708.07 Basis of Payment. This material will be paid for either on the contract unit price per pound or lump sum price whichever is stated in the contract.

A. Per Pound Price. The weights as determined herein will be paid for at the contract unit price for hardware complete in place, which price and payment shall be full compensation for all materials, galvanizing, labor, equipment, painting, if required and all work incidental thereto.

B. Lump Sum Price. When a lump sum price is stated in the contract, that price and payment shall include all costs of furnishing, galvanizing, placing and painting, if required, of all hardware necessary to complete the structure in accordance with the plans and specifications or as directed by the Engineer.

Payment for this item includes all direct and indirect costs and expenses required to complete the work.

Payment will be made under:

Item No.	Pay Item	Pay Unit
7081000	Hardware	Lump Sum
7082000	Hardware	Pounds

SECTION 709

STRUCTURAL STEEL

709.01 Description. This work shall consist of furnishing, fabricating and erecting steel structures as required by the plans and the special provisions. It shall also include incidental metal work on other structures not otherwise provided for in these specifications.

This work shall be performed in conformance with these specifications and in reasonably close conformity to the lines, grades and dimensions shown on the plans or established by the Engineer.

709.02 Design and Details of Design. Structural Steel design and details of design shall comply with the requirements of the section of the current edition of the AASHTO Standard Specifications for Highway Bridges, Division I, entitled *Structural Steel*, and the requirements of these specifications. In case of conflict between these specifications and the referenced AASHTO specifications, the requirements of these specifications shall govern.

709.03 Plans. The Department will furnish plans (design drawings) showing a complete design with sizes, sections, and the relative locations of the various members. Plans shall indicate camber of structural members, tolerances, finishes, type of fasteners and other information as may be required for the proper preparation of shop plans and working drawings.

709.04 Shop Drawings and Working Drawings. Upon acceptance and execution of the contract, the Contractor shall prepare and furnish shop drawings showing complete details and sizes of component parts of the structure and details of all miscellaneous parts such as nuts, bolts, drains, etc. Any additional stress sheets and working drawings requested by the Engineer shall also be submitted. Shop Drawing and Working Drawings submissions will conform to the requirements of Section **725**.

MATERIALS

709.05 Structural Steel.

A. General Requirements. Unless otherwise shown on the plans, all structural steel shall conform to the following requirements:

	AASHTO	ASTM
Structural Steel	M 270 Grade 36	A 709 Grade 36
High-Strength Low Alloy Steel	M 270 Grade 50	A 709 Grade 50
High-Strength Low Alloy Steel	M 270 Grade 50W	A 709 Grade 50W
Quenched and Tempered Low Alloy Steel	M 270 Grade 70W	A-709 Grade 70W
High Yield Quenched and Tempered Alloy Steel	M 270 Grades 100/100W	A 709 Grades 100/100W

Notes:

1. When these materials are specified on the plans, the longitudinal Charpy V-Notch criteria shall comply with the requirements of AASHTO M 270. Zone 2.

2. Sampling shall be in accordance with the H frequency in AASHTO T 243.

3. Testing shall be performed in accordance with AASHTO T 266.

Specifically, Charpy testing shall be required as follows:

1. Simple Span Rolled Beam. The beam itself as well as bottom cover plate, if applicable.

2. Simple Span Plate Girder. The web, bottom flange plate and splice plates for web, and bottom flange excluding any filler plates.

3. Continuous Span Rolled Beam. The beam itself

as well as any top or bottom cover plate located in a tension region as indicated in the plans. Also, all splice plates for web and top and bottom flange plates excluding any filler plates.

4. Continuous Span Plate Girder. All web plates, the top flange plates and the bottom flange plates located in a tension region as indicated in the plans. Also, all splice plates for web and top and bottom flange plates excluding any filler plates.

5. Curved Girder. In addition to Charpy testing of web, flange and splice plates as applicable and as specified in items a through d above, all diaphragm members, connection plates and gusset plates shall require Charpy testing.

B. Copper Bearing Steel. When copper-bearing steel is specified, the steel shall contain not less than 0.20 percent copper.

C. Notch Toughness of Weld Metal. The Charpy V Notch Toughness of weld metal shall comply with the requirements of the latest edition of ANSI/AASHTO/AWS D1.5 *Bridge Welding Code*, Table 4.1, 4.2, or 4.3 as applicable.

D. Protection of Steel. The stock steel to be used in the project shall have been protected such that all surfaces are free from heavy rust and rust pitted areas at the start of and during fabrication.

E. Corrosion Resistant Steel. All welding shall produce weld metal with atmospheric corrosion resistance and coloring characteristics similar to that of the base metal in accordance with Section 4.1.4 of the latest edition of ANSI/AASHTO/AWS D1.5 *Bridge Welding Code*.

All Structural steel shall be cleaned to the requirements of Near White Blast Cleaning in accordance with the Steel

Structures Painting Council Surface Preparation SP10 (current edition) *No. 10 Near White Blast Cleaning Method*. Any contamination of the structural steel during erection or concrete placement shall be removed by the Contractor. All cleaning of the structural steel shall be by an acceptable method approved by the Engineer and shall restore the surface finish to the specified "Near White Blast Clean" condition.

The Corrosion Resistant Steel shall not be painted unless specifically shown on the plans.

All bolts for corrosion resistant steel shall comply with ASTM A 325, Type 3. All bolts, nuts, and washers shall be non-galvanized. Bolt assemblies shall contain an epoxy coated direct tension indicator with a black color.

709.06 High Strength Structural Steel Fasteners.

A. General. All high strength bolts, nuts, washers, and direct tension indicators shall be furnished in accordance with the appropriate ASTM materials specification as amended and revised herein.

Additional requirements for field or shop installation of ASTM A 325 high strength bolts are also included.

B. Material Specifications.

1. Bolts. All bolts shall meet the requirements of ASTM A 325 and the revisions contained herein.

2. Nuts. All nuts shall meet the requirements of ASTM A 563.

3. Washers. All washers shall meet the requirements of ASTM F 436 and these revisions.

4. Direct Tension Indicators. The Direct Tension Indicators shall comply with ASTM F 959, and shall be

accepted and installed in accordance with Subsection **709.06H**.

C. Manufacturing.

1. Bolts. All Type 1 bolts shall be mechanically galvanized in accordance with ASTM B 695 , Class 50. When atmospheric corrosion resistant steel, ASTM A 709, Grade 50W is required by the plans, Type 3 bolts shall be used and shall be non-galvanized.

Hardness for bolt diameters 1/2 inch to 1 1/2 inch inclusive, shall be as noted below:

Hardness Number					
Bolt Size (Inches)	Bolt Length, (Inches)	Brinell		Rockwell C	
		Min.	Max.	Min.	Max.
A 325 (1/2 to 1, incl.)	Length < 3 Dia.	253	319	25	33
A 325 (1/2 to 1, incl.)	Length > 3 Dia.	---	319	---	33
A 325 (1 1/8 to 1 1/2, incl.)	Length < 3 Dia.	223	286	19	30
A 325 (1 1/8 to 1 1/2, incl.)	Length > 3 Dia.	---	286	---	30

2. Nuts. Nuts shall be ASTM A 563, Grade DH or DH3. Nuts shall be mechanically galvanized in accordance with ASTM B 695, Class 50. Nuts for Type 3 bolts shall be Grade DH3, plain (non-galvanized).

Galvanized nuts shall be tapped oversize the minimum amount required for proper assembly. The amount of overtap in the nut shall be such that the nut will assemble freely on the bolt in the coated condition and shall meet the mechanical requirements of ASTM A 563 and the rotational capacity test herein.

Galvanized nuts shall be lubricated with a water-

soluble lubricant containing a dye of any color that contrasts with the color of the galvanizing.

3. Washers. Washers for Type 1 bolts shall be mechanically galvanized in accordance with ASTM B 695, Class 50. Type 3 washers shall not be galvanized.

4. Direct Tension Indicators. The Direct Tension Indicators (DTI) for Type 1, and Type 3 bolts shall be mechanically galvanized in accordance with ASTM B 695, Class 50. In addition, DTI for Type 3 bolts shall be epoxy coated with a black color.

5. Marking. All bolts, nuts, and washers shall be marked in accordance with the appropriate ASTM specification.

D. Testing.

1. Bolts. Proof load tests ASTM F 606, Method 1 shall be required.

Wedge tests on full size bolts ASTM F 606 paragraph 3.5 are required. Tests shall be performed after galvanizing. Minimum frequency of tests shall be as specified in ASTM A 325, Paragraph 9.2.4.

The thickness of the zinc coating shall be measured. Measurements shall be taken on the wrench flats or top of bolt head.

2. Nuts. Proof load tests ASTM F 606, Paragraph 4.2 are required. Minimum frequency of tests shall be as specified in ASTM A 563, Section 9. Tests shall be performed after galvanizing, over-tapping and lubricating.

The thickness of the zinc coating shall be measured. Measurements shall be taken on the wrench flats.

3. Washers. Hardness testing shall be performed after galvanizing. Coating shall be removed before taking hardness measurements.

The thickness of the zinc coating shall be measured.

4. Direct Tension Indicator (DTI). The DTI's shall be tested in accordance with ASTM F 959.

5. Assembly and Verification. Rotational-Capacity tests shall be required and performed after bolts, nut and washer assemblies are galvanized by the manufacturer or distributor before shipping. Washers are required as part of the test.

The following shall apply:

a. The Rotational-Capacity test shall be performed in accordance with the requirements contained in Subsections **709.06J** and/or **709.06K**.

b. Each possible combination of bolt production lot, nut lot and washer lot shall be tested as an assembly. Three assemblies of each combination of materials shall be sampled by the Department for verification testing.

c. A Rotational-Capacity lot number shall be assigned to each combination of lots tested.

d. The minimum frequency of testing shall be two assemblies per Rotational-Capacity lot.

e. The bolt, nut, and washer assembly shall be assembled in a Tension Measuring Device (TDM). For guidance in performing the test, use the procedure for long bolts as detailed in Sub-

section **709.06J**. For short bolts which are too short to be assembled in the TDM, (see item (i.) below.) DTI's are not included in this Rotational-Capacity test.

f. The minimum rotation, from an initial tension of 10% of the specified minimum installation tension shall be:

240° (2/3 turn) for bolt lengths equal to 4 bolt diameters or less.

360° (1 turn) for bolt lengths greater than 4 bolt diameters, but not more than 8 bolt diameters.

480° (1 1/3 turn) for bolt lengths greater than 8 bolt diameters, but not more than 12 bolt diameters

(Note: These values differ from the ASTM A 325 specifications.)

g. The tension at the above rotation shall be equal to or greater than 1.15 times the required installation tension. The installation tension and the tension for the turn tests are shown below:

Minimum Installation Tension Requirements and Turn Test Tension (Tension in kips)									
Diameter (inches)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
A 325 Bolts	*12	19	28	39	51	56	71	85	103
Turn Test	**14	22	32	45	59	64	82	98	118

Notes:

*Installation Tension equals 70% x Min. Tensile Strength.

**Turn Test Tension equals 1.15 x 70% x Min. Tensile Strength.

h. After the required installation tension listed above has-been exceeded, one reading of tension and torque shall be taken and recorded. The torque value shall conform to the following:

$$\textbf{Torque} \leq \textbf{0.25 x P x D}$$

Where:
Torque = measured torque (foot-pounds)
P = Turn test tension (pounds)
D = bolt diameters (feet)

i. Bolts that are too short to test in a TDM may be tested in a steel joint. The tension requirement of Subsection **709.06D.5.g** need not apply. The maximum torque requirement of Subsection **709.06D.5.h** shall be calculated using a value of P equal to the turn test tension shown in the table in Subsection **709.06D.5.g**. For guidance in performing the test, use the procedure for short bolts as detailed in Subsection **709.06K**.

j. Failure of any portion of the Rotational-Capacity (RC) test for either of the two samples tested shall constitute failure of the RC lot.

6. Reporting. The results of all tests (including the

zinc coating thickness) required herein and in the appropriate ASTM specification shall be recorded on the appropriate document.

Location where tests are performed and date of tests shall be reported on the appropriate document.

7. Witnessing. The tests need not be witnessed by an inspection agency; however, the manufacturer or distributor that performs the tests shall certify that the results recorded are accurate.

E. Documentation.

1. Mill Test Report(s) (MTR). MTR shall be furnished for all mill steel used in the manufacture of the bolts, nuts, and washers.

MTR shall indicate the place where the material was melted and manufactured.

2. Manufacturer Certified Test Report(s) (MCTR). The manufacturer of the bolts, nuts and washers shall furnish test report (MCTR) for the item furnished. Each MCTR shall show the relevant information required in accordance with Subsection **709.06D.6**.

The manufacturer performing the rotational capacity test shall include on the MCTR:

a. The lot number of each of the items tested.

b. The Rotational-Capacity lot number as required in Subsection **709.06D.5.c**.

c. The results of the test required in Subsection **709.06D.5**.

d. The pertinent information required in Subsection **709.06D.6**.

e. A statement that MCTR for the items are in conformance to this specification and the appropriate ASTM specification.

f. The location where the bolt assembly components were manufactured.

3. Distributor Certified Test Report(s) (DCTR). The DCTR shall include MCTR above for the various bolt assembly components. The Rotational-Capacity test may be performed by a distributor (instead of a manufacturer) and reported on the DCTR. The DCTR shall show the results of the tests required in Subsection **709.06D.5**. The DCTR shall also show the pertinent information required in Subsection **709.06D.6**. The DCTR shall show the Rotational-Capacity lot number as required in Subsection **709.06D.5.c**. The DCTR shall certify that the MCTR are in conformance to this specification and the appropriate ASTM specification.

F. Shipping.

1. Marking. Each container shall be permanently marked on the side of the container with the Rotational-Capacity lot number such that identification will be possible at any stage before installation.

2. Documentation. The appropriate MTR, MCTR, or DCTR shall be supplied to the owner through the Contractor.

G. Installation. The following requirements for installation apply in addition to the specifications in AASHTO Division II, Section 11 when high strength bolts are installed in the field or shop.

Bolts shall be installed in accordance with AASHTO Division II, Article 11.5.6.4. During installation, regardless

of the tightening method used, particular care should be exercised so that the snug tight condition as defined in Article 11.5.6.4.4 is achieved. Snug tight is defined as the tightness that exists when the plies of the joint are in firm contact. Hardened washers are required under the turned element for all installation methods.

The rotational capacity test described in Subsection **709.06D.5** shall be performed on each Rotational-Capacity lot before the start of bolt installation. Hardened steel washers are required as part of the test.

The Contractor shall provide a TDM and a dial type torque wrench of suitable range at each job site during erection. Periodic testing shall be performed to assure compliance with the installation test procedures required in AASHTO Division II, Article 11.5.6.4. Bolts that are too short for the TDM may be tested using Direct Tension Indicators (DTI). The DTI's must be calibrated in the TDM using longer bolts.

Periodic re-testing shall be conducted as directed by the Engineer to confirm that storage has not reduced the effectiveness of the lubricant. Re-testing shall be performed by the Contractor and witnessed by the Engineer. The lot of failing assemblies shall be rejected for use.

Galvanized nuts shall be checked to verify that a visible lubricant is on the threads. When the bolt head is to become the turned element in assembly, a lubricant approved by the Engineer shall be added to the washer face under the bolt head or to the washer.

Bolts or nuts not satisfying the requirements above and bolts, nuts or washers that are weathered, rusty, or dirty shall be rejected. The Contractor may submit, for approval, a procedure for cleaning and re-lubricating rejected fastener lots. Re-cleaned or re-lubricated bolt, nut and washer assemblies shall be re-tested before installation.

Bolt, nut and washer combinations as installed shall be from a lot represented by an accepted rotational capacity test as certified by the manufacturer or distributor.

H. Procedures for Verification and Installation of High Strength Bolts Direct Tension Indicator (DTI).

1. Verification of DTI Performance. Verification of DTI performance is required before installation of bolts in the work. In bridge work, the manufacturers are typically specifying smaller gaps in the spaces between the protrusions on the washer than either normally used in other construction or the gap specified for testing in the product specification ASTM F 959. The basic principle used in this verification test is to make sure that there is a DTI gap when the test tension is 1.05 times greater than the job installation tension requirement.

a. Equipment Required.

(1) Calibrated bolt tension measuring device with a special flat insert in place of normal bolt head holding insert. The special insert is required to allow access to measure DTI gap.

(2) Tapered leaf thickness (feeler) gauge 0.005 inch. Same gauge as to be used to inspect the bolts after installation.

(3) Bolts, nuts, and standard washers to be used in the work with the DTI's.

(4) Impact and manual wrench to tighten bolts. Equipment should be the same as to be used in the work.

b. Verification Test Procedure. Three bolts from each Rotational-Capacity lot and position of DTI

shall be tested.

(1) Install bolt, nut, DTI, and standard washer into bolt tension measuring device. Assembly should match that to be used the work.

(2) Use another wrench on the bolt head to prevent rotation of the head against the DTI if the DTI is to be used under the unturned element.

(3) Tighten bolt to tension listed below (1.05 times the minimum installation tension). Use another wrench on the bolt head to prevent rotation of the head against the DTI if the DTI is to be used under the unturned element. If an impact wrench is used, tighten to a load slightly below the required load and use a manual wrench to attain the required tension. The load-indicating needle of the DTI cannot be read accurately when only an impact wrench is used.

***Bolt Tension**
(kips)

Bolt Diameter (inch)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
M 164 (A 325) Bolts	13	20	29	41	54	59	75	89	108

Note:

*****Bolt Tension equals 1.05 x Min. Installation Tension

(4) Determine and record the number of spaces between the protrusion on the DTI that a 0.005 inch feeler gauge is refused. The total number of spaces in the various sizes and grade of DTI is shown below.

Number of Spaces on DTI

Bolt Diameter (inches)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
M 164 (A325) Bolts	4	4	5	5	6	6	7	7	8

(5) The 0.005 inch thick feeler gauge should be refused in less than one half of the gaps. If the feeler gauge is refused in one half or more of the gaps, the DTI fails the verification test.

(6) The bolts should be further tightened to the smallest gap allowed in the work. Normally, this smallest gap condition is achieved when the gaps at all the spaces are less than 0.005 inch (or a gap size as approved by the Engineer), and not all gaps are completely closed. When such a condition is achieved, the 0.005 inch thick feeler gauge is refused at all spaces but a visible gap exists in at least one space. Note the load in the bolt at the smallest gap. The bolts in this installation verification test and in the actual installation should not be tightened to a no visible gap condition when all the gaps are completely closed. The load in the bolt becomes indeterminate when no gap exists. It is possible to cause failure by tightening beyond complete crushing of the washer. The bolt load at this smallest gap should not cause excessive permanent inelastic deformation of the fastener. The degree of inelastic deformation is judged by removing the fastener from the test apparatus and turning the nut by hand the full length of the threads on the bolt after the test.

(7) Remove the bolt from the calibrator and turn the nut on the threads of the bolt by hand. The nut should be able to be turned on the complete length of the threads, excluding the thread runout. Alternatively, if the nut is unable to go the

full length, but the load at the minimum DTI gap (measured in step (6) above) is less than 95% of the bolt tension recorded at the nut rotation required in Subsection **709.06D.5.1.f** for the Rotational-Capacity test, the assembly, including the DTI, is deemed to have passed the test. If the nut cannot be run the full thread length, and if the load at the smallest gap condition is greater than the 95% of the bolt tension recorded at the nut rotation required for the Rotational-Capacity test, the load required for the smallest gap in step (6) is too large and the DTI lot shall be rejected.

(8) Bolts from Rotational-Capacity lots that are too short to fit in the tension measuring device shall be tested in accordance with Subsection **709.06.D.5.i** by tightening to the minimum DTI gap (measured in step (6) above) and checked in accordance with step (7). The 95% alternative cannot be used since short bolts are not tested in the tension-measuring device for Rotational-Capacity. The DTI used with the short bolt should be checked in accordance with steps (1) through (5) using a longer bolt in the tension measuring device.

2. Installation of DTI.

a. The use of a DTI under the unturned bolt head requires that the element bearing against the DTI not turn. Two workers are required: One to operate the wrench, and the other to prevent turning of the element with the DTI and to monitor the gap. If the DTI is used under the turned element, an additional hardened washer must be used between the turning element and the protrusion on the DTI.

b. Tighten the bolts systematically to the inspection

gap. The number of spaces in which the 0.005 inch thickness gauge is refused should be equal or greater than the number shown in the table below. Tightening beyond the smallest gap established above in Subsections **709.06H.1.b.(6)** and **709.06H.1.b.(7)** is not allowed. Bolts which have a DTI with a smaller gap or no gap shall be replaced and the bolts tightened with a new DTI.

J. Procedure For Performing Rotational-Capacity Test (Long Bolts In Tension Measuring Device).

1. Equipment Required.

a. Calibrated Tension Measuring Device (TDM) of size required for bolts to be tested.

b. Calibrated torque wrench.

c. Spacers and/or washers with hole size no larger than 1/16 inch greater than bolt to be tested.

d. Steel section to mount TDM. Flange of girder or cross frame accessible from the ground is satisfactory.

2. Procedure for Performing Rotational - Capacity Test.

a. Install nut on bolt and measure stick out of bolt when 3 to 5 threads of the bolt are located between the bearing face of the nut and the bolt head. Measure the bolt length, the distance from the end of the threaded shank to the underside of the bolt head.

b. Install the bolt into the TDM and install the required number of shim plates and/or washer (one washer under the nut must always be used) to produce the thread stick-out measured in step a

above.

c. Tighten bolt using a hand wrench to the snug tensions listed in table below (-0 kips, +2 kips):

***Initial Tension Load (kips)**

Bolt Diameter (inches)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
A 325 Initial Tension Min.	1	2	3	4	5	6	7	9	10

Note:

*****Approximately 10% of Minimum Installation Tension.

d. Match mark the nut, bolt, and the face plate of the TDM.

e. Using the calibrated manual torque wrench, tighten the bolt to at least the tension listed below and record the torque required to reach the tension and the value of the bolt tension. Torque must be measured with the nut in motion.

***Minimum Installation Tension (kips)**

Bolt Diameter (inches)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Tension A 325 bolts	12	19	28	39	51	56	71	85	103

Note:

*****Installation Tension equals 70% x Min. Tensile Strength.

f. Further tighten the bolt to the rotation listed below. The rotation is measured from the initial marking in step (d). Record the bolt tension. Assemblies that fail before this rotation either by stripping or fracture fail the test.

***Rotation**

Bolt Length (measured in step a)	4 x bolt Diameter or less	Greater than 4 bolt dia., but not more than 8 x bolt dia.	Greater than 8 x bolt Diameters
Required Rotation	2/3	1	1 1/3

Note:

*Turn Test Tension equals 1.15 x 70% x Min. Tensile Strength.

g. The bolt tension measured in step (f) after the required rotation must equal or exceed the values in the table shown below. Assemblies which do not meet this tension have failed the test (Value is 115% of Minimum Installation Tension).

Turn Test Bolt Tension
(kips)

Bolt Diameter (inches)	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
A 325 Bolts	14	22	32	45	59	64	82	98	118

h. Remove the fastener assembly from the TMD. There should be no signs of thread shear failure, stripping or torsion failure of the bolt. Check for stripping by running the nut on the bolt threads to where it was during the test. This should be accomplished without the use of tools. Assemblies that have evidence of stripping have failed the test.

i. Calculate and record the value of 0.25 x tension (in pounds, measured in step (e) x bolt diameter in feet). The torque measured and recorded in step e, must be equal to or less than this calculated value. Assemblies with torque values exceeding this calculated value failed the test.

K. Procedure For Performing Rotational-Capacity Test on Bolts Too Short to Fit Tension Measuring Device.

1. Equipment Required.

a. Calibrated torque wrench and a spud wrench or equivalent.

b. Spacers and/or washers with hole size no larger than 1/16 inch greater than bolt to be tested.

c. Steel section with normal size hole to install bolt. Any available splice hole can be used with a plate thickness that will provide the number of threads under the nut required in step a below. Mark off a vertical line and line 1/3 of a turn, 120º; 1/2 of a turn, 180º; and 2/3 of a turn, 240º; from vertical in a clockwise direction on the plate.

2. Procedure for Performing Rotational-Capacity Test.

a. Install nut on bolt and measure stick out of bolt when 3 to 5 threads of the bolt are located between the bearing face of the nut and the bolt head. Measure the bolt length, the distance from the end of the threaded shank to the underside of the bolt head.

b. Install the bolt into the hole and install the required number of shim plates and/or washers (one washer under the nut must always be used) to produce the thread stick-out measured in step (a) above.

c. Snug the bolt using a hand wrench. The snug condition should be the normal effort applied to a

12 inch long wrench. The applied torque should not exceed 20% of the torque determined in Subsection **709.06J.2.e**.

d. Match mark the nut, bolt, and plate.

e. Tighten the bolt by turning the nut using the torque wrench to the rotation listed below. A second wrench must be used to prevent rotation of the bolt head during tightening. Record the torque required to reach this rotation. Torque must be measured with the nut in motion.

Rotation for A 325 Bolts

Bolt Length (measured in step a)	4 x bolt diameters or less
Required Rotation	1/3 Turn

The measured torque should not exceed the values listed below. Assemblies which exceed the listed torque have failed the test.

***Torque**
(foot-lbs.)

Bolt dia. (inches)	1/2	5/8	3/4	7/8	1	1 1/8	1 /4	1 3/8	1 1/2
A 325 Bolts	150	290	500	820	1230	1500	2140	2810	3690

Note:

*****Torque ≤ 25% x P x D, where P is Turn Test Value from Subsection **709.06J.2.g**, and D is bolt diameter.

f. Tighten the bolt further to the rotation required below. The rotation is measured from the initial

marking in step d. Assemblies which fail prior to this rotation either by stripping or fracture fail the

test.

Rotation
(Twice the rotation listed in step (e) above)

Bolt Length, measured in step (a)	4 x bolt diameters or less
Required rotation A 325 bolts	2/3

g. Remove the fastener assembly from the TMD. There should be no signs of thread shear failure, stripping, or torsion failure of the bolt. Check for stripping by running the nut on the bolt threads to where it was during the test. This should be accomplished without the use of tools. Assemblies that have evidence of stripping have failed the test.

L. Measurement and Payment. No separate measurement or payment will be made for fasteners since they are considered incidental to the contract price bid for Structural Steel.

709.07 Miscellaneous Metals and Fasteners.

A. Metals. Metals not otherwise specified shall meet the following:

1. Steel Forging. Steel forging shall conform to the requirements of AASHTO M 102 (ASTM A 668), Class C, D, F, and G).

2. Steel Castings. Steel castings shall conform to the requirements of AASHTO M 103 (ASTM A 27) as designated on the plans.

3. Iron Castings. Iron castings shall conform to the requirements of AASHTO M 105, Class No. 30 B. Test bars shall be Type B and shall be made and tested in accordance with AASHTO M 105.

4. Malleable Iron Castings. Malleable castings shall

conform to ASTM A 668. Grade No. 35018 shall be furnished unless otherwise specified.

5. Bronze Castings. Bronze castings shall conform to the requirements of AASHTO M 107 (ASTM B 22), Alloy 913 or 911.

6. Miscellaneous Metals. Other miscellaneous metals shall conform to the requirements of the current AASHTO Standard Specifications for Highway Bridges, Division II, Section 23.

B. Certifications. The Contractor shall furnish five copies of a certification for the above listed metals stating that they meet all SCDOT specifications. The certification shall indicate the project file number and the number of pieces being furnished.

C Low Carbon Bolts. All bolts, nuts and washers other than high strength bolts shall conform to the requirements of ASTM A 307.

709.08 Elastomeric Bearing Pads. Elastomeric bearing pads shall meet the requirements of Section **724**. The size and thickness of elastomeric material and laminae shall be as indicated on the plans.

709.09 Stainless Steel Bearings. All stainless steel bearing and expansion plates shall conform to the requirements of ASTM A 167 for Type 301 or Type 302, No. 1 Finish.

709.10 Paint. Unless otherwise specified, paint and paint systems shall conform to the requirements of Section **710**. The required paint system shall be specified on the plans or special provisions.

A. General Conditions. The painting of metal structure shall include, unless otherwise provided in the contract, the proper preparation of the metal surfaces, the application, protection and curing of the paint coatings, the pro-

tection of pedestrians, vehicular or other traffic upon, near, or underneath the bridge structure, the protection of all portions of the structure (superstructure and substructure) against disfigurement by spatter, splashes and smirches of paint or of paint material and the supplying of all tools, tackle, scaffolding, labor, workmanship and materials necessary for the entire work.

The Contractor shall have available at each bridge the name, telephone number and address of the person(s) who shall be responsible for processing all claims. All claims shall also be processed in an expedient manner.

B Welded, Bolted, Concrete Contact, and Inaccessible Surfaces. Surfaces to be welded together in the shop or the field shall not be painted. Surfaces on which welding shall be performed shall not be painted. Surfaces to be bolted together in the shop or the field shall be painted. All surfaces to be in contact with concrete (exclusive of top surfaces of beam flanges where welded shear connectors are in place) may receive a prime coat of paint. Surfaces which will be inaccessible after assembly or erection, shall be painted before assembly or erection.

C. Slip Critical Surfaces. For friction type connections designated on the plans to be Class B Slip Critical, the contact surfaces shall be blast-cleaned and coated with an inorganic zinc-rich paint as defined in the Steel Structures Painting Council System -SSPC 10.

FABRICATION

709.11 Notice of Beginning of Work. The Contractor shall give the Engineer ample notice of the beginning of work at the fabrication shop and in the rolling mill or foundry when specified so that inspection may be provided. No work shall be performed before the Engineer has been notified and inspection is provided.

709.12 Type of Fabrication. Shop fabrication of bridge

members will generally be shop welded and field bolted.

The Contractor shall provide the falsework and all tools, machinery and appliances, including drift pins and fitting-up bolts, necessary for the expeditious handling of the work.

709.13 Quality of Workmanship. Workmanship and finish shall be equal to the best general practice in modern bridge shops. Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting and chipping shall be done carefully and accurately.

All structural steel fabrication shall be performed by a fabricator certified in accordance with The American Institute of Steel Construction (AISC) Quality Certification Program for the category of work to be done.

709.14 Storage of Materials. Structural materials, either plain or fabricated, shall be stored at the fabricating shop above the ground upon platforms, skids or other supports. It shall be kept free of dirt, grease and other foreign matter and shall be protected a far as practicable from corrosion.

709.15 Facilities for Inspection. The Contractor shall furnish facilities for the inspection of material and workmanship in the mill and shop and the inspectors shall be allowed free access to the all parts of the work.

709.16 Inspector's Authority. Inspectors shall have the authority to reject any materials or work which does not meet the requirements of the contract. In case of dispute, the Contractor may appeal to higher authority. The acceptance of any material or finished members by the Engineer's representative shall not be a bar to their subsequent rejection, if found defective. Materials and workmanship whether previously inspected or not, will be inspected after its delivery to the site of the work or after being erected in the structure.

Rejected material or workmanship shall be replaced promptly or made satisfactory.

709.17 Mill Test Reports and Shipping Statements. The Engineer shall be furnished with complete certified mill test reports showing chemical analysis and the physical tests for each heat of steel for all members. The Contractor shall furnish the Engineer with five certified copies of mill test reports and five copies of shipping statements.

709.18 Identification of Steels During Fabrication. Each piece of steel to be fabricated shall be properly identified for the Engineer. Pieces of steel which are to be cut to smaller size pieces shall, before cutting, be legibly marked as to heat number and piece mark. Individually marked pieces of steel which are used in furnished size, or are reduced from furnished size only by end or edge trim may be used without additional identification as long as the original heat number is legible.

The Contractor may furnish from stock, material that can be identified by heat number an mill test report. Any excess materials placed in stock for later use shall be marked with the SCDOT Project File No., the mill test report number, AASHTO/(ASTM) specification identification, when separated from the full size piece furnished by the supplier.

709.19 Straightening Material. Rolled material, before being laid off or worked, must be straight. If straightening is necessary, it shall be done by methods approved by the Engineer that will not injure the metal. In no case shall the maximum temperature of the steel exceed 1125ºF. Sharp kinks and bends shall be cause for rejection of the material.

709.20 Flame Cutting. Flame cutting of structural steel shall conform to the requirements of Article 3.2.2 of the latest edition of the ANSI / AASHTO / AWS D1.5 *Bridge Welding Code*.

709.21 Edge Planing. Sheared edges of plate more than 5/8 inch in thickness and carrying calculated stress shall be

planed, milled, ground or thermal cut to a depth of 1/4 inch.

709.22 Structural Welding. Welding of steel structures, and all subsequent references to welding, shall conform to the latest edition of ANSI / AASHTO / AWS D1.5 “Bridge Welding Code,” the plans, or the special provisions. In addition, the following shall be understood:

A. Field Welding.

1. General. All field welding, except welding of reinforced pile tips, temporary false-work (unless specified), SIP formwork, armor plate at bridge ends and armor plate at expansion joints shall be considered structural welding and shall be performed by a SCDOT certified welder. All field personnel welding structural steel, steel reinforcement, steel pile splices, and other types of field structural welds shall have been qualified to perform the type of welding in accordance with the qualification procedure of the latest edition of the ANSI / AASHTO / AWS D 1.5 *Bridge Welding Code* as follows:

> A welder or tacker (hereafter known as “welder”) may be qualified by preparing test specimens in accordance with section 5.22, figure 5.7A, Position 2G for limited thickness groove welding (butt welding) and section 5.23, figure 5.8A, Position 2F for fillet welding. Testing as shown in figure 5.8B will not suffice for fillet welding qualification.

The above testing is minimum and will qualify the welder for general welding at the job site. By choice of the welder, he may qualify for additional positions and unlimited metal thickness as part of the above testing.

Specialized welding and welding positions at the job site may require additional welder qualification testing if

required by the Engineer.

The test specimens shall be prepared in the presence of and tested and evaluated by an independent laboratory person qualified as a Welding Inspector. All radiographic nondestructive testing shall be performed by an ASNT Level II or III technician. The independent laboratory shall furnish a welder qualification test report on company letterhead stationery stating the type welding approved, name of the welder, the welder's social security number, along with a statement that the welder is duly qualified as a field welder in accordance with the SCDOT requirements. The report shall show the name of the independent laboratory technician(s) making the evaluation and shall be signed by the independent laboratory manager.

The independent laboratory shall submit a copy of the report for processing to:

Research and Materials Engineer
SCDOT Research and Materials Laboratory
P.O. Box 191
Columbia, SC 29202,

The welder will be forwarded a SCDOT certification good for two years and renewable every two years provided the welder has been engaged in welding procedures during the preceding two year period.

A list of qualified independent laboratories capable of administering this testing may be obtained from the SCDOT Research and Materials Laboratory. An independent laboratory may request to be included on the list by furnishing to the Research and Materials Engineer a letter stating their qualifications to perform the testing and the names of their personnel who will be performing the evaluations.

2. Submittals. The Contractor shall notify the Engi-

neer and the Research and Material Engineer ten (10) calendar days before performing any field welding including the welding of reinforced pile tips, armored plated at bridge joints, temporary false-work and SIP form-work. The Contractor shall document this notification by completing the form entitled *SCDOT Sample Welding Procedure Specification* and forwarding one copy each to the Engineer and the Research and Materials Engineer.

B. Electrodes. The electrodes used in welding structural steel shall conform to the requirements set forth in the latest edition of the ANSI / AASHTO / AWS D 1.5 *Bridge Welding Code*.

C. Preheat and Interpass Temperatures. The pre-heat and interpass temperatures required for welding structural steel shall be as specified in the latest edition of the ANSI / AASHTO / AWS D 1.5 *Bridge Welding Code*.

D. Inspection.

1. General. The structural steel fabrication including welding shall be in accordance with the latest edition of ANSI / AASHTO / AWS D1.5 *Bridge Welding Code* except as noted herein. Fabrication and Welding Quality Assurance (QA) inspection in the fabricating shops will be done by the Department's representative, either a Department Research and Materials Laboratory inspector or an inspector from a commercial testing laboratory acting for the Department.

2. Nondestructive Testing of Welds and Metals. Radiographic, ultrasonic, magnetic particle, and dye penetrant testing of welds shall be performed on welds in conformance with the requirements of the latest edition of the ANSI / AASHTO / AWS D1.5 *Bridge Welding Code* with the following exceptions:

a. All girder flange butt welds shall be tested ra-

dio-graphically, whether in tension or compression.

b. Quality Assurance (QA) and Quality Control (QC) nondestructive testing as referenced in AASHTO and AWS shall be interpreted as follows:

Quality Assurance (QA) nondestructive testing required by the contract documents shall be performed by the Department's inspector or authorized inspection agency's inspector acting for the Department. At the discretion of the Department's inspector or authorized representative, Quality Control (QC) nondestructive testing, performed by the Contractor in the presence of the Department's inspector may be used to satisfy like nondestructive testing requirement(s) specified for QA. The observing inspector shall maintain test result records for the work performed.

The cost of the QC nondestructive testing shall be borne by the Contractor regardless of the Department's acceptance for QA testing. The cost of Department performed QA testing shall be borne by the Department.

The cost of re-testing of repaired welds shall be borne by the Contractor.

F. Restricted Welded Processes. Gas metal arc and flux cored arc welding shall not be used except with written approval of the Department. If authorization is granted, the procedure and operator qualifications shall be in accordance with the latest edition of the ANSI / AASHTO / AWS D 1.5 *Bridge Welding Code*. Electro-slag and electro-gas welding shall not be permit-

ted.

709.23 Electrically Welded Studs.

A. General Requirements. Welding of shear connector studs and all subsequent references to shear connector studs shall conform to the latest edition of the ANSI / AASHTO / AWS D1.5 *Bridge Welding Code*. In addition the following shall be understood:

Shear connector studs shall be of a design suitable for welding to steel beams and girders with automatically timed stud-welding equipment. The type, size or diameter and length of stud shall be as specified by the plans or the special provisions and shall be listed on the Department's *Approved Electrical Weld Shear Connector Studs*.

Only approved studs shall be used. Before placing orders for studs, the Contractor shall submit to the Engineer for approval the following information on the studs to be purchased:

1. The name of the manufacturer.

2. A detailed description of the stud and arc shield to be furnished.

3. A certification from the manufacturer that the stud meets the Department's requirements.

4. A copy of a qualification test report as certified by a reputable testing laboratory.

The studs, after welding, shall be free from any defect or substance that would interfere with their function as shear connectors.

B. Materials Requirements. Shear connector studs shall conform to the requirements of AASHTO M 169,

(ASTM A 108), Cold-drawn Bar, Grades 1015, 1018, or 1020, either semi or fully-killed. If flux-retaining caps are used, the steel for the caps shall be of a low carbon grade suitable for welding and shall comply with ASTM A 109.

Tensile properties as determined by tests of bar stock after drawing or of finished studs shall conform to the following requirements:

Longitudinal and lateral spacing of studs with respect to each other and to edges of beam or girder flanges shall not vary more than one-half inch from the dimensions shown on the plans except that a variation of one inch will be permitted where required to avoid obstruction with other attachments on the beam or where a new stud is being welded to replace a defective one.

The first two studs welded on each beam or girder, after being allowed to cool, shall be bent 45 degrees by striking the stud with a hammer. If failure occurs in the weld of either stud, the procedure shall be corrected and two successive studs successfully welded and tested before any more studs are welded to the beam or girder. The Engineer shall be promptly informed of any changes in the welding procedure at any time during construction.

When the temperature of the base metal is below 32ºF, one stud in each 100 studs welded shall be bent 45 degrees in addition to the first two bent as specified above.

D. Inspection Requirements. If visual inspection reveals any stud which does not show a full 360° weld, any stud which has been repaired by welding or any stud in which the reduction in height due to welding is less than normal, such stud may be tested by being struck with a hammer and bent 15° off the vertical. For studs showing less than 360° weld, the direction of bending shall be opposite to the lack of weld. Studs that crack in either the weld or the shank shall be replaced.

After welding, 10 studs shall be selected at random along the top of each girder. These 10 studs shall be hammered out of line 30° toward the center of the span. Not more than one of these test studs shall show any signs of failure.

If more than one stud fails, then all studs on the girder shall be hammered (but not necessarily bent the full 30°) and all that fail shall be replaced. Before replacing the stud, the area shall be ground free of any metal left from the old weld, or in the case of a pocket, it shall be filled with E-7018 weld metal and ground flush.

In addition to the above test, if more than two studs in any group of studs checked should show the need for additional all around welding due to faulty operation of the welding gun, all the studs in the group shall be removed as required in the paragraph above and replaced.

The studs tested that show no sign of failure may be left in the bent position.

If during the progress of the work, inspection and testing indicates in the judgment of the Engineer that the shear connectors being obtained are not satisfactory, the Contractor will be required at his expense to make such changes in welding procedure, welding equipment and type of shear connector as necessary to secure satisfactory results.

At the option of the purchaser, the manufacturer of the studs may be required at any time to submit sample studs for re-qualification, at the manufacturer's expense.

709.24 Fit of Stiffeners. End stiffeners of girders and stiffeners intended as supports for concentrated loads shall have full bearing on the flanges to which they transmit load or from which they receive load. Full bearing shall be obtained by milling, grinding or welding as shown on the plans. Stiffeners

not intended to transfer load, unless shown or specified otherwise shall fit sufficiently tight to exclude water after being painted.

709.25 Camber. A camber diagram shall be furnished to the Engineer by the Fabricator, showing the camber at each panel point in the cases of trusses or arch ribs, and at the location of field splices and fractions of span length (1/4 points minimum, 1/10 points maximum) in the cases of continuous beam and girders or rigid frames. When the shop assembly is Full Truss or Girder Assembly or Special Complete Structure Assembly, the camber diagram shall show the camber measured in assembly. When any of the other methods of shop assembly is used, the camber diagram shall show calculated camber.

Girders shall be cambered before heat curving. Camber for rolled beams may be obtained by heat-cambering methods approved by the Engineer. Girders and rolled beams shall be cambered in accordance with the camber diagram as shown in the plans. Camber for rolled beams may be obtained by heat cambering methods or by cold bending with hydraulic rams. Moderate deviations from the specified camber may be corrected by a carefully supervised application of heat when approved by the Engineer. Horizontal heat curving may tend to change vertical camber. This effect may be more pronounced when the top and bottom flanges are of unequal width on a given transverse cross-section.

709.26 Bolt Holes.

A. Holes for High-Strength Bolts. All holes for bolts shall be either punched or drilled. Material forming parts of a member composed of not more than five thickness' of metal may be punched 1/16 inch larger than the nominal diameter of the bolts whenever the thickness of the material is not greater than 3/4 inch for structural steel, 5/8 inch for high-strength steel or 1/2 inch for quenched and tempered alloy steel, unless sub-punching and reaming are required under Subsection **709.31**.

When there are more than five thickness' or when any of the main material is thicker than 3/4 inch for structural steel, 5/8 inch for high-strength steel, or 1/2 inch for quenched and tempered alloy steel, all holes shall either be sub-drilled or drilled full size.

When required under Subsection **709.31**, all holes shall be either sub-punched or sub-drilled (sub-drilled if thickness limitation governs) 3/16 inch smaller and, after assembling, reamed 1/16 inch larger or drilled full size to 1/16 inch larger than the nominal diameter of the bolts.

When permitted by the Bridge Design Engineer, enlarged or slotted holes are allowed with high-strength bolts.

B. Holes for Ribbed Bolts, Turned Bolts or Other Approved Bearing Type Bolts. All holes for ribbed bolts, turned bolts or other approved bearing-type bolts shall be sub-punched or sub-drilled 3/16 inch smaller than the nominal diameter of the bolt and reamed, assembled or drilled to a steel template or, after assembling, drilled from the solid at the option of the Fabricator. In any case, the finished holes shall provide a driving fit as specified on the plans or in the special provisions.

709.27 Punched Holes. The diameter of the die shall not exceed the diameter of the punch by more than 1/16 inch. If any holes must be enlarged to admit the bolts, such holes shall be reamed. Holes must be clean cut without torn or ragged edges. Poor matching of holes will be cause for rejection.

709.28 Reamed or Drilled Holes. Reamed or drilled holes shall be cylindrical, perpendicular to the member, and shall comply with the requirements of Subsection **709.26** as to size. Where practicable, reamers shall be directed by mechanical means. Burrs on the outside surfaces shall be removed. Poor matching of holes will be cause for rejection.

Reaming and drilling shall be done with twist drills. If required by the Engineer, assembled parts shall be taken apart for removal of burrs caused by drilling. Connecting parts requiring reamed or drilled holes shall be assembled and securely held while being reamed or drilled and shall be match marked before disassembling.

709.29 Accuracy of Punched, Sub-punched or Sub-drilled Holes. All holes punched full size, sub-punched or sub-drilled shall be so accurately punched that after assembling (before any reaming is done) a cylindrical pin 1/8 inch smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75% of the contiguous holes in the same plane. If the requirement is not fulfilled, the badly punched pieces will be rejected. If any hole will not pass a pin 3/16 inch smaller in diameter than the nominal size of the punched hole, this will be cause for rejection.

709.30 Accuracy of Reamed and Drilled Holes. When holes are reamed or drilled, 85% of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 1/32 inch between adjacent thickness of metal.

All steel templates shall have hardened steel bushings in holes accurately dimensioned from the centerlines of the connection as inscribed on the template. The centerlines shall be used in locating accurately the template from the milled or scribed ends of the members.

709.31 Preparation of Field Connections. Unless otherwise specified in the special provisions or on the plans, holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders and rigid frames shall be sub-punched (or sub-drilled if sub-drilling is required according to Subsection **709.26**) and subsequently reamed while assembled onto a steel template, as required by Subsection **709.33**. Holes for field splices of rolled beam stringers continuous over floor beams or crossframes may be drilled full size unassembled to

a steel template. All holes for floor beams and stringer field end connections shall be sub-punched and reamed to a steel template or reamed while assembled. Reaming or drilling full size of field connection holes through a steel template shall be done after the template has been located with utmost care as to position and angle and firmly bolted in place. Templates used for reaming matching members, or the opposite faces of a single member, shall be exact duplicates. Templates used for connections on like parts or members shall be so accurately located that the parts or members are duplicates and require no match-marking.

Unless otherwise authorized by the Engineer, the adjacent panels or sections of each individual truss, arch, continuous beam or girder shall be assembled in the shop before reaming or full drilling is commenced. The shop assembly shall consist of blocking up and setting the parts that make up the joint to be reamed or drilled to the exact relative position and grade that such parts will later assume in the completed bridge, and fastening such parts securely in position before and during the reaming or drilling of the holes in the joint.

For any connection, instead of sub-punching and reaming or sub-drilling and reaming, the fabricator, at his option, may drill holes full size with all thickness or material assembled in proper position.

If additional sub-punching and reaming is required, it shall be specified in the special provisions or on the plans.

Alternately, for any connection or splice designated above, in lieu of sub-sized holes and reaming while assembled, or drilling holes full-size while assembled, the Contractor shall have the option to drill or punch holes full-size in unassembled pieces and/or connections including templates for use with matching sub-sized and reamed holes by means of suitable numerically controlled (N/C) drilling or punching equipment subject to the specific provisions contained in this article. Full-size punched holes shall meet the requirements of Subsection **709.26**.

If N/C drilling or punching equipment is used, the Engineer, unless otherwise stated in the special provisions or on the plans, may require the Contractor, by means of check assemblies, to demonstrate that this drilling or punching procedure consistently produces holes and connections meeting the requirements of Subsections **709.30** and **709.33**.

The Contractor shall submit to the Engineer for approval a detailed outline of the procedures that he proposes to follow in accomplishing the work from initial drilling or punching through check assembly, if required, to include the specific members of the structure that may be N/C drilled or punched, the sizes of the holes, the location of common index and other reference points, composition of check assemblies, and all other pertinent information.

Holes drilled or punched by N/C equipment shall be drilled or punched to appropriate size through individual pieces, or drilled through any combination of pieces held tightly together.

709.32 Fitting for Bolting. Surfaces of metal in contact shall be cleaned before assembling. The parts of a member shall be assembled, well pinned and firmly drawn together before drilling, reaming or bolting is commenced. Assembled pieces shall be taken apart, if necessary, for the removal of burrs and shavings produced by the operation. The member shall be free from twists, bends, and other deformation.

The drifting done during assembling shall be only such as to bring the parts into position and not sufficient to enlarge the holes or distort the metal.

709.33 Shop Assembly.

A. General. The field connections of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders and rigid frames shall be assembled in the shop with milled ends of compression

members in full bearing and then shall have their sub-size holes reamed to specified size while the connections are assembled. Assembly shall be Full Truss or Girder Assembly unless Progressive Truss or Girder Assembly, Full Chord Assembly, Progressive Chord Assembly, or Special Complete Structure Assembly is specified in the special provisions or on the plans.

Check Assemblies with Numerically Controlled Drilled or Punched Field Connections and template drilled field connections of rolled beam stringers continuous over floorbeams or cross frames shall be in accordance with Subsection **709.33G**.

Each assembly, including camber, alignment, accuracy of holes and fit of milled joints, shall be approved by the Engineer before reaming is commenced or before an N/C drilled check assembly is dismantled.

B. Full Truss or Girder Assembly. Full Truss or Girder Assembly shall consist of assembling all members of each truss, arch rib, bent, tower face, continuous beam line, plate girder or rigid frame at one time.

C. Progressive Truss or Girder Assembly. Progressive Girder Assembly shall consist of assembling initially for each arch rib, continuous beam line, or plate girder at least three contiguous shop sections. Progressive Truss Assembly shall consist of assembling initially for each truss, bent, tower face or rigid frames, all members in at least three contiguous panels, but not less than the number of panels associated with three contiguous chord lengths. Successive assemblies shall consist of not less than two sections or panels of the previous assembly (repositioned if necessary and adequately pinned to assure accurate alignment) plus one or more sections or panels added at the advancing end. In the case of structures longer than 150 feet, each assembly shall be not less than 150 feet long regardless of the length of individual continuous panels or sections. At the option of the fabricator,

sequence of assembly may start from any location in the structure provided the preceding requirements are satisfied.

Assemblies consisting of less than three shop sections or panels shall require approval of the Engineer.

D. Full Chord Assembly. Full Chord Assembly shall consist of assembling, with geometric angles at the joints, the full length of each chord of each truss or open spandrel arch or each leg of each bent or tower, then reaming their field connection holes while the members are assembled and reaming the web member connections to steel templates set at geometric (not cambered) angular relation to the chord lines.

Field connection holes in web members shall be reamed to steel templates. At least one end of each web member shall be milled or shall be scribed normal to the longitudinal axis of the member and the templates at both ends of the member shall be accurately located from one of the milled ends of scribed lines.

E. Progressive Chord Assembly. Progressive Chord Assembly shall consist of assembling contiguous chord members in the manner specified for Full Chord Assembly and in the number and length specified for Progressive Truss or Girder Assembly.

F. Special Complete Structure Assembly. Special Complete Structure Assembly shall consist of assembling the entire structure, including the floor system. (This procedure is ordinarily needed only for complicated structures such as those having curved girders or extreme skew in combination with severe grade or camber).

G. Check Assemblies with Numerically Controlled Drilled Field Connections. A check assembly shall be

required for each major structural type of each project, unless otherwise designated on the plans or in the special provisions, and shall consist of at least three contiguous shop sections or, in a truss, all members in at least three contiguous panels, but not less than the number of panels associated with three contiguous chord lengths (i.e., length between field splices). Check assemblies should be based on the proposed order of erection, joints in bearings, special complex points and similar considerations. Such special points could be the portals if skewed trusses, etc.

Use of either geometric angles (giving theoretically zero secondary stresses under dead-load conditions after erection) or cambered angles (giving theoretically zero secondary stresses under no-load conditions) should be designated on the plans or in the special provisions.

The check assembles shall preferably be the first such sections of each major structural type to be fabricated.

No match marking and no shop assemblies other than the check assemblies shall be required.

If the check assembly fails in some specific manner to demonstrate that the required accuracy is being obtained, further check assemblies may be required by the Engineer for which there shall be no additional cost to the Department.

709.34 Match Marking. Connecting parts assembled in the shop for the purpose of reaming holes in field connections shall be match marked and a diagram showing such marks shall be furnished to the Engineer.

709.35 Bolts and Bolted Connections. The requirements of this subsection do not pertain to the use of high-strength

bolts. Bolted connections fabricated with high-strength bolts shall conform to Subsection **709.36**.

A. General. Bolts shall be unfinished, turned or ribbed bolts conforming to the requirements of ASTM A 307, Grade A. Bolted connections shall be used only as indicated by the plans or the special provisions. Bolts shall have single self-locking nuts or double nuts unless otherwise shown on the plans or in the special provisions. Beveled washers shall be used where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

B. Unfinished Bolts. Unfinished bolts shall be furnished unless other types are specified.

C. Turned Bolts. The surface of the body of turned bolts shall meet the ANSI roughness rating value of 125. Heads and nuts shall be hexagonal with standard dimensions for bolts of the nominal size specified or the next larger nominal size. Diameter of threads shall be equal to the body of the bolt or the nominal diameter of the bolt specified. Holes for turned bolts shall be carefully reamed with bolts furnished to provide for a light driving fit. Threads shall be entirely outside of the holes. A washer shall be provided under the nut.

D. Ribbed Bolts. The body of ribbed bolts shall be of an approved form with continuous longitudinal ribs. The diameter of the body measured on a circle through the points of the ribs shall be 5/64 inch greater than the nominal diameter specified for the bolts.

Ribbed bolts shall be furnished with round heads conforming to ANSI B 18.5 unless otherwise specified. Nuts shall be hexagonal, either recessed or with a washer of suitable thickness. Ribbed bolts shall make a driving fit with the holes. The hardness of the ribs shall be such the ribs do not mash down enough to permit the bolts to turn in the holes during tightening. If, for any reason, the bolt twists before drawing tight, the hole shall be carefully reamed and an oversized bolt used as a replacement.

709.36 Connections Using High Strength Bolts.

A. General. This subsection covers the assembly of structural joints using ASTM A 325 or ASTM A 490 high-strength bolts, or equivalent fasteners, tightened to a high tension. The bolts are used in holes conforming to the requirements of Subsections **709.26**, **709.27**, and **709.28**.

B. Bolts, Nuts, and Washers. Bolts, nuts, and washers shall conform to the requirements of Subsection **709.06B**.

C. Bolted Parts. The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material.

ASTM A 325 and ASTM A 490 bolts shall not be galvanized nor shall they be used to connect galvanized material.

D. Installation.

1. Fit-up of Steel. Twenty-five percent (25%) of the holes shall be filled with cylindrical erection pins to fair up the metal, and the remaining holes shall be filled with high strength bolts. Twenty-five percent (25%) of the bolts, in a random pattern over the joint, shall be given an identifying mark and shall be firmly tightened in order to pull all plies of the metal into firm contact.

2. Bolt Tension. Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum bolt tension shown in **Table D-I** for the size of fastener used.

Threaded bolts shall be tightened by one of the methods described in Subsections **709.36D.4**,

709.36D.5, and **709.36D.6**. If required because of bolt entering and wrench operational clearances, tightening by the selected procedure may be done by turning the bolt while the nut is prevented from rotating. Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 seconds.

ASTM A 490 and galvanized ASTM A 325 bolts shall not be re-used. Non-galvanized ASTM A 325 bolts may be re-used, but not more than once, if approved by the Engineer. Re-tightening previously tightened bolts that may have been loosened by the tightening of adjacent bolts shall not be considered as a re-use.

Table D-I
*Minimum Bolt Tension

Bolt Size (inches)	ASTM A 325 Bolts (pounds)	ASTM A 490 Bolts (pounds)
1/2	12,050	14,900
5/8	19.200	23,700
3/4	28,400	35,100
7/8	39,250	48,500
1	51,500	63,600
1 1/8	56,450	80,100
1 1/4	71,700	101,800
1 3/8	85,450	121,300
1 1/2	104,000	147,500

Note:

*Equal to 70% of specified minimum tensile strength of bolts.

3. Washers. All fasteners shall have a hardened washer under the element (nut or bolt head) turned in

tightening. Hardened washers shall be used under both the head and nut, regardless of the element turned, in the case of ASTM A 490 bolts, if the material against which it bears has a specified yield strength less than 40 ksi.

Where an outer face of the bolted parts has a slope more than 1:20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism.

4. Turn-of-Nut Tightening. When the turn-of-nut method is used to provide the bolt tension specified in Subsection **709.36D.2**, there shall first be enough bolts brought to a “snug tight” condition to ensure that the parts of the joint are brought into full contact with each other. Snug tight is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified in **Table D-II** 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.

Table D-II			
Nut Rotation[1] from Snug Tight Condition			
	Disposition of Outer Faces of Bolted Parts		
Bolt length measured from underside of head to extreme end of point	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20 (bevel washer not used).	Both faces sloped not more than I:20 from normal to bolt axis (bevel washers not used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
[2]Over 8 diameters but not exceeding 12 diameters	2/3 turn	5/6 turn	1 turn

Notes:

[1] Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn and less, the tolerance should be plus or minus 30º; for bolts installed by 2/3 turn and more, the tolerance should be plus or minus 45º.

[2] No research work has been performed by the Research Council on Riveted and Bolted Structural Joints to establish the turn-of-nut procedure when bolt lengths exceed 12 diameters. Therefore, the required rotation must be determined by actual tests in a suitable tension device simulating the actual conditions.

5. Lock-Pin and Collar Fasteners. The installation of lock-pin and collar fasteners shall be by methods and procedures approved by the Engineer.

6. Tightening by Use of a Load Indicating Fastener System. Tightening by this means is permitted provided it can be demonstrated by an accurate direct measurement procedure that the bolt has been tightened in accordance with **Table D-I**. Tightening shall be by methods and procedures approved by the Engineer.

E. Inspection. The Engineer shall determine that the requirements described below are met in the work. The Contractor shall provide the Engineer with accommodations necessary to accomplish the observations and inspections specified.

The Engineer shall observe the installation and tightening of bolts to determine that the selected tightening procedure is properly used and shall determine that all bolts are tightened and in the case of the direct tension indicator method that the correct indication of tension has been achieved. Bolts may reach tensions substantially above the value given in **Table D-I,** but this shall not be cause for rejection.

The following inspection procedure shall be used unless a more extensive or different inspection procedure is specified.

1. Either the Engineer or the Contractor in the presence of the Engineer, at the Engineer's option, shall use an inspection wrench that may be a torque wrench.

2. Three bolts of the same grade, size and condition as those under inspection shall be selected for inspection. The length may be any length representative of bolts used in the structure. The selected bolts shall be placed individually in a calibration device capable of indicating bolt tension at least once each working day. There shall be a washer under the part turned in tight-

ening each bolt if washers are so used on the structure. If no washer is used, the material abutting the part turned shall be of the same specification as that used on the structure.

3. Each bolt specified in Subsection **709.36E.2** shall be tightened in the calibration device by any convenient means to an initial condition equal to 15% of the required tension and then the minimum tension specified for its size in Subsection **709.36D.2**. The inspecting wrench then shall be applied to the tightened bolt and the torque necessary to turn the nut or head 5 degrees (approximately one inch at 12-inch radius) in tightening direction shall be determined. The average torque measured in the tests of three bolts shall be taken as the job inspecting torque to be used in the manner specified in Subsection **709.36E.2**.

4. Bolts, represented by the sample prescribed in Subsection **709.36E.2** and have been tightened in the structure, shall be inspected by applying, in the tightening direction, the inspecting wrench and its job inspecting torque to 10% of the bolts, but not less than two bolts, selected at random in each connection. If no nut or bolt head is turned by this application of the job inspection torque, the connection shall be accepted as properly tightened. If any nut or bolt head is turned by the application of the job inspecting torque, this torque shall be applied to all bolts in the connection, and all bolts whose nut or head is turned by the job inspecting torque shall be tightened and re-inspected, or alternatively, the Fabricator or Erector, at his option, may retighten all of the bolts in the connection and then resubmit the connection for the specified inspection.

The procedures for inspecting and testing the lock-pin procedures and collar fasteners and their installation to assure that the required pre-load tension is provided shall be as approved by the Engineer.

709.37 Facing of Bearing Surfaces. The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the ANSI surface roughness requirements as defined in ANSI B46.1, Surface Roughness, Waviness and Lay, Part I:

Steel slabs	ANSI 2000
Heavy plates in contact in shoes to be welded	ANSI 1000
Milled ends of compression members, milled or ground ends of stiffeners and fillers	ANSI 500 ANSI 500
Bridge rollers and rockers	ANSI 125
Pins and pin holes	ANSI 125
Sliding bearings	ANSI 125

709.38 Bridge Bearing Assemblies.

A. General. Unless otherwise specified, all steel bearing plates shall be rolled steel conforming to the requirements of AASHTO M 270 (ASTM 709), Grade 36.

B. Sole Plates. The exposed face of the sole plate embedded in the concrete shall be straight and truly perpendicular to the vertical axis of the concrete girder. A variation of 1/16 inch from a plane perpendicular to the vertical axis shall not be exceeded at any place.

C. Rocker and Masonry Plates. Sliding surfaces of both the rocker and the plate shall be machined to a flat ANSI 125 finish in direction of movement. If machined in a direction other than the expansion, it shall be machined to a flat ANSI 63 finish. Notice shall be given when the fabricator is ready for inspection so that arrangements may be made by the Department for inspection. Machined surfaces shall not be painted until after inspection. Plates may be cut to size by torch, and holes and slots may be cut by torch provided the ends of slots are drilled

before cutting is done. Burrs from torch cuts shall be removed. Bridge bearing components including bridge rollers, rockers and sliding bearings that are to be hot dipped galvanized shall be machined to an ANSI surface roughness requirement of ANSI 250 or better regardless of expansion direction.

D. Elastomeric Bearing Pads. Elastomeric bearing pads shall meet the requirements of Section **724**. The size and thickness of elastomeric material and laminae shall be as indicated on the plans.

E. Flange Bearing Area. Flange surfaces bearing on sole plates shall conform to the tolerances specified in the latest edition of the ANSI / AASHTO / AWS D 1.5 *Bridge Welding Code* which requires that 75% of the projected web and stiffener area be flat within 0.01 inch and the remaining 25% of the projected area to be within 1/32 inch. In addition, the remaining contact area between the flange and sole plate shall not deviate more than 1/16 of an inch from a plane measured perpendicular to the web. The field fit-up of the flange to the sole plate shall produce a gap not to exceed 1/8 inch. Gaps exceeding 1/8 inch in fit-up shall be corrected by a method approved by the Engineer before welding the flange to the sole plate.

709.39 Abutting Joints. Abutting joints in compression members designed to transfer stress shall be faced and brought to an even bearing. Where joints are not required elsewhere to be faced or brought to even bearing, the opening shall not exceed 1/4 inch.

709.40 End Connection Angles. Floor beams, stringers and girders having end connection angles shall be built to exact length back to back of connection angles. If end connections are faced, the finished thickness of the angles shall not be less than that shown on the detail drawings.

709.41 Web Splices. At bolted web splices, the ends of the beams or girders shall be cut and ground smooth. During

shop assembly, the clearance between the ends of the members (web and flanges) shall not exceed 1/4 inch.

709.42 Bent Plates. Unwelded, cold-bent, load-carrying, rolled-steel plates shall conform to the following:

A. General. They shall be so taken from the stock plates that the bend line will be at right angles to the direction of rolling.

B. Bending. Bending shall be such that no cracking of the plate occurs. Minimum bend radii, measured to the concave face of the metal, are given in the following table:

For All Grades Of Structural Steel In this Specification					
Thickness of Plate	Up to 1/2	Over 1/2 to 1	Over 1 to 1 1/2	Over 1 1/2 to 2 1/2	Over 2 1/2 to 4
Minimum Bending Radius for Thickness, t in Inches	2t	2 1/2 t	3t	3 1/2t	4t

For break press forming, the lower die span should be at least 16 times the plate thickness. Multiple hits are advisable.

If a shorter radius is essential, the plates shall be bent hot at a temperature not greater than 1125ºF. Any plates from all ASTM or AASHTO designations inadvertently heated above 1125ºF shall be rejected or re-quenched and re-tempered using correct ASTM procedures.

Before bending, the corners of the plate shall be rounded to a radius of 1/16 inch throughout the portion of the plate at which the bending is to occur.

709.43 Finished Members at Fabrication Shop. Finished members shall be true to line, free from twists, bends, and

open joints.

709.44 Weighing Members. In case it is specified that any part of the material is to be paid for by actual weight, finished work shall be weighed in the presence of the Inspector, if practicable. In such case, the Contractor shall supply satisfactory scales and shall perform all work involved in handling and weighing the various parts.

709.45 Marking and Shipping. Each member shall be painted or marked with an erection mark for identification and an erection diagram shall be furnished with erection marks shown thereon.

The Contractor shall furnish to the Engineer as many copies of material orders, shipping statements and erection diagrams as the Engineer may direct. The weights of the individual members shall be shown on the statements. Members weighing more than 3 tons shall have weights marked thereon.

Structural members shall be loaded on trucks or cars in such a manner that they may be transported and unloaded at their destination without being excessively stressed, deformed, or otherwise damaged.

Bolts of one length and diameter and loose nuts or washers of each size shall be packed separately. Pins, small parts and packages of bolts, washers and nuts shall be shipped in boxes, crates, kegs or barrels, but the gross weight of any package shall not exceed 300 pounds. A list and description of the contained material shall be plainly marked on the outside of each shipping container.

ERECTION

709.46 Delivery of Materials. If the contract is for erection only, the Contractor shall receive the materials entering into the finished structure free of charge at the place designated and loaded or unloaded as specified. The Contractor shall

unload promptly upon delivery any material delivered to the place designated, that he is required to unload. Otherwise, he shall be responsible for demurrage charges.

709.47 Handling and Storing Materials. Material to be stored shall be placed on skids above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and stored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection. If the contract is for erection only, the Contractor shall check the material turned over to him against the shipping list and report promptly in writing any shortage or injury discovered. He shall be responsible for the loss of any material while in his care, or for any damage caused to it after being received by him.

709.48 Falsework. The falsework shall be properly designed, substantially constructed, and properly maintained for the loads it is intended to support. The Contractor, if required, shall prepare and submit to the Engineer for review and acceptance, working drawings for falsework or for changes in an existing structure necessary for maintaining traffic. Review and acceptance of the Contractor's working drawings shall not be considered as relieving the Contractor of any responsibility. Working drawings for falsework shall be submitted as specified in Section **725**.

709.49 Methods and Equipment. Before starting erection work, the Contractor shall submit to the Engineer for approval, an *Erection Plan* that fully details the method of erection he proposes to follow and the amount and type of equipment to be used. The approval of the Engineer shall not relieve the Contractor of the responsibility for the safety of his method or equipment or from carrying out the work in full accordance with the plans and specifications. No work shall be started until such approval by the Engineer has been obtained.

709.50 Bearings and Anchorages. Bridge bearings shall be set level, in exact position, and must have full an even bearing on the masonry.

Elastomeric bearing pads, if used, shall set directly on the concrete masonry.

The Contractor shall drill holes for anchor bolts and set them in Portland cement grout or preset them as shown on the plans or as specified.

Location of anchors and setting of rockers or rollers shall take into account any variation from mean temperature at time of setting and anticipated lengthening of bottom chord or bottom flange due to dead load after setting, the intention being that, as near as practicable, at mean temperature and under dead load, the rockers and rollers shall set vertical and anchor bolts at expansion bearings will center their slots. Care shall be taken that full and free movement of the superstructure at the movable bearings is not restricted by improper setting or adjustment of bearings or anchor bolt and nuts.

Bridge bearings shall not be placed on masonry bearing areas that are irregular or improperly formed.

709.51 Erection of Structure. If the substructure and superstructure are built under separate contracts, the superstructure erector shall expect reasonable variations from the theoretical distances between embedded anchor bolts, condition of bearing areas or elevation of pier caps. The superstructure erector shall verify for himself by field measurements the actual distance between embedded anchor bolts and pier caps or elevation of pier caps before fabrication of the superstructure steel so that adjustments can be made if found necessary. Necessary corrections of variations considered excessive will be paid for as extra work, when such work is authorized by the Engineer.

The Contractor shall erect the metal work, remove the temporary construction and do all the work required to complete the bridge or bridges as covered by the Contract, including the removal of the old structure or structures, if stipulated, all in accordance with the plans and these specifications.

709.52 Straightening Bent Material. The straightening of plates, angles, other shapes and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or other injury. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by carefully planned procedures and supervised application of a limited amount of localized heat, not exceeding 1125ºF. In no case shall the maximum temperature of the ASTM or AASHTO designated metals exceed 1125ºF nor shall the temperature exceed 950ºF at the weld metal or within 6 inches of weld metal. Heat shall not be applied directly on weld metal. The metal temperature shall be controlled by means of temperature indicating crayons, liquids or bimetal thermometers. All metal inadvertently heated above 1125ºF shall be rejected or re-quenched and re-tempered using correct ASTM procedures.

Parts to be heat straightened shall be substantially free of stress and from external forces, except stresses resulting from mechanical means used in conjunction with the application of heat.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture.

709.53 Assembling Steel. The parts shall be accurately assembled as shown on the plans and any match-marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged. Hammering which will injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled.

Unless erected by the cantilever method, truss spans shall be erected on blocking so as to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are fully bolted and all other truss connections pinned and bolted. Permanent bolts in splices of butt joints of compressing members or permanent bolts in railings shall not be tightened until the span has been swung. Splices and field connections shall have one-half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before bolting with high-strength bolts. Splices and connections carrying traffic during erection shall have 3/4 of the holes so filled.

Fitting-up bolts shall be of the same nominal diameter as the high-strength bolts and cylindrical erection pins shall be 1/32 inch larger.

709.54 Misfits. The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation, which prevents the proper assembling and fitting up of parts by the moderate use of pins or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Inspector and his approval of the method of correction obtained. The correction shall be made in his presence. If the contract provides for complete fabrication and erection, the Contractor shall be responsible for all misfits, errors and injuries and shall make the necessary corrections and replacements. If the contract is for erection only, the Inspector, with the cooperation of the Contractor, shall keep a correct record of labor and materials used and the Contractor shall render within thirty (30) days an itemized bill for the approval of the Engineer.

709.55 Removal of Old Structure and Falsework. If stipulated in the agreement, the Contractor shall dismantle the old structure that, unless otherwise provided, shall be the property of the Department, and shall store the material in the immediate vicinity of the bridge site as the Engineer may d-

rect. If the old structure is to be re-erected, it shall be dismantled without unnecessary damage and the parts match-marked and carefully stockpiled.

Upon completion of the erection and before final acceptance, the Contractor shall remove all falsework, excavated or useless materials, rubbish and temporary buildings, replace or renew any fences damaged and restore in an acceptable manner all property, both public and private, that may have been damaged during the prosecution of this work and shall leave the bridge site and adjacent highway in a neat and presentable condition satisfactory to the Engineer. All excavated material or falsework placed in the stream channel during construction shall be removed by the Contractor before final acceptance.

709.56 Computation of Weights. Structural Steel weights shall be the computed weights, assuming the weight of steel at 490 pounds per cubic foot and the weight of cast iron at 450 pounds per cubic foot.

The weights of rolled shapes, bars and plates shall be computed on the basis of the nominal weights as given in the manufacturers' handbooks, without plus tolerances for rolled plates, using the dimensions shown on the approved shop drawings. Deduction shall be made for all copes, cuts and open holes. No allowance shall be made for overrun in weight.

The weight of high strength bolts, nuts, and washers shall be established by scale weight.

The weight of castings shall be computed from the dimensions shown on the approved shop drawings, with an addition of 5% for fillets and overrun.

The right is expressly reserved to weigh a portion or all of the material to be used in the work and if the weight of any

member is more than 2% less than the computed weight, the member may be rejected. This applies to both the pound price and lump sum price.

709.57 Method of Measurement. Measurement will be made on the pound price or lump sum basis, as specified in the contract. When the contract is awarded on a pound-price basis, the quantities to be paid under this section shall be the weight in pounds of all Structural Steel actually entering into and becoming a part of the completed structure and accepted by the Engineer.

709.58 Basis of Payment. This work will be paid for either on the per pound price or on a lump sum basis. The method that will prevail will be stated in the contract. Partial payments will be made as indicated in Subsections **109.06** and **109.07**.

A. Pound Price. Structural steel will be paid for at the contract unit price, which price and payment shall be full compensation for all materials, fabrication, erection and painting and all work and materials incidental to the completion of the structure in accordance with the plans and specifications, or as directed.

The Department's computed weights shall be final unless such weights are found in error by more than 1 1/2%.

B. Lump Sum Price. Structural steel will be paid for at the contract lump sum price for the structural steel complete in place, which price and payment shall be full compensation for all materials, fabrication, erection and painting and all work and materials necessary to complete the structure in accordance with the plans and specifications, or as directed.

The average price per pound obtained by dividing the lump sum price by the estimated weight of structural steel shall be used in adjusting changes in structural steel from that required by the contract.

Payment for this item will include all direct and indirect costs and expenses required to complete the work.

Payment will be made under:		
Item No.	**Pay Item**	**Pay Unit**
709110X	Structural Steel	Lump Sum
7091120	Structural Steel	Pound

SECTION 710

PAINT FOR STRUCTURAL STEEL

710.01 Description. This work shall consist of furnishing paint and paint materials meeting the requirements of these specifications, and of the application of paint as indicated on the plans and in accordance with the provisions and requirements of these specifications.

710.02 General Requirements. All paint shall be thoroughly ground and shall not settle excessively nor cake in the container and shall mix readily with a paddle to a smooth, uniform consistency. Small amounts of anti-skinning agents and anti-settling agents may be added during manufacture. All paint kept in storage shall retain their original characteristics for a period of not less than the stated shelf life. All containers of paint shall remain unopened until required for use. Containers that have been recently opened and premixed or blended together shall be used first. Paint that has livered, gelled, or otherwise deteriorated during storage or is beyond the stated shelf life shall not be used. Wet paint shall be protected against damage from dust, sand, blast debris, or other detrimental foreign matter to the extent practicable. During the painting operation, precautionary measures shall be taken to protect any surfaces not to be painted or which have already been painted. The Contractor will also be responsible for repairing and spot-