of the deep truss cross girder and lighter boom is that the deflection in the crane travel direction at the outreach is expected to be less than that of a standard STS crane.

In the ABC concept, the connection of the pylons to the boom means they rotate with the boom and, when the boom is raised, the stays supporting the waterside part of the boom do not need to fold, unlike on a standard STS crane. In the stowed position, the top of the pylons, the 'apex beam', is near the landside cross beam. With this concept, the boom is similar to a cable-stayed bridge with one pylon.

Cable stay design

The ABC concept uses multiple stays to support the boom, with five pairs of steel wire cable stays to support the waterside portion of the boom, and two pairs of stays to support the landside portion. On a standard STS crane, two pairs of heavy steel 'H-beam' sections are used for the forestays. The use of many stays should result in a lighter boom structure per unit length, and the total weight of the 10 stays is expected to be comparable to the total weight of the four conventional steel H-beam forestays.

Cable stays were used to support boom structures on early container cranes, but were no longer used in the 1970s due to concerns about corrosion and deflection. Since then, significant advances have been made in the design and construction of cable stays and the end fittings. In particular, high-density fully locked cables, significantly stiffer than standard wire ropes, and corrosion resistant end fittings and coatings have been developed for cable-stayed bridges.



The operating and stowed positions of the ABC concept

Test crane evaluation

Liftech had already analysed a recent STS crane structure sized for operating alongside a 23-wide container vessel. The crane had a 30.5m rail span, 68m outreach, and 48m lift height, and was designed for a typhoon (hurricane) region for storm wind. In our evaluation, we redesigned the existing crane model for the new ABC concept and sized all structural members to the same design criteria used for the standard STS crane.

In the evaluation, Liftech calculations indicate that, with the same design criteria, the ABC should be lighter and should have an improved weight distribution, smaller wheel loads and tie-down loads for the stowed condition, and smaller waterside operating wheel loads. The ABC may have slightly higher landside operating wheel loads, but the landside stowed wheel loads should control the design and should be smaller than for the STS crane.

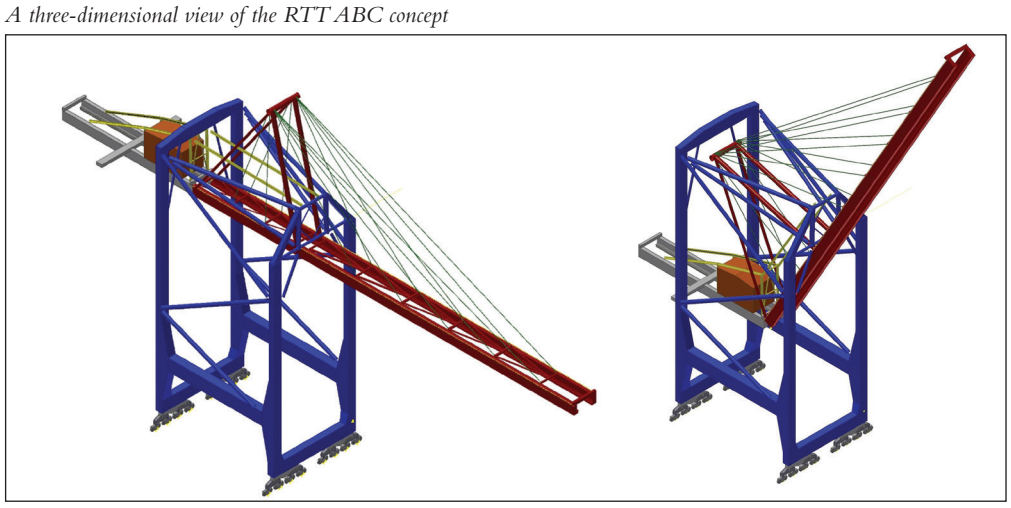
The evaluation indicates that the ABC total weight could be approximately 8% lighter than the standard STS crane, and the boom structure over the water would be 20% lighter. Calculations also indicate that lowering the girder, machinery house, and A-frame also reduces stowed wheel loads and improves stability.

The accompanying table presents a comparison of estimated service (ASD) level wheel loads and factored (LRFD) level tie-down loads for the RTT ABC concept and standard STS crane.

The trolley travel direction stiffness of the RTT ABC concept is expected to be comparable to that of a standard STS crane. Calculations indicate that the lateral deflection in the gantry travel direction at the outreach would be approximately 30% less than that of the standard STS crane. The vertical deflection at the outreach of the ABC concept would be higher than the standard STS crane, but is expected to comply with normal industry standards.

The Liftech preliminary evaluation of the RTT ABC is based on a complete stress and fatigue analysis of the primary structure, including a second order analysis of the behaviour of the stays with the boom in the raised position for storm wind. The ABC analysis methodology and design criteria are similar to those Liftech has performed for hundreds of STS cranes operating worldwide. Liftech encourages crane operators to consider the ABC concept for their facilities. ❑

A three-dimensional view of the RTT ABC concept



**This article is written by Simo Hoite, Kenton Lee, and Lu Yan, at Liftech Consultants Inc. Liftech has added the following disclaimer: "Liftech is presenting this new crane concept as a practical alternative design where wheel loads, tie-down loads, or excessive maintenance at the girder-boom joint are significant limiting factors for crane owners. The concept will need further detail design and development by the selected manufacturer. Liftech is not patenting the design, but if it is used, requests that users acknowledge Liftech's contribution and to work with Liftech to help refine the concepts and details".*

ABC concept relative to standard STS crane

	Service wheel loads		Tie-down loads
	Operating	Storm	
Waterside	15% lower	7% lower	20% lower
Landside	7% higher*	15% lower	5% lower

**Storm condition controls. Source: Liftech*

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