A PERSPECTIVE FROM THE MANUFACTURING, ASSEMBLY AND TESTING OF MOVABLE BRIDGE COMPONENTS

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The three most typical types of movable bridges are the vertical lift bridge, the swing bridge, and the bascule bridge, and all three have common problems with regard to manufacturing and their own unique problems associated with each type of mechanism. We will not discuss the floating pontoon bridge which is commonly used as a detour bridge or a temporary bridge, since often the mechanical systems on this bridge are a marine type utilizing winch and cable. All movable bridges share similar manufacturing, assembly and testing problems, and in addition their own unique problems.

Some common problems from a manufacturing standpoint are associated with locking systems, alignment, air buffers, shop tolerances versus field practices, and translation of design drawings into workable shop detail drawings. From a practical standpoint it is to the manufacturers best interest to pre-assemble and simulate the field conditions as much as possible in the shop. Obviously, this is in order to eliminate as many field problems as possible and to insure proper operation in the field.

All templates should have centerlines, be properly match marked and oriented with the corresponding parts.

BASCULE BRIDGES

Of the different types of bascule bridges, the two types primarily are the rolling bascule bridge that utilizes tread and track plates and the straight rack, and the trunnion type bridge that utilizes a curved segmental rack bolted or fabricated to a structural steel support and connected to the bascule girder.

The rolling bascule bridge is a straight forward manufacturing mechanical system with a straight rack and pinion, a machinery frame and the tread and track plates. The tread and track plates may be fabricated out of high strength, low alloy plate, machined, and have the lugs either pressed in place or machined from solid. Obviously the latter is very expensive and almost cost prohibitive.

In the case of the curved tread plate manufactured from structural steel rather than castings, rough machining should be completed in the flat condition removing most of the stock and relieving the stresses in the metal. Stock should be left for finish machining the outside diameter and inside diameter after rolling the tread plate to the desired radius. Finish machining of the outside diameter and inside diameter to drawing size will then eliminate any flat spots and insure true radii. Bolt holes for mounting the tread to the girder should be drilled only after all other machine work is completed to insure accuracy and prevent distortion of holes.

It is imperative that the track and tread be set up in the producer's shop and actually blued, match marked and rolled the length of travel and tested after all machine work is completed to insure proper contact and tracking ability.

The trunnion type bascule bridges rotate around their trunnions and trunnion bearings and may be driven through curved racks that are bolted or fabricated to the rack support. From a manufacturing standpoint, it is less time consuming to weld the rack material, a low carbon forging or low carbon cast steel, to the structural steel support and machine the connection plate between the structural steel support and the main girder. This insures a common pitchline and a flat machine surface to bolt against the structural steel. If the rack is bolted to the rack support and the rack support is not machined at the bolted connection, a greater possibility exists of not maintaining a true arc between the center line of the trunnion and the pitch line. The result could be an inconsistent backlash with the drive pinion. A consistent backlash can be maintained with the use of shims between the rack support and the girder only if the pitch diameter is consistent with the machined top flange of the rack support.

SWING BRIDGES

The mechanical swing spans require a much closer coordination between the structural steel supplier, erector, and machinery manufacturer due to the greater number of bearing supports, drive shafts, right angle gearing, and drive gearing transmitting from the operators house or drive frame thru the bridge down to the drive pinion. Common templates for machinery supplier and structural supplier are mandatory in order to insure the fit of mating parts.

The heart of the swing type bridge is the center pivot assembly. From the machining standpoint it is extremely important that the center pivot top disk and the center pivot bottom disk be machined to exact spherical radii shown on the drawings to insure only the amount of contact desired. Blueing and placing the two disks together will prove this contact and will also verify that there are no flat or depressions in the polished surface.

As in all situations, the accuracy attained in the mechanical suppliers shop can be totally negated by incorrect installation. The center pivot base must be totally level at assembly or the span will never track properly and will create problems with related pieces of mechanical equipment, i.e. track and or rack to pinion mesh.

Consequently, the track must be installed level and in true relationship to the center pivot to establish proper tracking with the balance wheel assemblies.

VERTICAL LIFT BRIDGES

Obviously the largest components on a vertical lift bridge are the counterweight sheaves. From engineering and design criteria it is imperative that the wire rope grooves, the pitch line, and the trunnion journals are all concentric in order to evenly load all ropes and operate smoothly. From a manufacturing standpoint this concentricity is best achieved while the rough fabricated sheave is on the machine and all operations are performed in the same machine set-up. At that time dial indicators should be used to establish the concentricity between the hub bore, the pitch diameter fo the grooves and the pitch diameter of the ring gear. After the trunnion shaft is installed into the sheave hub it is very difficult to accurately determine the concentricity relationship.

Premachining of all components of the fabricated sheave prior to welding is highly recommended in order to insure proper fabrication fit-up and to eliminate excess stock at final machining. All hubs should be match marked to webs and rim plates to facilitate the fit-up during fabrication.

The two most commonly used counterweight bearings are spherical roller bearings and bronze bushed bearings. Both have advantages and disadvantages with regard to manufacturing; however, the bronze bushed bearings with stepped shims double the amount of assembly time and boring time of the bearing. For best results the bronze bushing should not be finished machined prior to placement in the cast steel housings.

Spherical roller bearings must be completely preassembled, packed with grease and checked for any runout by the manufacturer. The inner race should then be removed from the spherical bearing and mounted on the trunnion shaft to verify the operating clearances and accuracy. After the verification the inner race should not be shipped in place due to the possibility of brinnelling the inner race during transit. The inner race should be protected and boxed separately for shipment. Final positioning of the inner race should be accomplished just prior to erection and final installation of the counterweight sheave.

The bases of all bearings should be subdrilled to templates and match marked. If practical the sheave assembly should be shop assembled and finally checked for proper backlash, runout, and freedom of movement.

A side note with regard to the counterweight ropes, the contractors and owners and inspectors should be advised of the wire rope shrinkage tendencies and that counterweight wire ropes will not regain their prestress length until the ropes are actually operated and put under load due to the modulas of elasticity of the rope and the construction stretch.

THINGS MANUFACTURER'S WOULD LIKE TO SEE INCORPORATED OR DELETED IN DESIGN

AIR BUFFERS

Speaking from the manufacturer's point of view, air buffers which require plating should not have blind bottoms. Blind bottoms cause an excessive build up of plating at the bottom of the cylinder during the plating process. Grinding tends to push off and follow the plating rather than straightening the bore which makes the cylinder smaller in inside diameter as the bore approaches the closed end of the cylinder.

From a manufacturing point of view, the unplated cast iron machines better and is less prone to porosity and cold tears.

LOCK BAR OPERATORS

For all locking systems the torque switch settings should be dictated by the design engineer with consideration to all factors and preset at the manufacturer.

We feel all lock bar operators should be specified to include boots to protect the operating mechanism from dirt and foreign matter.

TURNED BOLTS

We would like to see turned bolts used only when shear conditions demand and then only a sufficient quantity to insure the engineering shear stress criteria is met. In many cases a sufficient number of taper dowels would perform this function as well as turned bolts. Among the reasons for limiting the use of turned bolts are the following:

A. Structural steel bolts are approximately 20% of the cost of turned bolts.

B. A substantial savings of time through limited field reaming.

C. Replacement structural bolts could be easily obtained without excess delay. Turned bolts would have a longer delivery and it is almost impossible to retain the proper fit.

D. Many holes in reality are not accessible for reaming in the field.

CASTINGS

With regard to manufacturing castings or cast girders and machining, it is often less expensive to eliminate lightening holes or cored pockets that were originally designed for prudent use of cast metal. Due to the inherent problems with cast steel, i.e. burned in sand, metal penetration, the shifting of cores, and the possibility of insufficient machine stock, it is less expensive to machine a solid casting with a minimum of cored pockets or holes. This is a combination of high labor costs in foundries and cheaper material costs in the castings.

BEARINGS

Double keyways often used to secure bronze bushings to cast steel bearings are very labor intense, therefore making this process very expensive. Possibly other methods of securing the two parts together would result in less overall cost to the owners.

BEARING BASES

In the case of vertical lift bridges, we see benefit to having the bearing supports included with the mechanical item insuring that the supports are fully machined and the bearings are assembled together.

GENERAL NOTES TO CONTRACTORS/INSTALLERS

The aim of all general contractors is to complete the project on time with a minimum of problems and hopefully make a reasonable profit. Several key steps can help insure that this does take place.

A. Experienced, competent millwrights can greatly decrease installation time simply bynot having to do the same tasks twice.

B. Extremely accurate measuring equipment must be available to the millwrights.

C. All of the necessary tools must be available to the millwrights. Note that when tools are required to be furnished by the mechanical supplier, these tools are normally furnished solely for the owner's maintenance use and are not for installation. For this reason such tools are not normally furnished until after installation.

D. Lubrication of all components is essential during installation. Never assume any item doesn`t require lubrication, even those items lubricated at manufacture.

E. Co-ordination of drawings between structural supplier, mechanical supplier, and electrical supplier during drawing submittal phase can save many manhours and expense at field assembly. Small things such as location of conduit boxes to prevent fouling with other equipment and locating hydraulic fitings in such a manner as to minimize the amount of piping necessary can be a big time saver and eliminate many headaches.

F. The alignment of the guide socket and receiving sockets and lockbars should be match marked, aligned and shimmed at manufacturing point duplicating field conditions as closely as possible. This may require re-aligning when actually assembled into place. Any locking system should be properly aligned and fastened rigidly to prevent any possible movement. If movement does take place, the locking systems are easily misaligned and will not realign themselves. The locking system is not a bridge alignment tool and if not properly aligned damage will occur.

G. Proper storage at the construction site of the machined components prior to installation is a big problem. Every site is different and ideal storage is not often possible. However, a few common sense guidelines can be practically followed.

Wooden lagging is commonly used to protect many finished machined surfaces during handling and transit. All wooden lagging should be removed from the finished surfaces as soon as practical in order to prevent the acid in the wood from attacking the rust preventative and pitting the finished surfaces.

A good practice is to remove all rust preventative once a machined item gets to the jobsite and re-rust preventative it there to insure proper protection and coverage.

All vulnerable items should be protected from condensation and weather conditions.

MACHINERY FRAMES

Whenever possible the machinery should be mounted on a common machinery drive base. This enables assembly and alignment to be done in a shop situation under ideal conditions rather than on site where weather, access,and equipment may present a problem. The typical time required for site work is usually at least five times greater than shop work due to these uncontrollable factors. Ideally all items to be mounted on the machinery base should be sent to the mechanical supplier including motors, brakes, couplings and all items which interface with the mechanical. Alignment of all items should be completely accomplished using a transit and checked prior to drilling mounting holes. In my opinion this is the only guaranteed method of assuring proper alignment. I know of no way of laying out and pre-drilling which would be as accurate as scribing the holes after correct alignment. After alignment and drilling the machinery should be bolted tightly and run for a period of time to verify alignment and check bearings for excessive heat.

Machinery base plates should be "beefy" enough for rigidity in handling and installation to prevent misalignment caused by flexing and distortion. Accuracy of alignment at shop assembly can be totally negated by one lift if the frame is not rigid enough to prevent distortion, thus creating an expensive and time consuming nightmare for the installer to try to re-align. The problem can compound if the misalignment problem is not discovered prior to installation of related items.

The problems addressed above can be eliminated at very little additional cost simply by making the machinery base plate more rigid. There should be no additional machining cost, and only a small additional material and fabrication cost. Numerous days of contract time can be saved if the mis-alignment problem is prevented.