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WELDING STRUCTURAL STEEL PART II

In Part I of this article (MATES Issue No. 55) we discussed welding design, workmanship, and welding techniques, and the various critical factors that must be addressed in the welding process. In the following discussion, we will address qualification requirements, inspection techniques, and some summary comments.

Qualification Requirements

Welders (the machines that do the welding), welder operators, and welding procedures must all be qualified prior to commencing the actual welding operations. It must be proven that the welding machine and operator can weld with the selected process in an approved manner. They must weld in various positions (flat horizontal, horizontal, vertical, and overhead) to demonstrate these abilities in order to qualify for welding in those same positions during production. They must also qualify their ability to weld on various plate thicknesses and materials depending on the types of materials and thicknesses required on the job. All welding is witnessed by technicians certified in welding inspection by the American Welding Society, and steel plates used to qualify welding ability are tested destructively. Welder and welder operator qualification provide documentation of a welder's ability.

Welding procedure qualification requires the fabricator to submit to MDOT in writing, details for welded joints to be used in production. These written details show the actual joint (butt or fillet weld), welding travel speed (inches/minute), amperage and voltage, welding symbol, preheat, electrode, and the number of weld passes required to get the size of weld specified. Once the written welding procedure has been approved by the Department, a qualified welder operator runs the procedure by welding the joint submitted for approval. If this test weld passes all nondestructive and mechanical testing requirements, the fabricator can begin production with both a qualified welder, operator, and a qualified procedure.

Inspection Techniques

A specified percentage of welds must be inspected using an approved nondestructive testing (NDT) method. This means testing a welded joint without altering it in any way, to determine complete fusion of weld and base metals and to detect possible flaws. MDOT requires that all personnel performing NDT be certified by the American Society for Nondestructive Testing as Level II NDT inspectors. Types of NDT include visual, liquid dye penetration, magnetic particle testing (MT), ultrasonic testing (UT), and radiographic testing (RT). MDOT's Standard Specifications for Construction require NDT testing of butt and fillet welding in the fabrication shop. Any other requirements, including any NDT done on field welding, must be specified by Special Provision in the contract documents.

In application, liquid dye penetration and magnetic particle testing are only used to detect surface cracking.

These methods are used extensively for fillet weld flaw detection, and for areas where UT and RT are not feasible. In the first of these methods, a penetrating liquid dye is applied to the welded area. When the excess dye is wiped away, surface flaws will be visible. Magnetic particle testing involves the establishment of a magnetic field within the material to be tested, any flaws at or near the surface will set up leakages in the magnetic field which become visible when a metallic powder is applied.

Ultrasonic testing is a process where sound waves are sent into the metal, and special techniques are used to detect returning waves reflected from flaws in the weldment. It is used for a variety of inspection techniques but for welding inspection it is used most often to detect flaws in complete penetration groove welds. Ultrasonic testing is excellent for detecting subsurface flaws. Extensive training is required in order to use this method of inspection correctly.

Radiographic testing uses photographic film to record all defects. It is an X-ray testing method similar to that used in the medical profession, and is used most often in shop weld applications and on complete joint penetration groove welds. Unlike the other NDT methods, the film provides a permanent record.

Conclusion

In general, all applications of shop welding are covered by MDOT specifications. Any welding required to be performed in the field must be accompanied by a Special Provision for field welding unique to that job. Many variables must be considered and all phases of the process must be approved prior to welding, in order to obtain high quality welded products. Specifications beyond those used in conventional welding applications are established for fracture critical members; that is any supporting members or components whose failure would be expected to result in the collapse of major portions of a bridge. Fracture critical members have very tight requirements on preheat, post-heat (heating the weldment just after finishing a pass), and weld repair for any defects detected by NDT.

Welding a joint correctly involves more than just butting two plates together and running a bead of weld. Preliminary investigation must be done on all structural members to determine the most economical and practical way to form a quality connection by welding. After all design and preliminary studies are complete for the given joint, qualification testing must begin. After all qualification is complete, production welding can commence with qualified welders, followed by NDT providing proper inspection and documentation. If such preparations are not taken, hidden defects might occur which could lead to future fatigue cracking and, ultimately, catastrophic failure of the structure could occur.

If you have any questions about shop or field welding, or about MDOT's specifications regarding welding, our Structural Services Unit personnel would be glad to help you. (517) 322-5709.

-Steve Cook

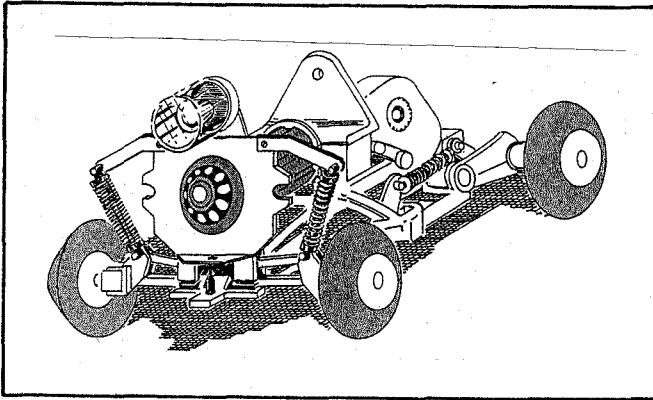
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MDOT'S PEEPING TOM

Since edge drains have become a standard feature of Michigan's highways, it is important to be able to inspect them to ensure that they are properly functioning. To do this, the Division's Pavement Technology Unit purchased a small, portable television system. This proprietary unit consists of a watertight housing, about 2-1/2 in. in diameter and 5-1/4 in. long, which contains a small television camera, surrounded by an array of 10 quartz lights. A power control/monitor unit with a 9-in. TV screen provides a clear picture of the interior of the pipe, and the system allows videotaping for later viewing. The camera housing rides through the pipe on flexible spring steel skids, and is pushed along by a flexible cable.



This unit proved to be a very practical device for inspecting our 4 and 6-in. edge drains. It was not, however, very effective when attempting to inspect larger diameter pipes, as the lighting provided with the system was insufficient to illuminate their interiors. Adding more lighting required a means for supporting it, so the Division's machine shop fabricated a small sled which carried the original camera head as well as a larger, stronger light. Because of the added weight of the sled and lighting, the unit could no longer be pushed through a pipe with the flexible cable. It either had to be pulled through, or a system of connectable 10-ft lengths of thin-wall electrical conduit was used to push the sled along.

Although this unit now allowed the inspection of larger diameter pipe, it could not be introduced through manholes because of the length of the conduit, and this severely limited the sled device. Another limitation of the system was that it was only effective for about 100 ft. Therefore, our Instrumentation and Data Systems Unit was asked to devise another system that could be used in storm sewers and culvert-size pipes.

After considering the problem, it was decided that a self-propelled vehicle of some sort might be the answer. The initial step was to purchase a remote-controlled scale model toy truck from a local hobby shop. The first obstacle noted was that the weight of the little vehicle was insufficient to pull the cable behind it. With 7 or 8 lb of lead added to gain sufficient weight, stiffer springs were required, and the steerable front wheels of the vehicle were locked. The additional weight also required replacing the electric motor with a more powerful one, and the vehicle was changed from a two-wheel to a four-wheel drive system. The wheels and tires that came with the vehicle proved to be incapable of getting sufficient traction in many cases, so they were replaced with a set designed and fabricated by our machine shop. In short, almost nothing remained of the vehicle as purchased in the hobby shop except for the vehicle chassis.

We now have a remotely controlled motorized vehicle which is capable of carrying the camera and additional lighting nearly twice as far as before, or about 200 ft. The on-board lighting adequately illuminates the interior of the larger diameter pipes for detailed viewing. A more flexible cable was added so that the unit is easily introduced through manholes or other small entrance ports. Though the original system continues to do yeoman duty in the inspection of the small diameter edge drain pipes, this new system has made our inspection procedures much more versatile, allowing us to carefully inspect sewer and culvert size pipes, up to 24 in. in diameter, as well.

As more and more attention is paid to providing adequate drainage for our pavements, post-construction inspection is an effective means for evaluating a drainage system. As the demands for more versatile equipment increase, the Research Laboratory Section will continue to strive for creative means to meet them.

-Jerry Sweeney
-Leo DeFrain

TECHADVISORIES

The brief information items that follow here are intended to aid MDOT technologists by advising or clarifying, for them, current technical developments, changes or other activities that may affect their technical duties or responsibilities.

PERSONNEL NOTES

With the death on August 22nd of **Tony Price**, MDOT lost one of its superior employees, and those of us in M&T lost one of our dearest friends. Tony was the man who always went the extra mile, always took on the extra task, and always was there to help out a friend. His friends in the Division feel the loss acutely, and wish him peace.

Jim Zubierna retired on July 1, from the Testing Laboratory Section's Bituminous Technical Services Unit after 37 years of service. **Zubie** worked in the bituminous testing area, and over the years accumulated an encyclopedic knowledge of bituminous materials and mixes. A cheerful, helpful man, and an asset to the Division, we wish him all the best in his retirement.

A number of new employees have been added to the staff, **Melissa Luttrell** has been appointed to the position of Environmental Quality Specialist in the Geoenvironmental Unit... **Chris Davis** joins the Research Laboratory's Structural Research Unit as an Engineering Technician...The Testing Laboratory has added two new members, **Keith Klee** joins the Structural Services Unit as an Engineering Technician, and **Dung Nguyen** has been appointed as an Engineering Technician in the Bituminous Technical Unit. We welcome these new employees, and look forward to working with them.

Bob Pena transferred, with a promotion, from our Pavement Technology Unit to the Engineering Services Division. Although we will miss him in the Division, we are pleased to see him take another step upward in his career.

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