AASHTO/NSBA Steel Bridge Collaboration

S 10.1 - 2007

Steel Bridge Erection Guide Specification

AASHTO/NSBA Steel Bridge Collaboration

Preface

This document is a standard developed by the AASHTO/NSBA Steel Bridge Collaboration. The primary goal of the Collaboration is to achieve steel bridge design and construction of the highest quality and value through standardization of the design, fabrication, and erection processes. Each standard represents the consensus of a diverse group of professionals

It is intended that Owners adopt and implement Collaboration standards in their entirety to facilitate the achievement of standardization. It is understood, however, that local statutes or preferences may prevent full adoption of the document. In such cases Owners should adopt these documents with the exceptions they feel are necessary.

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Section 1
General

1.1 Definition

Steel bridge erection is the process of transporting, handling, and assembling steel bridge components to result in a bridge structure that meets all the geometric and structural requirements of the Contract documents.

Commentary

Steel erection is complete when all field connections are completed to the final design condition and falsework or temporary bracing is/can be removed. Erection should proceed in a safe, methodical fashion ensuring all performance criteria are satisfied.

1.2 Erector Qualifications

Structural steel shall be erected by a qualified, competent Erection Contractor. Qualification shall be evidenced by certification acceptable to the Owner and/or documented evidence of previous, equivalently complex erection projects, which may include the following (as applicable):

- any one lift using two or more cranes/ derricks/poles,
- spans over water or active railroad/rapid transit tracks,
- erection with floating equipment,
- phased construction requiring lane closures combined with active lanes,
- girders with significant curvature and/or skew,

Commentary

A “qualified, competent Erection Contractor” has knowledge, training, and experience and has demonstrated the technical proficiency and ability to complete the work specified. The Contractor should be able to resolve common problems associated with the complexity of the work proposed. American Institute of Steel Construction (AISC) Advanced Certified Steel Erectors, or those with similar industry-based recognition, should be considered based on the requirements for such certifications. Certification alone may not be sufficient evidence of qualification for complex or monumental bridge structure types, such as suspension, cable-stayed, tied arch, cantilever truss, or moveable bridges.

A skew angle greater than 30 degrees may be considered significant. For spans less than 200 feet, a radius of curvature less than 1100 feet may be considered significant; for spans between 200 and 250 feet, a radius of curvature less than 1200 feet may be considered significant; for spans greater than 250 feet, a radius of curvature less than 1500 feet may be considered significant.

- field-assembled suspension, cable-stayed, truss or tied arch spans, or
- field splicing primary members (exception: rolled beam bridges with no more than one field splice per girder line).

Section 2
Erection Procedures

2.1 General

The Contractor shall submit a detailed erection procedure to the Owner for each bridge structural unit, prepared under the supervision of a licensed Professional Engineer qualified in steel erection. The procedure shall address all requirements for erection of the structural steel into the final designed configuration and satisfy all written Owner comments prior to the start of erection. The procedure, as a minimum, shall include the following information:

Commentary

The qualifications of the engineer preparing the erection plan are evidenced by knowledge, training, and experience in steel erection and having demonstrated the ability to resolve problems related to steel bridge erection. Complex or monumental structures (see commentary to Section 1.2) should have specific erection requirements noted in the Contract. The erection procedure should be submitted as soon as possible after Contract award. Erectors are encouraged to attend prebid and preconstruction meetings. Projects that involve complex erection or multi-agency review can be expected to require additional time for review of the submitted erection procedure.

2.2 Drawings

a) plan of the work area showing permanent support structures (piers and abutments), roads, railroad tracks, waterways (including navigational channel), overhead and underground utilities, and other information pertinent to erection

b) erection sequence for all members noting any temporary support conditions, such as holding crane positions, temporary supports, falsework, etc. Member reference marks, when reflected on the erection plan, should be the same as used on shop detail drawings

c) primary member delivery location and orientation

d) location of each crane for each primary member pick, showing radius and crane support (barges, mats, etc.)

e) capacity chart for each crane configuration and boom length used in the work

f) center of gravity locations for primary members

Commentary

Other parameters also may need to be shown on the plan of the work area, such as right-of-way.

Erection sequence should indicate specific cross frames or lateral bracing required by stability calculations.

For operations on navigable waterways, the configuration of the barge(s), loading sequence, stability provisions (tie downs, piles, etc.), and calculations.

g) detail, weight, capacity, and arrangement of all rigging for primary member picks
h) lifting weight of primary member picks, including all rigging and pre-attached elements
i) details of any temporary lifting devices to be bolted or welded to permanent members, including method and time (shop or field) of attachment, capacity, and method, time and responsibility for removal.
j) bolted splice assembly requirements per Section 6.7
k) lifting/handling procedure for any primary member that has a lifted length divided by width (L/b) greater than 85

Slender members, traditionally defined as those having a length to width ratio (L/b) greater than 85, are prone to lateral buckling and require particular attention when lifting/handling.

l) blocking details for bridge bearings

Bridge bearings may allow movement/ rotation in all planes and axes. During erection of a single girder, in addition to other stability provisions, the bearings may require blocking to limit movement and/or rotation.

2.3 Calculations

Commentary

a) design calculations indicating the load capacity and verifying the stability of temporary supports for structure and crane(s) for each pick and release

Design criteria to be established or approved by the Owner.

b) calculations to substantiate structural adequacy and stability of girders for each step of bridge assembly

Complex erection projects may require input from the structural designer in addition to the original design calculations such that the Contractor can confirm constructability of the structure during various erection stages. The Owner should ensure that the structural designer is available to consult with the Contractor in these cases.

c) calculations to verify adequate capacity of Contractor-fabricated rigging such as lift beams, welded lugs, spreader beams, beam clamps, etc. Submit manufacturers' certification or catalog cuts for pre-engineered devices

2.4 Coordination Items

a) review/approval by other agencies as required (e.g., railroads, Coast Guard, local jurisdictions, etc.)

b) construction activities that occur concurrently with steel erection, such as setting forms or concrete deck pours

Commentary

The Contractor should coordinate activities with the Owner/Engineer, Fabricator, and Erector. Special coordination requirements may be included in the Contract. Examples would be maintenance and protection of traffic, waterway navigation, school bus routes, and emergency vehicle routes. Safety measures (emergency boat, notification plans), coordination plan for regulatory agencies and other water traffic, and the details and anticipated schedules of obstructing the navigable channel should be shown.

Section 3
Transportation

3.1 Responsibility

The Contractor is responsible for coordinating delivery from the Fabricator to the jobsite and for providing adequate site access.

3.1.1 Shipping Plan

The Contractor is responsible for preparing a shipping plan indicating support, lateral bracing, and tie-down points for primary members during transportation to the jobsite.

Commentary

Complex or monumental structures may require a more detailed shipping plan.

3.2 Handling

Ship primary members upright, unless otherwise approved by the Owner. Load, support, and unload primary members in a manner that will not damage, excessively stress, or permanently deform the steel and not cause repeated stress reversals.

Commentary

Care should be exercised to avoid coatings damage from slings, chokers, clamps, etc. Also, limiting the length of members overhanging the rear wheels of a trailer may reduce the range of stress reversals and potential damage from ground strikes.

3.3 Fasteners

Ship all fastener components in sealed, watertight containers with the contents clearly listed on external tags.

Commentary

High-strength steel fastener thread lubrication requires protection from the elements. This does not apply to anchor rods or end welded shear studs.

Section 4
Material Storage at Jobsite

4.1 Fabricated Material

Store fabricated material on blocking above the ground. Properly drain the ground and keep material clean. Store primary members upright and shored or braced for stability. Support all members to prevent permanent distortion or damage.

4.2 Fasteners

Store fasteners and machine-finished parts inside covered structures or otherwise protect them from the weather. Fasteners removed from storage should be installed by the end of the work shift. Return unused fasteners to storage at the end of a work shift or otherwise protect them from the weather.

4.3 Welding Consumables

Store and handle welding consumables in accordance with the AASHTO/AWS D1.5 Bridge Welding Code.

4.4 Damage

Report any damaged structural steel to the Owner, including a description of the damage and proposed Contractor disposition (repair or replace).

Section 5
Bearings and Anchorages

5.1 Survey

Document all substructure locations (lateral and longitudinal), existing anchor rod locations, bearing seat elevations, and other pertinent information in a Contractor survey, conducted prior to the start of the associated erection. Notify the Owner prior to this survey so that they may participate. Document and report any discrepancies between the survey findings and the Contract plans to the Owner.

5.2 Bridge Seats

Place bearing devices on properly finished bridge seat bearing areas. Notify the Owner if seats are not level or at incorrect elevations, and propose corrective actions.

Commentary

Bridge bearings may allow movement/ rotation in all planes and axes. During erection of a single girder, in addition to other stability provisions, the bearings may require blocking to limit movement and/or rotation.

5.3 Temperature Adjustments

When setting bearings, make appropriate corrections for ambient temperature and/or anticipated rotation due to dead load deflection of the supported member. Position high load, multi-rotational bearings such that the initial position, including corrections for temperature and dead load rotation, is within manufacturer's requirements. Notify the Owner if anchor bolt locations do not permit proper positioning, and propose corrective actions.

Commentary

See recommendations in AASHTO/NSBA Steel Bridge Collaboration G 9.1, "Steel Bridge Bearing Design and Detailing Guidelines" for thermal movement calculations.

5.4 Tolerances

In addition to the dimensional tolerances in the AASHTO/AWS D1.5 Bridge Welding Code for steel bearing contact areas, members shall seat on bearing devices with no final gaps exceeding $^{1}/_{16}$ inch.

Section 6
Lifting and Assembly

6.1 General

Lift, position, and assemble all members in accordance with the procedures satisfying Section 3. The proposed crane location(s) and member delivery location(s) may require modification in the field to suit changing jobsite conditions. However, cranes and material must be located such that the lift is safe and within the crane manufacturer's rated capacity for all required positions.

Commentary

Jobsite conditions vary on a daily basis and often are not as they were anticipated to be when the erection procedure was conceived and submitted to the Owner. Consequently, the need to deviate from the submitted erection procedure may arise during the course of a bridge project. It is the Contractor's responsibility to erect the steel in a safe and efficient manner. The Owner's review and disposition of erection procedure changes to suit jobsite conditions should be handled in an expeditious fashion to avoid delaying the work.

6.2 Lifting Devices

Install lifting devices, including welded lugs and bolted assemblies using existing bolt holes (splices, cross frame connection plates, etc.), in accordance with Sections 7 or 8 and use Owner-approved details.

6.3 Erection Stability

Girders shall be stabilized with falsework, temporary bracing, and/or holding cranes until a sufficient number of adjacent girders are erected with diaphragms and/or cross frames connected to provide the necessary lateral stability and to make the structure self-supporting.

Commentary

Removal of falsework, temporary bracing, and holding cranes shall be in accordance with stability calculations provided in the erection procedure.

6.4 Trusses

All trusses shall be erected on falsework, unless approved by the Owner. When erecting trusses on falsework, the falsework shall remain in place until all connections are completed and the truss is self-supporting.

6.5 Falsework and Temporary Supports

Falsework and temporary supports shall be detailed to ensure that the temporary elevation of supported steel accommodates the deflections expected to occur as the structure is completed.

Commentary

If dead load, beyond the steel dead load, is to be applied to the structure while temporary supports remain in place, they must have provision to be lowered or "jacked down."

6.6 Pins

Pins are normally used to align holes for bolted field connections. Field reaming to facilitate fit-up will only be allowed with the Owner's prior approval. Any abnormal distortion of the member or of the holes during the alignment process shall be immediately reported to the Owner.

Commentary

Examples of abnormal member distortion would include strain exceeding yield and perceptible web distortion. Abnormal hole distortion may include holes that are non-cylindrical, not perpendicular to the faying surface, or out of round by more than $^{1}/_{16}$ inch.

6.7 Connections

For splice connections of primary members, as well as connections of diaphragms or cross frames designed to brace curved girders, fill at least 50 percent of the holes prior to crane release. The 50 percent may be either erection bolts in a snug tight condition or full-size erection pins, but at least half (25 percent of all holes) shall be bolts, and sufficient pins shall be used near outside corners of splice plates and at member ends near splice plate edges to ensure alignment. Uniformly distribute the filled holes.

Commentary

Filled holes should be distributed between the web and flange connections for primary members such that approximately 50 percent of the web connections are filled and approximately 50 percent of the flange connections are filled. For diaphragms or cross frames, the filled holes should be uniformly distributed between all the bolt groups connecting the diaphragm or cross frame to the primary member.

The 50 percent requirement may be waived if a reduced percentage is calculated as sufficient and shown on the approved erection procedure.

Permanent bolts may be used as erection bolts, provided they are installed in accordance with Section 7.4. For complex structures (arches, trusses, etc.), install bolts and pins in accordance with erection procedures.

Primary member splice connections that are made up on the ground (prior to erection) shall be 100 percent complete, in the no-load condition, prior to any lifting operation.

Achieving the no-load condition on the ground will require blocking.

6.8 Abnormalities

Any abnormal member deformation or brace deflection after crane release or temporary support removal shall be immediately reported to the Owner for swift resolution. Further work affecting the area, except for restoring support or adding bracing, shall be stopped until the deformation/deflection is resolved.

Section 7
Field Bolted Connections

7.1 Bolts

Use bolts meeting the requirements of ASTM A325, ASTM A490, or ASTM F1852, as specified in the Contract documents.

7.2 Faying Surfaces

No loose mill scale, dirt, metal shavings, or other foreign material that would preclude solid seating of the parts or frictional transfer of load is allowed on faying surfaces of bolted connections.

Commentary

The steel Erector generally is not responsible for faying surface preparation, unless required by the Contract. The Erector's only responsibility for faying surfaces is to keep them clean from contamination during erection.

7.3 Installation Method

Verify bolt installation method prior to bolt installation, in accordance with the Specification for Structural Joints Using ASTM A325 or A490 Bolts by the Research Council on Structural Connections (referred hereafter as the "Bolt Specification" and available at http://www.boltcouncil.org/). Additionally, perform fastener assembly rotational capacity test per Appendix 1 or 1A. Verify direct tension indicators (DTI) per Appendix 2.

7.4 Installation

Install and tighten bolts using any of the methods allowed per the Bolt Specification. Tighten bolts to the minimum tension shown in the Bolt Specification.

Commentary

All bolts in a connection are installed in the snug tight condition prior to fully tightening. However, it may be difficult to achieve the snug tight condition for large primary member connections, which have many bolts and/or plies of thick material. In this case, the Owner may permit a portion of each connection be filled with fully tightened temporary bolts prior to installing permanent bolts in the remaining holes to the snug tight condition. Snug tight permanent bolts can then replace the temporary bolts, resulting in a connection completely filled with snug tight bolts. Final tightening can then proceed in accordance with the Bolt Specification.

7.5 Tensioning

Fully tighten all bolts in the bridge by completion of steel erection (unless otherwise specified) in accordance with the Bolt Specification. Fully tighten bolts before exposure to the elements affects their rotational capacity test characteristics.

Section 8
Field Welded Connections

8.1 General

Field welding and nondestructive testing shall be performed in accordance with the AASHTO/AWS D1.5, Bridge Welding Code (referred hereafter in this section as "D1.5") or other code(s) as specified in the Contract documents. Field welding on permanent material is not allowed, unless shown on the plans or approved by the Owner.

Commentary

D1.5 is written mostly for the use of shop fabricating structural steel members. Field welding structural steel members presents environmental and geometric conditions that exceed those in the shop. Rain, humidity, temperature, and wind are examples of conditions that cannot be controlled in the field but can be controlled in the shop. Difficulty in steel fit-up, access to the joint by the welder, and welding position are geometric constraints that can adversely affect the quality of the weld.

However, despite the environmental and geometric challenges, experience on numerous bridges over the past 50-plus years has shown that field welding can readily be accomplished successfully and provides a useful tool for experienced Contractors.

Because bridge field welding is not customary in many states, the Contract documents should make it clear whether or not field welding is allowed.

8.2 Weld Procedure Specifications

All structural field welding shall be done using automatic stud welding per D1.5 Section 7 or Owner-approved welding procedure specifications (WPSs) for shielded metal arc welding (SMAW), self-shielded flux cored arc welding (FCAW-S), and/or submerged arc welding (SAW). Gas metal arc welding (GMAW) and gas-shielded flux core arc welding (FCAW-G) processes are prohibited, unless the Owner specifically approves WPSs that include appropriate wind shelters.

Commentary

Low hydrogen practices are required for field welding and can produce good quality welds when done in accordance with D1.5. When wind speeds exceed 20 mph, the granular flux required for SAW may blow away if precautions are not taken to block strong winds. Welding with gas-shielded processes has been prohibited because of potential loss of shielding gases by drafts from nearby moving objects or when wind speeds exceed 5 mph (barely perceptible).

Automatic stud welding is an approved welding process. Because of production proof testing, written WPSs are not required.

8.3 Qualification

8.3.1 Welder Qualification

Qualify welders in accordance with D1.5, and any additional Owner requirements, for the position(s) and process(es) approved for field welding.

Commentary

Unlike shop welding, workers welding in the field for Contractors move from project to project; therefore, keeping track of qualified welders can be difficult. Some Owners have programs that address qualification of field welders.

8.3.2 Weld Procedure Qualification

Field welding shall be performed in accordance with WPSs approved by the Owner for the specific application and location. Welding procedures that do not satisfy D1.5 requirements for prequalification shall be qualified by test per D1.5

Commentary

Qualification tests for non-standard joints or primary member WPSs should be performed prior to arrival at the jobsite. Variations in consumables or geometry are governed by D1.5.

8.4 Welding Requirements

8.4.1 Welders

Welders shall have a written copy of the approved WPS.

8.4.2 Contact Surfaces

Prior to welding, the contact surfaces and joints to be field welded and the surrounding area (3 inches on either side of the joint) shall be cleaned of contaminants by solvent wiping, blasting, grinding, or wire brushing in accordance with D1.5.

8.4.3 Joined Parts

The parts to be joined shall be aligned in accordance with D1.5, and joint faces shall comply with the geometric tolerances of D1.5.

8.4.4 Environmental Conditions

Field welding shall not be allowed when the ambient air temperature is below 0^{o}F or during periods of precipitation, unless the welder is housed in a heated and/or protected area in a manner approved by the Owner.

Commentary

Heating and/or housing should be used when the ambient air temperature is below 0^{o}F, when surfaces are wet or exposed to rain or snow, and/or the welders' ability to make sound welds is a concern. See D1.5 Commentary for a detailed explanation of the effect of environmental conditions on weld.

8.4.5 Consumables

Electrodes and flux shall be purchased, stored, dried, and used in accordance with D1.5.

Commentary

It is required that electrodes and flux be kept dry at all times. Electrodes should be purchased in hermetically sealed containers. If electrodes are not stored according to the requirements of D1.5, they will absorb moisture and produce poor quality welds during production welding. Electrode drying ovens should be at the project site located near the welders work station at all times. Once the electrode container is opened, electrodes should be placed in the ovens and stored at temperatures meeting the requirements of D1.5.

8.4.6 Preheat

Surfaces to be welded shall satisfy preheat requirements of D1.5 for 3 inches in all directions from the weld. Higher preheat and/or post-weld heating may be required for fracture critical welds, for welds in areas with high restraint, or to avoid defects. Preheating methods shall avoid damage to adjacent coated surfaces, neoprene bearings, and other heat sensitive components. Damage caused by heating shall be corrected at the Contractor’s expense.

Section 9
Inspection

9.1 General

Inspect and test repaired welds, coatings, and/or base metal in accordance with this Section. Verify the alignment, profile, and fastening of the erected steel conforms to the Contract requirements.

Commentary

Material quality, damage repair, and conformance to plan dimensions and assembly requirements are subject to the verification inspection of the Owner.

9.2 Tolerances for plate girder or rolled beam spans

Commentary

Geometric tolerances for other structures (arches, trusses, etc.) should be established by the Contract or mutually agreed between the Owner and Erector.

9.2.1 Deviation from theoretical horizontal alignment

$\pm ^1/_8$ inch × (total length along girder, in feet, between supports)/10.

Erected horizontal alignment shall be measured under steel dead load at the centerline of the top flange or other location mutually acceptable to the Owner and Contractor and shall not deviate from the theoretical horizontal alignment by more than the value computed above. The theoretical horizontal alignment is to be provided by the Owner and calculated under the steel dead load only condition.

9.2.2 Deviation from theoretical erected web position

$\pm ^1/_8$ inch × (web depth, in feet)

Erected web position shall be measured under steel dead load and is the differential in horizontal displacement between the top and bottom of the web. The erected web position shall not deviate from the theoretical erected web position by more than the value computed above. The theoretical erected web position is to be provided by the Owner and calculated under the steel dead load only condition.

Commentary

The location of the measurement for deviation from theoretical web position will vary depending on bridge type. Webs of straight girders should assume their specified position at all locations under steel dead load; but in highly skewed structures, webs may deform laterally under the weight of the deck. If bracing connections are detailed for the steel dead load only condition, curved girder webs also should be in their specified position under steel dead load but will increasingly deviate approaching midspan under deck load. For other bridge types, measurement locations should be provided by the Owner.

Web position can be affected in the field by conditions not considered by the designer and/or beyond the control of the Contractor. Web positions within the tolerance noted here are considered acceptable. Web positions beyond the tolerance noted here may be acceptable; however, they must be evaluated regarding cause, and impact on bridge service, and approved by the Owner.

9.2.3 Deviation from theoretical vertical alignment (elevation)

–0, +$^{1}/_{4}$ inch × (total length, in feet, from nearest support)/10

Erected vertical alignment shall be measured under steel dead load at the centerline of the top flange or other location mutually acceptable to the Owner and Contractor and shall not deviate from the theoretical erected vertical alignment by more than the value computed above. Maximum deviation is $^{3}/_{4}$ inch in cantilever sections or $1^{1}/_{2}$ inches between supports. The theoretical vertical alignment is to be provided by the Owner and calculated under the steel dead load only condition.

Commentary

Tolerance in the negative direction (i.e. vertical alignment lower than theoretical) has been prohibited to ensure that the distance between top of flange and top of deck can be maintained, thereby avoiding thickening the haunch (or deck) to suit. Installed locations lower than theoretical may be acceptable upon review by the Owner. For a typical girder bridge, some agencies may choose to control only the elevation of the girder splices and accept vertical alignment between splices (within the tolerance on shop camber). Some of the tolerance on vertical alignment may be "consumed" by the tolerance on shop camber of the fabricated girder.

9.3 Surveys

It is the Contractor's responsibility to survey steel profile and alignment during steel erection and after completion with verification by the Owner. Surveys during erection must consider support conditions and anticipate deflections from subsequent steel placement or support release.

9.4 Bolting

Bolting inspection shall conform to the requirements of the Bolt Specification.

9.5 Welding

Unless the Owner requires otherwise, visual inspection and nondestructive testing (NDT) shall be performed on field welds in accordance with D1.5. Welds shall be evaluated for acceptance in accordance with D1.5.

9.5.1 Magnetic Particle Testing

Magnetic particle testing (MT) shall be applied to all fillet and partial penetration groove welds on primary, load-carrying members and 10 percent of field fillet welds on non-primary members (railings, utility supports, etc.). Field slot welds specified by the Contract and areas where welded erection aids were removed shall be 100 percent MT inspected.

9.5.2 Ultrasonic Testing

Ultrasonic testing (UT) shall be applied to all complete joint penetration groove welds.

9.5.3 Radiographic Testing

In addition to UT, radiographic testing (RT) shall be applied to complete penetration groove welds in butt joints subjected to tension and when specified by the Contract plans. Field plug welds shall be 100 percent UT and RT inspected, even in compression areas.

Commentary

Contract documents should show all locations where RT will be required.

Section 10
Repair

10.1 Documentation

The Contractor is responsible for documenting damage due to handling, removal of erection aids, aligning members and other actions, uncorrected misfits at connections, and misalignments exceeding tolerances in erected members. As-received damage attributable to transport or fabrication shall also be documented.

Commentary

Damage such as minor arc strikes or handling damage to paint may not need extensive documentation, unless they are a recurring problem. Widespread problems such as paint damage throughout several girders, especially if the cause is not apparent, or multiple misaligned girders may require the services of outside experts.

10.2 Implementation

The Contractor shall propose a method of repair and basis for acceptance for the Owner's review.

10.3 Repair Procedures

Submit repair procedures for damaged or misaligned steel in the form of sketches and/or written procedures as applicable. Information must provide sufficient detail for the Owner to adequately review the repair application. After repairs are complete, the Contractor shall provide as-built detailed drawings, NDT results, and procedures/materials used to the Owner for inclusion in the project file.

10.4 Welds

Field or shop welds that are unacceptable must be repaired in accordance with D1.5. Responsibility for the cost of the repair and subsequent inspection shall be based on the cause.

Appendix 1
Rotational Capacity Test
(ASTM A325 and ASTM A490 Long Bolts in Tension Calibrator)

From FHWA Report No. FHWA-SA-91-031, dated May 1991, Appendix A1, revised February 2005, "Procedure for Performing Rotational Capacity Test, Long Bolts in Tension Calibrator."

EQUIPMENT REQUIRED:

1. Calibrated bolt tension measuring device of the size required for the bolts to be tested.
2. Calibrated torque wrench and spud wrenches.
3. Spacers with holes $^1/_{16}$ inch larger than bolt to be tested or nominal diameter washers.
4. Steel section to mount the tension calibrator.

PROCEDURE:

A rotational capacity test consists of 2 assemblies.

1. Measure the bolt length (the distance from the end of the bolt to the washer face at the bolt head to shank interface).
2. Install the bolt in the tension calibrator with the required spacers or washers so that the bolt stick-out is flush with the nut to a maximum of three threads. This will typically provide three to five threads within the grip (the distance between the bolt head and the inside face of the nut). This same stick-out requirement applies during installation.
3. Tighten the fastener assembly using a spud wrench to the tensions listed below –0 kips / +2 kips.

Bolt Diameter (inch)	$^1/_2$	$^5/_8$	$^3/_4$	$^7/_8$	1	$1^1/_8$	$1^1/_4$	$1^3/_8$	$1^1/_2$
ASTM A325 Initial Tension (kips)	1	2	3	4	5	6	7	9	10
ASTM A490 Initial Tension (kips)	2	2	4	5	6	8	10	12	15

4. Match mark the bolt, nut, and face plate of the calibrator.
5. Using the calibrated torque wrench, tighten the fastener assembly to at least the minimum installation tension listed below and record both the tension and torque. Torque shall be read with the nut rotating. The torque value from the test shall not exceed T = .25 PD. P = tension in pounds. D = diameter (in.)/12 = bolt diameter in feet.

Bolt Diameter (inch)	$^1/_2$	$^5/_8$	$^3/_4$	$^7/_8$	1	$1^1/_8$	$1^1/_4$	$1^3/_8$	$1^1/_2$
ASTM A325 Tension (kips)	12	19	28	39	51	56	71	85	103
ASTM A490 Tension (kips)	15	24	35	49	64	80	102	121	148

6. Further tighten the bolt to the rotation listed below. The rotation is measured from the initial marking in Step 4.

Bolt Length (L)	L ≤ 4 × Bolt Diameter (BD)	4 × BD < L ≤ 8 × BD	8 × BD < L
Required Rotation	$^2/_3$	1	$1^1/_6$

7. Record the tension at the completion of the rotation in Step 6. The tension shall equal or exceed 1.15 times the minimum installation tension. The minimum required values are listed in the table below.

Bolt Diameter (inch)	$^1/_2$	$^5/_8$	$^3/_4$	$^7/_8$	1	$1^1/_8$	$1^1/_4$	$1^3/_8$	$1^1/_2$
ASTM A325 Tension (kips)	14	22	32	45	59	64	82	98	118
ASTM A490 Tension (kips)	17	28	40	56	74	92	117	139	170

8. Loosen and remove the nut. There shall be no signs of thread shear failure, stripping, or torsional failure. The nut shall turn, with your fingers, on the bolt threads to the position it was in during the test. The nut does not need to run the full length of the threads. If you cannot turn the nut with your fingers, it is considered thread failure.

FAILURE:

The following constitute a failure of the rotational capacity test.

1. Exceeding the maximum allowable torque in the torque/tension comparison.
2. Failure to achieve the required rotation.
3. Failure to achieve the required tension at the required rotation.
4. Thread failure.

Failure of any one of these items on either assembly constitutes a failure of the rotational capacity test. When a failure occurs, the subject lot of fasteners is rejected. The contractor is given the option to clean and re-lubricate as necessary and then retest the fastener assemblies.

Appendix 1A
Rotational Capacity Test
(ASTM A325 and ASTM A490 Bolts too Short to Fit Tension Calibrator)

From FHWA Report No. FHWA-SA-91-031, dated May 1991, Appendix A1, revised February 2005, "Procedure for Performing Rotational Capacity Test, Bolts too Short to Fit Tension Calibrator."

Only those bolts too short to fit in the tension measuring device shall be tested using this procedure. Typically, these bolts are less than four times the bolt diameter in length.

EQUIPMENT REQUIRED:

1. Calibrated torque wrench and spud wrenches.
2. Spacers with holes $^1/_{16}$ inch larger than bolt to be tested or nominal diameter washers.
3. Steel section with holes $^1/_{16}$ inch larger than the bolt diameter. Splice holes in the steel on the project can be used.

PROCEDURE:

A rotational capacity test consists of 2 assemblies.

1. Measure the bolt length (the distance from the end of the bolt to the washer face at the bolt head to shank interface).
2. Install the bolt in the steel plate with the required spacers or washers so that the bolt-stick out is flush with the nut to a maximum of three threads. This will typically provide three to five threads within the grip (the distance between the bolt head and the inside face of the nut). This same stick-out requirement applies during installation.
3. Provide an initial tension in the fastener assembly using a spud wrench. The torque should not exceed 20 percent of the maximum torque allowed in Step 5.
4. Match mark the nut, bolt, and plate.
5. Tension the bolt using a torque wrench to rotate the nut as required in the table below. Prevent the bolt head from rotation. Read the torque at the required rotation with the nut in motion.

Bolt Length (L)	$L \le 4 \times$ Bolt Diameter (BD)	$4 \times BD < L \le 8 \times BD$
Required Rotation	$^1/_3$	$^1/_2$

The measured torque shall not exceed the values listed below. Assemblies that exceed the listed torques have failed the test. These torque values are based on an assumed tension of 1.15 times the minimum installation tension.

Bolt Diameter (inch)	$^1/_2$	$^5/_8$	$^3/_4$	$^7/_8$	1	$1^1/_8$	$1^1/_4$	$1^3/_8$	$1^1/_2$
ASTM A325 Torque (ft-lbs)	150	290	500	820	1230	1500	2140	2810	3690
ASTM A490 Torque (ft-lbs)	180	370	630	1020	1540	2160	3050	3980	5310

6. Further tighten the bolt to the rotation listed below. The rotation is measured from the initial marking in Step 4. Assemblies that fail prior to this rotation either by stripping or fracture fail the test.

Bolt Length (L)	$L \le 4 \times$ Bolt Diameter (BD)	$4 \times BD < L \le 8 \times BD$
Required Rotation	$^2/_3$	1

7. Loosen and remove the nut. There shall be no signs of thread shear failure, stripping, or torsional failure. The nut shall turn, with your fingers, on the bolt to the position it was in during the test. The nut does not need to run the full length of the threads. If you cannot turn the nut with your fingers, it is considered thread failure.

FAILURE:

The following constitute a failure of the rotational capacity test.

1. Exceeding the maximum allowable torque.
2. Failure to achieve the required rotation.
3. Thread failure.

Failure of any one of these items on either assembly constitutes a failure of the rotational capacity test. When a failure occurs, the subject lot of fasteners is rejected. The contractor is given the option to clean and re-lubricate as necessary and then retest the fastener assemblies.

Appendix 2
Direct Tension Indicators (DTI)
(Verification Test Procedure)

From FHWA Report No. FHWA-SA-91-031, dated May 1991, Appendix A6, revised April 1992, "Procedure for Verification of High Strength Bolts with Direct Tension Indicators (DTIs)."

EQUIPMENT REQUIRED:

1. Calibrated bolt tension measuring device with a special flat insert in place of the normal bolt head holding insert. Special insert required to allow access to measure DTI gap.
2. Tapered leaf thickness (feeler) gage 0.005 inch. Same gage as to be used to inspect the bolts after installation.
3. Bolts, nuts, and standard washers to be used in the work with the DTIs.
4. Impact and manual wrench to tighten bolts. Equipment should be the same as to be used in the work.

PROCEDURE:

1. Install bolt, nut, DTI, and standard washer (if used) into bolt tension measuring device. Assembly should match that to be used in the work.
2. Use another wrench on the bolt head to prevent rotation of the head against the DTI if the DTI is against the turned element.
3. Tighten bolt to tensions 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 against the turned 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 tension measuring device 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	$1^1/_8$	$1^1/_4$	$1^3/_8$	$1^1/_2$
ASTM A325 Bolt	13	20	29	41	54	59	75	89	108
ASTM A490 Bolt	NA	NA	37	51	67	84	107	127	NA

4. Determine and record the number of spaces between the protrusions on the DTI that a 0.005 inch thickness gage is refused. The total number of spaces in the various sizes and grades of DTIs is shown below.

	Number of Spaces								
Bolt Diameter (inch)	$^1/_2$	$^5/_8$	$^3/_4$	$^7/_8$	1	$1^1/_8$	$1^1/_4$	$1^3/_8$	$1^1/_2$
ASTM A325 Bolt	4	4	5	5	6	6	7	7	8
ASTM A490 Bolt	NA	NA	6	6	7	7	8	8	NA

5. The number of spaces which the 0.005 inch gage is refused should not exceed the number given in the table below. If the number of spaces exceeds the number in the table, the DTI fails the verification test.

Number of spaces in washer	4	5	6	7	8
Maximum number of spaces gage is refused	1	2	2	3	3

Note: If the test is a coated DTI under the turned element, the maximum number of spaces the gage is refused is the number of spaces on the washer minus one.

6. The bolt 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 completely closed. When such a condition is achieved, the 0.005 inch gage is refused at all spaces but a visible gap exists in at least one space. Note the load in the bolt at this smallest gap. The bolts in this verification test and in the actual installation should not be tightened to a no visible gap condition (i.e. a condition when all the gaps are completely closed). The load in the bolt becomes indeterminate when no gap exists. It is possible to cause bolt failure by tightening beyond complete crushing of the washer.

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 run-out. Alternatively, if the nut is unable to go the full thread length, but the load at the minimum DTI gap (measured in Step 6 above) is less than 95 percent of the maximum load achieved in Step 6 of the Rotational Capacity test, the assembly, including the DTI, is deemed to have passed this 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 percent of the maximum strength of the bolts from the Rotational Capacity test, the load required for the smallest gap in Step 6 is too large. If approved by the Engineer, the test could be repeated with a larger minimum gap (for example, one space that will accept a 0.005 inch feeler gage) or the DTIs could be replaced.

SHORT BOLTS:

Bolts from Rotational Capacity lots that are too short to fit in the tension measuring device shall be tested by tightening to the minimum gap in Step 6 above and checked in accordance with Step 7 above. The 95 percent 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 above using a longer bolt in the tension measuring device.

ERECTION PROCEDURE CHECKLIST

PART 1 – Drawing

PLAN:

- ☐ To-scale plan of work area showing supporting structures, roads, railroads, waterways, overhead and underground utilities, adjacent structures, etc.; and framing plan with member shipping marks (match those used on shop drawings) and field splice locations if applicable
- ☐ Location of temporary supports, falsework, holding cranes
- ☐ Location of crane positions on plan showing pick radii
  Elevation view of crane and member ☐ Included ☐ Not Applicable
  Crane Support Method: barges, mats ☐ Included ☐ Not Applicable
- ☐ Member delivery location and orientation

DETAILS:

- ☐ Detail and arrangement of member rigging: show sizes, capacities, and location of center of gravity of each pick
- ☐ Falsework and temporary support details: show sizes and capacities
- ☐ Crane capacity chart indicating crane type, lifting capacity at given radius and orientation, counterweight requirements, and boom length
- ☐ Pick weight chart indicating weight of member, plus rigging and any attachments
- ☐ Written procedure indicating erection sequence for primary and secondary members (cross frames, diaphragms, etc.), including the following: method of tie down of individual pieces, time and method of connections of diaphragms, lateral bracing, and field splices

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PART 2 – Calculations

- ☐ Calculations for load capacity and stability of temporary supports for structure (falsework, tie downs, lifting beams, spreader beams, etc.)
  Calculations indicating capacity of temporary crane supports: ☐ Included ☐ Not Applicable
- ☐ Calculations to substantiate structural integrity and stability of members prior to completion of bridge assembly
- ☐ Calculations indicating structural integrity of any partially bolted primary splice after release of external support system
- ☐ Calculations to substantiate structural integrity of abutments and retaining walls affected by surcharge from crane

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PART 3 – Associated Data

- ☐ Manufacturer's cut sheets for rigging devices (beam clamps, slings, wire rope, shackles, turnbuckles, chains, straps, etc.) and pre-engineered falsework, if applicable
- ☐ Statement as to status of coordination with parallel entities requiring review: railroads, Coast Guard, U.S. Army Corps of Engineers, etc.

PROJECT DESCRIPTION ____

COMPLETED BY ____

<ERECTOR COMPANY NAME> <QUALIFIED INDIVIDUAL NAME>

ERECTION INSPECTION CHECKLIST

PART 1 – Pre-Erection

☐ Erection Procedure – approved

☐ Site Preparation – access roads, crane pads, bearing pedestals, finish and elevation, anchor bolts survey, falsework foundation pads, all obstacles noted

☐ Personnel
- foreman – competent person
- crane operators – qualified, licensed, training, medical
- welders – certification current, qualified for positions
- any required training and instruction complete

☐ Lifting Equipment
- crane inspection – current, schedule during project
- lifting devices and rigging – certification, inspection

☐ Bolted Connections
- check bolt quality, size and lengths, certifications
- installation procedure, method of tensioning
- Skidmore machine – calibration, certification
- impact wrenches – condition, proper size, and capacity
- torque wrenches – calibration

☐ Welded Connections
- weld procedure specifications (WPS) – approved
- welding equipment – sufficient capacity, grounding
- welding consumables – proper storage, drying ovens

☐ Safety/Fall Protection – nets, lifeline lanyards, platforms, scaffolds, manlifts, floats, emergency boat

☐ Coordination Items – railroads, local agencies, Coast Guard, emergency services, etc.

PART 2 – Erector Responsibility

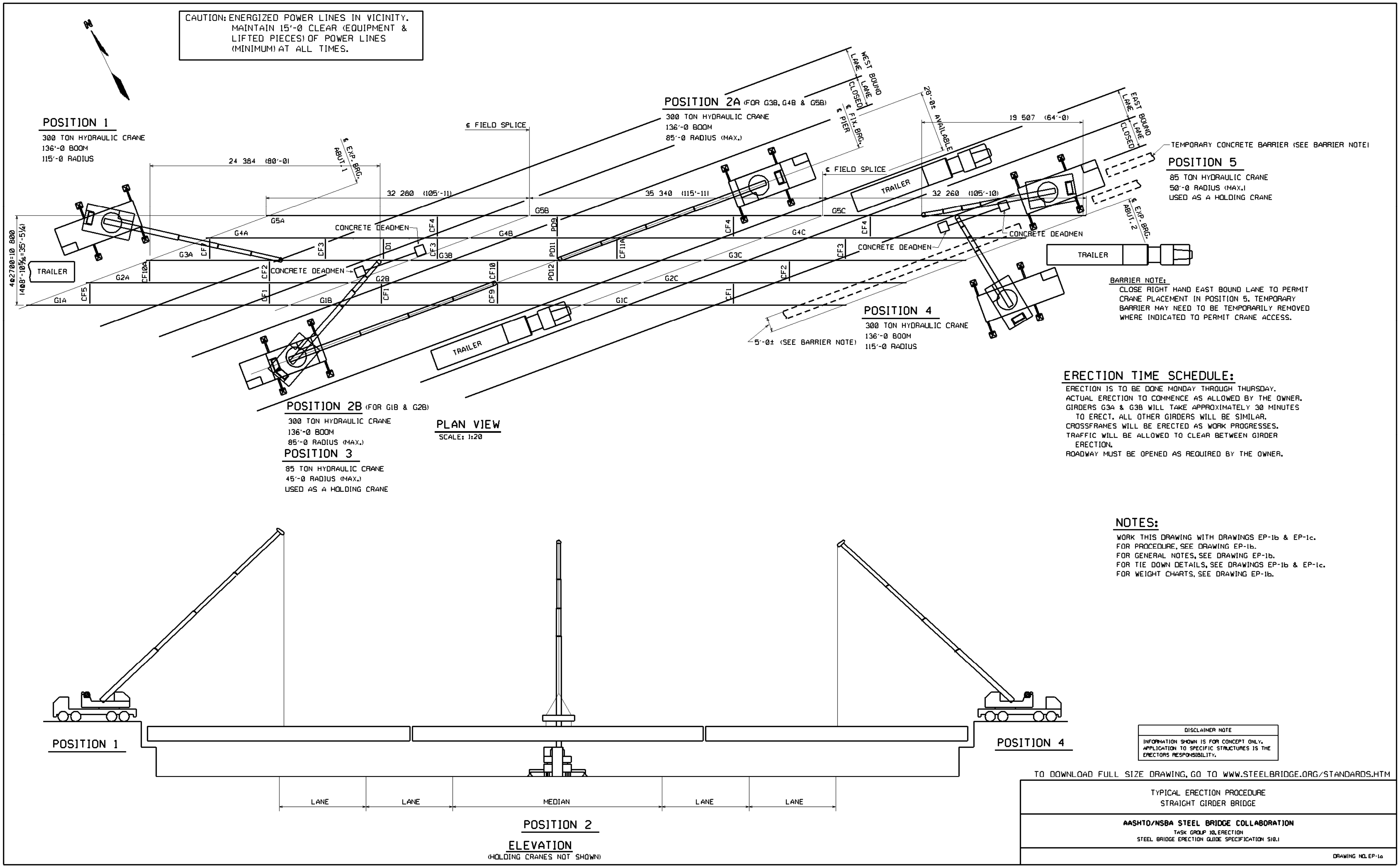
☐ Provide for Inspector – prior to erection
- framing plan, erection procedure
- crane operator qualifications
- welder certifications
- crane inspection certifications
- Skidmore-Wilhelm and torque wrench calibration certifications
- bolt manufacturer certifications
- weld procedure specifications

☐ Provide for Inspector – during erection
- access to work – ladders, manlift, scaffold, or platform
- torque wrench
- Skidmore-Wilhelm Calibrator
- temperature indication crayons

ERECTION INSPECTION CHECKLIST

PART 3 – Inspector Responsibility

- ☐ Check all personnel certifications – crane operator, welders, etc.
- ☐ Check all equipment certifications – cranes, etc.
- ☐ Check fall protection – requirements, installation
- ☐ Check crane radii.
- ☐ Check temporary supports – installed per erection procedure
- ☐ Check assembly marks – proper location and orientation
- ☐ Check minimum number of bolts and pins installed before release of crane/temporary supports
- ☐ Monitor bolt installation procedure
- ☐ Check field weld size/geometry, consumables, and variables per WPS and NDT results
- ☐ Check bearing alignment/adjustment


CAUTION: ENERGIZED POWER LINES IN VICINITY. MAINTAIN 15'-0 CLEAR (EQUIPMENT & LIFTED PIECES) OF POWER LINES (MINIMUM) AT ALL TIMES.
POSITION 1
300 TON HYDRAULIC CRANE
136'-0 BOOM
115'-0 RADIUS
POSITION 2A (FOR G3B, G4B & G5B)
300 TON HYDRAULIC CRANE
136'-0 BOOM
85'-0 RADIUS (MAX.)
POSITION 2B (FOR G1B & G2B)
300 TON HYDRAULIC CRANE
136'-0 BOOM
85'-0 RADIUS (MAX.)
POSITION 3
85 TON HYDRAULIC CRANE
45'-0 RADIUS (MAX.)
USED AS A HOLDING CRANE
POSITION 4
300 TON HYDRAULIC CRANE
136'-0 BOOM
115'-0 RADIUS
POSITION 5
85 TON HYDRAULIC CRANE
50'-0 RADIUS (MAX.)
USED AS A HOLDING CRANE
TEMPORARY CONCRETE BARRIER (SEE BARRIER NOTE)
BARRIER NOTE:
CLOSE RIGHT HAND EAST BOUND LANE TO PERMIT CRANE PLACEMENT IN POSITION 5. TEMPORARY BARRIER MAY NEED TO BE TEMPORARILY REMOVED WHERE INDICATED TO PERMIT CRANE ACCESS.
5'-0± (SEE BARRIER NOTE)
PLAN VIEW
SCALE: 1:20
ERECTION TIME SCHEDULE:
ERECTION IS TO BE DONE MONDAY THROUGH THURSDAY.
ACTUAL ERECTION TO COMMENCE AS ALLOWED BY THE OWNER.
GIRDERS G3A & G3B WILL TAKE APPROXIMATELY 30 MINUTES TO ERECT. ALL OTHER GIRDERS WILL BE SIMILAR.
CROSSFRAMES WILL BE ERECTED AS WORK PROGRESSES.
TRAFFIC WILL BE ALLOWED TO CLEAR BETWEEN GIRDER ERECTION.
ROADWAY MUST BE OPENED AS REQUIRED BY THE OWNER.
NOTES:
WORK THIS DRAWING WITH DRAWINGS EP-1b & EP-1c.
FOR PROCEDURE, SEE DRAWING EP-1b.
FOR GENERAL NOTES, SEE DRAWING EP-1b.
FOR TIE DOWN DETAILS, SEE DRAWINGS EP-1b & EP-1c.
FOR WEIGHT CHARTS, SEE DRAWING EP-1b.
WEST BOUND LANE CLOSED
EAST BOUND LANE CLOSED
℄ EXP. BRG. ABUT. 1
℄ EXP. BRG. ABUT. 2
℄ FIX. BRG. ℄ PIER
℄ FIELD SPLICE
20'-0± AVAILABLE
24 384 (80'-0)
32 280 (105'-11)
35 340 (115'-11)
32 260 (105'-10)
19 507 (64'-0)
4@2700=10 800
14@8'-10 5/16=35'-5 1/4
TRAILER
CONCRETE DEADMEN
G1A G2A G3A G4A G5A
G1B G2B G3B G4B G5B
G1C G2C G3C G4C G5C
CF1 CF2 CF3 CF4 CF5 CF9 CF10 CF10A CF11 CF11A
D1 PD11 PD12 PD9
POSITION 1
POSITION 2
POSITION 4
LANE LANE MEDIAN LANE LANE
ELEVATION
(HOLDING CRANES NOT SHOWN)
DISCLAIMER NOTE
INFORMATION SHOWN IS FOR CONCEPT ONLY. APPLICATION TO SPECIFIC STRUCTURES IS THE ERECTORS RESPONSIBILITY.
TO DOWNLOAD FULL SIZE DRAWING, GO TO WWW.STEELBRIDGE.ORG/STANDARDS.HTM
TYPICAL ERECTION PROCEDURE
STRAIGHT GIRDER BRIDGE
AASHTO/NSBA STEEL BRIDGE COLLABORATION
TASK GROUP 10, ERECTION
STEEL BRIDGE ERECTION GUIDE SPECIFICATION S10.1
DRAWING NO. EP-1a

PROCEDURE:

STEP 1: PLACE 300 TON CRANE IN POSITION 1, 300 TON CRANE IN POSITION 2A AND 85 TON CRANE IN POSITION 3. SWING G3A INTO PLACE WITH CRANE IN POSITION 1 AND HOLD. SWING G3B INTO PLACE WITH CRANE IN POSITION 2A AND HOLD. CONNECT THE FIELD SPLICE BETWEEN G3A AND G3B. HOOK CRANE IN POSITION 3 TO G3A APPROXIMATELY 80'-0 EAST OF ABUTMENT 1. SECURE AT ABUTMENT 1 AND THE PIER WITH A TEMPORARY TIE DOWN (AND AT MID SPAN WITH CONCRETE DEADMEN AS NEEDED).

STEP 2: MOVE CRANE IN POSITION 1 AS REQUIRED. SWING G4A INTO PLACE WITH CRANE IN POSITION 1 AND HOLD. ERECT THE INDICATED CROSSFRAMES BETWEEN G3A AND G4A WITH A BOOM TRUCK. MOVE CRANE IN POSITION 2A AS REQUIRED. SWING G4B INTO PLACE WITH CRANE IN POSITION 2A AND HOLD. CONNECT THE FIELD SPLICE BETWEEN G4A AND G4B. ERECT THE INDICATED CROSSFRAMES BETWEEN G3B AND G4B WITH A BOOM TRUCK. FILL IN THE REMAINING CROSSFRAMES BETWEEN GIRDER LINES G3 AND G4 WITH A BOOM TRUCK AND/OR CRANE IN POSITION 3. REMOVE TIE DOWNS AND INSTALL END DIAPHRAGMS. REPEAT THIS STEP FOR GIRDERS G5A & G5B, G2A & G2B AND G1A & G1B.
NOTE: ERECTION OF G2B AND G1B WILL BE DONE FROM CRANE IN POSITION 2B. HOLDING CRANE IN POSITION 3 MAY BE RELEASED UPON ERECTION OF INDICATED CROSSFRAMES BETWEEN G3 AND G4 (STEP 2). THIS CRANE MAY BE THEN USED IN LIEU OF BOOM TRUCK TO ERECT REMAINING CROSSFRAMES.

STEP 3: PLACE 300 TON CRANE IN POSITION 4 AND 85 TON CRANE IN POSITION 5. SWING G5C INTO PLACE WITH CRANE IN POSITION 4 AND HOLD. CONNECT THE FIELD SPLICE BETWEEN G5B AND G5C. HOOK CRANE IN POSITION 5 TO G5C APPROXIMATELY 64'-0 WEST OF ABUTMENT 2, AND HOLD. SECURE AT ABUTMENT 2 WITH A TEMPORARY TIE DOWN.

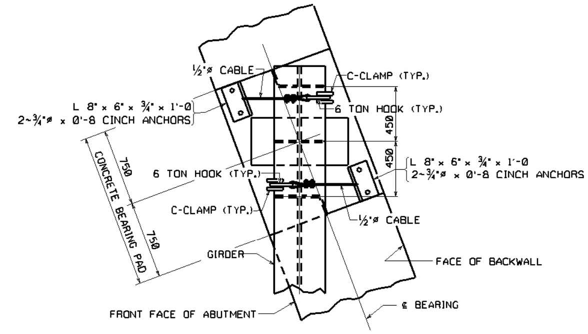
STEP 4: MOVE CRANE IN POSITION 4 AS REQUIRED. SWING G4C INTO PLACE WITH CRANE IN POSITION 4 AND HOLD. CONNECT THE FIELD SPLICE BETWEEN G4B AND G4C. ERECT THE INDICATED CROSSFRAMES BETWEEN G5C AND G4C WITH A BOOM TRUCK. FILL IN THE REMAINING CROSSFRAMES BETWEEN GIRDER LINES G5 AND G4 WITH CRANE IN POSITION 4. REPEAT THIS STEP FOR GIRDERS G3C, G2C AND G1C.

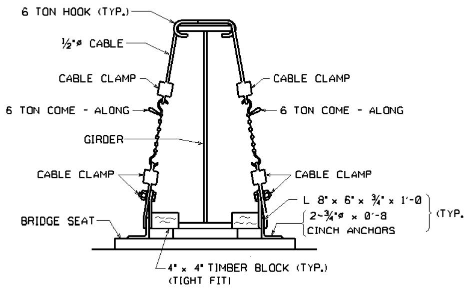
	CRANE - POSITION 1			
	METRIC		ENGLISH	
MARK	WEIGHT	MAX. RADIUS	WEIGHT	MAX. RADIUS
G5A	15 691 kg	36 350 mm	34,594#	120'-0
G4A	15 591 kg	36 350 mm	34,373#	120'-0
G3A	15 501 kg	36 350 mm	34,175#	120'-0
G2A	15 631 kg	36 350 mm	34,461#	120'-0
G1A	15 941 kg	36 350 mm	35,145#	120'-0

	CRANE - POSITION 2			
	METRIC		ENGLISH	
MARK	WEIGHT	MAX. RADIUS	WEIGHT	MAX. RADIUS
G5B	22 906 kg	25 908 mm	50,498#	85'-0
G4B	22 936 kg	25 908 mm	50,565#	85'-0
G3B	22 836 kg	25 908 mm	50,344#	85'-0
G2B	23 076 kg	25 908 mm	50,873#	85'-0
G1B	22 906 kg	25 908 mm	50,498#	85'-0

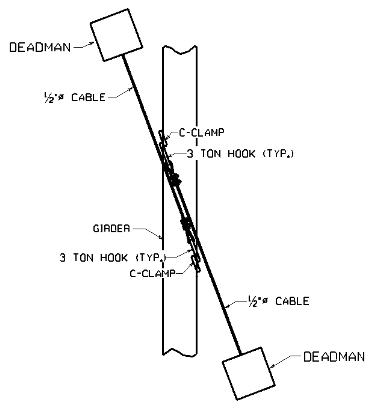
	CRANE - POSITION 4			
	METRIC		ENGLISH	
MARK	WEIGHT	MAX. RADIUS	WEIGHT	MAX. RADIUS
G5C	15 931 kg	36 350 mm	35,123#	120'-0
G4C	15 661 kg	36 350 mm	34,528#	120'-0
G3C	15 491 kg	36 350 mm	34,153#	120'-0
G2C	15 551 kg	36 350 mm	34,285#	120'-0
G1C	15 651 kg	36 350 mm	34,506#	120'-0

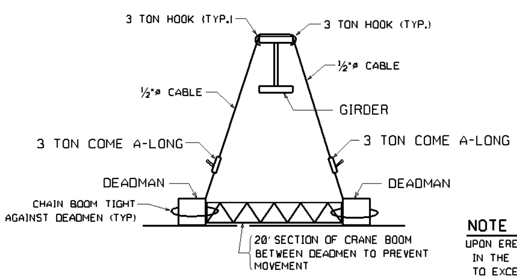
NOTE: WEIGHT OF EQUIPMENT IS INCLUDED IN WEIGHT.





TEMP. TIE DOWN
AT ABUTMENTS





DEADMEN DETAIL

NOTE A:
UPON ERECTION OF G3A & G3B:
IN THE EVENT WIND EXCEEDS, OR IS EXPECTED TO EXCEED 25 MPH PRIOR TO ERECTION OF G4A AND G4B AND INDICATED CROSSFRAMES, CEASE ERECTION OPERATIONS AND (SAFETY PERMITTING) INSTALL THIS TIE DOWN ASSEMBLY AS SHOWN.

EQUIPMENT:
TWO - 300 TON HYDRAULIC CRANE
ONE - 85 TON HYDRAULIC CRANE
THREE - 25 TON BEAM CLAMPS
ONE - 10'-0 SPREADER BEAM
TWO - 1¾"ø x 10'-0 TRI-FLEX CABLES
SIX - 17 TON SHACKLES

GENERAL NOTES

THE CONTRACTOR IS TO COORDINATE ALL ARRANGEMENTS BETWEEN THE STRUCTURAL STEEL ERECTOR AND THE OWNER OF THE PROJECT.

SPLICES ARE TO BE BOLTED 100% BEFORE CRANE LETS GO.

ALL CROSSFRAME CONNECTIONS ARE TO BE PINNED & BOLTED 50% BEWTEEN EACH PAIR OF GIRDERS BEFORE ERECTING NEXT GIRDER.

OUTRIGGERS ARE TO BE EXTENDED FULLY.

NO WORK SHALL BE PERFORMED IF WIND GUST EXCEEDS 25 MPH.

NO CRANE WILL BE OPERATED IN A MANNER THAT WILL EXCEED ITS RATED CAPACITY AT ANY RADIUS AS SPECIFIED BY THE CRANE MANUFACTURER.

THE ERECTOR SHALL BE RESPONSIBLE FOR VERIFYING THE WEIGHT OF EACH LIFT AND INSURING THE STABILITY OF EACH MEMBER DURING ALL PHASES OF ERECTION.

THIS PROCEDURE IS TO BE USED ONLY AS A GUIDE AND MAY CHANGE DUE TO ACTUAL SITE CONDITIONS.

WORK THIS DRAWING WITH DRAWINGS EP-1a & EP-1c.

DISCLAIMER NOTE
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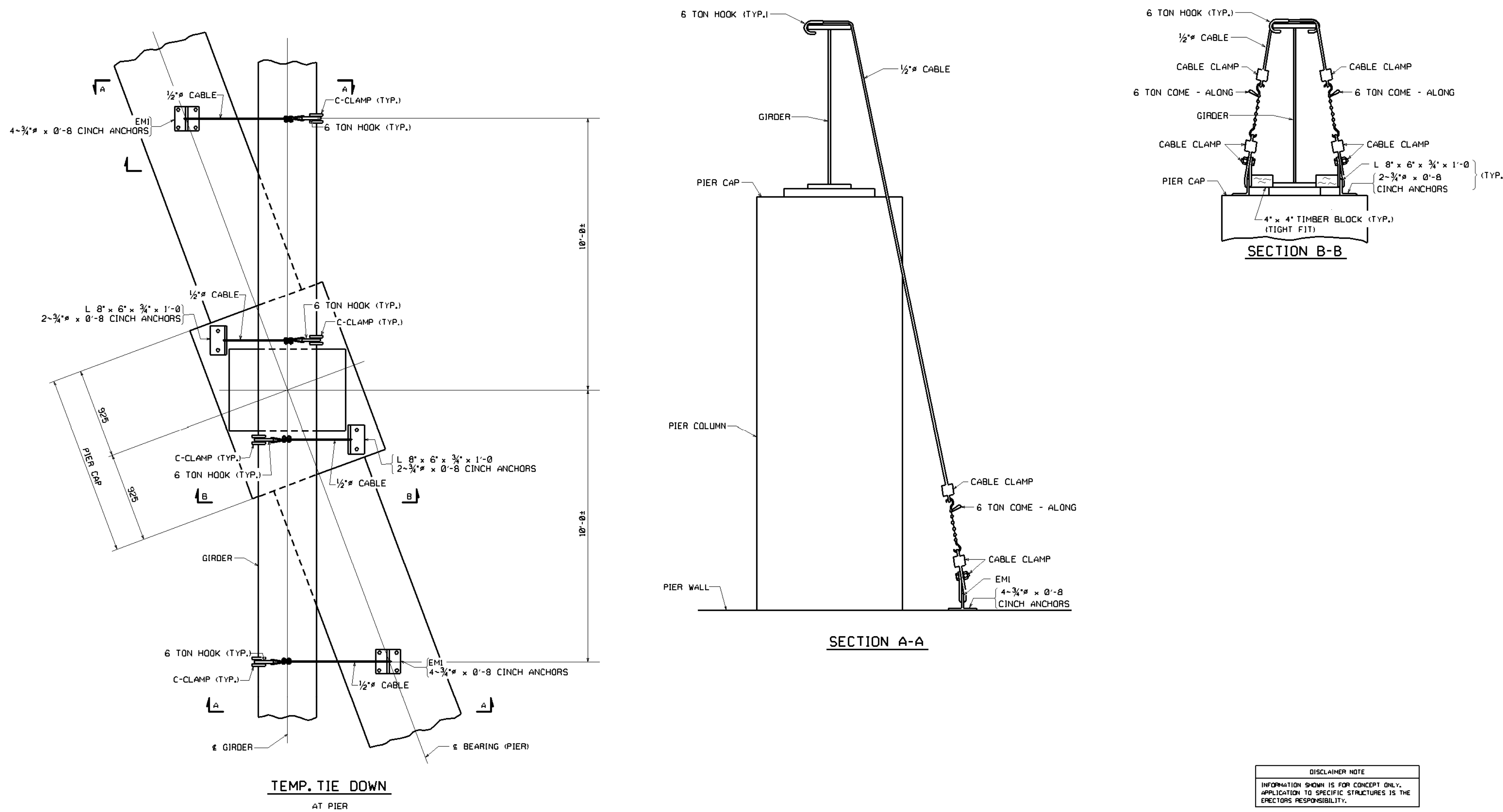
TYPICAL ERECTION PROCEDURE
STRAIGHT GIRDER BRIDGE

AASHTO/NSBA STEEL BRIDGE COLLABORATION
TASK GROUP 10, ERECTION
STEEL BRIDGE ERECTION GUIDE SPECIFICATION S10.1

DRAWING NO. EP-1b



DISCLAIMER NOTE

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NOTES:

WORK THIS DRAWING WITH DRAWINGS EP-1a & EP-1b.
FOR PROCEDURE, SEE DRAWING EP-1b.
FOR GENERAL NOTES, SEE DRAWING EP-1b.
FOR OTHER TIE DOWN DETAILS, SEE DRAWINGS EP-1b.
FOR WEIGHT CHARTS, SEE DRAWING EP-1b.

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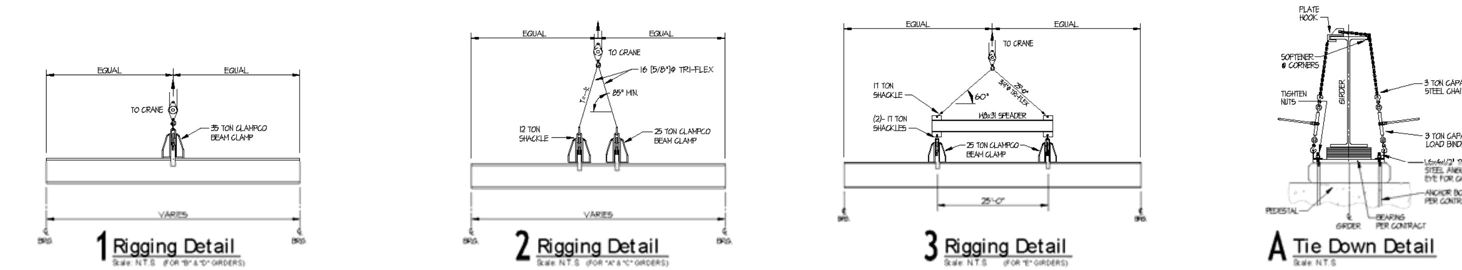
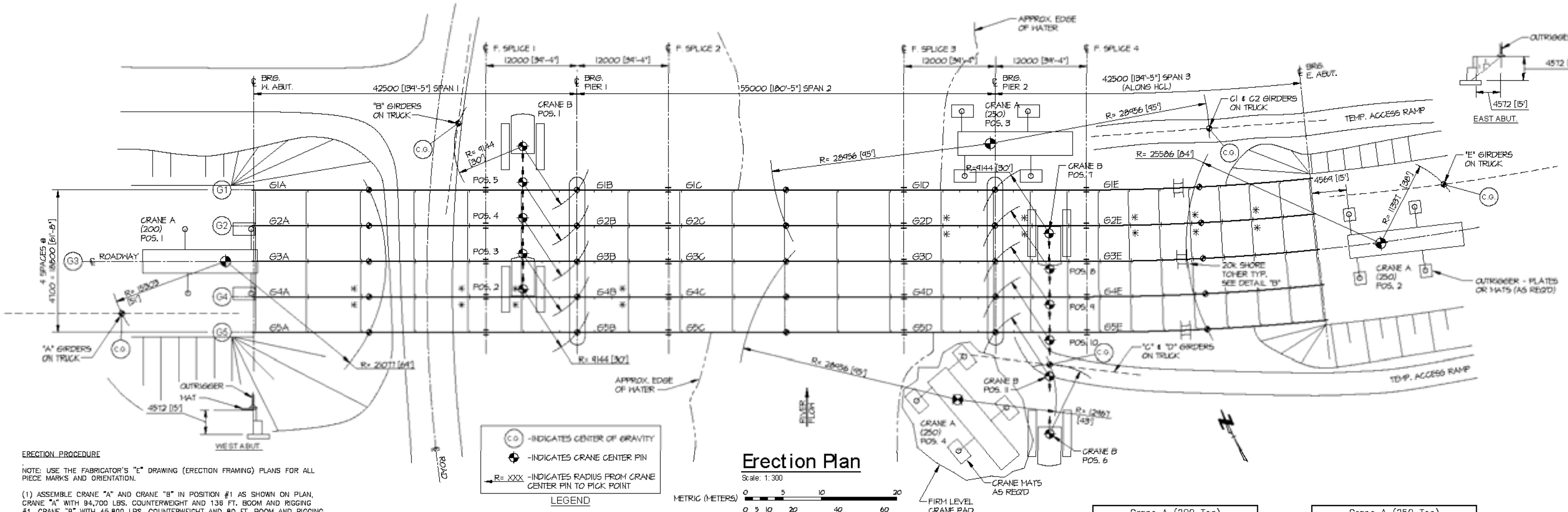
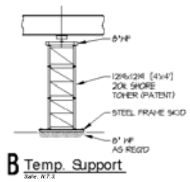
DRAWING NO. EP-1c







ERECTION PROCEDURE

NOTE: USE THE FABRICATOR'S "E" DRAWING (ERECTION FRAMING) PLANS FOR ALL PIECE MARKS AND ORIENTATION.

(1) ASSEMBLE CRANE "A" AND CRANE "B" IN POSITION #1 AS SHOWN ON PLAN. CRANE "A" WITH 94,700 LBS. COUNTERWEIGHT AND 136 FT. BOOM AND RIGGING #1. CRANE "B" WITH 45,800 LBS. COUNTERWEIGHT AND 80 FT. BOOM AND RIGGING #3.

(2) DELIVER GIRDER G5A TO UNLOAD POSITION. WITH CRANE "A" ERECT AS SHOWN ON PLAN. SECURE AS PER DETAIL "A" AND REMAIN HOLDING UNTIL G5B IS ERECTED.

(3) DELIVER GIRDER G5B TO UNLOAD POSITION AND WITH CRANE "B" PICK AND CARRY TO POSITION 2. ERECT AS SHOWN ON PLAN. SECURE AS PER DETAIL "A" AND REMAIN HOLDING UNTIL GIRDER G4A IS ERECTED. MAKE SPLICE PER GENERAL NOTE (L). RELEASE CRANE "A" FROM G5A.

(4) HANG (4) CROSSFRAMES OR DIAPHRAGMS MARKED (*) AS SHOWN ON PLAN ON BOTH SIDES OF GIRDER G4A (ON TRUCK OR GROUND) PRIOR TO ERECTING.

(5) ERECT GIRDER G4A AS SHOWN ON PLAN. SECURE AT ABUTMENT AS PER DETAIL "A". CONNECT CROSSFRAMES OR DIAPHRAGMS BETWEEN G4A AND G5A AS PER GENERAL NOTE (K). REMAIN HOLDING WITH CRANE "A". RELEASE CRANE "B" FROM GIRDER G5B.

(6) HANG (4) CROSSFRAMES OR DIAPHRAGMS MARKED (*) AS SHOWN ON PLAN ON BOTH SIDES OF GIRDER G4B (ON TRUCK OR GROUND) PRIOR TO ERECTING.

(7) ERECT GIRDER G4B (UNLOAD POSITION 1, PICK AND CARRY TO POSITION 3) AS SHOWN ON PLAN. SPLICE AS PER GENERAL NOTE (L) AND CONNECT CROSSFRAMES OR DIAPHRAGMS AS PER GENERAL NOTE (K) PRIOR TO CRANES "A" AND "B" RELEASE.

(8) COMPLETE ALL CROSSFRAMES OR DIAPHRAGMS BETWEEN GIRDER LINES 4 AND 5 AS PER GENERAL NOTE (K).

(9) ERECT GIRDER G3A AS SHOWN ON PLAN, SAME AS STEP (5). CRANE "A" TO REMAIN HOLDING UNTIL GIRDER G3B IS ERECTED.

(10) ERECT GIRDER G3B FROM POSITION 4 AS SHOWN ON PLAN, SAME AS STEP (7) PRIOR TO CRANES "A" AND "B" RELEASE.

(11) COMPLETE CROSSFRAMES OR DIAPHRAGMS BETWEEN LINES 3 AND 4 AS PER GENERAL NOTE (K).

(12) HANG CROSSFRAMES ON G3A AND G3B FOR LINES 3 TO 2 AND TIE BACK TO ALLOW GIRDER LINE 2 TO BE ERECTED.

(13) ERECT GIRDER G2A AS SHOWN ON PLAN SAME AS STEP 5.

(14) ERECT GIRDER G2B FROM POSITION 5 AS SHOWN ON PLAN SAME AS STEPS (7) AND (8) .

(15) ERECT GIRDER G1A AS SHOWN ON PLAN SAME AS STEP (5).

(16) ERECT GIRDER G1B FROM POSITION 6 AS SHOWN ON PLAN. SAME AS STEPS (7) AND (8).

"E" (CURVED) AND "D" GIRDERS:

(17) INSTALL SHORING AS SHOWN ON PLAN AND AS PER DETAIL "B".

(18) ASSEMBLE CRANE "A" WITH 138,000 LBS. COUNTERWEIGHT, 121 FT. BOOM AND RIGGING #3 AS SHOWN ON PLAN AND CRANE "B" WITH 45,800 LBS. COUNTERWEIGHT, 80 FT. BOOM AND RIGGING #1 AS SHOWN ON PLAN.

(19) DELIVER GIRDER G1E TO UNLOAD POSITION AND ERECT AS SHOWN ON PLAN. SECURE AT ABUTMENT AS PER DETAIL "A" AND TEMPORARY SUPPORT AS PER DETAIL "B" AND REMAIN HOLDING WITH CRANE "A".

(20) DELIVER GIRDER G1D TO UNLOAD POSITION AND PICK AND CARRY TO POSITION 7 AND ERECT AS SHOWN ON PLAN. SPLICE AS PER GENERAL NOTE (L) AND SECURE AT PIER 2 AS PER DETAIL "A". REMAIN HOLDING UNTIL G2E IS ERECTED.

(21) HANG (6) CROSSFRAMES OR DIAPHRAGMS MARKED (*) AS SHOWN ON PLAN, ON BOTH SIDES OF GIRDER G2E ON GROUND OR ON TRUCK.

(22) ERECT GIRDER G2E AS SHOWN ON PLAN AND SECURE AT ABUTMENT AS PER DETAIL "A". CONNECT CROSSFRAMES OR DIAPHRAGMS BETWEEN G1E AND G2E AS PER GENERAL NOTE (K). REMAIN HOLDING WITH CRANE "A". RELEASE CRANE "B" FROM GIRDER G1D.

(23) HANG (4) CROSSFRAMES OR DIAPHRAGMS ON GIRDER G2D (ON TRUCK OR GROUND) PRIOR TO ERECTING.

(24) ERECT GIRDER G2D (UNLOAD POSITION 6, PICK AND CARRY TO POSITION 8) AS SHOWN ON PLAN. SPLICE AS PER GENERAL NOTE (L) AND CONNECT CROSSFRAMES OR DIAPHRAGMS AS PER GENERAL NOTE (K) PRIOR TO CRANES "A" AND "B" RELEASE.

(25) COMPLETE INSTALLATION OF CROSSFRAMES OR DIAPHRAGMS BETWEEN GIRDER LINES 1 AND 2 AS PER GENERAL NOTE (K).

(26) ERECT GIRDER G3E AS SHOWN ON PLAN. CONNECT CROSSFRAMES OR DIAPHRAGMS BETWEEN G2E AND G3E. SECURE AT ABUTMENT AS PER DETAIL "A" AND TEMPORARY SUPPORT AS PER DETAIL "B". CRANE "A" TO REMAIN HOLDING UNTIL G3D IS ERECTED.

(27) ERECT GIRDER G3D (UNLOAD POSITION 6, PICK AND CARRY TO POSITION 9) AS SHOWN ON PLAN. SPLICE AS PER GENERAL NOTE (L) AND CONNECT CROSSFRAMES OR DIAPHRAGMS AS PER GENERAL NOTE (K) PRIOR TO CRANES "A" AND "B" RELEASE.

(28) COMPLETE INSTALLATION OF CROSSFRAMES OR DIAPHRAGMS BETWEEN GIRDER LINES 2 AND 3 AS PER GENERAL NOTE (K).

(29) HANG CROSSFRAMES OR DIAPHRAGMS ON GIRDERS G3D AND G3E FOR LINES 3 AND 4 AND TIE BACK TO ALLOW GIRDER LINE 4 TO BE ERECTED.

(30) ERECT GIRDER G4E AS SHOWN ON PLAN, SAME AS TEPS (29) AND (26).

(31) ERECT GIRDER G4D (UNLOAD POSITION 6, PICK AND CARRY TO POSITION 10) AS SHOWN ON PLAN. SAME AS STEPS (29) AND (27).

(32) ERECT GIRDER G5E AS SHOWN ON PLAN. SAME AS STEPS (29) AND (26).

(33) ERECT GIRDER G5D (UNLOAD POSITION 6, PICK AND CARRY TO POSITION 11) AS SHOWN ON PLAN. SAME AS STEPS (29) AND (27).

"C" GIRDERS

(34) ASSEMBLE CRANE "A" IN POSITION #3 WITH 94,700 LBS. COUNTERWEIGHT AND 136 FT. BOOM AND RIGGING #2.

(35) DELIVER GIRDER G1C TO UNLOAD POSITION AND ERECT AS SHOWN ON PLAN. SPLICE AS PER GENERAL NOTE (L) PRIOR TO CRANE RELEASE.

(36) ERECT GIRDER G2C USING STEP (35).

(37) INSTALL ALL CROSSFRAMES OR DIAPHRAGMS BETWEEN G1C AND G2C AS PER GENERAL NOTE (K).

(38) MOVE CRANE "A" TO POSITION #4 WITH 94,700 LBS. COUNTERWEIGHT, 136 FT. BOOM AND RIGGING #2.

(39) ERECT GIRDER G3C, G4C AND G5C AS SHOWN ON PLAN USING STEPS (35) AND (37).

(40) VERIFY PROFILE PRIOR TO RELEASE OF EXTERNAL SUPPORT SYSTEMS.

(41) COMPLETE ALL BOLTING AND TENSIONING OF ALL BOLTS TO CONTRACT SPECIFICATIONS.

(42) ADJUST AND WELD BEARINGS TO SATISFACTION OF ENGINEER IN CHARGE (E.I.C.) OR AS SPECIFIED.

Pick Weight Table								
Piece Mark	Piece Weight (In lbs.)	Piece Weight (In kgs.)	Attachments Weight (In lbs.)	Attachments Weight (In kgs.)	Rigging Weight (In lbs.)	Rigging Weight (In kgs.)	Total Pick Weight (In lbs.)	Total Pick Weight (In kgs.)
G1A THRU G5A	37 536	17 026	1 400	635	2 100	953	41 036	18 614
G1B THRU G5B	45 382	20 585	1 400	635	2 000	907	48 782	22 127
G1C THRU G5C	39 678	17 998	--	--	2 100	953	41 778	18 950
G1D THRU G5D	45 382	20 585	1 400	635	2 000	907	48 782	22 127
G1E THRU G5E	38 343	17 392	2 100	953	3 100	1 406	43 543	19 751

Crane A (200 Ton) Lifting Capacity			
Radius (In ft.)	Radius (In meters)	Capacity over Side/360° (lbs.)	Capacity over Side/360° (kgs.)
20	6.10	92 000	41 730
25	7.62	87 000	39 463
30	9.14	82 000	37 195
35	10.67	76 000	34 473
40	12.19	71 000	32 205
45	13.72	65 000	29 484
50	15.24	61 000	27 669
55	16.76	57 000	25 855
60	18.29	54 000	24 494
65	19.81	51 000	23 133
70	21.34	48 000	21 772
75	22.86	45 000	20 412
80	24.38	41 400	18 779

Crane Notes:

A.) Grove GMK6220 all terrain hydraulic crane w/ 200 ton capacity and 136 ft. boom.

B.) All capacities shown on fully extended outriggers w/ 94,700 lbs. counterweight.

Crane A (250 Ton) Lifting Capacity			
Radius (In ft.)	Radius (In meters)	Capacity over Side/360° (lbs.)	Capacity over Side/360° (kgs.)
20	6.10	121 000	54 885
25	7.62	121 000	54 885
30	9.14	118 000	53 524
35	10.67	109 000	49 442
40	12.19	99 000	44 906
45	13.72	90 000	40 823
50	15.24	83 000	37 648
55	16.76	77 000	34 927
60	18.29	72 000	32 659
65	19.81	66 000	29 937
70	21.34	62 000	28 123
75	22.86	58 000	26 308
80	24.38	53 000	24 040
85	25.91	48 000	21 772
90	27.43	43 000	19 504
95	28.96	40 000	18 144

Crane Notes:

A.) Grove GMK6220 all terrain hydraulic crane w/ 250 ton capacity and 121 ft. boom.

B.) All capacities shown on fully extended outriggers w/ 138,800 lbs. counterweight.

Crane B Lifting Capacity			
Radius (In ft.)	Radius (In meters)	Capacity over Side/360° (lbs.)	Capacity over Side/360° (kgs.)
17	5.18	120 000	54 431
20	6.10	100 800	45 722
25	7.62	70 425	31 944
30	9.14	53 750	24 381
35	10.67	43 250	19 618
40	12.19	36 025	16 341
45	13.72	30 725	13 937
50	15.24	26 700	12 111
60	18.29	20 975	9 514
70	21.34	17 075	7 745
80	24.38	14 275	6 475

Crane Notes:

A.) Lima 700-HC crawler crane w/ 80 ton capacity and 80 ft. boom

B.) All capacities shown on fully extended crawlers w/ 45,800 lbs. counterweight.

GENERAL ERECTION REQUIREMENTS

(A) NO CRANE SHALL BE OPERATED IN A MANNER THAT WILL EXCEED IT'S RATED CAPACITY AT ANY RADIUS AS SPECIFIED BY THE CRANE MANUFACTURER.

(B) THE CRANE CHART PREPARED BY THE CRANE MANUFACTURER THAT DESCRIBES THE MAXIMUM LIFT AT ALL CONDITIONS OF LOADING SHALL BE POSTED IN EACH CRANE CAB IN CLEAR VIEW OF THE OPERATOR.

(C) CONTRACTOR IS RESPONSIBLE FOR PROVIDING A LEVEL AND STABLE GROUND SURFACE ON WHICH CRANES WILL OPERATE. (SEE NEW OSHA SUB PART R)

(D) THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING THE WEIGHT OF EACH LIFT AND FOR INSURING THE STABILITY OF EACH MEMBER DURING ALL PHASES OF ERECTION.

(E) THE CONTRACTOR SHALL TAKE THE NECESSARY PRECAUTIONS TO LOCATE AND PROTECT EXISTING UTILITIES IN THE AREA AS REQUIRED. OVERHEAD POWER LINES ADJACENT TO WORK AREAS ARE TO BE SHUT DOWN DURING ERECTION OPERATIONS WHEN THE CONTRACTOR BELIEVES THEY MAY INTERFERE, OR ARE TOO CLOSE TO THE WORK. WHEN POWER LINES IN THE WORK AREA CAN NOT BE DEENERGIZED CONTRACTOR SHALL MAINTAIN A SAFE DISTANCE AS DETERMINED BY THE UTILITY COMPANY.

(F) CONTROL LINES SHALL BE ATTACHED TO EACH END OF THE GIRDERS BEING LIFTED AND ADEQUATELY MANNED THROUGHOUT THE ERECTION OPERATIONS.

(G) MEMBERS SHALL BE SUBJECT TO ONLY LIGHT DRIFTING IN ORDER TO ALIGN HOLES. ANY DRIFTING THAT RESULTS IN DISTORTION OF THE MEMBER OR DAMAGE TO THE HOLES WILL BE CAUSE FOR REJECTION OF THE MEMBER.

(H) FIELD REAMING OF HOLES WILL NOT BE ALLOWED UNLESS SPECIFICALLY NOTED OTHERWISE IN THE CONTRACT DOCUMENTS OR OTHERWISE APPROVED BY THE OWNER.

(I) THE FINAL ALIGNMENT AND PROFILE OF THE ERECTED STEEL SHALL CONFORM TO THE REQUIREMENTS OF THE CONTRACT DOCUMENTS. MEASUREMENTS SHALL BE MADE BY THE CONTRACTOR TO VERIFY THESE REQUIREMENTS.

(J) ERECTION WORK SHALL NOT BEGIN WITHOUT THE APPROVAL OF THE OWNER.

(K) BETWEEN THE FIRST TWO LINES OF GIRDERS, EACH DIAPHRAGM OR CROSSFRAME TO GIRDER CONNECTION SHALL BE MADE WITH AT LEAST FIFTY PERCENT OF THE HOLES FILLED WITH THE APPROVED HIGH STRENGTH BOLTS. THE BOLTS SHALL BE TIGHTENED UNTIL THERE IS NO GAP BETWEEN THE CONNECTING PARTS. AFTER THE FIRST TWO LINES ARE ERECTED AND STABILIZED, DIAPHRAGMS OR CROSSFRAMES INSTALLED BETWEEN SUBSEQUENT LINES OF GIRDERS SHALL HAVE EACH OF THEIR CONNECTIONS MADE WITH A MINIMUM OF TWO HIGH STRENGTH BOLTS IN EACH CONNECTION. EXCEPT FOR CURVED GIRDERS WHICH REQUIRE 50% IN ALL CONNECTIONS.

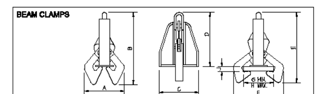
(L) SPLICES OF GIRDERS SHALL BE MADE WITH A MINIMUM OF 50% OF THE HOLES FILLED WITH APPROVED HIGH STRENGTH BOLTS AND FULL SIZE ERECTION PINS BEFORE THE EXTERNAL SUPPORT SYSTEMS ARE RELEASED. AT LEAST ONE HALF OF THIS PERCENTAGE SHALL BE BOLTS, TIGHTENED TO SPECIFICATION REQUIREMENTS. THE BOLTS AND PINS SHALL BE INSTALLED UNIFORMLY THROUGHOUT THE CONNECTION EXCEPT THAT ERECTION PINS SHALL BE USED IN THE EXTREME CORNERS OF ALL MAIN SPLICE PLATES. ELEVATION SHOULD BE VERIFIED BEFORE TIGHTENING.

(M) THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING ADEQUACY OF ALL TEMPORARY SUPPORTS.

(N) MAINTENANCE AND PROTECTION OF TRAFFIC SHALL BE APPROVED BY EIC AND THE REGIONAL TRAFFIC ENGINEER.

(O) DUE TO AVAILABILITY, CONTRACTOR MAY SUBSTITUTE CRANES FOR THOSE SPECIFIED HEREIN PROVIDED THAT THE SUBSTITUTE CRANE CAPACITY AT THE INDICATED RADII MEET OR EXCEED THE LOAD TABLES SPECIFIED AT THE VARIOUS CONDITIONS OF THE PICK. SUBJECT TO APPROVAL OF THE OWNER

BEAM CLAMPS



MODEL NO.	WORKING LOAD LIMITS TONS	FLANGEGRIP WIDTH RANGE MIN. MAX.	FLANGEGRIP DEPTH	WT. LBS.	A	B	C	D	E	F	G	H	J
F-5	5	4 TO 10	1	51	9 1/2	26	12	20	25 1/2	16 3/4	4	10	1
F-15	15	7 TO 17	2	125	15 1/3	34	17	27	34 1/3	25	7	17	2
NS-15	15	7 TO 17	2	120	15 1/3	34	17	27	34 1/3	25	7	17	2
F-25	25	16 TO 24	3	244	23	48	22 1/4	36	53	37 1/4	16	24	3
NS-25	25	16 TO 24	3	234	23	48	22 1/4	36	53	37 1/4	16	24	3
F-35	35	16 TO 36	4	445	30	64	27 1/2	48	58	53	16	36	4
NS-35	35	16 TO 36	4	484	30	64	27 1/2	48	58	53	16	36	4

ALL DIMENSIONS IN MILLIMETERS U.O.N.

ALL WEIGHTS IN KILOGRAMS U.O.N.

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AASHTO/NSBA STEEL BRIDGE COLLABORATION
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DRAWING NO. EP-2