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"Putting the Pieces Together: Integrating Steel Repairs with Bridge Painting Projects"

By Kevin H. Keith, PE, LiRo Engineers, Inc.

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PUTTING THE PIECES TOGETHER: INTEGRATING STEEL REPAIRS WITH BRIDGE PAINTING PROJECTS

Kevin H. Keith, PE, LiRo Engineers, Inc. Philadelphia Pennsylvania, USA

Many bridge painting projects include steel repairs as part of the contract. Painting and steel repairs are performed by separate trades and often separate contractors. Even designers may see them as separate activities. However, steel repairs and coatings must work together and be installed as a system to perform as intended. This paper is a discussion about the process of installing steel repairs and painting a bridge at the same time. It includes lessons learned by a resident engineer with experience managing major bridge painting and steel repair contracts. Ironworking operations discussed include some important design requirements, slip critical criteria, scheduling, installation, inspection, and documentation. Paint requirements include specific surface preparation requirements for faying surfaces, slip critical coating requirements, paint compatibility, bolt preparation and coating, scheduling, inspection, and documentation. In addition to advising field personnel, the paper is intended to give constructability guidance to design professionals and facility owners. The goal is to prevent compromised repairs and coatings by integrating the design with the installation.

Steel repairs are often included with bridge painting projects to rehabilitate the steel portion of the superstructure. Repairs can be designed for known deficiencies on the bid set or designed "on the fly" after blasting reveals unknown repairs or the true extent of a deficiency that was covered with rust and paint. In either case there are many impacts to the schedule of the project, paint operations, and coordination between parties. First of all, the painting and repair work is performed by separate trades and often separate contractors. Either trade contractor may be a subcontractor to the other or both maybe subcontractors to a general contractor. Next, the steel repair pieces are generally not off the shelf and must be detailed, reviewed, fabricated, and delivered before being installed. Surface preparation and painting requirements are different than general painting and it generally has to be done separately from the "production" painting. For repairs discovered after blasting the deficiencies have to be field measured, repairs designed, and then they go to the detailer and fabricator. Change orders will be involved in additional units of repairs designed on the bid set and with repairs designed after blasting. Although decisions made during design can affect the outcome and prevent unwanted change orders and schedule delays, cooperation and coordination is required in the field to minimize undesired outcomes.

It can be challenging for trades to work together or perform work that is considered part of the other trade. On a non-union job, this can be potentially worked out by a superintendent or the resident project manager. Union jobs will generally require agreements by the sperate trade unions, known as project labor agreements or tenuous informal agreements on site. Project labor agreements are generally done in advance of a project starting, because the negotiations take time. Informal agreements can collapse suddenly or be prohibited by the unions involved, so they can stop work without warning and for an unknown amount of time. Every contract leadership arrangement, whether the lead entity is a paint contractor, steel contractor, or general

contractor faces this difficulty. The overlapping work involves paint (frequently lead paint) removal, surface preparation, painting, bolt cleaning, and caulking. These are paint trade tasks but, the challenge is scheduling the painters to fit into the steel repair installation schedule.

The steel repair process first involves an inspection to find the deficiency that needs to be repaired. This can be done before or after the blasting. Before blasting, an inspection can find obvious deficiencies and determine the approximate extent of the deficiency. After blasting, the exact extent of the deficiency can be measured and unknown deficiencies can be discovered. Many contracts have provisions for possible extra repair work by having additional units of designed repairs, stock repair designs (that only require dimensional changes), and/or contingency funds of either additional money or additional pounds of generic steel. Despite the provisions, the process does not change for the individual repair to be done but, they do make the financial transactions faster. After the inspection the deficiency is evaluated by an engineer to determine if a repair is required, desired, or not needed. Next the repair is designed; i.e. the parameters such as thickness, dimensions, configuration, type of steel, temporary support requirements, and other installation requirements. After the design is done, the design is sent to the contractor to fabricate and install. The contractor will check field dimensions and possible installation problems and review any contradictions with the designer. After resolving the field problems, the design is revised if needed and sent by the contractor to the detailer. The detailer prepares the instructions for the fabricator. These instructions are known as shop drawings and before the fabricator receives them, they are reviewed by the designer to make sure the details are correct. After the review is accepted, the shop drawing is sent to the fabricator, the repair is fabricated, and delivered.

The process from inspection to delivery can last from a month up to six months or more. Additional money for overtime or the pressure of an emergency situation can expedite delivery of fabricated repairs, but the minimum amount of time to include each step is usually a month. If everything has been designed for the repair in the bid set, the time can be cut in half, since the initial steps of inspection, evaluation, and checking field installation and measurements can be eliminated. In any case this time has to be considered in the schedule and with the coordination of installing the repair. Specifications will often have a recoat window of two weeks. After two weeks the surface must be pressure washed and possibly solvent cleaned before coating over it. As noted above, two weeks is the shortest possible time for a repair to be delivered under a perfect design. Rarely, is a design perfect and rarely the repair process goes that fast. Even a minor mistake on the shop drawings can result in a several days of delays by the time the mistake is corrected and reviewed. Thus, steel repair work and how it has been designed and specified must be considered carefully in the overall schedule.

After delivery, the faying surfaces must be ready before the repair is installed. There are different ways to prepare faying surfaces depending on the assumptions the designer used to specify the preparation. The surfaces can be paint to paint, primer to primer, or unfinished to unfinished. Other combinations are possible, but generally not specified. The surface preparation specification depends on the amount of friction the designer desires between the pieces. Since bolt holes are slightly bigger than the bolts, there is a potential for slip between the

pieces. A connection where the potential slip is accepted is called a bearing connection. The requirements for surface preparation are not important, because the bolts will resist movement beyond the size difference between the holes and the bolts. A connection where the slip is not acceptable is called a slip-critical connection. For these connections, the bolts are tightened to a specified force so the movement between the pieces is resisted by friction between the pieces. Slip critical connections require either unpainted surfaces or surfaces primed with a tested and certified primer. The primer's certificate includes if it meets Class A, B, or C requirements. The classes are different coefficients of friction specified by the Research Council on Structural Connections (RCSC). They also specify the testing procedures. The designer determines the class required for the design. Testing is done under standardized conditions, with the same primer on each surface. Thus, in the field the test parameters specified on the certificate must be followed. Some of the parameters specified include maximum thickness, cure time, and amount of thinner. These requirements can be different than the general painting of the steel. If fabricated repairs come primed by the fabricator, it may not be the same product used for other priming, the maximum thickness may be higher for other painting, and cure times may be different for overcoated versus a full cure. Again, all of these factors have to be considered in the schedule for the project.

After installation of the repair, the exposed surface must be prepared for painting. If it is not primed already, the repair surface will have to be prepared to the specified level of cleanliness and have the specified anchor profile. Blasting may not be possible, so a needle gun or other tool that gives the surface a profile should be used. Solvent cleaning should also be done to the surface to eliminate any residual oils on the surface. Before priming, or subsequent painting (if the repair piece was primed in the shop) the protective wax coating must be removed from the bolts. This involves rotating solvent cleaning, wire brushing, and wiping with a cloth until no more residue appears on the cloth. Alternatively, this can be done before the bolts are installed to save some time. After all these steps are complete the repair can be painted and caulked, if specified. Replacing pieces that involve existing connections, such a replacing gusset plates on a truss, will add another step before installation. The old paint on the remaining part of the existing connection needs to be removed and the area prepared as specified for the connection faying surface. Obviously for most bridges this old paint contains lead and must be removed properly. Just like painters, if this paint removal is left to the ironworkers, they have to follow the same rules and be protected by a lead health and safety plan that includes biological monitoring. Most repairs on bridges are bolted, but occasionally welding is used. All paint must be removed from the area being welded and from a specified distance from the weld.

Peeling paint, rust bleeding, and other paint failures can occur if the painting process is not followed step by step. Just like any other painting projects, atmospheric conditions must be favorable and checked during the work. Mixing and application also needs to be done properly. Quality control and record keeping are the same for production painting and faying surface painting. The quality control individual must document the atmospheric conditions before during and after the painting, record batch numbers, record the mixing process, record the amount of thinner used, take wet film tests, and record how the paint is applied. Cold, rain, or snow may not bother ironworkers, but a repair can be delayed if it cannot be painted.

Structural failure can happen if the steel repair process is not followed step by step. Incorrect dimensions have led to failure, for example. Although it was not the result of a repair, the I-35W Bridge in Minneapolis collapsed because gusset plates were too thin. No one has determined who made the mistake; the designer, detailer, or fabricator. That is why there are many checks and reviews of each party's work. Each step is logged and documented explicitly to make sure the process has been completed correctly.

Other factors influencing the installation schedule include traffic control requirements, temporary support requirements, equipment needed (for example cranes and lifts), the fabricator's schedule, the delivery schedule, and the time it takes for the detailer and the reviewers. Even hours can be different between the trades; painters may work 10-hour shifts and ironworkers may work 8-hour shifts. All of these items can require significant coordination between all of the separate parties. Some examples are: the owner has to approve the traffic control schedule, the general contractor will provide the crane, the detailer may have different priorities than the installer, the fabricator may not deliver repairs in the order needed, and the ironworkers can't work overtime. On a big job, these factors can add more time to the standard repair process.

The best place to plan this is during design, but the Contractor's input is missing and designers usually don't have an in-depth knowledge of painting and work only with standard painting specifications. Thus, it is important to begin the discussion of the repair process during the pre-construction meeting or even during the pre-bid meeting. The baseline schedule should be checked for a realistic timeframe for repairs. Often steel repairs can be the schedule driver for a project. A painting schedule is rather straight forward and most painting contractors know their production rates for structure types they have worked on; leaving weather as the primary chance variable. Ironwork, because of the long process, has many chance variables and the planning does not end until the project is over. An entire book could be written on all of the scenarios, combinations of factors, and challenges to solve with combining steel repairs with painting projects. To condense the subject the following is the best practices from the Author's ten years of experience as a resident engineer for painting and steel repair projects and five years as a designer of bridge rehabilitation projects.

<u>Recommendations for the Designer</u>

- Inspect the structure carefully before designing repairs. Do not rely exclusively on the routine inspections to design repairs. Take field measurements, note fatigue prone details, and note areas where deficiencies may be hidden or larger than visible (this is usually every deficiency before blasting). At least a day per span for two individuals should be dedicated to the pre-design inspection.
- Try to design stock repairs that only need dimensional changes. Try to use combinations of rolled angles, standard plates, and other standard rolled shapes.
- Carefully discuss contingency planning with the owner and how the contingency will be paid for. If it is anticipated that unforeseen repairs will have to be designed and/or intricately detailed then it is probably better to recommend a bid with a price per pound for additional repairs. That way the owner gets a competitive bid price for the detailing

in addition to the steel. If the anticipated repairs are already designed plate sections (or other standard repairs) then additional units of these repairs is appropriate. If it is really unknown what unforeseen repairs might be found, for example there are a number of fatigue details that may or may not have cracks, then a cash contingency can be recommended.

- As a corollary, quantities will generally be under estimated, so a contingency is needed.
- Consider adding an inspection component to the construction contract or the construction monitoring contract for fatigue details, post blast inspections, field measurements for repair dimensions, or other things that may be discovered on the bridge (for example plug welds). Be sure to factor this into the designer's schedule and to specify qualifications of the inspectors.
- Specify criteria for unforeseen repairs and specify the limits of repair dimensions. For example, "Repair all areas with greater than 50% section loss to the thickness of the component spread over greater than 0.5 square feet of the component. The final row of bolts for a repair shall be in full thickness area of the component and three inches beyond the limits of deterioration." Analyze the components of the bridge to determine the criteria for repairs.
- Don't arbitrarily specify slip critical connections. Specify when required by code or when needed for the design.
- Carefully specify faying surface preparation and coatings (if they are going to be coated). Reference following the manufacturers slip critical certification criteria if it is a coated slip critical connection. Each manufacturer has different criteria, so this should be referenced rather than specified if multiple paint manufactures are permitted. An example would be: "Faying surfaces shall be primed with a Type B Slip Critical Certified Primer. Submit the manufacturers slip critical certification with the product data sheet for the primer. Prepare surfaces using mechanical tool cleaning to SSPC SP 11 with an anchor profile as specified by the manufacturers slip critical certification. Prime the surfaces with the same primer on each surface following curing, thickness, and any other criteria on the manufacturers slip critical certification."
- Use primed faying surfaces when the surrounding area is painted and the repair is bolted. For weathering steel and welded repairs bare faying surfaces can be specified. Welding will seal the repair to prevent rust bleeding. If the repair is not slip critical, then the area can be painted.
- Specify caulking around the perimeters of repairs. This will provide extra protection from rust bleeding. Make sure to add the quantity to the overall quantity of caulking.
- For the designer's schedule, allow at least 3 months from the time field measurements are taken to the time the steel is delivered to the site. For repairs discovered after blasting add more time; at least 4 months from field measurements to delivery.
- Allow masking repairs, so painting in the areas surrounding the repair can be completed. Specify the size of the mask beyond the repair to allow for welding, caulking, etc. If the entire area is primed while the repair is fabricated and installed, most likely the entire area will have to be pressure washed and possibly solvent cleaned before paint is applied. Also, leaving the entire area with only primer, may push painting into another season if

the repair is not completed before the winter. If the surrounding area and the repair area are painted, then the paint has to be removed from the repair. In either case the extra work can result in schedule delays. Masking the area avoids having to clean a large area and keeps production painting moving.

- Carefully review standard specifications or "cut and paste" specifications. Rewrite the specifications if needed.
- Specify galvanized bolts, because they do not need to be coated. If they are galvanized bolts will be painted, notes about surface preparation and cleaning, described above, should be added. Black bolts are black because they are covered with mill scale, which inhibits coating adhesion. The most efficient way to remove the mill scale is blasting. This is not practical for individual bolts before installation and adds another step in the repair sequence if done in place. Black bolts can be specified for weathering steel connections, however.
- Once the plans and specifications are done, double check the repair locations on site. On a large bridge, it can be easy to locate repairs in the wrong locations.
- Remember the steel repair and painting are a system and not separate components.

<u>Recommendations for the Owner:</u>

- Always have a contingency for steel repairs. This is explained above, along with some recommendations of how to set up the contingency.
- Allow changes to standard specifications or allow special provisions if recommended by the designer.
- Expedite changes and change orders for unforeseen repairs to prevent delays.
- Include inspection time, with access equipment, at least two inspectors, and required support (such as MPT) in the designer's budget. This well worth the expense.
- Avoid the temptation just to have all repairs bid by the pound. Bid prices will have a large range if the contractor does not know how much detailing and complex fabrication will need to be done. Even a set of stock designs, without dimensions, is better than nothing.
- Allow flexibility in the field. There are some situations where the contractor can find a better way to do things.
- Have engineering and design support during construction. This can be from the designer or from a suitably qualified construction monitoring firm.
- Take advantage of in-place platforms and structural access during painting for inspections and to get additional repairs done. This will save the cost of access in a future contract.

<u>Recommendations for the Contractor:</u>

- Hire one party to manage the detailing, fabrication, and installation of the steel repairs. This is the best insurance that priorities for each entity will be aligned.
- Carefully review priorities and the painting schedule with the steel contractor. Emphasize getting field measurements and shop drawings done in the same order of

areas as the painting contractor. This prevents on site stockpiles of repairs that can't be installed until other work is completed. The steel contractor should be giving the same priorities to the detailer and the fabricator. Monitor shop drawing submissions, deliveries, and installation to make sure everyone's priorities are in alignment.

- Even though it can be difficult to manage the two contractors in the same space, avoid having the steel and painting split up. This is to make sure faying surfaces are done correctly, required touch up and paint repairs are reduced, platforms (if used) and containment can be taken down promptly, and the entire area can be closed out at the same time. The results are a better quality paint system and avoids extra work that is not needed. It also prevents forgetting steps.
- Clearly define the work the painters and ironworkers will do. I recommend having painters prepare and coat faying surfaces, caulk, and paint repairs. The iron workers should install repairs, clean bolts, tighten bolts, and clean up reaming or other debris from the installation. If ironworkers are responsible for any of the painting tasks, they need to be properly trained, have proper personal protective equipment, and have any required biological monitoring for the task. Bolt cleaning, caulking, and clean-up are often the tasks that get forgotten and cause finger pointing between the trades. Painting quality control (proper mixing, atmospheric condition testing, and documentation) is usually not understood by ironworkers. Because the bolt cleaning might interfere with installation or torqueing, it is best left to the iron workers to do after they have finished torqueing the repair. Also caulking is generally done between paint coats, so the painters will know when to caulk.
- Assign a small paint crew to work with the ironworkers. Usually two dedicated painters for up to three ironworking crews is sufficient. The need for coordination increases exponentially when the ratio of painters is lower. Dedicated painters will work out responsibilities and timing more efficiently than sending a couple of workers over from paint crews doing other work. Again, this helps ensure tasks are not forgotten and improves the quality of the finished product.
- Another difficulty can be having the painters and the ironworkers work the same hours. Managing repair work is easier when one trade does not leave before the other. If switching hours is not possible, then the extra time has to be coordinated between the trades.
- Do not be afraid to prepare RFIs for constructability problems based on the plans or specifications. Standard specifications, "cut and paste" specifications", arbitrary requirements (such as specifying every connection as slip critical), or unforeseen issues may cause problems in the field that require changing plans.
- Remember to follow cure times and certification requirements for slip critical connections.
- If steel repair pieces are primed in the shop, then the same primer in the field must be used. Remember inorganic zinc is often used in the shop, this may be difficult to apply in the field at the repair location, so the shop may have to switch to organic zinc.
- The primer must also be compatible with the paint system for the edges around the repair that were not primed before. Most specifications require the same brand be used

to help guarantee compatibility. The type of primer and the brand must be coordinated with the shop.

- Steel must be bare for welding. Make sure to leave enough bare space around the weld to dissipate the heat, so the surrounding paint is not damaged. Clean flux and weld splatter before coating the weld and area around welds.
- Welds and bolts should be stripe coated with the layer of paint specified (primer, intermediate and/or final coat).
- Check with the ironworkers about cleaning bolts before installation to make sure they can be installed and torqued correctly.
- Caulk around repairs to add additional protection to avoid rust bleeding. If it is not specified, consider posting the question during the bid if caulking around repairs will be required and if it is paid for under the general caulking or as part of the repair.
- Remember quality control and good painting practices apply for painting repairs and faying surfaces. Atmospheric conditions need to be checked at the location of the repair, mixing done properly (with only whole kits used), and documentation of details (atmospheric conditions, batch numbers, application method, etc.) must be done.
- Whole kits of primer must be used, to make sure the ratio of zinc to paint is correct. Some primers are formulated with the volume of zinc and some formulated with weight. Whole kits, from the same manufacturer will have the correct ratios. Do not use zinc from other manufacturers or from different kits. Again, in order to achieve the slip critical requirements this is very important. Buy small quantity kits or plan ahead for priming multiple areas to reduce primer waste.

<u>Recommendations for the Construction Monitor (if applicable):</u>

- Start planning for steel repairs during the pre-construction meeting. Go over requirements for faying surfaces, bolt cleaning, painting, and slip critical connections.
- Look carefully at the schedule and check for realistic timeframes and synchronicity with the painting. Recommend changes to make the schedule conform to the suggestions above. Other things to look for include steel repair work being done in the winter. Heating plans or paint substitutions may be required for the painting during the winter depending on the local climate.
- Make sure the required support is in place for the repairs. For example, work involving jacking or temporary support may not be able to be done under live loads. Have road closure plans been submitted? Have the road closures been coordinated with the agency and adjacent agencies? Has the public been informed about the road closure far enough in advance?
- Check the contractor's painting procedure and quality plan. Have the proper procedures and quality control for steel repair work been included?
- Keep planning for steel repairs through discussions in progress meeting and pre-activity meetings. Things will change after blasting.

- Perform the post blast inspections soon after priming; if the construction monitor is responsible for them. Identify areas to be masked and coordinate with the owner and designer about repairs to add. Consider masking off potential repair areas also.
- Monitor shop drawing submissions, deliveries, and installations to check if the work is being prioritized correctly.
- Monitor installation procedures to check them for contract compliance.
- Check steel storage areas and laydown areas for protection from the elements. Also check what is in storage. Are there a lot of pieces that cannot be installed? That is a sign that priorities are not aligned between the installer, detailer, or fabricator.
- Monitor field surface preparation and painting facilities and procedures. Sometimes a contained area of the bridge will be set up for priming and/or coating steel repairs. Check to make sure the set up meets the same requirements as on the bridge for containment and weather protection. Make sure procedures are correct and steps are not forgotten or short cuts are taken. Seeing an installed steel repair flash rusted does not give one much confidence the faying surfaces were done correctly.
- As always, document each process and step thoroughly.

As you can see from above, there are a significant number of recommendations for combining steel repairs with bridge painting projects. A key factor to remember is the paint and repair have to work together as a system. All parties need to understand the details of the entire system in order to specify and install them correctly. Many of the detail decisions have schedule and cost considerations, in addition to technical considerations. Thus, active leadership and cooperation from everyone involved is required, because it is next to impossible to have a perfect design or a bridge without unforeseen deficiencies. Deliberate planning and communications at every step will help ensure the steel repairs are done correctly and look good for a long time.