

**SPECIFICATIONS FOR**  
**SUPPLY, FABRICATION AND DELIVERY OF STRUCTURAL STEEL**

**1.0 DESCRIPTION**

The Work shall consist of:

- .1 The supply of materials and fabrication of structural steel components (e.g. girders, diaphragms, jacking beams, stiffeners, girder coverplating) as shown and described on the Drawings and in this Specification;
- .2 The supply of all associated welding consumables and the necessary welding;
- .3 The handling and storage;
- .4 The loading and transportation of fabricated components to the job site; and
- .5 The quality control testing of all materials.

The Contractor shall notify the Department of any sub-contractors (Fabricators) that have been sub-contracted by the Contractor to fabricate, load or transport the structural steel components. The Contractor shall remain responsible for the work of such sub-contractors. All requirements, such as right of access, shall apply to such sub-contractors.

**2.0 REFERENCES AND RELATED SPECIFICATIONS**

The latest edition of the following standards, specifications and publications are applicable to the Work described under this Specification:

2.1 References

**Canadian Standards Association (CSA)**

G40.20/G40.21	General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steels
S16	Design of Steel Structures
W47.1	Certification of Companies for Fusion Welding of Steel Structures
W48	Filler Metals and Allied Material for Metal Arc Welding
W59	Welded Steel Construction (Metal Arc Welding)
W178.1	Certification of Welding Inspection Organizations
W178.2	Certification of Welding Inspectors

**Canadian Institute of Steel Construction (CISC)**

Handbook of Steel Construction

**Canadian General Standards Board (CGSB)**

48.9712	Nondestructive Testing - Qualification and Certification of Personnel
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**American National Standards Institute (ANSI)**

B46.1 Surface Texture (Surface Roughness, Waviness and Lay)

**ASTM International**

A 325 Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

A 325M Structural Bolts, Steel, Heat Treated 830 MPa Minimum Tensile Strength [Metric]

A 490 Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength

A 490M High Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints, [Metric]

A 563 Carbon and Alloy Steel Nuts

A 563M Carbon and Alloy Steel Nuts [Metric]

A 588/A 588M High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance

F 436 Hardened Steel Washers

F 436M Hardened Steel Washers [Metric]

**American Welding Society (AWS)**

AWS A5.XX - *XX: All Applicable Filler Metal Specifications*

AWS D1.1/D1.1M Structural Welding Code – Steel

AWS D1.5/1.5M Bridge Welding Code

**International Organization for Standardization/ International Electrotechnical Commission**

ISO/IEC 17025:1999 General Requirements for the Competence of the Testing and Calibration Laboratories

**Definitions**

Bearing Contact Area: the overlapping area between two steel plates either in contact with one another or that have a separation not greater than 0.1 mm between them.

Erection Diagram: complete set of drawings prepared by the Fabricator showing the dimensioned layout of the steel structure from which Shop Drawings and details are made and that relate the structural steel fabricator's piece markings with the piece locations in the finished structure.

Faying Surface: the interface between two structural steel members bolted together.

Fracture-Critical Member: a structural steel component of the bridge that is subject to tensile stress in the permanent condition whose failure could lead to a collapse of the bridge or a collapse of a bridge span.

Inspector: refers to a person that is a Canadian Welding Bureau certified Level II or Level III welding inspector in accordance with CSA W178.2 and whom has proven and documented knowledge and experience in the fabrication of structural steel for bridges.

New Steel: structural steel that has not been previously used in any application whether permanent or temporary.

Non-Destructive Testing Technician: refers to a person holding a valid certificate qualification to a Level II or Level III according to CAN/CGSB 48.9712 and the CWB for the specific non-destructive testing method specified or required.

Primary Tension Member: a structural steel component of the bridge that is subject to tensile stress in the permanent condition of the bridge but not including fracture critical components nor secondary components.

Snug Tight: bolt tightness obtained by the full effort of a person using a spud wrench. A similar tightness may also be achieved by applying a few impacts using an impact wrench.

## 2.2 Related Specifications

- Specifications for Erection of Structural Steel
- Specifications for Coating Structural Steel

## 3.0 SUBMITTALS

The Contractor shall submit the following to the Engineer for approval prior to commencing fabrication in accordance with the Special Provisions:

- .1 Design calculations and Shop Drawings for all structural steel components. These design calculations and Shop Drawings shall be stamped, signed and dated by a Professional Engineer registered or licensed to practice in the Province of Manitoba. Shop Drawings submitted for review shall include:
  - a) Full detail dimensions and sizes of all component parts of the structure. Components shall be detailed to compensate for changes in shape due to weld shrinkage, camber, and any other effects that cause finished dimensions to differ from initial dimensions;
  - b) Erection marks to uniquely identify all fabricated components;
  - c) All necessary specifications for the materials to be used;
  - d) Identification of areas requiring special surface treatment;
  - e) Identification of fracture-critical and primary tension members and component parts. Attachments having a length of more than 100 mm in the direction of tension and welded to the tension zone of a fracture-critical or primary tension member shall be treated as part of that member;
  - f) Bolt installation requirements, including number of fitting up bolts and drift pins required at each connection and oversize and slotted holes;
  - g) Details of all welds;
  - h) Identification of material and welds requiring non-destructive testing, including the limits of the weld to be tested and the frequency and type of testing;
  - i) Temporary welds; and
  - j) Location of shop and field welded and bolted splices.

- .2 An Erection Diagram that is stamped, signed and dated by a Professional Engineer registered or licensed to practice in the Province of Manitoba and includes at least the following:
  - a) Principal dimensions of the bridge;
  - b) Erection marks;
  - c) Sizes of all members;
  - d) Field welding requirements, including identification of welds requiring non-destructive testing;
  - e) Size and type of bolts;
  - f) Bolt installation requirements, including the number of fitting up bolts and drift pins required at each connection and identification of oversize and slotted holes;
  - g) Bracing and all other temporary works required for erection of structural steel; and
  - h) Treatment at faying surfaces for joints designed as slip critical.
- .3 Proposed welding procedures conforming to AWS D1.5 or CAN/CSA W59 and CAN/CSA W47.1 to be used in fabricating the various components. The following shall be included in the submitted welding procedures:
  - a) The welding process, position of weld, filler metal, flux, shielding gas if required, joint configurations, number and size of passes, preheat and inter-pass temperatures if required, sequence of passes, current, rate of pass, electrode size, electrical stick-out and polarity;
  - b) Methods proposed for edge preparation;
  - c) Measures proposed to control distortion, shrinkage and residual stresses;
  - d) Proposed methods and sequence of assembly; and
  - e) Welding equipment to be used.
- .4 Mill test certificates showing chemical analysis and physical tests of all structural steel shall be submitted to the Engineer for review prior to commencement of fabrication.

One copy of mill test certificates for all material to be used in the fabrication shall be available for review at the fabricating plant during fabrication. The mill test certificates shall clearly indicate that the material meets the requirements shown on the Drawings and described in this Specification.

If material cannot be identified by mill test certificates, coupons shall be taken and tested and these test certificates shall be made available.

Where mill test certificates originate from a mill outside Canada or the United States of America, the Contractor shall have the information on the mill test certificate verified by independent testing by a Canadian laboratory. This laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests or type of tests required by the material standard specified on the mill test certificate. The mill test certificates shall be stamped with the name of the Canadian laboratory and appropriate wording stating that the material is in conformance with the specified requirements. The stamp shall include the appropriate material specification number, testing date, and the signature of an authorized officer of the Canadian laboratory.

- .5 Proof shall be submitted to the Engineer demonstrating that the bolts, nuts, and washers meet the chemical composition, mechanical properties, dimensions, workmanship, and head burst as required by ASTM A 325/A 325M, A 563/A 563M or F 436/F 436M. Verification of the

- acceptability of assemblage of zinc coated bolts shall be provided with the bolts, nuts, and washers delivered to the job site shall also be submitted to the Engineer.
- .6 For bolts supplied from a manufacturer outside Canada or the United States of America, the above information shall be independently verified by testing by a Canadian laboratory as outlined in the clause 3.4.
- .7 Loading and transportation procedures for structural steel girders, including the proposed route and all traffic control procedures shall be stamped, signed and dated by a Professional Engineer registered or licensed to practice in the Province of Manitoba.
- .8 Repair procedures, if required, for repair of fabricating defects or other damage to structural steel components.

#### **4.0 MATERIALS**

##### **4.1 Structural Steel**

Structural steel shall be new and of the grade and category specified on the Drawings and in this Specification and shall be according to CSA G40.20/G40.21.

ASTM A 588M may be substituted for CSA G40.20/G40.21 grade 350A steel. When the Charpy impact energy requirements are verified by the submission of test documentation, ASTM A 588M may be substituted for CSA G40.20/G40.21 grade 350AT steel.

Substitution of material for size and grade is not permitted unless approved in writing by the Engineer.

##### **4.2 High Strength Bolts, Nuts and Washers**

High strength bolts, nuts, and hardened washers shall be in accordance with ASTM A 325/A 325M, A 563/A 563M, and F 436/F 436M. The nuts, bolts, and washers shall be shipped together as an assembly.

High strength bolts, nuts, and washers for use with unpainted corrosion-resistant steel shall be Type 3. Bolts, nuts, and washers used with steel specified on the Drawings or in this Specification to be painted or to be galvanized, shall be Type 1 and shall be galvanized.

Galvanized fastener nuts shall be over-tapped by the minimum amount required for assembly and shall be lubricated with a lubricant containing a visible dye.

##### **4.3 Shear Connectors**

Shear connectors shall be of a headed stud type supplied according to CSA W59, Appendix H.

##### **4.4 Welding Consumables**

The selection, supply, and storage of electrodes for SMAW and fluxes for SAW shall be according to CSA W59 requirements. Only controlled hydrogen designation electrodes and low hydrogen wire consumables shall be used for the SMAW and flux-cored arc welding processes, respectively. Electrodes and fluxes shall be strictly stored and maintained as required by CSA W59, section 5.2.

The weld filler metal in fracture critical and primary tension members shall meet the Charpy V notch impact energy requirements of Table 6.

Weld metal used with corrosion resistant steels shall have similar corrosion resistance and colour to the base metal and shall be supplied according to CSA W59.

#### 4.5 Replacement of Damaged Materials

All material supplied by the Fabricator that in the opinion of the Engineer has been damaged or otherwise rendered unusable by improper storage or handling by the Contractor shall be replaced by the Contractor at his expense.

### 5.0 CONSTRUCTION

#### 5.1 Material Preparation

##### .1 Straightening Material

All steel shall be flat and straight according to the specified mill tolerances before commencement of fabrication. Material with sharp kinks or bends shall only be straightened with the approval of the Engineer. The Contractor shall submit written procedures for approval to the Engineer and shall not commence straightening work until he has received permission from the Engineer.

When straightening is approved, material may be straightened using mechanical means or by the application of controlled heating according to CSA W59.

Details of the method of straightening shall be according to CSA W59 and submitted to the Engineer two weeks prior to the Contractor arranging for inspection of the straightened material and non-destructive testing.

The Engineer shall be given one week notice to arrange for their inspections.

##### .2 Edge Preparation

Sheared edges of plates with a 16 mm thickness or greater and that carry calculated tension shall have 3 mm of edge material removed by planing, milling or grinding.

Oxygen cutting of structural steel shall be done by machine except hand-guided cutting will be allowed for copes, blocks and similar cuts where machine cutting is impractical. Re-entrant corners shall be ground smooth and shall have a fillet of the largest practical radius, but in no case shall the radius be less than 25 mm.

Plasma arc cutting shall only be done when approved in writing by the Engineer. All nitrogen plasma arc cut edges shall be ground back by 0.5 mm when welding will be carried out on these edges.

The quality of the cut edges and their repair shall be according to CSA W59. All cut edges that are not to be welded shall have a surface roughness not greater than 1000 as defined by CSA B95. Edges of all flanges shall be rounded to a 1.5 mm radius by grinding. In addition all edges of all members and plates exposed to view or weather in the finished assembly shall be rounded to a 1.5 mm radius by grinding.

All steel edges that will be painted whether resulting from rolling, cutting or, shearing operations shall be rounded to a 1.5 mm radius by grinding prior to blast cleaning.

The Brinell hardness of the edges of flanges plates for fracture critical or primary tension members shall not exceed 220. If the measured hardness exceeds 220, the edges shall be ground to remove the harder layer or annealed by means of a preheating torch.

### .3 Direction of Rolling

Steel plate for main members shall be cut so that the primary direction of rolling is parallel to the direction of tensile or compressive stress.

### .4 Bolt Holes

#### Hole Size

The nominal diameter of a hole other than oversize or slotted holes shall be 2 mm greater than the nominal bolt size with the exception of the following bolt and hole combinations:

- i. either a 19 mm (3/4") or an M20 bolt in a 22 mm hole;
- ii. either a 22 mm (7/8") or an M22 bolt in a 24 mm hole; and
- iii. either a 25 mm (1") bolt or an M24 bolt in a 27 mm hole.

Unless otherwise approved by the Engineer, oversize or slotted holes shall only be used when specified on the Drawings or in the Special Provisions. Non-specified oversize or slotted holes will only be considered for use in bracing and diaphragms.

Oversize holes when permitted shall not be more than 4 mm greater than the nominal bolt size for bolts 22 mm or less in diameter; 6 mm greater than the nominal bolt size for bolts between 23 and 26 mm in diameter; and, 8 mm greater than the nominal bolt size for bolts 27 mm and greater in diameter.

Short slotted holes when permitted shall be 2 mm wider than the nominal bolt diameter and shall have a length not greater than the oversize hole diameters specified above plus 2 mm.

Long slotted holes when permitted shall be 2 mm wider than the nominal bolt diameter and shall be no longer than 2.5 times the nominal bolt diameter.

#### Punched Holes

Holes shall only be punched to finish size in material 16 mm or less in thickness.

The diameter of a hole punched to finish size shall not be more than 2 mm larger than the nominal diameter of the bolt unless oversize holes are approved.

The diameter of the die shall not exceed the diameter of the punch by more than 2 mm. Holes shall be clean cut without ragged or torn edges. Sharp edges shall be ground smooth without reducing the cross-section of the member. The slightly conical hole that results from this operation is acceptable.

#### Drilled Holes

Holes which are drilled to finished diameter shall be 2 mm larger than the nominal diameter of the bolt unless oversize or slotted holes have been specified. Holes to be drilled shall be accurately located by using suitable numerically-controlled drilling equipment, or by using a steel template carefully positioned and clamped to the steel. The dimensional accuracy of holes and locations prepared in this manner shall be such that like parts are exact duplicates and require no match marking.

The holes for any connection may be drilled to the required finished diameter when the connecting parts are assembled and clamped in position, in which case the parts shall be match-marked before disassembling.

Reamed Holes

Holes which are to be reamed to the specified finished diameter shall first be sub-drilled or sub-punched to 4 mm less than the finished hole diameter. The holes shall be reamed to 2 mm larger than the nominal diameter of the bolts with connecting parts assembled and securely held in place during reaming. The connecting parts shall be match-marked before disassembling. Reamed holes shall be truly cylindrical and perpendicular to the member. All burrs shall be removed without reducing the cross section of the member.

Tolerances

Center to Center – 12 m or less:	+/- 1.0 mm
Center to Center – 12 to 18 m:	+/- 1.5 mm
Center to Center – 18 to 24 m:	+/- 2.5 mm
Center to Center – over 24 m:	+/- 3.0 mm

Pins and Rollers

Pins and rollers shall be accurately turned to the dimensions and finish shown on the Drawings and shall be straight and free from flaws. Pins and rollers more than 175 mm in diameter shall be forged and annealed. Pins and rollers 175 mm or less in diameter may be either forged and annealed or may be made from cold finished carbon-steel shaft.

Holes for pins shall be bored to the diameter and to the finish specified on the Drawings or in the Special Provisions and at right angles to the axis of the member. The diameter of the pin hole shall not exceed that of the pin by more than 0.5 mm for pins 125 mm or less in diameter or by 0.75 mm for larger pins. Built up members shall be completely assembled prior to boring of pin holes.

.5 Bent Plates

General

Rolled steel plates to be bent shall be cut from the stock plates so that the bend line is at right angles to the direction of rolling except as otherwise approved for orthotropic decks.

Before bending, the edges of the plate within the bend region shall be rounded to a 3 mm radius by grinding in the region of the bend.

Cold Bending

Cold bending shall be carried out in such a manner that no cracking or tearing of the plate occurs. Minimum bend radii for various plate thicknesses (t), measured to the concave face of the metal shall be:

<u>t, mm</u>	<u>radius, mm</u>
$t \leq 12$	2 t
$12 \leq t \leq 25$	2-1/2 t
$25 \leq t \leq 38$	3 t
$38 \leq t \leq 65$	3-1/2 t
$65 \leq t \leq 100$	4 t



### Hot Bending

Forming radii less than that permitted for cold bending shall be done by hot bending at a plate temperature not greater than 600°C. Accelerated cooling of a hot bent component will only be permitted when the temperature of the component is below 300°C. Only compressed air or water shall be used for accelerated cooling.

#### .6 Camber

Girders shall be cambered before heat-curving.

When rolled sections are heat cambered, the proposed method of heat cambering shall be submitted to the Engineer for review one week prior to cambering.

Plate girders shall have the required camber cut into the web with suitable allowance for camber loss due to cutting and welding. All Nelson studs shall be welded to the top flange in the required areas before fit-up and subsequent final welding to the web.

Steel box girders fabricated with webs in an upright position shall have the fabricated camber verified by subtracting ordinates for deflections for girder segments from the relaxed camber diagram ordinates.

The ends of cambered girders shall be trimmed to be vertical under full dead load.

#### .7 Faying Surfaces

All faying surfaces of weathering steel shall be cleaned by sand blasting in the shop.

Faying surfaces of steelwork to be painted shall receive one coat of inorganic zinc primer. The slip coefficient of the primer shall be submitted to the Engineer for approval.

#### .8 Marking

Each member shall carry a unique erection mark for identification.

Permanent marking shall be affixed in an area not exposed to view in the finished structure.

#### .9 Temporary Welds

Temporary welds shall not be used on fracture-critical and primary tension members.

Temporary welds shall not be used on flange material in compression unless approved by the Engineer.

## .10 Stress Relief

Flange Plate Heat Curving

The required plan curvature of welded curved I girder flanges may be accomplished by heat curving provided that the flange plan radius is not less than 45,000 mm and also exceeds both:

$$\frac{37 b_f h}{\psi w \sqrt{F_y}} \text{ and } \frac{51700 b_f}{\psi F_y}$$

where

h = clear depth of web between flanges in millimetres

w = thickness of web in millimetres

F<sub>y</sub> = the specified minimum yield stress of the web material in megapascals

ψ = the ratio of the total cross-sectional area to that of both flanges

b<sub>f</sub> = width of widest flange in millimeters

## 5.2 Welded Fabrication

## .1 Fabrication Company Certification

The company(ies) undertaking welded fabrication shall be certified according to CSA W47.1, Division 1 or Division 2.

## .2 Assembly

Assembly shall be according to AWS D1.5 or CSA W59 and the following:

- a) Bearing stiffeners shall be vertical under full dead load;
- b) Intermediate stiffeners shall be either vertical or perpendicular to fabrication worklines; and
- c) Longitudinal web stiffeners shall be cut 25 mm short of the transverse web stiffeners.
- d) Tack welds of 75 mm or greater in length shall be incorporated into the final weld.

## .3 Welding of Fracture-Critical and Primary Tension Members

Only welding consumables certified by the CWB to applicable CAN/CSA W48 or AWS A5 requirements shall be used which includes Charpy V-notch toughness meeting the requirements of Table 6.

In groove welds connecting two different grades of steel, the classification of consumables used, including CVN impact requirements, shall be that applicable to the grade having the lower ultimate tensile strength.

For groove welds in fracture critical and primary tension members using certified consumables where the CVN test temperature required by Table 6 is lower than the test temperature in the CAN/CSA W48 or AWS A5 classifications, or where the standards are not applicable, welding consumables shall be approved by the CWB and qualified using a verification test assembly to establish the impact properties of the weld metal.

- a) Testing Procedures shall follow those of the relevant CAN/CSA W48 or AWS A5 standard except that only CVN tests are required and that welding shall be carried out using the preheat and the maximum heat input to be used in practice.
- b) CVN results shall meet the requirements of Table 6.
- c) Qualifications are required for each electrode diameter used and for the consumables supplied by each manufacturer.
- d) The qualification is valid for consumables for all groove weld procedures of the same or lower heat input as that used in the qualification test.

For groove weld procedures in fracture critical and primary tension members of 700Q and 700QT material, consumables shall be qualified by welding procedure tests approved by the Canadian Welding Bureau.

- a) Tests shall be conducted according to CAN/CSA W47.1 using 700Q or 700QT material for the base plate and shall include weld metal and heat affected zone CVN impact tests according to CAN/CSA W47.1 Appendix D.
- b) Weld metal impact tests shall meet the requirements of Table 4 and HAZ impact tests shall meet the requirements of Tables 4 and 5 for the base plate as appropriate.
- c) Only consumables supplied by the manufacturer supplying those qualified shall be permitted in fabrication.
- d) The qualification is valid for consumables for all groove weld procedures of the same or lower heat input as that used in the qualification test.

When the welding consumables have not been previously certified by the CWB, consumables shall be qualified by welding procedure tests in accordance with the provision of clause 8.2.2.4 of CAN/CSA W47.1 and shall include CVN impact tests of the weld metal.

- a) For steel other than 700Q or 700QT, CVN tests in the HAZ are not required.
- b) Weld metal CVN properties shall be established by qualification tests in accordance with CAN/CSA W47.1 (including Appendix D) and shall meet the requirements of Table 6.
- c) Only consumables supplied by the manufacturer supplying those qualified shall be permitted in fabrication.
- d) Qualification shall be done for each lot or batch of consumables.
- e) The qualification is valid for consumables for all groove weld procedures of the same or lower heat input as that used in the qualification test.

Tack welds shall not be used on fracture critical, primary tension members and flange material in compression, unless approved by the Engineer.

#### .4 Welding Repairs of Fracture-Critical and Primary Tension Members

##### General

Welding repairs shall be performed using any appropriate welding procedure approved by the CWB for the fabrication of fracture-critical members and primary tension members. All repair welding shall be subject to non-destructive testing.

All welding repair procedures shall be submitted to the Engineer at least 2 weeks prior to commencement of the work.

### Non-Critical Repairs

Repairs that may be classified as non-critical are as follows:

- a) The repair of welds because of rollover, undercut, or insufficient throat; those requiring excavation of defects including porosity, slag, and lack of fusion; the repair of arc strikes; and removal of tack welds not incorporated into a final weld;
- b) Visually detected planar and laminar discontinuities as defined in CSA W59, Table 5-2 but not deeper than 25 mm, or half of the thickness of the edge of the cut plate, whichever is less; and such discontinuities shall not be within 300 mm of a tension groove weld. There shall also be no visible planar or laminar discontinuity on any prepared face of a tensioned groove joint prior to welding;
- c) Gouges not more than 5 mm deep on otherwise satisfactory cut or rolled surfaces that may be repaired by machining or grinding without welding; and
- d) Occasional gouges, that may be repaired by welding, exceeding 5 mm but not more than 10 mm in depth on edges not to be welded.

Work on non-critical repair shall not commence until the Engineer has verified that the repair is a non-critical repair and has given written approval to proceed. The repair of gouges not more than 5 mm on otherwise satisfactory cut or rolled surfaces that may be repaired by machining or grinding without welding does not require prior approval.

### Critical Repairs

Repair procedures for more severe conditions than those described for non-critical repairs are considered critical and shall be individually approved by the Engineer before repair welding is begun.

Critical repairs include the following:

- a) Repair of lamellar tearing, laminations, and cracks except those meeting the requirements of paragraph b) in the Non-Critical Repairs clause;
- b) Repair of surface and internal defects in rolled products except those meeting the requirements of paragraph b) of the Non-Critical Repairs clause;
- c) Dimensional corrections requiring weld removal and rewelding; and
- d) Any correction by welding to compensate for a fabrication error such as improper cutting, punching, or incorrect assembly other than tack welded or temporary assemblies.

### Repair Procedures

Repair procedures shall be submitted to the Engineer at least two weeks prior to commencement of repair work and shall include sketches or full size drawings as necessary to adequately describe the deficiency and the proposed method of repair.

Procedures for critical repairs shall also include the location of the discontinuity.

Repair procedures except for visually detected planar and laminar discontinuities described in paragraph b) in the Non-Critical Repairs clause, shall include the minimum following provisions. The steps shall be listed in the order to be performed.

- a) Surfaces shall be cleaned and ground as necessary to aid visual and nondestructive tests to identify and quantify the discontinuities.

- b) The discontinuity shall be drawn as it appears from visual inspection and nondestructive testing.
- c) Arc-air gouging, shall be part of the approved welding procedure when required.
- d) Magnetic particle inspection or another inspection method approved by the Engineer shall be used to determine whether the discontinuity was removed as planned.
- e) All air carbon-arc gouged and oxygen-cut surfaces that form a boundary for a repair weld shall be ground to form a smooth bright surface. Oxygen gouging is not permitted.
- f) All required run-off tabs and back-up bars shall be shown in detail.
- g) Preheat and interpass temperature shall be according to Table 1. Preheat and interpass temperatures shall be maintained without interruption until the repair is completed.

**Table 1: Preheat and Interpass Temperatures**

Thickness, t	Grade, CSA G40.21
	<i>260WT, 300WT, 350WT, 400WT, 480WT, 350AT, 400AT, 480AT</i>
t ≤ 25 mm	65°C
25 < t ≤ 40 mm	120°C
t > 40 mm	175°C
NOTE: For grade 700QT steel, preheat and interpass temperature shall be in accordance with steel manufacturer's recommendations.	

- h) The repair procedures shall make reference to the applicable welding procedure specification and the related data sheet. If both of these were approved by the CWB prior to fabrication, they need not be prequalified by test for the specific method of repair unless a change in essential variables has been made or unless otherwise required by the Engineer.
- i) If the geometry of the repair joint or if the excavation is similar to the geometry of a prequalified joint preparation as defined in CSA W59, and permits good access to all portions of such joints or excavations during the proposed sequence of welding, the welding procedure shall not require prequalification by test unless required by the Engineer.
- j) Peening shall be noted as part of the approved procedure when required and shall be completely described. Peening equipment shall not contaminate the joint.
- k) Post-heat shall be employed and shall continue without interruption from the completion of repair welding to the end of the minimum specified post-heat period. Post-heat of the repair area shall be between 200°C and 260°C and shall be for a period of one hour minimum for each 25 mm of weld thickness or for two hours, whichever is less.
- l) Faces of repairs shall be ground flush with the plate or blended to the same contour and throat dimension as the remaining sound weld.
- m) If stress-relief heat treatment is required, it shall be completely described. Final acceptance by nondestructive testing shall be performed after stress relief is complete.

- n) Repairs of groove welds in fracture critical members shall be examined by ultrasonic testing (UT) and radiographic testing (RT). Repairs to groove welds in primary tension members shall be examined by UT or RT. Fillet weld repairs shall be examined by magnetic particle testing (MT). MT, RT, and UT shall be according to CSA W59. RT may be performed as soon as the weld has cooled to ambient temperature; however, final acceptance by MT and UT methods shall not be performed until the steel welds have been cooled to ambient temperature for at least the elapsed time indicated in Table 2.

**Table 2: Weld Minimum Cooling Period**

Plate Thickness	Magnetic Particle for Fillet Weld	Ultrasonic Examination of Groove Welds
t ≤ 50 mm	24 hours	24 hours
t > 50 mm	24 hours	48 hours

All repair welding and nondestructive testing shall be performed as described in the approved repair procedure.

All repair procedures for repairs requiring approval shall be retained as part of the project records.

.5 Heat Curving Members

Steel beams, welded girders and all other structural steel members with a specified minimum yield point greater than 350 MPa shall not be heat curved.

In heat curving, using either the continuous or V-type heating pattern, the temperature of the steel shall not exceed 600°C.

A detailed procedure for the heat curving operation shall be submitted for review to the Engineer. The procedure shall describe the type of heating to be employed, the extent of the heating patterns, the sequence of operations, and the method of support of the girder, including an assessment of any dead-load stresses present during the operation.

Transverse web stiffeners may be welded in place either before or after the heat-curving operation; however, unless allowance is made for the longitudinal shrinkage, the bracing connection plates and bearing stiffeners shall be located and welded after curving.

5.3 Bolted Construction

.1 General

ASTM A 325/A 325M high strength bolts shall be used for bolted connections. Bolts shall be sufficiently long to exclude threads from the shear plane.

.2 Assembly

The assembly of joints shall be according to CAN/CSA S16 except that Turn-of-Nut tightening method shall be the only installation method used.

Prior to assembly, all joint surfaces, including those adjacent to bolt heads, nuts and washers, shall be free of loose scale, burrs, dirt, and foreign material.

The faying surfaces of connections identified as slip-critical connections shall be prepared as

specified below.

- a) For clean mill scale, the surfaces shall be free of oil, paint, lacquer, or any other coating and then blast cleaned.
- b) For coated surfaces other than galvanized, the surfaces shall be free of oil, lacquer, or other deleterious coatings.
- c) Hot dip galvanized surfaces shall be roughened after galvanizing by means of hand wire brushing. Power wire brushing is not permitted.

This treatment shall apply to all areas within the bolt pattern and for a distance beyond the edge of the bolt hole that is the greater of 25 mm or the bolt diameter.

### .3 Bolt Tension

Pretensioned bolts shall be tightened to at least 70% of the specified minimum tensile strength given in the appropriate ASTM standard.

### .4 Reuse of Bolts

Bolts shall not be reused once they have been fully tightened. Bolts that have not been fully tensioned may be reused up to two times, providing that proper control on the number of reuses can be established. Retightening of bolts loosened due to the tightening of adjacent bolts is not considered to be a reuse.

### .5 Hardened Washers

Hardened washers shall be provided under the head and the nut of each bolt for a total of two (2) washers per bolt.

Hardened washers are required under the nut and bolt head adjacent to joint surfaces containing oversize or slotted holes.

When used with slotted holes the washers shall be at least 8 mm thick and of sufficient size to overlap the hole by 5 mm all around.

### .6 Bevelled Washers

Bevelled washers shall be used to compensate for lack of parallelism where an outer face of bolted parts deviates by more than 5% from a plane normal to the bolt axis.

### .7 Turn-of-Nut Tightening

After aligning the holes in a joint with a properly sized drift pin, sufficient bolts shall be placed and brought to a snug-tight condition to ensure that the parts of the joint are brought into full contact with each other.

Following the initial snugging operation, bolts shall be placed in any remaining open holes and brought to snug-tightness. Resnugging may be necessary in large joints.

When all bolts are snug-tight, each bolt in the joint shall be tightened additionally by the applicable amount of relative rotation given in Table 3, with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench. The bolt and nut shall be matched marked to enable the amount of relative rotation to be determined.

**Table 3: Nut Rotation From Snug-Tight Condition**

Outer Face Alignment of Bolted Parts	Bolt Length $L_b$	Turn From Snug
Both faces normal to bolt axis or, one face normal other face sloped 1:20 max – bevelled washers not used.	$L_b \leq 4 d_b$	1/3
	$4 d_b < L_b \leq 8 d_b$	1/2
	$L_b > 8 d_b$	2/3
Both faces sloped 1:20 from normal bolt axis – bevelled washers not used.	All Bolt Lengths	3/4
<p><b>NOTES:</b></p> <ol style="list-style-type: none"> <li>1. Bolt diameter is indicated as <math>d_b</math></li> <li>2. Tolerance on rotation is 30 degrees over/under.</li> <li>3. Table applies to coarse-thread. Heavy-hex structural bolts of all sizes and lengths used with heavy-hex semi finished nuts.</li> <li>4. Bolt length is measured from the underside of the head to the extreme end point.</li> <li>5. Bevelled washers shall be provided when A490 or A490M bolts are used.</li> </ol>		

**.8 Shop Trial Assembly**

Girders and other main components shall be preassembled in the shop to prepare or verify the field splices.

Components shall be supported in a manner consistent with the final geometry of the bridge as specified in the Drawings, with allowance for any camber required to offset the effects of dead-load deflection.

Holes in the webs and flanges of main components shall be reamed or drilled to finished diameter while in assembly. The components shall be drift pinned and firmly drawn together by a sufficient number of bolts before reaming or drilling.

Drifting done during assembly shall only be sufficient to align the holes and not to distort the steel. If holes are required to be enlarged they shall be reamed.

Where a number of sequential assemblies are required because of the length of the bridge, the second and subsequent assemblies shall include at least one section from the preceding assembly to provide continuity of alignment and distances for bearings.

Trial assemblies shall be made in the shop for all girder field-splices except as noted for holes drilled using numerically controlled machines. Each assembly shall be checked for camber, alignment, accuracy of holes, and fit-up of welded joints and milled surfaces.

**.9 Numerically Controlled Drilling**

As an alternative to the above shop trial assembly, when the bolt holes have been prepared by numerically controlled machines, the accuracy of the drilling may be demonstrated by a check assembly consisting of the first components of each type to be made. If the check assembly is satisfactory, further assemblies of like components are not required. If the check assembly is unsatisfactory for any reason, the work shall be redone or repaired in a manner acceptable to the Engineer. Further check assemblies shall be required as specified by the Engineer to demonstrate that the required accuracy of fit up has been achieved.



.10 Match Marking

Connecting parts that are assembled in the shop for the purpose of reaming or drilling holes shall be match-marked. A drawing shall be prepared for field use detailing how the marked pieces shall be assembled in the field to replicate the shop assembly.

5.4 Fracture Control

.1 General

The provisions of this clause shall apply to members designated as fracture critical and primary tension members as identified on the Drawings or in the Special Provisions. The Fracture Control requirements shall apply to both bolted and welded construction.

.2 Identification

Shop Drawings shall identify the extent of fracture critical and primary tension members.

Attachments having a length of more than 100 mm in the direction of tension and welded to the tension zone of a fracture critical or primary tension member shall be treated as part of that member.

Records shall be kept for each component of a fracture critical or primary tension member to identify the heat number of the material and its corresponding mill test certificate.

.3 Fracture Toughness Requirements

The Charpy V-notch requirements given in Tables 4, 5 and 6 are for standard full-size specimens.

Fracture Critical Members

For fracture critical members, Charpy V-notch tests shall be specified on a per plate frequency and the steel shall meet the impact requirements given in Table 4.

**Table 4: Fracture Critical Member Charpy V-Notch Impact Requirements**

Grade G40.21	Minimum Average Energy	Test Temperature Tt for Minimum Service Temperature Ts		
		Ts ≥ -30°C	-30°C > Ts ≥ -60°C	Ts < -60°C
<i>Commonly used steels</i>				
260WT	34 J	0°C	-20°C	-40°C
300WT	34 J	0°C	-20°C	-40°C
350WT	40 J	0°C	-20°C	-40°C
400WT	40 J	0°C	-20°C	-40°C
<i>Steels used only with prior MIT approval</i>				
350AT	40 J	0°C	-20°C	-40°C
400AT	40 J	0°C	-20°C	-40°C
480WT and AT	40 J	-10°C	-40°C	-60°C
700QT	50 J	-20°C	-40°C	-60°C

Primary Tension Members

For primary tension members, Charpy V-notch tests shall be specified on a per heat frequency and the steel shall meet the impact requirements given in Table 5.

**Table 5: Primary Tension Member Charpy V-Notch Impact Requirements**

Grade G40.21	Minimum Average Energy	Test Temperature Tt for Minimum Service Temperature Ts		
		Ts ≥ -30°C	-30°C > Ts ≥ -60°C	Ts < -60°C
<i>Commonly used steels</i>				
260WT	20 J	0°C	-20°C	-30°C
300WT	20 J	0°C	-20°C	-30°C
350WT	27 J	0°C	-20°C	-30°C
400WT	27 J	0°C	-20°C	-30°C
<i>Steels used only with prior MIT approval</i>				
350AT	27 J	0°C	-20°C	-30°C
400AT	27 J	0°C	-20°C	-30°C
480WT and AT	27 J	-10°C	-30°C	-40°C
700QT	34 J	-20°C	-40°C	-50°C

Service Temperature

The applicable minimum service temperature shall be the minimum daily mean temperature taken from “Canadian Climate Normals” published by Environment Canada.

Permanent Backing Bars

Permanent backing bars shall not be used unless absolutely necessary and approved for use in writing by the Engineer. Steel for permanent backing bars shall meet the requirements of clause 5.5.1.1 of CAN/CSA W59 or equivalent under AWS D1.5 and in addition, shall meet the CVN requirement of Tables 4 and 5 as appropriate.

Weld Metal Toughness

For fracture critical and primary tension members, the weld metal shall meet the impact requirements of Table 6.

**Table 6: Weld Metal Charpy V-Notch Impact Requirements**

Grade G40.21	Minimum Average Energy	Test Temperature Tt for Minimum Service Temperature Ts	
		Ts ≥ -40°C	Ts < -40°C
260 WT	20 J	-30°C	-40°C
300 WT	20 J	-30°C	-40°C
350 WT and AT	27 J	-30°C	-40°C
400 WT and AT	27 J	-30°C	-40°C
480 WT and AT	27 J	-45°C	-45°C
700 QT	40 J	-45°C	-45°C

5.5 Fabrication Tolerances

.1 Structural Members

Structural members consisting of a single rolled shape shall meet the straightness tolerances of CAN/CSA G40.20 except that columns shall not deviate from straight by more than 1/1000 of the length between points of lateral support.

A variation of 1 mm from the detailed length adjusted for temperature is permissible in the length of members which have both ends finished for contact bearing.

Members without finished ends may have a variation from the detailed length of not more than 2 mm for members 10 meters long or less, not more than 4 mm for members over 20 meters in length. The variation for members between 10 and 20 m in length shall be linearly interpolated.

.2 Abutting Joints

Where compression members are specified to bear against one another, the completed joint shall have at least 75% of the entire contact area in full bearing, defined as an area with no more than 0.5 mm of separation. The separation of the remaining area shall in no case and at no point exceed 1 mm.

At joints where loads are not transferred in bearing, the nominal dimension of the gap between main members shall not exceed 10 mm unless indicated otherwise on the Drawings.

.3 Bearing Plates

Rolled steel bearing plates 50 mm or less in thickness may be used without planing provided that a satisfactory contact bearing is obtained.

Rolled steel bearing plates over 50 mm but less than 100 mm in thickness may be straightened by pressing or by planing the entire bearing surface to obtain a satisfactory contact bearing.

Rolled steel bearing plates over 100 mm in thickness shall be planed on all bearing surfaces except for surfaces which are in contact with concrete or grouted to ensure full bearing.

.4 Bearing Surface Finish

The surface finish of bearing surfaces that are in contact with each other or with concrete, shall meet the following roughness requirements as measured according to ANSI B46.1.

Steel slabs or plates in contact with concrete	50 µm (2000 Micro inches)
Plates in contact as part of bearing assemblies	25 µm (1000 Micro inches)
Milled ends of compression members	12 µm (500 Micro inches)
Milled or ground ends of stiffeners	12 µm (500 Micro inches)
Bridge rollers or rockers	6 µm (250 Micro inches)
Pins and pin holes	3 µm (125 Micro inches)
Sliding bearings: steel and copper alloy or steel and stainless steel	3 µm (125 Micro inches)

Surfaces of flanges that are in contact with bearing sole plates shall be flat within 0.5 mm over an area equal to the projected area of the bearing stiffeners and web. Outside this area a 2 mm deviation from flat is acceptable. The bearing surface shall be perpendicular to the web and bearing stiffeners.

.5 Fabricated Components

Tolerances for welded components shall conform to Clause 5.4 of CAN/CSA W59.

Dimensional tolerances for welded built-up structural members shall conform to those prescribed by Clauses 5.8 and 12.5.3 of CAN/CSA W59.

Built-up bolted structural members shall satisfy the straightness tolerances for rolled wide flange shapes prescribed by CAN/CSA G40.29.

Bearing stiffeners fitted to bear shall have a minimum bearing contact area of 75% with a maximum separation not exceeding 1 mm over the remaining area.

Fitted intermediate stiffeners shall have a minimum bearing contact area of 25% and a maximum separation of 2 mm over the remaining area.

#### 5.6 Handling, Storage and Loading

Structural steel, either plain or fabricated, shall be stored upright above ground in a shored position on platforms, skids or other similar supports and shall be kept free from dirt and other foreign matter.

Structural material, either plain or fabricated, shall be protected from corrosion.

Long members shall be so supported as to prevent deflection.

##### Structural Steel Girders

The lifting devices shall be of such a nature as to avoid twisting, racking, or other distortions while handling, storing, moving and erecting the girders. The devices shown on the Drawings are minimum requirements and the Contractor and the Fabricator shall satisfy themselves as to the adequacy of the devices. The girders shall be picked up only by the lifting devices.

The Fabricator shall be responsible for storage of the girders from the completion of their fabrication until they are required by the Contractor.

During storage and hauling, the girders shall be maintained in an upright position and shall be supported at the bearing areas only unless otherwise approved in writing by the Engineer. Extreme care shall be exercised during the handling and storage of the structural steel girders to avoid twisting, deflection or other distortion that may result in damage to the girder.

#### 5.7 Transportation and Delivery

The structural steel fabricator shall schedule, coordinate and sequence structural steel transportation and delivery in cooperation with the erection of the structural steel by the structural steel erection contractor.

The Contractor shall perform all work necessary to ensure safe loading, transportation, unloading and storage of structural steel. The Work shall consist of loading the structural steel at the Fabricator's plant, transporting the structural steel to the site, and unloading and storing the structural steel at the site, including temporary works for access.

Structural steel shall be loaded for shipping in such a manner that it can be transported and unloaded at its destination in the correct orientation for erection without being excessively stressed, deformed, or otherwise damaged.

Structural steel shall be stockpiled to avoid excessive stress deformation or other damage while stored.

The transportation plan and schedule shall be provided to the Engineer not less than 7 Days before any shipping begins.

##### Structural Steel Girders

When transporting bridge girders, the Contractor shall be responsible for ensuring that all of the required permits have been acquired and the conditions of all permits are met.

The Contractor shall submit his proposed route for transporting the girders including traffic control procedures as part of the proposed loading and transporting procedure. In all traffic control

situations, the flagmen must be trained and properly attired in flagman's vest and approved headgear with approved flagman's stop/slow paddle or fluorescent red flag. The proper advance signing must also be in place.

No loose timber blocking will be permitted for use as temporary works for any aspect of girder handling, storage and transportation. Plate girders shall be transported with their webs in a vertical plane unless otherwise approved by the Engineer.

It is the Contractor's responsibility to ascertain the actual weight of the girders.

## **6.0 QUALITY MANAGEMENT**

### **6.1 Quality Control**

#### **.1 Non-Destructive Testing Agency**

The Contractor shall engage an independent testing organization certified by the Canadian Welding Bureau (CWB) to the requirements of CSA W178.1 for bridge structures by radiographic, ultrasonic, magnetic particle, and liquid penetrant test methods to perform all non-destructive testing of the welds.

All visual inspection of welds shall be performed in accordance with CSA W59 by a welding inspector certified by the CWB to the requirements of CSA 178.2 (Level II minimum) for bridges and structures.

Non-destructive testing shall be done by a non destructive testing technician certified to the Canadian General Standards Board (CGSB) in the test method specified and being performed by the Inspector..

Neither the technician nor the independent testing organization shall be changed without the approval of the Engineer.

#### **.2 Non-Destructive Testing of Welds**

Radiographic, ultrasonic, or magnetic particle testing shall be completed by the Contractor using procedures and frequency of testing according to CSA W59 however, notwithstanding the CSA W59 requirements, the amount and location of welding to be tested shall be at least:

- a) All welds shall be visually inspected.
- b) The frequency of radiographic or ultrasonic inspection of groove welds in flanges and webs of built-up girders shall be:
  - i. Flange splices in tension or stress reversal zones: 100% of all welds.
  - ii. Flange splices in compression zones: 100% of the weld of 1 in 4 splices.
  - iii. Web splices for 1/2 the depth from the tension flange: 100% of the weld length for each weld.
  - iv. Web splices for 1/2 the depth from the compression flange: 100% of the weld length of 1 in 4 splices.

If defects are found during testing, two additional splices shall be tested for each splice exhibiting defects.

- c) Magnetic particle inspection of web-to-flange fillet welds:
  - i. Submerged-arc welds: 25% of length of each weld.
  - ii. Semi-automatic welds: 50% of length of each weld.
  - iii. Manual welds: 100% of length of each weld.
- d) Magnetic particle inspection of fillet welds in connection plates and stiffeners to which diaphragms or cross bracing are attached:
  - i. For 1/2 the depth from the tension flange: 100% of weld length of each weld.
  - ii. Transverse welds on tension flanges: 100% of weld length of each weld.
- e) Arc strikes outside of the completed welds shall be lightly ground and checked for cracks by Magnetic Particle Inspection.

Radiographic and ultrasonic testing shall be performed prior to the assembly of the flanges to the webs after splice welds have cooled as per CSA W59.

## 6.2 Quality Assurance

Visual inspection and sampling will be done in the fabricating shop and in the field by the Engineer to confirm the material supplied and the fabrication has been done as specified on the Drawings, in this Specification and in the Special Provisions. The Contractor shall supply material specimens for testing when requested by the Engineer.

The Contractor shall provide full facilities for the unencumbered inspection of material, workmanship and all parts of the work at all stages of the work by the Engineer in the shop, in storage facilities and in the field. The Engineer shall be allowed free access to the work.

The Engineer will perform non-destructive testing of the works, destructive testing of samples obtained of materials to be incorporated into the work and any other additional inspection at his discretion.

## 6.3 Inspection Requirements for Fabrication Outside of the Province of Manitoba

Should all or any part of the structural steel fabrication be undertaken at a facility outside of the Province of Manitoba, expenses incurred by the Department and/or the Department's representative to carry out audit testing will be deducted as incurred by the Department from payments made to the Contractor. Expenses will include, but are not limited to all travel, boarding, lodging and the retention of services from a CWB certified inspection agency of the Department's choice for audit inspections at the fabrication plant of all related works.

## 7.0 METHOD OF MEASUREMENT

### 7.1 Supply and Fabrication of Structural Steel

The structural steel will be measured on a mass basis. The total mass to be paid for will be computed on the basis of the net finished dimensions on the plans, deducting the mass of copes, cuts, clips and all open holes, except bolt holes. The mass of rolled shapes will be calculated using the nominal mass listed in recognized handbooks or as follows:

<b>Material</b>	<b>Unit Mass (kg/m<sup>3</sup>)</b>
Structural Steel	7 850
Lead	11 320
Bronze	8 590

The mass of all paint, galvanizing material or other protective coatings, and all deposited weld metal used for either shop or field welding, will not be included in the mass of material to be paid for.

7.2 Delivery of Structural Steel

Delivery of structural steel will be paid for on a Lump Sum basis and no separate measurement will be taken for this work.

**8.0 BASIS OF PAYMENT**

8.1 Supply and Fabrication of Structural Steel

Supply and fabrication of structural steel will be paid for at the Contract Unit Price per kilogram for "Supply and Fabricate Structural Steel" measured as specified herein, which price will be payment in full for performing all operations herein described and all other items incidental to the Work.

8.2 Delivery of Structural Steel

Delivery of structural steel will be paid for at the Contract Lum Sum Price for "Delivery of Structural Steel, measured as specified herein, which price will be payment for performing all operations herein described and all other items incidental to the Work.