How to Organize an Effective Crane Runway Upgrade Project

In most cases, a substantial increase of the lifting capacity of overhead traveling cranes requires reinforcement or modification of the existing crane runway supporting structures, which include crane runway girders and building framing. This paper will present a step-by-step approach to developing project-specific design criteria and avoiding missteps that often occur when the goal is not well defined.

Increasing a steel mill's production requires, in most cases, an increase of the capacity of load lifting equipment. This includes the overhead traveling cranes — from heavy hot metal ladle cranes at meltshops and casters to light shipping cranes for coil and slab handling facilities and pipe mills.

The increase of the crane-lifted load capacity represents a straightforward task that can be solved in one of the following two ways:

1. Upgrading the existing crane by a crane engineering firm.
2. Buying a new crane, if the existing crane upgrade is not a feasible task.

Each of these two choices does not require a long downtime in crane operation, if backup cranes are available on the same runway.

The existing crane runway upgrade to satisfy increased crane-lifted loads, on the other hand, could be a challenging task.

The crane runway upgrade cost includes two major components:

1. The construction cost associated with crane runway and building framing modification (reinforcement).
2. The cost of the lost operation time associated with breaks in the crane operation due to the crane runway modification work.

To optimize the crane runway upgrade project, three consecutive phases should be considered:

- Planning.
- Preparation.
- Performance.

Planning

This phase should start by determining the required crane-lifted load increase to satisfy the needs of increased plant productivity. If the crane-lifted capacity increase is within 25% of the original crane capacity, it would probably be possible to modify the existing crane (or cranes).

This modification usually includes the crane trolley and bridge modification work performed by a crane engineering firm for a cost substantially lower than the cost of a new crane.

If an upgrade of the existing (often older) cranes is not feasible due to reasons such as a significant increase of the required crane lifting capacity, fatigue damage in older cranes or higher cost of the modification work, then a new crane(s) shall be considered.

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The crane specification with requirements for the upgraded or new crane should be developed by the plant engineers in the planning phase of the project.

In addition to specific mechanical requirements, which are out of the scope of this paper, it is recommended that the new crane specification should include requirements of the wider wheel base (spread between wheel trucks) and more crane wheels in comparison with the existing crane, if possible. This would minimize increased crane load effect on the existing crane runway support structures and may minimize or eliminate crane girders and building framing reinforcement.

Case Study 1 — An existing 25-ton, four-wheel crane was planned to be replaced with a 40-ton, eight-wheel crane and wide spread (11 feet, 8 inches) between wheel trucks.

The structural analyses proved that no reinforcement of the crane runway girders and building framing were required for this 60% lifting capacity increase.

The potential crane vendors for crane upgrades or new cranes shall provide to the plant engineer the expected crane load information to be used in crane runway and building framing analyses.

If the crane runway upgrade construction work is considered to be performed as a part of the overall downturn in the shop operation (such as equipment rebuild), and the runway work is not on the critical path in the project schedule, the following approaches can be considered:

- Replace the existing crane runway system (girders, backup and tie-back structures) with the new one designed for the increased crane loads. This is the most expensive and time-consuming approach, and it should be exercised only when it makes sense in the overall shop upgrade project cost.
- Modify the existing crane girders in place by reinforcing top and/or bottom flanges.

The reinforcement of the girder top and bottom flanges is labor-intensive and time-consuming work. The top flange reinforcement, in most cases, requires the crane rail removal, which means a long downtime in the crane operation. A continuous welded or bolted attachment of the reinforcement parts to top and bottom flanges is extremely costly from a labor point of view and may create fatigue-sensitive details.

If a substantial increase of the crane-lifted load is considered, the total cost (fabrication and field work) of a conventional method of crane girder reinforcement could exceed the cost of girder replacement.

Alternatively, if the crane runway operation must continue during the runway upgrade project, the best way to reinforce crane girders is to provide the reinforcement installed only below the girder bottom flange.

In most cases, a simple plate or tee-type reinforcement, installed below the bottom flange, would not significantly increase the section properties of the girder enough to satisfy the required crane lifting capacity increase.

The installation of a truss-type or mid-span support beam reinforcement below the girder bottom flange[7] could provide the low-cost and effective crane runway reinforcement solution.

It is recommended that all crane runway reinforcement concepts should be reviewed by plant engineers, which will help to develop the optimal solution at the lowest cost.

Preparation

The available existing building design information shall be obtained. It should include design drawings for crane runways, building framing and foundations, as well as information for soil bearing capacity. It makes sense (prior to crane runway upgrade project origination) to perform a crane runway structural inspection. As one engineer said, “the story of a building is written on its walls.” These words can also be applied to the existing crane runways and building framing.

The crane runway inspection will detect defects in construction and fatigue-related damage which occurred in the past. Repairs of defects and damages should be included in the scope of the crane runway upgrade project.

A brief, free-format specification for the crane runway upgrade modification should be developed by the plant engineers and presented to engineering firms to compete for the project. This specification should explain what is expected to be included in the project, such as conceptual crane runway modification alternate solutions (two or three), and requirements for building framing analyses, preferably with the space frame response included.

The framing analyses with the space frame response included[2] provide a more accurate determination of the framing loads in comparison with a planar model framing analysis, and that could mean there is no or minimum framing reinforcement required after analyses are completed for the increased crane loads.

Alternate runway modification concepts would give the client (plant personnel) choices that could better meet operation conditions.

This type of specification will place all bidders for the project on a level platform.

As has happened before, the cheapest bidder, who used simplified design models for crane runway and building framing analyses, won the project. Eventually, this resulted in a more costly construction and longer shutdowns of the crane operation or cancellation of the project because of high projected cost.

Case Study 2 — The steel mill wanted to upgrade the old coil shipping aisle crane runway from the 10-ton capacity to 25 tons.

The first engineer, chosen by the mill, proposed to replace older crane girders with new ones. The estimated cost was US$1,300,000 plus a minimum of four weeks of downtime in crane operation. This was not acceptable for the client.

The second engineer, who was given a chance to review the project, proposed to reinforce the existing runway using the below-girder, truss-type reinforcement and almost no downtime in crane operation.

This alternate solution was accepted by the mill operation. The total cost was US$350,000, but the engineering cost was higher.

The point is, if the project specification has been developed before the project was awarded, the mill would save time and money.

Engineers who bid on the project shall provide bids in accordance with the project specification requirements. In these bids, engineers shall present a brief description of design methods they will use to achieve the best results in terms of the cost and downtime in crane operations.

An interview of bidders would help the mill management to choose the most successful engineer for the project, based on engineering experience and qualification to do this type of project and the proposed conceptual solutions, but not on the lowest price for engineering services.

Performance

After the runway upgrade project is awarded, it makes sense to establish a few project checkpoints:

- A 25% project progress review should be performed during the field verification of the modified crane runway area. The field verification will help to detect possible obstructions and limitations to the implementation of the accepted methods of modifications and to develop customized solutions for any found problems.
- Further project development shall continue until the project is 90% complete. The design firm shall present the 90% completed project to the client (steel mill) for review and approval.
- It makes sense at this time to set up the project review meeting with the participation of the client, the design engineer and a potential structural contractor(s) for this work. It would help to optimize the final project solution if contractors' review notes would be considered in this time.
- To optimize the construction stage of the crane runway upgrade modification, it is preferable that the construction schedule should be developed by the contractor together with the plant personnel.

Table 1 is the Crane Runway Upgrade Checklist, which can be converted into a project development schedule for works included in the project.

It also makes sense to include in the construction phase of the project the cost of the field review of the construction by design engineers who developed the project. This cost is often omitted in the construction estimate. During field visits, the design engineer could solve some unexpected problems and avoid construction delays associated with solutions of the above problems.

Summary

A typical request from steel mill management in the process of increasing the mill's production is, "Tell us how much of an increase of the crane-lifted load capacity can handle our existing building structures."

The response to this request should be, "What are your requirements for increasing the crane-lifted loads, and how much can you afford or want to spend?"

It is a difficult and time-consuming process to investigate the existing crane runway and building structures in search of the weakest link (crane girders, columns, roof trusses or all three), without knowing the desired new (upgraded) crane lifting capacity that would satisfy the mill production needs.

A qualified engineer can use all available engineering tools, including crane load dynamic analyses, field tests and space frame response of building framing to crane loads, to optimize the results, but engineers need to know what the ultimate goal is.

Table 1

Crane Runway Upgrade Checklist

Task description	Completion
Phase 1: Planning	
Determination of required crane lifting capacity increase	
Decision	
Upgrade existing crane	
Purchase new crane	
Contact and meet with crane vendors	
Decision	
Modify existing crane runway system	
Install new crane runway system	
Phase 2: Preparation	
Obtain existing building design information	
Structural drawings (crane runway, building framing and foundations)	
Soils information (allowable bearing pressure)	
Structural inspection of the crane runway and building framing	
Crane runway upgrade project specification development	
Interview of potential engineering firms for the project	
Award the upgrade project to a qualified engineering firm	
Phase 3: Performance	
Perform a 25% project progress review	
Field-verify existing conditions	
Determine possible obstructions that might require customized solutions	
Further project development up to 90% completion	
Review project with the participation of potential construction contractors	
Optimization of the upgrade project and development of the final solution	
Development of a construction phase schedule	

References

1. *Guide for the Design and Construction of Mill Buildings,* AIST, Technical Report No. 13, 2003.
2. Milman, R.S., "Old Mill Building vs. Current Design Loads — A Survival Approach," *Iron and Steel Engineer,* May 1991.
3. Milman, R.S., and Hanson, D.J., "Knee-Braced Crane Girders — Problems and Solutions," *Iron and Steel Engineer,* April 1993.
4. Milman, R.S., "Fatigue Life Analyses of Crane Runway Girders," *Iron and Steel Engineer,* July 1996.
5. Milman, R.S., and Hoppel, C.L., "Crane/Building Interaction Review," *AIST Crane Maintenance and Technology Advancement, 2004 Symposium,* Pittsburgh, Pa., USA.
6. Milman, R.S., and Hoppel, C.L., Crane Runway Upgrades — A Challenging but Rewarding Task and How to Optimize It," 2006 Crane Maintenance and Technology Symposium, *Hoist Magazine* (U.K.), October 2006.
7. Milman, R.S., and Hoppel, C.L., "Non-Conventional Crane Runway Upgrade Solutions," *Iron & Steel Technology,* Vol. 9, No. 6, 2012, pp. 76–80. ✦

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This paper was presented in June 2012 at AIST's 19th Annual Crane Symposium, Pittsburgh, Pa.