Best Practices for Bridge Crane Implementation and Installation: A Case Study

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Overhead Cranes, which are more commonly referred to as bridge cranes, provide a substantial amount of flexibility with respect to the user's ability to move material and heavy equipment throughout a factory or manufacturing facility. Oftentimes, the client is not aware of the benefits of implementing bridge cranes rather than using mobile gantry cranes. The client may not be aware of the benefits of bridge crane installation occurring at the beginning of a project or in fact, including it in the initial design of the project, rather than considering it in the middle of the project. This case study will discuss the advantages of implementing the use of bridge cranes rather than gantry cranes. Additionally, the case study will discuss the benefits of installing bridge cranes at the beginning of a project so that they can be used to install heavy equipment. It will also address the issues that occur if the client decides upon a bridge crane installation during or after the manufacturing facility is built out and fully functioning. The overall objective of this case study is to inform current and future industry members, as well as educators, of the best practices for bridge crane implementation and installation.

Key Words: Overhead Cranes, Gantry Cranes, Bridge Cranes, Bridge Crane Installation

Introduction

The use of cranes is quite prevalent in construction, manufacturing, and shipping applications. There are many different types of cranes including tower cranes, gantry cranes, crawler cranes, bridge cranes, and hammerhead cranes. These cranes differ in their mobility, locational usage, operation, and control system. Cranes have varying amounts of mobility including permanently affixed, fully mobile, and semi-mobile. For example, a shipyard crane is generally permanently affixed, a gantry crane on wheels is fully mobile, and a bridge crane or overhead crane, which runs on a fixed overhead track, is semi-mobile. There are both indoor and outdoor cranes that possess unique space requirements and applications to best serve the specific industry for which they function. Indoor cranes are used to move material around within a building. Indoor mobile cranes are usually gantry cranes on an A-frame with wheels so they can be moved around where needed. Outdoor cranes, such as those used in manufacturing and shipyards, can be gantry cranes that use a hoist on a trolley between two beams on elevated or ground-level tracks. Both indoor and outdoor cranes can be bridge cranes that run on an overhead track or gantry cranes that can run on wheels or run on a track on the floor. Regarding control systems, cranes can be pendant-controlled, remote-controlled, automatic, or cab-operated. Crane Manufacturers Association of America (CMAA) provides a rating system in which each type of crane is rated based on hoists per hour and on a percentage of those hoists compared to the crane capacity (American Society Of Mechanical Engineers, 2011).

Objectives

The objectives of this case study are as follows:

- To discuss the advantages of using bridge cranes versus mobile gantry cranes.
- To highlight the advantages of installing bridge cranes at the beginning of the design-build project to maximize efficiencies.
- To emphasize the importance of a proactive process for bridge crane installation.
- To discuss the issues associated with installing bridge cranes after the manufacturing plant is operational and most of the build-out has already been completed.

Methodology

This case study uses primarily qualitative research collected through multiple primary sources, including government publications, industry standards reports, and interviews. Secondary sources, including website articles, are also used. A substantial portion of the primary information was obtained by interviewing four individuals from the General Contractor after their project had been completed. The General Contractor is a company listed in the top 20 on the Engineering News-Record "ENR 2020 Top 400 Contractors" ("ENR 2020 Top 400 Contractors," n.d.). The individuals interviewed at the General Contractor about the confidential project included the Senior Project Manager, Project Manager, Superintendent, and Project Engineer.

General Background

Gantry Cranes

There are many different types of gantry cranes that can be utilized in a wide variety of industries. The American Society of Mechanical Engineers defines a gantry crane as, "a crane similar to an overhead crane except that the bridge for carrying the trolley or trolleys is rigidly supported on two or more legs running on fixed rails or other runways" (American Society Of Mechanical Engineers, 2011, p.2). A gantry crane is usually supported by two steel A-frame legs which are either on fixed rails or on wheels. For this case study, a gantry crane will be defined as a portable gantry crane which is a gantry crane that runs on casters or rubber wheels that is not affixed to a rail system.

Figure 1. Common Types of Gantry Cranes ("Gantry Crane Basics," n.d.).

Advantages of Gantry Cranes

One of the main advantages of gantry cranes is that they are very versatile and may have adjustable spans and heights. Of course, the benefit of gantry cranes on wheels is that they are mobile, therefore the user is able to move the gantry crane with its load anywhere in the factory or warehouse thus reaching all corners of the plant or factory ("What is a Gantry Crane? A Closer Look at the Different Types and Design," 2018). Additionally, the rolling gantry can be moved outside of the factory if there are sufficient ramps for egress. Another advantage of portable gantry cranes is that they can be moved out of the work area when not in use or transported to another factory or manufacturing location. Some gantry cranes can be easily disassembled for storage or transportation purposes. A gantry crane is generally easy to assemble and does not require permanent installation; therefore, it is beneficial if the user is renting or leasing a facility ("Gantry Crane Basics," n.d.).

Disadvantages of Gantry Cranes

One disadvantage of using portable gantry cranes is that usually two employees are required to move the portable gantry crane, one on either side of the crane. If the load of the item being transported is quite heavy, it may be difficult for two employees to move the crane, and it may be difficult to move at a constant rate so that the load does not swing back and forth or tip over. Moving a fully loaded gantry crane also requires a free and clear path along which the crane will be moved, which may be difficult in a fully functioning factory.

Gantry cranes can also pose substantial safety issues. For example, on rough or uneven surfaces, such as asphalt, it may be difficult to roll the gantry crane. Per OSHA reports regarding injuries related to gantry cranes, there have been 40 reportable accidents involving gantry cranes since 2003 (Occupational Safety and Health Administration, n.d.-c). There were substantially more injuries and fatalities caused by gantry cranes than bridge cranes. In fact, since 2003 there have only been 12 reportable accidents involving bridge cranes. Based on this data, gantry crane reportable accidents are approximately three times more likely than bridge cranes reportable accidents (Occupational Safety and Health Administration, n.d.-b).

For example, Accident #202350989 involved an employee who was moving a heavy engine and transmission in a salvage yard with a portable gantry crane. One of the caster wheels got caught in a "shallow depression in the ground. The momentum of the portable gantry crane which was moving the auto engine and transmission caused it to topple over striking [the] employee on the head." Unfortunately, the employee died of his injuries (Occupational Safety and Health Administration, n.d.-a).

Due to the fact that injuries and fatalities result in OSHA fines, workers' compensation claims, lawsuits, and low employee morale, companies may favor the benefits of bridge cranes over portable gantry cranes if bridge cranes are able to meet the needs of the company.

Bridge Cranes

There are many different types of bridge cranes that can be utilized in a wide variety of industrial applications. An overhead crane or bridge crane is defined by the American Society of Mechanical Engineers as, "a crane with a single or multiple girder movable bridge carrying a movable or fixed hoisting mechanism and traveling on an overhead fixed runway structure" (American Society Of Mechanical Engineers, 2011, p.2). One of the key components of the bridge crane is the bridge beam of the crane. The bridge is defined as, "part of a crane consisting of one or more girders, trucks, end

ties, footwalks, and drive mechanism, which carries the trolley or trolleys" (American Society Of Mechanical Engineers, 2011, p.2). A bridge crane system is typically supported by either its own independent structure or it is connected to the building's existing structural members. Usually a newly designed building will be designed with the crane in mind and the bridge will be attached to the building's structure. When bridge cranes are installed in an existing building, the structural engineer will typically design the bridge crane to have its own free standing steel structure.

Figure 2. Common Types of Bridge Cranes (Dongqicrane, 2016).

Advantages of Bridge Cranes

One of the main advantages of bridge cranes is that they can be operated by just one employee. Additionally, due to the fact that the bridge crane is installed overhead, there are no issues with the need for a free and clear path along which to roll the crane. There is no need to worry about obstructions on the factory floor as the bridge crane can lift the load high over any obstacles. Bridge crane structures can be attached to the wall or on beams along the wall so as to minimize floor space interference. Bridge cranes can operate at high speeds as they are not pivoting or swinging thereby allowing loads to be moved more quickly. Bridge cranes have high stability due to the rigid runways used, so there is no shaking or shuddering. As a result, there is less risk of a load shifting or falling, unlike with portable gantry cranes which are less stable. Bridge cranes usually come with precision controls that allow a load to be placed with precision and without positioning errors. Ultimately, this saves time because small adjustments for correct load positioning are not required ("Uses and Benefits of Overhead Cranes," 2016). These cranes can also be easily customized by adding many accessories including lifting beams, spreader beams, roll & coil lifters, tongs, sheet lifters and pallet lifters ("The Benefits of Having an Overhead Bridge Crane," 2015)

Disadvantages of Bridge Cranes

One of the main disadvantages of using bridge cranes is that they are permanently affixed in the factory or manufacturing facility; therefore, loads can only be moved along the track of the bridge crane. If a large load crane is installed, it will likely use support beams offset from the walls which will reduce the amount of floor space the crane load can access. Although this case study analysis is not focusing on costs, it is worth noting that the costs of installing a permanent bridge crane are likely to be substantially more than the cost of a gantry crane. The crane also needs to be professionally installed and aligned because if the runway is out of alignment or skewed it can cause stress in the

runway beams and cause crane failure or derailment. A crane that is not tracking properly can also cause excessive wheel and bearing wear, as well as premature wear on motor drives ("5 Common Problems with Overhead Cranes and How to Avoid Them," 2017).

Case Study

The General Contractor was hired by the client to make improvements to a large 200,000 square foot warehouse. The client owns the building and was using the space for storage. The client determined that it would be beneficial for their operations if they leased a second warehouse, which shared a common wall with the warehouse already owned by the client. The second warehouse is also 200,000 square feet. Throughout this case study, the client-owned warehouse will be referred to as Building #1, and the second warehouse, which the client leased, will be referred to as Building #2. The client decided to move all of the contents in Building #1 to Building #2 so that they could make substantial improvements to Building #1 and transform it into a manufacturing and repair shop.

After the General Contractor made tenant improvements to Building #2 for the client, the client moved its inventory from Building #1 to Building #2. The General Contractor then proceeded to complete a substantial amount of improvements to Building #1, which included building walls in the space as well as constructing multiple workstations. The workstations required overhead lighting, large ceiling fans, heaters, and access to compressed air. Additionally, the client planned to move manufacturing equipment into Building #1 from another location which was offsite.

Project Specifications

- Project Cost: $20 Million
- Project Timeline: 14 Months
- Delivery Method: Design-Build
- Project Location: California
- Project Scope: Tenant Improvement of two 200,000 square foot warehouses

Discussion

The General Contractor was hired at the beginning of the design process. After the design was completed, they began by making tenant improvements in Building #2. The client then transferred all the contents of Building #1 to Building #2, so that the General Contractor could make substantial improvements to Building #1. The General Contractor proceeded to spend approximately 8 months installing interior walls, workstations, and rough-in of mechanical, electrical, and plumbing in Building #1.

Throughout the course of the design sequence of the confidential project, the owner decided that they only needed 5 bridge cranes based on what the stakeholder managers had determined. Originally, bridge cranes were only requested for certain manufacturing and quality control areas of the facility. After a substantial amount of the job had been completed, the client entered the warehouse with the floor managers who would be using the workspace. Multiple floor managers expressed their concerns about the work that had already been completed. More specifically, the managers indicated that the use of bridge cranes would substantially improve their productivity and safety. The managers brought up multiple safety concerns due to the fact that they had been using portable gantry cranes that were

overloaded or difficult to maneuver because of their “shopping cart wheels.” Accordingly, the client requested bids from the General Contractor to increase the number of bridge cranes.

The General Contractor pointed out to the client that there would have to be many design changes in order to accommodate the installation of additional bridge cranes. This included moving fans, heaters, and compressed air access, all of which were already either partially or completely installed. Also, the CNC machines and press brakes had already been installed in Building #1; therefore, the warehouse space was not free and clear, which negatively impacted the installation of the bridge cranes. Additionally, there would be a time delay in the completion of the project because the bridge cranes would have to be designed, ordered, custom manufactured, and shipped to California. Also, the client wanted to have their employees begin using the space as a manufacturing and repair shop, so the crane installation would have to be completed at night.

Long after the General Contractor had obtained bids for the initial 5 bridge cranes from the specialty crane contractors, the owner decided that they would in fact need a total of 14 bridge cranes. The owner decided to have the new bridge cranes cover almost every corner of the facility including a small 40’x40’ area for which they requested a 2-ton bridge crane.

Design Changes

Bridge Cranes

Due to the complete overhaul of the bridge crane designs, the owner and contractor decided that their best course of action was to over-engineer the crane structure to allow for future expansion of their hoisting capabilities as needed. It was ultimately decided that the crane structure would run the length of the manufacturing facility from the receiving office on one end to the shipping office on the other end. Due to the fact that the facility needed to operate 24 hours a day, 7 days a week, and 365 days a year, the client had a tight timeline in which the General Contractor could move the owner’s manufacturing equipment into Building #1. The machinery that was being moved into the building included large CNC machines, press brakes, and metal shears. Once these machines were installed, they were calibrated by the manufacturer of the machines; therefore, they could not be moved again without being recalibrated. This posed a major problem in the crane installation sequence as this meant that the crane structure had to be designed around the machinery that was not in the warehouse at the beginning of the project design. In fact, if the bridge cranes had been installed first, they could have been used to move the CNC machines and other machines into place.

Figure 3. Bridge Cranes on the Job Site

The design process for the crane structure involved 13 to 14 shop drawing revisions due to the technical aspect of the design of the crane structures. The design team would often have to move cross

members or other parts of the structure to allow the crane structure to fit around the existing machinery. This also resulted in installation challenges because some cross members had to be welded on-site rather than being pre-assembled off-site. Once all the designs and shop drawings were approved by the owner, the contractor, and the rest of the design team, it then took about 4 months from procurement to delivery of the cranes. Additionally, another issue arose during the design and procurement process because steel prices increased substantially due to a trade war with China at the time.

Fans

Prior to the design changes from 5 bridge cranes to 14 bridge cranes, the owner had requested multiple *Big Ass Fans® (BAF)* to be installed throughout the manufacturing facility. Two days before the *BAFs* were to be installed in Building #1, the owner decided that they needed the highest hook height possible for the bridge cranes in order to allow for lifting of loads over CNC machines, press brakes, and other large manufacturing equipment. As a result, all overhead fixtures had to be removed with the exception of the high bay lighting. This meant that the *BAFs* could not be installed in most of the manufacturing facility and that an alternate solution had to be presented. However, the fans are an essential part of this facility because during the summer, the combination of the California heat, welding stations, and machinery can cause the facility to reach extreme temperatures. The best way to mitigate this is the use of fans in the manufacturing areas.

The solution proposed and carried out by the General Contractor was to install commercial workstation fans that would be mounted to the walls of the areas with the cranes overhead. This would also allow each worker to control their own workspace temperature. The existing wiring for the *BAFs* had to be removed and replaced with wiring for each of the smaller commercial workstation fans which were spaced out on the walls every five to ten feet. The client had already taken delivery of the *BAFs,* therefore they could not be returned. Accordingly, costs could have been avoided on the *BAFs* and the wiring for the *BAFs* if the original design plan had included all 14 bridge cranes.

Heaters

The original design of Building #1 included the installation of large natural gas tube heaters to help keep the facility warm during the winter. These natural gas tube heaters were to be installed about a week after the *BAFs* were to be installed. Most of the natural gas piping and the wiring for these large tube heaters were already installed and were ready for the tube heaters to be mounted and connected. The planned location of these tube heaters was in the direct line of travel of the bridge beam of the newly added bridge cranes. This meant that an alternative had to be presented for the heating of the work station areas. The contractor and mechanical engineer came to the conclusion that the best alternative would be to install smaller, wall-mounted, natural gas heaters that would be spaced out every five to eight workstations. This would allow each group of workers to control the climate in their area while also allowing for the use of the overhead bridge cranes. Ultimately, it was determined that this was the best choice because it would provide employees with individual temperature control while also providing the largest amount of area covered by the bridge cranes. Accordingly, the natural gas piping had to be rerouted and smaller heaters had to be ordered and installed.

Compressed Air and Power

In the last design, before the owner decided to add the new bridge cranes, a majority of the manufacturing and maintenance area had ceiling-mounted compressed air and power drops. These

compressed air and power drops were partially installed before the design change was implemented. The piping for the compressed air was already plumbed to the planned ceiling drop locations and most of the electrical rough-in for the ceiling drops was completed. The design change caused by the new cranes was especially difficult for the compressed air and power drop locations because each drop was chosen to coincide with workstations or manufacturing equipment. Due to the flexibility and long reach of the compressed air hose reels, it was determined that the best place to install these reels would be along all the walls so that there was complete coverage of the work area. The compressed air reels were chosen to be placed on the wall because they are not used for long periods of time; therefore, the owner did not need to worry about the long reach along the length of the work stations.

As for the electrical drops, the design process became a little more complex because the electrical drops would be used more often than the compressed air. These electrical drops were meant to power smaller, handheld tools or equipment that did not require a large electrical load. The entire design and construction team had to sit down with the owner and walk through each of the power drop locations to determine if a wall-mounted receptacle would suffice or if they required a unistrut post mounted to the floor of the warehouse with a receptacle and potentially a safety switch. After multiple design changes occurred with the owner and the architect, it was determined that eleven unistrut post receptacles were required throughout the manufacturing area serviced by the bridge cranes. In order to add these new receptacle locations, the existing warehouse floor slab had to be saw cut and trenched to have the conduit run below the slab to each of the decided locations for the receptacles. This added a large amount of time to the schedule as the General Contractor had to remobilize the electrical subcontractor to perform more trench work. The schedule was also extended because concrete needed to be poured back once the trenching was complete. The concrete also required a 28 day cure time due to the fact that the machinery in that area was extremely heavy.

Timing and Labor Issues

Due to the crane design changes, there were now 9 more crane systems that had to be designed, purchased, and built before they could be delivered to the job site. This meant that the bridge cranes would need to be installed 4 months after the job had received its certificate of occupancy. By the time the cranes were to be delivered, the facility would already be up and running at full capacity. Consequently, the cranes would need to be installed during the slow hours of the production facility. The hours that the owner agreed upon for the crane installation were from 6:00 pm to 6:00 am, which meant that the labor rate would increase because all the work would have to be during off-hours.

Once the cranes arrived, they were installed during the agreed-upon hours; however, there was one issue that occurred. During the installation process each night, the workstations and any other items had to be rolled out of the way. The workers installing the cranes had to use and move ladders, man lifts, and forklifts to install the bridge beams. After one of the shifts installing the bridge cranes, the owner notified the contractor that one of their highly specialized custom products had been damaged. The owner brought photos as proof of the damage to the product that had just received its final coat of paint the day before the shift. The contractor and subcontractor agreed to cover the costs of this incident in the spirit of good faith to keep the relationships intact. A few days later, the owner notified the General Contractor that they would not need to be compensated for the damages of the custom product because, after a review of their CCTV system, the owner realized that it was one of their own night shift employees that had caused the damage.

The owner of this project was a union shop and therefore required all labor and contractors to be union members. This became an issue during the subcontractor bid process as all of the bridge crane manufacturers are non-union because their trade is considered a “specialty” trade. After almost 2

weeks of meetings and discussion with the owner and union, it was determined that union ironworkers would build the crane structure and hoist the bridge beams into place. While the union ironworkers were installing the crane, they would be supervised by the bridge crane contractors who would certify and warranty all of the work performed. Once the structural work was complete, the union electrical subcontractor would come in and hook up the crane systems to their appropriate J-boxes, again under the supervision of the crane subcontractor. After all of the work that could be performed by union trades was completed, the specialty crane subcontractor came in to finish the connections to the electrical systems. The specialty crane subcontractor also performed the start-up and made any necessary adjustments to the bridge system.

The crane contractor then performed all the load testing and commissioning of the crane structures. Load testing could not be performed using the traditional water bags method because the maintenance facility was full of equipment that could not receive any direct water contact. The General Contractor and crane contractor decided to utilize existing raw materials in the facility that had known weights, in order to weight-test each of the cranes. This expedited the testing timeline and allowed the owner to use the crane systems sooner.

Lessons Learned

Benefits of Bridge Cranes

There are numerous benefits to the use of bridge cranes on a job site. Efficiency is incredibly important when manufacturing and the use of bridge cranes certainly promotes this value. By providing a quick and easy way to move loads around a factory or manufacturing facility, whether indoors or outdoors, the use of a bridge crane cuts down on manual labor and saves the owner money in the long run. Bridge cranes promote a safe environment as they help keep the work area clear of items on the floor and assist with maneuvering equipment or other various heavy products. In comparison to gantry cranes, bridge cranes offer a superior benefit when there is a constant path of travel along which items are being moved. Additionally, bridge cranes are stronger than gantry cranes and have better lifting abilities, which are very safe when the rigging is done correctly. Finally, when installing and operating bridge cranes, workers do not have to worry about an uneven floor and they are able to easily use custom hoisting rigs (“The Benefits of Having an Overhead Bridge Crane,” 2015).

Benefits of Installing Bridge Cranes at the Beginning of the Project

There are numerous benefits to the installation of bridge cranes at the beginning of a project. Evident through the issues that arose in this case study, it is clear that a substantial amount of time and money could have been saved if the bridge cranes had been installed at the beginning of the job. The cranes should have been installed at the beginning of the project so that they could have been used to easily move equipment around the building. Due to the fact that a substantial amount of heavy equipment was installed in the building prior to the installation of the bridge cranes, it was difficult to install the bridge cranes after the fact. It is important to emphasize the inefficiency of installing equipment including CNC machines, press brakes, and metal shears before bridge cranes. Had the cranes been installed at the beginning, they would have had free and clear access to the area of installation, unobstructed by the heavy equipment. Furthermore, the additional MEP work required before the bridge cranes were installed in this case study could have been avoided. They would not have had to rewire the electrical for the fans and heaters, trench for the electrical outlets, and re-route the compressed air and natural gas lines. In addition to all the extra touch-up work, they also had to

re-mobilize the electrical subcontractors, steel subcontractors, and finish subcontractors to complete the installation of the cranes. Overall, these issues could have been avoided if the bridge cranes had been installed first, thereby resulting in a more economical and efficient construction process.

Issues Associated with Installing Bridge Cranes in a Functioning Manufacturing Facility

Several issues arise when bridge cranes are installed in a fully functioning manufacturing facility. In order for bridge cranes to be installed later in a project, the location of the steel structure and bridge crane assembly must be cleared of all mobile workstations, small tools, forklifts, and mobile racking. Additionally, to refrain from disrupting the factory or manufacturing operations, the work of installing bridge cranes must be completed at night and on the weekends. These abnormal hours may often result in substantially higher wage rates, particularly if the contract is a union job, thereby further increasing the cost of a late bridge crane installation. Furthermore, the installation of the large and heavy steel beams and bridges will require a free and clear path in the manufacturing facility. Therefore any heavy equipment that has been previously installed will have to be moved to clear the area or the bridge cranes will have to be designed around the equipment. In the above case study, the General Contractor had to deal with many of these issues when the client provided a late notice request for bridge cranes. Because of the existing structure of the job site, the General Contractor had to move all workstations that were in the path, pay higher wages to install the bridge cranes at night and design the bridge crane structures around the pre-installed, heavy equipment. Even the load testing had to be done on the night shift using onsite materials and machinery. Finally, the space in which the bridge cranes were to be installed was so tight that sometimes, there were 14 to 15 shop drawing revisions, caused by changing cross member locations and heavy equipment that could not be moved.

Conclusion

The use of bridge cranes in a manufacturing or repair shop is beneficial and contributes to the safety and efficiency of employees, especially when compared to the use of portable gantry cranes. This case analysis empirically substantiates that the installation of bridge cranes is far more efficient and beneficial when completed at the beginning of the tenant improvement construction. However, if a client strongly desires bridge cranes to be installed later in the project, as long as the contractor is able to properly assess, delineate, and resolve the issues associated with installing bridge cranes in a fully functioning manufacturing or maintenance facility, the task can be successfully completed.

Future Research

Due to the confidential nature of this project, it was not possible to obtain specific cost information. Future research could focus on the cost of purchasing gantry cranes versus bridge cranes, specifically comparing cranes that are able to move the same tonnage. Additional factors to consider include the labor costs and efficiency of utilizing wheeled gantry cranes requiring two employees to be available to move the cranes versus one employee to use the pendant control of a bridge crane. Also, one could further research employee injuries occurring from the use of gantry cranes due to their potentially unstable structure relative to bridge cranes, more specifically, the OSHA fines, the workers' compensation claims, and the risk of adverse employee morale if an employee is fatally injured. Finally, research could be performed comparing the costs of installing bridge cranes at the beginning of a project versus later in the construction process.

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