New concepts for future wheel equalization system

Michael Jordan, Chief Structural Engineer, and Erik Soderberg, President, Liftech Consultants, USA, explain the thinking behind the Future Wheel Equalization System.

The wheel loads of STS and other cranes have traditionally been "equalized" using a cascading series of beams and pins. The main and sub-equalizing beams are massive, heavy, and problematic. Loads to the wharf are great. Were cascading beams a good solution? Yes, at the time. Rail joints were bolted and the base was cementitious grout. Joints slipped, the grout failed; vertical rail offsets were as much as 30mm. Now, joints are welded and the base is epoxy grout. Construction tolerances are much better. Consequently the vertical differential between eight wheels is only a few millimeters. Since the problem has changed - the rails are nearly level - it is time for a better solution. Cascading beams are unnecessary. Even more important, crane leg loads are larger now and will be much larger when mega cranes are developed to produce the moves demanded by mega ships. As we learned from FastNet, the traditional equalizer systems are not practical for extreme leg loads. If the loads are so great that multiple rails are necessary, a new equalization concept is required.

New concepts

Liftech has developed two new equalization concepts for cranes:

1. A linkage system
2. An elastomeric bearing system

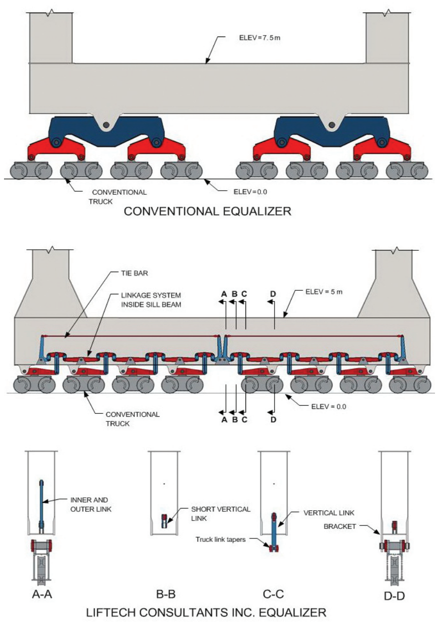
With both concepts, no cascading equalizing beams are required. The trucks are connected directly to the crane sill beam. The concepts reduce cost and weight. The height of the system is reduced, so the top of the sill beam is lower, improving container operations. Prying and bending in the components due to lateral loads are significantly reduced. Connections are simpler. If multiple rails are needed, the concepts will allow the sill beams to rotate about the rail axis without special articulation devices. The concepts can be applied to other cranes with large corner loads, such as Goliath shipyard cranes. The new concepts will not only save work and materials, but also reduce the potential of structural fatigue cracking. If for any reason a truck develops problems while the crane is operating, the vertical link can be locked. The load to each of the remaining seven wheels will increase by 14 percent. The crane can continue to operate with this overload until the truck can be repaired. The concepts are simple; but, as with all new ideas, it will take some time for the ideas to be fully understood and for engineers to get used to a very different approach to a new problem.

A linkage system

The linkage equalizer system shown is a refinement to the wire rope equalizer system used on FastNet cranes and waterside girder supports. The FastNet concept uses ropes and sheaves. The concept presented here uses links and tie rods. The principles of the wire rope and linkage mechanisms are the same. The trucks are conventional.
A horizontal link extends from a bracket under the sill beam to the truck pin to the first vertical link. Nearly all of the truck load travels directly to the sill beam. The share to the vertical link is a fraction of the wheel load, so the linkage components are relatively small. Construction tolerances for the truck pin and the horizontal link need to be as strict as they are now for the conventional system. The tolerances for the rest of the linkages can be relaxed. If a truck needs to be removed, the vertical link can be locked in position so the truck will be unloaded. The other trucks will still be equalized. The unloaded truck can be removed or be inactive until repairs can be made. The crane can continue to operate with a small and acceptable overload in the active trucks.
The sketch shows one row of eight wheels in one line. However, with an additional linkage, two or more lines of fully equalized wheels can be used. So, instead of eight wheels per corner there could be 16 or more. FastNet has 16 wheels for each "corner." Since all of the wheels in multiple rows are fully equalized, the sill beam can rotate about an axis parallel to the rail without special trucks or mechanisms. Multiple rows allow the rails to be separated, which improves the load distribution to the piles. The vertical link load is transferred to the articulated links inside the sill beam. A tie bar between the outer links completes the system. If multiple rows of wheels are used, an additional linkage at the ends of the tie bars can equalize multiple sets of tie rods. The short vertical links inside the sill beam, although not needed for the mechanism to work, allow for considerable tolerance of the internal bracket location and the small horizontal dimensional changes due to link rotation.

Other issues

- The rotating bearings can be lubricated from a manifold located outside the sill beam. This could be automated.
- The forces and moments in the sill beams are no greater than in a conventional system. The effects of lateral rail loads are smaller.
- The sill beams can be narrower.
- The electrical and communication wiring passes from the bottom of the sill beam directly to truck.
- A damper could be installed in the tie rod, so the crane would be base isolated. This will significantly reduce earthquake forces at a small cost.
- In the rare case where there are significant differences in the elevation of landside and waterside rails along a wharf, a screw jack could be used to keep the crane level. WPD



World Port Development would like to thank the authors of this article. Two new concepts for wheel equalization were mentioned - this article detailed the Linkage concept - the second concept - an elastomer bearing system will be explained in a future article.