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ADAPTING THE PROPOSED AASHTO CONTROLLED SHOT PEENING *SPECIFICATION TO MOVABLE BRIDGES*

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ABSTRACT

Recent studies of bridges determined most cracks occurred due to fatigue. A traditional method of extending fatigue life is peening. Hammer peening was successfully used on the Yellow Pond Bridge on Interstate 95 in the late seventies. Unfortunately, limitations of hammer peening have prevented everyone from utilizing this process. For this reason controlled shot peening has been proposed to AASHTO, since it has none of the limitations of hammer peening.

Controlled shot peening of fatigue critical components on movable bridges and structures will be discussed.

ADAPTING THE PROPOSED AASHTO CONTROLLED SHOT PEENING SPECIFICATION TO MOVABLE BRIDGES

In 1983 the New Jersey Department of Transportation (N.J.D.O.T.) asked the contractor erecting the Passaic Avenue Bridge to peen the cover plate termination welds. The peening was to overcome an irregularity introduced by an inconsistent welding procedure. The contractor could not find anyone to do the hammer peening and the N.J.D.O.T accepted a controlled shot peening procedure suggested by Metal Improvement Company, Inc., Carlstadt, New Jersey. It is this incident that led to the proposal of a controlled shot peening specification to the AASHTO Welding and Bridge Design Committees in 1988. In January 1990, research was proposed at the Transportation Research Board A2F07 Fabrication and Inspection of Metal Structure Committee Meeting to develop simple and economic equipment, procedures and inspection methods for processes such as controlled shot peening that are effective means of preventing fatigue cracking in low fatigue strength details on existing bridges.

In a recent study(1) of cracking in bridges, all but 5 of the 130 bridges studied developed cracks due to fatigue, and the majority of the fatigue cracks initiated near a weld. This is not surprising since welding introduces three fatigue strength reducing details:

1. High tensile stresses as high as the yield strength of the material are introduced as the weld cools.

2. The stress riser at the weld toe magnifies the problem. Most fatigue cracks initiate here.

3. Poor welding procedures introduce potential porosity, slag inclusions and poor fusion.

Nondestructive evaluation such as magnetic particle inspection should expose existing cracks, inclusions and porosity. Grinding the weld smooth to eliminate the stress riser at weld toe is suggested to improve the fatigue strength. This has been adapted for new construction. Cover plate termination welds with a stress category "E" rating can be improved to category "B" by providing a transition with a radius equal to or greater than 24".(2) Grinding to such a radius may not be possible on existing structures or economically prohibitive. Therefore, an alternative to excessive grinding on existing bridges is needed. Gas tungsten arc remelt at the weld toe is difficult if not impossible to do in the field.(3) Hammer or needle peening can be accomplished in the field. However, holding a 10 pound hammer overhead while exerting constant pressure to pound a 1/8" wide groove is difficult to do all day long, like jack hammering the ceiling. As the N.J.D.O.T. experienced, finding someone to do this physically taxing detailed work can be a problem. The solution of bolted splices was compared at $2,000.00 per splice to $50.00 per peened cover plate termination weld on the demonstration project of retrofitting the Yellow Pond, Interstate 95 Bridge in Bridgeport, Connecticut in 1978.

Controlled shot peening will cost slightly higher ($75.00 per cover plate termination weld) yet offer quality controls the other methods lack.

Peening (hammer, needle and controlled shot) offers a fatigue raising characteristic none of the other methods have. By cold working the surface to a specific depth, residual tensile stresses as high as yield are converted to compressive stresses equal to 50 to 60% of the ultimate tensile strength of the steel. For example, A-588 grade B steel may have an ultimate tensile strength of 70,000PSI and a yield strength of 50,000PSI. Tensile stresses from welding may be as high as 50,000PSI. Compressive stresses from peening of -42,000PSI would result in a stress reduction as high as 92,000 PSI.

The second fatigue strength raising characteristic not commonly known of controlled shot peening is as follows: When a compressed stress layer is induced in and below any surface discontinuity such as the stress riser at the weld toe, the bottom of the surface discontinuity is in compression and fatigue strength is increased as if the discontinuity were not there. This is explained by the retardation of crack initiation by compressive stresses.

The third fatigue strength raising characteristic offered by controlled shot peening is introduced when the fluorescent tracer is specified to prove uniform coverage. The fluorescent tracer is painted on the area of the weld and heat affected zone (approximately 2"-3" either side of the weld). The characteristic of the dye is that it can't be removed until a shot impact stretches the surface to form a dimple. Any fluorescent dye visible when inspected with a black light indicates areas that have not been peened. The dye works its way into porosity, inclusions and cracks opened up by the peening and, therefore, acts as a quality control method on the weld itself. This provides the inspector the leverage needed to improve the welding procedure or remove any deep flaw by grinding. Depending on the condition of the weld, controlled shot peening can conceivably raise the stress category by three or more.

When then can controlled shot peening be applied to movable bridge components?

Studies of existing bridges reveal the low fatigue strength details in the least desirable form of stress relief - cracking. The retrofit should include a post weld stress relief as controlled shot peening.

Finite analysis of stresses set up by actual traffic can point out low fatigue strength details. Some of these low fatigue strength details on movable bridges are as follows:

1. Bascule main girders
    a. Butt welds on tension leg flanges
    b. Butt welds on web splices
    c. Fillet welds joining web to flange
    d. Fillet welds attaching stiffeners
    e. Any visible out of plane bending
    f. Grating support bars
    g. Welds attaching grating
    h. Locking mechanism attachment points

2. Trunnion radii and undercuts

3. Gear teeth

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3. Fisher, John W.; Hausammann, Hans; Sullivan, Michael D.; Pense, Alan W. Detection and Repair of Fatigue Damage in Welded Highway Bridges 1979

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