A Brief History of The Development of Total Shop Painting for Bridge Girders in Michigan

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BACKGROUND

Michigan's first bridge with total shop painting was built in 1981. The job was a limited success, apparently because of resistance to change within the system. Fabricators tended to think of themselves as welders and not as painters; painting seemed to be regarded as more of a nuisance than a profitable operation. Construction workers did not treat the steel as a finished product, and they caused damage that required many expensive repairs. The system seemed doomed to failure, and the company may have preferred it.

Departmental staff suspected that a lack of long-term commitment may have caused many of the problems associated with the first job. Therefore, the department made a commitment to require shop painting for a minimum of two years, and then the process was taken far more seriously by fabricators. Two fabricators set up paint areas, more joined in, and now many fabricators are equipped to do the work. Two fabricators now have separate buildings for painting. About 40 bridges were completed in the interval from 1983 to 1985. In 1985, the department made a long-term commitment to total shop painting. Other states started to experiment with the system as well.

COATING SYSTEMS

In 1983, we began the use of an inorganic, zinc-rich primer with an epoxy top coat and an additional urethane top coat on the fascias only. Problems developed in the application of two top coats of the same color. Also, on the interior portions of the bridge, the epoxy paints became very dirty in non-repaired areas.

In 1985, an improvement was made. The components of the revised system were the same as those of the previous system, but the color of the intermediate coat was changed to white to help ensure proper coverage of the urethane top coat. Urethane was used on all the steel rather than just the fascias. This system worked quite well.

Still, it could be improved upon for resistance to damage during transit. The inorganic primer was not as hard and durable as it might have been; therefore, in September of 1987, we switched from an inorganic to an organic, zinc-rich primer and continued to use the epoxy intermediate and urethane top coats. The system had worked well in field applications for five years. Organic zinc can be put on thicker without developing problems. The specification for surface profile had been 1 to 2 mils for inorganic zinc, and some shops were running 2.3 to 2.5 mils. Organic zinc goes on in profiles of 1 to 2.5 mils.

The change provided much more abrasion resistance for the total system. In addition, it provided us with one specification and one system for both shop and field use, avoiding some confusion in the preparation of the jobs. The same system works on weathered ASTM A-588 steel as well.

PROCEDURES

When we began total shop painting procedures, we used a shop primer coat and a field top coat. After the beam had been blast cleaned, the primer was applied in the shop and the girders were hauled to the site, erected in the field, and finish coated after bridge construction. Field splices are made with uncoated bolts so that torque wrenches could be used in tightening. Later, some sand blasting was required to prepare the bolted areas for finish coating. The deck is cast in place and then the finish coat is applied. This all sounds very straightforward; however, as with many things in the field of construction, it does not always work out the way it was intended. Some problems developed in the system.

In some cases, the top flange was left unpainted in order to weld on the shear developers, and rust from this uncoated area ran down onto the primed surface. It was difficult to see whether the problem was rust coming through a thin primer or rust running down from above and staining. When repairs were necessary, the question was, "Who is responsible and who pays?" When the problem is extensive, it is quite serious and the repair is expensive.

Mud and concrete get on the primer. The inorganic, zinc-rich primers are very porous, and it is difficult to remove contaminants once they are on the surfaces. The repair painting of field welds damages the surrounding primer. Concrete slurry leaks through the forms, gets on the porous primer, and is extremely difficult to remove.

Improper site storage has caused considerable contamination of the primer and other damage. Conflicts emerge on the job as to who was responsible for the damage and who should pay for the cleaning and repair of damaged areas. The painter who has bid the job does not want to find that he has dirt, concrete slurry, and other damage to take care of before he can start painting.

In early jobs, repairs were not done properly. Proper surface preparation needed to be done. Sandblasting of the bolt heads was necessary to remove the rust. Also, proper application procedures are necessary. Paint should be sprayed on, not brushed on. Improper surface preparation and application procedures have led to early failures at many places on relatively new structures. It appeared that the only option was to choose either total field painting or total shop painting.

Total shop painting started in 1983, as mentioned previously. Surface preparation is very inexpensive in the shop. Consider the difference in time and labor it takes to blast a girder by running it through a wheelabrator than by doing it in the field as in total field painting.

In total shop painting, the prepared surface is easy to inspect. The inspector places testex replica tape on the surface to determine whether the surface profile is adequate for the paint coating. Painting and inspection can be done easily, without scaffolding, with ready access to all parts of the girder. The surface profile is easy to check. The horizontal surfaces of the girder are vacuum cleaned.

Once surfaces are carefully coated to a controlled dry film thickness, members can be handled with little or no damage. A crane hook with rubber pads on it is used to pick up the girders and move them around without damaging the surface. Top coats can be applied with ready access to all surfaces of the girder. Faying surfaces are masked to keep the finish coats away. These surfaces are coated only with inorganic, zinc-rich primers in order to maintain the necessary friction constant within the bolted connections.

Since it sits up on blocks, the girder can be picked up once the coating has dried. The blocks can be moved a little, that particular area can be finish coated, and the product is totally coated and ready to go. After proper loading, the beam is approved, the inspectors tag affixed, and is ready for shipping.

Splice plates are carefully controlled, on one side for friction and on the other for corrosion. The separate sides have to be kept track of, oriented properly, and inspected. Then the girders are ready for shipping, blocked, and loaded on a rail car. The diaphragms are carefully packaged on pallets in the proper order for assembly on the site. In many cases, girders are shipped by truck instead of by rail. On some occasions, there will be some minor damage, such as an edge scraped during shipping and handling. Carefully specified procedures are used for repairing the minor areas of girders that get damaged.

Care needs to be taken when a finished product is on-site. A contractor cannot place a finished girder on a dirty surface. A mat with gravel on it can ruin the coating and require repair that would have been unnecessary if the product had been properly stored. Rough handling and careless storage at the site can amount to a considerable amount of damage, which requires repairs to be made in all areas.

In the event that a girder with only a primer coat is sprayed with oil from a broken hydraulic line during transportation, the removal of the oil in order to get adequate bond and performance of the top coat, would be an expensive operation. If the girder has been total shop painted, the oil is harmless and will gradually disappear from the surface.

Improper blocking can result in the bending of the web. To repair it by flame straightening destroys the paint. Blocking drawings now are required, and proper storage on-site is required.

The beams need to be properly blocked. Small pieces of inexpensive carpeting or carpet pad can prevent all damage to the coating when set on the blocks. Splice plates and associated bolts are shipped in place. Splice plates are simply slid back from the shipped position and slipped forward again once the beam is in place. Lifting the member does not hurt the coating. Crane hooks with rubber pads on them can be used to pick up the girder and set it in place without hurting the coating at all. With proper lifting devices on-site, the diaphragms can be picked up and carried into place without being damaged. A double lift can take two at a time to the assembly site. The diaphragms are dropped between the stringers by the crane operator and are bolted into place. In some instances, an area of the steel may be inaccessible after the bridge is built and there would have been no way to coat the back part of the steel had it not been coated prior to erection.

The use of galvanized bolts eliminates the need for field blasting the bolts. Field welding has now been eliminated entirely because of the damage to the coating, and all such field connections are made by bolting. The small areas are ground clean on the top flange for the placement of the welded sheared developers. On a few girders with extremely thin top flange plates, it was found that the coating was burned on the opposite side of the top flange from the studs, requiring a field repair at each location. Therefore, an agreement was made with the Design Division in which flange plates no thinner than three-fourths of an inch were used. This procedure eliminated the problem and was completely acceptable to the designers.

Where a primer has been applied too thin, causing an early failure of the system, the mistake usually shows up prior to the final inspection and the contractor pays for the repairs. The affinity of epoxy top coats to retain dirt has led to the use of urethane for the complete top coat. In older jobs, in which the interior girders did not have the urethane top coat, repair areas were required to have a three coat procedure that included the urethane top coat.

The worst of the jobs we had required 3 to 4 percent of the surface to be repaired. A typical job now requires about 0.5 percent of the surface to be repaired.

Paint fumes have unwanted side effects if the painting contractor does not use adequate protection for his personnel. Effective procedures are available, and if the painting is done in accordance with the specifications, the coating can be applied without harming the people involved. Although some other types of coatings that might be easier to handle in this respect are available, they do not have the performance or the surface toughness that this series of coatings has.

COSTS

The cost of the coatings is difficult to determine since it is included in the price of furnishing, fabricating, and coating the girders. The difference appears to be smaller than the normal bid variations that occur, but fabricators are reluctant to disclose the prices that make up their total cost.

The first few jobs were quite expensive. It looked as though we were paying $2.30 to $2.50 per square foot, or about the same as we pay for field coating. It is difficult to estimate something one has never done before, and that is probably part of the reason. However, we found that the bid prices rapidly decreased after the materials had been in use for awhile. Over the last few years, the bid prices have been quite constant. Our best estimate of the system at the present time is between $1.60 and $1.80 per square foot (including touch-up). Surface preparation is much cheaper to do in the shop because automatic (instead of manual) sandblasting is done by running an entire girder through a wheelabrator. It is much more efficient than doing it on-site. Accessibility is much more convenient because the girder is at ground level, where scaffolding is not needed. The same system on field application jobs is running $2.60 to $3.00 per square foot. The total shop painting system seems to be well established. The prices are stabilized, and some of the fabricators are even promoting the system.

ADVANTAGES AND DISADVANTAGES

The advantages of the system are: 1) it is far easier to inspect, because we can do it where it is easy to get to the beam for both coating and inspection; 2) it appears to be very cost effective; 3) we do not get contamination of primer coats or intermediate coats due to transportation, on-site handling, or construction of decks and other items; 4) it is much easier to maintain quality in the shop than in the field; and, 5) the surfaces that are inaccessible after erection have already been completely coated so there is no rust streaking from the crevices on the new structure.

There are some disadvantages: 1) it requires a high level of technical competence to get the system started and to address complaints; 2) unfamiliarity with a new system of this type will naturally generate some problems during start up; and, 3) in some areas, there are environmental problems for fabricators with the use of volatile organic compounds (V.O.C.), although early test results are promising on some high performance, low V.O.C. paints. We believe it is worth solving the problems.

Total shop painting is not a cure-all, but the advantages of the system outweigh the disadvantages. We are pleased with the total shop painting system and will continue to use it. If you have doubts about the cost of this type of system or would like to see what happens on your job, you might consider entering a total shop coating specification as an approved alternative in your contract documents. Some contractors that are not familiar with these procedures may not use them; however, you may find contractors who have used the system previously bidding your jobs, saving you some money, and giving you a good project.

Finally, I recognize MDOT staff members who have worked continuously to develop specifications, solve problems, and make the system work. They are James D. Culp, P.E., construction bridge engineer; Jon W. Reinche, P.E., bridge fabrication engineer; and, Gary L. Tinklenberg, former coatings specialist.

These dedicated people have worked continuously to develop specifications, solve problems, and make the system work. Their services to MDOT are gratefully acknowledged.