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SESSION WORKSHOP NOTES

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"Savings Thru Shop Assembly ... MB Components", Jerry Shivers,
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COST AND TIME SAVINGS THROUGH

SHOP ASSEMBLY OF MOVABLE BRIDGE COMPONENTS

TRADITIONALLY FIELD ASSEMBLED

SOME THOUGHTS ON PRACTICAL APPROACHES TO EASING FIELD CONSTRUCTION PROBLEMS

No matter what cost, what design capacity or what quality of workmanship the performance of Operating Machinery will be no better than that permitted by the integrity of its installation on the movable structure.

Past and current design standards are conservative, fortunately. During regular operation the equipment sees only a small portion of the loads it is capable of handling. Service factors and modest values for working stresses are such that substantial momentary shock loads and short term overloads can be carried without undue distress, permanent damage or catastrophic failure of the machinery.

Albeit, any reduction in useful service life, any condition that causes abnormal wear, any unnecessary failure resulting in unscheduled service interruptions is a nuisance, a costly inconvenience and a situation that must be addressed and remedied.

In addition to consideration of the integrity of the installation is the economics of the situation. Not only the original cost to the owner but also to his continuing costs of maintenance and repairs.

There are many elements that contribute to the original and continuing reliability of a machinery system. Such things as adequate design, quality of materials nad workmanship, correct assembly and proper installation, regular maintenance and adjustments, environmental influences, etc. All impact and influence the satisfactory and long term successful operation of the machinery.

It is the purpose of this paper to take an in-depth look at the cost and time savings to be achieved by shop assembly of movable bridge machinery components together with the desirable advantages gained by achieving proper alignments and interfaces between the various components.

In the earliest designs all the gearing was open; that is, not enclosed such as a speed reducer, shafts were supported on individual bearings and shaft ends connected by rigid flange or sleeve couplings. The engineers and owners recognized the desirability of assembling this hodgepodge of parts in the shop prior to shipment to the site. (Slide - Shop assembly, open gear drive) the best reason being just to assure themselves it would indeed fit together and have the ability to rotate without undue interference and binding.

Labor was readily available and inexpensive in those days, so that the extra hours consumed in the field attempting to duplicate the shop floor assembly did not have a significant impact on the overall cost of the project. Unfortunately, even with the expenditure of massive numbers of labor hours it was questionable if the proper alignments were possible and achievable in the field.

Probably the outstanding problem in duplicating an accurate shop assembly in the field occurred because in the shop the supports for the bearings, machinery mounts and motors were usually seated on a reasonably accurate bed plate. When the proper alignments were obtained the various components were match marked and disassembled. Now, when assembly in the field was undertaken there was no common bedplate, instead the machinery supports were attached to structural steel elements and shimmed in order to maintain the required alignment. Accurate alignment under such conditions is not possible since the machined finishes and accurate tolerances of the machinery components are not compatible or adaptable to the relatively loose tolerances and surface conditions of the structural elements.

Another associated difficulty was line drilling and reaming the mounting bolt holes so correct fits were obtained with the bolts. Often space restrictions prohibited the use of proper drilling equipment to perform the task and poor fits resulted.

The next step was to incorporate certain of the components into common frames. Gears, their supporting shafts and bearings were naturals; so now there were composite assemblies that could be completed in the shop (Slide - Shop assembled machinery frame-Passayunk Avenue) and required only minimal field assembly. By having the primary and secondary reductions shop assembled in their own frames reduced the field installation time and permitted more accurate assemblies.

This concept was further advanced with the increasing availability of commercially manufactured speed reducers. In addition the notion of assembling the motors, brakes, reducer and auxiliary drive on one common base plate or frame was advanced. (Slides - Shop assembled machinery platform - motor, brakes, reducer, etc. - Spuyten Duyvil).

This found wide usage since it facilitated field installation, insured more accurate alignments between the components and represented substantial savings in time and labor in the field. After all, contrary to the situation in the 30's, 40's and 50's there was not a great skilled labor source and hourly rates were now a significant figure.

The whole idea was two fold: (Slide with ideas 1 & 2)

1. Obtain an accurate installation so that reliability and integrity were achieved.

2. Reduce the field installation time and costs.

One concept that gained wide usage in the State of Florida embraced a design that mounted all the lifting machinery for a trunnion bascule on a common frame. This became known as a Hopkins frame (Slide - typical Hopkins Frame), and, although limited in application, has been used in a number of smaller bridges.

Mr. Hopkins' approach even included devices to set the rack pinion(s) at the correct radius from the trunnion centerlines (Slide - side view Hopkins Frame showing radius arms).

Once again, cost savings in field assembly and installation time motivated the use of such schemes.

Other engineers utilized assemblies consisting of machinery platforms having reducers, bearings and associated equipment shop mounted. Field installation was reduced to relatively simple positioning and aligning using shims and then connecting the primary and secondary elements with floating shafts utilizing flexible, gear couplings. (Slide - 78th Avenue Clearwater).

Of course, the demands of the installation can pretty much dictate the approach the Engineer will follow. For instance, on the massive Chicago Style Bascules, there are normally two mechanically separate drives on each leaf. In such an instance each drive is shop assembled on a separate platform (Slides-Columbus Drive) with comparable labor and time savings during installation.

The ultimate in keeping field installation time to a minimum on Bascule Bridge Operating Machinery is the use of one central speed reducer directly connected by transverse shafts to the rack pinions. Here it is seen that the only critical alignments required are those between the pinions and the racks. Once having set these properly it is an easy matter to correctly position the reducer, motor and brake assembly. (Slides - Groton Assembly, New Pass, Sunrise Boulevard and Sunny Isles (?)).

This concept of utilizing shop assembly to reducer field labor time while gaining the advantage of achieving accurate assemblies under desirable, controlled shop conditions has been well advanced by Steward Machine Co. to include not only machinery but also other components together with their associates steel structures and interfaces.

Recently we furnished the machinery for rehabilitation of Amtrak's Spuyten-Duyvil Bridge in New York City. In working with American Bridge Co., the prime contractor, it was their plant to pre-assemble the maximum number of parts and to make those assemblies as complete as possible, including structural steel elements and interfaces. The assemblies would then be barged from a remote staging area to the site and installed on the structure. This plan dictated that accurate assemblies be made, properly match marked and disassembled and shipped to the staging area for reassembly on the barge. It was essential that each piece, no matter how large or small, accurately fit its mating pieces and that the completed components work properly individually as well as in concert with all other components.

It was mutually agreed that in-so-far as possible all machinery elements would be shop mounted on the structural supports. This, of course, required shipment of major structural members to Steward's shop for assembly and fitting up of the machinery.

The Spuyten Duyvil Bridge is a double track, rim bearing type swing span originally built in 1899. The present rehabilitation included major structural improvements as well as replacement of the operating and wedge drive machinery, upper and lower track plates, rim roller assembly and centering post assembly. This slide is a schematic representation of the bridge (Slide - line drawing of Spuyten Duyvil).

After manufacture of the equipment Steward made shop assemblies of the equipment together with the associated structural parts supplied by American Bridge.

Let's take a look at how this was accomplished.

To start the center post assembly was made. Then the lower track was put together so that it was concentric to the center post. Correct elevation with the center post was maintained using adjustable stands supported by timer blocks. Now the rack was attached to the track, correct location and concentricity is assured by the accurately machined registration diameters on both the track and rack.

While this was being accomplished separate sub-assemblies were made up on the rim rollers and retainers. These were then positioned on the lower track and attached to the centering ring by radial arms. Proper adjustment of the radial locations of the rollers is required to insure true rolling of each roller.

The next step was to assemble the upper track to the drum girder. This was done up-side down; that is, with the track in the upper position. The whole assembly was then picked up, turned over and placed in its proper position on top of the track/rim roller assembly. A perfect fit, it even rotates.

Next the structural girders and beams that transfer the live and dead loads to the drum girder and which support the final speed reducers and pinion shafts were fitted. The reducer and pinion supports installed.

Finally the pinions were aligned to the rack and the pinion shaft bearings located, shimmed and bolted to the supports; and the parallel shaft, vertical reducer positioned and bolted in place.

Adjustments were made constantly during all assembly operations to assure that each element was properly located as required and that no binding or interferences were present. One goal was to eliminate time consuming, costly field adjustments, disassembly and reassembly and other problems that eat into construction schedules and pocketbooks. This was accomplished.

Similar procedures were followed on the end wedge machinery. Here it may be seen that the entire structural steel ends were shop assembled with the end wedge machinery in Steward's shop.

After thoroughly checking each assembly, they were match marked so that the shop assembly could be duplicated in the field.

As most of the assemblies were too large for over the road shipment certain disassembly was required. Desirably, this was kept to a minimum so that reassembly on the barge was as little as possible. (Note - Slides illustrating the various steps and operations will be used throughout the whole discourse).

According to the contractor the savings in field labor were significant in addition to the fact there was no question about the pieces fitting together and functioning as they should.

Another concept that Steward has advanced is that of shop machining and assembly of trunnions and racks into bascule bridge girders.

In the past great difficulty has been experienced in obtaining concentricity of the trunnions' and rack centerlines together with accurate alignment of the rack teeth faces with the centerline of rotation. The major cause of this is that usually the bore in the girder web for the trunnion hub is made independently of locating the rack in the mounting frame. Also the rack mounting frame normally is a weldment which is either bolted or welded o the bottom flange of the girder. Since it is not machined it holds only structural fabrication tolerances which are not compatible with those required for accurate alignment of the trunnions and racks.

A typical trunnion-rack frame assembly is illustrated in the slide at which we're looking. Here it is seen that two conditions must exist in order to have the rack mounted properly with respect to the trunnions' centerline:

1. The centers of the trunnions and rack pitch circle must be coincidental.

2. The sides of the rack must be parallel and perpendicular to the trunnions' centerline.

A difficult, time consuming and costly installation to perform in the field.

Steward has perfected a method in which the rack frame and girder assembly are machined at one setting on a horizontal boring mill. This is accomplished by finish machining the bore and mounting surfaces for the trunnion hub then, before removal of the piece machining the inside surfaces of the rack frame so that they are perpendicular to the hub bore.

After removal the hub is assembled to the girder and the trunnion shrunk into the hub bore. The racks are then mounted in the frame and the concentricity of its pitch circle and parallelism of its teeth faces with respect to the trunnion centerline checked with accurate optical instruments. In this way as much as possible is removed from chance and an accurate installation is assured. (Slides - machining the web and rack frame and checking the rack/trunnion alignment on the South Slough girders).

Yes, it has been proven that many field construction problems can be eased and substantial labor hour and associated cost savings effected by use of competent shop assembly of movable bridge components.