SECTION 742

HEAT STRAIGHTENING (IN-PLACE) OF DAMAGED STRUCTURAL STEEL

742.1 DESCRIPTION

Use heat straightening to repair damaged sections of the existing structural steel beams and girders shown in the Contract Documents, or designated by the Engineer.

BID ITEM	UNITS
Heat Straightening Repair	Linear Foot

742.2 MATERIALS

Provide materials that comply with the applicable requirements.

Organic Zinc Primer	**SECTION 1802**
Waterborne Acrylic Top Coat	**SECTION 1806**
Calcium Sulfonate Alkyd Paint System	**SECTION 1808**

742.3 CONSTRUCTION REQUIREMENTS

a. General. Heat Straightening is a repair procedure in which a limited amount of heat is applied in specific patterns to plastically deformed regions of damaged steel in repetitive cycles of heating and cooling to produce a gradual straightening of the member. A limited amount of force may be used to restrain the member from excessive out of plane movement during heating. Force is not the primary method of straightening.

Procedures using forces that result in stresses over the yield stress of the material at the applied temperature, such as Hot Mechanical Straightening and Hot Working, are prohibited.

The repair must be directly supervised by a person with successful experience in heat straightening repairs of comparable bridge structures. Provide the Engineer with written documentation of past experience before beginning the repair work.

b. Equipment. Use an oxygen-fuel combination for heating. For fuel, use propane, acetylene or a similar fuel. Apply heat using either single or multiple orifice tips only. The maximum tip size is limited to 1 inch.

Verify temperatures during heat straightening with temperature sensitive crayons, a pyrometer, or an infrared non-contact thermometer. Provide the heat indicating device, and make it available to the Engineer at all times.

Use either hydraulic or mechanical jacks, come-alongs or other force application devices.

c. Application of Heat. Apply heat to the member with vee (triangular shaped) heats or line heats to the flange and with vee, line or strip heats to the web. The base of individual vee heats shall not exceed 10 inches.

A series of heats applied consecutively to different elements of the member at the same cross section is referred to as a heating pattern. Select heating patterns and sequences to match the type of damage and cross section shape.

Do not heat the steel over 1100°F during heat straightening unless specified otherwise in the Contract Documents. Heat the steel in a single pass following the heating pattern and allow cooling to 250°F prior to reheating. Water-cooling is not permitted.

Shift vee heats along the zone of yielded material on successive heating patterns. Simultaneous vee heats are permitted provided that the clear spacing between vees is greater than the width of the plate element.

Heating patterns other than those suggested in the Contract Documents may be used if approved by the Engineer. If no suggested heating patterns are provided in the Contract Documents, submit proposed heating patterns to the Engineer for approval.

d. Application of Jacking Forces. Only use jacking forces to restrain the members or elements against undesired movement associated with expansion during the cycles of applying heats. Place jacks to resist forces during the heating process. As the straightening occurs during cooling, the forces should be relieved.

The maximum allowable jacking force for members may be calculated by a licensed Professional Engineer, in accordance with the methods outlined in US DOT report no. FHWA-IF-99-004, "Heat-Straightening Repairs of Damaged Steel Bridges", with calculations submitted for approval by the Bridge Office before work begins; or, the limit may be estimated in the field by limiting the jacking force to the force required to produce the following deflections on the unheated steel members.

For 36 ksi Steel:
$\delta_{max} = 1/y_{max} * (L/140)^2$

For 50 ksi Steel:
$\delta_{max} = 1/y_{max} * (L/120)^2$

where: δ = The maximum deflection (in inches) between supports for a jacking force producing a maximum bending stress equal to ½ of the yield stress. For lateral displacements this would be the lateral deflection.
y_{max} = The distance (in inches) from the centroid of the steel section to the extreme fiber about the axis of bending. For lateral displacement of an "I" shaped beam this would be ½ of the flange width.
L = The distance (in inches) between supports, for lateral displacements this is the distance between the cross frames/diaphragms in place during heat straightening.

Do not increase the jacking force during heating or until the steel is cool to the touch between heats.

Assume that the existing steel has a yield strength of 36,000 psi, unless specified otherwise in the Contract Documents.

No deflection is allowed for other bridge members being used as supports for the jacking device.

For repairs of local flange bending, the jacking force is limited to that which produces no deflection of the unheated flange.

e. Tolerances. Completed tolerances for straightness of the bottom flange are within ¼ inch of horizontal at the flange edge and ½ inch of horizontal sweep in 20 feet at the point of impact. The completed tolerances for the web are $1/100^{th}$ of the web depth or ¼ inch, whichever is greater, out of vertical alignment; and no more than ¼ inch of localized deviation as measured with a straightedge vertically and horizontally against the web. Meet these tolerances before attaching any cross frames. Do not force the member into position and then attach the cross frame to hold the member in position.

f. Crack and Gouge Repair. Grind smooth all nicks, gouges and scrapes. Arrest all web cracks by drilling a 1 inch hole at each end of each crack. Locate the end of each crack by dye penetrant, magnetic particle or other approved non-destructive testing method.

g. Inspection. After straightening is complete inspect the flanges for crack by dye penetrant, magnetic particle or other approved non-destructive testing method. The Engineer will witness this testing. Remove minor (< ½ inch) cracks found by this inspection by grinding. Larger cracks found will be reviewed by the Engineer and repaired as directed by the Engineer. Any crack repair, unless shown in the Contract Documents, by methods other than grinding or drilling is considered Extra Work, **SECTION 104**.

h. Painting. Restore the paint on the damaged portions of the beams, girders, cross frames and diaphragms, including paint damaged by the repair process.

If the existing surface is a lead based paint system, clean the surfaces of loose material and oil, then coat the cleaned surfaces with a calcium sulfonate alkyd paint system according to the manufacturer's recommendations.

If the existing surface is not a lead based paint system, sandblast the surfaces clean, then coat the cleaned surfaces with an organic zinc primer and waterborne acrylic top coat according to "Repainting Existing Steel Bridges- Painting in Kind", **SECTION 702**.

As far as it is practicable, match the finish coat to the existing paint color. The Engineer is the final arbitrator of color match.

742.4 MEASUREMENT AND PAYMENT

The Engineer will measure the linear feet of primary member that requires heat straightening repair. Inspection, non-destructive testing, crack and gouge repair, secondary member heat straightening and painting are subsidiary.

Payment for "Heat Straightening Repair" at the contract unit price is full compensation for the specified work.