# Heat Straightening of Damaged Girders, Item SPV.0105

## A Description

This special provision describes heat straightening portions of bent or damaged girders which are left in place, back to their original shape. Straighten the girders back into their original position and shape within the tolerances listed below or as necessary to mate the existing and new work.

## B Materials

## Vacant

## C Construction

## Contractor Qualifications

## The contractor’s personnel performing the heat straightening shall have at least 5 years of experience in conducting heat-straightening repairs to primary structural members of in-service damaged steel structures. During the immediately preceding three-year period, the personnel shall have conducted at least three successful heat-straightening projects. A minimum of 15 working days prior to the pre-construction meeting, submit to the engineer for approval a report documenting the experience of the personnel and the projects worked on including the date, location, bridge owner, number and type of members straightened, and duration of each project, along with contact names, current phone numbers and e-mail addresses.

## Existing Paint Removal

Remove existing paint according to SSPC-SP15 Commercial Grade Power Tool Cleaning or equal. Remove all existing paint, mill scale, and rust within the heat affected zone except that up to 33% staining from rust and mill scale is permitted to remain. Remove paint as necessary to perform inspections and straightening work and to the engineer’s satisfaction. Feather the edges of remaining old paint so that the repainted surface has a reasonably smooth appearance.

## Grinding Flange Edges

Round all damaged/impacted exposed corners of main members as necessary to achieve a 1/16 inch radius or equivalent flat surface at a 45 degree angle. Grind edges at all locations of planned work to prevent edge cracking during the straightening work and to the engineer’s satisfaction

## Damage Inspection

Visually inspect all areas of damage, suspected damage, yield lines and zones of plastic bending. Also inspect all secondary members and connections between main and secondary members that potentially distributed forces causing damage. Perform this work with inspected surfaces being within approximately 24 inches from the inspector. Use access equipment, illumination, and nondestructive testing as necessary to identify, measure and document the location and details of: buckling; crimps; misalignment; twists; tears; burrs; damaged edges; punched holes; pull out of secondary members; cracks or other physical distress. Remove existing paint and test using magnetic particle testing all areas of detected and suspected hairline cracking according to the procedures and techniques for dry powder magnetic particle examination using the yoke method, ASTM E709, Practices for Magnetic Particle Examination.

## Straightening Work Plan

Use field data from the damage inspection to develop a straightening work plan. The work plan should include documentation of the Contractor’s means and methods including: jacking or bracing plans; surface preparation methods; calculation and control of allowable jacking and pulling forces; heating methods and shapes; heating equipment; and temperature indicating devices. Submit the work plan to the engineer a minimum of 5 days prior to beginning heat straightening.

## Straightening Damaged Members

Perform straightening using methods which will not permanently damage the metal’s material properties. Heat members using: controlled jacking, pulling or restraining forces; specified heating patterns; and controlled temperatures that result in controlled shrinkage to straighten the member. Do not heat members then use large jacks or pullers which mechanically hot work the material. Mechanical hot working permanently damages the metal’s material properties. Prior to straightening a damaged compression member, install adequate bracing to support loads and prevent buckling.

## Restraints or Preloads

Apply jacking, pulling or restraining forces to the damaged member in the direction that tends to straighten the member. Position jacks, pullers, or restraining forces such that heat straightening shrinkage will relieve the force during the cooling cycle. Do not allow jacks, pullers or restraining forces to subject any part of the structure to unit stresses that exceed 50 percent of the material’s nominal yield (Fy) at ambient temperature. Provide pressure gages or load cells to control jacks, pullers or restraining forces. Secure jacks, pullers or retraining forces so they do not dislodge during cooling. Apply jacks, pullers or restraining forces prior to heating. Do not apply additional jacking, pulling or restraining forces after beginning the application of heat. Do not apply the next cycle of jacking, pulling or restraining forces until the steel has cooled below 250 ºF.

## Application of Heat

Heat opposite faces of a plate or rolled shape concurrently when the material thickness equals or exceeds 1-1/4 inch. When heating thick plates, it may be necessary to interrupt heating for periods of less than one minute to allow the heat to soak into the flange and avoid surface over-heating. Perform heating using single and multi-orifice (rosebud) heating torches sized according to the following table. Manipulate the torches to avoid overheating. Heat using propane, natural gas, or acetylene unless other methods are accepted by the engineer.

| **Limits on Torch Tip Size** | | |
| --- | --- | --- |
| **Steel Thickness** | **Orifice type** | **Orifice Size** |
| less than 1/4inch ( 6mm) | Single | 3 |
| 3/8 inches (9.5mm) | Single | 4 |
| 1/2 inch (13mm) | Single | 5 |
| 5/8 inch (16mm) | Single | 7 |
| 3/4 inch(19mm) | Single | 8 |
| 1 inch (25mm) | Single or Rosebud | 8 single, 3 rosebud |
| 1 1/4 inch (32mm) | Single or Rosebud: on both sides\* | 8 single, 3 rosebud |
| 2 inch (51mm) | Single or Rosebud: on both sides\* | 8 single, 4 rosebud |
| 3 inch (76mm) or greater | Rosebud: on both\* sides | 5 |

\* - Heat applied concurrently to both sides

## Shape of Heating Patterns

Perform heating using four basic heating patterns: Strip, Line, Spot or “V”.

## Temperature Control

Control heat so the internal temperature of the steel does not exceed 1200 ºF. The internal temperature of the steel is the surface temperature approximately five seconds after passage of the torch. Control the application of heating so it is confined inside the limits of the four basic heating patterns. Bring the steel within the pattern to the desired temperature as rapidly as possible without overheating.

Control the application of heat by checking the internal temperature of the steel by frequent use of appropriate temperature range indicating crayons or an infrared, non-contact thermometer. The department will require investigative testing for damage to the metal’s material properties for any procedure which causes the internal temperature of the steel to exceed the specified maximum heating temperature. Provide the inspector with access to infrared thermometers or heat-indicating crayons as necessary to document and verify compliance with the temperature restrictions as stated in these specifications.

Do not accelerate cooling with water, water mist or other cooling accelerants. After the steel surface temperature is less than 600 ºF (315 ºC) cooling may be accelerated with dry compressed air. After completing a planned set of heat patterns along the member, do not apply additional heat until the entire member has cooled below 250 ºF and the straightening movement has been verified.

## Tolerances

Do not measure dimensional tolerances for final acceptance until all heating and welding operations are completed and the member has cooled to 160 ºF or less.

Girder straightness: The difference between the original as-built position and the final repair position when measured from a string line stretched along the member shall conform to the minimum tolerances as stated in the table below:

**Tolerances for Heat Straightening Repair.**

|  |  |  |
| --- | --- | --- |
| Member Type | Minimum Tolerance1,2 | |
| English (in) | SI (mm) |
| Beams, Truss members, or Columns  overall  at impact point | ½ in over 20 ft  ¾ in over 20 ft | 13 mm over 6 meters  19 mm over 6 meters |
| Local Web Deviations | d/100 but not less than ¼ in | d/100 but not less than 6 mm |
| Local Flange Deviations | b/100 but not less than ¼ in | b/100 but not less than 6 mm |

1Units of member depth, d, and flange width, b, are inches and millimeters, respectively, for English and SI units

2Tolerances for curved or cambered members should account for the original shape of the member.

## Final Inspection

Perform a final arms-length inspection of all surfaces that were repaired or heated. Perform the inspection after the work is complete and cooled to 160 ºF or less. Perform non- destructive testing at locations of detected or suspected hairline cracking as part of this inspection. Test these areas using magnetic particle testing. Immediately notify the engineer of any cracking found.

## D Measurement

The department will measure Heat Straightening of Damaged Girders as a single lump sum unit acceptably completed.

## E Payment

The department will pay for measured quantities at the contract unit price under the following bid item:

|  |  |  |
| --- | --- | --- |
| ITEM NUMBER | DESCRIPTION | UNIT |
| SPV.0105.01 | Heat Straightening of Damaged Girders | LS |

Payment is full compensation for heat straightening portions of bent or damaged girders and diaphragm members to the original tolerances as specified; inspecting all suspected areas of cracking by visual and non-destructive testing (NDT); providing temperature-indicating devices to the inspector; and for furnishing all labor, tools, equipment, materials, and incidentals necessary to complete the contract work.