Reducing the Environmental Impact of Quayside Cranes on Neighboring Communities

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Introduction

The continuing growth of marine container terminals is causing increasing environmental concerns among neighboring communities. The increasing container volumes have resulted in increased truck traffic and larger and faster container handling equipment. The higher truck traffic has raised concerns about diesel fumes and traffic congestion. The larger cranes have raised concerns about noise levels and visual impact. The increase in number and size of the cranes and the encroachment of the terminals and the neighboring communities on each other exacerbate the problem.

This paper examines the environmental impact of the ever-increasing size of dockside container cranes on neighboring communities and presents potential solutions to reduce the impact. The paper focuses on reducing the noise levels generated by the crane operations and reducing the visual impact of the large cranes.

The paper also presents case studies demonstrating designs that reduce the noise levels and visual impact of large cranes. The noise reduction technology was recently applied to new cranes in Amsterdam and other European ports. The visual impact of large cranes is currently being studied at the Port of Los Angeles. The Port of Los Angeles study also demonstrates how high level graphics is used to communicate the impact of the large cranes.

Noise

For the neighboring communities, dockside container cranes are a primary source of noise in a container terminal. Noise generated by other activities, such as the straddle carrier operations and setting spreaders on containers, is mostly contained within the terminal. The discussion below focuses on the noise generated by dockside cranes.

A typical dockside crane with no noise abatement treatment generates a sound intensity level of approximately 110 dB(A) at the source, which is equivalent to 65 dB(A) at 60 m from the source, approximately the noise level of freeway traffic. The primary noise sources for a dockside crane are hoist equipment and fans in the machinery house, trolley drive equipment for machinery trolley cranes, and web vibrations of the girder and boom structure.

Case Study: Ceres Paragon Terminal in Amsterdam

The Ceres Paragon Terminal in Amsterdam is located across the channel from a residential community. See Figure 1 and Figure 2. The community was concerned about the increased noise levels of the terminal, so Ceres used existing technologies applied in new ways to reduce the noise. Each piece of equipment and each container handling activity at the Ceres Terminal was assigned a certain noise level. Each dockside crane was required to meet a noise level of 55 dB(A) at 60 m from the crane, approximately the noise level of street traffic or a large office. This meant a reduction of approximately 10 dB(A) in the total noise level of each crane. Recall that decibels are a log measure, so a 10dB reduction is a 10^{10} reduction of intensity.

Figure 1: Terminal and Surrounding Neighborhood

Figure 2: Ceres Amsterdam Dockside Container Cranes

The following noise abatement strategy was used to reduce the noise level by 10 dB(A).

Machinery House: Sound-absorbing panels in the walls, roof, and floor; narrow insulated rope openings; isolation pads for machinery and plugs for hatch openings.

Trolley Drive: Rope towed trolley, eight wheels to reduce wheel load, and buffers to reduce wheel noise. See Figure 3 and Figure 4.

Girder and Boom: Stiffened web panels.

Festoon Trolley: Polyurethane wheels and isolated supports.

The Ceres cranes are the quietest cranes capable of serving 22-wide vessels. The noise abatement strategy resulted in only a minor increase in the cost of each crane.

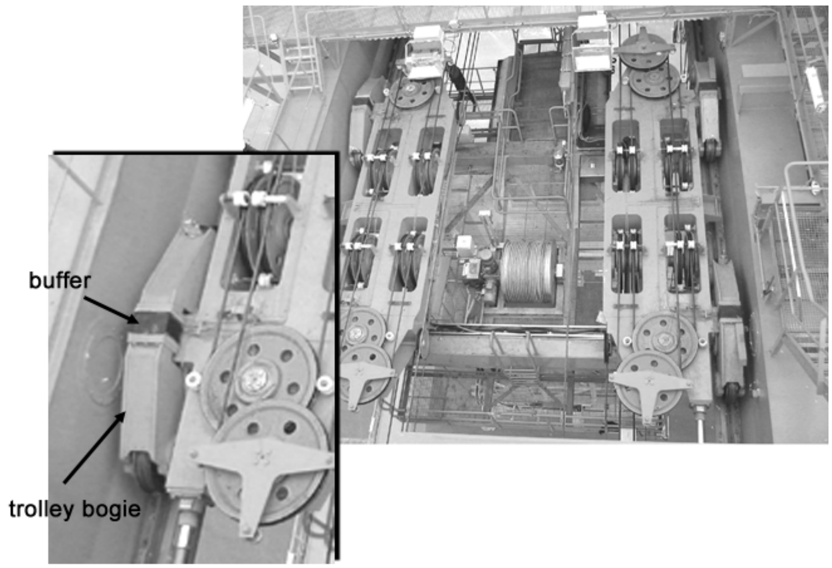

Figure 3: Ceres Trolley

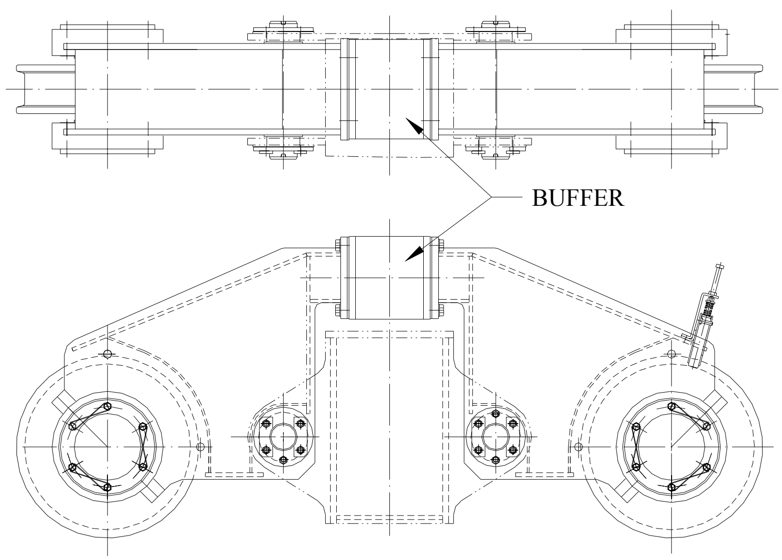

Figure 4: Ceres Trolley Bogie Drawing

Visual Impact

Dockside container handling cranes continue to grow in size in response to ever-increasing container ship size. The increased vessel size requires a greater number of cranes to service the ship. In addition, as ports and communities expand, they find that they are growing closer to each other. In some cases, these factors result in the cranes replacing the usual waterfront skylines. Many ports are finding that the neighboring communities are objecting to the increasing number of large cranes blocking their views.

__Reducing the Visual Impact__

Since the global economy requires the continued use of containerization, we must find ways to reduce the visual impact of the cranes while maintaining productive ports. The remainder of this section identifies possible solutions and discusses the features of each solution, which are summarized in Table 1. Since every port has a different geographical interaction with its community, as well as different operation requirements, each port will need to evaluate how the pros and cons relate to their situation.

Different people perceive the visual impact of the large cranes differently. Lower profile cranes may be a solution for some, while softer paint schemes that blend with the water and sky may be a solution for others. This paper addresses the various crane configurations as options for reducing the visual impact.

Alternate Crane Configurations

Conventional Cranes

Conventional cranes are of a modified A-frame configuration. Recent cranes have an overall height of 110 m with the boom in the raised position, and are 138 m long with the boom in the operating position. The booms on earlier cranes were fully raised to clear ships while berthing and to keep the channel unobstructed for ship traffic. Booms on recent cranes are normally stowed at 45 degrees, which is tall enough to clear the berthed vessels. The overall height of the crane with the boom at 45 degrees is about 90 m. See Figure 6.

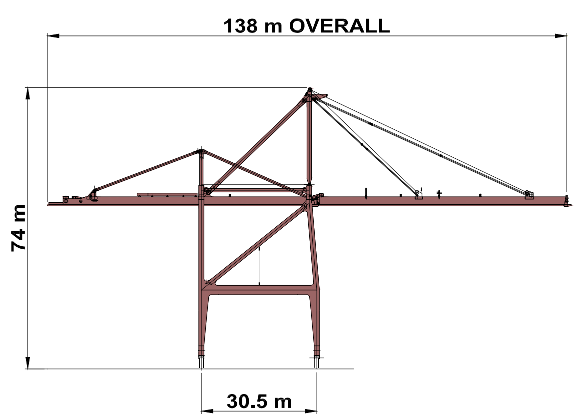

Figure 5: Conventional Crane Operating Mode

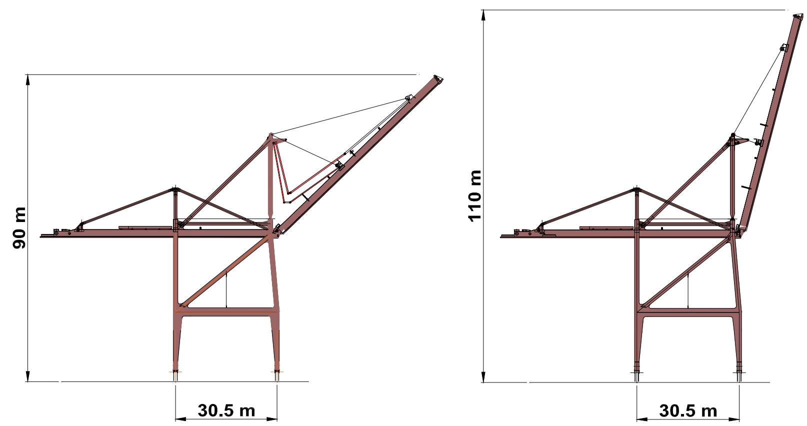

Figure 6: Conventional Crane Stowage Modes

<u>Articulated Boom Cranes</u>

Articulated boom cranes are similar to conventional, straight boom cranes except the boom forms an inverted L shape when raised. The inner boom section is nearly vertical when raised and the outer section is nearly horizontal. Articulated boom cranes were developed as a lower height crane to meet aircraft clearance requirements. The overall height of an articulated boom crane is about 75 m. See Figure 7.

Since the only difference between a conventional crane and an articulated boom crane is the configuration of the boom; the weight, wheel loads, and tie-down forces are very similar to a conventional crane. There is slightly more maintenance involved with the articulating parts of the boom.

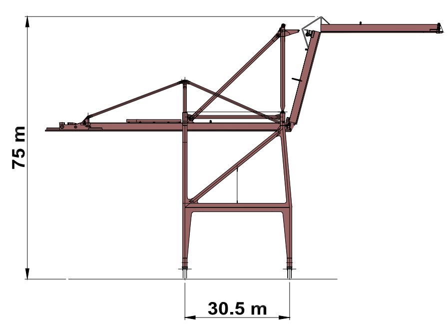

Figure 7: Articulated Boom Crane

<u>Low Profile Cranes</u>

Low profile cranes feature a shuttle boom that moves in and out for operating and stowed modes. The trolley runway is located in the lattice shuttle boom that rolls on supports inside the frame. Low profile cranes were developed to meet restrictive aircraft clearance requirements. The overall height for a 22-wide low profile crane is approximately 54 m. See Figure 8.

Since about half of the weight of a low profile crane is in the boom, the center of gravity of the crane shifts dramatically when the boom moves from operating to stowed mode. Because of the shift in weight, the crane often needs ballast for operating stability, and also to provide enough weight to get the traction required to drive the gantry wheels on the lighter side. The result is a heavier crane with higher wheel loads and tie-down forces. The machinery house could be moved in opposite direction to the boom motion to reduce the wheel loads.

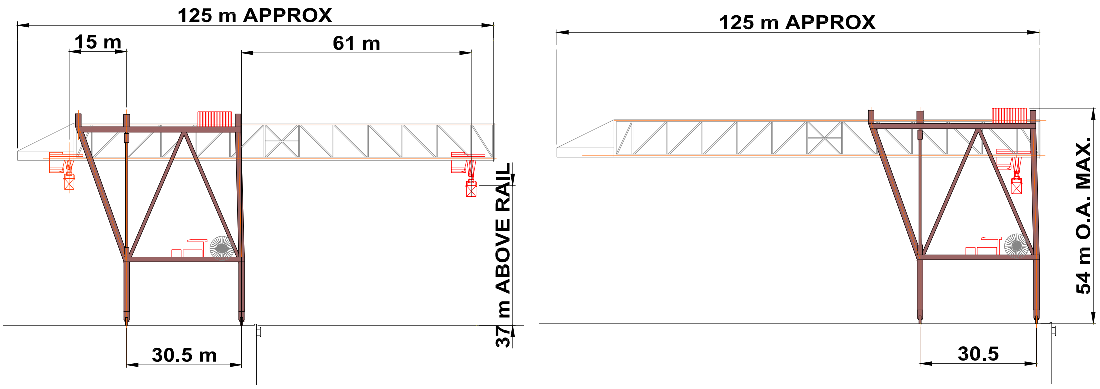

Figure 8: Low Profile Crane Operating and Stowed Modes

<u>Mobile Harbor Cranes</u>

Mobile harbor cranes are typically used for small to medium sized ports. These cranes can be rail mounted similar to conventional cranes, or mounted on rubber tires or crawlers and moved around the terminal. The cranes operate by swinging a large boom over the ship and rotating the boom with load back to the land. The hook attachments are relatively easy to change, and thus the cranes are especially useful at facilities that handle both container and bulk cargo. The overall height of a mobile harbor crane in the maximum height configuration is approximately 98 m. See Figure 9.

The productivity of a group of mobile harbor cranes (lifts/crane-hour) is about half of that of a group of conventional cranes. This is partially due to the speed of the operation, and partly due to the limited number of cranes that can safely operate on one ship.

The load rating of mobile harbor cranes reduces as the boom outreach increases.

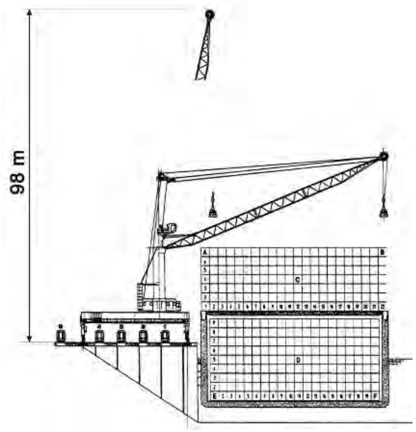

Figure 9: Mobile Harbor Crane

Table 1. Features of Alternate Crane Configurations

Crane Configuration	Pros	Cons
Conventional A-Frame	Least expensive Lowest wheel loads May not require tie-downs	Highest profile with boom stowed nearly vertical or at 45 degrees
Articulated Boom	Nominal cost increase Wheel loads and tie-downs similar to conventional cranes	Lower height than conventional A-Frame crane, higher than low profile crane
Low Profile	Lowest height	Significantly more expensive Higher wheel loads May require tie-downs
Mobile Harbor Cranes	Can handle container and bulk cargo Less overall height with boom lowered	Higher profile with operating booms than low profile cranes Not suitable for 22-wide operations Lower productivity and higher cost per box for large terminals

Evaluating the Alternatives

There is no one right solution for reducing visual impact. The right solution for a small port in a rural area will be different from a large port in an urban area. Each port that faces this problem should study the alternatives and how they relate to their situation.

One of the challenges is how to evaluate the subjective aesthetic appeal of these alternate crane configurations without spending millions of dollars for a prototype. Use of graphic renderings can assist in this process greatly. In addition, the graphic renderings can help evaluate the effect of changing paint colors.

The Port of Los Angeles is involved in the process of reducing the visual impact of their cranes on the neighboring communities. The following case study demonstrates one approach to evaluating the alternatives.

Case Study: Port of Los Angeles (POLA)

The Issue

Some members of the neighboring community felt that the four new conventional A-frame cranes at the existing Berth 100 at POLA interfered with the view of the Vincent Thomas Bridge. The cranes are capable of serving 22-wide vessels. POLA has undertaken an extensive study to evaluate different alternatives that will meet their productivity needs while addressing the community needs regarding the visual impact of the new cranes (Liftech, 2003; and POLA, 2003).

The Study

The process involved studying the various crane configurations with the community, and narrowing the alternatives to low profile cranes and mobile harbor cranes. POLA then invited and evaluated priced proposals for both types of cranes. This process resulted in the Port choosing low profile cranes for further study.

POLA used graphic renderings to give the Port and the community a realistic view of how low profile cranes would look compared to the conventional cranes. Figure 10 shows a photo of the terminal with six existing cranes and graphically added new conventional cranes in the foreground. Figure 11 shows the same photo, with two new low profile cranes instead of the conventional cranes.

Figure 10: Evergreen Terminal at POLA with Rendered Conventional Cranes

Figure 11: Evergreen Terminal with Rendered Low Profile Cranes

Wheel Loads, Tie-downs, and Stability

The geometry and capacity of the low profile cranes to be studied are comparable to those of the cranes ordered for Berth 100. The low profile cranes result in wheel loads exceeding the allowable wheel loads and require tie-downs at waterside. POLA included in their study the cost of upgrading the wharves to meet the higher loads.

Initial study showed that the cranes with the boom retracted may tip over backwards under the design seismic loads. POLA is investigating this further with a detailed crane-wharf interaction analysis, moving the machinery house opposite to the boom motion, and applying base isolation technique to the boom support.

Notes on Graphic Rendering

The visualization process involves adding computer generated models of the cranes in a photo of an existing terminal. The crane must be realistically modeled, and is usually constructed from electronic plans. Paint schemes can be applied to the crane, allowing different color combinations to be tested out at relatively little cost.

The crane needs to be placed in a real world frame of reference. Two points need to be identified: the position of the crane on the terminal and the position of the virtual camera. If an existing static photo is to be altered, it is important to understand the location of the camera that generated the photo, as well as the time of day and the approximate position of the sun. Figure 12 shows an aerial photograph that was used to indicate the position of a camera used to photograph existing dock cranes.

Figure 12: Example Camera Location

Once one or more crane locations and camera positions are identified, a 3D modeling program is used to take a virtual photograph, of a new crane from the correct point of view. This process is called rendering. The rendered image can be merged with the existing background. Figure 10 and Figure 11 show the result of this process.

The techniques described above can also be used to generate virtual drive-bys or fly-bys by defining a camera path and rendering a large number of frames from slightly different angles and then merging them together to generate an animation. These types of tools can be very valuable resources to help educate everyone involved with a new crane purchase, from port commissioners to the local community, about the potential aesthetic impact of a new crane purchase.

Conclusion

The ever increasing size of terminals and cranes is causing more interaction between the ports and their communities. More and more ports find themselves trying to balance their needs with the community's needs. The crane noise can be reduced significantly at a nominal cost. Visual impact of the cranes is subjective and dependant on the viewer's location. The height of the conventional cranes may be objectionable to some, particularly from a distance, whereas others may find the low profile cranes objectionable. The low profile cranes may not be suitable for existing berths. The articulated boom cranes may provide a visual balance. Certain color schemes may also help reduce the visual impact of the cranes. The modern graphical capabilities provide an inexpensive tool to study the various alternates.

There is no one solution to any problem. Each port must look at its own needs and the needs of the community to find a viable, economic solution to the problem, and the ideas presented in this paper may help the ports in their endeavors.

References

Liftech Consultants Inc. *Low Profile Crane Study, Port of Los Angeles*. Los Angeles: POLA, 2003.

Port of Los Angeles Engineering and Construction Management Division, et al. *Low Profile and Mobile Harbor Crane Study*. Los Angeles: POLA, 2003.