



State of Illinois
Illinois Department of Transportation

STEEL STRUCTURE CONSTRUCTION INSPECTION COURSE



Participant Guide

December 27, 2016

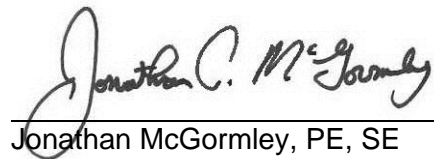


Illinois Department of Transportation
Division of Highways/Bureau of Construction
2300 South Dirksen Parkway/Springfield, Illinois/62764

STEEL STRUCTURE CONSTRUCTION INSPECTION COURSE

Participant Guide

December 27, 2016



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TABLE OF CONTENTS

| | |
|--|-----|
| Executive Summary | 1 |
| Module 1 - Introduction and Course Overview | 8 |
| Overview and Instructional Method..... | 8 |
| Presentation Notes..... | 8 |
| Module 2 - Overview of Steel Structure Construction..... | 14 |
| Overview and Instructional Method..... | 14 |
| Presentation Notes..... | 14 |
| Module 3 - Acceptance of Steel Materials at Job Site | 23 |
| Overview and Instructional Method..... | 23 |
| Presentation Notes..... | 23 |
| Module 4 - Erection of steel girders..... | 47 |
| Overview and Instructional Method..... | 47 |
| Presentation Notes..... | 47 |
| Module 4a - Erection of steel girders - Bolting | 69 |
| Overview and Instructional Method..... | 69 |
| Presentation Notes..... | 69 |
| Module 5 - Bolting of steel girders | 84 |
| Overview and Instructional Method..... | 84 |
| Presentation Notes..... | 85 |
| Module 6 - Inspection of Secondary Structural Members and Bearings | 138 |
| Overview and Instructional Method..... | 138 |
| Presentation Notes..... | 138 |
| Quiz and Exercise Answers | 152 |
| Appendix A - Course Handouts | |
| Appendix B - Erection Plans | |
| Appendix C - IDOT Inspection Checklists | |

NOTICE

The contents of this guide reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect policy of the Illinois Department of Transportation. This guide does not constitute a standard, specification, or regulation.

STEEL STRUCTURE CONSTRUCTION INSPECTION COURSE

Participant Guide

December 27, 2016

EXECUTIVE SUMMARY

The Illinois Department of Transportation (IDOT) commissioned Wiss, Janney, Elstner Associates, Inc. (WJE) to develop a steel structure construction inspection training course under the Department's Specific Task Training Program. The Steel Structure Construction Inspection Course is designed to improve quality and ensure consistency in the documentation and inspection of steel structure construction projects in Illinois. The course focuses on the inspection of steel girders, setting and erection of steel structures, structural bolting, and inspection of steel bracing members.

The course design follows the cognitive domain of learning, which begins with knowledge level learning and advances to comprehension, application, and then higher order skills involving analysis, synthesis, and evaluation or problem solving. A combination of interactive instructional strategies, including lectures, videos, case studies, and hands-on exercises that incorporate adult learning principles, are used to achieve the Global Learning Outcomes shown in Table ES.1. The learning outcomes define the core competencies required of IDOT steel structure construction inspectors. Individuals completing this course will be prepared to fulfill their roles and responsibilities as a steel structure construction inspector.

Table ES.1 - Global Learning Outcomes

| |
|--|
| 1. Identify structural and fastening systems found in and equipment used for steel structure construction. |
| 2. Describe current Department policies, specifications, and procedures related to the acceptance, erection, installation, and bolting of steel structure girders. |
| 3. Explain the role of the steel structure construction inspector in the acceptance of steel and fasteners at the job site, the safe erection of girders, the verification of fastener installation, and the inspection of other steel components including bracing and bearings associated with steel structure construction. |
| 4. Conduct regular, systematic inspections in accordance with Department standards utilizing, where available, job aids such as checklists or forms. |
| 5. Recognize and report potential problems associated with steel structure construction. |

The expected course audience includes IDOT construction supervisors, inspectors, field engineers, resident engineers, structural engineers, materials engineers, and other technical personnel involved in the construction inspection of steel structures. It is also expected that personnel involved in steel structure design and materials acceptance may participate in the course. The target participant is defined as an IDOT employee having a four-year Bachelor of Science degree in Civil Engineering and three to five years of transportation experience with exposure to two or more bridge construction projects.

The Steel Structure Construction Inspection Course is expected to be a stand-alone course, although a number of IDOT Quality Control/Quality Assurance (QC/QA) courses and other Specific Task Training Courses will be helpful to the achievement of the Global Learning Outcomes and improve the overall performance of construction inspectors. To get the most out of this course, participants should be familiar with construction terminology and have a general understanding of bridge construction. Participants should have taken the IDOT Documentation of Quantities Course, although this course is not a pre-requisite. The course covers general safety topics specific to the work to be performed by steel structure construction inspectors but is not a construction safety course. Participants should seek appropriate safety training through IDOT and/or OSHA.

Participants should have a general knowledge of IDOT specifications and standards for steel structure construction and have the ability to read and interpret contract documents and construction drawings. The expected level of knowledge is consistent with a person who has three to five years of experience, and served as a construction inspector on two or more bridge construction projects.

The Steel Structure Construction Inspection Course provides approximately six hours of instruction over an eight hour day. The instructional day is organized into seven instructional modules as shown in Table ES.2. Specific learning outcomes are established for each module, and build to achieve the Global Learning Outcomes (Table ES.1). The flow of learning for each module is designed to maximize participant motivation, comprehension, and application and transfer to job performance.

Table ES.2 - Instructional Modules

| Module | Description |
|--------|---|
| 1 | Introduction and course overview |
| 2 | Overview of steel structures and equipment used in their construction |
| 3 | Acceptance of steel, fasteners, and bearings at job site |
| 4 | Erection of steel girders |
| 5 | Inspection of secondary structural members and bearings |
| 6 | Qualification testing and inspection of fastening systems |
| 7 | Evaluation |

This Participant Guide accompanies the course presentation materials and is designed to serve as a ready-reference of the topics covered throughout the presentation. Participants are encouraged to complete written exercises, questions, and take notes to record their learning. Existing IDOT references are noted wherever possible to provide ready access to relevant resources and inspection forms. References used in this guide are illustrated in Figure ES.1.

The narratives accompanying the slide material generally represent the verbal content to be conveyed by the instructor, and are not meant to provide a comprehensive discussion of the subject matter for that slide. The content of this guide and the presentation materials do not constitute a standard, specification, or regulation for steel structure construction. However, it should be noted that care was taken regarding the use of the word “shall”. When used, the word “shall” reflects a narrative or concept taken directly from an IDOT publication, whether referenced herein or not. Otherwise, terms such as “should”, “will”, etc. were used when describing the duties of the inspector or others involved in steel structure construction.

BOLT CKLIST

*Construction Inspector's Checklist for Structural Steel Bolting,
IDOT, Rev 12/14/07*

State of Illinois
Department of Transportation
CONSTRUCTION INSPECTOR'S CHECKLIST
STRUCTURAL STEEL BOLTING

The installation of fasteners in bridge construction is a critical element in the proper behavior of the structure. All construction on this checklist requires the required documentation with the intent issue of the Specification for Structural Steel using AISC or AISI bolts for all critical connections as defined in the Revised Standard Specification for Steel Construction of the Engineering Foundation. The pertinent parts of the specification are discussed in detail in Section 502 of the Construction Manual. While a visual inspection is required, the checklist is provided to give the inspector a quick overview of the required items. Items requiring any further evaluation the inspector should read the Section with all of the requirements for the type of fastener used. If your answers to any of the following questions are "No," IDOT will review the required information before continuing.

1. INSTALLATION INSPECTION

Have you read Section 502 of the Standard Specifications, the Supplemental Specifications, the Special Provisions and Section 502 of the Construction Manual? _____

Are all fasteners being used in their original containers so that they are protected from oil and moisture or otherwise of any? Yes (initial for use and the container not opened under power) _____

Do all delivered fastener assemblies have approved manufacturer's markings? Markings should be on the containers, not on the bolts. (See 502.04(b)(2)(ii)) _____

CONTAINER INFORMATION REQUIREMENTS

A. Manufacturer identification _____
B. Contents _____
C. Container numbers (verify with MCTE) _____
D. P.C. lot number _____

Have you received the required certifications from the manufacturer and/or distributor. (See 502.04(b)(2)(iii)) _____

MILL TEST REPORT (MTR) (See 502.04(b)(1))

A. From mill producer or their firm _____
B. One report for each component _____
C. Report must contain following:

1. Heat number _____
2. Chemical analysis _____
3. Location where melted and manufactured _____
4. Location where tested (indicated) _____
5. Date of test _____

Sheet 1 of 2

BRIDGE CKLIST

*Construction Inspector's Checklist for Bridge Superstructures,
IDOT, Rev 03/2009*

State of Illinois
Department of Transportation
CONSTRUCTION INSPECTOR'S CHECKLIST
BRIDGE SUPERSTRUCTURES

While its use is not required, this checklist has been prepared to provide the field inspector a summary of what to look for in the preparation, review of the proper construction of all steel bridge components. It is intended to be used in conjunction with the Revised Standard Specifications, appropriate sections of the Construction Manual (CM), the Manual of Practice (MOP), the Manual of Inspection (MI) and the Special Provisions (SP).

1. PREPARATION PRIOR TO SUPERSTRUCTURE CONSTRUCTION

2. **Office Review (General Items)**

(1) Have you thoroughly reviewed the Contract (Special Conditions, Plans and the Standard and Supplemental Specifications)? _____

(2) Have you completed the volume of SSC Concrete Item 601.02(b) and the length (issue of) Reinforcement Bars for Bridge and the length (issue of) Reinforcement Bars for Deck? This will help determine your work, but your work is not a substitute for the actual work. Note: This will be a documentation requirement if Form No. 23, Attachment C, History of Final Conditions is part of the project. _____

(3) Have you reviewed the Plans (Provisions Guide (PPG)) for items being inspected? _____

(4) If this contract contains the Required Special Provisions for Quality Control Assurance (QCA) of Concrete Methods, have you reviewed the QCA item in conjunction and discussed the requirements with the area's Materials officer? In addition, has the area Materials officer approved the contractor's Quality Control Plan? _____

(5) Have you determined what material must be inspected prior to incorporation into the work and what material certifications are required? (See PPG 602.02.1) _____

(6) Have you reviewed the appropriate sections of the Construction Manual (CM), Section 601.02, the Manual of Practice (MOP), the Manual of Inspection (MI), the Manual of Construction (MOC), the CM Form 2000, Construction Memorandum No. 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, and the Plans Provisions Guide (PPG)? _____

Sheet 1 of 4

IDOT BC2320

Rotational-capacity Worksheet, Revised 6/96

Illinois Department of Transportation

Rotational Capacity Test Worksheet

The test procedure, as detailed in Section 502 of the Construction Manual, should be followed unless the contractor has a written approval to deviate from it. The contractor shall be held out for each individual case by its number and on the project.

1. Test Order: A325 A490 _____

2. Assumed R-C LOT NUMBER: _____

3. Manufacturer: _____

4. Bolt Diameter: _____

5. Measured Tension: _____

6. Measured Torque: _____

7. Maximum Permitted Torque (see back): _____

8. Measured Tension: _____

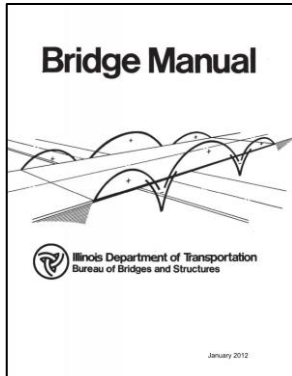
9. Measured Torque (see back): _____

10. Verify Thread Condition: _____

Tested by: _____
Witnessed by: _____
Date: _____ Location: _____

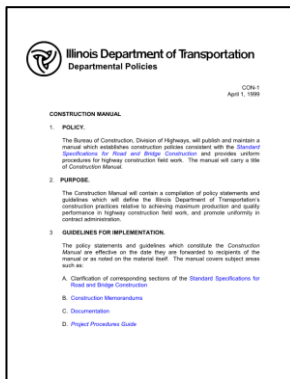
MS 2320 (Rev. 6/96)

Figure ES.1 - References used in this Guide



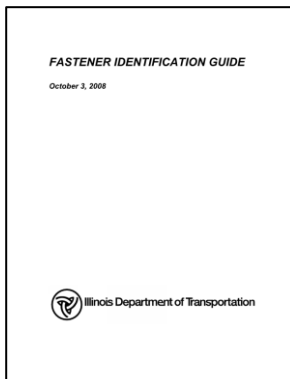
[IDOT BM](#)

Bridge Manual, January 2012



[IDOT CM](#)

Construction Manual, January 2006 with updates to Section 500, STRUCTURES, adopted March 2009. (Downloaded 11/5/2015)



[IDOT FG](#)

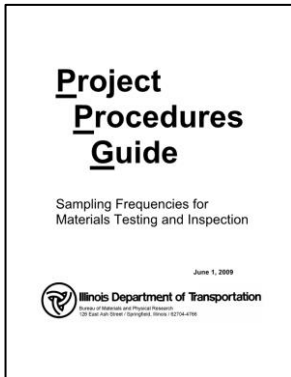
Fastener Identification Guide, October, 2008

Figure ES.1, Continued - References used in this Guide



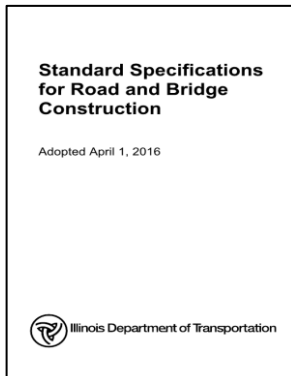
[IDOT MMI](#)

Manual for Materials Inspection, April 2015



[IDOT PPG](#)

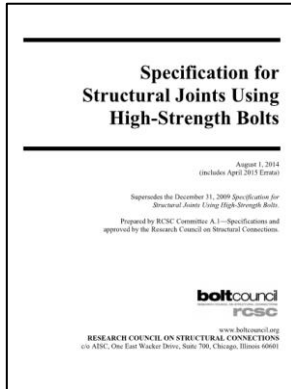
Project Procedures Guide, Sampling Frequencies for Materials Testing and Inspection, June 2009



[IDOT SPEC](#)

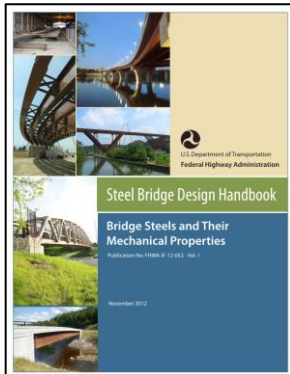
Standard Specifications for Road and Bridge Construction, April 2016

Figure ES.1, Continued - References used in this Guide



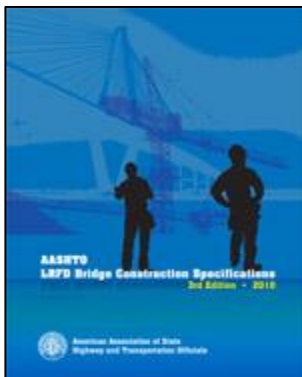
RCSC

Specification for Structural Joints Using High-Strength Bolts, Bolt Council, Research Council on Structural Connections, August 2015 (w/April 2015 errata)



SBDH

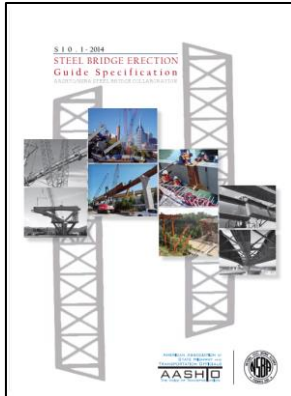
Steel Bridge Design Handbook, Bridge Steels and Their Mechanical Properties, Publication No. FHWA-IF-12-052, Vol. 1; November 2012



AASHTO_SPEC

LRF Bridge Construction Specifications, 3rd Edition, American Association of State Highway and Transportation Officials, 2010 w/all Interim Revisions thru 2016.

Figure ES.1, Continued - References used in this Guide



EREC_GUIDESPEC
*S10.1-2014 Steel Bridge Erection Guide Specification, AASHTO/NSBA
Steel Bridge Collaboration, 2014.*

Figure ES.1, Continued - References used in this Guide

MODULE 1 - INTRODUCTION AND COURSE OVERVIEW

Overview and Instructional Method

The overall course structure, Global Learning Outcomes, and the course agenda are reviewed in this module. The interactive learning approach is also described and requires participants to be engaged in the discussions and exercises. The experience and training needs of participants are assessed through a probative self-introduction process led by the instructors. Participants are evaluated on their ability to transfer course knowledge into job performance through the exercises and an end-of-course exam. This Participant Guide and other course materials are also introduced.

This module is designed to achieve the following learning outcomes:

1. List steel structure construction inspection experience and state desired learning goals.
2. Summarize the course structure and Global Learning Outcomes.
3. Recognize that performance-based evaluations and an end-of-course exam will be administered.

An 11x17 placemat-type handout is included with the course material (Appendix A). As shown in Figure 1.1, the handout provides an agenda summary and the Global Learning Outcomes. Space is provided for participants to record their relevant experiences and list personal training objectives. Space for notes and questions is also provided.

Presentation Notes

As participants arrive they are asked to complete the experience and personal objectives sections on the placemat-type handout. The intent is to use this as a pre-course activity. At the designated start time, participants are officially welcomed to the course. Instructors start with a brief introduction of their steel structure experience.

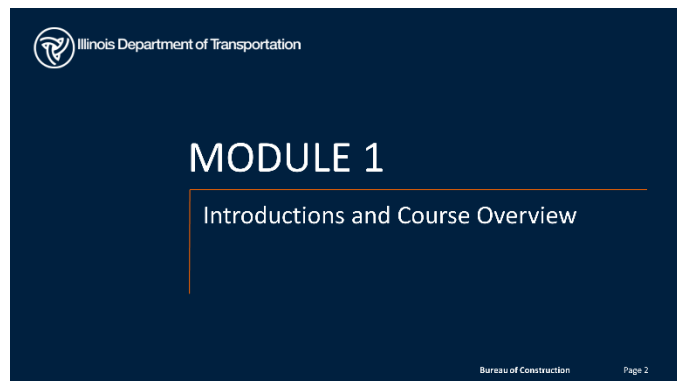




Figure 1.1 - Course placemat -type Handout

| Illinois Department of Transportation | | STEEL STRUCTURE CONSTRUCTION INSPECTION COURSE | |
|--|--|--|--|
| <p>AGENDA</p> <ol style="list-style-type: none"> 1. Introductions and Course Overview 30 min 2. Overview of steel structure documents and inspection responsibilities Break 40 min 3. Acceptance of steel at job site 15 min 4. Erection of steel girders 60 min 4A. Erection - Connections 60 min 5. Qualification testing and inspection of fastening Break 45 min 6. Inspection of secondary members and bearings Exam 30 min <p>Total Training Time 8.5 hrs</p> | | <p>GLOBAL LEARNING OUTCOMES</p> <ul style="list-style-type: none"> Identify structural and fastening systems found in and equipment used for steel structure construction. Describe current Department policies, specifications, and procedures related to the acceptance, erection, installation, and bolting of steel structure girders. Explain the role of the steel structure construction inspector in the acceptance of steel and fasteners at the job site, the safe erection of girders, the verification of fastener installation, and the inspection of other steel components including bracing and bearings associated with steel structure construction. Conduct regular, systematic inspections in accordance with Department standards utilizing, where available, job aids such as checklists or forms. Recognize and report potential problems associated with steel structure construction. | |
| <p>EXPERIENCE</p> <p>List your steel structure construction experience. At the end of the course, check the box if your knowledge of this topic was enhanced as a result of the training.</p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> | | <p>PERSONAL OUTCOMES</p> <p>Check if personal outcome was achieved?</p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> | |
| <p>NOTES</p> | | <p>NOTES</p> | |

Exercise #1.1 - The instructors will lead a probative self-introduction process that selectively calls on participants to share their steel bridge experience and personal objectives. Note that as part of the pre-course activity, participants will have recorded their steel structure construction experience and personal objectives on the 11x17 placemat-type handout (See Figure 1.1 with expanded views provided in Figures 1.2 and 1.3.).

Exercise #1.1

- Name?
- General construction inspection experience?
- Steel structure experience?
- What do you hope to get out of the course?



 Illinois Department of Transportation
Bureau of Construction
Page 4

Through this exchange, the instructors gain an appreciation for the experience level and goals of the participants, which may lead to site-specific training needs that will enhance the course experience for all. At the end of the course, the participants will be asked to self-evaluate their learning to determine if the course enhanced their understanding of the topics covered.

| EXPERIENCE | |
|---|--------------------------|
| <i>List your steel structure construction experience. At the end of the course, check the box if your knowledge of this topic was enhanced as a result of the training.</i> | <input type="checkbox"/> |
| | <input type="checkbox"/> |
| | <input type="checkbox"/> |
| | <input type="checkbox"/> |

Figure 1.2 - Participants record their relevant steel structure experience.

| PERSONAL OUTCOMES | Check if personal outcome was achieved? |
|-------------------|---|
| | <input type="checkbox"/> |
| | <input type="checkbox"/> |
| | <input type="checkbox"/> |
| | <input type="checkbox"/> |

Figure 1.3 - Personal goals for the course

At the conclusion of this exercise, the instructors lead a review of the Global Learning Outcomes and course agenda, which are provided on the 11x17 placemat-type handout (See Figure 1.1 with expanded views of Global Learning Outcomes and agenda provided in Figures 1.4 and 1.5, respectively.)

| GLOBAL LEARNING OUTCOMES |
|---|
| <ul style="list-style-type: none"> ▪ Identify structural and fastening systems found in and equipment used for steel structure construction. ▪ Describe current Department policies, specifications, and procedures related to the acceptance, erection, installation, and bolting of steel structure girders. ▪ Explain the role of the steel structure construction inspector in the acceptance of steel at the job site, the safe erection of girders, the verification of fastener installation, and the inspection of other steel components including bracing and bearings associated with steel structure construction. ▪ Conduct regular, systematic inspections in accordance with Department standards utilizing, where available, job aids such as checklists or forms. ▪ Recognize and report potential problems associated with steel structure construction. |

Figure 1.4 - Global Learning Outcomes

| AGENDA | |
|--|----------------|
| 1. Introductions and Course Overview | 30 min |
| 2. Overview of steel structure documents and inspection responsibilities | 40 min |
| <i>Break</i> | 15 min |
| 3. Acceptance of steel at job site | 60 min |
| 4. Erection of steel girders | 60 min |
| <i>Lunch</i> | 60 min |
| 4A. Erection - Connections | 45 min |
| 5. Qualification testing and inspection of fastening | 110 min |
| <i>Break</i> | 15 min |
| 6. Inspection of secondary members and bearings | 45 min |
| Exam | 30 min |
| Total Training Time | 8.5 hrs |

Figure 1.5 - Course Agenda

Course structure

GOAL: Provide or strengthen the core competencies of IDOT steel structure construction inspectors so as to improve the quality, consistency, and documentation of construction

INTERACTIVE PROCESS

EVALUATION



 Bureau of Construction Page 13

The course has been designed to provide and/or strengthen the core competencies of IDOT steel structure construction inspectors so as to improve the overall quality, consistency, and documentation of construction in Illinois. The course was developed using Instruction System Design methodologies and employs adult learning strategies to make the learning relevant and improve on-the-job performance of IDOT construction inspectors. The course is configured into discrete modules, each with a set of learning outcomes that lead to the

achievement of the global learning outcomes for the course. The course utilizes varied instruction methods consisting of lecture, interactive discussion, small and large group exercises, and self-directed exercises to enhance the learning experience. An end of course exam is administered to validate the effectiveness of the training.

To maximize learning, participants are encouraged to engage in the discussions and exercises. Participants are asked to demonstrate their ability to transfer course knowledge into job performance through the exercises and an end-of-course exam.

The module is concluded with a wrap-up review of the module learning outcomes.

Wrap-up

Module 1 Learning Outcomes

1. List steel structure construction inspection experience and state desired learning goals
2. Summarize the course structure and global learning outcomes.
3. Recognize that performance-based evaluations and an end-of-course exam will be administered.

MODULE 2 - OVERVIEW OF STEEL STRUCTURE CONSTRUCTION

Overview and Instructional Method

This module provides a common base of knowledge related to the terminology and types of documentation that will be covered in the course. Using interactive exercises and discussions, participants are introduced to the terminology and documentation used in steel structure construction. Photographs showing typical steel structure components are presented, and participants are asked to identify proper terminology and inspection tasks associated with each component.

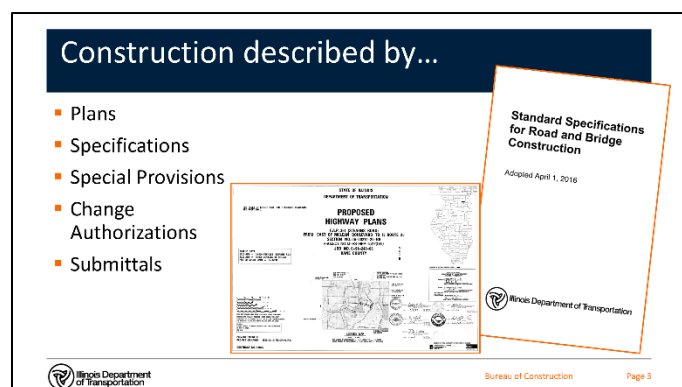
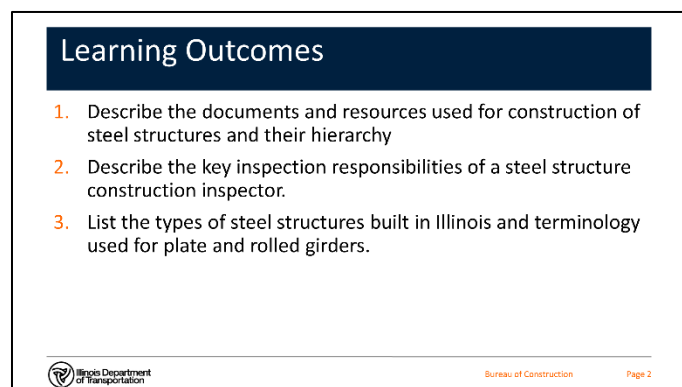
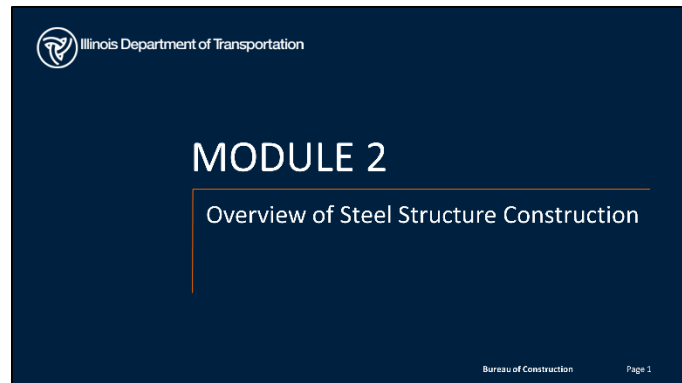
This module is designed to achieve the following learning outcomes

1. Describe the documents and resources used for construction of steel structures and their hierarchy
2. Describe the key inspection responsibilities of a steel structure construction inspector.
3. List the types of steel structures built in Illinois and terminology used for plate and rolled girders.

Presentation Notes

A typical Illinois steel structure construction project is described by plans, specifications, special provisions, change orders, contract, and submittals. These documents describe the responsibilities of the various parties involved in the project and the scope and quality of the final work product. This course generally refers to the provisions of the IDOT *Standard Specifications for Road and Bridge Construction* and *Supplemental Specifications and Recurring Special Provisions*, both of which have an April 1, 2016 adoption date.

Plans typically describe the arrangement, quantities, and sizes of materials used in a steel structure project. Plans may also contain general notes that further describe the work. Addendums or change authorizations to the various construction documents may be issued prior to contract award or throughout a project's lifespan. In either case, they become part of the documents that describe a project. The contract and any submittals required by the construction documents including the progress schedule also describe a project.



Those responsible for construction inspection should review and become intimately familiar with all of these documents prior to executing their duties.

The plans show the location, character, dimensions, and details of the work to be done. (IDOT_SPEC 101.28) For steel structures, the approved plans generally show the bridge layout, profiles, and typical cross-sections within the context of the overall project; elevation and plan views for the foundations, substructure, superstructure and deck; and details specific to each of these elements. The contractor is responsible for performing the work as described in the plans; however before steel fabrication begins, the contractor shall submit shop drawings for review and approval (IDOT_SPEC 505.03) and any other working or layout drawings, as may be required to describe the work. Steel structure construction may then proceed in accordance with the approved shop drawings, and any other drawings or submittals as required. (IDOT_SPEC 105.04)

The specifications describe the manner or method of performing and paying for the work. The specifications also describe the quality of the materials to be furnished and responsibilities of the Department and contractor. (IDOT SPEC 101.43) Special provisions and revisions to the specifications are described in the *Supplemental Specifications and Recurring Special Provisions* and cover conditions peculiar to an individual project. (IDOT SPEC 101.42)


The contract is a written agreement between a contractor and the Department setting forth the obligations of the parties to the performance of the work, the furnishing of labor and materials, and the basis for payment. (IDOT SPEC 101.09) Changes in quantities, alterations in the work, and the performance of extra work may be needed to satisfactorily complete the project. Such changes are described by written agreements that modify the obligations of the parties to the contract. (IDOT SPEC 104.02)

Throughout the project, the contractor is responsible for furnishing a variety of documents that further describe or document the work. These documents are described in the Plans, Specifications, and Special Provisions and are generally termed “submittals”. Upon approval, submittals become part of the requirements for the project. The format and submission requirements for these documents are generally associated with the various elements of the project. For example, the required submittals for steel structures are described in Section 505 of the Specifications while submittals pertinent to concrete structures are described in Section 503. The Progress Schedule is an important submittal and shows how the contractor proposes to execute the various items of work. The schedule is submitted shortly after project award. (IDOT SPEC 108.02)

The various documents that comprise a project are intended to be complimentary to describe the complete project. If a conflict arises between the various documents, the hierarchy described in Section 105.05 of the Specifications shall govern.

Exercise #2.1 - Using Worksheet #2.1 organize the various documents in order of their hierarchy or control of the work from highest to lowest priority.

Worksheet #2.1 - Document Coordination


| | | |
|---|---|--|
| <ul style="list-style-type: none">■ Plans■ Supplemental Specifications■ Standard Specifications■ Recurring Special Provisions■ Special Provisions |  | Highest hierarchy <u>1.</u> _____ <u>2.</u> _____ <u>3.</u> _____ <u>4.</u> _____ <u>5.</u> _____ Lowest hierarchy |
|---|---|--|

Quiz #2.1 - Complete the following interactive quiz.

Quiz #2.1

Plans may include drawings specific to a given project, and general IDOT standard details. In this case, project-specific drawings hold priority over the IDOT standard details.

a) True
b) False

 Bureau of Construction Page 5


Note that standards referenced by the revision number listed in the Index of Highway Standards on the plans shall hold priority over Highway Standards listed elsewhere. (IDOT_SPEC 105.05)

Quiz #2.2 - Complete the following interactive quiz.

Quiz #2.2

The required dimension for a particular bridge detail is NOT specified in the drawings, but can be obtained by scaling the drawing or using other available information to calculate the dimension. In this case, the scaled dimension holds priority over the calculated dimension.

- a) True
- b) False

Bureau of ConstructionPage 6


Additionally, the following manuals and policy memorandums pertinent to the construction inspection of steel structures are available on the IDOT website at www.idot.illinois.gov, under the Doing Business/Procurements/Construction/Contractor's Resources or Doing Business/Material Approval.

- Construction Manual (IDOT_CM)
- Manual for Materials Inspection (IDOT_MMI)
- Product Procedures Guide (IDOT_PPG)
- Policy Memorandums

The above manuals do not constitute a set of specifications, and nothing in these document changes the requirements described in the contract documents, drawings, or specifications unless specifically referenced by the contract documents. Rather, these manuals provide clarification of IDOT specifications and tools (e.g. checklists) for use by the inspectors to ensure the quality of construction. Those responsible for construction inspection should review and become intimately familiar with all of these documents prior to executing their duties.

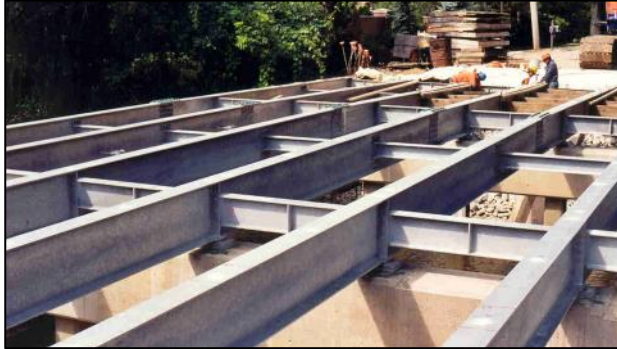
IDOT manuals and policy memos

- Construction Manual
- Manual for Materials Inspection
- Product Procedures Guide
- Policy memorandums

Bureau of ConstructionPage 11

The remaining portion of this module was developed to provide familiarity with terminology and construction details common to steel structures. Superstructure steel systems may include rolled beam, plate girders, box girders, and trusses. This course will focus primarily on rolled beam and plate girder bridges, as these superstructure systems are the most commonly used. Example photographs of these systems are presented below.

Exercise #2.2 - Identify the bridge type and list the common elements typically associated with each.



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| Bridge Type: |
| Common Elements: |
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| Bridge Type: |
| Common Elements: |
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| Bridge Type: |
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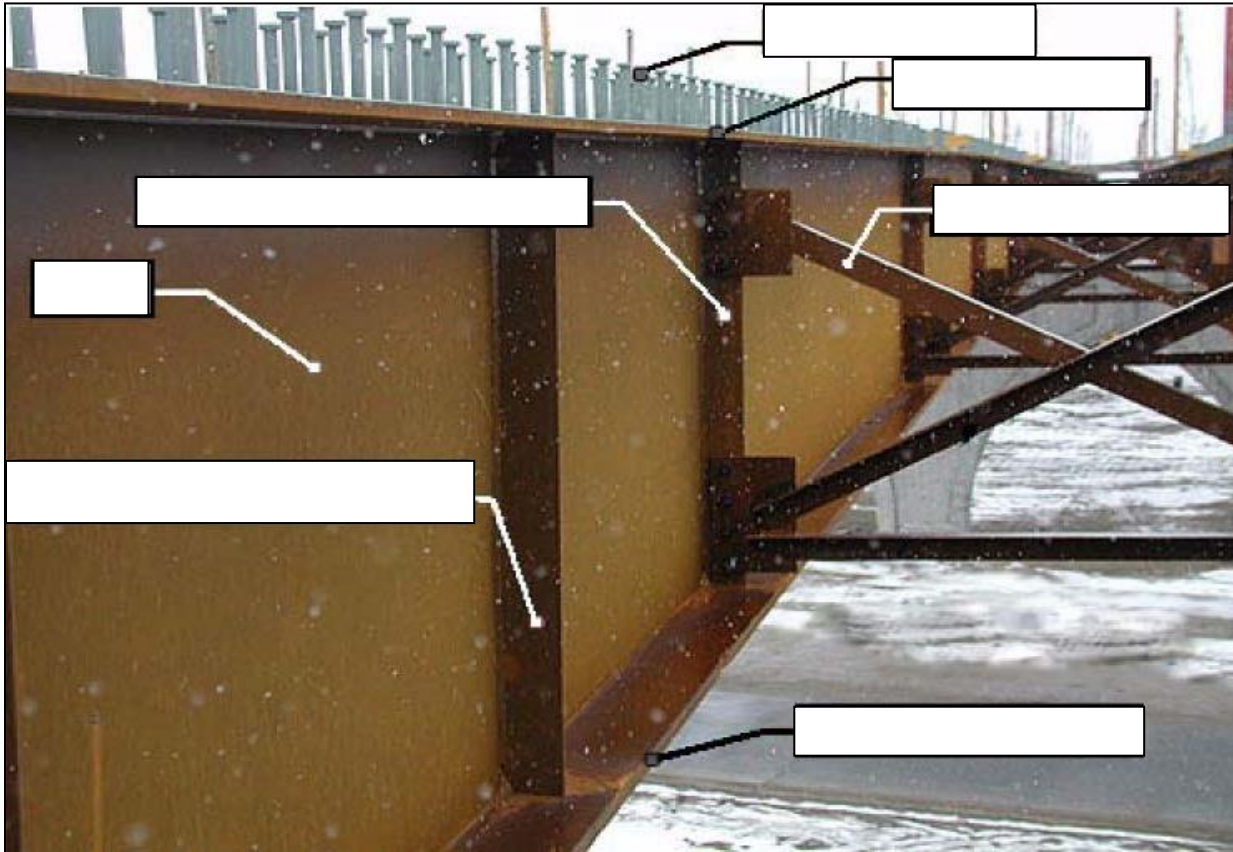


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| Bridge Type: |
| Common Elements: |
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| Bridge Type: |
| Common Elements: |
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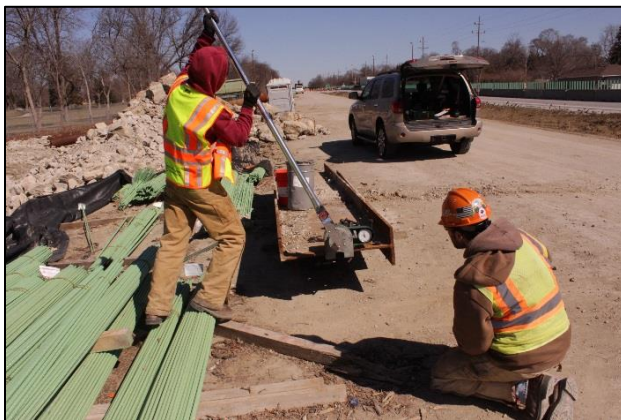
Quiz #2.3 - Identify the common elements of a plate girder superstructure.



Exercise #2.3 - For each of the following bridge construction photos, list typical responsibilities of the steel structure construction inspector. Limit responses to responsibilities associated with construction of steel elements.



| Typical responsibilities of steel structure construction inspector: |
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| Typical responsibilities of steel structure construction inspector: |
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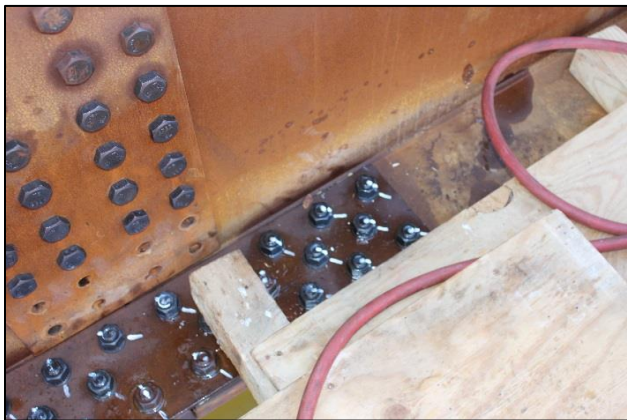
| Typical responsibilities of steel structure construction inspector: |
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| Typical responsibilities of steel structure construction inspector: |
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| Typical responsibilities of steel structure construction inspector: |
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| Typical responsibilities of steel structure construction inspector: |
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The module is concluded with a wrap-up review of the module learning outcomes.

Wrap-up

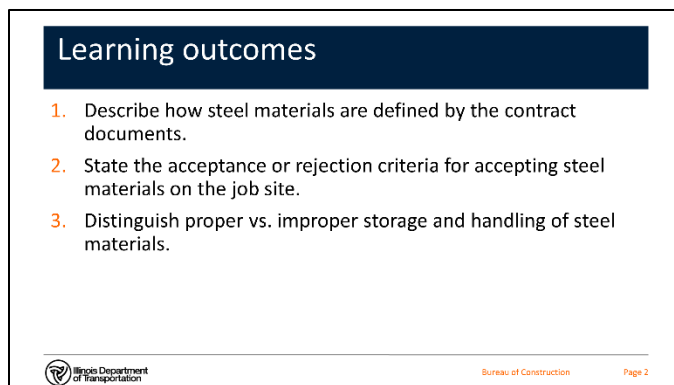
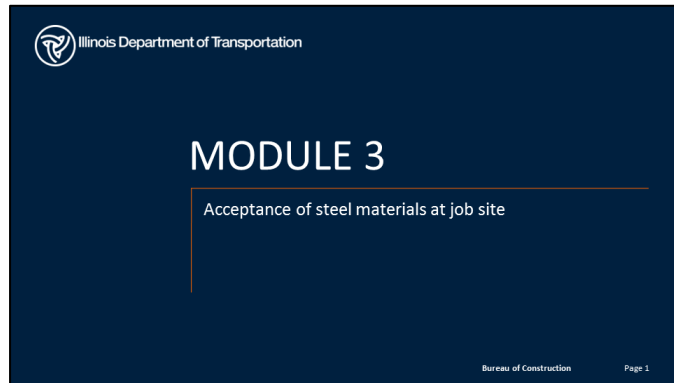
Module 2 Learning Outcomes

1. Describe the documents and resources used for construction of steel structures and their hierarchy
2. Describe the key inspection responsibilities of a steel structure construction inspector.
3. List the types of steel structures built in Illinois and terminology used for plate and rolled girders.

 Illinois Department of Transportation Bureau of Construction Page 17

MODULE 3 - ACCEPTANCE OF STEEL MATERIALS AT JOB SITE

Overview and Instructional Method



Interactive exercises and discussions are used to convey how steel materials are described in contract documents. Steel materials include structural steel, fasteners, and bearings. Emphasis is placed on understanding how the requirements for these materials are described in the contract documents and requirements for their acceptance at the project site. Record keeping requirements for steel materials are discussed. Proper handling and storage of steel materials is also reviewed. Participants practice how to maintain records and utilize IDOT job aids for steel material acceptance.

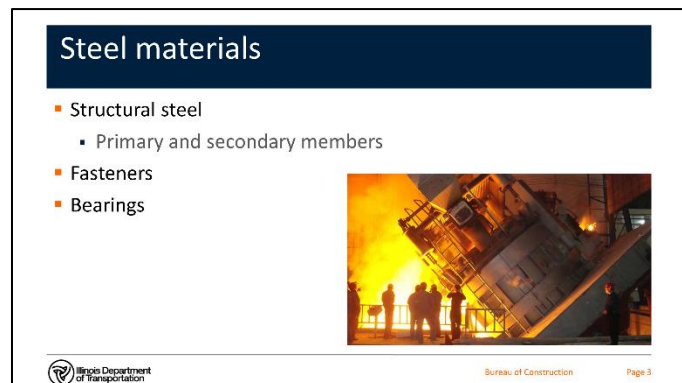
Module 3 is designed to achieve the following learning outcomes

1. Describe how steel materials are defined by the contract documents.
2. State the acceptance or rejection criteria for accepting steel materials on the job site.
3. Distinguish proper vs. improper storage and handling of steel materials.

Presentation Notes

Those engaged in the construction inspection of steel structures will be responsible for the inspection and acceptance of steel materials. While it is understood that steel materials may also be used in substructures, foundations, and other bridge elements, this course focuses on the understanding of the following steel superstructure components:

- Primary members (Girders)
- Secondary members (Cross frames, lateral bracing, diaphragms, etc.)
- Fasteners
- Bearing assemblies



Structural steels used in bridges will be subject to a harsh outdoor environment for 50 to 100 years; relatively large temperature changes, both seasonally and daily; and millions of cycles of live loading. In addition, Illinois steel bridges will be exposed to corrosive environments containing chlorides, primarily from de-icing salts. To perform safely under these conditions, structural steel bridges must meet strength, ductility, and durability requirements for all loading combinations expected over their life span. This

includes providing adequate performance with respect to fatigue and fracture limit states. For these reasons, structural steels used in Illinois bridges are required to meet corrosion resistance and fracture toughness requirements that generally exceed those found in building applications. The material requirements for structural steel used as primary (e.g. superstructure, girders, trusses, etc.) and secondary members (e.g. cross frames, diaphragms, etc.) are reviewed in the next few slides.

Section 1006.04 of the IDOT SPEC describes the general requirements for structural steel. Unless noted otherwise in the project documents, structural steel shall conform to AASHTO M270, Grade 36. Grade 36 steel is considered a weldable, carbon-manganese structural steel. It is the easiest and cheapest to produce and has a minimum yield strength of 36 ksi. The steel making practice in the U.S. has moved away from blast furnace operations which relied on the use of iron ore to electric arc furnace operations where large percentages of scrap steel is used to produce modern structural steels. The use of scrap materials introduces alloying elements into the steel that improves its strength. Consequently, steels delivered today as Grade 36 will typically have yield strengths closer to 50 ksi.

Structural steel

- **AASHTO M270 Grade 36 (IDOT Default)**
 - Plain carbon steel
 - Still available in plate and some angle sizes and used as secondary members
- **AASHTO M270 Grade 50 (Most common)**
 - High-strength low-alloy steel
 - Available in plates, shapes, and angles
 - Most common steel used in painted or galvanized applications

Illinois Department of Transportation Bureau of Construction Page 4

Grade 50 is the most common grade of structural steel used today in bridge construction. It is manufactured with the addition of small alloying materials typically consisting of columbium, vanadium, and sometimes titanium. The addition of these alloys cause a 39% increase in the yield strength as compared to A36 steels. It is the most common material choice for primary bridge members that are to be painted or galvanized for service. Despite the more common use of Grade 50 steels, the IDOT_SPEC specifies Grade 36 as the default material unless otherwise noted

Corrosion resistance is an important consideration in the selection of structural steel materials for IDOT structures given the frequent use of de-icing salts on Illinois roadways. To help off-set the deleterious effects of corrosion, a special version of Grade 50 steel was developed. This material meets the requirements of AASHTO M270, Grade 50W, where “W” stands for weathering. This steel is commonly referred to as “weathering steel” and is often used in unpainted applications, or in painted applications beneath joints where high concentrations of chlorides are expected from deck run-off. “Weathering steel” achieves its enhanced atmospheric corrosion resistance through the addition of copper, chromium, and nickel.

Structural steel

- **AASHTO M270 Grade 50W**
 - High-strength low-alloy steel
 - **W**eathering characteristics that slow atmospheric corrosion
- **AASHTO M270 Grade HPS70W**
 - Quenched and tempered low-alloy steel
 - Improved weldability characteristics
 - **W**eathering characteristics that slow atmospheric corrosion

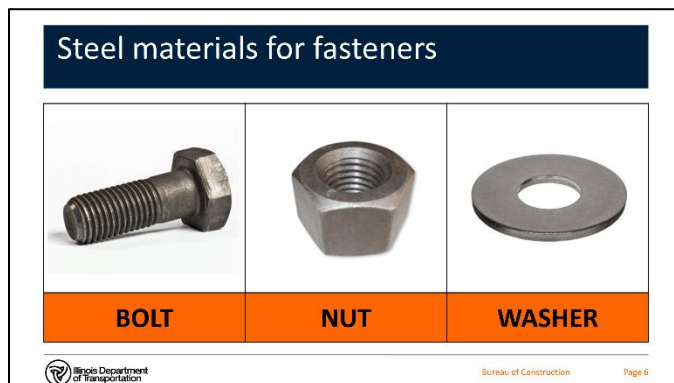
Illinois Department of Transportation Bureau of Construction Page 5

All steels interact with their environment. When the constituent materials at the steel surface interact with oxygen in the presence of water or air moisture, they are oxidized to form what is typically called rust. As the process progresses, the rust forms a barrier to the environment which slows the oxidation process but does not eliminate it. The rust layer on most ordinary steels (Grade A36 and A50) is porous and not tightly

adhered to the surface, which allows the corrosion process to continue when the barrier is disturbed. With “weathering steel”, the rusting process proceeds in much the same manner. However, the addition of copper, chromium, and nickel causes the initial corrosion layer to be densely developed and tightly adhered to the surface. This rust layer, or “patina”, provides a stable barrier that impedes further access to oxygen, moisture, and contaminants. The weathering resistance is similar to the way a copper roof is protected from corrosion as it transitions from its original color to a green patina due to the oxidation process.

“Weathering steels” will perform well under most conditions except when the surface is exposed to extended periods of moisture. When moisture is trapped against the surface of “weathering steel”, it eventually penetrates the patina causing the corrosion process to accelerate.

To achieve longer bridge spans with less material, engineers and manufacturers developed high strength, high performance steels that have yield strengths in the 70 to 100 ksi range. These materials are described by the AASHTO M270, Grade HPS70W specification, where “HPS” stands for “high performance steel” and “W” stands for “weathering”. These materials are developed through special chemistries and manufacturing processes. In addition to higher yield strengths, they have improved weldability and enhanced fracture toughness as compared to non-HPS grades. These higher strength materials are only provided in a “weathering steel” grade for bridge use. HPS steels cost more than conventional steel, and are only used in special situations, and will be governed by project-specific provisions generally associated with long span bridges.



Fasteners consist of three components: bolt, nut, and washer. For clarity throughout this guide, the term bolt is used only to refer to the headed stud shown in the left side of the slide. Fastener is used to refer to the assembly of all three components. Furthermore, the fastener may be one of several types as described later. The fastener shown here is comprised of a heavy hex head bolt, heavy hex head nut, and hardened washer, which represents the most common fastener system used in Illinois.

Heavy hex structural bolts for members requiring slip critical connections, which is the most common superstructure connection, are required to meet the requirements of ASTM A325¹ or A490². A325 and A490 bolts are intended for use in connections assembled in accordance with the requirements of the Research Council on Structural Connections Specifications (RCSC). The minimum tensile strength for A325 bolts is 120 ksi for diameters up to and including 1 inch and 105 ksi for diameters beyond 1 inch. A490 bolts are heat-treated to achieve a higher minimum tensile strength of 150 ksi, for all diameters.

The ASTM A325 and A490 specifications describe two chemistry requirements for bolts, and are designated as Type 1 and Type 3. The Type 2 bolt designation was withdrawn from the A325 specification

¹ Formerly under the jurisdiction of Committee F16 on Fasteners, this guide was withdrawn in May 2016 and replaced by Specification F3125/F3125M for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions.

² Formerly under the jurisdiction of Committee F16 on Fasteners, this specification was withdrawn in May 2016 and replaced by Specification F3125/F3125M for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions.

in 1991 and the A490 specification in 2002. Type 1 bolts are suitable for painted and galvanized applications and have chemistry compatible with carbon-manganese steels. Type 3 bolts have atmospheric corrosion resistance and weathering characteristics compatible with weathering steel chemistry. Type 3 bolts are used in unpainted applications in conjunction with other weathering steel materials.

A325 is the most common heavy hex head bolt used in Illinois, and is the default bolting material per IDOT_SPEC 1006.08. A490 bolts are typically used in large connections where the higher strength of these bolts allow fewer fasteners to be used. The IDOT_SPEC 1006.08 indicates that bolts, nuts, and washers shall conform to ASTM A325, although strictly speaking this specification pertains to bolts only. The ASTM A325 specification does however provide reference to other ASTM specifications for compatible nuts (See ASTM A563) and washers (See ASTM F436). It should be further noted that six ASTM specifications pertinent to heavy hex head bolts (A325, A325M, A490, A490M) and twist-off bolts (F1852, and F2280) have been consolidated and replaced by ASTM F3125/3125M effective May 2016.

Galvanized heavy hex head bolts fabricated using the hot-dipped or mechanically galvanized process are permitted under the IDOT specifications, and may be A325. However, galvanized A490 bolts are not allowed by IDOT. Because of their higher strength, A490 bolts are susceptible to stress corrosion cracking and embrittlement that may accompany the galvanizing process. Because of the possible adverse effects caused by the galvanizing process, all galvanized fastener assemblies are required to be tested by the manufacturer to ensure they meet adequate strength and ductility requirements.

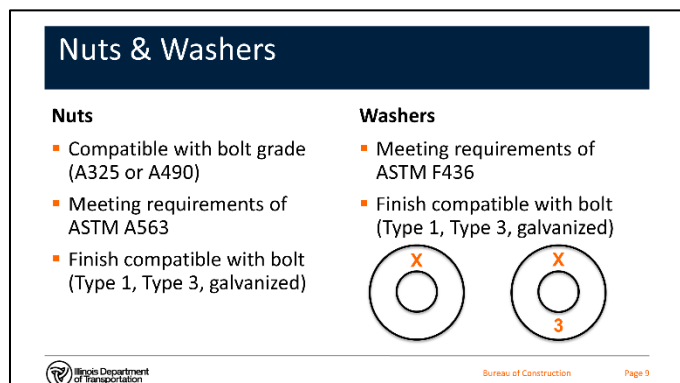
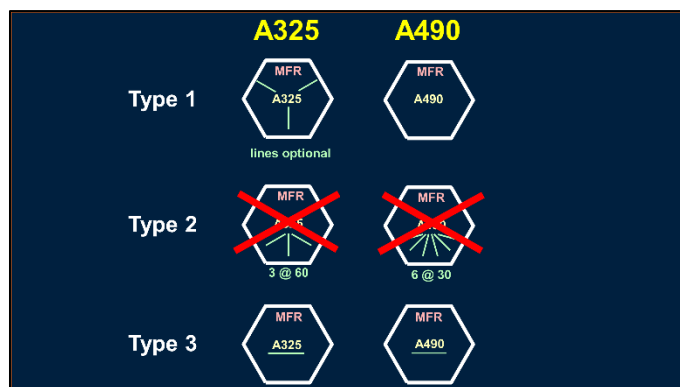
Fasteners are marked for easy identification. Head markings on bolts indicate the strength (ASTM A325 or A490) and type of bolt (Type 1 or Type 3). Type 3 bolts shall have the strength grade underlined. Bolt heads will also bear the mark symbol of the manufacturer. All markings shall be located on the top of the bolt head and may be raised or depressed at the option of the manufacturer. The IDOT Fastener Identification Guide (IDOT_FG) provides additional information about bolt markings used in Illinois.

Compatible nuts and washers are required for use with A325 or A490 structural bolts. The nuts must meet the appropriate grade as

| High strength bolts | | |
|---------------------|----------------|------------------------|
| Grade | Diameter (in.) | Tensile Strength (ksi) |
| A325* | 0.5 to 1.0 | 120 |
| | 1.125 to 1.5 | 105 |
| A490** | All | 150 |

* Available in Type 1 or Type 3 grades.
 • Type 1 compatible with carbon steels in painted or galvanized applications
 • Type 3 compatible with weathering steel in unpainted applications
 * Galvanized A490 bolts not permitted.

Illinois Department of Transportation Bureau of Construction Page 7



described in the ASTM A563 specification. This means that the nut must be strong enough and have a thread engagement depth sufficient to develop the strength of the bolt before the nut threads strip. A563 nuts are available in a variety of grades (based on hardness due to method of manufacture) and come in both hex and heavy hex sizes. The most common nut grade used in Illinois is A563, DH. Construction inspectors are advised to contact the bridge office when other nut grades are shipped.

Similar to bolts, nuts are marked with the grade designation or have three circumferential lines 120 degrees apart. All nuts shall also be marked with a symbol identifying the manufacturer. Markings may appear on the top or bearing surface of the nut or one of the wrenching flats. Markings located on the top or bearing surface or on the top of the flange shall be positioned with the base of the mark oriented toward the nut periphery.



Washers meeting the requirements of ASTM F436 specification are required under all parts of the bolt assembly that will be turned during installation, regardless of the method of tightening. (IDOT_SPEC 505.04(f)2). Washers should be compatible with the bolt finish (Type 1, Type 3, or galvanized). As discussed in more detail later, it is noted that the washer supplied for twist-off applications must be provided by the assembly manufacturer. Other requirements pertinent to washer use are discussed later in this course.

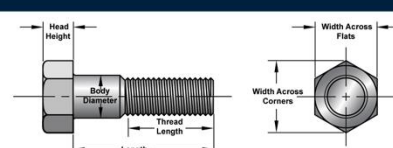
All circular washers shall be marked with a symbol identifying the manufacturer using depressed markings. Washers having improved atmospheric corrosion resistance and of a weathering type shall be marked with the numeral “3”. Markings shall be depressed.

The IDOT_FG provides additional information about bolt, nut, and washer markings used in Illinois. “X” used in the above slides represents the manufacturer.


The IDOT_BM requires the following standard note be included on bridge drawings, when applicable.

Fasteners shall be ASTM A325 Type 1, mechanically galvanized bolts (in painted areas and ASTM A325 Type 3 in unpainted areas). Bolts ___ in. Φ , in holes ___ in. Φ , unless otherwise noted.

Fastener materials



Fasteners shall be ASTM A325 Type 1, mechanically galvanized bolts (in painted areas and ASTM A325 Type 3 in unpainted areas). Bolts ___ in. Φ , in holes ___ in. Φ , unless otherwise noted. IDOT General Note


Bureau of Construction
Page 11

Heavy hex head fasteners represents the most common fastening system used in Illinois, and are specified by diameter and length.

The material requirements for structural steel are provided by the AASHTO specifications by reference in IDOT Specification Section 1006.04. The material requirements for fasteners are generally provided by the ASTM specifications by reference in IDOT_SPEC 1006.08. AASHTO specifications and ASTM specifications are referenced for hot dipped and mechanical galvanized fasteners, respectively. The use of

AASHTO designations is generally limited to bridge owners, while producers, fabricators, and others who supply steel materials to both bridge and non-bridge owners often use the corresponding ASTM designations. The use of AASHTO or ASTM standards can cause confusion, although in most cases the two are identical for most steel products. The adjacent slide shows the applicable AASHTO and ASTM standards for typical steel product categories. The use of “M” following the designation represents the metric equivalent. As noted above, the A325 and A490 specifications have been phased out and replaced by ASTM F1325.

All in a name...

| Product | AASHTO | ASTM |
|------------------|---------------------------------------|--------------------|
| Structural Steel | M 270/M270M | A709/A709M |
| Bolts | M164 M253 | A325* A490* |
| Galvanized Bolts | M232/M232M, Class C M298, Class 50 | A153/A153M B695 |
| Nuts | M291 | A563 |
| Washers | M293 | F436 |

** Effective 5/2016, ASTM replaced these specifications with F1325*

Illinois Department of Transportation Bureau of Construction Page 12

Given the above discussion regarding Type 1 and Type 2 fasteners, and the exclusion of galvanizing for A490 bolts, it is prudent here to provide a few remarks regarding galvanizing treatments. Two types of processes may be employed to fabricate galvanized fastener components; either hot-dipped or mechanical galvanizing. In the hot dipped galvanizing process, the fastener components are degreased and cleaned using caustic and acid solutions. After rinsing, the bolt, nut, and washer are dipped in molten zinc, where a metallurgical reaction occurs between the liquid zinc solution and the fastener steel. This reaction produces a series of zinc-iron alloys that form on the fastener surface. The zinc layers are anodic to steel providing a sacrificial coating for corrosion protection. The zinc coating also provides a barrier further protecting the fastener material from corrosion. The full process is described in ASTM A153.

Under the mechanically galvanizing process, the fastener is similarly cleaned and rinsed. This is followed by tumbling of the fastener component in a barrel with glass beads and zinc powder. The glass to fastener component impact causes the zinc powder to be mechanically cold welded to the surface of the fastener. The process is performed at room temperatures, unlike the hot dipped process which involve elevated temperatures. The mechanical galvanizing process generally produces a more uniform coating thickness on the threaded elements of the fastener as compared to the hot dipped process, although the hot dipped process provides better zinc adherence at sharp corners and edges. The mechanical galvanizing process is described in ASTM B695.

It is very easy to distinguish between the two galvanizing processes. Hot dipped components have a shiny, irregular coating appearance while mechanical galvanized components have a dull, uniform appearance.

Galvanizing treatments

- Hot-dipped galvanized
- Mechanical galvanized



Note: Lubricant shall have a color that contrasts with the zinc coating

Illinois Department of Transportation Bureau of Construction Page 13



Nuts are generally lubricated with a colored lubricant. For example, green and pink lubricants for hot-dipped and blue for mechanically galvanized. Although this is just a rule of thumb, as lubricant colors vary by manufacturer. Additional discussion regarding special treatment for galvanized fasteners is provided in Module 6.

Bearing assemblies come in a wide variety of styles and materials that vary from simple steel plates or elastomeric pads to complicated, proprietary systems (e.g. pot bearings). Per IDOT_SPEC 521.04, bearings shall be furnished as a complete unit from one manufacturing source. As such, the materials and finish for bearings will be described in the drawings and special provisions, both of which are specific and unique to the project in which the bearings will be used. When bearings arrive at the project site they will be accompanied by documentation describing the materials and finish used. The documentation will be compared to project-specific requirements. Additional discussion of bearing assemblies is provided in Module 5.

Quiz #3.1 thru #3.3 - Complete the following questions.

Quiz #3.1

ASTM A490 bolts may be mechanically galvanized, but not hot-dip galvanized?

- a) True
- b) False, neither can be galvanized in any form
- c) False, ASTM A490 bolts may also be hot-dip galvanized

Quiz #3.2

What is the correct designation for a high-strength ASTM A325 bolt that has weathering steel characteristics?

- a) ASTM A325-3
- b) ASTM A325W
- c) ASTM A325, Type 3
- d) None of the above

Structural steel quiz #3.3

What is the steel grade shown in this delivery ticket?



- a) Grade 50
- b) Grade 36
- c) Grade 709

Construction materials do not just “appear” on the jobsite. In most cases, the material has been pre-inspected or may have been produced under a Department-approved Quality Control program. Evidence of Materials Inspection is the minimum proof that Method of Acceptance sampling and testing has been performed. The remainder of this module identifies the type of evidence that is required for steel structure materials. Detailed information regarding materials inspection programs such as certified products, Quality Control/Quality Assurance (QC/QA) programs, Evidence of Inspection, and fabrication inspections can be found in the Manual for

Job site acceptance and storage

- Structural steel
 - Primary members
 - Secondary members
- Fasteners
- Bearing assemblies



Construction materials do not just “appear” on the jobsite. In most cases, the material has been pre-inspected or may have been produced under a Department-approved Quality Control program. Evidence of Materials Inspection is the minimum proof that Method of Acceptance sampling and testing has been performed. The remainder of this module identifies the type of evidence that is required for steel structure materials. Detailed information regarding materials inspection programs such as certified products, Quality Control/Quality Assurance (QC/QA) programs, Evidence of Inspection, and fabrication inspections can be found in the Manual for


Materials Inspection (IDOT_MMI). If the Evidence of Materials Inspection is not clear, contact the Bureau of Materials and Physical Research (BMPR) for assistance.


The inspector/resident engineer is responsible for ensuring all materials are inspected and approved before they are used in the work. While it is understood that the inspector may not perform all these duties personally, he/she should ensure that inspections, sampling, and testing are done in accordance with the Project Procedures Guide (IDOT_PPG) and the pertinent specifications and policies contained or referenced in the project documents.

Exercise #3.1 - List the duties of the inspector when structural steel (primary and secondary members) arrives at the project site.

Acceptance of structural steel

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.



Bureau of ConstructionPage 25

Materials arriving at the project site should be accompanied by Evidence of Materials Inspection tag. The inspector has the right to question, sample, and/or reject material arriving on the project. The inspector should contact the District Office for guidance when materials arrive without an Evidence of Materials Inspection tag. It is the contractor's responsibility to source and supply materials that are in compliance with the project requirements. The contractor is also responsible for providing Evidence of Inspection tags for all materials delivered to the job site.

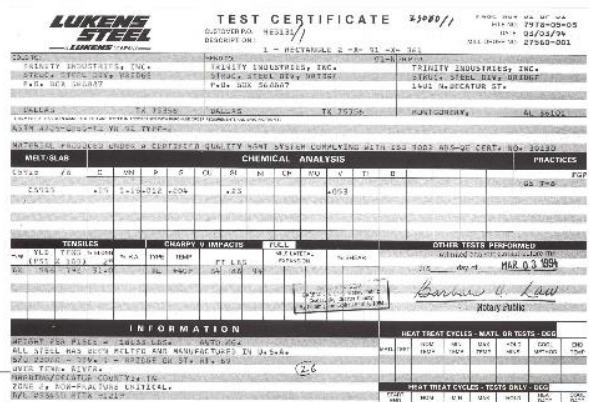
The following items may be submitted as Evidence of Materials Inspection for structural steel (IDOT_MMI). The inspector will collect these items upon arrival. The inspector should also collect the Bill of Lading, which should show the product identification or piece number as referenced to the approved shop drawings, source, lot, and weight.


- The BBS59 report which identifies BBS's acceptance of fabrication of structural steel. BBS usually performs this inspection and testing. (See next page)
- CERT which is the manufacturer's written certification that indicates material complies with the specifications or contract. (See below) A visual examination of the materials and accompanying paperwork is required.

The Illinois Steel Products Procurement Act (30 ILCS 565/1) applies to all structural steel materials used in Illinois bridges. This act requires steel products used or supplied in the performance of public works contracts or any subcontract thereto be manufactured or produced in the United States.

Evidence of Inspection


- BBS59 (or BB59)
- CERT






Mill certificates

- Specification designation
- Heat number
- Chemical analysis
- Nominal plate sizes
- Tension test results (F_y , F_u , percent elongation, gage length)
- Heat treatments (including final tempering requirements)
- Supplemental testing (e.g. CVN)


Bureau of Construction
Page 21



**Illinois Department
of Transportation**

Structural Fabrication

Original To: _____ Date: _____
Fabricator

Fabricator Address: _____

Fabricator Job Number: _____ IDOT Contract No.: _____

Route _____ Section _____

County _____ Structure Number _____

Subject: _____

1. Structural Steel Materials verified by comparison with:
 - Mill Test Reports the fabricator must submit to the Bureau of Materials and Physical Research (BPMR).
 - Material Assignment Sheets furnished by BPMR after entering on Mystic Systems.
2. High Strength Bolts (M164/A325 or M253/A490) have been:
 - Sampled at producer by BPMR and approval: Received Not received
 - Sampled at fabricator (inspector witnessed) and BPMR approval: Received Not received
 - No sampling witnessed, no BPMR approval received.
 - Required only for bracing connections, etc. in shop.
 - Required for primary connections in shop.
 - Shop bolts tested for Rotational Capacity (RC) and Installation Check Torque (ICT).
3. Shop Painting
 - Blast Profile / surface preparation (SP _____) and corners acceptable prior to primer application.
 - Primer applied and accepted – manufacturer, trade name and batch number: _____
 - BPMR approved batch number: _____ Dated: _____
4. Field check / acceptance waived to RE for: _____
5. Approved shop drawings received by Inspector

Comments: _____

Printed name and title of Fabricator's Representative

Signature of Fabricator's Representative

Signature of Inspector for Illinois Department of Transportation

Agency (if other than IDOT)

Copies To: District Engineer
 Bridge Engineer
 Contractor

All signatures on Original in Blue Ink

888 59 (Rev. 3/2000)

Members will be identified using a unique, permanent marking system to correctly determine the position of the member in the final bridge assembly, as described by shop and erection drawings. (IDOT_SPEC 505.07) Parts of connections reamed or drilled in assembly shall be individually match marked while assembled and so indicated in the shop drawings. Die stamp markings shall be lightly struck to produce an impression that can be clearly seen, but does not unnecessarily create a stress riser in the member.

Markings

- Member identification
 - Tags
 - Permanent marker
 - Stamped
- Match marks



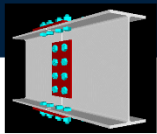
Illinois Department of Transportation Bureau of Construction Page 29

Upon arrival, the inspector will inventory the steel based on their markings. This is typically done using the shop drawings, a highlighter to mark receipt of members on the drawings, and keel to mark the steel once it has been inspected.

Faying surfaces are surfaces placed in contact during bolting operations and include the surfaces beneath the bolt head, nut, and/washer. The faying surface shall be free of the following: dirt and loose scale (except tight mill scale), burrs, pits, oil, paint and lacquer, galvanizing, and any other thing that would prevent a completely tight joint. Inspect faying surfaces upon arrival at the job site, and report discrepancies to the bridge office.

Faying surface

- Free of rust, scale except tight mill scale, burrs, paint, oil, or other contaminants



| Class A | Class B | Class C |
|--|--|-------------------------------------|
| Clean mill scale | Unpainted blast-cleaned steel | Hot dipped galvanized and roughened |
| Blast-cleaned steel with Class A coating | Blast-cleaned steel with Class B coating | Slip coefficient 0.35 |
| Slip coefficient 0.33 | Slip coefficient 0.5 | |

Illinois Department of Transportation Bureau of Construction Page 30

The proper functioning of structural connections depends on the ability of the plate surfaces within the connection to develop frictional resistance once clamped together. In general, bridges to receive a final top coat of paint will arrive at the project site with the faying surface coated by a special primer. Areas to be covered by splice plates will be masked off and primed. Presence of top coat should be documented and reported to the bridge office.

Weathering steel bridges will be blast cleaned; connections at expansion joints will be primed with a special primer. The type of preparation determines the class of finish (Class A, B, or C) and the frictional resistance provided by the surface.

The finished bolt hole diameter shall be 1/16 inch larger than the nominal diameter of the fasteners. Holes may be Standard (STD), Oversized (OVS), Short-Side Slotted (SSL), or Long-Side Slotted (LSL). Holes sizes for each hole category are presented in Figure 3.1 for 3/4, 7/8 and 1 inch diameter bolts. Hole sizes for other bolt diameters can be determined using the formula in Figure 3.2. The hole fabrication process is dependent upon the size

Bolt holes

- 1/16 in. larger than bolt diameter
- Visually inspect hole
 - Inside surface free of defects
 - Edges smooth and free of burrs
- Visually inspect hole alignment

| | |
|------------|------------|
| STD | Standard |
| OVS | Oversize |
| SSL | Short Slot |
| LSL | Long Slot |

Illinois Department of Transportation Bureau of Construction Page 31

of the fastener and materials and number of plates to be joined. Regardless of the processes used, the inspector shall examine holes to ensure damage has not occurred during transit and their condition is suitable for use in the final structure. The inside hole surface should be clean cut without torn or ragged hole edges. Hole edges should be smooth to allow proper fit-up of adjacent plies.

Holes may be punched or drilled. However, IDOT_SPEC 505.04(d) places limits on the thickness of steel that can be punched, as well as limiting the use of punched holes to thinner materials, typically comprising secondary members. Holes in carbon steels thicker than 3/4 in. or alloy steel thicker than 5/8 in. shall be drilled or subdrilled and reamed. Punching or subpunching of these materials shall not be permitted. For thinner materials, punching or drilling is permitted. Where subpunched or subdrilled holes are permitted, final hole geometry may be obtained by reaming.

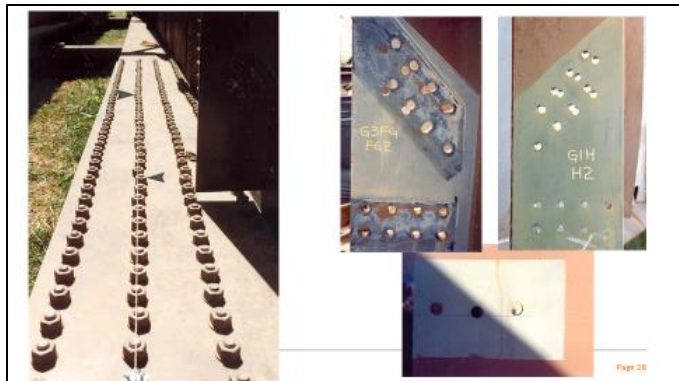
| | 3/4" | 7/8" | 1" |
|------------|--------------------------|---------------------------|----------------------------|
| STD | 13/16 | 15/16 | 1-1/16 |
| OVS | 15/16 | 1-1/16 | 1-1/4 |
| SSL | 13/16 x 1 | 15/16 x 1-1/8 | 1-1/16 x 1-5/16 |
| LSL | 13/16 x 1-7/8 | 15/16 x 2-3/16 | 1-1/16 x 2-1/2 |

Figure 3.1 - Holes sizes for 3/4, 7/8 and 1 inch diameter fasteners

| | |
|------------|---|
| | $D \geq 1-1/8"$ |
| STD | $d + 1/16"$ |
| OVS | $d + 5/16"$ |
| SSL | $(d + 1/16") \times (d + 3/8")$ |
| LSL | $(d + 1/16") \times (2.5 \times d)$ |

Figure 3.2 - Holes calculations

Poor examples of hole fabrication are shown in the adjacent slide. Note the errant placement of holes and alignment issues. These connections were accepted, and later contributed to a bridge failure during construction. A case study of this failure is presented later in the course.



Mishandling during transportation, unloading, and storage of structural steel can result in damage to surface coatings, welds, or the primary girders and secondary bracing members themselves. As such, it is important that the condition of each individual item is checked prior to incorporation in the project. A general inspection of the member should include a quick review of the geometry, sweep, and camber to make sure the member fabrication is in general conformance to the shop drawings and has not been altered during shipment. In situations where fabrication and erection are performed under separate contracts, damage inspections must be performed upon arrival and while steel is being unloaded. (IDOT_SPEC 505.07(a))


Edges of material should be smooth, free of cracks or notches and cut to an accurate profiles, e.g. straight and true. Re-entrant cuts shall have a radius of not less than 3/4 in. and finished smooth. Rough surfaces or gouges should be brought to the attention of the engineer for review and possibly repair. Bearing surfaces shall be finished to within 1/16 in. of planar, and shall be smooth. (IDOT_SPEC 505.04)


Damage findings should be documented with notes and photographs and reported to the bridge office before the work is incorporated into the final project.

Exercise #3.2 - When reviewing a steel girder or secondary bracing member, list the types of damage commonly observed and where such damage occurs.

Damage inspection: What & Where

1. Bolt holes and faying surfaces (as discussed)
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.





Bureau of Construction

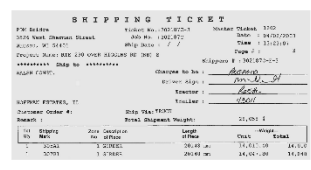
Page 35


Structural steel members should be shipped in the upright position, secured to the transit vehicle in a manner that prevents damage, deformation, or excessive stress. (IDOT_SPEC 505.07) The tie down points should be protected from abrasion due to rubbing of the tie down devices. Bearing surfaces should similarly be protected from abrasion during transit. The materials should be accompanied by the required documentation described previously in this module.

Structural materials shall be removed from the transit vehicle in accordance with an approved lifting plan as described in the erection submittal. Materials shall be stored above ground and protected from dirt, grease, or other foreign matter. Platforms, skids, blocking or other supports may be used to keep structural materials off of the ground. These materials should also be protected, as far as is practical, from corrosion.

Shipping

- Girders and beams should be shipped in upright position
- Secured to transit vehicle in manner to prevent damage, deformation, and excessive stress
- Accompanied by paperwork





Bureau of Construction

Page 37

When possible, ground support for girders shall be placed near the same location as the final bearings or at locations where girders were supported during transit. Tall beams and girders shall be shored to prevent rotation or buckling. Kickers or lateral supporting members shall be located to prevent out-of-plane displacement of the top flange. Girders and beams shall be handled, stored, and shipped in an upright position that matches the final erection position, unless otherwise approved by the engineer.

Handling and storage

- Stored above ground
- Kept free of dirt, grease, or foreign matter
- Protected from corrosion

For long steel members or large assemblies, lifting points, temporary supports and lifting sequences shall be identified in the erection drawings. Calculations shall be submitted to the engineer for review before these items arrive at the project site. In general, lifting lugs on members are not permitted. If used, their location, attachment and removal method shall be detailed on shop drawings approved by the engineer. (IDOT_SPEC 505.07)



One cause of damage to girders is associated with improper chaining or restraint of the load during transport. ‘Softeners’ are devices designed to protect the flanges from damage caused by chains used to secure the girder during transport. If ‘softeners’ have not been used, look for flange damage. Pay particular attention to bearing device locations. The finished mating surfaces of bearings can be easily damaged if used as a hold down point for chaining the load, or as a lifting point for off-loading.

The contractor should store bridge members in an upright and level position; i.e. on blocks to keep them out of the mud and well drained, as shown in the next two slides. The contractor will provide the bridge members, in transport and storage, with the proper support so that excessive deflection does not occur. Improper handling can result in geometric changes in the beam or girder making them difficult to construct. Plate girders will have to be chained, shored, or cribbed in the storage area so that accidental overturning does not occur. Rolled beams are inherently more stable and less likely to turnover; however, long span, tall rolled beams may need to be braced. The order in which the pieces are stored will usually match the sequence in which they are to be erected. Look for damage on each piece in the field before it is installed in the bridge, paying particular attention to bearing and faying surfaces to ensure they are free of dirt or debris



Secondary members should be stored in a manner that prevents damage or distress to members. Connection locations should be protected from accumulation of dirt and debris. It is particularly important that weathering steel members are stored in a manner that does not allow continuously wet surfaces.



Exercise #3.3 - List the duties of the inspector when fasteners arrive at the project site

Acceptance of HS hex head fasteners

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.



Documentation that should accompany the fasteners to the jobsite include Evidence of Inspection as described in the IDOT_MMI and manufacturers certifications as described in the specifications (IDOT_SPEC 505.04(f)(3)e). The documentation provides traceability to verification testing (e.g. rotational-capacity tests) and quality of manufacture (e.g. mill reports).

Evidence of Materials Inspection for hex head fasteners will include one or more of the following documents (IDOT_MMI).

- The Bureau of Materials & Physical Research (BMPR) approval letter.
- LA-15 form which indicates that the material is from approved stock. This form is sometimes used as a Bill of Lading to indicate prior approval. The form should include supplier, proper contract/job designation, material description, manufacturer, specific approved material (test ID, number, lots, or batches), and quantity. The LA-15 form certifies that the material was inspected by IDOT and is approved.
- IL OK is the stamp used by an IDOT inspector at the place of fabrication. This stamp may be placed on the bolt container or a material tag affixed thereto.

Bolt documentation

- Evidence of inspection
- Manufacturer certifications



The inspector will collect and review Evidence of Materials documentation upon arrival of fasteners to the jobsite. The inspector should also collect the Bill of Lading, which should show the product identification, lot numbers, and weight.

The Illinois Steel Products Procurement Act (30 ILCS 565/1) applies to all fasteners used in Illinois bridges. This act requires steel products used or supplied in the performance of public works contracts or any subcontract thereto be manufactured or produced in the United States.

In addition to the above, the IDOT_SPEC Section 505.04(f)(3)e requires the following certifications from the mill, manufacturer, and/or distributor. The information required to be included in each certification is outlined in the above specification section. These documents shall be provided by the contractor and verified by the inspector.

- Mill Test Report (MTR)
- Manufacturer Certified Test Report (MCTR)
- Distributor Certified Test Report (DCTR)

If the above documentation is not provided, the inspector shall obtain a minimum sample from each production lot consisting of three bolts of each diameter and length, three nuts of each size, and three washers of each size. The samples are to be sent to the Bureau of Materials and Physical Research for testing.

The MTR shall be furnished for all steel materials used in the manufacture of bolts, nuts, and washers. The MTR shall indicate where the material was melted and manufactured. (IDOT_SPEC 505.04(f)(3)e.1). The mill report should also indicate that the supplied material meets the ASTM requirements for the bolt, nut, or washer to be used on the project. The inspector should verify that the MTR heat numbers match the heat numbers used in the manufacture of the bolts, nuts, and washers.

Evidence of Inspection

- BMPR approval documentation
- IL OK stamp
- LA-15 form

Contractor: SMITH, INC.
Size and Type: #4 REBARS GR. 40
Quantity in this shipment: 3925 LB.
From: ASB
12/27/2009 - 12/31/2009

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION
BUREAU OF MATERIALS AND PHYSICAL RESEARCH

This material has been inspected at the source of supply, found to comply with the requirements of the specifications, and is certified.

Inspected by: R. JONES Date: 6/10/99
District: 93

Bureau of Construction Page 47

Illinois Department of Transportation

Supplier's Certification of Shipment of Approved Materials
Tunnel No. 284025

Shipment From: 60420
Anchor bolts
SH BATS
select 24

Shipment To: Fu Rebar
60430
look

Lot/Batch #: K0930

| Part No. | Part Description | Quantity | Material | Grade | Remarks |
|-------------|--------------------|----------|----------|-------|---------|
| 104 30 0004 | SH BATS 1 x 12 | 5412001 | H7994A | 28 | ea |
| 104 30 0005 | SH BATS 1 1/2 x 15 | 5912001 | H7994B | 28 | ea |
| 104 30 0006 | SH BATS 1 3/4 x 18 | 201100 | H7994B | 50 | ea |

Bureau of Construction Page 48

Material certifications

- Mill Test Report (MTR)
- Manufacturer Certified Test Report (MCTR)
- Distributor Certified Test Report (DCTR)

Content of these reports is described in IDOT Specification 505.04(f)(3)(e)

Bureau of Construction Page 49

Mill test report (MTR)

IDOT_SPEC 505.04(f)(3)e.1

1. Mill Test Report(s) (MTR).

(a.) MTR shall be furnished for all mill steel used in the manufacture of bolts, nuts, or washers.

(b.) MTR shall indicate where the material was melted and manufactured.

CHARTER STEEL

Melted in USA Manufactured in USA

CHARTER STEEL TEST REPORT

| Case # | Customer Part # | Charter Sales Order # | Ship Lot # | Grade | Process | Finish Date | Ship Date |
|--------|-----------------|-----------------------|------------|--------|-----------------|-------------|-----------|
| TE8002 | 9581 | 1715204 | 1715204 | 420800 | LIBRAV M SR V20 | 10/20 | 10/20 |

Fontana Fasteners Inc
3000 West State Road 20
Frankfort, IL 60441

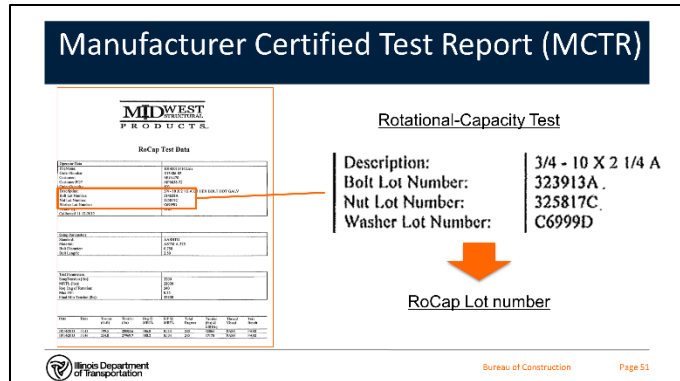
Test results of Test Lot # 101200

| Case # | Customer Part # | Charter Sales Order # | Ship Lot # | Grade | Process | Finish Date | Ship Date |
|--------|-----------------|-----------------------|------------|-------|---------|-------------|-----------|
| 101 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |

JOB#YR01
JOB#YR02
JOB#YR03
JOB#YR04
JOB#YR05
JOB#YR06
JOB#YR07
JOB#YR08
JOB#YR09
JOB#YR10
JOB#YR11
JOB#YR12
JOB#YR13
JOB#YR14
JOB#YR15
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JOB#YR98
JOB#YR99
JOB#YR00

Bureau of Construction Page 50

The MCTR shall be furnished for bolts, nuts, and washers. Each MCTR shall show the relevant information according to the reporting of the testing required. This will generally include physical properties per the applicable ASTM standard, such as chemistry, hardness, tensile strength, yield strength, fracture toughness, etc. The MCTR shall also include the results of rotational-capacity (R-C) tests performed on each lot number combination according to IDOT_SPEC 505.04(f)(3)e.2, including the U.S. location where the bolt assembly was manufactured. The lot combination is determined based on each conceivable arrangement of bolt, nut, and washer. Once arranged, each bolt, nut, and washer group is assigned a rotational-capacity lot number. The lot numbers allow for traceability of testing results throughout the project lifespan. Additional discussion of lot numbers and rotational-capacity testing will be provided in later modules.



Manufacturer Certified Test Report (MCTR)

MIDWEST INDUSTRIAL PRODUCTS

RotCap Test Data

| ITEM NO. | TEST DATE | TEST TYPE | TEST RESULT |
|----------|-----------|---------------------|-------------|
| 101 | 10/10/10 | Rotational Capacity | 323913A |
| 102 | 10/10/10 | Rotational Capacity | 325817C |
| 103 | 10/10/10 | Rotational Capacity | C6999D |

Rotational-Capacity Test

Description: 3/4 - 10 X 2 1/4 A
 Bolt Lot Number: 323913A
 Nut Lot Number: 325817C
 Washer Lot Number: C6999D

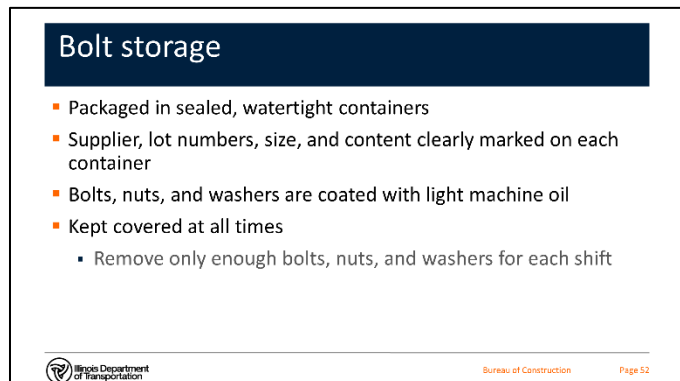
↓

RotCap Lot number

Illinois Department of Transportation Bureau of Construction Page 51

The contents of the DCTR is basically the same as the MCTR, but executed by the distributor rather than the manufacturer.

In accordance with IDOT_SPEC 505.04(f)(3)(f), bolts, nuts, and washers from each rotational-capacity lot (R-C Lot) shall be shipped in the same container. If there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. The container shall be permanently marked on the bucket and lid with the rotational-capacity lot number.



Bolt storage

- Packaged in sealed, watertight containers
- Supplier, lot numbers, size, and content clearly marked on each container
- Bolts, nuts, and washers are coated with light machine oil
- Kept covered at all times
 - Remove only enough bolts, nuts, and washers for each shift

Illinois Department of Transportation Bureau of Construction Page 52

Although not specifically covered in the presentation, the IDOT_CM requirements for lockpin and collar fasteners are the same as hex head fasteners except that R-C tests are not required.

Lockpin and collar type fasteners can be accepted if the following requirements are met:

- Mechanical galvanizing shall be measured and shall be between 2 and 6 mm in thickness. Hot dipped galvanized lockpin and collars are not permitted.
- In lieu of this check, the galvanizing thickness may be checked by the Bureau of Materials and Physical Research in which case will arrive at the job site with an ILL OK stamp or approval letter.

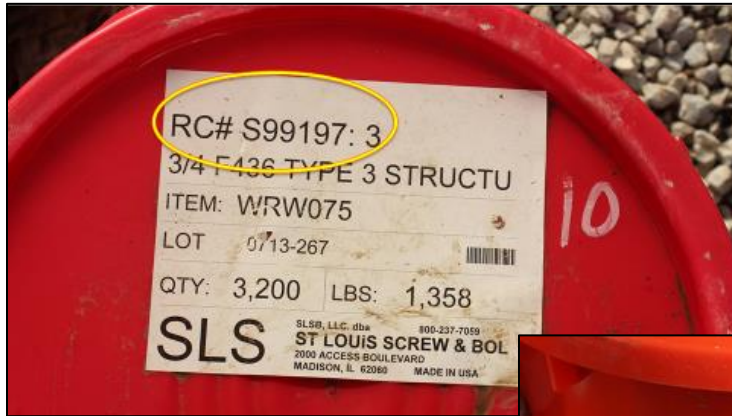
Fasteners should be delivered and stored in their original containers, protected from dirt and moisture. The container should be labeled with the supplier's name, lot identification number and marked to identify the contents and size of the fastener components. Markings should be clearly and permanently marked on each container. Containers lids should be kept on at all times unless access to the contents is required. Ideally, fasteners should be stored in a trailer or storage shed to protect against the elements. Do not store open containers under plastic tarps, as this can lead to condensation creating a wet environment below the tarp.

The next few slides show bolt storage for an Illinois bridge project. For this project, the fastener assembly represents only one production lot number, so bolts, nuts, and washers are stored in separate containers. The bucket and lid are labeled with the R-C Lot number (RC# S99197). In some instances the R-C Lot number is on the main label, while in other instances the lot number is printed on a small address-type label. The labels in this example are paper and unprotected from the environment.



The lid labels were partially submerged in water, and have begun to deteriorate and fall off. As shown below, the bucket labels for the current project are affixed over labels from previous projects. Several of the labels have fallen off and were observed on the ground. Over time, the remaining labels are likely to fall off and proper tracking of R-C Lot numbers and component sizes will be compromised. The IDOT_CM calls for all buckets and lids to be permanently marked.





Quiz #3.2 - Complete the following questions.

Acceptance quiz #3.4

The inspector's duties for acceptance of steel materials at the project site include the following

- Collection of Evidence of Inspection documentation
- Inspection for damage during transportation and handling
- Checking that steel is properly stored

- a) True
- b) False

Acceptance quiz #3.5

Fastener containers should be marked with which of the following information

- a) Container contents and size
- b) Rotational capacity lot number
- c) Manufacturer identification
- d) All of the above

Acceptance quiz #3.6

The fastener containers arrive at the job site with no or insufficient documentation or stamp indicating that its contents have been approved. What is the correct course of action?

- a) Allow their use since the paperwork is probably delayed and can be collected later
- b) Send three of each component to Bureau of Materials for testing and await test results prior to use.
- c) Use them if they pass a field rotational capacity test

The module is concluded with a wrap-up review of the module learning outcomes.

Wrap-up

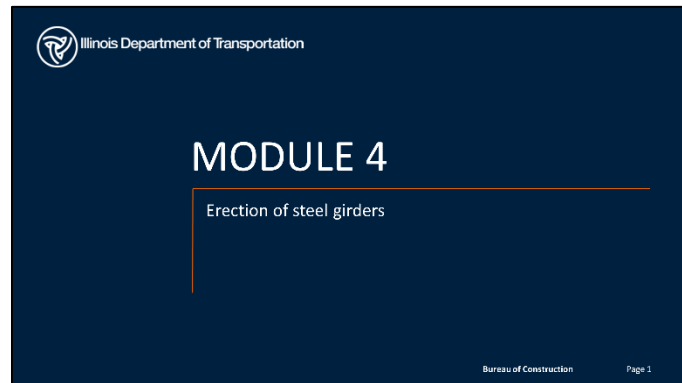
Module 3 Learning Outcomes

1. Describe how steel materials are defined by the contract documents.
2. State the acceptance or rejection criteria for accepting steel materials on the job site.
3. Distinguish proper vs. improper storage and handling of steel materials.

MODULE 4 - ERECTION OF STEEL GIRDERS

Overview and Instructional Method

Example contractor submittals describing the erection sequence and procedures are reviewed. Participants are guided through the erection submittal documents and develop a list of inspection tasks to be executed prior to and during erection. Key acceptance/rejection requirements for handling and bracing are reviewed. The consequences of improper erection and temporary bracing are also discussed through the use of case studies of steel bridge failures that occurred during erection.



Interactive exercises and discussions are used in this module, and allow participants to generate a list of their duties associated with steel girder erection, setting, and securing of members. This is then compared to IDOT inspection checklists (BRIDGE_CKLIST) for steel girder erection.

Module 4 is designed to achieve the following learning outcomes

1. Review and interpret erection sequence and erection plan.
2. Execute pre-erection review of key documents and prepare for pre-erection conference.
3. Identify temporary bracing and stability issues.
4. Describe consequences of improper handling, erection, and bracing.

Learning Outcomes

1. Review and interpret erection sequence and erection plans
2. Execute pre-erection review of key documents and prepare for pre-erection conference
3. Identify temporary bracing and stability issues
4. Describe consequences of improper handling, erection, and bracing


Bureau of Construction Page 2

Presentation Notes

Section 505.08 of the IDOT Specifications describes the responsibilities of the contractor for the erection of structural steel. Before starting work, the contractor shall submit an erection plan to the engineer for approval that describes the proposed methods and equipment to be used to construct the bridge

Erection plan

- Project drawings and specifications
- Fabrication shop drawings
- Narrative and drawings
 - Proposed methods of erection
 - Amount, type, and location of equipment
- Sealed by licensed structural engineer*



Illinois Department of Transportation

(IDOT_SPEC 505.08(e)). The erection plan should reference the contract documents, including drawings, specifications, special provisions, and fabrication shop drawings. The erection plan should include a narrative that describes the process for unloading, handling, storing, and transporting and incorporating each member to its final location within the bridge. The erection plan should include drawings or documentation that identify equipment and methods of final placement.

When required by Special Provisions, the erection plan must include calculations prepared by an Illinois Licensed Structural Engineer and approved by the engineer. A sample erection submittal prepared by a licensed structural engineer is included in Appendix B. Structures requiring an erection plan prepared by a structural engineer include curved girder bridges and construction projects where erection work will necessitate the use of in-place bridge structures for means and methods. Curved girder erection requirements are described by IDOT Guide Bridge Special Provision (GBSP) #55, while GBSP #67 describes erection requirements for projects utilizing in-place structures. Calculations shall also be submitted when handling and placement of complex assemblies and long span girders are required, per IDOT_SPEC 505.07 to ensure member stresses do not exceed 80 percent of the materials minimum yield strength. If falsework is required for erection, the contractor shall submit detailed plans prepared and sealed by an Illinois Licensed Structural Engineer for examination by the engineer. (IDOT_SPEC 505.08(d)).

The IDOT BRIDGE_CKLIST includes the following recommended pre-erection requirements.

Pre-Erection (General Items)

- (1) If this contract contains the Structural Assessment Reports (SARs)* special provision, has the erection SAR been approved? ____
- (2) Have you had a pre-erection meeting with the Contractor to discuss the erection plan, bolting requirements, jobsite samples, job site testing and test equipment, etc. as applicable? (This is not a contract requirement, but is highly recommended.) ____
- (3) Do you have proper evidence of inspection for all materials to be used? ____ (See IDOT_PPG Attachment 3)

Pre-Erection (Structural Steel items)

- (1) Before starting erection, has the Contractor submitted an erection plan detailing the proposed methods of erection and the amount, location(s) and type(s) of equipment to be used? Has the plan been approved by the Engineer? (See IDOT_SPEC 505.08(e)) (Note, if the contract contains the SARs special provision, the special provision holds over IDOT_SPEC 505.08(e) See IDOT_SPEC 105.05) ____
- (2) If falsework is needed for the erection process, has the Contractor submitted erection falsework plans for review, or has the submittal been waived by the Engineer? (See IDOT_SPEC 505.08(d)) (Note, if the contract contains the SARs special provision, the special provision holds over IDOT_SPEC 505.08(d) See IDOT_SPEC 105.05)

* A SAR may be required when a contractor's means and methods will impose loads on or change behavior of existing structure(s) or portions thereof. A SAR will generally be required whenever erection equipment, stored materials, or other contractor means and methods will be supported by existing construction. GBSP #67 requires the contractor to prepare a Structural Assessment Report for Contractors Means and Methods. This report shall be prepared by an Illinois Licensed Structural Engineer and shall describe the impact of the means and methods on structure(s) or portions thereof.

The SAR shall be submitted and approved prior to beginning work covered by the SAR. The SAR will include detailed procedures and sequencing necessary to complete the work in a safe and controlled manner, and when appropriate supported by design calculations verifying that the means and methods do not adversely affect existing structure(s). The inspector should be thoroughly familiar with the SAR and any special requirements described therein.

Prior to superstructure construction and attendance at the pre-erection conference, the inspector should review and become intimately familiar with all project documents. This includes the drawings and specifications, which describe the dimensional and physical attributes, respectively, of the superstructure in its final joined assembly. Project-specific requirements unique to each project are described in the Special Provisions and General Notes section of the drawings. These are supplemented by the IDOT standard specifications.

Pre-erection preparations

| | |
|---|--|
| <p>Review</p> <ul style="list-style-type: none"> ▪ Plans ▪ Specifications ▪ Special Provisions ▪ Shop Drawings ▪ Erection Plans | <p>Prepare</p> <ul style="list-style-type: none"> ▪ List of submittals ▪ List of required tests ▪ List of required inspections |
|---|--|

Illinois Department of Transportation
 Bureau of Construction Page 4

When reviewing these documents, the inspector should note any requirements that will have a bearing on the erection process. These provisions should be discussed at the pre-erection conference. This will include preparing a list of submittals, list of required testing, and list of required inspections.

The inspector should also ensure that fabrication shop drawings have been received, reviewed, and are available for reference when superstructure members arrive at the project site and throughout erection. He/she should thoroughly review the shop drawings making note of any provisions relevant to the erection process. These should be discussed at the pre-erection conference. The inspector should be familiar with the match marking system used in shop drawings and how the match marking system relates to the erection sequence described in the erection plan. IDOT's shop drawing review procedures are documented in BBS Memo dated August 30, 2013.

Pre-erection conference

- Parties
- Schedule
- Contract Requirements (shop drawings, SARs, plan notes, etc.)
- Pre-erection inspections
- Erection plan and procedures
- Bolting requirements, inspections, and testing
- Safety plans
- Traffic control

Illinois Department of Transportation
 Bureau of Construction Page 5

As noted above, a pre-erection meeting is not a contract requirement however it is highly recommended. The following agenda could be used to guide the discussion of a pre-erection meeting.

- I. Parties
 - a. Contact information for all parties involved in the erection process
- II. Scheduling
 - a. Material *(See Module 3 for additional detail)*
 - i. Structural steel and fastener delivery schedule
 - ii. Required documentation for steel materials and fasteners
 - iii. Storage requirements
 - iv. Handling requirements
 - v. Damage inspection
 - vi. Schedule for achievement of substructure pier cap concrete strength
 - vii. Contingency plans
 - b. Erection
 - i. Dates and duration

- ii. Detailed daily schedule and hours of work
 - c. Crane
 - i. Delivery schedule
 - d. Maintenance of traffic
 - i. Road closure schedule
 - e. Other scheduling items
 - i. Lighting
 - ii. Railroad coordination
 - iii. Utility coordination
 - iv. Other
 - III. Specification and Special Provision Requirements
 - a. List special provision requirements of the contract documents pertaining to erection
 - b. List inspection and other responsibilities outlined by these requirements
 - IV. Plan Notes
 - a. List requirements outlined by the standard specifications and plan notes pertaining to erection
 - b. List inspection and other responsibilities outlined by these requirements
 - V. Pre-erection inspections
 - a. Elevation and alignment controls
 - b. Bearing placement
 - c. Falsework submittals and inspection (if required)
 - d. Substructure inspection
 - VI. Erection Plan and Procedures
 - a. Prepared and sealed by Illinois Structural Engineer (if required by Special Provisions)
 - b. Approved by IDOT
 - c. Piece markings and sequencing described
 - d. Equipment capacities and picking procedures
 - e. Crane operations
 - i. Staging and suitability of site for crane operations, including accommodations for soil bearing at outrigger locations
 - ii. Room for outriggers and crane movement
 - iii. Underground and overhead utilities
 - iv. Protection of existing work
 - f. Method of lifting and stabilizing girders during handling and placement
 - g. Method of stabilization when girders are in place at each stage of construction
 - h. Narrative of erection plan and procedures
 - i. Contingency plans for any delays, faulty equipment, weather, etc.
 - j. Communications
 - VII. Inspection Requirements for Bolting
 - a. Platform and/or access for inspection personnel
 - b. Verification testing
 - c. Review of equipment and procedures (See IDOT_CKLIST and this manual)
 - d. Calibration of equipment
 - VIII. Safety Plans
 - a. Personal protection equipment
 - b. Crane safety and equipment inspections
 - c. Erection safety meeting agenda

IX. Traffic Control

- a. Describe traffic control issues prior to, during, and after erection
- b. Manor of providing traffic control
- c. Work zone ingress protection
- d. Public notifications
- e. Required inspection to open roadways below/adjacent to newly erected girders
- f. Contingencies

The most successfully executed bridge projects are those that include a thoroughly prepared and reviewed erection plan along with a detailed pre-erection meeting where the contractor's means and methods and inspectors responsibilities are fully vetted. Despite the best efforts of all parties, problems should be expected. However, if contingencies are discussed in advance the negative effects of problems on quality, safety, cost, and schedule can be substantially mitigated. The key elements of a well prepared erection plan are discussed in the following slides.

The erection plan submittal should include a detailed narrative describing the process of erection work. The narrative should include reference to sequencing of operations, placement and use of lifting equipment, maintenance of traffic, timing or scheduling, and contingencies. A narrative should be provided for each construction stage, including any pre-assembly work, if required.

The narrative should be accompanied by illustrations or drawings for each erection stage. The drawings should show complete details of erection accessories and devices, quantity and location of all bracing diaphragms, temporary supports, towers, posts, guys, falsework, tie-downs, etc. for each erection stage, along with supporting calculations and stability analysis for storage, handling, and during and after erection, as required by IDOT_SPEC 505.07 for long or large assemblies or GBSP #55 and GBSP #67 for curved and projects utilizing in-place structures for support of means and methods, respectively. Maintenance of traffic should also be described and illustrated. A sample erection plan with narrative is provided in Appendix B.

The drawings should show location of each crane and each lifting point with corresponding lifting radii and crane capacities at the load pick and the load release; noting the use of temporary support conditions, such as holding crane positions, temporary supports, guys, falsework, tie-down stability provisions, blocking of the bearings, etc. The primary member delivery location and orientation should be shown with consideration of maximum crane lift capacity and radii.

Narrative: Example

Stage 1: Steel work from West Abutment to Splice #2


Traffic Pattern: Utilize a right lane closure on westbound Archer Ave. for unloading girders and staging trucks

Erection of Girders: Day time operation which will not affect traffic

Stage 2: Steel work from Splice #2 to Splice #4


Traffic Pattern: Close westbound Archer Ave. with single lane traffic each way on eastbound Archer Ave.


Erection of Girders: Night/weekend/off-hour work using traffic control for girders J, K, L, M, & N


Bureau of Construction
Page 6

Erection drawings

- Sequencing of delivery and placement of members
- Lifting equipment and location information
- Load charts and rigging information
- Bearing information
- Temporary bracing
- Falsework or shoring
- Traffic control
- Calculations and sealed*

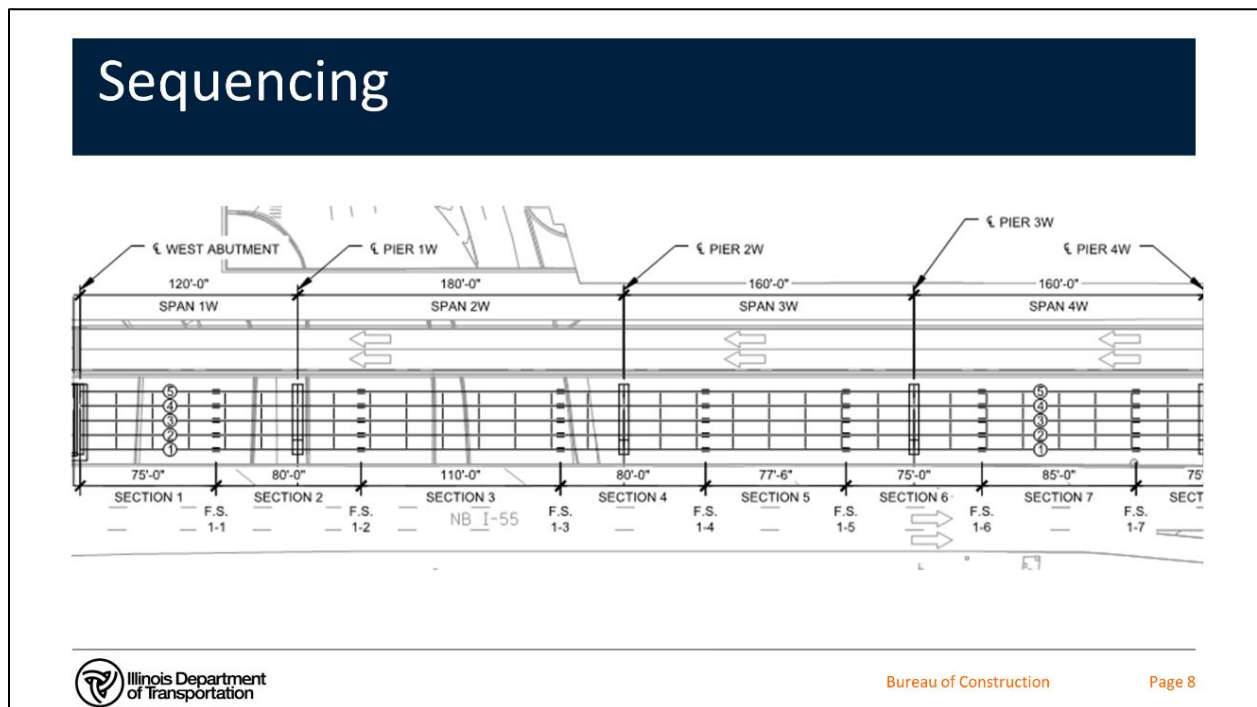


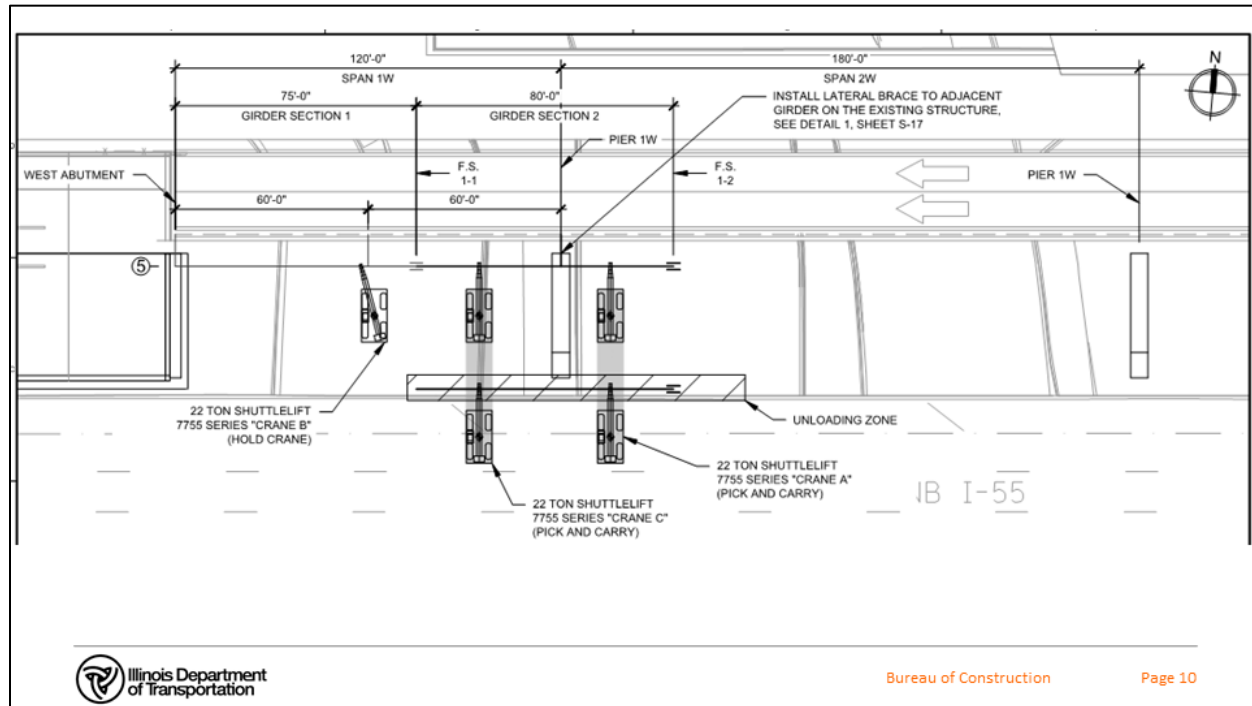
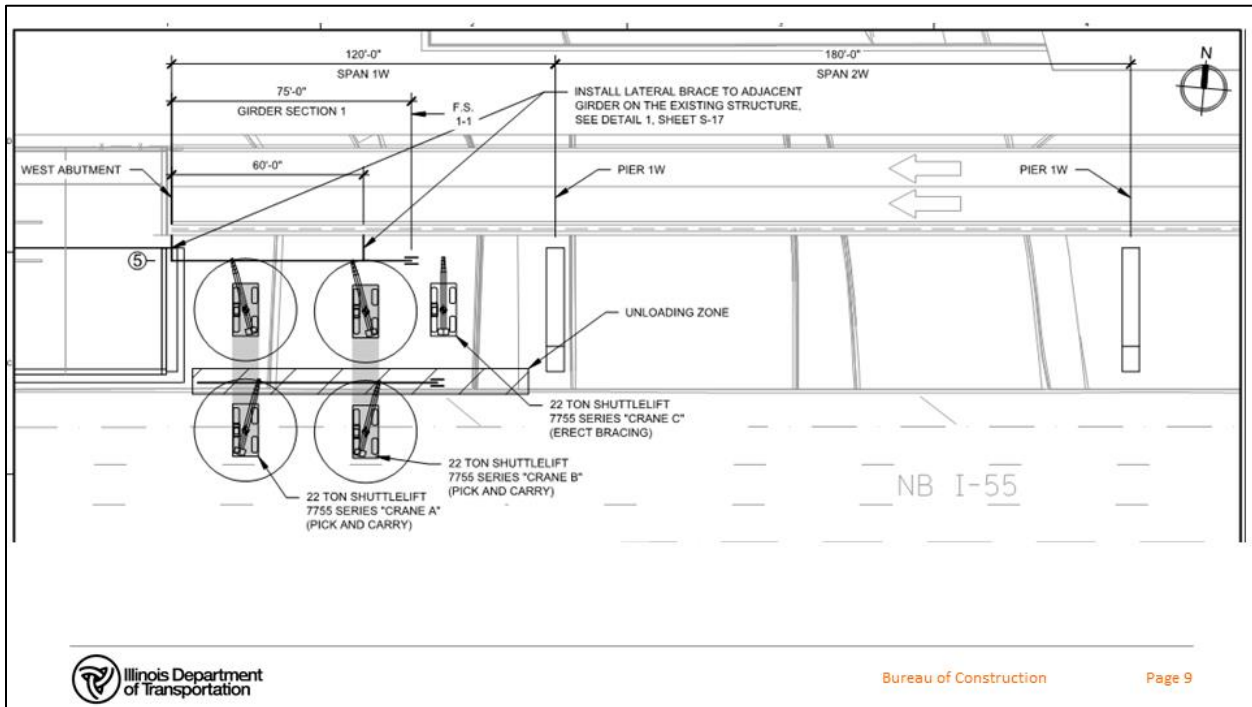

Bureau of Construction
Page 7

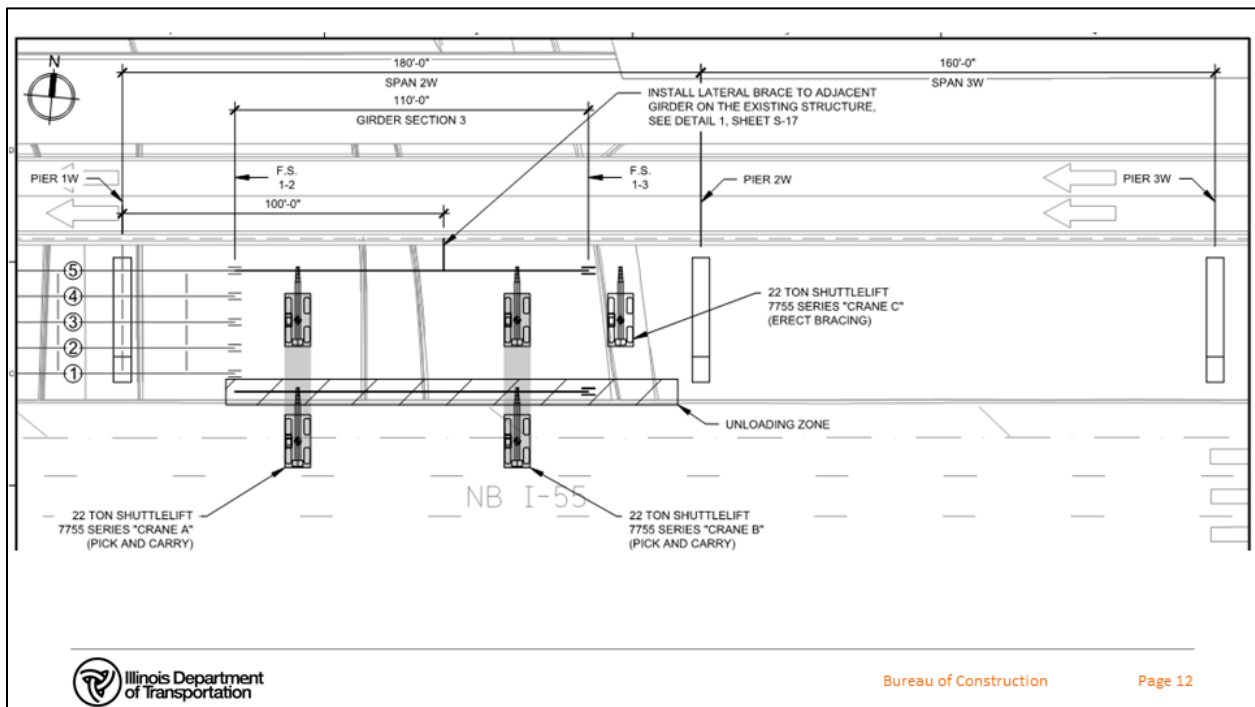
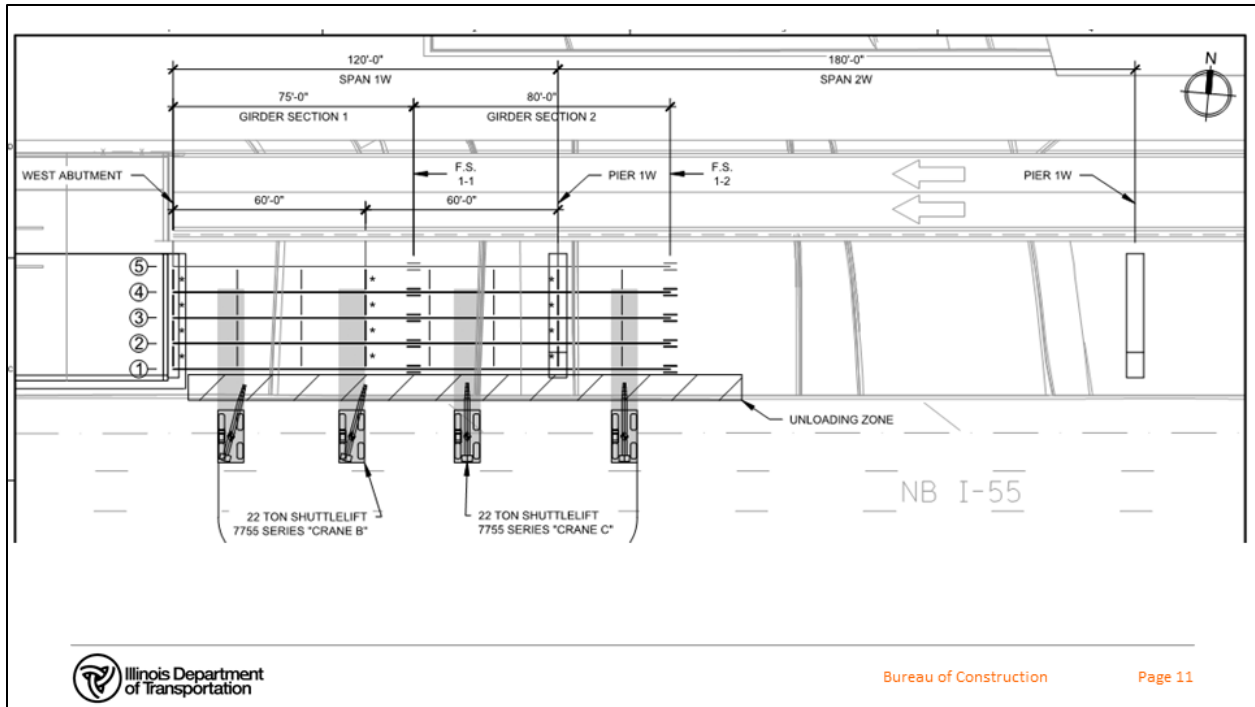
The crane information provided in the erection plan should include each crane location, each member pick, crane type, radius, crane support methods, and means of attachment to the girders being lifted or supported. The erection plan should describe the crane configuration, including boom length, counterweights, tail swing, outrigger spread, work zones, etc. Hold Cranes, if used, should be identified and clearly described when loads may be released. Limits on boom length, extension, and rotation should be clearly defined based on the weight for each lift.

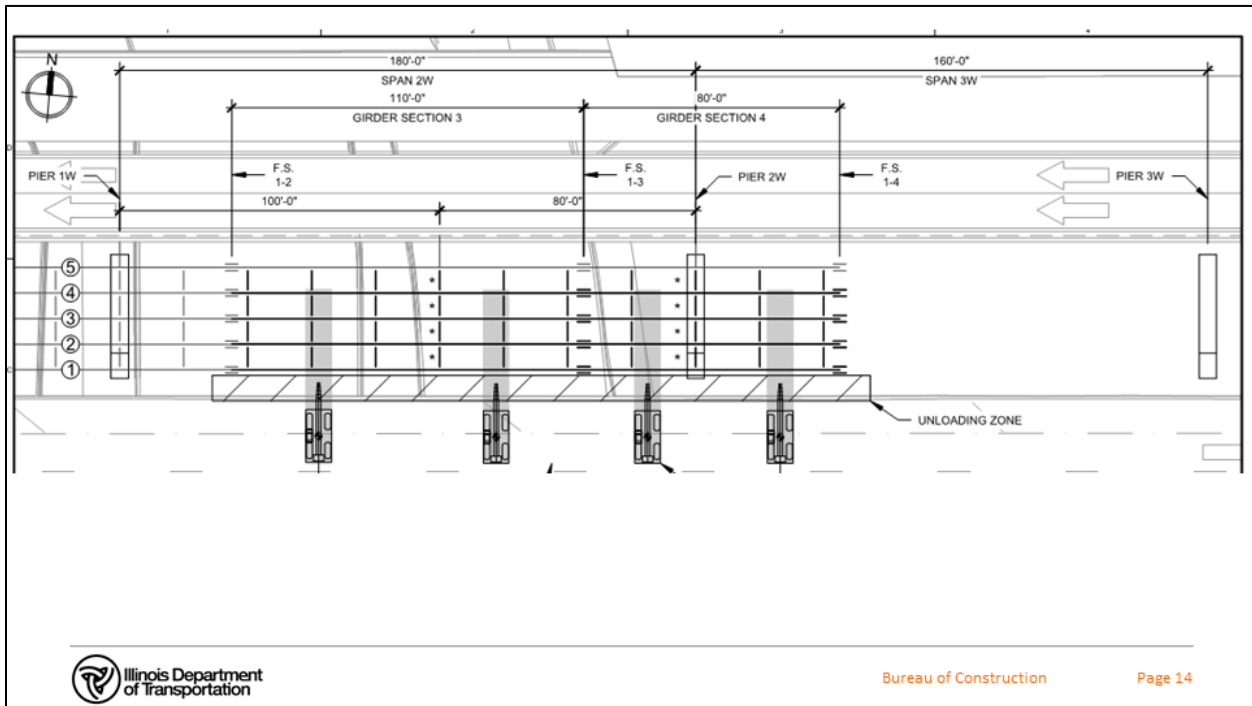
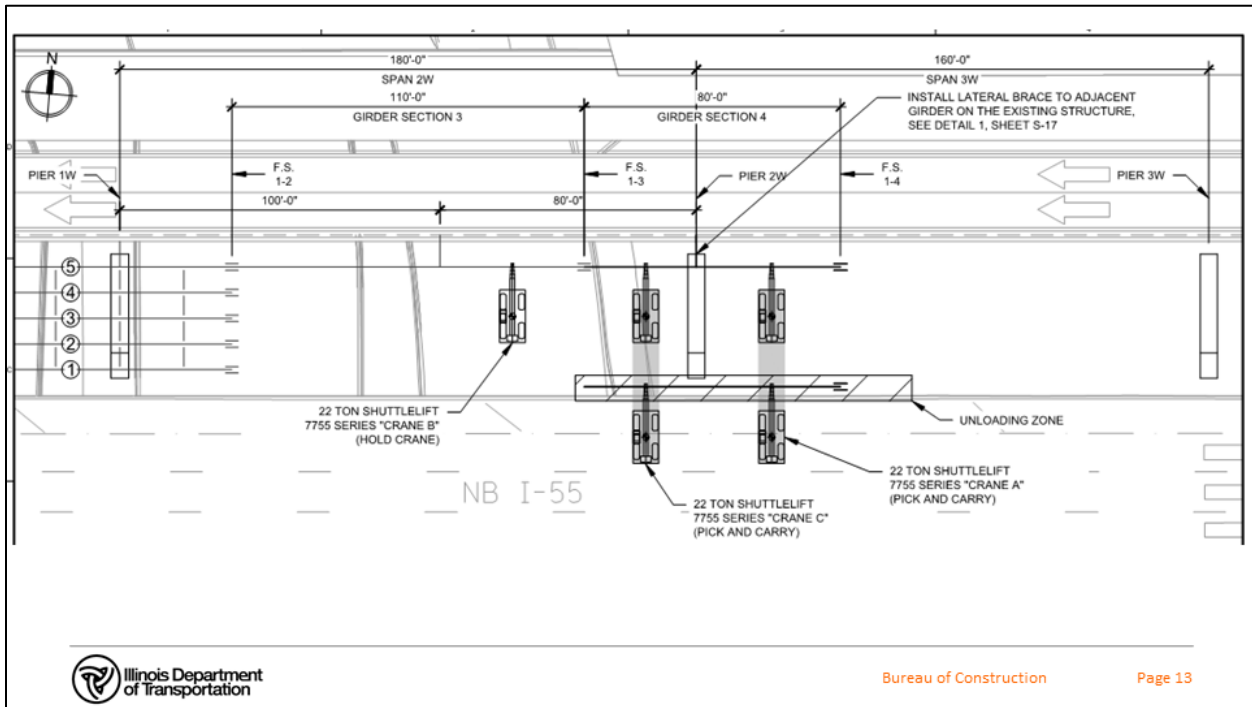
The erection plan will also describe the rigging attachment points and pre-attached elements such as cross frames, diaphragms, or splice plates. The approximate center of gravity location points should be provided. The type, configuration, weight, capacity, and arrangement of all rigging components should be described. This includes slings, chains, beam clamps, lifting hooks and spreader, lifting beams, or frames. Lifting beams when required should be clearly detailed, including limiting angles for cables or slings.

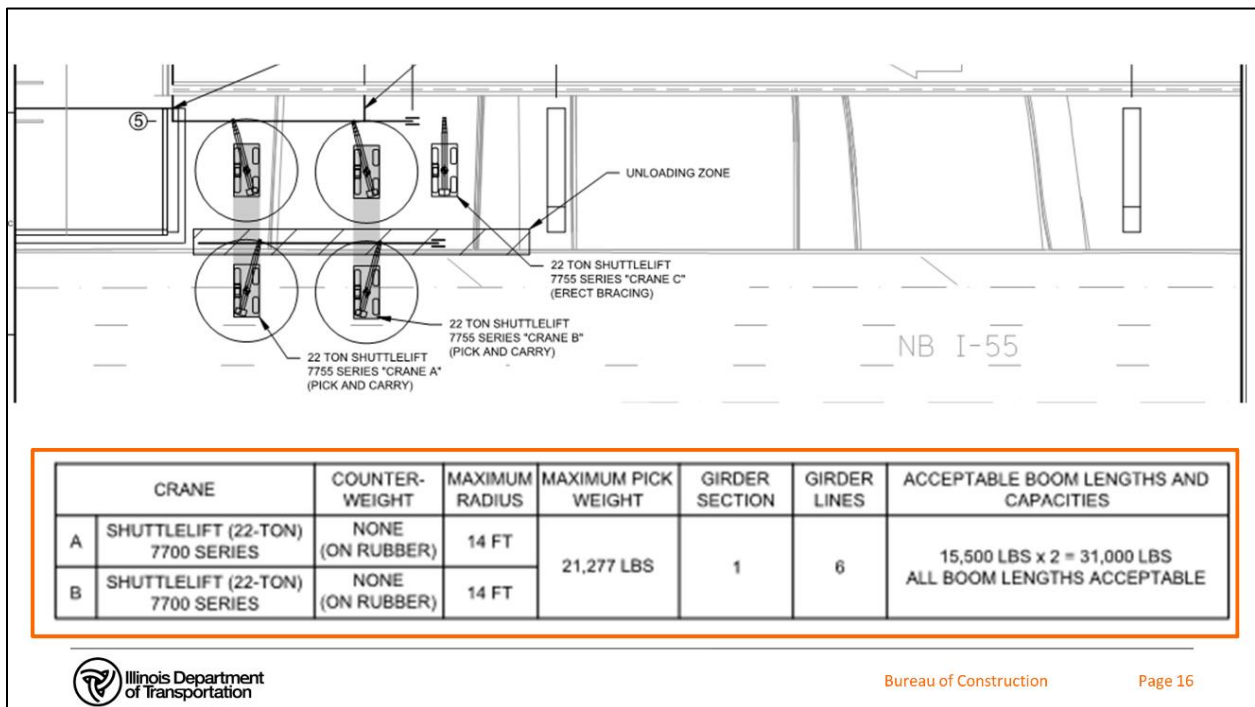
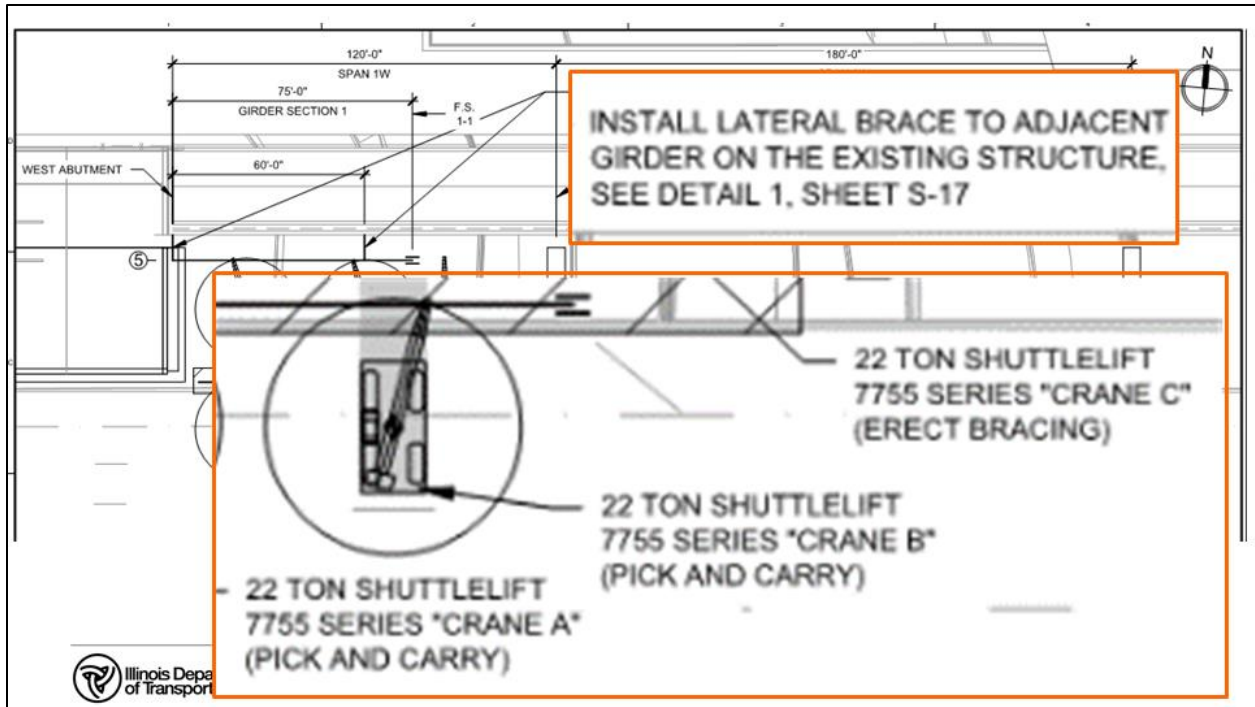
The following slides, which are taken from Appendix B, present example contents of an erection plan for a multi-span bridge. The first slide shows a general plan view of the project highlighting the various erection sections, from Section 1 to Section 7. Girder numbering and span notations are also shown. The next six slides show the sequencing of girder placements for Sections 1 through 4. Key attributes of the erection plan include illustration of the girder unloading zones and crane designations for each piece of equipment including path of travel and radius of operation. Of special note is the installation of lateral bracing to support the lateral stability of the first girder placed (i.e. Girder Line 5).









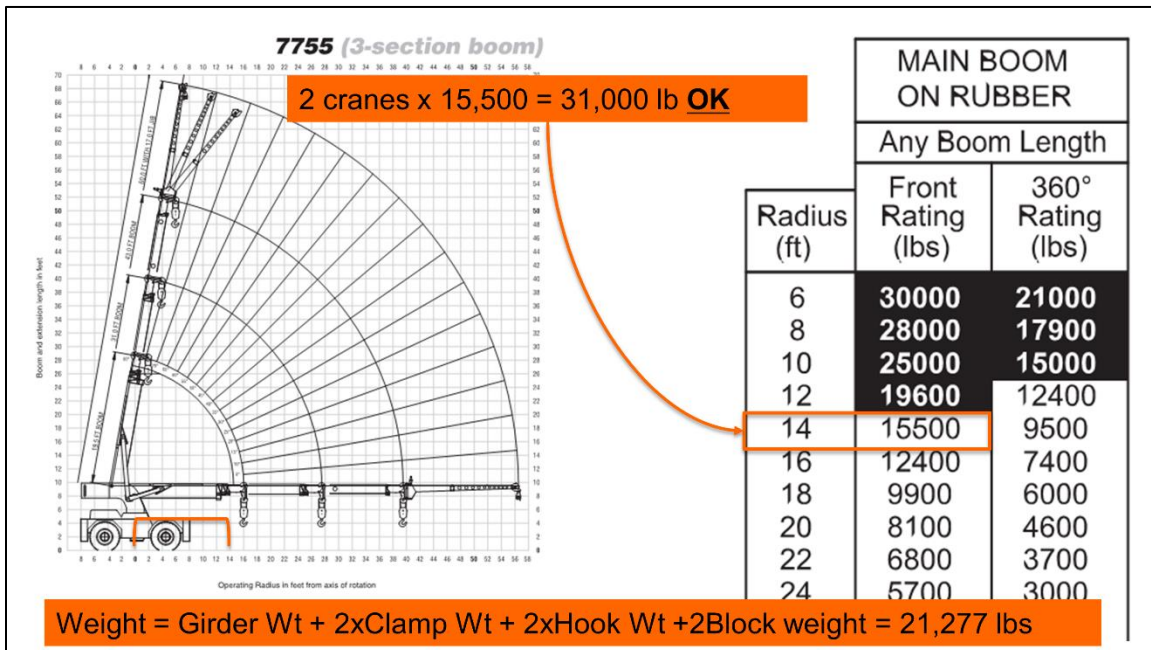


The structural engineer or contractor will review pick weights for each girder/assembly placement and the required crane configuration for each equipment position to ensure crane overturning or structural damage to the boom does not occur during erection. Maximum lifting weights and maximum picking loads should be described in the erection plans. Lifting weights should include girder weights, which can be found in the

materials table of the shop drawings, and the total weight of all lifting hardware (i.e. hook, blocking, clamps, etc.). Crane operating loads can be found in the crane manufacturer's literature, and will be dependent upon boom length and radius. In the above example, the erection drawings indicate that the 22-ton Shuttlelift 7755 crane has a 21,277 lb maximum lifting weight at a radius of 14 ft and for all boom lengths. The maximum radius is generally measured as the horizontal distance from the crane turret to the hook, but should be confirmed by review of the manufacturer's literature submitted with the erection plan.

The erection plan should include manufacturer's crane information, including safe operating limits. For this example, the Series 7700 literature includes radius charts and maximum safe pick weights for operations on rubber. The girder and equipment maximum weight is 21,277 lbs. Two cranes are used with a radius limit of 14 ft at any boom length thus providing a maximum capacity of 31,000 lbs, which will safely carry the maximum weight. Shaded areas in the charts designate load governed by structural strength of the boom, while non-shaded areas are governed by tipping. In this example, the load is taken from the Front Rating column indicating that the crane must operate within +/- 15 degrees of centerline. Ratings for operations on rubber are dependent upon adequate time pressure (i.e. 110 psi) and maximum operating speed of 2.5 mph. Jib use is not allowed when on rubber.

Newer model and some older model cranes are equipped with a load moment indicator (LMI) and/or a rated capacity limiter. A LMI will sound an alarm when the crane is approaching its overturning moment capacity, i.e. load multiplied by radius. A rated capacity limiter shuts off power when the crane's rated moment capacity is reached. Functions which decrease the severity of loading remain operational, so the operator can decrease the strain on the equipment.




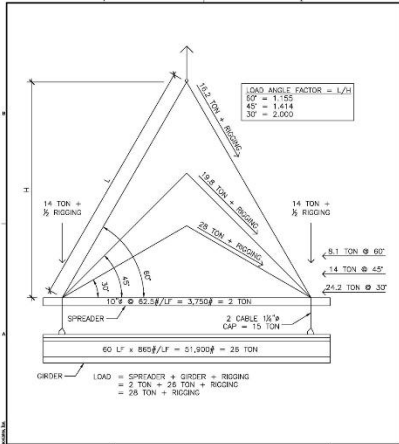
Rigging of girder lifts is an important element of the erection procedures, and depending on the method and equipment used can greatly reduce the load carrying capacity of the cranes. Therefore, the erection plans should include information pertinent to the rigging and equipment to be used. This includes self-weight and safe operating ranges for each device and lifting configuration. Important is the placement of lifting equipment on the girder, generally as measured from the girder end or midspan. When lifting beams are

used, the erection plan should include a description of the spreader beam and rope configuration, as shown in the next slide.


Rigging

- Loads on girders and lifting equipment
- Cables/chokers and spreader beams





| | | |
|---|--|----------------------|
| WJE WILLIAMS JENSEN ENGINEERS | Project: GIRDER ERECTION TRAINING COURSE | Prog. No.: 2009.0000 |
| | Client: ODOT / OCA | Date: 1-8-08 |
| Drawn: JFC | Checked: WPC | Scale: 3/16" = 1'-0" |
| Sheet No: GIRDER ERECTION / RIGGING DETAILS / LOADS | | Sheet No: SK1 |




Bureau of Construction


Page 18

Rigging equipment


Lifting Hook




Snatch Block




Girder Dog




Cable Clamps




Thimbles



Shackle






Bureau of Construction

Page 19

When outriggers are used, the contractor will need to take special care that the supporting soil is suitable to support the intended weights of the crane and supporting loads. OSHA 1926, Subpart P, Appendix A describes the compressive strength of unconfined cohesive soils and classifies soils into three types; Type A has a compressive strength of 1.5 tons per square foot (tsf) or greater, Type B has a compressive strength greater than 0.5 tsf but less than 1.5 tsf, and Type C has a compressive strength of 0.5 tsf or less. Many construction sites have Type B or Type C soil. A pocket penetrometer or thumb test can be used to estimate the unconfined compressive strength.

Outriggers

- Assumed soil condition
 - Type A ~ 1.5 tsf or greater
 - Type B ~ 0.5 to 1.5 tsf
 - Type C ~ less than 0.5 tsf
- Thumb or pocket penetrometer
- Check bearing stresses for total weight plus crane weight
- Effect of moisture



Illinois Department of Transportation Bureau of Construction Page 20

The thumb penetration test is described in ASTM D2488 - "Standard Recommended Practice for Description of Soils (Visual - Manual Procedure)." Type A soils can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils can be easily penetrated several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample. If the site is exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly. The pocket penetrometer test is described in ASTM WK27337, "New Test Method for Pocket Penetrometer", which refers to a working item as there is currently no standard for this test. Users of pocket penetrometers are advised to reference this working item or manufacturer's literature.

The soil conditions for safe operation of cranes should be judged by a competent person. However, the inspector should be familiar with conditions that can effect safe bearing conditions, such as undersized bearing pads and soil moisture content. The soil condition as measured with a thumb test or pocket penetrometer should be compared to the assumed value in the erection plans. A quick check of the bearing stress can then be calculated for the type of soil found at each bearing location. Moisture at or near the bearing location can decrease the capacity of the soil. If soil conditions are suspect, the contractor should be asked to review his procedures for that day's work.

The above discussion described the important elements of a well thought out erection plan, but by no means was exhaustive. Inspectors should carefully review the contractors' erection plan and discuss the plan in a pre-erection meeting, being sure to discuss issues that are not presented or unclear. The erection plan represents the contractors' proposed approach for handling, storing, and erecting the bridge. Inspectors observing the work should focus on making sure the contractor is following his/her agreed to plans. When erection plans are prepared by a licensed structural engineer they should not be changed unless approved by the engineer responsible for the original calculations. For most bridges, the erection plans are prepared by the contractor and therefore could be altered by him/her to address field conditions. However, it is best to have discussed contingencies in advance so the inspector is briefed on alternatives that may occur during the work.

The stability of girders on the project site and throughout handling, erection, and final assembly is critical and must be thoroughly described in the erection plan. The inspector should be familiar with the stability requirements specified by the contractor's structural engineer and monitor the contractor's work to ensure compliance with the approved plans. The stability calculations are highly dependent on the particular features of the bridge being erected and the sequencing of erection. Deviations from the approved plan can result in failure. Several case studies are reviewed below.

Stability


- Initial unloading
- On-site storage and handling
- Pre-assembly
- Lifting
- Initial and staged configurations
- Pre-deck condition





Bureau of Construction
Page 25

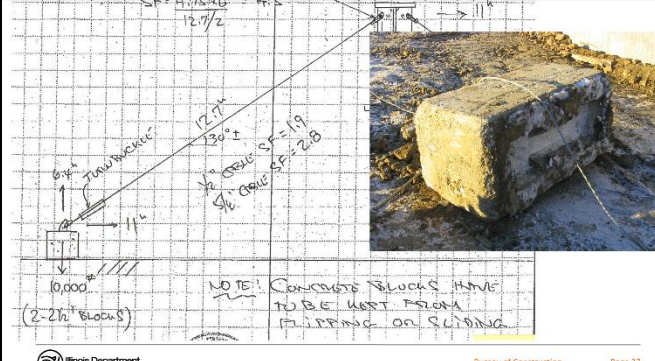
Cast Study #4.1 - Saskatchewan Bridge Collapse - Stability issues contributed to the collapse of a steel bridge project during erection. In this example, the contractor retained a structural engineer to design an erection procedure. The erection procedure required guy wire bracing to prevent lateral torsional buckling as the steel girders were transferred from temporary supports by cranes to a self-supported condition on the abutment and first pier. Upon unhooking of the cranes, the cranes began to move to the next pick point to continue the erection. However, before the next pick could be made the in-place girders rotated and collapsed.


Case Study #4.1 - Temporary bracing




Bureau of Construction
Page 26

The erection procedure sketches showed guy cables to be anchored by concrete blocks that were to be prevented from flipping or sliding when guy wires were placed at a 30 degree angle.




Bureau of Construction
Page 27

The actual configuration had the concrete blocks placed on frozen soil with no mechanism to prevent sliding or tipping. Furthermore, the achievement of a 30 degree angle was impossible due to clearance issues with the bottom flange of the adjacent girder. The actual angle of the guy wire was approximately 45 degree. The deviation of one much less two of these requirements from the approved erection plan should have been sufficient to warrant a stop in the work and a re-submittal of the erection plan. Changes to

erection plans should be submitted to the structural engineer responsible for the original erection plan, and the plans resubmitted and approved before work is allowed to continue.





Curved girder erection projects present unique challenges especially with respect to lateral stability issues. The requirements of IDOT Specification 505.08(e) are supplemented by the IDOT GBSP #55, which covers the topic of curved girder erection. Most curved girder erection procedures require the use of temporary shoring or falsework and specially designed lifting supports, or spreader beams. The erection plan shall completely describe these elements, supported with structural calculations and stability checks at all phases of the erection sequence. Participants are encouraged to review GBSP #55 and other information available in the specifications regarding inspection requirements for curved girders. This course does not provide a comprehensive treatment of curved girder construction and erection inspection requirements.

Curved girder concerns

- Lateral torsional buckling
- Falsework and temporary shoring
- Splice plate bolting procedures

IDOT Guide Bridge
Special Provisions
GBSP #55



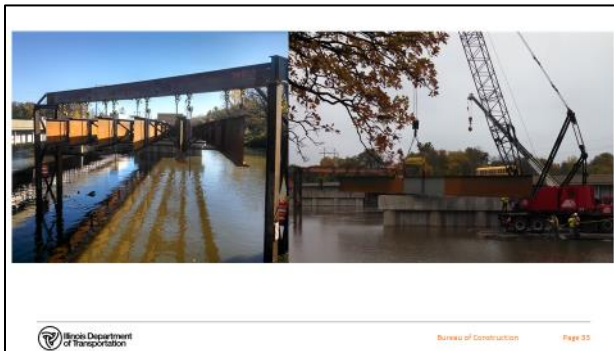

Bureau of Construction
Page 30

Exercise #4.2 - List the inspection responsibilities associated with the contractors means and methods illustrated in the following slides focusing on stability issues.



Supports for curved girder erection:

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Midspan supporting structure:

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Girder support on truck:

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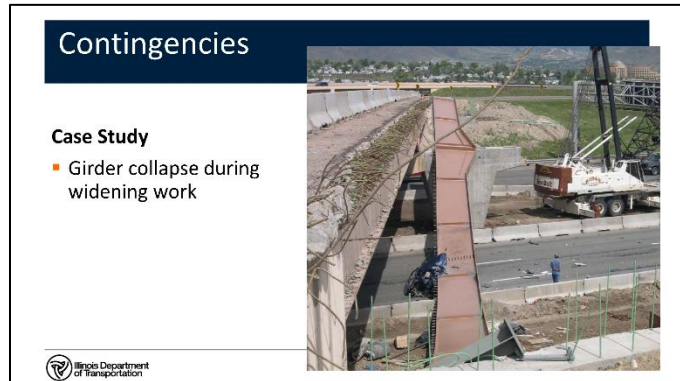
The pre-erection meeting should include detailed discussion of the contractor's means and methods, as well as contingencies in the event that the unexpected occurs. The following slides and Case Study #4.2 illustrate unexpected failures or mishaps that have occurred during steel girder erection.

Unexpected outcomes

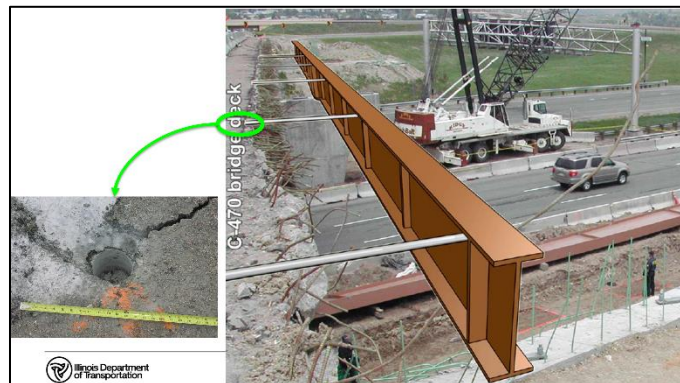
- Discuss contingencies at pre-erection meeting
- Confirm contractor is prepared for the worst



Case Study #4.2 - Colorado Bridge Widening Project Girder Collapse - As reported in the National Transportation Safety Board post-collapse investigation, workers at the Colorado Bridge Widening Project were to install two girders using cranes to pick up the first girder's two sections, splice them together while they were held in the air, and then set the newly joined girder in place parallel to the C-470 bridge deck. Next, while being held by the cranes, the first girder was to be braced to the existing C-470 bridge deck with angle-shaped steel braces ("angle irons") bolted to the new girder and attached to the paved bridge deck with expansion bolts. Once it was temporarily braced in this manner, the first girder would be released from the cranes. Then, the second girder would be installed the same way, and, once it was in place, the two girders would be cross-braced with diaphragms to stabilize them. The erection plan included no contingency plans; however, it was briefly discussed at the pre-erection meeting for a "few minutes" that if only the first girder could be erected that night, the contractor intended to stabilize the single girder by connecting it to the existing C-470 bridge deck with the angle braces thus allowing erection of the second girder to continue the following night.



Erection work was scheduled for a night-time closure, with all work scheduled to be completed in the early morning hours. After the contractor had lifted the two sections of the first girder, the DOT inspector noticed that one of the two sections was backward based on the placement of match marks and as noted on the shop drawings. The DOT inspector notified the contractor of the mistake, which meant that the girder had to be rotated 180 degrees. The realignment effort was also complicated by additional problems associated with the removal of shipping bolts. The contractor did not have impact wrenches or similar tools to remove these bolts and as such hand tools had to be used, which further delayed the process. The end result of the delays on the first night was that the second girder could not be installed.



The contractor then scrambled in the early morning pre-dawn hours to fabricate the temporary braces and install anchor bolts into the concrete deck. The anchors were to have been installed into the concrete deck; however, the asphalt topping was not removed and the anchors were installed in raveled, i.e. enlarged, holes

Lessons learned

- No formalized erection plan
- No involvement from licensed design professional
- Lack of control over sequencing which resulted in girder arriving 180 degree out of orientation
- No preplanning for proper equipment and bracing members
- Lack of communications
- No contingencies

and not anchored to the structural concrete deck. Weather delays and other circumstances contributed to a further delay of several more days until the second girder could be installed. During this time, the girder rotated slightly out of plumb and was subject to changing temperatures and wind loadings that were not accounted for in the contractor's erection plan. It eventually collapsed and killed a family of three.

The NTSB concluded that no contingency plan had been developed for securing a single girder. The temporary bracing system originally intended to stabilize the girder for a few hours was ultimately in place for more than three days, during which it was vulnerable to stresses caused by temperature variations, winds, and vibrations from passing traffic. During this time, no other inspections were performed to monitor the bracing systems or orientation of the girder. This among other factors contributed to the collapse and loss of life. The state was cited by NTSB for the failure of the state inspector to actively supervise and monitor safety-critical work by the contractor.

Group Exercise #4.3 - Participants will form groups of four to five participants. Using the sample Erection Plan provided in Appendix B, work together to complete the following questions. The sample erection plan pertains only to Stage I work. The following questions can be completed using information contained in the General Notes and Drawings S-1 thru S-3.

Group exercise #4.3

Q1: The inspector measures wind speeds of 35 mph. The procedure requires what action? (Sheet 2 of 10)

Q2: How many bolts must be installed in cross frames prior to releasing crane loads (Sheet 1 of 10)

Q3: How many girder lines must be installed prior to the end of an erection shift? Is an exception allowed? (Sheet 2 of 10)

Group exercise #4.3, cont.

Q4: Lifting points shall be located ____ distance from the end of the member and adjusted ____ in. to avoid cross frames (Drwg S-2)

Q5: Maximum angle of bracing members to the existing structure shall not exceed ____ degrees nor ____ ft in length. (Drwg S-17)

Q6: Maximum pick weight of the first girder installation is _____ lbs, and the crane capacity is _____ lbs with no boom length restriction. Rotation angle restriction is +/- ____ deg. (Drwg S-3 and Sheet 1 of 10)

Group exercise #4.3, cont.

Q7: Based on your review of the General Notes and drawings S-1 thru S-3, identify three additional responsibilities of the inspector.

A)

B)

C)

The answers to the above group exercises will be reviewed in class. The module is then concluded with a wrap-up review of the module learning outcomes.

Wrap-up

Module 4 Learning Outcomes

1. Review and interpret erection sequence and erection plans
2. Execute pre-erection review of key documents and prepare for pre-erection conference
3. Identify temporary bracing and stability issues
4. Describe consequences of improper handling, erection, and bracing

MODULE 4A - ERECTION OF STEEL GIRDERS - BOLTING

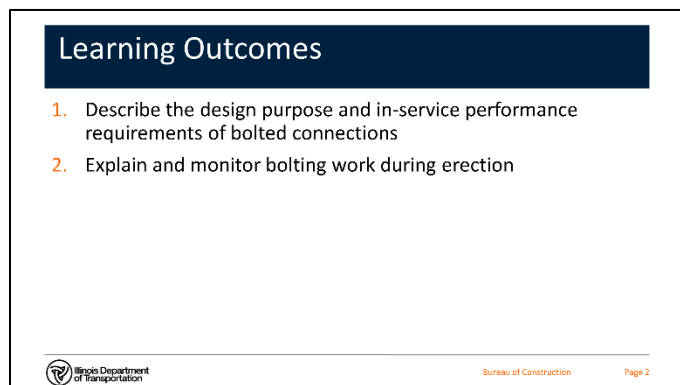
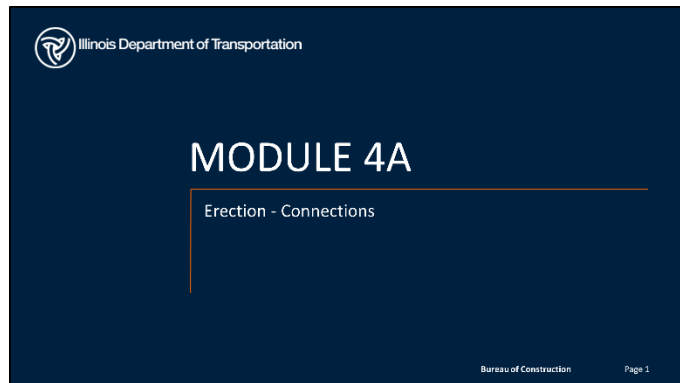
Overview and Instructional Method

Bolt assemblies described in IDOT specifications and used in Illinois bridges are discussed. Participants will review how bolting is handled as part of the erection process. The design purpose and in-service performance requirements of connections are also discussed.

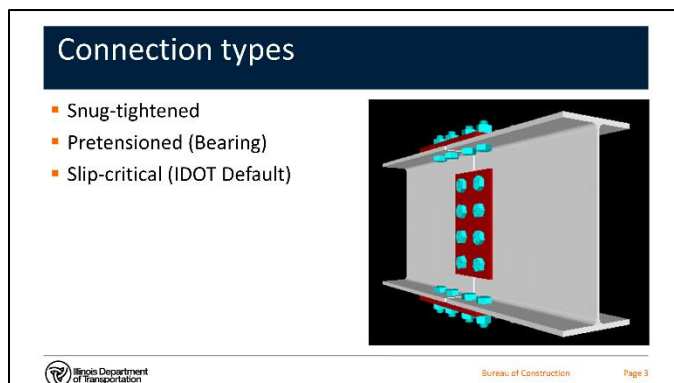
Working in small groups, participants work collectively to understand the role of the inspector in maintaining quality during erection bolting operations. Requirements contained in IDOT specifications and drawings are used to develop inspection checklists. Checklists are shared with the class and compared to IDOT bolt inspection job aids.

This module is designed to achieve the following learning outcomes

1. Describe the design purpose and in-service performance requirements of bolted connections
2. Explain and monitor bolting work during erection.



Presentation Notes




Splice plate and cross frame/diaphragm connections comprise the predominant connection systems utilized in steel structures. The method of load transfer distinguishes the connection type. The Research Council on Structural Connection Joints (RCSC) defines three joint types: Snug-tightened, Pretensioned, and Slip-critical.


Snug-tightened joints recognize that the ultimate strength of the connection is independent of the fastener pretension and slip movement. Therefore, snug-tightened joints can be used when slip movement is not detrimental to the serviceability of the structure. The snug tightened condition is the tightness that is attained with a few impacts of an impact wrench or the full effort of an ironworker using an ordinary spud wrench to bring the plies into firm contact. (RCSC)

Snug-tightened

2014 RCSC Definition: The snug tight condition is the tightness that is attained with a few impacts of a wrench or the full effort of an ironworker using an ordinary spud wrench to bring the plies into firm contact.

- No faying surface requirements



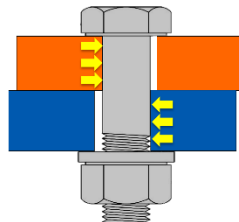

Bureau of Construction
Page 4

Note that the definition for snug tight changed with the issuance of the 2009 RCSC to “A snug-tightened condition exists when all of the plies in a connection have been pulled into firm contact by the bolts in the joint and all of the bolts in the joint have been tightened sufficiently to prevent the removal of the nuts without the use of a wrench.” This definition proved problematic for turn-of-nut method, and was abandoned in the 2014 RCSC Specification. Additional discussion on this issue is provided in Module 5.

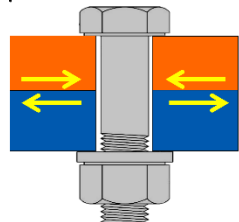
Pretensioned and slip-critical joints are distinguished by their primary method of load transfer under service loadings. Pretensioned joints achieve load transfer through bearing of the plate components on the bolt body. In almost all scenarios, the bolt threads are excluded from the shear plane(s) as the capacity of the connection is greater with the threads excluded from the shear plane. Pretensioned joints support shear and/or tensile loadings in connections where the bolts have been installed to provide a pretension in each bolt but where the faying surface does not meet the requirements associated with slip-critical joints. There is a high likelihood that the connection will go into bearing under service load, and as such pretensioned joints should only be used where serviceability and fatigue issues are not a concern. Slip displacement at the joint will be twice the hole tolerance, which could be problematic in some applications.


Method of load transfer

Pretensioned

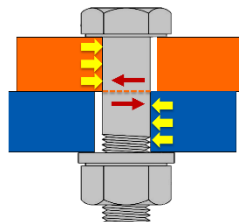


Slip-critical





Bureau of Construction
Page 5

Pretensioned (Bearing)



- Bolts installed with pretension
- Under load, plates slip into bearing on bolt shank
- Creating shear through shank
- Subject to fatigue concerns through load reversal
- Subject to serviceability concerns due to slip


Bureau of Construction
Page 6

A slip-critical connection transfers shear load through frictional resistance of adjacent plies where the normal force is generated by pretensioning of the bolts and the faying surface finish is specially treated in the project specifications to develop the required frictional resistance. The frictional resistance prevents the connected components from slipping into bearing against the bolt body. This is accomplished by limiting the service load demand to the frictional resistance provided by the bolt group. Despite this design philosophy, the bolts must still be designed for bearing since slip-critical joints are only designed for service load conditions.

The faying surfaces in slip-critical joints require special preparation and protection during construction. Frictional resistance (F) is represented by the product of the static frictional coefficient for the materials in contact (μ) and the clamping or normal force (N).

$$F = \mu N$$

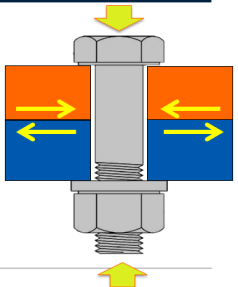
The coefficient of friction is highly dependent upon the condition of the faying surfaces. The inspector shall check all faying surfaces before erection to confirm that they are clean and free of dirt or debris. If faying surfaces are to be field painted, the engineer shall assure the coating has cured for the minimum time recommended by the paint manufacturer. To achieve frictional resistance, the bolted parts shall fit solidly together when assembled. As such, contact surfaces, including those adjacent to bolt heads, nuts, or washers, shall be free of mill scale, dirt, burrs, and other defects that would prevent proper seating of all plies and fasteners.

By their nature, slip-critical connections are best suited for situations where fatigue, vibration, load reversal and/or dimensional stability is a concern. For these reasons, all IDOT connections used in primary structural members shall be slip-critical unless noted otherwise. The IDOT standard note included on steel bridge drawings states that “all connections be slip-critical unless noted otherwise”, thus making slip-critical joints the default joint type used in Illinois steel structures. Fasteners shall be installed, tightened, and inspected (IDOT_SPEC 505.04(f)2) in accordance with “Specification for Structural Joints Using ASTM A325 or A490 Bolts” for slip critical connections as issued by the Research Council of Structural Connections (RCSC) Joints of the Engineering Foundation. Pertinent requirements of this specification are summarized in IDOT_CM, Section 500.

As described in Module 4, the procedure for erection will follow the approved erection plan. In general, this process requires that the girder be lifted and held in position. Lifts start at the fixed bearing and work toward the expansion bearing, with successive elements installed in accordance with the match marks indicated in the erection plan. As the successive elements are lifted into place, the adjacent pieces are pinned and partially bolted per the IDOT specifications and erection plan. Cross-bracing, diaphragms, and other lateral supporting members are then bolted into place per the IDOT specification and erection plan. Once the superstructure section has been configured to safely support its own self-weight, the cranes can be removed.

Slip-critical (IDOT default)

- Pretensioned bolts create clamping force and thus frictional resistance between plates
- Special preparation of faying surface required
- Resist slip under service load
- Suitable for joints subject to fatigue w/load reversal, or where serviceability or oversized holes are a concern



Illinois Department of Transportation

General bolting during erection

- Girders positioned per approved erection procedures and beginning at fixed bearing
- Placed in sequence per match marks in erection plan and supported until splices are **pinned and partially bolted**
- Cross-bracing or other lateral support **bolted** in place
- Cranes removed as permitted by the approved procedure

Illinois Department of Transportation Bureau of Construction Page 8

The inspector should monitor the superstructure alignment throughout the erection process, understanding that sequence of erection has a significant impact on the structure's overall final geometry. Fabrication and erection tolerances and practices, member deflections, and bolting/pinning practices can contribute to errors in the horizontal and vertical alignment. Thermal expansion and contraction of members throughout the course of a given day and over the course of weeks for longer erection projects can cause horizontal and vertical misalignment. As a result of these factors, control of horizontal and vertical alignment from substructure construction through all stages of superstructure construction is critical to attaining a well-positioned and erected structure.

The bolting procedures during erection having the greatest impact on alignment and stability are those associated with splice plates and lateral bracing systems. The erection bolting procedures associated with each are discussed below.

Fastener installation at splice plate connections requires first that the joined members are properly aligned, or fit-up. This is then followed by erection bolting and snug tightening the connection, which is followed by final tightening. Final tightening occurs once the full girder line has been installed and horizontal and vertical alignment has been confirmed.

Alignment uses drift pins, supplemented with erection pins, erection bolts, or "fitting-up" (non-production) bolts to properly align the girder segments. Drift pins are steel pins that are tapered on both ends and cylindrical in the middle. The cylindrical portion has a nominal diameter 1/32 in. smaller than the hole. When placed in the connection, the pins cause the girder to "drift" into position thereby causing the remaining holes to become better aligned, assuming good alignment was achieved during

Alignment

- Erection sequence
- Fabrication and erection tolerances
- Member deflections
- Bolting and pinning practices
- Thermal-induced changes in member dimensions



**CONTROL OF HORIZONTAL
AND VERTICAL ALIGNMENT**

Splice plate bolting

- Alignment
- Erection bolting
- Snug tightening
- Final tightening



Alignment tools

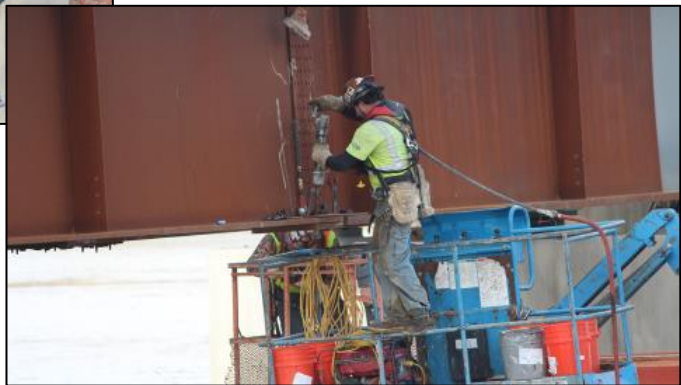


Initial alignment

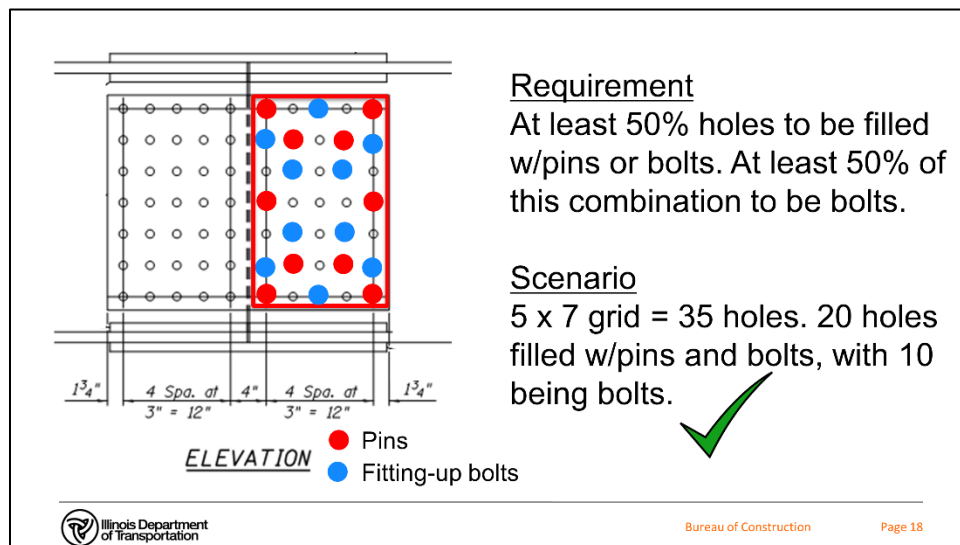
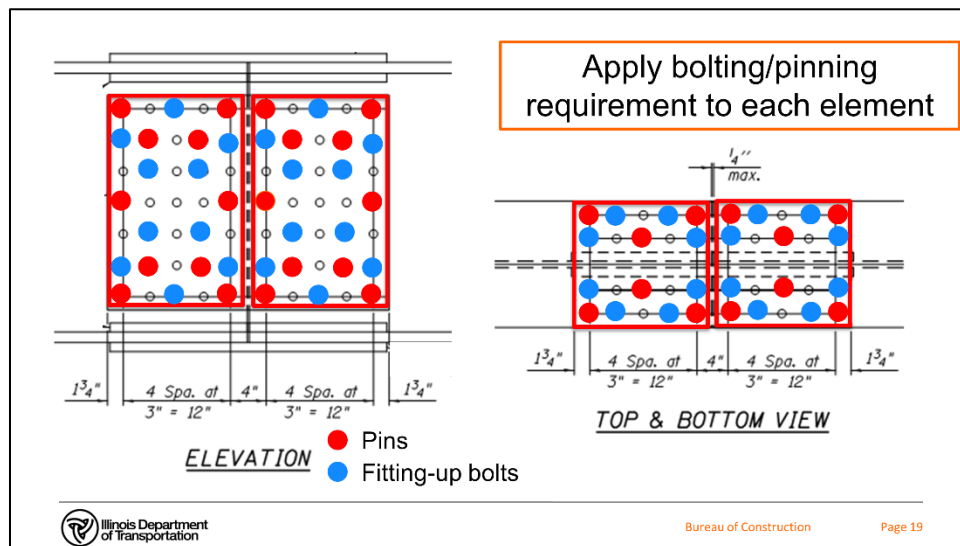
- Vertical
 - Drift pins placed near four corners of web plate for initial alignment
- Horizontal
 - Drift pins placed near four corners of flange plates
- Misfits
 - Reaming not permitted, unless approved by engineer
 - Do not use bolts to drift alignment

fabrication. Bolts installed following drift pin installation will be theoretically centered within their holes and therefore properly placed to achieve a slip-critical connection upon tightening.

Drift pins are typically driven into the splice through all the plies at the corners of the web plates to align the pieces vertically. The flanges are then drifted into correct horizontal alignment by driving drift pins into the corners of the flange plates. For proper alignment only light drifting is allowed; heavy drifting, which would deform the bolt holes, is not allowed. Initially, align the members vertically by lightly drifting the corners of the web plates. The member is then aligned horizontally by lightly drifting the corners of the flange plates. Reaming of holes to aid in drifting the connection will not be permitted, unless approved by the engineer. Corrective work, if approved, must be executed in the presence of the engineer (IDOT_SPEC 505.08(1)).



After the girders are brought into alignment, the connection is secured in accordance with IDOT_SPEC 505.08(h). High-strength bolted splices and primary connections shall have one-half of the holes filled with a combination of finger tight bolts and cylindrical drift pins. One half of this combination, or 25% of all holes, shall be finger tight bolts. Finger tight bolts may be the same as to be used in the final connection, or fitting-up bolts having the same diameter. Fitting-up bolts are non-production used specifically for securing the bridge during erection, but eventually removed and not incorporated in the final work. Per IDOT_SPEC 505.08(h) and IDOT_CM, bolts in continuous beams and girders shall not be tightened until the entire continuous length is in place on the substructure.



Erection of steel girders is a dangerous business, and in practice contractors may need to use more pins and bolts than prescribed by IDOT_SPEC 505.08(h) or need to tighten some bolts to bring the plies into firm contact. The contractor may also desire to use fewer bolts and pins in an effort to speed-up erection. The IDOT specification also does not address situations where newly installed girders will be placed over traffic lanes or subjected to construction or live loads. Furthermore, the specification does address special

considerations associated with curved girder bridges, trusses, highly skewed or complex bridges. In the case of some of these situations, the erection bolting requirements may be addressed in the approved erection plans and therefore will take precedence over the specification. The inspector must become familiar with these requirements in order to properly monitor erection bolting operations.

The AASHTO_SPEC Art. 11.6.5 and EREC_GUIDESPEC Art. 6.7 better address some of the above needs of contractors. The erection bolting requirements specified in EREC_GUIDESPEC Art. 6.7 more closely match the current practices of contractors, as compared to the IDOT specification. Article 6.7 requires that 50% of the holes in splices and primary members be filled prior to crane release. The 50 percent may be either fitting-up bolts in a snug tight condition or full-size drift pins. Note that the use of full-size drift pins is specified in EREC_GUIDESPEC while the IDOT_SPEC and AASHTO_SPEC require pins be 1/32 in. smaller than the hole size.

The AASHTO_SPEC Art. 11.6.5 addresses field assembly of connections carrying traffic during erection. Many state departments of transportation also use this provision to address erected structures placed over traffic. This specification requires splices and primary connections carrying live or erection loads or positioned over traffic to have three-fourths of the holes filled with drift pins and fitting-up bolts, with at least half of this group being fitting-up bolts.

The above specified ratio of pins and bolts shall apply to each element of the splice, for example, top flange, web, and bottom flange of girders. Fitting-up bolts should be placed uniformly throughout each element to properly draw the plates together. It should be noted that the 50% requirement may be waived if a reduced percentage is calculated as sufficient and shown on the approved erection plans. (IDOT_CM)

| Erection bolting (AASHTO) | | |
|--|----------------------------------|-------------------------------------|
| Condition | Holes with pins/fitting-up bolts | Percentage of fitting-up bolt usage |
| Typical Girder | 50% or more | In at least 25% of holes |
| Girder under live loads or positioned over traffic | 75% or more | In at least 37.5% of holes |

✓ IDOT SPEC 505.08(h): 50% of holes filled; 25% pins and 25% finger-tight bolts

Illinois Department of Transportation Bureau of Construction Page 17

The adjacent erection bolting slide conveys the consolidated intent of the above discussion.

Fitting-up bolts are temporary bolts used at the discretion of the contractor and/or owner for erection purposes, and shall be the same diameter as the specified bolts. Fitting-up bolts should be clearly marked as such, and may not be incorporated into the final work. It is more typical to see the use of fitting-up bolts in applications where DTI, lock-pin and collar, and twist-off fastening systems are used. It is also typical to see fitting-up bolts used in large connections with multiple plies of thick material. In the latter case, the fitting-up bolts are used to bring the connection together so snug tightening levels for the specified production bolts are not excessive. It is permissible to use the specified high-strength hex head bolts for fitting-up. When used, these bolts may be left in place, as long as they are not damaged during erection. High-strength bolts will be considered damaged and will need to be replaced if they are tensioned past snug tight while being used to draw two members together, driven into place with a hammer, or have any deformation of the threads.

Exercise #4A.1 - List the issues associated with the erection bolting shown in the following slides.





Girders erected in accordance with IDOT specifications will have 25% of holes filled with pins and 25% of holes filled with finger-tight bolts. After all girders have been erected and elevations have been verified and adjusted as necessary, the contractor will return to each connection to complete detailed bolting work. Detailed bolting work involves bringing the fasteners to a snug tight condition prior to pretensioning. Per IDOT_SPEC 505.08(h), bolt tightening shall not commence until all erection pins at a splice have been removed


and all holes are filled with finger-tight bolts. Bolt tightening shall be according to IDOT_SPEC 505.04(f). These procedures are typically not followed by contractors, and are currently under review by the bridge office. For most bridges erected under an approved plan developed by a structural engineer, this has not been an issue because the structural engineer's procedure takes precedent. For other bridges, the inspector should review the bolting procedure with the contractor at a pre-erection meeting. If the contractor elects to use a procedure different from IDOT_SPEC 505.08(h) then this procedure should be documented as part of the contractor's erection plan submittal and reviewed with the bridge office.

Standard practice in the fabrication of structural steel is to provide 1/16 in. oversize holes for bolts and 1/4 in. maximum spacing between adjoining webs. Under these tolerances, the maximum amount of slip that can occur in a joint is equal to twice the hole clearance, provided all holes are perfectly positioned. In practical terms, experience has demonstrated that slip movement is much less; usually about one-half of the hole clearance. Drift pins, which are 1/32 in. smaller than the hole diameter) maintain the joint geometry. As pins are removed the load is transferred to the remaining pins which can cause these pins to become trapped. In extreme cases drift pins have to be cut off and core drilled to relieve stresses before they can be driven out. As the last pins are removed, the connection will slip bringing the bolts into bearing. This scenarios may be realized when the procedures of IDOT_SPEC 505.08(h) and 505.04f(2) are strictly followed.

The use of pins having a diameter nearly the same size or equal to the hole diameter allows very little to no movement to occur at connections and consequently helps the contractor maintain the final geometry of the structure and prevent trapping pins and bolts. For this reason, most contractors prefer to keep a minimum number of pins in the connection until the remaining bolts are tightened. NCHRP Synthesis 345, *Steel Bridge Erection Practices* (2005), indicates that only three states require pins to be removed prior to tightening. Two of these three states require all holes to be filled with snug-tight bolts prior to pin removal, while Illinois is the only state that requires holes to be filled with finger-tight bolts before pin removal. The AASHTO_SPEC and many other states (NCHRP 345) allow tightening of the balance of high-strength bolts before removal of pins and fitting-up bolts.


IDOT tightening procedures

- At conclusion of erection,
 - Holes filled with 25% pins and 25% finger-tight bolts
- Contractor returns to each connection to pretension bolts
 - Per IDOT_SPEC 505.08(h), pins are removed and all holes filled with finger-tight bolts
 - Bolts then tightened per IDOT_SPEC 505.04(f)

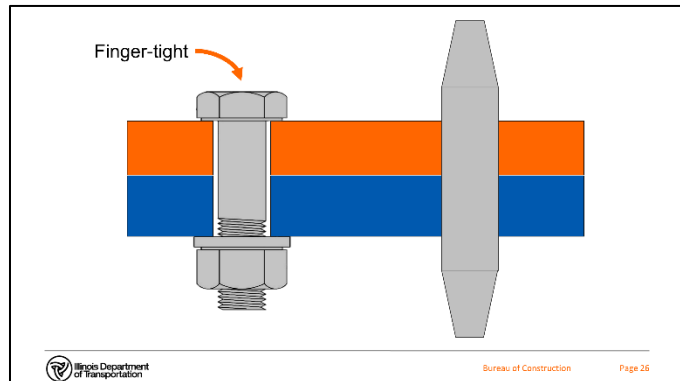

Bureau of Construction
Page 24

AASHTO tightening procedures

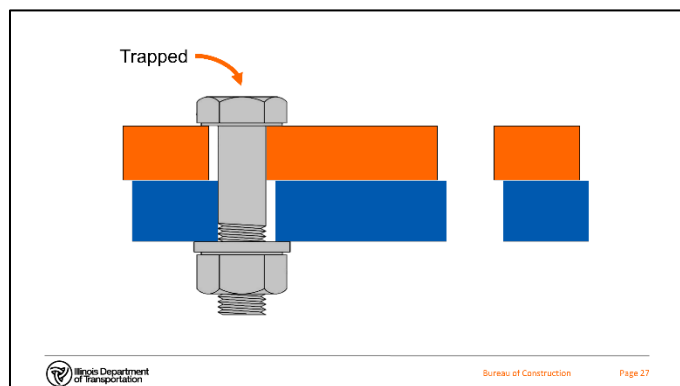
- Splices shall have 50% of holes filled with pins and bolts before installing and tightening the balance of high-strength bolts
- Concerns
 - Trapping pins/bolts
 - Pretension full length of bolt
 - Maintain geometry
 - Systematic tightening


Bureau of Construction
Page 25

If plate slippage occurs during erection, the plates will move into contact with the bolt shank. When this occurs, the bolt is likely to become trapped. A trapped bolt is one which is pinched between the steel plies. The tensioning behavior of the bolt is effected when the shank is trapped in this manner. A pinched bolt will undergo strain only between the turned head and the point of pinching, and as such cannot be tensioned over its full grip length. Failure to induce tension over the full bolt length fails to produce a clamping force at the faying surface, which is necessary for slip critical joints. This behavior is also critical to the proper performance of direct tension indicators (DTI), which are placed under the unturned head. (The behavior of DTI's is discussed in Module 5). If tensioning strain occurs only between the turned head and point of pinching, the unturned head and hence DTI located there will not participate in the clamping behavior.



To overcome trapping issues and better maintain girder geometry during pretensioning, fitting-up bolts and pins should be removed and replaced with production bolts in a systematic manner only after the splice has the remainder of its holes filled with specified bolts in a tightened condition to provide enough clamping force to prevent slip. If there are significant gaps between plies of the splice, it may be necessary to use fitting-up bolts to bring the plies into contact before production bolts are snugged. Similarly for connections where one abutting plate is full thickness and the abutting plate is comprised of thinner plates, it may be necessary to use fitting-up bolts to bring the multiple plates into contact before production bolts are snugged throughout the connection.



Per IDOT_SPEC 505.04(f), tightening shall progress systematically from the most rigid part of the connection to the free edges in a manner that minimizes relaxation of previously tightened fasteners. This requirement applies to both initially snugging-up and the final tightening procedure, regardless of tightening method used. (IDOT_CM) The IDOT_SPEC and IDOT_CM envisions an ideal situation where all bolts are installed in a finger-tight condition and 100% of the bolts can be systematically tightened at both the snug-tight and final tightening stage. Under an ideal scenario, the bolts would be tightened as shown in the adjacent slide.

| | | | |
|----|----|----|----|
| 23 | 21 | 22 | 24 |
| 19 | 17 | 18 | 20 |
| 11 | 5 | 6 | 15 |
| 9 | 1 | 3 | 13 |
| 10 | 2 | 4 | 14 |
| 12 | 7 | 8 | 16 |
| 27 | 25 | 26 | 28 |
| 31 | 29 | 30 | 32 |

Per IDOT_SPEC 505.04(f), tightening shall progress systematically from the most rigid part of the connection to the free edges in a manner that minimizes relaxation of previously tightened fasteners.


In reality, the selected method of tightening, joint complexity, joint thickness, use of fitting-up bolts, and timing of pin removal as discussed above will require some modification to how the systematic tightening of a bolt group will be accomplished. Regardless, the contractor and inspector will need to understand that previously tightened bolts will experience relaxation as the joint is brought up to a final tight condition. The relaxation will need to be addressed with touch-up retightening until all bolts in the joint group are uniformly tight and all plies are in uniform contact.

The snug tightening procedure should bring the faying surfaces into firm contact. This is accomplished by progressively tightening the fasteners from the most rigid part of the connection to the free edge. The tightening process for each fastener should be the same used in the verification testing to achieve snug tight (as described in Module 5). Snug tight is usually accomplished by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. (RCSC)

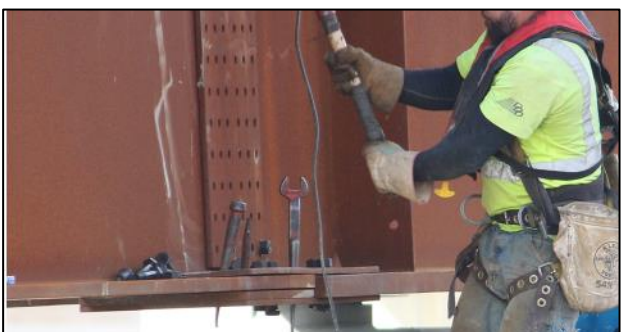
The IDOT_CM and IDOT_SPEC describes snug tight as a procedure that produces approximately 10 kips but does not produce more than 50% of the required final tension. Snug tight tensions above 50% of the final tension could result in bolts failing when tightened to their final tension. It should be noted that this provision may be removed from the IDOT specifications and likely replaced with the current RCSC definition.

Initial tightening – Snug tight

- Bring faying surface into full, uniform contact
- Snug systematically from rigid part of connection to free edges
- Repeat again systematically tightening in similar pattern as necessary to fully compact faying surfaces


Bureau of Construction
Page 20

The next several slides illustrate situations where it may be difficult to achieve snug tight conditions without imparting significant tension into the bolt and where fitting-up bolts might be considered. In these scenarios, the fitting-up bolts would be used to bring the plies into contact. Once the faying surface is brought into firm contact, permanent bolts would be installed in open holes and snug tightened with a few hits of an impact wrench or the full effort of a man using an ordinary spud wrench. The fitting-up bolts would be removed and permanent bolts installed in their place, then snug tightened. This procedure in the illustrated scenarios would be particularly appropriate for applications where DTI, lock-pin and collar, and twist-off fastening systems are used.



The fasteners in the joint shall be systematically tightened as necessary using a similar pattern until all fasteners are simultaneously snug tight and the connection is fully compacted. For slip-critical connections, no visible gap shall remain between faying surfaces when all bolts are tightened to a snug tight condition. For connections with individual plates 1 in. and thicker, a minimum of two cycles of systematic snug tightening will be required. (IDOT_SPEC 505.04d(1))

Final tightening can proceed only after the structure erection and alignment has been completed. However, fasteners shall not be fully tightened until the entire structure has been set on the substructure. IDOT_SPEC 505.08(h) states “splices in continuous beams and girders shall not be torqued until the entire continuous length is in place on the substructure.

The IDOT_SPEC describes four tensioning methods for high strength fasteners, as follows. Similar to the snug tightening procedure, the final tightening will proceed from the most rigid part of the connection to the free edges.


- Turn-of-nut (IDOT_SPEC 505.04f(2)(d))
- Load indicating washers (IDOT_SPEC 505.04f(2)(a))
- Twist-off, tension controlled fasteners (IDOT_SPEC 505.04f(2)(b))
- Lock-pin and collar type fasteners (IDOT_SPEC 505.04f(2)(c))

Each tightening method will be discussed in Module 5. Note that calibrated wrench method is not permitted per IDOT_SPEC 505.04f(2). The inspector will be responsible for monitoring the tightening method as described in Module 5. The inspection procedures giving the best assurance that fasteners are properly installed and tensioned is provided by inspector observation of the verification testing of the fasteners using the selected installation procedure followed by monitoring of the work in progress to assure that the procedure which was demonstrated to provide the specified tension is routinely adhered to. When such a program is followed, no further evidence of proper bolt tension should be required. (IDOT_CM)

Final tightening

- Use approved tightening procedure
 - Turn-of-nut
 - Load indicating washers
 - Twist-off, tension controlled
 - Lock-pin and collar type

- Apply final tension to all bolts proceeding from most rigid part of the connection to the free edge

Bureau of ConstructionPage 34

The answers to the following questions will be reviewed in class. The module is then concluded with a wrap-up review of the module learning outcomes.

Quiz #4A.1

The contractor experiences fit-up problems and uses a production bolt and his air wrench to bring plies into full contact. Is it permitted to keep this bolt in the bridge?

- Yes
- No

Quiz #4A.2

The contractor experiences fit-up problems and uses his sledge hammer to drive the bolt into place. Should this bolt be removed?

- Yes
- No

Wrap-up

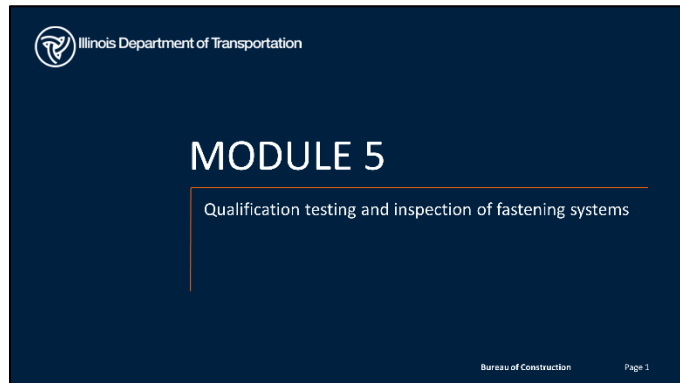
Module 4A Learning Outcomes

1. Describe the design purpose and in-service performance requirements of bolted connections
2. Explain and monitor bolting work during erection

MODULE 5 - BOLTING OF STEEL GIRDERS

Overview and Instructional Method

Participants are introduced to fastener qualification testing, including rotational-capacity test and verification testing. Participants participate in hands-on demonstrations of these methods using a Skidmore-Wilhelm Tension Calibrator. Participants also gain experience in the use of typical bolting tools. The effect of rust and lubricants on bolt tension performance is also discussed.



The installation and inspection requirements for turn-of-nut, direct tension indicator (DTI), and twist-off bolts will be reviewed. Working in small groups, participants work collectively to understand the role of the inspector in maintaining quality during bolting operations. Requirements contained in IDOT specifications and drawings are used to develop inspection checklists.

This module is designed to achieve the following learning outcomes

1. Describe the various types of fastener tensioning methods used in Illinois
2. Complete job aid checklists for qualification of bolt assemblies prior to use on projects.
3. Execute and describe verification testing for each bolt tensioning method.
4. Monitor fastener installation throughout bridge construction.

Learning Outcomes

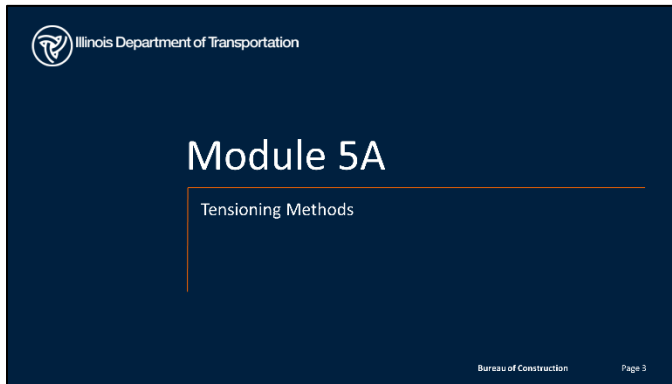
- Describe the various types of bolt tensioning methods used in Illinois
- Complete job aid checklists for qualification of bolt assemblies prior to use on job
- Execute verification testing for each bolt tensioning method
- Monitor fastener installation throughout bridge construction

Bureau of Construction Page 2

This module is organized into submodules 5A through 5K, as follows:

| Module | Title | Module | Title |
|--------|---|--------|---|
| 5A | Tensioning Methods | 5F | Field inspection of twist-off method |
| 5B | Qualification of bolting assemblies | 5G | Verification Testing – Lock-pin and collar fasteners |
| 5C | Verification Testing – Turn-of-nut Method | 5H | Field inspection of Lock-pin and collar fastening systems |
| 5D | Field inspection of turn-of-nut method | 5I | Verification Testing – Direct Tension Indicators |
| 5E | Verification Testing – Twist-off Bolt | 5J | Field inspection of direct tension indicators |

Presentation Notes



This module has been divided into ten subsections. Module 5A describes the various bolt tensioning methods used in Illinois. Modules 5B through 5D focus primarily on heavy hex head fasteners installed using the turn-of-nut method. The rotational-capacity test is described in Module 5B for heavy hex head fasteners. Module 5C covers verification testing for heavy hex head fasteners, and Module 5D describes the production installation of heavy hex head fasteners per the turn-of-nut method. The inspector's

responsibilities are described throughout Modules 5B to 5D.

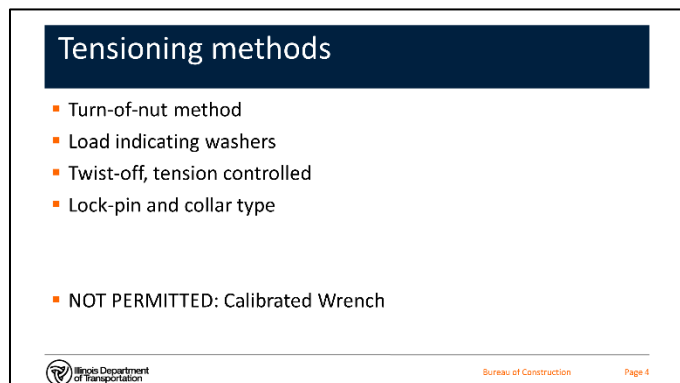
The remaining subsections of this module describe the verification testing and production installation requirements for three additional tensioning methods other than turn-of-nut method. The information presented in Modules 5E through 5J will not be discussed during the course, and as such is provided here as reference only.

The IDOT_SPEC describes four tensioning methods for high strength fasteners, as follows:

- Turn-of-nut (IDOT_SPEC 505.04f(2)d)
- Twist-off, tension controlled fasteners (IDOT_SPEC 505.04f(2)b)
- Lock-pin and collar type fasteners (IDOT_SPEC 505.04f(2)c)
- Load indicating washers (IDOT_SPEC 505.04f(2)a)

Each method will be briefly discussed in submodule 5A.

Note that calibrated wrench method is not permitted per IDOT_SPEC 505.04f(2). For reference, the calibrated wrench pre-tensioning method is performed by applying a calculated average torque value to fasteners based on daily testing of representative fastener assembly samples using the exact configuration of installation tools and power supplies under as nearly identical conditions as possible as actual installation conditions, within one day or less.

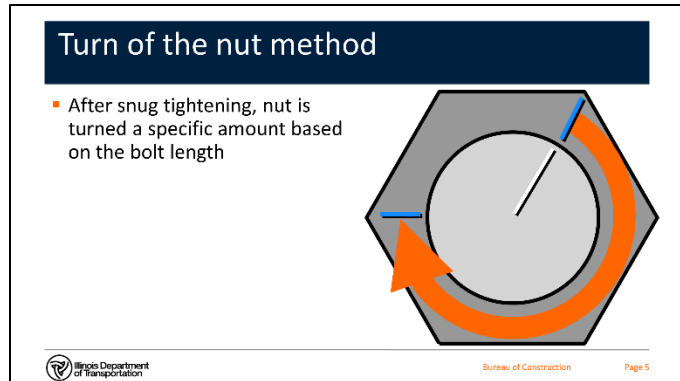


Tensioning methods

- Turn-of-nut method
- Load indicating washers
- Twist-off, tension controlled
- Lock-pin and collar type

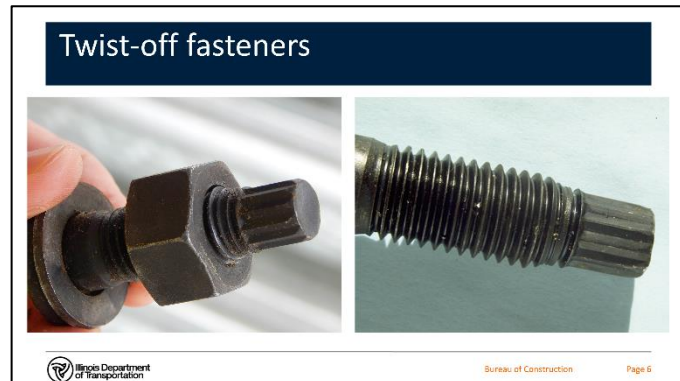
▪ NOT PERMITTED: Calibrated Wrench

The turn-of-nut method is the most common bolt tensioning method used in Illinois. Tension is achieved by applying a prescribed turn of the nut which causes the bolt to elongate as the nut travels down the sloped bolt threads. In essence, the turn-of-nut method is a strain control process that produces a commensurate change in the tensile load as the bolt elongates. Within the elastic range, both the starting point at snug tight and the amount of rotation applied beyond snug tight will be influential in determining the preload. However, in the inelastic range the load versus strain curve is relatively flat such that additional rotation results in only minor variations in preload.

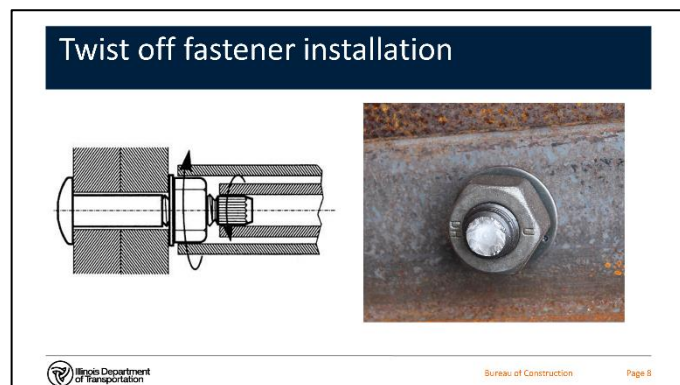


The reliability of the method is dependent upon the joint plates being well compacted and all bolts being uniformly brought to a snug tight condition. Reliability is also dependent upon the rotation of the nut relative to the bolt shank, which requires that the bolt head be prevented from rotation during installation. This method is easily inspected through the use of match marks placed after snug tightening. The inspector can visually examine the match markings to determine that the prescribed turn of the nut was applied to each nut in a connection.

Twist-off fasteners have a specially fabricated spline end that twists off (fractures) at a torque corresponding to the proper bolt pretension. The assembly requires careful control of lubrication, bolt and nut finish, and spline end dimensions so that the torque needed to twist off the splined end within the circular notched zone occurs after the bolt achieves the desired tension.



Because of the need for a high degree of precision in the bolt and nut finish, these fasteners are manufactured as a nut-bolt assembly under strict quality control. This minimizes some of the negative aspects seen in heavy hex head fasteners where nuts and bolts may be fabricated by different manufacturers.



The torsional failure occurs at a bolt tension above the minimum required pretension only if the bolt is properly fabricated and the desired frictional performance at the thread and nut interface is realized. As such, lubrication and bolt condition are important parameters for proper functioning twist-off fasteners. In fact, the RCSC requires twist-off type fasteners be used in the as-received, clean, lubricated condition.

The torsional failure occurs at a bolt tension above the minimum required pretension only if the bolt is properly fabricated and the desired frictional performance at the thread and nut interface is realized. As such, lubrication and bolt condition are important parameters for proper functioning twist-off fasteners. In fact, the RCSC requires twist-off type fasteners be used in the as-received, clean, lubricated condition.

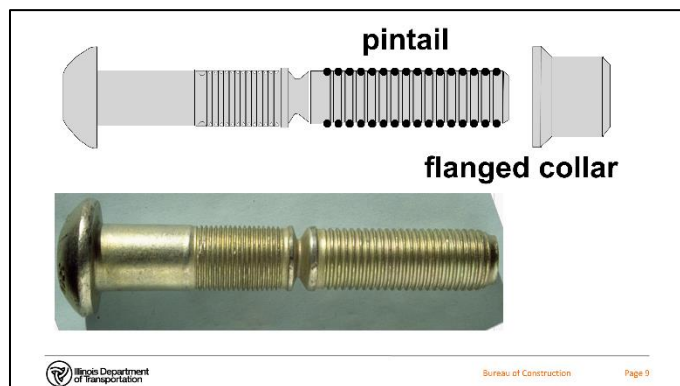
The installation of twist-off fasteners is achieved from one side only, and as such is usually supplied with a rounded bolt head as there is no need to hold the head from turning. Although for appearance sake, hex head bolt heads are available. Like turn-of-nut method, twist-off bolts are brought to a snug tight condition before final tightening.



The installation process requires the use of a specially designed wrench and socket that provides a means for turning the nut relative to the bolt. The two-part socket can hold the bolt at the splined end while simultaneously turning the nut. A typical installation is done in two steps similar to the turn-of-nut method by first bringing all fasteners to a snug tight condition then completing the installation until the splined end is torqued off.

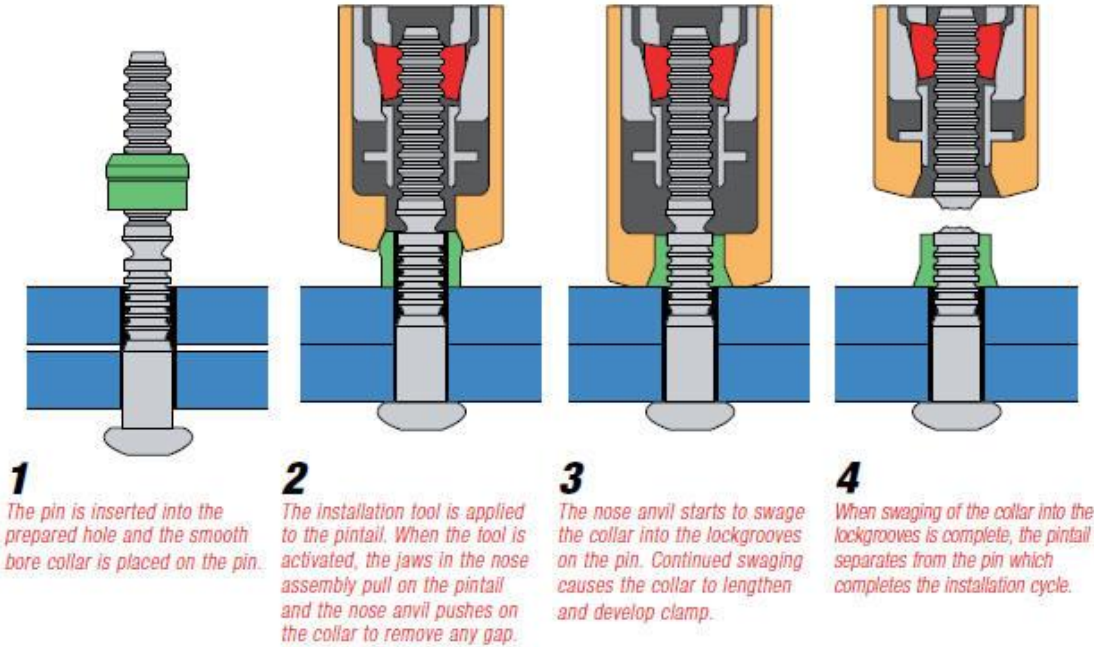
The fractured end of the bolt allows an easy means of inspection to assure the fasteners were properly installed and achieved the desired pretension.

Lock-pin and collar fasteners, sometimes referred to as Huckbolts, are specially designed to achieve consistent clamping force and may be used as an alternate for conventional high strength, hex head fastening systems. The fastener consists of a pin and locking collar. The pin has a head, annular lock rings, a breakneck groove, and pull grooves. The fastener is available in strengths equivalent to A325, with diameters from 1/2 to 1-1/8 in. and grip lengths from 1/4 to 6 in. depending on diameter.



The fastener installation sequence begins by placing the pin into the hole, and placing the collar over the shank. A special hydraulic tool compresses the collar bringing the plies into bearing. As the tool is advanced, it pulls and twists the pintail until it fractures at the breakneck groove. The action on the pintail causes the collar to become swaged onto the lock annular grooves. The installation sequence imparts a bolt tension in the fastener comparable to conventional high-strength, hex head fasteners. The fracturing of the pintail provides the visual indication that the fastener was properly installed. Load indicating washers and torque checks are not necessary. Lock-pin and collar systems are not subject to the rotational-capacity testing required of other installation methods. The installation sequence is highlighted below in a graphic taken from the Huckbolt website.

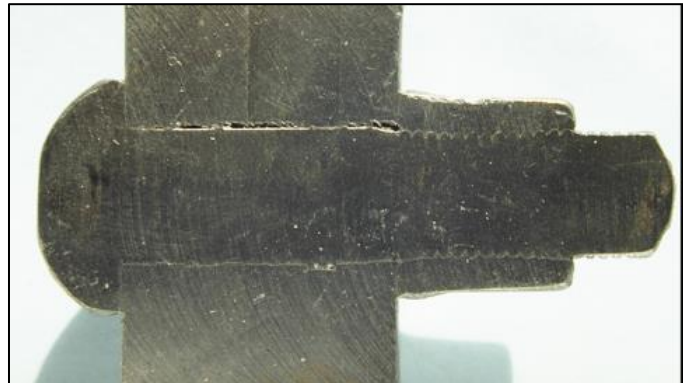
Installation Sequence



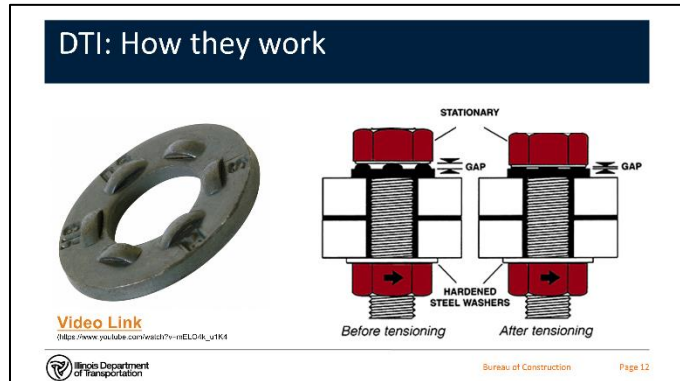
3

Courtesy Huckbolts by Alcoa

A cross section of the swaged collar is shown in the adjacent slide. The swaging process creates a locking mechanism that is highly resistant to vibratory effects, while maintaining a consistent clamping force without coming loose.

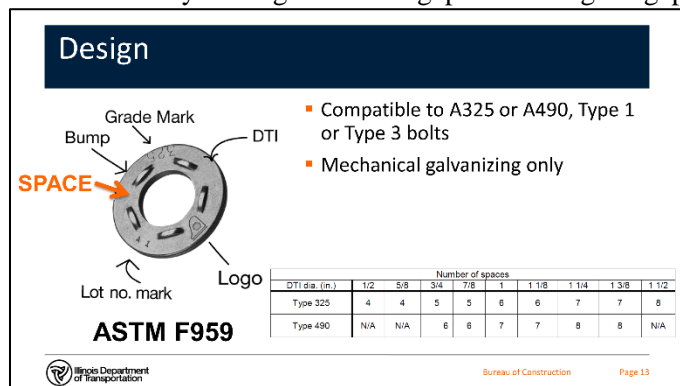


Load indicating washers, or alternatively direct tension indicators (DTI's), are mechanical load cells that are engineered to deform when the prescribed bolt tension is achieved. The washer shaped devices incorporate small arch-like protrusions that are designed to deform in a controlled manner when compressed. When placed under a stationary fastener element (bolt head, nut, or washer), the protrusions compress as the turned fastener element is rotated and tension develops in the bolt. In effect, the protrusions act as single-use mechanical load cells that measure bolt preload independent of lubrication or bolt condition.



Prior to load a gap is present between the bolt head and face of the washer, which is equal to the protrusion height. As the nut is tightened, the protrusions deform effectively closing this initial gap. The change in gap depth is measured using a feeler gage, which is shipped with the washers.

DTI washers conform to the requirements of ASTM F959 and may be purchased for use with A325 or A490 bolts. DTIs are available for Type 1 bolts either plain or mechanically galvanized, and for Type 3 bolts either mechanically galvanized with an epoxy coating or from weathering steel. The hardness of DTI's will typically be considerably lower than the hardness of a standard, F436 washer.



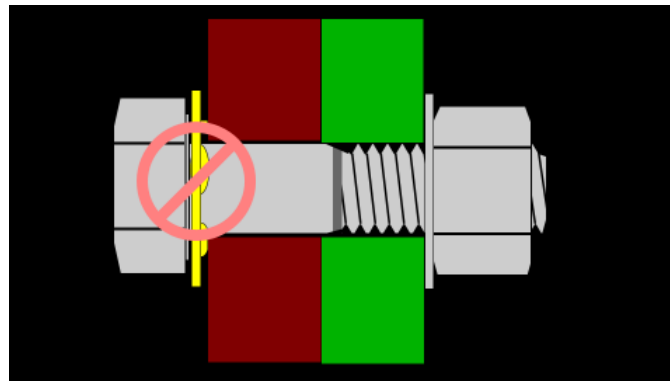
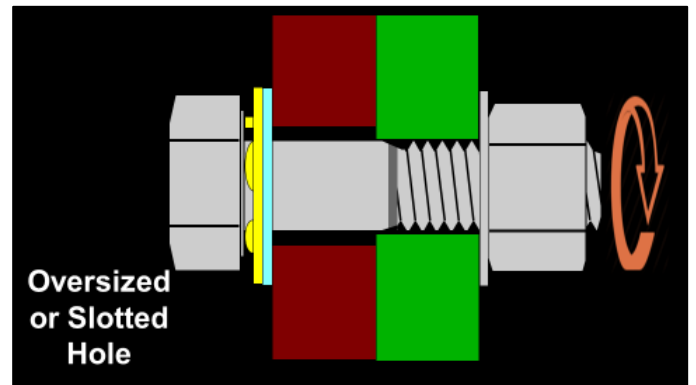
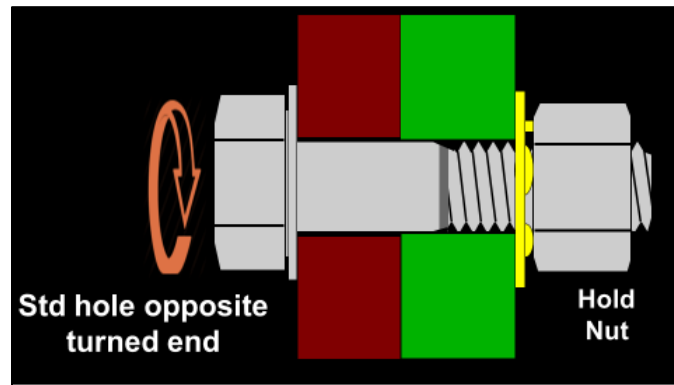
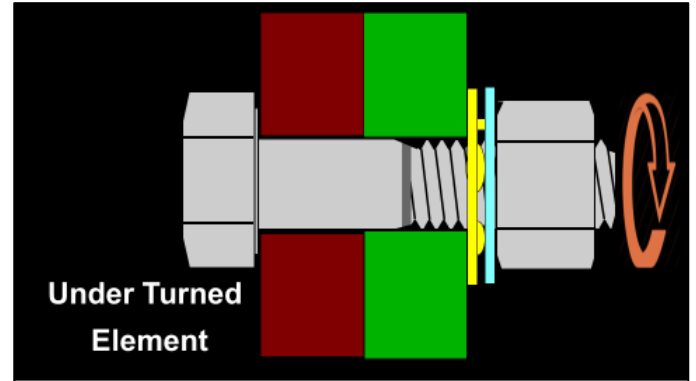
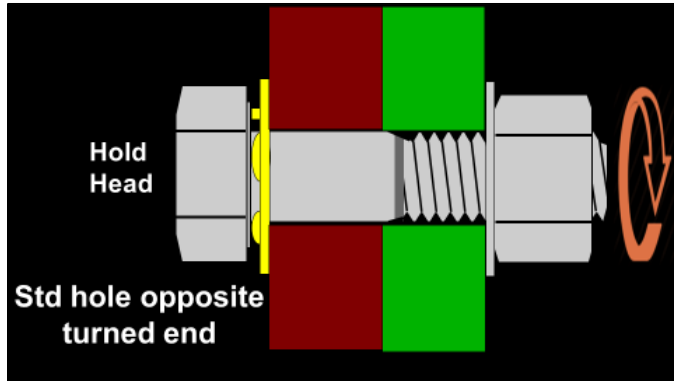
Thus, DTI's shall not be used as a substitute for hardened steel washers. The number of protrusions, or bumps, is dependent on the diameter of the DTI, as shown in the adjacent table.

The performance of DTIs requires that the protrusions be uniformly loaded against a stationary surface and that the washer is uniformly supported from both below and above. As such, the protrusions are placed in contact with the non-turned bolt head or nut, if the bolt head is turned. The preferred installation orientation for DTIs is under the non-turned element. If this installation is not possible, the protrusions are placed against a stationary hardened washer, positioned underneath the turned element. It is noted however that galvanized A325 bolts shall always have the galvanized DTI under the bolt head with only the nut being permitted to be turned (IDOT_SPEC 505.04f(2)a.2)).

Placement of DTIs under the side opposite the turned element ensures that the DTI is indicating tension on the bolt along its full length, and that the bolt has not been "trapped" by premature removal of drift pins or inadequate snug-tightening. A "trapped" bolt is one which is pinched between steel plies such that it can't be uniformly tensioned along its full length.

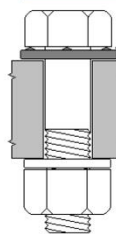
To ensure uniform loading of all protrusions, the DTI shall be adequately supported across enlarged and slotted holes. This may require the use of additional hardened washers or steel plate washers.

The following examples illustrate the proper orientation and support of DTI washers for different tightening scenarios.




A feeler gauge is used to determine when the proper deformation of the washer protrusions has occurred. After the bolt has been tightened, a tapered 0.005 inch feeler gauge is inserted into each gap. When the gage does not enter, meaning that the tip of the gage does not touch the bolt shank, then the gage is considered to have met refusal.


Proper installation



When .005 inch feeler gage does not enter gap, it is considered refused.

Refusal at 50% of the gaps with one gap still visible represents a proper installation

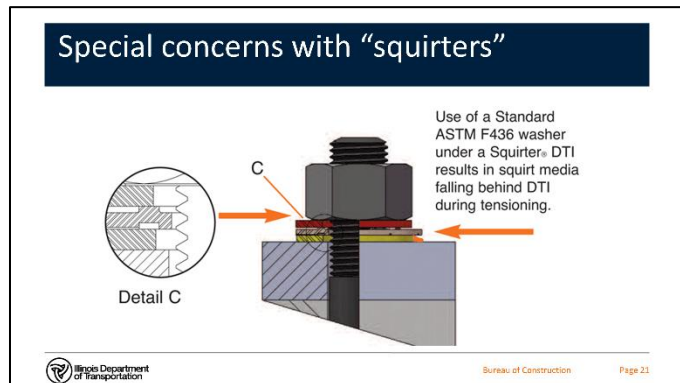


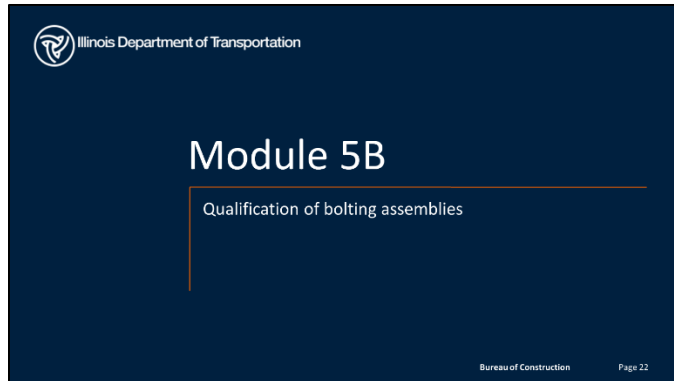

Bureau of Construction
Page 19

Washer markings and/or geometrical protrusions/notches are strategically placed to assist the inspector in locating the gaps. In this slide example, the edge notches in the washer designate the gap locations. Other manufacturers use dimples, washer edge knobs, or lettering to designate gap locations. The DTI examples shown in previous slides illustrate some of these patterns.

Squirter DTIs are DTIs with a flexible silicone embedded in the depressions under the protrusions. As the protrusions are compressed, the silicone is extruded through channels cut into the back of the washer. When the colored silicone appears at the boundary of the washer the desired pretension has been achieved.

Non-standard holes and improper use of washers with Squirter DTIs will compromise the ability of the ironworker to confirm proper tensioning of fasteners. If a F436 washer is used under the Squirter DTI, the silicone reservoir may be partially exposed thus allowing silicone to extrude quicker than designed or fall behind the DTI. A special washer with a larger outside diameter or plate washer should be used when the potential for this occurs.





Rotational-capacity tests (R-C) are required per IDOT_SPEC 505.04f(3) for the following installation methods: Turn-of-nut method, Load Indicating Washer, and Twist-Off Type Fastener Systems. The rotational-capacity test is intended to ensure that the bolt and nut assembly can develop the necessary pretension without galling or stripping of threads or shearing of the bolt and that the bolt has good ductility. The rotational-capacity test also defines the relationship between torque and pretension for the specific bolts and nuts to be

used on each project based on their condition at the time of testing. The condition of the fastener assembly has a significant influence on the rotational-capacity test, and as a result use of torque tables or calculations is not allowed.

Rotational-capacity tests shall be required on all black or galvanized bolt, nut, and washer assemblies, and shall be performed on each combination of nut and bolt to be used on a project. Because thread fit between bolt and nut can vary considerably between manufacturers and fastener lots, rotational-capacity tests shall be performed at the source where the nuts, bolts, and washers are combined to form an assembly. Each combination of bolt production lot, nut lot, and washer lot shall be tested as an assembly, and a rotational-capacity lot number assigned to each combination. Documentation of the rotational-capacity testing performed at the manufacturer or distributor shall accompany the bolts at delivery. (IDOT_SPEC 505.04(f)(3)b)

A rotational-capacity test shall also be performed at the jobsite. (IDOT_SPEC 505.04(f)(3)g.1) Jobsite tests shall be performed on all black or galvanized bolt, nut, and washer assemblies of the same rotational-capacity lot (R-C Lot) number as received from the supplier. Two assemblies per each R-C Lot shall be tested and the results documented using IDOT Form BC2320. (IDOT_CM) Only bolts, nuts, and washers from the same rotational-capacity lot can be used together. Bolts, nuts, and washers from different rotational-capacity lots cannot be intermixed.

Rotational-capacity tests are most typically performed using a Skidmore-Wilhelm High-Strength Portable Bolt-Tension Calibrator. Inspectors should be familiar with the equipment used for their particular project. The material covered in this course assumes that Skidmore-Wilhelm equipment is being used.


Qualification of bolting assemblies

- Rotational capacity test @ manufacturer
 - Each combination of bolt, nut, and washer tested as an assembly
 - Rotational-capacity (R-C) Lot No. assigned
- Rotational capacity test @ job site
 - Minimum of two assemblies per R-C Lot No.
 - Results reported on IDOT Form BC2320

Illinois Department of Transportation Bureau of Construction Page 23

R-C testing equipment

- Calibrated bolt tension measuring device
- Calibrated torque wrench
- Spacers
- Rigid mounting



Illinois Department of Transportation Bureau of Construction Page 24

The contractor shall provide the bolt tensioning device and a calibrated dial inspection torque wrench for the R-C testing. (IDOT_SPEC 505.04(f)(2)) The inspector should request documentation that the supplied devices have been calibrated, and that the calibration is not more than one-year old. (IDOT_CM) Written documentation attesting to the calibrations of both devices shall be provided and kept with the bridge file. In some instances, the calibration will be indicated by a sticker placed on the Skidmore or wrench. The inspector should take a photograph of this documentation for the file. The inspector shall also examine the tensioning device and wrench prior to use to assure they are in good working order.

R-C testing equipment

- Skidmore-Wilhelm
 - Calibration within last year
 - Correct bushing, front plate, and spacers for bolt being tested
 - Visual inspection
- Torque wrench
 - Calibration within last year
 - Visual inspection



 Illinois Department of Transportation
Bureau of Construction
Page 26


The tensioning device should be securely mounted for field R-C testing. This can usually be accommodated by affixing the device to the flange of a pile or steel beam or other stationary object of sufficient weight to prevent injury.

The device shall be configured according to the manufacturer's specifications to accommodate the diameter and length of the bolt being tested. The hole diameter of all test components including spacers and washers shall be no more than 1/16 in. greater than the test bolt. (IDOT_CM)

The following video (<https://www.youtube.com/watch?v=DnXvhFCpPMA>) shows the execution of a R-C test. The following slides describe the steps of the R-C test and are provided as reference material for future reference when access to the video is not possible.


ROCAP Video (<https://www.youtube.com/watch?v=DnXvhFCpPMA>)

- Step 1 – Record fastener parameters and measure bolt
- Step 2 – Configure test apparatus and install bolt
- Step 3 – Snug tight
- Step 4 – Match mark bolt, nut, and face plate
- Step 5 – Tighten to required tension; record torque
- Step 6 – Check torque; compare to maximum permitted torque
- Step 7 – Additional nut rotation; verify minimum tension
- Step 8 – Inspect bolt

 Illinois Department of Transportation
Bureau of Construction
Page 27

STEP 1 - Using IDOT Form BC2320 record fastener parameters and measure bolt dimensions. Include manufacturer and lot information for bolt, nut, and washers. Also include R-C Lot Number assigned by either the manufacturer or distributor. Measure bolt dimensions per illustration below.

Step 1 – Record parameters; measure bolt



Illinois Department of Transportation

Rotational Capacity Test Worksheet

The test procedure, as detailed in Section 500 of the Construction Manual, should be followed when filling out this form. One worksheet shall be filled out for each rotational capacity lot number used on the project.

1. Bolt Grade: A325 A490

2. Assigned R-C LOT NUMBER: _____

County _____

Section _____

Route _____


District _____

Contract No. _____

Job No. _____

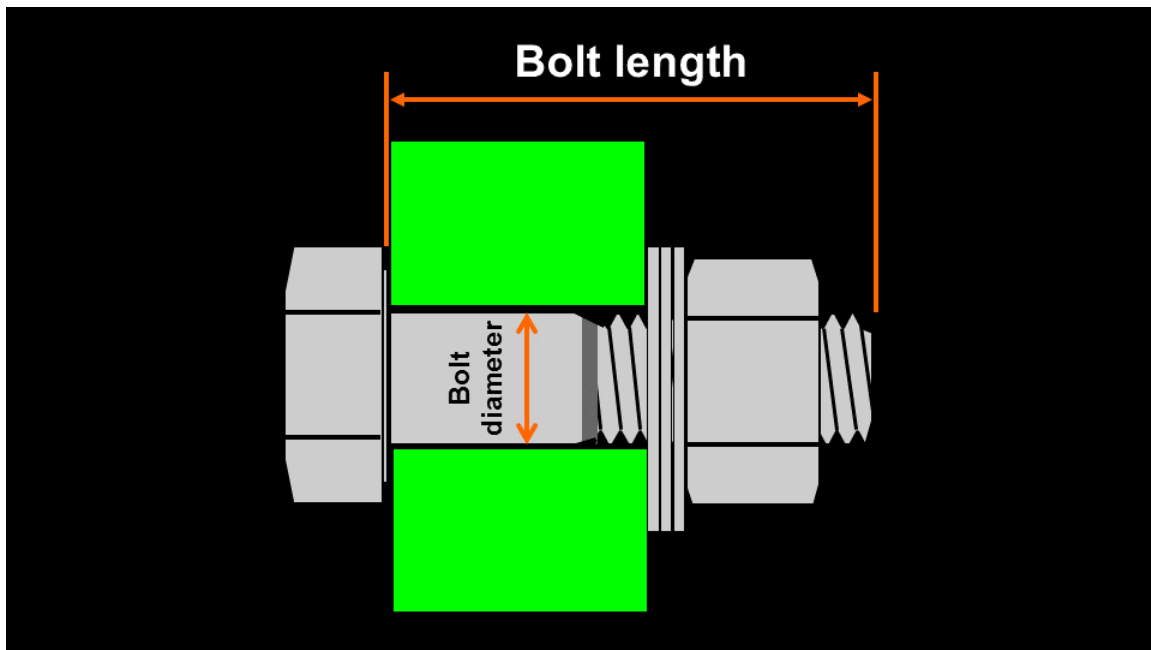
Project _____

| | Bolt | Nut | Washer |
|-------------------|------------|--------------------|--------------|
| 3. Manufacturer: | _____ | _____ | _____ |
| Lot Number: | _____ | _____ | _____ |
| 4. Bolt Diameter: | _____ Inch | Bolt Length: _____ | _____ Inches |



Bureau of Construction

Page 28





Rotational Capacity Test Worksheet

The test procedure, as detailed in Section 500 of the Construction Manual, should be followed when filling out this form. One worksheet shall be filled out for each rotational capacity lot number used on the project.

County
Section
Route
District
Contract No.
Job No.
Project

1. Bolt Grade: A325 A490
2. Assigned R-C LOT NUMBER:

- | | Bolt | Nut | Washer |
|-------------------|---------------------------|----------------------|-----------------------------|
| 3. Manufacturer: | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| Lot Number: | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| 4. Bolt Diameter: | <input type="text"/> Inch | Bolt Length: | <input type="text"/> Inches |

| | Sample I | Sample II |
|--|-------------------------------|-------------------------------|
| 5. Measured Tension | <input type="text"/> kips | <input type="text"/> kips |
| 6. Measured Torque | <input type="text"/> ft - lbs | <input type="text"/> ft - lbs |
| 7. Maximum Permitted Torque (see back) | <input type="text"/> ft - lbs | <input type="text"/> ft - lbs |
| | <input type="checkbox"/> OK | <input type="checkbox"/> OK |
| after twice the installation rotation: | | |
| 8. Measured Tension | <input type="text"/> kips | <input type="text"/> kips |
| 9. Minimum Tension (see back) | <input type="text"/> kips | <input type="text"/> kips |
| | <input type="checkbox"/> OK | <input type="checkbox"/> OK |
| 10. Verify Thread Condition | <input type="checkbox"/> OK | <input type="checkbox"/> OK |

Tested by:
Witnessed by:
Date: Location:

| 3/4 Inch | | 7/8 Inch | |
|----------|--------|----------|--------|
| Tension | Torque | Tension | Torque |
| kips | ft-lbs | kips | ft-lbs |
| 28 | 437 | 39 | 711 |
| 29 | 453 | 40 | 729 |
| 30 | 469 | 41 | 747 |
| 31 | 484 | 42 | 766 |
| 32 | 500 | 43 | 784 |
| 33 | 516 | 44 | 802 |
| 34 | 531 | 45 | 820 |
| 35 | 547 | 46 | 839 |
| 36 | 562 | 47 | 857 |
| 37 | 578 | 48 | 875 |
| 38 | 594 | 49 | 893 |
| 39 | 609 | 50 | 911 |
| 40 | 625 | 51 | 930 |
| 41 | 641 | 52 | 948 |
| 42 | 656 | 53 | 966 |
| 43 | 672 | 54 | 984 |
| 44 | 688 | 55 | 1003 |
| 45 | 703 | 56 | 1021 |
| 46 | 719 | 57 | 1039 |
| 47 | 734 | 58 | 1057 |
| 48 | 750 | 59 | 1076 |
| 49 | 766 | 60 | 1094 |
| 50 | 781 | 61 | 1112 |
| | | 62 | 1130 |
| | | 63 | 1148 |
| | | 64 | 1167 |
| | | 65 | 1185 |

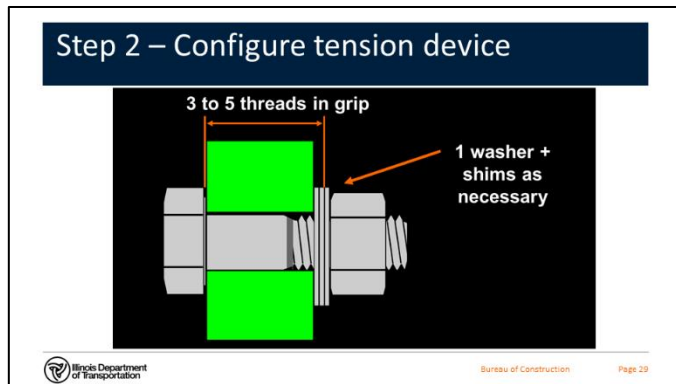
Minimum Measured Tension (step 9 on front side)

| | A325 bolt | A490 bolt |
|----------|-----------|-----------|
| 3/4 inch | 32 | 40 |
| 7/8 inch | 45 | 56 |

Step 2 - Configure bolt tension indicator and install bolt. The thickness of the plates and spacers used in the Skidmore-Wilhelm device shall be determined as follows:

1. Advance nut and one washer until 3 to 5 threads are left showing below the washer.
2. Check that there is thread stick out extending beyond the nut.
3. Measure the gap (i.e. distance between washer and underside of bolt head). This is the target gap dimension for the tension device.

The measured gap dimension shall be taken as the thickness of the tension device, which may be made up of plates and/or spacers. The plates and spacers should be those provided by the tension device manufacturer. The manufacturer provides a variety of spacers having variable length or thickness and diameters to accommodate most high strength bolt configurations. In some instances it may be necessary to add additional washers to achieve the desired thickness. The addition of more than three washers should be avoided as it does not reflect field conditions and effects the accuracy of R-C testing.



It should be noted that for projects where DTIs are specified, R-C testing shall be conducted with only hardened washers. The performance of DTIs is confirmed through verification testing only.

After the tension device has been secured and properly set-up, insert the bolt and place washer and nut on threads. Hand tighten the nut and measure the thread stick-out, which should be approximately equal to the dimension determined in Step 4 above. If these values are approximately equal the device is properly configured.


Step 3 - The nut is then tightened to “snug tight” using a hand wrench until the prescribed tension is achieved, as shown in the table included in the adjacent slide. The tension exhibited on the device gauge shall be not less than the value shown in the table or more than 2 kips above that value.

Step 3 - Snug tight

- Tighten nut to “Snug Tight” using hand wrench until prescribed tension is achieved

| | | | | | | | | | |
|---------------------|---------------|---------------|---------------|---------------|---|-----------------|-----------------|-----------------|-----------------|
| Bolt Dia. (in.) | $\frac{1}{2}$ | $\frac{5}{8}$ | $\frac{3}{4}$ | $\frac{7}{8}$ | 1 | $1-\frac{1}{8}$ | $1-\frac{1}{4}$ | $1-\frac{3}{8}$ | $1-\frac{1}{2}$ |
| Snug Tension (kips) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 10 |

- Tolerance – 0 kips to + 2 kips

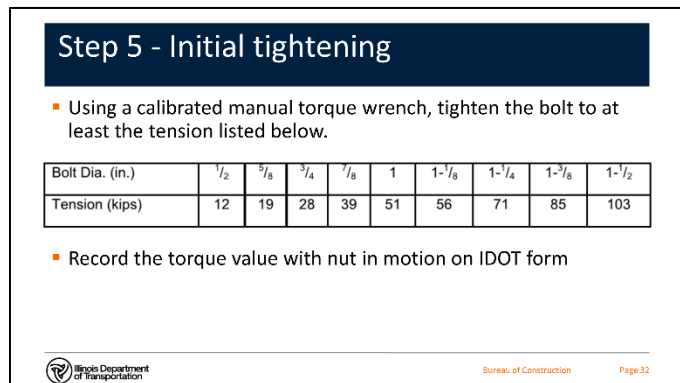

Bureau of Construction
Page 30

Step 4 - Match-mark the nut and washer to a mark on the face plate of the tension device. This match-mark is the reference mark for the final turn-of-nut in Step 7.



Over time the face plate can become congested with the markings from past tests, so care must be taken to carefully track which marks apply to the current test. To avoid this problem, set the initial mark for all R-C tests and verification tests at the vertical position. Markings are then transferred from the vertical position onto the nut and shank for all testing. Rotational turn markings for turn-of-nut and R-C required rotation are then always measured from vertical.

Step 5 - Using a hand or torque wrench, tighten the nut until the device shows the minimum tension as shown in the table included in the adjacent slide. The minimum tension is shown by red and green markings on the Skidmore dial face for A325 and A490 bolts, respectively. The minimum tension is 70% of the specified minimum tensile strength of the bolts specified in the respective ASTM standards for A325 and A490 bolts.



Step 5 - Initial tightening

- Using a calibrated manual torque wrench, tighten the bolt to at least the tension listed below.

| Bolt Dia. (in.) | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1-1/8 | 1-1/4 | 1-3/8 | 1-1/2 |
|-----------------|-----|-----|-----|-----|----|-------|-------|-------|-------|
| Tension (kips) | 12 | 19 | 28 | 39 | 51 | 56 | 71 | 85 | 103 |

- Record the torque value with nut in motion on IDOT form

Illinois Department of Transportation Bureau of Construction Page 32

| Bolt Dia. (in.) | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1-1/8 | 1-1/4 | 1-3/8 | 1-1/2 |
|-----------------|-----|-----|-----|-----|----|-------|-------|-------|-------|
| Tension (kips) | 12 | 19 | 28 | 39 | 51 | 56 | 71 | 85 | 103 |

Just after the required installation tension has been exceeded, one reading of torque and tension shall be taken and recorded. Record the tension while the nut is in motion. This value should be recorded in the IDOT R-C test form. This process typically requires two persons, with one monitoring the device gauge for tension and the other monitoring the wrench torque. Do not bounce or jerk the wrench during installation, as this will produce a commensurate jump in the tension and torque gages. Most torque wrenches include a memory needle that will keep or maintain the maximum torque value after the pressure is removed. Bouncing or jerking the wrench negates the ability of this memory needle to accurately reflect the torque value.



Bouncing or jerking the wrench negates the ability of this memory needle to accurately reflect the torque value.

With practice, you learn how to position yourself relative to the tension device and advance the nut in a steady motion to achieve the required tension. You will also note that as you relieve the pressure on the wrench, the tension value will decrease slightly. Through practice you will learn to compensate for this relaxation by going slightly beyond the required tension as you advance the nut.

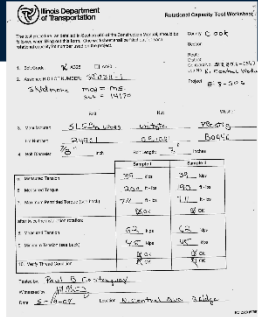
Step 6 - The measured torque required to bring the bolt to its minimum tension in Step 5 is then compared to the calculated torque, which is determined using the following equation.

$$\text{Max Torque} = 0.25 \times P \times D$$

Where P = Bolt Tension obtained during initial tightening (lbs)
 D = Bolt Diameter (ft)


Note that the bolt diameter is converted to feet units for use in this equation. To complete this conversion, divide the bolt diameter in inches by 12. The torque calculated using the above equation is presented on the back of the IDOT_BC2320 form for 3/4 and 7/8 in. diameter bolts.

Calculated torque



$\text{Max Torque} = 0.25 P D$

Where P = Bolt Tension (lb)
 D = Bolt Diameter (ft)


Bureau of Construction
Page 34

Check that the measured torque is less than the calculated torque. If so, continue the R-C test. The fastener is disqualified for use on the project if it fails this comparative test. The contractor may however elect to re-lubricate the bolt and nuts and re-test the fastener assemblies.

Step 7 - Mark the final rotation of the bolt by placing a new mark on the base plate that is positioned at the required rotation (see table below) as measured from the initial mark placed on the base plate in Step 4. Confirm that the bolt shank did not turn. The required rotation is dependent on the length of the bolt shank measured in Step 1 as a ratio to its diameter.

| Length | 4 bolt diameters or less | Greater than 4 but less than or equal to 8 bolt diameters | Greater than 8 bolt diameters |
|-------------------|--------------------------|---|-------------------------------|
| Required rotation | 2/3 | 1 | 1-1/3 |

Further advance the nut using a hand or torque wrench until the mark on the nut is aligned with the second mark on the base plate.

You will note that as you relieve the pressure on the wrench, the tension value on the device gauge will decrease. The relaxation experienced at this stage of the R-C procedure is typically more than was experienced in the initial tightening step. Through practice you will learn to compensate for this relaxation by going beyond the required tension as you advance the nut.

The forces required to advance the nut to its final position are considerable and may require reposition of the wrench to secure better leverage. Once you are satisfied that you have advanced the socket to its final position, remove the socket and confirm that the match mark on the bolt end is aligned with the third match mark on the base plate. Also confirm that the bolt has not rotated.

Record the bolt tension and compare this value to the tension in the table below. The measured bolt tension must meet or exceed the tabulated value for the given bolt diameter. If the bolt tension does not meet the stated tension below, the fastener assembly is disqualified for use on the project. Tension values reported below are 15% greater than the minimum tension obtained in Step 5.

| | | | | | | | | | |
|-----------------|-----|-----|-----|-----|----|-------|-------|-------|-------|
| Bolt Dia. (in.) | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1-1/8 | 1-1/4 | 1-3/8 | 1-1/2 |
| Tension (kips) | 14 | 22 | 32 | 45 | 59 | 64 | 82 | 98 | 118 |

Step 8 - Remove the fastener from the tension device and visually examine the bolt and nut for signs of stripping, thread shear failure, or torsional failure. Stripping may occur in either the tread of the fastener or nut. Galvanized nuts are overtapped to allow for the thickness of the galvanizing coating, which causes them to be more susceptible to stripping as compared to black nuts. Stripping occurs when the strength of the thread area in the nut is not sufficient to develop the force generated in the bolt. Bolt and nut assemblies that exhibit these conditions fail the R-C test.

Some minor amount of stretch is expected between the face of the nut and the bolt head and does not constitute failure. However, the nut should move freely to the approximate location where it was positioned in the test frame at the end of the R-C test.


END OF ROTATIONAL-CAPACITY TEST

Step 7 - Final tightening

- Place a second mark on the base plate measured from the first mark at the rotation indicated in the table below

| Length | 4 bolt diameters or less | Greater than 4 but less than or equal to 8 bolt diam. | Greater than 8 bolt diameters |
|-------------------|--------------------------|---|-------------------------------|
| Required rotation | 2/3 | 1 | 1-1/3 |

- Advance nut until the mark on the nut is aligned with the second mark on the base plate.
- Record the tension and compare to minimum tension


Bureau of Construction
Page 35

Step 8 - Post-test inspection

- Examine thread and nut for
 - Stripping
 - Thread shear failure
 - Torsional failure





Figure 21: Failure modes to look for after Skidmore procedure.


(a) Torsional Failure


(b) Tension Failure


Bureau of Construction
Page 36

Lubrication

- Black bolts/nuts
 - Oily to the touch
- Galvanized bolts/nuts
 - Clean and dry to touch
 - Visible dye for identification
- Rotational Capacity checks required
 - If proper lubrication is suspect
 - Bolts/nuts are re-lubricated



 Bureau of Construction Page 37

Bolts and nuts that are not properly lubricated will experience increased frictional forces during installation and may experience fracture or stripping during rotational-capacity testing, verification testing, or installation. The effect of lack of lubrication is briefly discussed below.

Bolts and nuts that are not properly lubricated will experience increased frictional forces during installation. For galvanized fasteners, this can cause galling of the galvanizing on the

threads or face of the turned element. This galling can cause seizing or binding of the bolt, which can result in bolt tension being out of specification. Similarly, dry or rusty bolts are more difficult to tighten such that some of the applied torque is used up in overcoming frictional resistance and does not impart the desired pretension to the fastener.

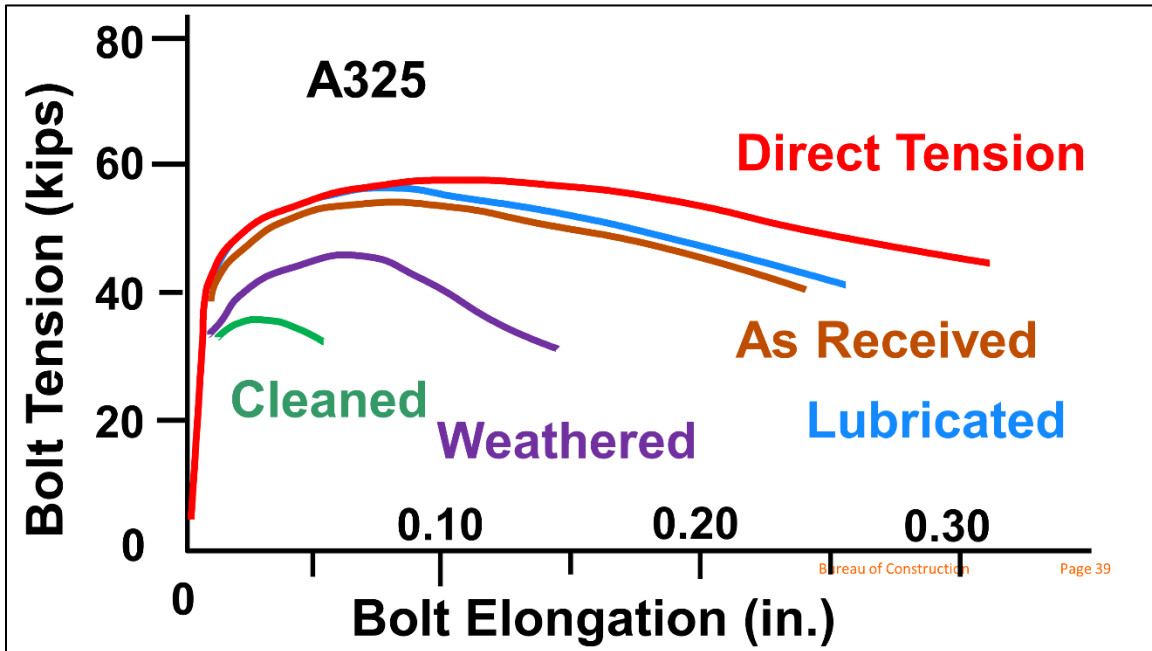
Black bolts are considered to be properly lubricated if they are oily to the touch. For galvanized fasteners, the nuts must be lubricated with a lubricant that is clean and dry to the touch. The dye must contain a visible coloration so it can be easily identified as being lubricated. If improper lubrication is suspected and/or lubricant is added, the assembly shall be retested for rotational-capacity.

The following lubricants have been successfully used in the field. Lubricants should be water-soluble and easy to clean-up. Use of other lubricants should be approved by Bureau of Materials (IDOT_CM)

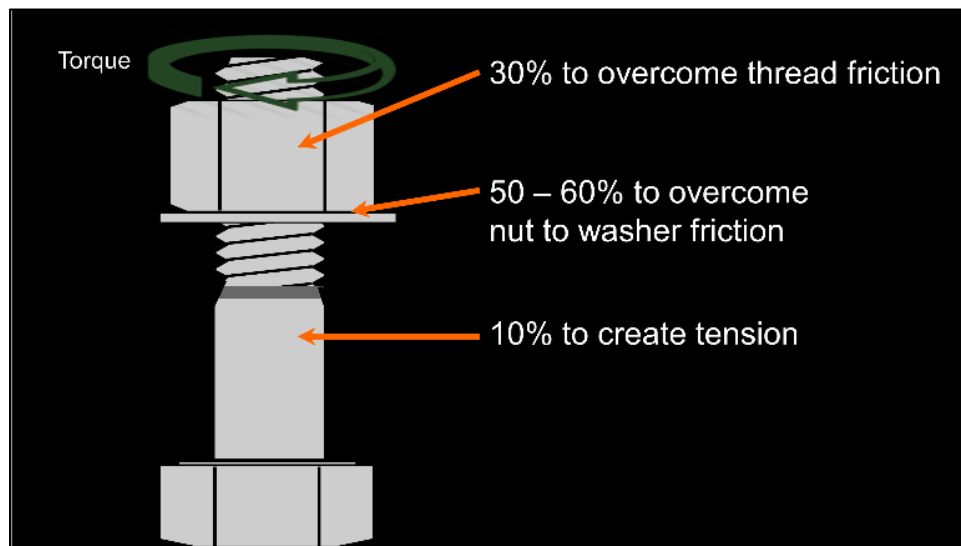
- Safety Film 616 by Chem-Trend, Inc.
- Jon Cote 639 by Johnson Wax
- Chem-Trend 140 Stick Wax by Chem-Trend



The slide below illustrates the load-displacement curve for various bolt conditions for an A325 fastener. The top curve, or red line, depicts the load-displacement behavior of a fastener tested in direct tension, i.e. pulled to failure in a test frame.



If a bolt, nut, or washer has lost its lubrication, the component(s) must be re-lubricated prior to installation. As much as 50 to 60% of the torque used to tighten a bolt is used to overcome the friction between the nut and washer and another 30% is used to overcome the friction between bolt and nut threads. Only about 10% of the applied torque is actually used to create tension in the bolt.




Fasteners too short to be tested in a tension calibration device shall be tested in a steel joint. The tension requirement specified in IDOT_SPEC 505.04(f)(3)b.7 or Step 5 of the R-C test procedure above need not apply. Rather, the nut is advanced to a torque value determined using the torque-tension relationship equation ($\text{Max Torque} = 0.25 \times P \times D$) in IDOT_SPEC 505.04(f)(3)b.8 where P is the turn test tension, or 115% of the minimum installation tension.

Because a calibration test device is not used for testing short fasteners, the rotational test procedure must utilize the torque-tension relationship and a calibrated torque wrench. The R-C test procedure using torque-tension relationship for short bolts shall be as follows. This procedure is taken from FHWA, *Procedures for Performing Rotational-capacity Test*, Appendix A1.

(See <https://www.fhwa.dot.gov/bridge/a325short.cfm>)

Short fasteners


- Short fasteners must be tested in steel joint
- R-C Test using Torque-Tension relationship
- R-C Test using calibrated DTI




Bureau of Construction
Page 41

Short fastener R-C procedure

- Measure bolt length, from end of bolt to washer face at bolt head
- Install bolt in steel plate
- Add washers or steel plate until 0 to no more than 3 threads are exposed beyond nut
- Snug tight the nut
- Match mark the nut, bolt, and plate



Bureau of Construction
Page 42

1. Measure the bolt length, the distance from the end of the bolt to the washer face at the bolt head to shank interface. Realistically short bolt scenarios have bolt to diameter ratios less than 4.
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. Snug tighten the nut. The torque required to achieve snug tight should not exceed 20% of the maximum torque allowed in step #5.

Snug tight short bolts

- Install to the full effort of a man or a few hits of an impact wrench
- Do not exceed 20% of maximum torque allowed

| Bolt diameter | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1-1/8 | 1-1/4 | 1-3/8 | 1-1/2 |
|---------------------|-----|-----|-----|-----|------|-------|-------|-------|-------|
| Max Torque (ft-lbs) | 150 | 290 | 500 | 820 | 1230 | 1500 | 2140 | 2810 | 3960 |
| 20% of Max | 30 | 58 | 100 | 164 | 216 | 300 | 428 | 562 | 792 |


Bureau of Construction
Page 44

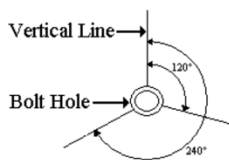
4. Match mark the nut, bolt, and plate. When marking the plate, start with a vertical mark. Place a mark to represent the initial R-C turn value and an additional mark to represent the total R-C turn value. Realistically short bolt scenarios have bolt to diameter ratios less than 4.

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 initial R-C rotation with the nut in motion. The measured torque should not exceed the values listed below. Assemblies that exceed the listed torque values have failed the test.

Match mark

- Realistically, the length of short bolts will be less than 4 bolt diameters and as such the required rotation for R-C testing will be 2/3 of a turn


Vertical Line →



Bolt Hole →

| Bolt Length | Initial R - C (Turns) |
|-------------------|-----------------------|
| $L \leq 4D$ | 1/3 |
| $4D < L \leq 8D$ | 1/2 |
| $8D < L \leq 12D$ | 2/3 |

| Bolt Length | Total R - C Turns |
|-------------------|-------------------|
| $L \leq 4D$ | 2/3 |
| $4D < L \leq 8D$ | 1 |
| $8D < L \leq 12D$ | 1 1/3 |


Bureau of Construction
Page 44


Short fastener R-C procedure, cont.

- Prevent head from rotation, and rotate nut per table

| Bolt length = L (from step 1) | $\leq 4 \times$ bolt diameter | $> 4 \times$ but $< 8 \times$ bolt diameter |
|----------------------------------|-------------------------------|---|
| Required rotation | 1/3 | 1/2 |

- Check torque does not exceed values listed

| Bolt diameter | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1-1/8 | 1-1/4 | 1-3/8 | 1-1/2 |
|-----------------|-----|-----|-----|-----|------|-------|-------|-------|-------|
| Torque (ft-lbs) | 150 | 290 | 500 | 820 | 1230 | 1500 | 2140 | 2810 | 3960 |


Bureau of Construction
Page 45


6. Further tighten the bolt to the final match mark location or rotation listed below. The rotation is measured from the vertical mark. Assemblies that fail prior to this rotation either by stripping or fracture fail the test.

Short fastener R-C procedure, cont.

- Further tighten bolt to rotation listed, with rotation measured from original match mark

| Bolt length = L (from step 1) | $\leq 4 \times$ bolt diameter | $> 4 \times$ but $< 8 \times$ bolt diameter |
|----------------------------------|-------------------------------|---|
| Required rotation | 2/3 | 1 |

- Loosen and remove nut, and check for signs of shear failure, stripping, or torsional failure
- Check that nut can be finger tightened to final nut position


Bureau of Construction
Page 46

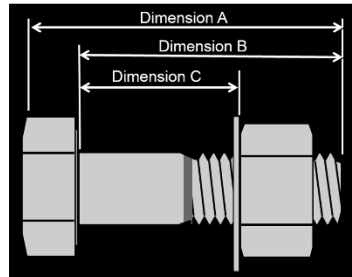
7. Loosen and remove the nut. There shall be no signs of thread shear failure, stripping or torsional failure. The nut shall turn, with your fingers, on the bolt to the position it was in during the test. The nut does not need to run the full length of the threads. If you cannot turn the nut with your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

Quiz #5B - Complete the following questions.

RoCap Quiz #5B.1

Which dimension is used as the length for determining the required rotation beyond the initial tension?

- a) Dimension A
- b) Dimension B
- c) Dimension C

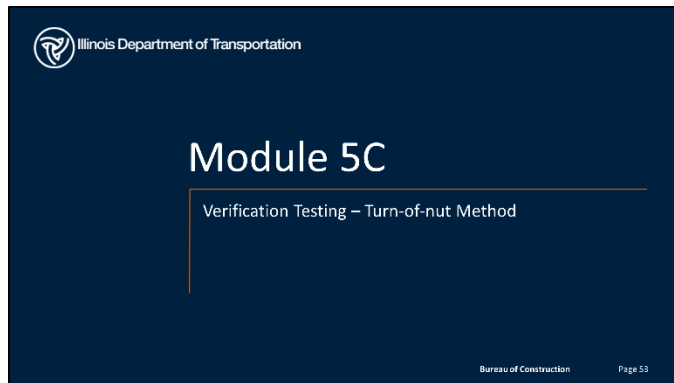


RoCap Quiz #5B.2

Using the equation below, calculate the maximum torque for a 3/4 inch diameter A325 fastener.

$$\text{Max Torque} = 0.25 \times P \times D$$

- a) 5.25
- b) 437
- c) 503
- d) 525



To achieve consistency and reliability in pretensioning fasteners using the turn-of-nut method requires the following:

- Joint is well compacted and all bolts are uniformly tight to a snug tight condition before application of the turn-of-nut method.
- Assurance that the turn-of-nut is relative between the bolt and nut, which requires the element opposite the turned end be prevented from rotating.
- Confirmation of desired bolt tension through verification testing of the turn-of-nut method using a tension indicator device.


Prior to initiating bolting operations, a series of verification tests are performed at the jobsite to assure the contractor's tightening procedures will achieve the minimum required tension in the fastener assembly and that all crew members and inspectors are familiar with the tightening procedure to be used on the project.

The verification testing is performed for each fastener assembly lot prior to the use of that assembly lot in the work. Verification testing is conducted to determine the:

- Suitability of the complete fastener assembly, including lubrication, and adequacy of installation equipment to achieve specified minimum pretension
- Define and calibrate crew procedures
- Determine inspection torque

Verification testing



- Performed for each fastener assembly lot before use of that lot in the work
- Conducted to determine
 - Suitability of the complete fastener assembly, including lubrication, and adequacy of installation equipment to achieve minimum pretension
 - Define and calibrate crew procedures
 - Determine inspection torque


 Illinois Department of Transportation
Bureau of Construction
Page 54

The IDOT_SPEC 505.04f(2)) requires three (3) assemblies of each diameter, length, grade, and lot to be tested in a calibrated tension device, such as a Skidmore-Wilhelm Tension Calibrator. The verification test defines the standards expected of the bolting personnel using jobsite equipment that will be employed during actual installation of bolts in the structure. As such, the verification testing verifies the appropriateness and ability of the contractor's equipment to achieve the required bolt tension. Verification testing will be performed according to the Procedures for Installation and Tightening as set forth in the IDOT_CM.

Equipment and samples

- Equipment
 - Calibrated bolt tension measuring device
 - Proper spacers with appropriate hole size
 - Installation equipment to be used by ironworkers
- Fastener samples
 - Three bolt, nut, and washer assemblies of each diameter, length, grade and lot to be used in work

 Illinois Department of Transportation
Bureau of Construction
Page 55

Each power tool to be used in the actual field installation will be used for at least one of the samples tested. Each worker who is to perform field installations must pass at least one of the sample tests utilizing the same equipment and methods to be used during actual field installations. Workers who undertighten or

overtighten the fastener during the test will not be allowed to perform fastener installations unless they successfully complete a retest using the tension indicator device. If a fastener fails to achieve the required minimum tension, the lot from which it was taken will be rejected.

The equipment required for verification testing includes a Skidmore-Wilhelm tension indicator, which is a hydraulic load cell that has been calibrated to measure bolt tension. As the bolt nut is tightened the clamping force is transmitted through the bearing plates exerting pressure on the internal hydraulic fluid. This amount of hydraulic pressure is represented by a gauge that has been graduated to represent bolt tension in pounds. The accuracy of the device requires that it is calibrated and well maintained. The inspector should confirm that the device has been calibrated within the last year, and inspect the device for unusual wear and tear. (IDOT_CM)


The contractor shall provide the bolt tension device (IDOT_SPEC 505.04f(2)) capable of testing the shortest bolt length encountered on the structure down to the following minimum lengths.

| Bolt Diameter | Minimum Length |
|-------------------------------|------------------|
| 5/8 and 3/4 in. (M16 and M20) | 2 in. (50 mm) |
| 7/8 in. (M22) | 2.25 in. (60 mm) |
| 1 in. (M26) | 2.5 in. (65 mm) |

Verification testing will include the following steps:

Verification Testing

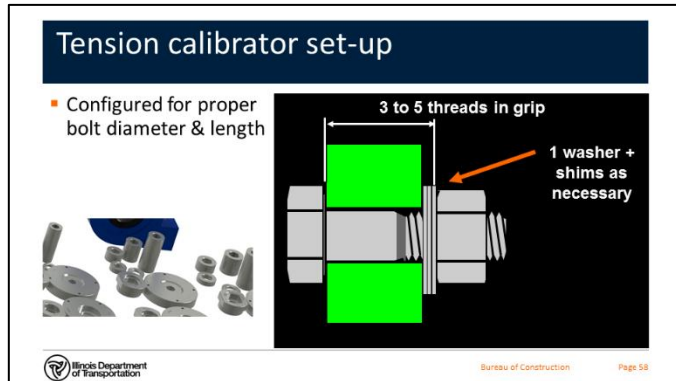
- Step 1 – Record fastener parameters and measure bolt
- Step 2 – Configure test apparatus and install bolt
- Step 3 – Snug tight
- Step 4 – Match mark bolt, nut, and face plate
- Step 5 – Advance nut to required turn
- Step 6 – Confirm measured tension exceeds required tension



Bureau of Construction

Page 56

Configure the tension device as required to accept each unique fastener assembly. Plates, bushings, and spacers should be those provided by the tension device manufacturer and selected based on the bolt head type, diameter, and length. The manufacturer provides a variety of spacers having variable length or thickness and diameters to accommodate most high strength bolt configurations. In some instances it may be necessary to add additional washers to achieve the desired thickness. The addition of more than three washers should be avoided as it does not reflect field conditions and may affect the results of the verification testing.




The assembly is then brought to snug tight, using the RCSC definition for snug tight. As part of the verification testing discussed later in this module, workers must demonstrate that their chosen snug tight procedure whether using spud or pneumatic wrenches does not impart an initial tension of greater than 50% of the required tension. Under adequate conditions of lubrication the full effort of a man or a few impacts of a torque wrench will yield tensions of up to 10 kips. If the fastener is over-lubricated it is possible to impart a significant tension during snug tightening that may cause fasteners to fail when final tightening is applied.

Snug tight

- Apply snug tightening procedure to be employed
- Assure snug tightening procedure does not produce more than 50% of the required tension below.

TABLE 1 - REQUIRED FASTENER TENSION (Kips)

| Bolt Dia. (in) | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 1 3/8 | 1 1/2 |
|----------------|-----|-----|-----|-----|----|-------|-------|-------|-------|
| M164 (A325) | 13 | 20 | 29 | 41 | 54 | 59 | 75 | 89 | 108 |
| M253 (A490) | 16 | 25 | 37 | 51 | 67 | 84 | 107 | 127 | 155 |



Bureau of Construction



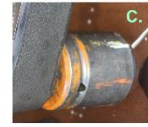
Page 58

Using a wax crayon or paint stick, place a mark on the end of the bolt, top and side of nut and faceplate of the tension calibration device. Then place the socket over the nut, and extend the match mark to the side of the socket.


Following snug tightening and match marking, further tighten the nut to the rotation shown below. When impact wrenches are used they should be of sufficient capacity to achieve tightening within approximately 10 seconds.

Match mark

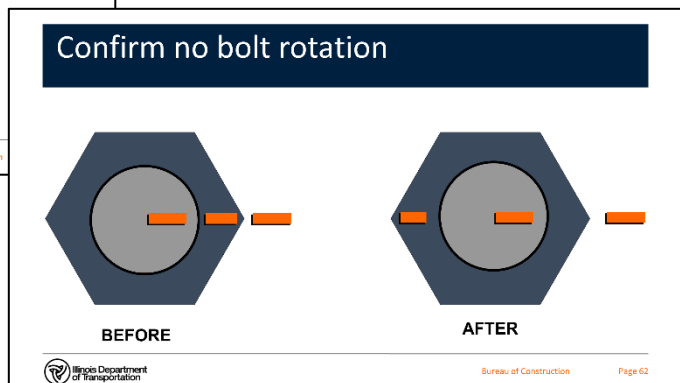
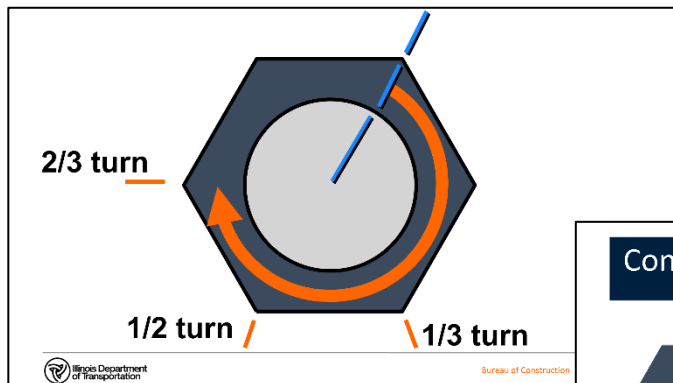
- Match mark the nut, bolt, and Skidmore faceplate

- Place socket over nut, and extend match mark to face of socket

 Illinois Department of Transportation
Bureau of Construction
Page 59

| Bolt Length | 4 x bolt dia. or less | Greater than 4 but no more than 8x bolt dia. | Greater than 8 x bolt dia. |
|-------------------|-----------------------|--|----------------------------|
| Required Rotation | $1/3$ | $1/2$ | $2/3$ |



After the rotation has been achieved, remove the nut and confirm that the bolt did not rotate from its original position. The unturned element should be prevented from turning. The bolt match mark should remain aligned with the faceplate match mark. If the bolt rotated, replace the socket and advance the nut as required to compensate for the bolt rotation.

The tension value displayed on the dial gauge of the Skidmore-Wilhelm device should be recorded and checked against the bolt tension requirement of the IDOT_CM (see slide below). At this juncture, it is important to note that the tension requirement specified for verification testing is 105% of the tension desired for bolts placed in the bridge.

The RCSC recognizes that natural scatter is found in the results of pre-installation verification testing and that testing of a representative sample must be slightly higher to provide confidence that the majority of fastener assemblies will achieve the minimum required pretension. Accordingly, the pre-installation verification testing is 1.05 times that required for proper pretension in production fasteners. If the measured tension exceeds the tabulated bolt tension value, the verification test is passed thus indicating that the workers, equipment, and procedures used with the turn-of-the-nut method will achieve satisfactory pretension in the fastener assemblies to be placed in the bridge.

The tension gauge on the Skidmore-Wilhelm device includes red and green markings that represent the minimum required bolt tension for different diameters of A325 and A490 bolts, respectively. When using the device to verify the installation method, the nut shall be advanced to a tension that is 5% greater than that shown by the red/green markings for a given bolt diameter. For example, when verifying the installation of a 7/8 in. diameter, A325 bolt, the bolt assembly will be tightened to 41 kips. This compares to the bolt tension value of 39 kips shown on the face of the Skidmore-Wilhelm for the 7/8 in. diameter, A325 bolt (red).


The minimum required tension (Table 8.1 from RCSC) represents approximately 70% of the tension strength of the fastener. As such, stripping or failure of the fastener is not expected. Nonetheless, the fastener and nut are visually examined after each test. Tension values considerably above the minimum required tension should be avoided. If the testing does not yield the minimum required tension at the required turn-of-nut, the bolts and nuts should be re-lubricated and the R-C and verification testing repeated. It is the goal of the verification testing to demonstrate that the tightening method to be used on the project will achieve the desired pre-tension required by RCSC Table 8.1 and IDOT_CM. Once the tightening method is verified, the contractor may begin production installation of fasteners on the project.

Confirm required tension

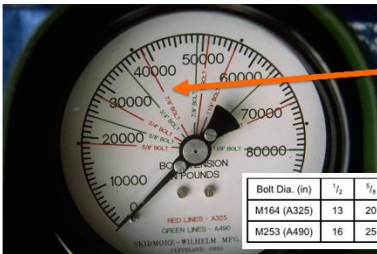
- Check that measured tension exceeds the bolt tension requirement

| Bolt Dia. (in) | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 1 3/8 | 1 1/2 |
|----------------|-----|-----|-----|-----|----|-------|-------|-------|-------|
| M164 (A325) | 13 | 20 | 29 | 41 | 54 | 59 | 75 | 89 | 108 |
| M253 (A490) | 16 | 25 | 37 | 51 | 67 | 84 | 107 | 127 | 155 |

- Verification Test PASSED


Bureau of Construction
Page 63

Verification tension vs. bolt tension



A325, 7/8 bolt

Bolt tension = 39 kips

Verification tension = 41 kips

| Bolt Dia. (in) | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 1 3/8 | 1 1/2 |
|----------------|-----|-----|-----|-----|----|-------|-------|-------|-------|
| M164 (A325) | 13 | 20 | 29 | 41 | 54 | 59 | 75 | 89 | 108 |
| M253 (A490) | 16 | 25 | 37 | 51 | 67 | 84 | 107 | 127 | 155 |



Bureau of Construction
Page 64

Table 8.1. Minimum Bolt Pretension, *Pretensioned* and *Slip-Critical Joints*

| Nominal Bolt Diameter, d_b , in. | Specified Minimum Bolt Pretension, T_m , kips ^a | |
|------------------------------------|--|---------------------|
| | ASTM A325 and F1852 | ASTM A490 and F2280 |
| ½ | 12 | 15 |
| ⅝ | 19 | 24 |
| ¾ | 28 | 35 |
| ⅞ | 39 | 49 |
| 1 | 51 | 64 |
| 1⅛ | 56 | 80 |
| 1¼ | 71 | 102 |
| 1⅝ | 85 | 121 |
| 1½ | 103 | 148 |

^a Equal to 70 percent of the specified minimum tensile strength of bolts as specified in ASTM Specifications for tests of full-size ASTM A325 and A490 bolts with UNC threads loaded in axial tension, rounded to the nearest kip.

Verification testing is conducted under controlled conditions, generally using a solid mass within the grip length. As such, the snug tight condition is quite easy to obtain. In the field, the effects of plate fit-up and over-use of impact wrenches generally result in snug-tight conditions that can exceed the full efforts of a man. Therefore, some discussion regarding the effects of overtightening at the snugging-up stage is warranted here as it will have a corresponding increase in the final tension value after application of the required turn-of-the-nut.

The following chart represents the load displacement (measured as a function of turn of the nut) behavior of A325 and A490 bolts having a larger diameter. For a given A325 fastener, the L/D ratio is 6.3 (= 5.5 / 0.875) which requires an installation turn-of-nut of 1/2 turn past snug tight. If snug tight was performed to 10 kips, the application of a half turn past snug tight will produce a bolt tension of approximately 47 kips. This is above the 39 kips minimum tension required, and as such the bolt installation would be acceptable. If snug tight was performed to 50% of the minimum tension, the application of a half turn past snug tight will produce a bolt tension of approximately 49 kips.

This illustrates that the turn-of-nut method is likely to induce a bolt tension that exceeds the elastic limit of the threaded portion. Furthermore, the displacement curve shows that the application of up to 1.5 turns or three times the recommended turn-of-nut could be sustained and still maintain a bolt tension in excess of the 39 kip minimum. While this is not recommended, it does illustrate the ability of bolts to sustain some level of over-tightening at either the snug tightening or final tightening stage.

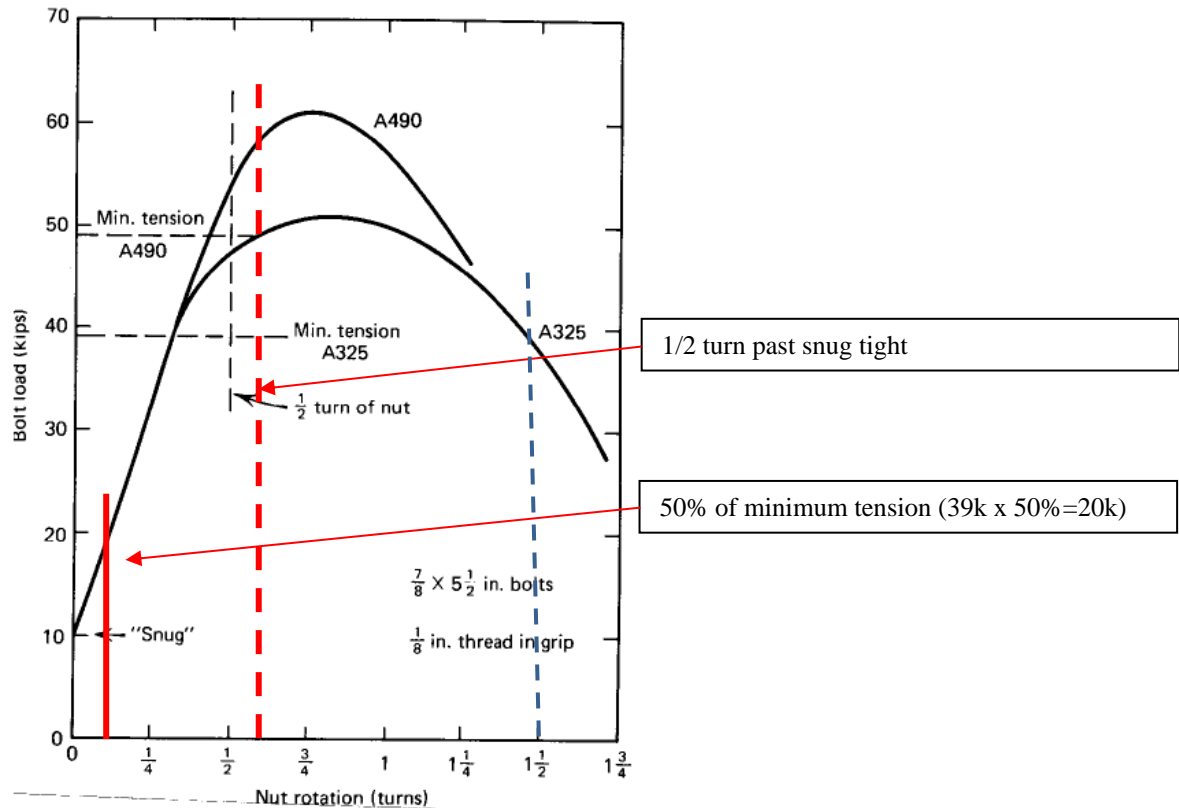



Fig 4.20. Comparison of bolt load versus nut rotation relationships of A490 and A325 bolt

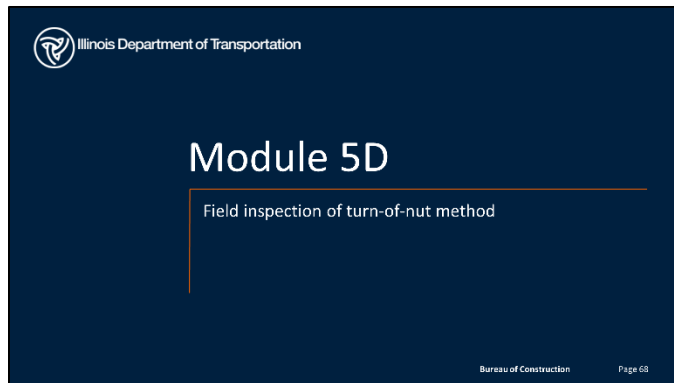
The inspection procedures giving the best assurance that bolts are properly installed and tensioned is provided by inspector observation of the verification testing of the fasteners using the selected installation procedure followed by monitoring of the work in progress to assure that the procedure which was demonstrated to provide the specified pre-tension is routinely adhered to during production bolting. When such a program is followed, no further evidence of proper bolt tension should be required. (IDOT_CM)

However, inspectors and contractors familiar with the inspection procedures of AASHTO_SPEC will use the verification testing to develop a job inspection torque. This torque is determined after the turn-of-nut verification testing, but prior to nut removal. With the fastener in the Skidmore, advance the nut five additional degrees (or approximately 1 in. at a 12 in. radius) and record the torque with a calibrated torque wrench. The average of the torque for all three bolts shall be taken as the job inspection torque (AASHTO_SPEC Art. 11.5.6.4.9c). The job inspection torque can then be used to quantitatively assess tightened fasteners in the field to resolve disputes. Additional discussion of the use of job inspection torque is provided in Module 5.D. Note that the use of job inspection torques is not required by either the IDOT_SPEC or IDOT_CM.

Inspection torque

- After conducting turn-of-nut verification testing and prior to nut removal, advance the nut five additional degrees and record the torque
- The average of the torque for all three bolts shall be taken as the job inspection torque
- Used to quantitatively assess fasteners in the field and resolve disputes
- See AASHTO_SPEC 11.5.6.4.9


Bureau of Construction
Page 67



The construction inspector documents and observes the verification testing procedures, including noting the workers and equipment that were used. The inspector then monitors fastener installation to assure the same procedure, workers, and equipment used in the verification testing are used on the structure. By use of the same procedures and equipment, the inspector and iron workers can be assured that the required pre-tension is present in the installed fasteners. If changes to the bolt conditions, procedures, equipment, or workers

occur, the verification testing will need to be repeated.

The contractor should perform verification testing at the start of work for a representative sample of not less than three fastener assemblies of each diameter, length, and grade to be used on the project. The inspector shall witness the verification testing. (IDOT_CM)

The inspector should confirm that the proper fasteners are being used at the proper location. Bolts installed in beam flange splices are generally oriented to allow the turned element to be rotated with wrenches positioned in a down-hand orientation. In external beams, bolts should be oriented with the head facing outward of the beam web. For internal beams, bolt head orientation should remain the same in a single splice and for all splices along the beam line. The number of fasteners removed from storage should be suitable for a given days' work. Unused fasteners should be returned to protected storage. The surface condition of the fasteners should be checked for dirt and rust. The condition of the lubrication should be confirmed to be consistent with that present during the verification testing.

Given the above, the inspection requirements for turn-of-nut method are focused primarily on recognition that the procedures established through the verification testing are successfully applied to the production tightening work. This includes both the snug tightening and final tightening procedures.

Bolt installation – General checklist

- Witness verification testing (3 fasteners of each diameter, length, grade)
- Confirm proper fasteners being used
- Confirm surface of fastener is free of rust or dirt
- Confirm lubrication is unchanged from verification testing
- Confirm installation method is consistent with that used for verification testing
 - Snug tightening & final tightening

Illinois Department of Transportation Bureau of Construction Page 60

The purpose of snug tightening is to bring all the plies into firm contact and uniformly tighten all fasteners to approximately the same preload, per IDOT_SPEC 505.04f(2), using the procedures established in verification testing. This is accomplished by progressively tightening the fasteners from the most rigid part of the connection to the free edge. The tightening process for each fastener shall be the same used in the verification testing to achieve snug tight, as described previously. Several repetitions of this process may be necessary.

Snug tightening inspection

- Verify each nut tightened as demonstrated in verification testing
- Verify faying surface is fully compacted
 - Work proceeds systematically from rigid part of connection to free edges; repeat as necessary to fully compact surfaces
- Verify that length of bolt is proper for grip

During snug tightening, the inspector should confirm that the proper bolt was used and a washer is located under the turned element of the fastener, which in most instances will be the nut unless an obstruction conflicts with the use of iron workers tools. If an obstruction exists, it will most likely be discovered during snug tightening. The end of the bolt must be at least flush with the face of the nut. This will serve as a check that the correct bolt length is being used.

After all bolts in a connection are brought to a snug tight condition, the outer face of the nut, bolt end, and plate at all fasteners shall be match marked by the ironworker. Following match marking, the nut will be tightened to its required rotation using the same procedures established in verification testing and progressing systematically from the most rigid part of the connection to the free edges. The wrenches should be of adequate capacity to achieve the required rotation in approximately 10 seconds. The inspector will monitor final tightening to confirm adherence to the procedures, equipment, and personnel used for the verification testing.

Final tightening

- Verify match marks placed on turned element
- Verify tightening procedures same as those used in verification
 - Work proceeds systematically from rigid part of connection to free edges
- After applying required turn-of-nut, verify that proper turn was achieved
- Verify that non-turned element did not turn

The inspector shall check match marks between the bolt end and plate to confirm that the bolt did not turn relative to its original snug tight position. Only the nut shall have turned. If some bolt rotation has occurred, then the nut will need to be further advanced to achieve the required turn-of-nut. The final turn-of-nut shall be measured relative to the match mark on the bolt end.

In situations when the nut is obstructed, tightening may be done by turning the bolt head using a washer under the head. In this case, the nut shall be kept from rotating with match marks placed as described above as well as on the bolt head. The inspector will need to confirm here that the nut did not turn relative to the match mark on the plate. If some nut rotation has occurred, the bolt will need to be further advanced to achieve the required turn-of-nut. The final turn-of-nut in this scenario shall be measured relative to the match mark on the nut face.

If based on visual examination of the match marks the fasteners have been tightened to their required turn-of-nut, the installation is accepted.

Exercise #5D.1 - List the inspector's duties associated with the fastener work performed in each slide.



| Snug tightening |
|-----------------|
| |
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| Match marking |
|---------------|
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| Match marking |
|---------------|
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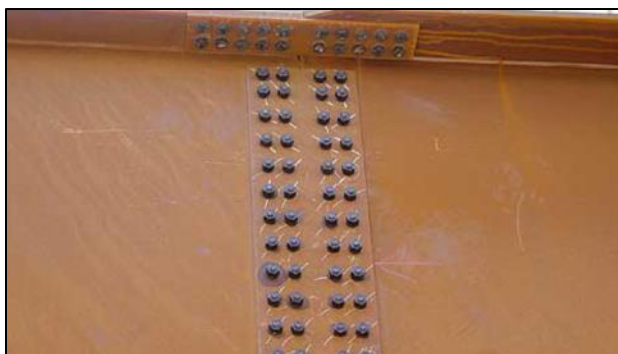
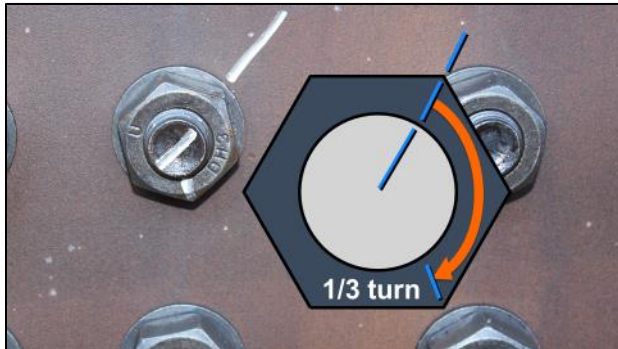
| Required nut rotation | |
|-----------------------|----------|
| Bolt Length | Rotation |
| $L \leq 4D$ | 1/3 turn |
| $4D < L \leq 8D$ | 1/2 turn |
| $8D < L \leq 12D$ | 2/3 turn |

* Required rotations must be adjusted for sloped surfaces



Illinois Department of Transportation Bureau of Construction Page 57

| Turn of nut |
|-------------|
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| Turn of nut |
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| Final installation tolerances |
|-------------------------------|
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The required nut rotation is based on the bolt length, as measured from the end of the bolt to the underside of the bolt head, and bolt diameter. These required rotations are only applicable for connections where both faces are flat. If there is a sloping surface beneath either head or nut that exceeds 1:20 (approximately 3 degrees), a matching beveled washer is required. For surfaces with less than 1:20 slope and beveled washer omitted, the turn-of-nut rotation shall be increased per RCSC, Section 8.2.1, Table 8.2.

Table 8.2. Nut Rotation from Snug-Tight Condition for Turn-of-Nut Pretensioning^{a,b}

| Bolt Length ^c | Disposition of Outer Faces of Bolted Parts | | |
|--|--|--|--|
| | Both faces normal to bolt axis | One face normal to bolt axis, other sloped not more than 1:20 ^d | Both faces sloped not more than 1:20 from normal to bolt axis ^d |
| Not more than $4d_b$ | $\frac{1}{3}$ turn | $\frac{1}{2}$ turn | $\frac{2}{3}$ turn |
| More than $4d_b$ but not more than $8d_b$ | $\frac{1}{2}$ turn | $\frac{2}{3}$ turn | $\frac{5}{6}$ turn |
| More than $8d_b$ but not more than $12d_b$ | $\frac{2}{3}$ turn | $\frac{5}{6}$ turn | 1 turn |

^a Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. For all required nut rotations, the tolerance is plus 60 degrees ($\frac{1}{6}$ turn) and minus 30 degrees.

^b Applicable only to *joints* in which all material within the *grip* is steel.

^c When the bolt length exceeds $12d_b$, the required nut rotation shall be determined by actual testing in a suitable *tension calibrator* that simulates the conditions of solidly fitting steel.

^d Beveled washer not used.


Note A in the above table provides information regarding the acceptable tolerance for turn-of-nut method. This footnote provides a tolerance for nut rotation of plus-60 degrees (1/6 turn) and minus-30 (1/12 turn).

Exercise #5D.2 - As a group, respond to the following issues associated with lubrication for black bolts. What are the potential causes of loss of lubrication? What is the proper materials and method to re-lubricate fasteners? What testing is required when fasteners are re-lubricated?

Black bolts, nuts, and washers are received in a lubricated condition. This lubricant must be present when installed. The fastener must also be clean of rust, dirt, sand, grit, or other foreign matter. As such, fasteners shall be protected from dirt and moisture at the jobsite. This requires proper storage and use on the job site. Only as many fasteners as are anticipated to be installed and tightened during a work shift shall be taken from protected storage. Unused fasteners shall be returned to protected storage at the end of the shift. Fasteners shall not be cleaned of lubricant that is present in as-delivered condition. Fasteners that develop a rusty or dirty appearance must be cleaned of accumulated rust or dirt, re-lubricated, and have a rotational-capacity test performed prior to installation. (IDOT_CM)

Exercise #5D.2: Lubrication, Black bolts

- Causes of loss of lubrication?
- Proper materials and process of re-lubrication?
- Required testing?




Illinois Department of Transportation Bureau of Construction Page 78

Most lubricants are water-soluble and over time will evaporate or may be washed off if exposed to moisture. If the adequacy of a lubricant is uncertain, the fastener should be tested in a Skidmore-Wilhelm (or similar) device. Loss of lubrication can be caused from improper storage or handling. Delay in tightening from erection to final tightening can also result in loss of lubrication. If a bolt, nut, or washer has lost its lubrication, the component(s) must be re-lubricated prior to installation. Recall that as much as 50 to 60% of the torque used to tighten a bolt is used to overcome the friction between the nut and washer and another 30% is used to overcome the friction between bolt and nut threads. Only about 10% of the applied torque is actually used to create tension in the bolt. Applying lubrication with fasteners in place is not appropriate. Fasteners should be removed, re-lubricated, and re-installed.

Exercise #5D.3 - The adjacent slide shows iron workers using a squeeze oil can to oil the threads of bolts which had “dried-out” after having been left in place for an extended period before final tightening. What concerns are associated with this re-lubrication procedure?

Issue #5D.3: Lubrication, Black bolts

- What is the concern with use of oil to provide re-lubrication?



Illinois Department of Transportation
Bureau of Construction
Page 60





Exercise #5D.4 - As a group, respond to the following issues associated with lubrication for galvanized bolts. What are the causes of stripping? What is the proper materials and method to re-lubricate fasteners? What testing is required when fasteners are re-lubricated?

Galvanized nuts are generally lubricated using wax-based products, which may not always be detectable by touch. As such, a dye is added to the lubricant to provide a visual indication that the nut has been lubricated. The nut is the only lubricated component of the assembly. The nut must arrive from the manufacturer with a lubricant that is clean and dry to the touch. Green and pink lubricants are commonly used for hot-dipped and blue for mechanically galvanized. Although this is just a rule of thumb, lubricant colors vary by manufacturer.

Issue #5D.4: Lubrication, galvanized bolts

- Causes of stripping?
- Proper materials and process of re-lubrication?
- Required testing?

Illinois Department of Transportation
Bureau of Construction
Page 62

If the adequacy of a lubricant is uncertain, testing in a Skidmore-Wilhelm (or similar) device is required. Nuts may be re-lubricated using a wax-based or similar lubricant. The lubricant should be applied to the threads of the nut and the face of the nut bearing against the washer. After re-lubrication, the fastener assembly should be subjected to a rotational-capacity test.

When the lubricant is inadequate or omitted, the nut will gall and seize on the bolt making it impossible to properly install the fastener. The soft zinc layer is subject to wear caused by abrasion of the sliding thread surfaces that increases the frictional resistance at the threads. This is exacerbated by the fabrication of the nut itself, which is overlapped to account for the thickness of the zinc coating. Excessive overlapping causes lesser thread engagement, leading to thread stripping. The uniformity of coating thickness for mechanically

galvanized fasteners allows a somewhat smaller overlap, which reduces stripping problems for this type fastener. Note that bolts and nuts must be galvanized using the same process, as the degree of coating thickness and hence overlapping are unique for each individual process. For this reason, the RCSC and ASTM A325 specification requires galvanized bolts and nuts to be manufactured as an assembly and coated using the same process.

Exercise #5D.5 - Due to a space conflict with the wrench, the contractor elected to remove the lower two rows of web fasteners in order to tighten the bottom flange fasteners. The web fasteners are black A325 and had been fully tightened using the turn-of-nut method. Following completion of the bottom flange work, the contractor re-used the web fasteners, using hand tools to complete the re-installation. Is this acceptable?

Issue #5D.5: Fastener Re-use

Due to a space conflict with the wrench, the contractor elected to remove the lower two rows of fully installed web fasteners in order to tighten the bottom flange fasteners. The web fasteners were re-used later using hand tools.



Is this acceptable?


Bureau of Construction
Page 83

Black A325 fasteners that have been previously pretensioned may be removed and re-used only with the Engineer's permission. As discussed in the earlier exercise, the thread region of the bolt may experience inelastic deformation. If this occurs the nut will likely not pass through this region. To check A325 bolts to see if they can be reused, run the nut up the entire length of the bolt threads by hand. If this can be achieved, the fastener can be reused.

Galvanized bolts and A490 bolts shall not be reused in any case.

Fasteners installed to snug tight, but subsequently loosened when adjacent bolts are tightened, are not considered as a reused fasteners. Similarly, fasteners that are touched up in the pretensioning process are not considered reused.


Exercise #5D.6 - The contractor experienced a significant delay and was unable to return to the connection to execute final tightening until 10 days after installation. What would be the appropriate course of action?

At least three assemblies for each size and length should be removed from the bridge and tested in the Skidmore to verify that the loss of lubricant will not hinder achieving the required tension using the verification test. If significant loss of lubricate has occurred, the R-C test may also be required.

Exercise #5D.6

- Elapsed time between installation and final tensioning is more than 10 days




Bureau of Construction
Page 84

If the assemblies have been found acceptable, the inspector can use the job inspection torque determined during verification testing to inspect at least 10 percent of the bolts where were delayed in tightening. Bolts that rotate prior to the job inspection torque shall be removed, inspected, and re-tightened.

The module is concluded with a wrap-up review of the module learning outcomes.

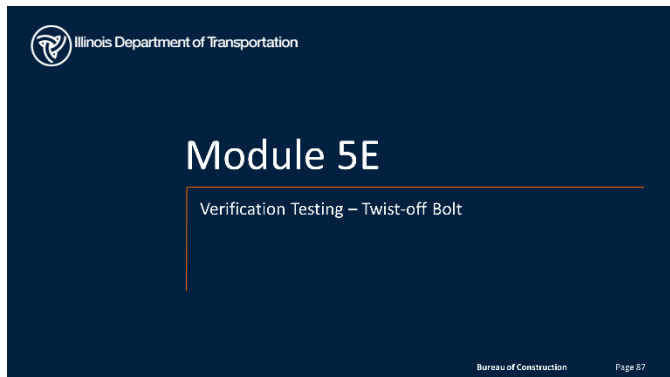
Wrap-up

Module 5 Learning Outcomes

- Describe the various types of bolt tensioning methods used in Illinois
- Complete job aid checklists for qualification of bolt assemblies prior to use on job.
- Execute verification testing for each bolt tensioning method
- Monitor fastener installation throughout bridge construction

NOTE - Course presentations do not include submodules 5E thru 5J. Course presentations also do not include bearings.

Participants should skip forward to Module 6, Secondary Members, page 147 to follow along.



Modules 5E and 5F describe the verification testing and production installation requirements for twist-off bolts, respectively. Because of insufficient time in the Steel Structure Construction Course this material will not be presented. However, it is covered here to serve as a reference in the event inspectors encounter twist-off fasteners in the course of their work.

Prior to initiating bolting operations, a series of verification tests are performed at the jobsite to assure the contractor's tightening procedures using twist-off fasteners will achieve the minimum required tension in the fastener assembly and that all crew members and inspectors are familiar with the tightening procedure to be used on the project. The verification testing is performed on representative lots (bolt, nut, and washer) prior to their use on the project. Unlike heavy hex head fastener components (bolt, nut, and washer), twist-off bolts, nuts, and washer components are manufactured to tight quality control standards and as such are not subject to many of the variables affecting torque/tension relationship. They are produced and shipped as a nut-bolt assembly. Nonetheless, verification testing is still required to ensure the suitability of the fastener and crew procedures to achieve minimum pretension.

Verification testing

- Performed for each fastener assembly lot before use of that lot in the work
- Conducted to determine
 - Suitability of the complete fastener assembly, including lubrication, and adequacy of installation equipment to achieve minimum pretension
 - Define and calibrate crew procedures
 - Determine inspection torque

Illinois Department of Transportation Bureau of Construction Page 88

Verification Testing

- Step 1 – Record fastener lot information and measurements
- Step 2 – Configure test apparatus and install bolt
- Step 3 – Snug tight
- Step 4 – Complete tightening per manufacturer's instruction until spline shears off
- Step 5 – Confirm measured tension exceeds required tension

Illinois Department of Transportation Bureau of Construction Page 89

The IDOT_SPEC 505.04f(2)) requires three (3) assemblies of each diameter, length, grade, and lot to be tested in a calibrated tension device, such as a Skidmore-Wilhelm Tension Calibrator. The verification test defines the standards expected of the bolting personnel using specialized jobsite equipment that will be employed during actual installation of twist-off bolts in the structure. As such, the testing verifies the appropriateness and ability of the contractor's equipment to achieve the required bolt tension. Verification testing will be performed according to the Procedures for Installation and Tightening of High Strength Fasteners Alternate Design Fasteners (Twist-off Bolts) as set forth in the IDOT_CM. Testing should be done immediately prior to the start of installation of the fasteners in the work. Fasteners should be retested when any significant difference is noted in the surface condition or level of lubrication of fastener threads, nuts, or washers.


Each power tool to be used in the actual field installation will be used for at least one of the samples tested. Each worker who is to perform field installations must pass at least one of the sample tests utilizing the same equipment and methods to be used during actual field installations. Workers who fail to properly tighten the twist-off fastener during the test will not be allowed to perform fastener installations unless they successfully complete a retest using the tension indicator device. If a fastener fails to achieve the required minimum tension, the lot from which it was taken will be rejected.

The equipment required for verification testing includes a Skidmore-Wilhelm tension indicator, which is a hydraulic load cell that has been calibrated to measure bolt tension. As the bolt nut is tightened the clamping force is transmitted through the bearing plates exerting pressure on the internal hydraulic fluid. This amount of hydraulic pressure is represented by a gauge that has been graduated to represent bolt tension in pounds. The accuracy of the device requires that it is calibrated and well maintained. The inspector should confirm that the device has been calibrated within the last year, and inspect the device for unusual wear and tear.

The proper Skidmore-Wilhelm tension indicator bushing will need to be used to accommodate the circular, button-shaped head common in most twist-off bolts. Plates and spacers may need to be added to achieve the required thickness. Plates, bushings, and spacers should be those provided by the tension device manufacturer and selected based on the bolt head type, diameter, and length. The manufacturer provides a variety of spacers having variable length or thickness and diameters to accommodate most twist-off bolt configurations. In some instances it may be necessary to add additional washers to achieve the desired thickness. The addition of more than three washers should be avoided as it does not reflect field conditions and may effect verification testing. When properly installed, two to three threads of stick out beyond the face of the nut will be present in the finger tight condition. The inspector should confirm that at least three and no more than five full threads are exposed between the nut face and the underside of the bolt head. The

Equipment and samples

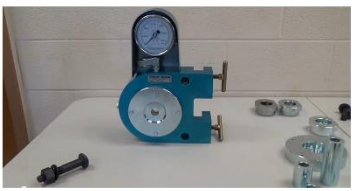
- Equipment
 - Calibrated bolt tension measuring device
 - Proper spacers with appropriate hole size
 - Installation equipment to be used by ironworkers
- Fastener samples
 - Three bolt, nut, and washer assemblies of each diameter, length, grade and lot to be used in work



Illinois Department of Transportation Bureau of Construction Page 90

Tension calibrator set-up

- Unique set-up of Skidmore Wilhelm for twist-off bolts is shown in this [video](https://www.youtube.com/watch?v=er06BoafVmA)



Illinois Department of Transportation Bureau of Construction Page 91

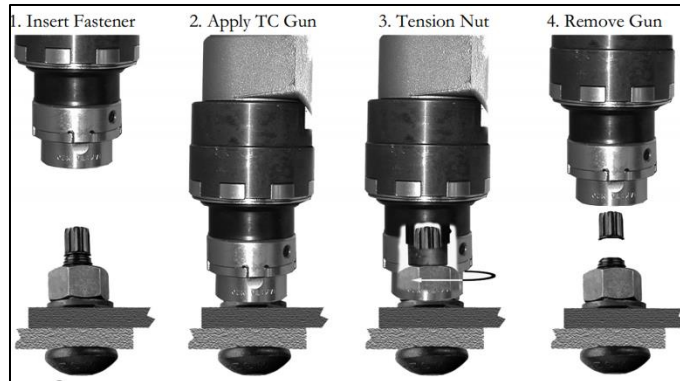
following video illustrates how to set-up the Skidmore-Wilhelm for twist-off fasteners. See (<https://www.youtube.com/watch?v=er088oaFVmA>)

The assembly is then brought to snug tight, which normally occurs at a tension of approximately 10 kips. As part of the verification testing discussed later in this module, workers must demonstrate that their chosen snug tight procedure whether using spud or pneumatic wrenches produces a tension of approximately 10 kips, but not more than 50% of the required final tension. Snug tight tensions above 50% of the final tension could result in fasteners failing when final tightening is applied.

Following the manufacturer's procedure, further tighten the nut until the spline shears off. Record the tension value displayed on the dial gauge of the Skidmore-Wilhelm device and confirm that this value is greater than the bolt tension requirement of the IDOT_CM (See slide). As discussed above for turn-of-nut verification testing, the tension requirement specified in the IDOT_CM is 105% of the minimum tension desired for bolts placed in the bridge. Take care to note that the red and green markings on the Skidmore-Wilhelm represent the minimum required bolt tension for different diameters of A325 and A490 bolts, respectively, and do not include the 5% increase required for verification testing. As such, the markings on the Skidmore-Wilhelm device should not be used to confirm required tension values. Rather they shall be increased by 5%.

The fasteners are considered to have passed the verification testing if all three fasteners achieve pretension values that exceed the required tension at spline shear-off. If so, the fasteners and procedures demonstrated during verification testing can be deployed for production fastener installation on the project.

Special accommodations will need to be made when twist-off bolts are too short to fit in the Skidmore-Wilhelm. Short bolts may be tested using direct tension indicators in a steel connection meeting the calibration gap described for direct tension indicators later in this module. The fastener is tightened to snug tight and then further tightened until the spline shears off. The fastener passes if the average gap in the direct tension indicator is less than the "calibrated gap" as established in the DTI calibration procedure. This requires that the DTI is calibrated first, generally using heavy hex head bolts of sufficient length to fit into the Skidmore-Wilhelm. After calibrating the DTI, extra DTI's from the same lot are used to test short twist-off bolts.



Snug tight

- Apply snug tightening procedure to be employed
 - Typically 10 kips but not more than 50% of required tension

| Bolt Dia. (in) | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 1 3/8 | 1 1/2 |
|----------------|-----|-----|-----|-----|----|-------|-------|-------|-------|
| M164 (A325) | 12 | 19 | 28 | 39 | 51 | 56 | 71 | 85 | 103 |
| M253 (A490) | 15 | 24 | 35 | 49 | 64 | 80 | 102 | 121 | 148 |

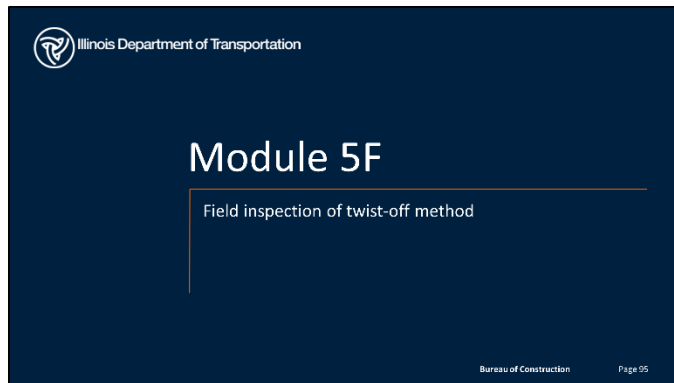
Illinois Department of Transportation Bureau of Construction Page 92

Confirm required tension

- Check that measured tension exceeds the bolt tension requirement

| Bolt Dia. (in) | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 1 3/8 | 1 1/2 |
|----------------|-----|-----|-----|-----|----|-------|-------|-------|-------|
| M164 (A325) | 13 | 20 | 29 | 41 | 54 | 59 | 75 | 89 | 108 |
| M253 (A490) | 16 | 25 | 37 | 51 | 67 | 84 | 107 | 127 | 155 |

Illinois Department of Transportation Bureau of Construction Page 94



The inspector documents and observes the verification testing procedures, including noting the workers and equipment that were used. The inspector then monitors fastener installation to assure the same procedures used in the verification testing are used on the structure. If changes to the bolt conditions occur, the verification testing will need to be repeated.

The inspector should confirm that the proper fasteners are being used at the proper location.

Bolts installed in beam flange splices should be oriented heads-up to allow the failed bolt to become engaged in bearing rather than falling out of their hole due to gravity. In external beams, bolts should be oriented with the head facing outward of the beam web. For internal beams, bolt head orientation should remain the same in a single splice and for all splices along the beam line. The number of fasteners removed from storage should be suitable for a given days' work. Unused fasteners should be returned to protected storage.

Bolt installation – General checklist

- Witness verification testing
- Confirm proper fasteners being used
- Confirm surface of fastener is free of rust or dirt
- Confirm lubrication is unchanged from verification testing
- Confirm installation method is consistent with that used for verification testing
 - Snug tightening
 - Final tightening

Illinois Department of Transportation Bureau of Construction Page 96

The surface condition of the fasteners should be checked for dirt and rust. The condition of the lubrication should also be confirmed to be consistent with that present during the verification testing. Twist-off bolts can be sensitive to lubrication conditions. It should be noted that some twist-off fastener manufacturers use a special, high-durability lubricant that is not as oily as common structural bolts. In this case, only the responsible manufacturer is permitted to apply re-lubrication. Verification testing is repeated if fasteners are re-lubricated.

The purpose of snug tightening is to bring all the plies into firm contact and uniformly tighten all fasteners to approximately the same preload, per IDOT_SPEC 505.04f(2), using the procedures established in verification testing. This is accomplished by progressively tightening the fasteners from the most rigid part of the connection to the free edge. The tightening process for each fastener shall be the same used in the verification testing to achieve snug tight, as described previously. Several repetitions of this process may be necessary. Do not allow the wrench to shear off the spline when snugging. If this occurs, remove the bolt and replace it with a new assembly (bolt, nut, and washer).

Snug tightening inspection

- Verify each nut tightened as demonstrated in verification testing
- Verify faying surface is fully compacted
 - Work proceeds systematically from rigid part of connection to free edges; repeat as necessary to fully compact surfaces
- Verify that length of bolt is proper for grip

Illinois Department of Transportation Bureau of Construction Page 97

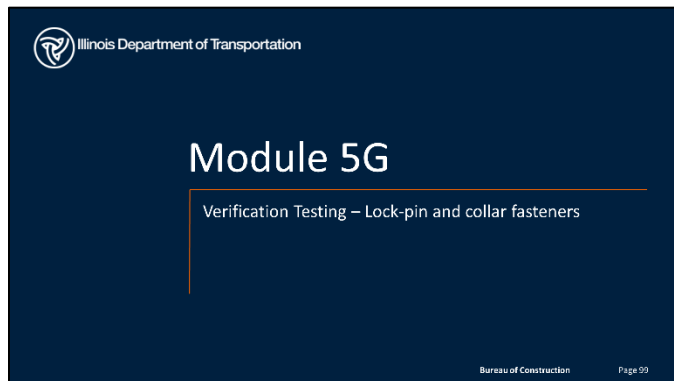
After all bolts in a connection are brought to a snug tight condition, the nut will be tightened the spline shears off using the same procedures established in verification testing and progressing systematically from the most rigid part of the connection to the free edges. The wrenches should be of adequate capacity to achieve the required rotation in approximately 10 seconds. The inspector will monitor final tightening to confirm adherence to the procedures, equipment, and personnel used for the verification testing. Splines should be collected and properly disposed. Do not allow splines to be ejected into rivers or soil.

Final tightening

- Verify tightening procedures same as those used in verification
 - Work proceeds systematically from rigid part of connection to free edges; repeat as necessary to fully compact surfaces
- Confirm that all splines have sheared off

If based on visual examination all of the splines have sheared off the installation may be accepted.

Because of the unique design of twist off bolts, fasteners can be installed from one side without the need for a second iron worker to prevent bolt rotation. However, the design can be a hindrance if a fastener needs to be removed. Procedures for bolt removal should be discussed with the contractor prior to starting work. The contractor should have procedures and equipment necessary to remove improperly installed fasteners.



Module 5G describes the verification testing procedures and inspection requirements for verification testing of lock-pin and collar fasteners. Module 5H describes the inspection requirements for production installation of these fasteners on the structure. These slides are not presented in the course, but are provided here for reference if encountered on the job site.

Prior to initiating bolting operations with lock-pin and collar fasteners, the inspector shall witness a verification test at the jobsite to assure the contractor's tightening procedures, fasteners, and equipment will achieve the minimum required tension in the fastener assembly and that all crew members and inspectors are familiar with the tightening procedure to be used on the project.

Similar to the procedures described above for turn-of-nut and twist-off methods, execute verification testing in accordance with the IDOT_CM, which describes the following steps:

Step 1 - Set-up Skidmore-Wilhelm per the manufacturer's instructions for the size and length of lock-pin fastener to be tested. The grip length shall be equal to the designed grip length for the fastener.

Step 2 - Select three representative fasteners for each diameter, length, and lot to be used on the project for that day.

Step 3 - Tighten to snug tight, which normally occurs at a tension of approximately 10 kips. As part of the verification testing discussed later in this module, workers must demonstrate that their chosen snug tight procedure whether using spud or pneumatic wrenches produces a tension of approximately 10 kips, but not more than 50% of the required final tension. Snug tight tensions above 50% of the final tension could result in fasteners failing when final tightening is applied.

Step 4 - Complete the fastener installation in accordance with the manufacturer's instructions until the pintail shears and the collar is swaged around the pin.

Step 5 - The tension value displayed on the dial gauge of the Skidmore-Wilhelm device should be recorded and checked against the bolt tension requirement of the IDOT_CM (see slide). As described above under the turn-of-nut method, the tension requirement specified in the IDOT_CM represents 105% of the minimum installation tension desired for lock-pin and collar fasteners placed in the bridge. As such, the markings on the Skidmore-Wilhelm device should not be used to confirm minimum tension values. Rather they shall be increased by 5%.

If all three fasteners pass the verification test, the lot can be used in production work on the project. If any fastener fails the testing, the lot it represents shall be rejected (IDOT_CM)

Verification testing

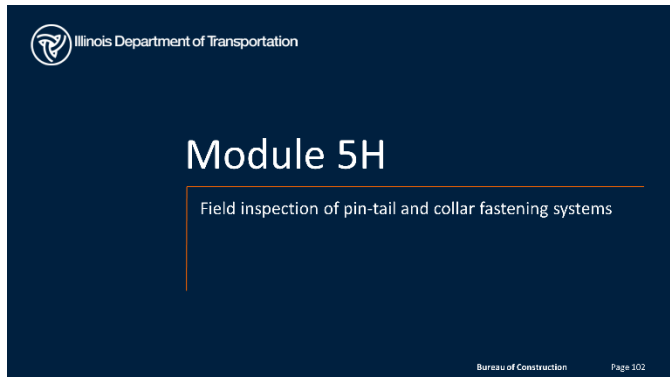
- Performed for each fastener assembly lot before use of that lot in the work
- Conducted to determine
 - Suitability of the complete fastener assembly, including lubrication, and adequacy of installation equipment to achieve minimum pretension
 - Define and calibrate crew procedures
 - Determine inspection torque

Illinois Department of Transportation Bureau of Construction Page 100

Verification testing

- Step 1 - Set-up Skidmore Wilhelm
- Step 2 - Select three fasteners representative of each diameter, length, and lot
- Step 3 - Tighten to snug tight without producing more than 50% of the required tension
- Step 4 - Follow manufacturer's instruction and tighten until pintail shears and collar is swaged around pin
- Step 5 - Confirm minimum tension per IDOT Construction Manual

Illinois Department of Transportation Bureau of Construction Page 101



Illinois Department of Transportation

Module 5H

Field inspection of pin-tail and collar fastening systems

Bureau of Construction Page 102

Prior to the start of work, the inspector should review and become familiar with manufacturer's installation instructions for Lock-pin and Collar fastening systems. The inspector shall also witness the verification testing. It is also good practice to include the manufacturer's representative at the verification testing to review and educate inspectors and iron workers on the proper use of these fastening systems.

Throughout the installation, the inspector will verify that the manufacturer's procedures are being followed and that the installation conforms to the procedures used in the verification testing. As with other fasteners, the inspector shall monitor that fastener installation is progressing systematically from the most rigid to free edges of the connections so as to minimize relaxation of previously tightened fasteners. This may require more than a single cycle of partial tightening before finalizing the installation.

Each fastener will be visually inspected according to the inspection chart provided by the manufacturer. A sample inspection chart is provided in this slide. The "A" dimension is checked for each fastener. Note that prior to tightening a washer matched to the finish of the lock-pin collar assembly may be added under the bolt head to decrease the stick-out below the maximum permissible "B" dimension. The "C" dimension indicates proper swage while the "D" dimension reflects proper anvil operation on the installation tool. Fasteners falling to meet the required ranges shall be removed and replaced with new fasteners.

Note that the "A" dimension may be increased by 1/8 in. and still meet all published values, provided there is no requirement to meet ASTM specifications pertaining to locking grooves (threads) in the shear plane.

Bolt installation – General checklist

- Review manufacturers installation instructions
- Witness verification testing
- Confirm proper fasteners being used
- Confirm iron workers understand installation procedures
- Confirm installation method is consistent with that used for verification testing
 - Snug tightening
 - Final tightening

Snug tightening inspection

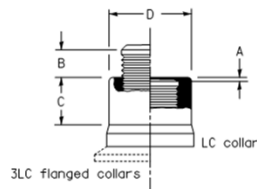
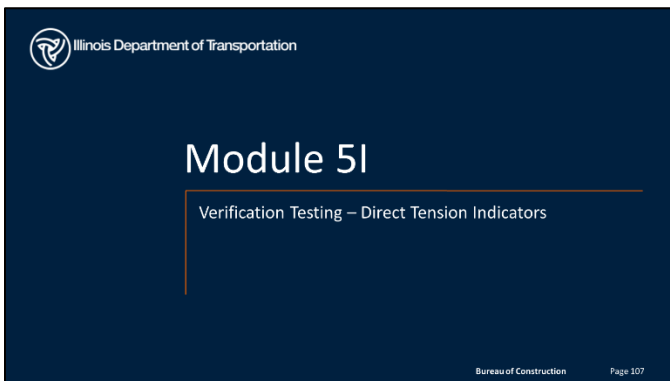
- Verify each fastener tightened as demonstrated in verification testing
- Verify faying surface is fully compacted
 - Work proceeds systematically from rigid part of connection to free edges; repeat as necessary to fully compact surfaces
- Verify that length of fastener is proper for grip


Final tightening

- Verify tightening procedures same as those used in verification
 - Work proceeds systematically from rigid part of connection to free edges; repeat as necessary to fully compact surfaces
- Confirm final geometry per manufacturers literature
- Each fastener to be "pinged" with a hammer for soundness
 - Loose fasteners to be removed and replaced

Lock-pin & collar installation guide

| Dia. | Pin Part. No. | Collar Type C | Collar Type | A Max. | B. Max | C Min. | D Max. |
|-------|---------------|---------------|-------------|--------|--------|--------|--------|
| 1/2 | C50L(-)116 | LC-2R16G | 3LC-2R16G | 1/16 | 3/8 | 11/32 | .733 |
| 3/8 | C50L(-)120 | LC-2R20G | 3LC-2R20G | 1/16 | 3/8 | 3/8 | .916 |
| 3/4 | C50L(-)124 | LC-2R24G | 3LC-2R24G | 1/16 | 3/8 | 21/32 | 1.110 |
| 7/8 | C50L(-)128 | LC-2R28G | 3LC-2R28G | 1/16 | 3/8 | 3/4 | 1.282 |
| 1 | C50L(-)132 | LC-2R32G | 3LC-2R32G | 1/16 | 3/8 | 7/8 | 1.465 |
| 1 1/8 | C50LR-BR36 | LC-2R36G | | 1/16 | 3/8 | 21/32 | 1.646 |

 Illinois Department of Transportation

Module 51

Verification Testing – Direct Tension Indicators

Bureau of Construction Page 107

Modules 5I and 5J describe the inspection requirements during verification testing and installation, respectively, when bolt pretensioning is accomplished using direct tension indicators (DTI). DTIs are special washers with raised protrusions on one face which compress when the fastener is tightened. They verify proper pretension without relying on turn-of-nut method.

Prior to initiating bolting operations, verification tests shall be performed at the

jobsite and witnessed by the inspector. The inspector then monitors fastener installation to assure the same procedure, workers, and equipment* (See next slide for explanation of special concern associated with impact wrenches) used in the verification testing are used on the structure. By use of the same procedures, the inspector and iron workers can be assured that the minimum tension is present in the installed fasteners. If changes to the bolt conditions, procedures, equipment, or workers occur, the verification testing will need to be repeated.

Verification testing

- Performed for each fastener assembly lot before use of that lot in the work
- Conducted to determine
 - Suitability of the complete fastener assembly, including lubrication, and adequacy of installation equipment* to achieve minimum pretension
 - Define and calibrate crew procedures
 - Verify pretension is achieved at required "gap" per ASTM F959
 - Determine inspection requirements

Verification tests are conducted to assure the contractor's tightening procedures using DTIs will achieve the minimum required tension in the fastener assembly and that all crew members and inspectors are familiar with the tightening and inspection procedures to be used on the project. The verification testing is performed for each fastener assembly lot prior to the use of that assembly lot in the work. Similar to turn-of-nut, the verification testing also confirms the adequacy of the lubrication and surface condition of the fasteners, just prior to use. Because of the unique aspects of the DTI washer, the pre-installation verification procedures demonstrate that the protrusions do not compress prior to achieving the required bolt tension (per ASTM F959).

It is recommended by some DOTs to use a manual non-impacting wrench for verification testing of DTI's. The impact action of these wrenches "shocks" the compressible hydraulic cylinder, and the DTI follows it to a higher-than-intended bolt tension, leading to too much DTI bump compression. This is unlike the action of an impact wrench when tightening a bolt (and DTI) in a solid steel connection. For states that incorporate this requirements in their specifications, it is required that verification testing be performed with a hand wrench or non-impacting electric wrench. The IDOT_CM procedures for verification testing of DTI's limit impact wrench use as follows: *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 following [video](https://www.youtube.com/watch?v=dwbMcJC_-DA) does a good job of explaining the verification testing for DTI's. https://www.youtube.com/watch?v=dwbMcJC_-DA.

The equipment required to complete verification testing of DTIs includes a calibrated bolt tension indicator device, such as a Skidmore-Wilhelm Tension Calibrator. The tension indicator is provided by the contractor, and should be examined by inspector to confirm it is in good working order. The contractor is required to provide documentation that the tension indicator has been calibrated within the last 12 months.

The IDOT_SPEC requires three (3) assemblies of each diameter and length to be tested as part of the pre-tension verification testing. The contractor should also provide an adequate number of metal feeler gages for performing verification testing.

*Impact equipment concern

- It is recommended by some DOTs to use manual non-impacting wrenches for verification testing.
- The action of impacting "shocks" the compressible hydraulic cylinder of the Skidmore, and the DTI follows it to a higher-than-intended bolt tension, leading to too much DTI bump compression.
- This is unlike the action of an impact wrench when tightening a bolt (and DTI) in a solid steel connection.

Equipment and fastener samples

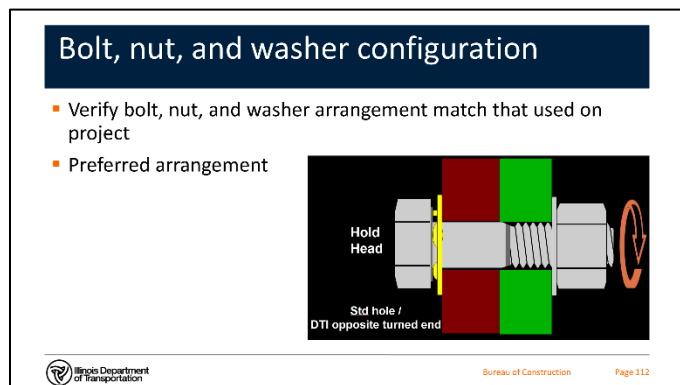
- Equipment
 - Calibrated bolt tension measuring device
 - Proper spacers with appropriate hole size, and special inserts
 - Installation equipment* to be used by ironworkers
- Fastener samples
 - Three bolt, nut, and DTI washer assemblies of each diameter, length, grade, and lot to be used in work
 - Tapered 0.001, 0.005, and 0.015 inch feeler gages

The standard plates that typically come with the Skidmore-Wilhelm are fabricated for testing hex nut fastener assemblies. The front plates and bore holes may not be conducive to DTI washers in two respects. First, they may not accommodate the knobbed flanges of some washers or access for the feeler gage. Similarly, the rear plate of the Skidmore-Wilhelm may also be incompatible with DTIs. The rear plate is typically configured to restrain a hex head bolt from turning as the nut is tightened. This configuration is problematic when the DTI washer is to be installed under the non-turned element. Use only plates and spacers supplied by the manufacturer designed to meet the diameter and length requirements for the bolt being tested.

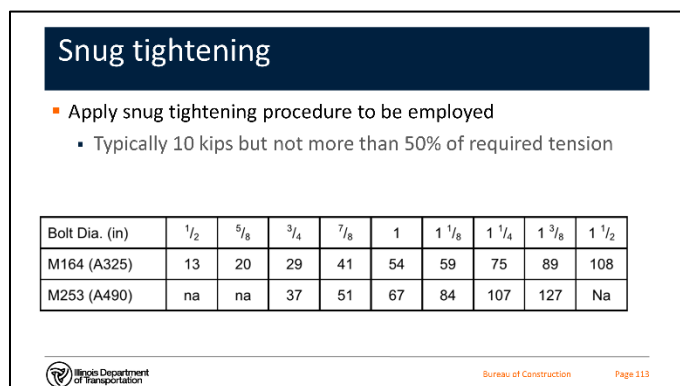


The photos in the adjacent slide illustrate some of the problems associated with DTI washers. The inspector should confirm that the feeler gage can be successfully installed using the Skidmore-Wilhelm verification testing set-up. The equipment to be used by the ironworkers during production installation should be used for the verification testing.

DTI's must be installed in strict compliance with the manufacturer's instructions, and configured in the arrangement that will be used on the project. The most common configuration has the DTI placed under the bolt head with the protrusions bearing against the underside of the bolt head. Acceptable configurations are illustrated at the beginning of Module 5A. In no case shall the DTI be placed with the protrusions in direct contact with the turned element or unsupported across bolt holes. Galvanized DTI's shall always be placed under the bolt head with only the nut being permitted to be turned (IDOT_SPEC 505.04f(2)a.2)). Similar to turn-of-nut verification testing, the properly configured and installed assembly should results in 3 to 5 threads located within the grip length.



After the Skidmore-Wilhelm and fastener have been properly configured, the fastener is brought to a snug tight condition. The Procedures for Verification Testing and Installation of High Strength Bolts with Direct Tension Indicators (DTIs) in the IDOT_CM state, "snug the bolt to no more than 50% of the required installation tension using the equipment which will be used in the work." The nonturned element should be prevented from rotation during tightening if the DTI is to be used under this element. When the fastener



is brought to snug tight condition, the protrusions on the DTI washer will partially compress. Per RCSC, whenever the snug-tightening operation causes one-half or more of the gaps to close to 0.015 in. or less (0.005 or less for coated DTIs), the direct tension indicator should be replaced.


Following acceptance of the snug tight condition, continue tightening the fastener by advancing the turned element while keeping the stationary end from rotating. Equipment used for final tightening should be the same as that expected for production installations, with the exception that impact wrenches are not used just prior to reaching the minimum tension. Rather, the turned element should be advanced until the tension indicator displays a tension slightly below the values noted in the adjacent table. A manual wrench is then used to complete the tensioning. Values in the adjacent table represent 105% of the minimum pretension for each bolt diameter and grade.

Final tightening

- Advance the turned element until Skidmore displays 105% of the minimum tension

| Bolt Dia. (in) | 1/2 | 5/8 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 | 1 3/8 | 1 1/2 |
|----------------|-----|-----|-----|-----|----|-------|-------|-------|-------|
| M164 (A325) | 13 | 20 | 29 | 41 | 54 | 59 | 75 | 89 | 108 |
| M253 (A490) | na | na | 37 | 51 | 67 | 84 | 107 | 127 | Na |


- If using impact wrench, stop prior to above values and finish advancement of the turned element with hand wrench


Bureau of Construction
Page 114

While the fastener is at the required 105% minimum tension, use the feeler gage to determine the number of spaces on the DTI between which the feeler gage experiences refusal. Refusal is defined as the condition wherein the feeler gage cannot touch the shank of the fastener when inserted into the gap between two protrusions. Record the number of refusals and the measured tension. A 0.005 in. feeler gage is used for galvanized DTIs and a 0.015 in. feeler gage is used for plain DTIs. If the feeler gage is refused at more than 50% of the total spaces, the DTI fails the test and the lot is rejected.

Check refusal criteria

- Check for refusals using 0.005 gage for coated and 0.015 gage for plain DTIs
 - Refusal occurs when gage cannot touch shank when inserted into a gap
- If feeler gage is refused at MORE than 50% of the gaps, DTI lot fails verification test


Bureau of Construction
Page 215

During production of this manual, a conflict between IDOT_CM, IDOT_SPEC and the 2014 RCSC was uncovered. The bridge office is currently looking into these issues, which have been highlighted in yellow as a precaution. Inspectors responsible for monitoring projects that include DTI's should contact the bridge office to get clarification on those items which are highlighted. The bridge office is currently considering revisions to resolve these issues.

Once the fastener is tightened to 105% of the minimum tension, IDOT_CM states *"If the thickness gage is refused in **more** than 1/2 of the total spaces, the DTI fails the test and the lot is rejected."*

2014 RCSC states in 9.2.4, *"After pretensioning, it shall be ensured by routine observation that the appropriate feeler gage is refused entry into at least half of the spaces between the protrusions."*

Consider a washer with four protrusions which experiences two refusals at 105% of the minimum pretension...

Under IDOT_CM this washer would be rejected in the verification test
Under 2014 RCSC this washer would be accepted in the field.


| Verification criteria | | | | | |
|--|----------------------|---|---|---|---|
| | No. of spaces on DTI | | | | |
| | 4 | 5 | 6 | 7 | 8 |
| Max. No. of spaces refused: <ul style="list-style-type: none"> All plain DTI's Coated* DTI's under "Unturned" element | 1 | 2 | 2 | 3 | 3 |
| Max. No. of spaces refused: <ul style="list-style-type: none"> Coated* DTI's under "Turned" element | 3 | 4 | 5 | 6 | 7 |

The number of refusals required by IDOT_SPEC is not consistent with the maximum number allowed and listed in the above table, which is consistent with the RCSC. (Note also that the refusal criteria is dependent upon whether or not the DTI was used under the turned or stationary element and the coating condition of the DTI, which is not addressed by the IDOT documents.)

The turned element should then be advanced until all protrusions are compressed, but a visible gap still exists in at least one space. This is defined as the zero gap state, at which a 0.001 inch feeler gage cannot enter any space in the DTI. The purpose of this final step is to determine the minimum allowable gap for the job. (IDOT_CM does not indicate to record tension at the zero gap state, or any other data to be collected. Comparatively, RSCS requires that the tension at the zero gap state be recorded and compared to a limit. If the tension exceeds the limit the DTI fails the verification test)

Zero gap test

- Advance turned element to compressed all protrusions but one gap remains visible
- Remove fastener
- Confirm that nut can be hand-advanced the full thread length
- If so, zero gap state is the minimum gap for the job
- If not, repeat this step stopping just prior to compressing all protrusions

 Illinois Department of Transportation
Bureau of Construction
Page 108

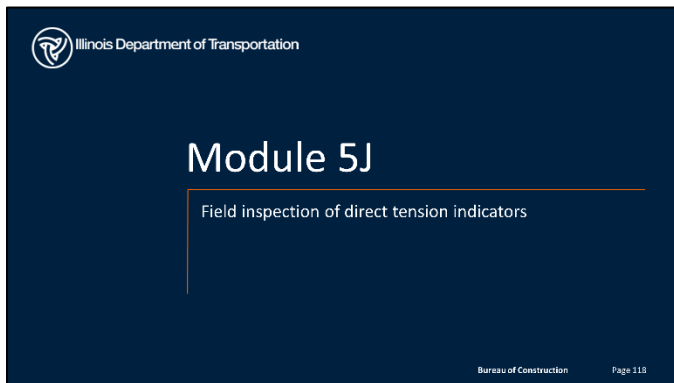
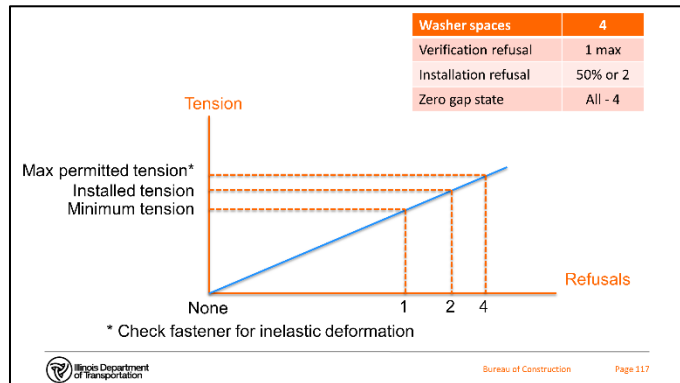
The fastener is then removed from the calibrator using the wrench. The threads are checked for distortion by running the nut by hand over the full thread length. If no distortion has occurred, the zero gap state is the minimum allowable gap for the job. If thread distortion has occurred, repeat the test with a larger minimum gap in prior test, for example one space will accept a 0.005 inch feeler gage. If successful, the repeat test will establish the minimum allowable gap for the job.

Installations found to go beyond the minimum gap, meaning closing more gaps than determined in the zero gap tightening procedure, should be rejected and the fastener removed and replaced.

The concern here is that fasteners installed well beyond the 50% refusal threshold may experience inelastic elongation which would lead to a loss of tensile and clamping force. If this occurs, the strength of slip-critical connections might be substantially reduced.

The zero gap test provides a means to quantify the suitability of bolts installed at tension levels above their minimum tension, but just prior to fully closing all the DTI gaps. The ability of a nut to be hand turned through the full length of the threads is indicative that the bolt has not undergone plastic elongation. As such, this installation while greater than the 50% refusal threshold should not be subject for fastener rejection provided the zero gap test did not indicate inelastic behavior of the bolt.

As the ironworker conducts the verification testing, he/she will gain an appreciation for the effort required to collapse the required number of protrusions as measured by the refusal of the 0.005 feeler gage per tables below and thus develop the minimum pretension. If using Squirter DTI's, he/she will also gain an appreciation for the amount and flow of silicone from the edges of the DTI washer at this pretension load. This knowledge, albeit somewhat subjective, is then transferred into production bolting.



Prior to the start of work, the inspector should review and become familiar with manufacturer's installation instructions for the DTIs to be used on the project. The contractor is required to provide installation documentation and an adequate number of feeler gages for performing verification and installation inspections.

Once verification testing has been successfully completed, the contractor may begin production installation of fasteners on the

structure. The inspector monitors fastener installation to assure the same procedures used in the verification testing are used on the structure.

The inspector should confirm that the proper fasteners are being used at the proper location. Bolts installed in beam flange splices should be oriented heads-up to allow a potentially failed bolt to become engaged in bearing rather than falling out of their hole due to gravity. In external beams, bolts should be oriented with the head facing outward of the beam web. For internal beams, bolt head orientation should remain the same in a single splice and for all splices along the beam line.

Bolt installation – General checklist

- Review DTI manufacturers installation instructions
- Witness verification testing
- Confirm surface of fastener is free of rust or dirt
- Confirm lubrication is unchanged from verification testing
- Verify that length of bolt is proper for grip
- Confirm washer is properly placed within the assembly and DTI is positioned as tested in verification testing

The most critical variable to achieving proper pretension is the condition of the bolts, nuts, and washers. Fasteners components shall be protected from moisture, dirt, debris, etc. while in storage, and only the number of fasteners needed for a given day's work should be removed. Unused fasteners should be returned to protected storage.

DTI's do not alter the frictional resistance of the fastener, and therefore are unaffected by the torque resistance produced at the bolt, nut, and washer surfaces. Nonetheless, adequate lubrication and clean fasteners need to be maintained to ensure proper tensioning within about ten seconds or less. Installations that experience difficulty during tightening can overheat during prolonged impacting, which can lead to stripping, galling, or seizing complications followed by either bolt or wrench failure. When high torque resistance is encountered, the cause should be discovered and remedied before continuing with the tightening operations.

The inspector should take care to verify the placement of the DTI within the fastener assembly. The DTI should be located as positioned for the verification testing. Verification testing should be repeated when the DTI is placed in a new position within the assembly. If the DTI is approved to be positioned such that the protrusions bear against a washer, the inspector shall verify that the washer is an F436 hardened washer. Remember that the preferred orientation is to position the DTI under the bolt head with the DTI protrusions pointing outward away from the steel and facing the bolt head. If an oversized or slotted hole is directly beneath the DTI in the outer ply, an F436 washer must be placed between the DTI and the steel.

The connection is to be initially brought up to snug tight condition to bring the plies into contact. This is accomplished by progressively tightening the fasteners from the most rigid part of the connection to the free edge. The tightening process for each fastener shall be the same used in the verification testing to achieve snug tight. Several repetitions of this process may be necessary.

Snug tightening inspection

- Verify each nut tightened as demonstrated in verification testing
- Verify faying surface is fully compacted
 - Work proceeds systematically from rigid part of connection to free edges; repeat as necessary to fully compact surfaces
- Verify that non-turned element is prevented from rotation
- Verify that the DTI has not been over-compressed

The inspector shall confirm that the non-turned element is prevented from rotation. For assemblies with the DTI placed under the bolt head, one worker must hold the bolt head as the nut is turned. If the bolt head turns the DTI must be replaced. For assemblies with the DTI placed under the nut, one worker must hold the bolt head if the nut is turned or hold the nut if the bolt head is turned.

Some partial compression of the protrusions will occur during snug tightening, which is acceptable. However, the inspector should verify that the DTI has not been over-compressed by confirming that at least half of the gaps accept the feeler gage. Use table below to complete snug tight inspection and a 0.015 in. gage for plain DTIs and a 0.005 in. gage for coated DTIs.


| Type 325 DTI | | | | |
|---------------------|----------------|----------------------|----------------------|-----------------------------------|
| Bolt Diameter | Number of Gaps | Min. entries at snug | Max refusals at snug | Min. refusals after pretensioning |
| 1/2 | 4 | 3 | 1 | 2 |
| 5/8 | 4 | 3 | 1 | 2 |
| 3/4 | 5 | 3 | 2 | 3 |
| 7/8 | 5 | 3 | 2 | 3 |
| 1 | 6 | 4 | 2 | 3 |
| 1-1/8 | 6 | 4 | 2 | 3 |
| 1-1/4 | 7 | 4 | 3 | 4 |
| 1-3/8 | 7 | 4 | 3 | 4 |
| 1-1/2 | 8 | 5 | 3 | 4 |

| Type 490 DTI | | | | |
|---------------------|----------------|----------------------|----------------------|-----------------------------------|
| Bolt Diameter | Number of Gaps | Min. entries at snug | Max refusals at snug | Min. refusals after pretensioning |
| 1/2 | 5 | 3 | 2 | 3 |
| 5/8 | 5 | 3 | 2 | 3 |
| 3/4 | 6 | 3 | 2 | 3 |
| 7/8 | 6 | 3 | 2 | 3 |
| 1 | 7 | 4 | 3 | 4 |
| 1-1/8 | 7 | 4 | 3 | 4 |
| 1-1/4 | 8 | 4 | 3 | 4 |
| 1-3/8 | 8 | 4 | 3 | 4 |
| 1-1/2 | 9 | 5 | 4 | 5 |

For production bolting, the ironworker is asked to advance the turned element so as to compress at least 50% of the gaps, as determined by the refusal of the 0.005 feeler gage for coated DTI's or 0.015 for plain DTI's. This is one more refusal than required to achieve the minimum tension. (not per IDOT_CM. See notes above) The final tightening work should proceed in a systematic manner starting at the most rigid part of the connection and working outwards. During final tightening, the inspector should verify that the non-turned element is restrained from rotation particularly for installations where the protrusions bear directly against a surface that can move. If the fasteners are tightened in a single continuous operation, direct tension indicators may give the inspector a misleading indication that the bolts have been properly pretensioned. The installation procedures should follow those used for verification testing. The inspector

Final tightening inspection

- Verify tightening procedures same as those used in verification
 - Work proceeds systematically from rigid part of connection to free edges; repeat as necessary to fully compact surfaces
- Confirm at least 50% of the gaps refuse feeler gage, and
- Confirm no more than 10% of DTIs exceed the zero-gap condition


Bureau of Construction
Page 121

shall ensure by routine observation that the appropriate feeler gage is refused entry into at least half of the spaces between the protrusions.

Because of the nature of the bolting process, it is expected that some fastener installations will result in situations where the feeler gage is refused at more than 50% of the gaps. Moreover, it may be expected that some installations will result in situations where a feeler gage is refused at all gaps. Once all the gaps are completely closed, the DTI can no longer indicate the amount of additional pretension that was imparted to the bolt. Therefore, the contractor should avoid fastener installations where no gap is visible between the DTI surface and the surface against which the protrusions bear. The IDOT_SPEC (505.04(f)(2)a2) requires that no more than ten percent of the bolts within in any one connection may exist in a zero gap state. If the number of zero gap state DTI's exceeds ten percent of the bolts in the connection, a sufficient number of bolts shall be removed and replaced to bring the percentage within the ten percent allowed.

The IDOT_CM describes the required inspections for DTI's used in production bolting. All DTI's used in the first two connections by each bolting crew must be checked. All DTI's in the connection shall meet or exceed the minimum number of refusals at pretension (See table above) and no more than ten percent shall have surpassed the minimum gap state, as determined in verification testing. In most instances, the minimum gap state is equivalent to the zero gap state. Further, no more than ten percent of


the DTIs shall have gaps larger than 0.005 in. for galvanized DTIs or 0.015 in. for plain DTIs. Additional tightening will be required on any bolts which exceed the ten percent allowable. Testing of 100 percent of the fasteners in a connection shall continue until the above requirements are met.

Once met, testing of 20 percent (but not less than 10 DTI's per splice connection and not less than 1 DTI per cross frame or diaphragm connection) shall be examined with feeler gages. The remainder of the fasteners shall be visually examined. If more than ten percent of the fasteners tested in fail the feeler gage measurements then the entire connection shall be tested.

Spot checking DTI's

- First 2 connections
 - All DTI's exceed minimum number of refusals at pretension
 - <10% shall have surpassed minimum gap (or zero-gap state)
- If satisfied, 20% of fasteners in remaining connections tested
 - DTI exceeds minimum number of refusals at pretension
 - 10 DTIs per splice connection and 1 DTI per cross frame

Illinois Department of Transportation Bureau of Construction Page 123



Illinois Department of Transportation

END OF MODULE

Bureau of Construction Page 124

MODULE 6 - INSPECTION OF SECONDARY STRUCTURAL MEMBERS AND BEARINGS

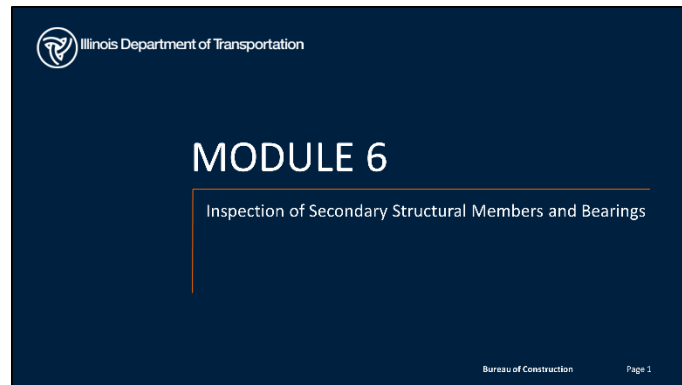
Overview and Instructional Method

The various bearing systems and bracing, or secondary structural members, used in Illinois bridge construction are reviewed. Example contract documents are reviewed and critical aspects associated with the coordination and installation of these systems are discussed. Avoidance of problems associated with the installation and coordination of these systems is discussed using case studies to better understand where problems might occur.

Participants work independently and utilize IDOT specifications and drawings to respond to several questions regarding these systems.

This module is designed to achieve the following learning outcomes

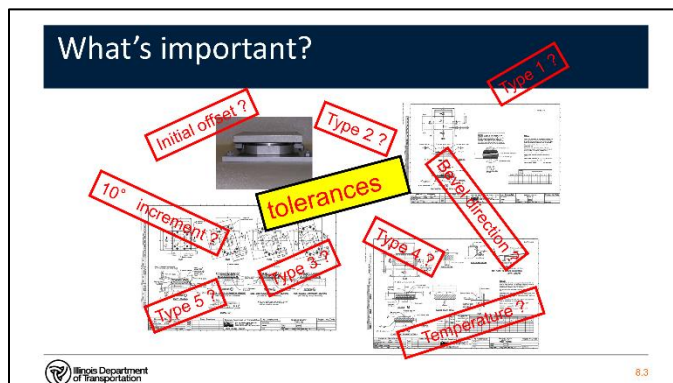
1. Describe the various types of bracing and bearing systems typically used in steel structure construction in Illinois.
2. List requirements for proper setting and final bearing of superstructure elements
3. Explain how these systems are coordinated with other elements of steel structure bridge construction.
4. Define inspection requirements for the installation of these systems.



Learning outcomes

- Describe the various types of bracing and bearing systems typically used in steel structure construction in Illinois
- List requirements for proper setting and final bearing of steel superstructure elements
- Explain how these systems are coordinated with other elements of steel bridge construction
- Define inspection requirements for the installation of these systems

Presentation Notes



The IDOT Checklist for Bridge Superstructures includes the following reminders for construction inspectors responsible for the monitoring of bearing installations:

- (1) Are bearings being handled properly to prevent damage? This is particularly important for Type II bearings, since the stainless steel and Teflon sliding surfaces are very easily damaged.
- (2) Are all bearing sliding surfaces clean

before installation and kept clean after installation?

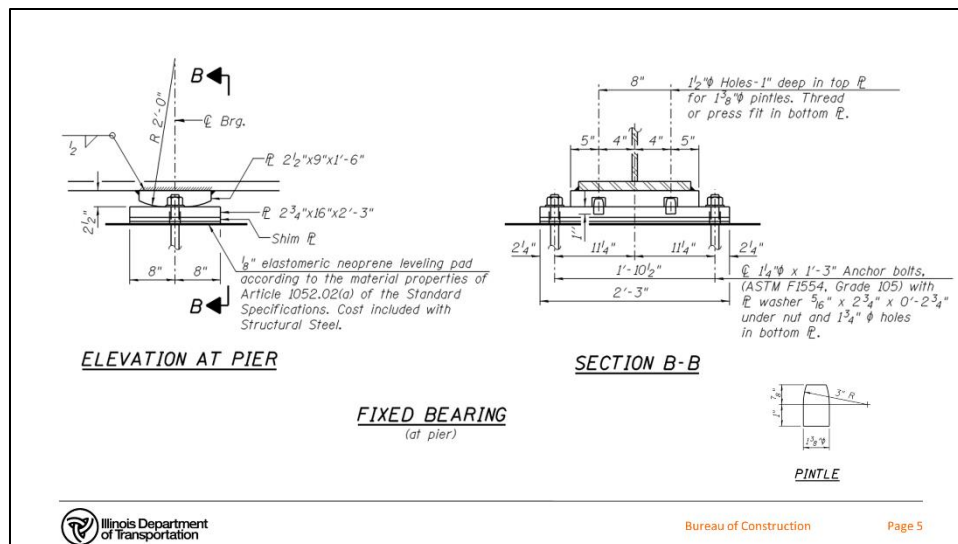
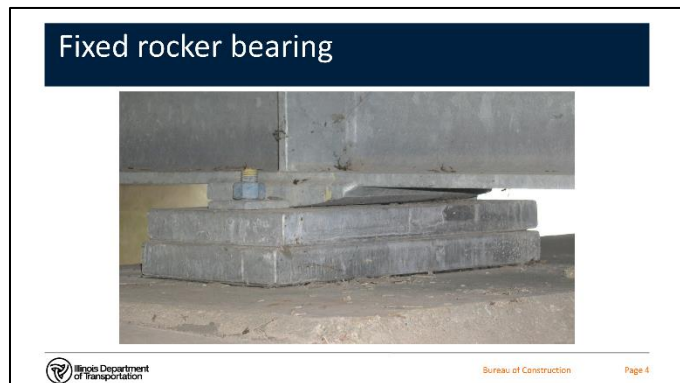
- (3) If Type II Elastomeric, Type III Elastomeric, or High Load MultiRotational bearings are utilized are they being adjusted to center vertically over bearing and base plates at 10 °C (50 ° F)? (See bridge plan detail)

- (4) If Type II Elastomeric, Type III Elastomeric, or High Load Multi-Rotational bearings are utilized are their anchor bolt holes being drilled after bearings are in place? (See bridge plan note and Art. 521.06)
- (5) After anchor bolts are installed, have you check the upper ends of the bolts to verify proper embedment? Anchor bolt lengths should leave the exposed end projecting between 12 mm (1/2 in.) and 50 mm (2 in.) above the top of the nut. (See Art. 521.06)
- (6) Have all bearing side retainers been secured in place prior to forming the bridge deck (See Art. 505.08(f))

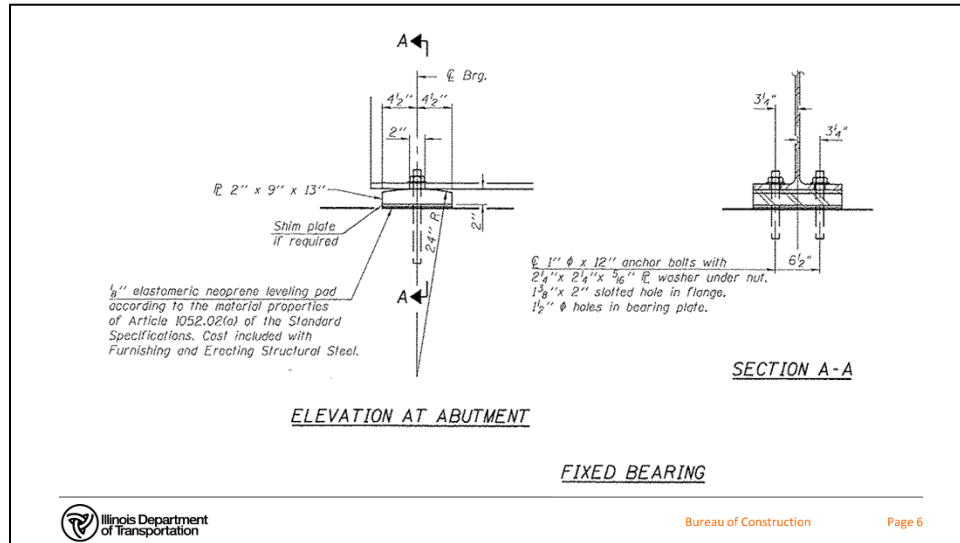
Of these various tasks, which are important to the success of steel structure construction? One could argue that the success of steel erection and hence all bolting operations hinges on the correct placement of bearings. Without a good starting point, problems will persist from erection throughout deck construction.

Before discussing the inspection requirements for bearings, one must understand the various types of bearings typically encountered on Illinois steel bridge structures. Plans will designate the bearings as either fixed or expansion (F or E). A fixed bearing prevents longitudinal movement, but allows rotational movement about the bearing. An expansion bearing allows movement in both the longitudinal and rotational directions. Generally, both types of bearings prevent movement in the transverse direction.

Fixed rocker bearings come in a variety of shapes and sizes. The detail shown in the adjacent slide is probably the most typical configuration. This type of bearing is fabricated from structural steel and includes a top assembly (or sole plate), a bottom assembly (or masonry plate), and shim plates. The sole plate is fixed to the girder, and the masonry plate is fixed to the abutment or pier cap. The assembly is free to rotate, but fixed against longitudinal and transverse movement by a pintel, which is set into the masonry plate as shown in the drawing. The drawing represents the standard, low profile fixed bearing used by IDOT in



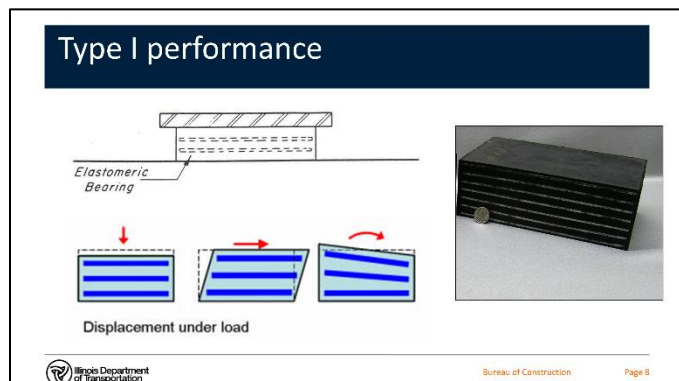
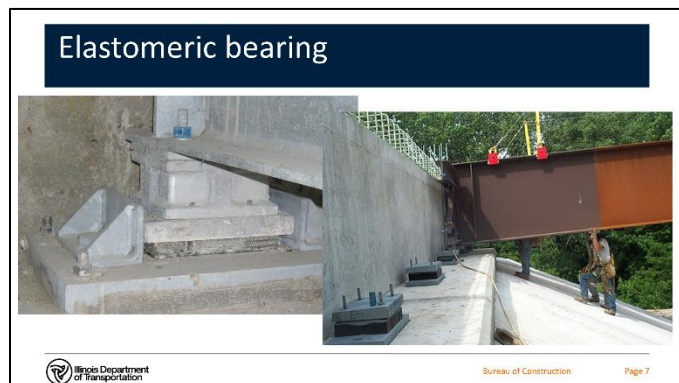
conjunction with standard elastomeric expansion bearings. The standard fixed bearing used for steel beams at integral abutments is detailed in the slide below. The two bearing illustrations were obtained from representative IDOT steel bridge projects.



Elastomeric bearing assemblies are divided into three types according to the expansion lengths that they will accommodate. Elastomeric bearings consist of steel plates laminated within custom molded neoprene or natural rubber. The assembly may include Teflon-coated plates for expansion or shear restrictor pins for the prevention of movement. Depending on the configuration of the bearing, it can accommodate longitudinal and rotational movement.

Type I bearings accommodate movement through distortion of the neoprene or rubber. This type of bearing is limited to 75 ft for the 6 in. wide pad and 200 ft for the 15 in. wide pad.

Type II bearings incorporate a Teflon sliding surface to provide additional movement capacity. Movement is accomplished through both deformation of the rubber/neoprene and sliding on the Teflon surface. Type II bearings are limited to 150 ft long spans for the 6 in. wide pads and 400 ft for the 15 in. wide pads.

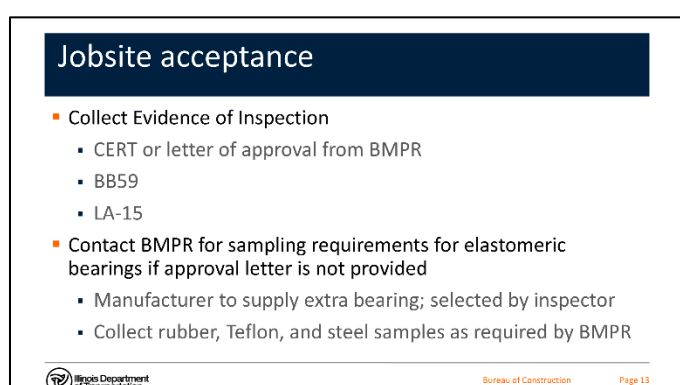
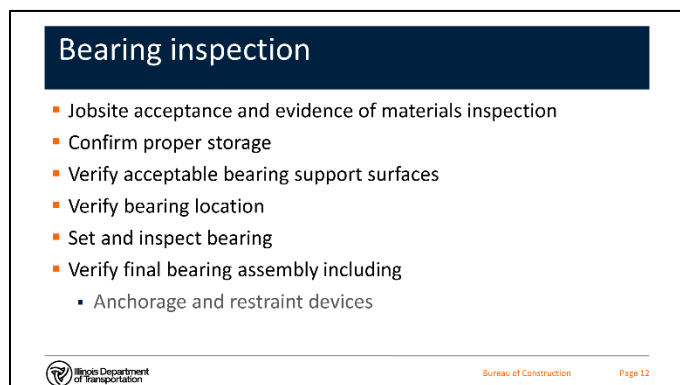
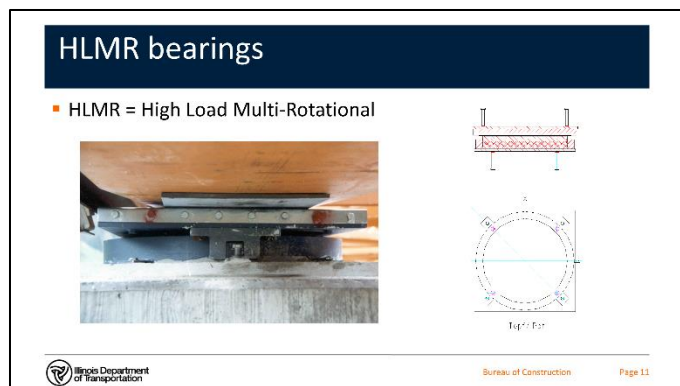
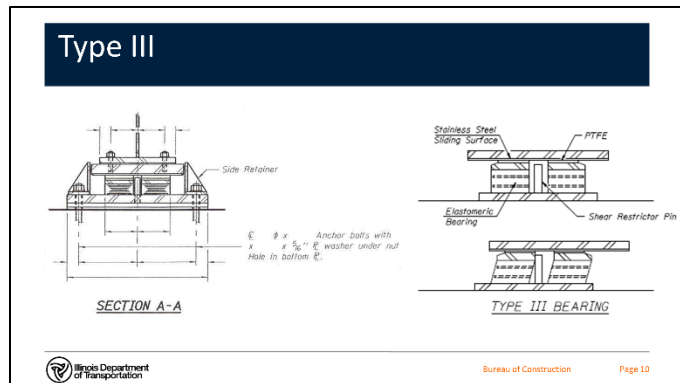


Type III bearings accommodate expansion lengths that exceed the limits of the other elastomeric bearing types. The Type III bearing includes shear restrictors to prevent overstressing the rubber/neoprene in shear as movement occurs.

High Load, Multi-Rotational (HLMR) bearings are specialized bearing systems that are classified as either fixed, guided expansion, or non-guided expansion. HLMR fixed bearings allow rotation in all directions, but do not allow any horizontal movement. HLMR guided bearings allow rotation in all directions while allowing horizontal movement in only one direction, as shown on the plans and resist horizontal forces in the constrained direction. HLMR non-guided bearings allow rotation and horizontal movement in all directions. The term pot bearing is typically used for HLMR bearings.

The inspection requirements for bearings includes collection of jobsite evidence of materials documentation; review of storage procedures; verification of acceptability of bearing surface prior to setting of bearings; confirmation of the bearing location in the vertical, longitudinal, and transverse direction; verification of the proper setting and orientation of each bearing; and verification of the final assembly of the bearing including installation of any anchorage and restraint devices.

Bearings like structural steel and fasteners, bearings just do not arrive at the site. They must arrive with proper documentation. Elastomeric and pot bearings (HLMR) are accepted by letter of approval or CERT from Bureau of Materials and Physical Research (BMPR) and BB59 and LA-15 documentation. The BB59 report pertains to the acceptance of steel materials used in the bearing, which is usually performed by BBS. The CERT is the manufacturer's certification indicating compliance of materials to IDOT specifications. The CERT will typically include documentation of steel materials (possibly using the BB59



documentation of steel materials (possibly using the BB59

form) and other materials used in the bearing. The LA-15 form indicates that the material is from approved stock. The LA-15 form should include supplier, proper contract/job designation, material description, manufacturer, specific approved material (test ID, number, lots, or batches), and quantity. The LA-15 form certifies that the material was inspected by IDOT and is approved.

If the elastomeric pad is to be sampled for testing, BMPR will notify the supplier and district involved. For Type I bearings, one extra pad will be supplied and may be sent to the job site. The inspector will then pick one pad at random for testing by BMPR. Sampling procedures for Type II and III will be the same, except the manufacturer will also supply samples of rubber, Teflon, and stainless steel from the same lots used in the bearings. These materials will be sent to BMPR for testing. The sampling procedures for pot bearings are the same as Type I bearings, with the addition of rubber and Teflon samples from the same lots as used in the pot bearings. Note that the Domestic Steel Act applies to bearing materials.

Bearings arrive at the job site as complete units and marked as indicated in the shop drawings. All bearings should be supplied with two 1/8 in. thick shim plates. Bearings should be handled with care and stored in a manner that will prevent contamination from dirt or debris and moisture. Care should be taken during unloading to not scratch or damage bearings. Bearings should be protected from the elements and stored off the ground on a durable surface. Bearings include elements with specially machined and polished surfaces that are shipped with a protective film. The protective film should be kept intact until the bearing is set or ready to accept the girder. Bearings should not be unpackaged until ready to be used, then handled with care. Nylon straps should be used.

The bearing support locations on abutments or piers should be inspected and checked for proper elevation prior to superstructure erection. The concrete surfaces shall have obtained the required compressive strength as shown in the drawings and specifications. The finished surface shall be within 1/8 inch (+/-) of the plan elevation and smooth and level. Level is typically defined no more than 1/16 inch per foot.

Bearings must be set as precisely as possible, in both the vertical, longitudinal, and transverse direction. This requires tight control of construction tolerances for the build-out of the substructure and fabrication of the steel girders, as the bearing assembly provides the interface between these two elements. The bearing stiffener locates the centerline of bearing and is a critical control line of the structure. The centerline of the abutments or piers may or may not be the same as the centerline of bearing, as in the case of a unit change on a common pier. It is important to insure that the centerline of bearing of the girder is located over the centerline of bearing location on the pier or abutment.

Shipping, handling, and storage


- Confirm bearing is furnished as complete unit from one source
- Observe handling and storage to protect bearing from damage





Bureau of Construction
Page 14

Verify beam supports

- Confirm bearing elevations
- Confirm acceptability of bearing surfaces
 - Vertical elev. +/- 1/8 inch of specified
 - Smooth and level (0.005 radians or 1/16 inch per foot)
 - Adequate strength



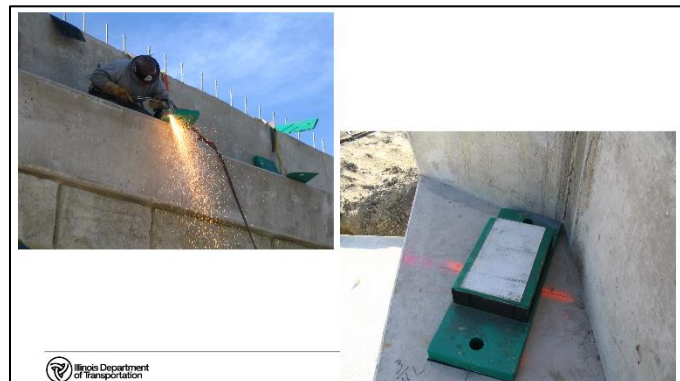
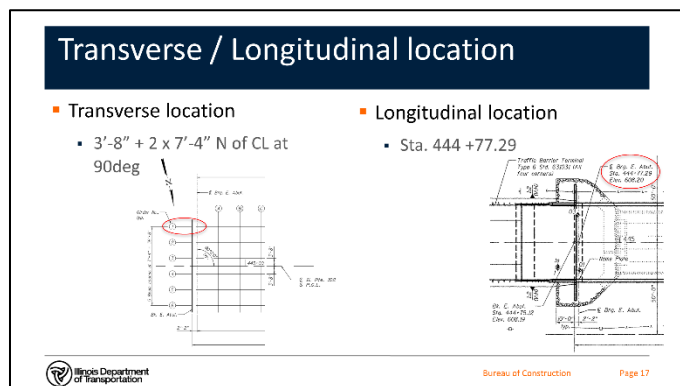
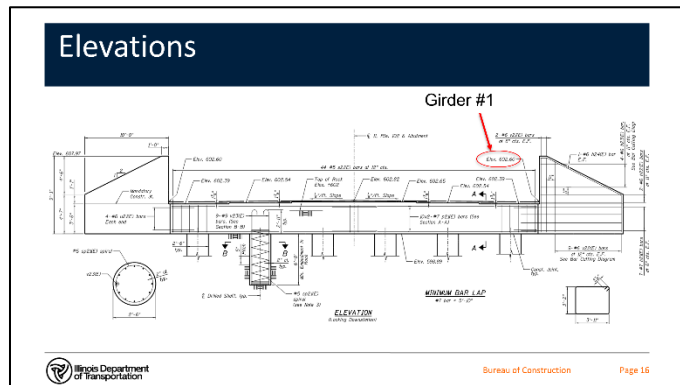

Bureau of Construction
Page 15

The vertical location or elevation is shown in the drawings and confirmed by the contractor during finishing of the abutment seat or pier cap. The elevation should be checked by the inspector.

The transverse bearing locations are also shown in the drawings, generally in the steel framing plans. The example given in the adjacent slide shows the transverse location as 3 ft-8 in. + 2 x 7 ft-4 in. north of the centerline of Rte 102 and at 90 deg to the route centerline. The theoretical longitudinal bearing position is given as the Station Number 444+77.29 in the adjacent slide. Whenever possible, elevation, transverse, and longitudinal bearing locations should be taken from route and survey station data and not calculated or measured off of constructed substructure elements. The inspector should never assume that these elements were correctly placed, and therefore should determine bearing locations to the global datum for the project.

The engineer should be notified of any errors found in the location of the bearings. Any modifications should be reviewed with the engineer. Once the location has been confirmed and the bearing set, the inspector should scribe the bearing position and longitudinal/transverse centerlines as shown in the adjacent slide. The markings will allow the inspector to confirm the bearing location should it be accidentally displaced prior to or during girder erection.

The bearing position must be accurately determined and is likely to require adjustment for temperature to ensure the bridge will expand and contract properly once in service. The best time to set or check the position of the bearings is at first light (dawn) while the superstructure is at uniform temperature throughout. The span lengths, girder dimensions, etc. shown in the drawings are based on a design temperature of 50°F.



The fixed bearing must be positioned over the bearing lines shown in the contract documents, as described above. However, the position of the expansion bearings may need to be adjusted (based on bearing type) to accommodate the expansion or contraction of the steel, which is determined by the difference between 50°F and the existing air temperature. When determining fixed bearing locations it is only necessary to correct for steel tape expansion/contraction, if one is used to measure offsets from the project datum. When setting a girder on a fixed bearing, the centerline of the bearing should coincide with the centerline of the bearing stiffener. The bearing stiffener is the critical control line of the steel structure. Prior to locating the expansion bearing location, it will be necessary to determine the expansion or contraction of the steel girder due to temperature differentials from 50°F. The amount of movement is calculated on the basis of a coefficient of expansion of 0.0000067 per degree F. The change in length is calculated using the following equation:

$$\Delta L = (\text{Air Temp in } ^\circ\text{F} - 50^\circ\text{F}) \times 0.0000067/^\circ\text{F} \times (\text{length in feet}) \times 12 \text{ in/ft}$$

Exercise #6.1 - Using the above equation, calculate the temperature adjustment for a 180 ft long span. Will the adjustment be based on a contraction or expansion of the steel girder?

In order to understand how temperature will influence girder movement, it is important to understand the structure behavior as either a simple span or continuous span. Thermal movements are shown in the adjacent slide.


For continuous spans, what length (L) value would be used in the above equation?

What length would be used in the equation for simple spans?

Temperature correction


- Fixed bearings
 - Position over bearing lines shown in drawings
- Expansion bearings
 - Adjust for contraction/expansion of steel due to temperature

$$\Delta L = (\text{Air Temp in } ^\circ\text{F} - 50^\circ\text{F}) \times 0.0000067/^\circ\text{F} \times (\text{length in feet}) \times 12 \text{ in/ft}$$

 Illinois Department of Transportation
Bureau of Construction
Page 19

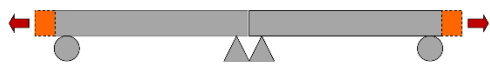
Temperature correction

- Short span exercise
- Givens:
 - L = 180 ft
 - Temperature at placement = 30 degF
 - Coefficient of thermal expansion = 0.0000067 in/degF


 Illinois Department of Transportation
Bureau of Construction
Page 20


Span behavior under thermal loads

- Simple

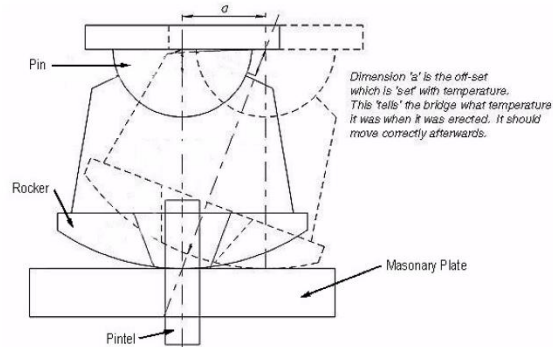


- Continuous



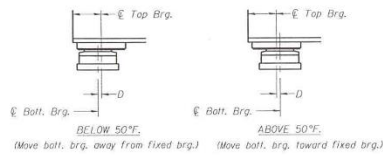
 Illinois Department of Transportation
Bureau of Construction
Page 21

Setting rocker bearings



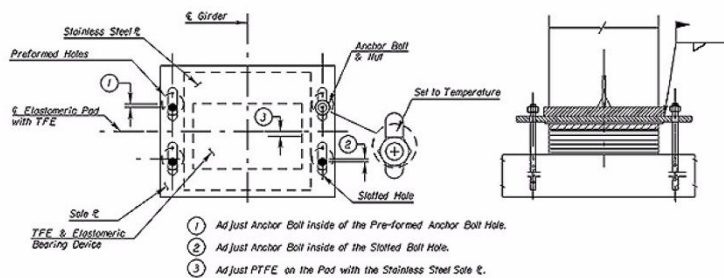
Setting elastomeric pads

- Verify position of sliding surface
- Verify position of lower assembly
- Verify position of anchor bolt



SETTING ANCHOR BOLTS AT EXP. BRG.
D = $\frac{1}{8}$ " per each 100° of expansion for every 15° temp. change from the normal temp. of 50°F.

Setting Elastomeric Type 2 & 3 bearings



PLAN OF ELASTOMERIC BEARING DEVICE
(Example Only)

Setting pot bearings



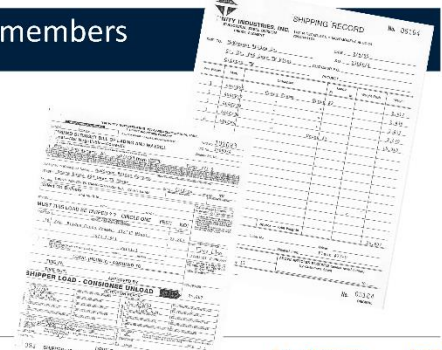
Elastomeric inspection check list

- Elevation and alignment?
- Correct bearing type?
- Beam seat and structural member contact surface?
- Bearing free of defects?
- Correct temperature at time of installation
- Protective films removed?

The inspection of secondary members, such as cross frames and diaphragms are discussed in the remainder of this module

Secondary members

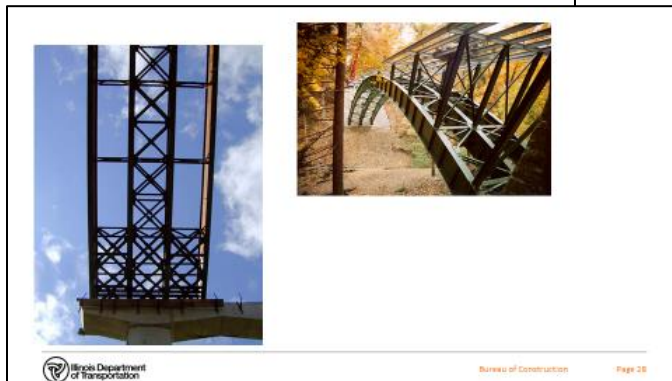
- Diaphragms
- End frames
- Cross frames
- Lateral bracing



SHIPPING RECORD No. 29155

SHIPPER LOAD - CONSIGNEE UNPAID

Bureau of Construction Page 27



Similar to girders and beams, cross-frames will be detailed in the approved shop drawings and their installation will be covered in the erection plan. The inspector should become intimately familiar with these documents. Match-marking and piece numbers will be identified in the shop drawings, while bolting and installation requirements are generally covered in the erection plan procedures.

The primary function of cross frames and diaphragms is to provide stability to individual girders or flanges. In most cases the erection procedures requires that they be installed prior to removal of cranes. Bolting requirements during erection were covered in Module 4A, and require at least 50% of the connection holes be filled with bolts or drift pins with at least half (25% percent of the holes) filled with bolts in a snug tight condition. The holes at all bolt groups connecting the diaphragms or cross frames to the primary girder should be filled uniformly to meet these requirements at each connection. Inspectors should refer to

Secondary member information

| | |
|--|--|
| <p>Shop drawings</p> <ul style="list-style-type: none"> Approved by Engineer Full detailed dimensions and sizes Grade of steel System of assembly-marking individual pieces | <p>Erection procedures</p> <ul style="list-style-type: none"> Approved by Engineer Sequence of erection Initial and final bolting requirements |
|--|--|

Illinois Department of Transportation Bureau of Construction Page 29



Guide Bridge Special Provision (GBSP) #55 for erection bolting information of curved girder bridges. The requirements for erection bolting is more stringent for curved girders given their inherent instability.

After the structure has been erected and set to its final profile, the contractor may finish bolting of secondary members. The following fastening systems and installation methods will be allowed as options for all high-strength bolted connections: load indicating washer system, twist-off type fastener system, lock-pin and collar type fastener system, and turn-of-the-nut method. The Calibrated Wrench method will not be permitted.

Like primary members, the inspector will be required to execute Rotational-Capacity Testing to qualify the fastener assemblies to be used in secondary member connections. Two assemblies per each R-C Lot shall be tested and the results documented using IDOT Form BC2320. The Rotational-Capacity Testing procedures are described in Module 5B. Verification Testing will then be performed on three assemblies of each diameter, length, grade, and lot to be used in the work, as described in Module 5C for Turn-of-Nut Method, Module 5E for Twist-off Bolts, Module 5G for Lock-pin and collar fastening systems, and Module 5I for DTI systems.

Note that most secondary connections involve two plates with a total thickness that is less than that encountered in girder splices. As such, bolt lengths tend to be shorter. In some instances, the shorter bolt lengths are not accommodated by the tension device used for rotational-capacity and verification testing. When this occurs, the inspector will use modified procedures for short bolt testing, as described in Module 5B (Page 103) for rotational capacity testing of short bolt assemblies.

Inspection of final tensioning at secondary members will be the same as inspection of primary member splice plates, as described in Module 5. For example and considering that Turn-of-Nut Method is the most common installation method, the inspector will observe installation to confirm that methods used were those demonstrated in the Verification Testing. The inspector will witness final position of match marks to ensure all nuts were turned the required distance for the bolt length to diameter ratio. The inspector will also confirm that nut turn distance was proportionally increased in the event the bolt shank rotated.

Final tightening requirements

- Rotational-Capacity Testing of each unique lot combination
- Verification Testing
 - Module 5C – Turn-of-Nut Method
 - Module 5E – Twist-off Bolts
 - Module 5G – Lock-pin and collar system
 - Module 5I – Direct Tension Indicators (DTI)

Illinois Department of Transportation Bureau of Construction Page 31

Inspection duties

- Monitor installation per verification testing
- Checks per method of installation
 - Turn-of-Nut
 - Final match mark per required turn of nut
 - Confirm shank has not turned

Illinois Department of Transportation Bureau of Construction Page 32

Inspection issues

- Short bolt lengths
- Fit-up issues
 - Minor field corrections assumed part of erection when
 - Removal of less than 1/8 in. material
 - Reaming of less than 5% of holes
 - Corrective action subject to engineer approval and witness

Illinois Department of Transportation Bureau of Construction Page 33


In general, more fit-up issues are experienced at secondary member connections. To overcome fit issues, holes in secondary members may be oversized. In severe cases, the contractor may be unable to install bolts. When this occurs, the contractor may request permission to correct misfits. Minor field corrections are considered part of the erection when it involves removing less than 1/8 in. of material or reaming of less than five percent of holes at a connection. Any work beyond these limits shall be reported to the engineer, and corrective actions completed in the engineer's presence. (IDOT_SPEC 505.08(l))


Case Study #6.1 - A construction accident is discussed to emphasize the importance of diaphragms to the overall stability of long span girders.

Erection accident


Failure associated with secondary member

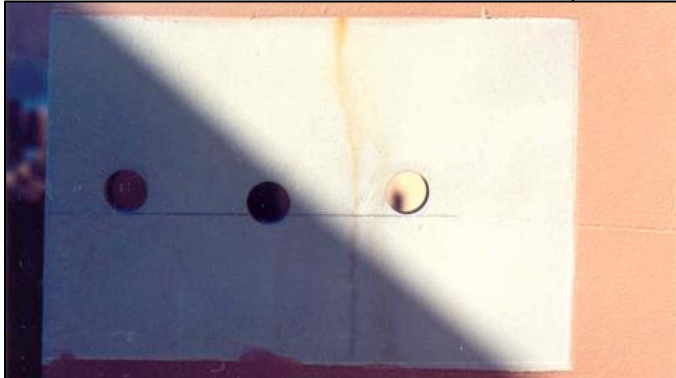
- 225 ft unbraced length of 14 ft deep girder
- Removal of a cross frame in conjunction with missing or incomplete cross frames





Illinois Department
of Transportation







The learning outcomes for Module 6 are summarized.

Learning outcomes

- Describe the various types of bracing and bearing systems typically used in steel structure construction in Illinois
- List requirements for proper setting and final bearing of steel superstructure elements
- Explain how these systems are coordinated with other elements of steel bridge construction
- Define inspection requirements for the installation of these systems

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QUIZ AND EXERCISE ANSWERS

Exercise #2.1 - Document coordination

- Plans
- Supplemental Specifications
- Standard Specifications
- Recurring Special Provisions
- Special Provisions



Highest hierarchy

1. Special Provisions
2. Plans
3. Recurring Special Provisions
4. Supplemental Specifications
5. Standard Specifications

Lowest hierarchy

Quiz #2.1

Plans may include drawings specific to a given project, and general IDOT standard details. In this case, project-specific drawings hold priority over the IDOT standard details.

- a) True
- b) False

Quiz #2.2

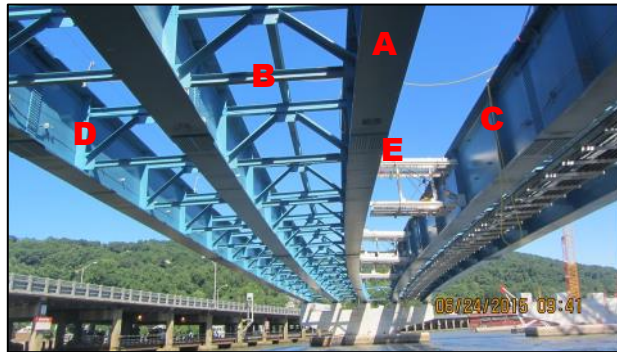
The required dimension for a particular bridge detail is NOT specified in the drawings, but can be obtained by scaling the drawing or using other available information to calculate the dimension. In this case, the scaled dimension holds priority over the calculated dimension.

- a) True
- b) False

Exercise #2.2 - Identify the bridge type and list the common elements typically associated with each.



| |
|---|
| Bridge Type: Rolled Beam |
| Common Elements: |
| <ul style="list-style-type: none"> A. Rolled Beams B. Intermediate Diaphragms C. End Diaphragms D. Bearings |



| |
|--|
| Bridge Type: Plate Girder |
| Common Elements: |
| <ul style="list-style-type: none"> A. Plate Girders B. Intermediate K-frame C. Intermediate Stiffeners D. Connection Stiffeners E. Bottom flange splice |



| |
|---|
| Bridge Type: Trapezoidal Box Girder |
| Common Elements: |
| <ul style="list-style-type: none"> A. End K-frame B. Web C. Bottom Flange D. Headed Studs |

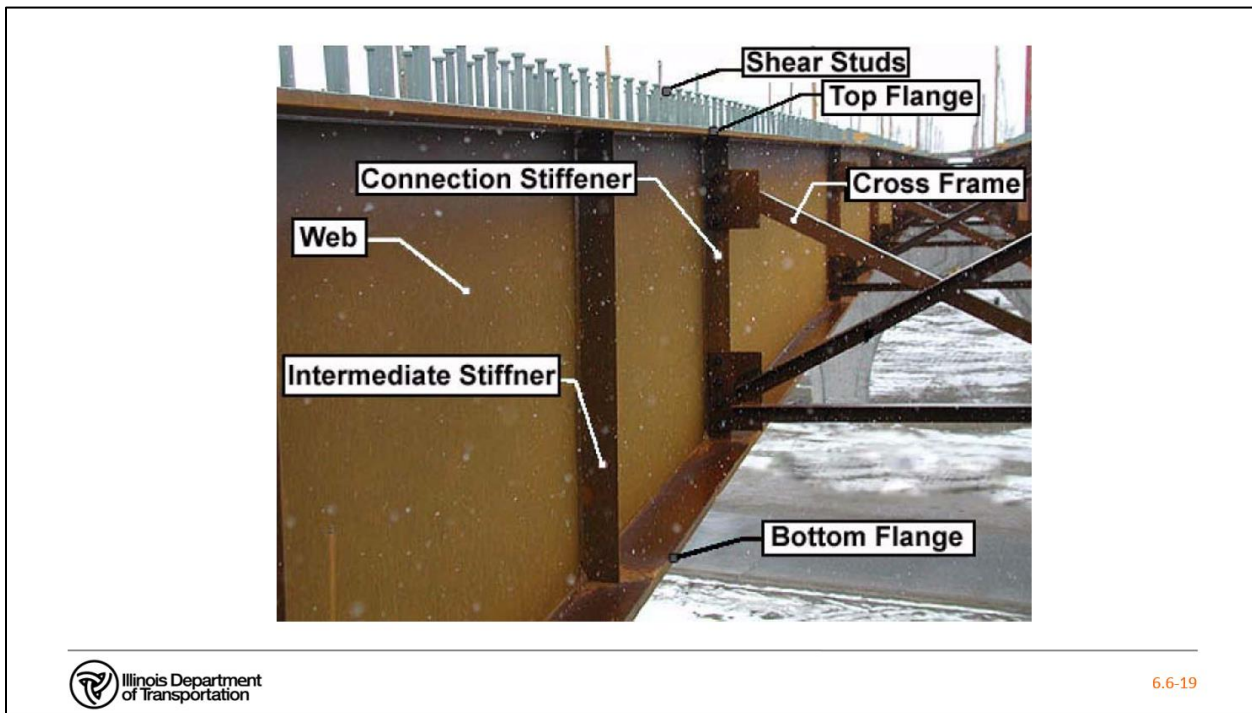


| |
|---|
| Bridge Type: Truss |
| Common Elements: |
| <ul style="list-style-type: none"> A. Bottom Chord B. Top Chord C. Vertical D. Diagonal E. Gusset Plate F. Floor Beam |



| |
|---|
| Bridge Type: Tied Arch |
| Common Elements: |
| A. Tie Girder B. Arch Rib C. Splice Plate |

Quiz #2.3 - Identify the common elements of a plate girder superstructure.

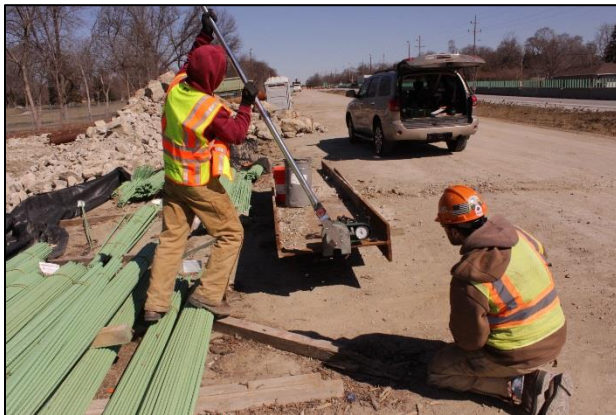


Exercise #2.3 - For each of the following bridge construction photos, list typical responsibilities of the steel structure construction inspector. Limit responses to responsibilities associated with construction of steel elements.



Typical responsibilities of steel structure construction inspector:

Check that girders are stored off the ground, and properly braced. When girders arrived, record piece numbers and check for damage during transit.



Typical responsibilities of steel structure construction inspector:

For each bolt, nut, and washer combination perform rotational-capacity check and daily turn of the nut calibration.



Typical responsibilities of steel structure construction inspector:

Confirm that girder lifting procedure follows approved procedures. Check placement of girder dogs, cranes, and spreader beam. Incorrect placement of any of these items can change the stresses in the girder and cranes.



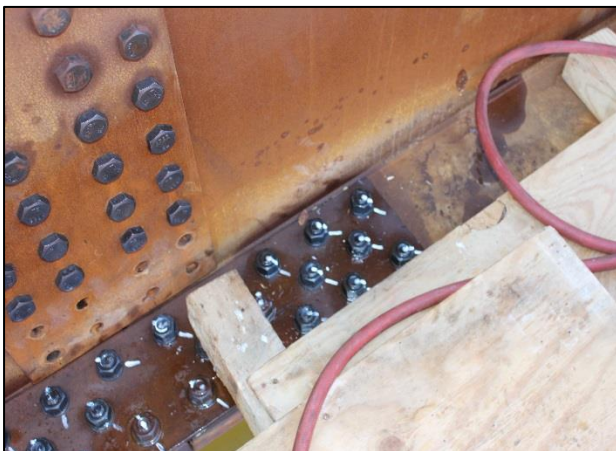
Typical responsibilities of steel structure construction inspector:

Check that proper bolt installation procedures were followed, paying particular attention to pinning and sequence of bolting installation.



Typical responsibilities of steel structure construction inspector:

Check plumbness and soundness of shoring tower foundations. Monitor lifting procedures and release of hold crane to ensure conformance to approved erection plans.



Typical responsibilities of steel structure construction inspector:

Monitor iron workers bolt installation to ensure marking and tightening are in conformance to approved turn of the nut procedures.

Quiz #3.1

ASTM A490 bolts may be mechanically galvanized, but not hot-dip galvanized?

- a) True
- b) False, neither can be galvanized in any form**
- c) False, ASTM A490 bolts may also be hot-dip galvanized

Quiz #3.2

What is the correct designation for a high-strength ASTM A325 bolt that has weathering steel characteristics?

- a) ASTM A325-3
- b) ASTM A325W
- c) ASTM A325, Type 3**
- d) None of the above

Structural steel quiz #3.3

What is the steel grade shown in this delivery ticket?

| MILL/SLAB | | CHEMICAL ANALYSIS | | | | | | | | | | PRACTICES | | |
|-----------|----|-------------------|------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|--------|----|
| GRADE | FS | C | MN | P | S | CU | NI | CR | MO | V | Ti | N | FS | FS |
| A572 | 50 | 0.25 | 0.60 | 0.015 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | 0.010 | FS 7-8 | FS |

| TEST CERTIFICATE | 23880// | FILE NO. 1974-05-05 |
|--|---------|--------------------------|
| CUSTOMER P.O. #E3133// | | DATE: 03/03/96 |
| DESCRIPTION: 1 - RECTANGLE 2 - R- 33 - X- 36 | | MILL ORDER NO. 27340-003 |
| <p>THIS MATERIAL HAS BEEN MANUFACTURED AND TESTED IN ACCORDANCE WITH PURC ASTM A709-GR50-T2 YR 92 TYPE-2</p> | | |

- a) Grade 50**
- b) Grade 36
- c) Grade 709

Exercise #2.3 - List the duties of the inspector when structural steel (primary and secondary members) arrives at the project site.

Acceptance of structural steel

1. Collect Evidence of Inspection documentation
2. Inventory steel using ID and match marks on members and connecting pieces
3. Check specified geometry including camber
4. Review hole layout and faying surfaces
5. Inspect for defects or damage
6. Review and observe handling while unloading
7. Confirm proper storage



Exercise #3.2 - When reviewing a steel girder or secondary bracing member, list the types of damage commonly observed and where such damage occurs.

Damage inspection: What & Where

1. Bolt holes and faying surfaces (as discussed)
2. Points of handling/lifting for marring or deformation
3. Points of bearing during transit/storage for marring or deformation
4. Tie-down points for marring or deformation
5. Weld cracking at bearing/tie-down points
6. Sweep and camber not altered during transit



Exercise #3.3 - List the duties of the inspector when fasteners arrive at the project site

Acceptance of HS hex head fasteners

1. Collect Evidence of Inspection documentation
2. Inventory pieces
3. Check markings, dimensions, and condition
4. Confirm proper storage



Acceptance quiz #3.4

The inspector's duties for acceptance of steel materials at the project site include the following

- Collection of Evidence of Inspection documentation
- Inspection for damage during transportation and handling
- Checking that steel is properly stored

- a) True
b) False

Acceptance quiz #3.5

Fastener containers should be marked with which of the following information

- a) Container contents and size
- b) Rotational capacity lot number
- c) Manufacturer identification
- d) All of the above

Acceptance quiz #3.6

The fastener containers arrive at the job site with no or insufficient documentation or stamp indicating that its contents have been approved. What is the correct course of action?

- a) Allow their use since the paperwork is probably delayed and can be collected later
- b) Send three of each component to Bureau of Materials for testing and await test results prior to use.
- c) Use them if they pass a field rotational capacity test

Exercise #4.1 - The following photographs highlight means and methods and common equipment used in steel bridge erection. For each photograph, list the responsibilities of the inspector associated with rigging and cranes being used.



- Girder Dog:**
- Location of girder dog along beam length per approved erection plan
 - Equipment type/model is as specified
 - Review the girder dog for faults or failure
 - Check safety chain is used when lifting
 - Check flanges for damage/deformation after use

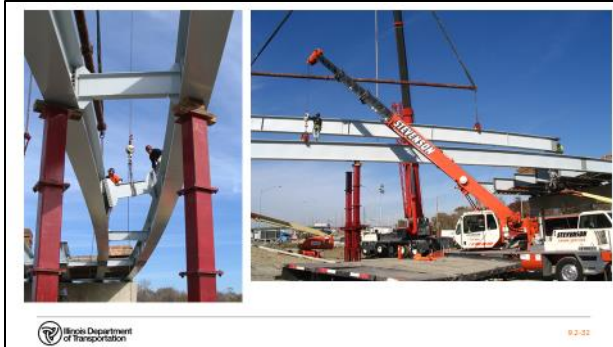


- Spreader beam:**
- Lifting location is per approved erection plan
 - Angle between beam and hook is per approved plan
 - Spreader beam is straight, and free of defects/damage
 - Attachment of cables/hooks is free of defects/damage



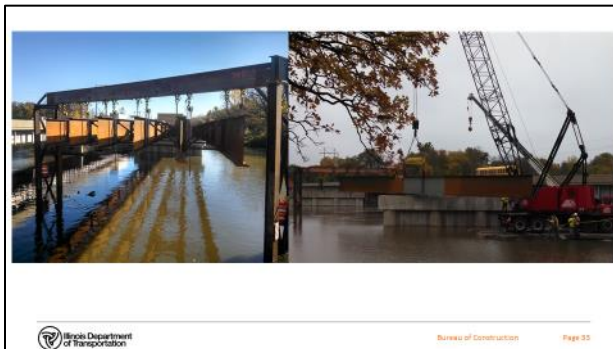
- Cranes:**
- Cranes are correctly positioned
 - Cranes are correct model/type
 - Operators understand approved radius and boom limits for lifting weight
 - Operators understand movement procedures
 - Outriggers, if used, are properly supported

Exercise #4.2 - List the inspection responsibilities associated with the contractors means and methods illustrated in the following slides focusing on stability issues.



Supports for curved girder erection:

- Shoring towers are plumb
- Blocking at top/bottom is secure and per drawings
- Bearing conditions are per specifications and are free of undue moisture
- Tower member sizes per drawings



Midspan supporting structure:

- Shoring tower constructed per erection plan drawings
- Members are plumb and true
- Chain falls and clamps conform to equipment specifications outlined in plan



Girder support on truck:

- Tie downs are secure
- Girder is supported by crane prior to tie down removal

Group Exercise #4.3 - Participants will form groups of four to five participants. Using the sample Erection Plan provided in Appendix B, work together to complete the following questions. The sample erection plan pertains only to Stage I work. The following questions can be completed using information contained in the General Notes and Drawings S-1 thru S-3.

Group exercise #4.3

Q1: The inspector measures wind speeds of 35 mph. The procedure requires what action? (Sheet 2 of 10)

14. The steel erection shall not be performed if wind gusts exceeding 25 MPH are anticipated or observed, or wind gusts/speeds exceed the maximum operating speed specified by the crane manufacturer.

Q2: How many bolts must be installed in cross frames prior to releasing crane loads (Sheet 1 of 10)

5. For the purposes of this erection procedure, the specified cross frames shall be installed with a minimum of three bolts installed snug tight at each corner of the cross frame prior to releasing load from the crane. For cross frames installed after the girder is erected, a minimum of three snug tight bolts shall be installed in each corner of the cross frame.

Group exercise #4.3

Q3: How many girder lines must be installed prior to the end of an erection shift? Is an exception allowed? (Sheet 2 of 10)

20. At the start of each Phase, the first 3 girder lines (Girders 5, 4 and 3) must be completed and all cross frames installed (minimum of three bolts installed snug tight at each corner) prior to the end of the first erection shift. However, it is permissible for the erection shift to end after Girders 5 and 4 are erected provided all the following conditions are met:

- All cross frames are installed between girders 5 and 4 with a minimum of three bolts installed snug tight at each corner.
- Maximum forecast wind speed for the interval between the end of the first shift and the anticipated erection of Girder 3 is no greater than 50 MPH, and no thunderstorms are forecast.
- The erector must monitor the forecast every 6 hours. If the forecast or observed conditions change such that the above assumptions are no longer valid, the erector shall notify the erection engineer to determine appropriate supplemental support (e.g. hold crane, temporary cabling) as required.

Group exercise #4.3, cont.

- Q4: Lifting points shall be located L/4 distance from the end of the member and adjusted +/-18 in. to avoid cross frames (Drwg S-2)
- Q5: Maximum angle of bracing members to the existing structure shall not exceed 45 degrees nor 12 ft in length. (Drwg S-17)
- Q6: Maximum pick weight of the first girder installation is 21,277 lbs, and the crane capacity is 31,000 lbs with no boom length restriction. Rotation angle restriction is +/- 15 deg. (Drwg S-3 and Sheet 1 of 10)

Group exercise #4.3, cont.

- Q7: Based on your review of the General Notes and drawings S-1 thru S-3, identify three additional responsibilities of the inspector. **Answers can vary widely, but could include:**
- A) **Girders shall be blocked at piers to prevent lateral movement, but no details are described. Cover this at pre-erection conference. (Sheet 2 of 10, #18)**
 - B) **Cranes can not be released until bracing installed and girder blocked at each bearing (Sheet 3 of 10, #9)**
 - C) **Any deviations from this plan shall be approved by the structural engineer (S-1, note e)**

Exercise #4A.1 - List the challenges associated inspecting each of these steel structure erection bolting slides. Consider the discussion of differences between the IDOT specification and practices of erection contractors.



Inspector will need to monitor clamping of plies to ensure faying surfaces are brought into firm contact. The bottom flange plates exhibit a splayed profile in this photo.



Web splice has just under 50% of the holes filled with bolts and pins, however pins occupy 60% of the filled holes while pins occupy the remainder. Further, all of the filled holes are located at the base of the web splice. Filled holes should be evenly distributed with half-filled will pins and the other half with fitting-up bolts.



The contractor has installed pins near the four corners, and all of the erection bolts on the left hand girder. Bolts should be evenly distributed throughout the joint.



This is a suitable erection condition, with at least half of the holes filled with bolts.

Quiz #4A.1

The contractor experiences fit-up problems and uses a production bolt and his air wrench to bring plies into full contact. Is it permitted to keep this bolt in the bridge?

- Yes
- No

Quiz #4A.2

The contractor experiences fit-up problems and uses his sledge hammer to drive the bolt into place. Should this bolt be removed?

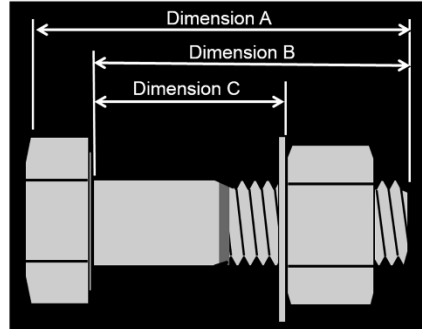
- Yes
- No

Quiz #5B - Complete the following questions.

RoCap Quiz #5B.1

Which dimension is used as the length for determining the required rotation beyond the initial tension?

- a) Dimension A
- b) Dimension B**
- c) Dimension C



RoCap Quiz #5B.2

Using the equation below, calculate the maximum torque for a 3/4 inch diameter A325 fastener.

$$\text{Max Torque} = 0.25 \times P \times D$$

- a) 5.25
- b) 437**
- c) 503
- d) 525

APPENDIX A



| AGENDA | | |
|--|--|------------------|
| 1. Introductions and Course Overview | | 30 min |
| 2. Overview of steel structure documents and inspection responsibilities <i>Break</i> | | 40 min 15 min |
| 3. Acceptance of steel at job site | | 60 min |
| 4. Erection of steel girders <i>Lunch</i> | | 60 min 45 min |
| 4A. Erection - Connections | | 110 min |
| 5. Qualification testing and inspection of fastening <i>Break</i> | | 15 min 45 min |
| 6. Inspection of secondary members and bearings Exam | | 30 min |
| Total Training Time | | 8.5 hrs |

| GLOBAL LEARNING OUTCOMES |
|---|
| <ul style="list-style-type: none"> ▪ Identify structural and fastening systems found in and equipment used for steel structure construction. ▪ Describe current Department policies, specifications, and procedures related to the acceptance, erection, installation, and bolting of steel structure girders. ▪ Explain the role of the steel structure construction inspector in the acceptance of steel and fasteners at the job site, the safe erection of girders, the verification of fastener installation, and the inspection of other steel components including bracing and bearings associated with steel structure construction. ▪ Conduct regular, systematic inspections in accordance with Department standards utilizing, where available, job aids such as checklists or forms. ▪ Recognize and report potential problems associated with steel structure construction. |

| PERSONAL OUTCOMES | <i>Check if personal outcome was achieved?</i> |
|--------------------------|--|
| | <input type="checkbox"/> |
| | <input type="checkbox"/> |
| | <input type="checkbox"/> |
| | <input type="checkbox"/> |

| EXPERIENCE | |
|---|--------------------------|
| <i>List your steel structure construction experience. At the end of the course, check the box if your knowledge of this topic was enhanced as a result of the training.</i> | <input type="checkbox"/> |
| | <input type="checkbox"/> |
| | <input type="checkbox"/> |
| | <input type="checkbox"/> |

| NOTES |
|--------------|
| |

APPENDIX B

Via Email: jrogers@sjconst.com

January 15, 2016

Mr. Joe Rogers
S & J Construction Co., Inc.
4245 166th Street
Oak Forest, IL 60452

Re: Structure 016-1501 Erection Procedure (Stages I and II)
Reconstruction of I-55 and US 41 (Lake Shore Drive) Interchange Outbound Structures
WJE No. 2015.4852.1

Dear Mr. Rogers:

At your request, Wiss, Janney, Elstner Associates, Inc. (WJE) has prepared an erection procedure for the steel girders of the I-55 Bridge southbound (outbound) ramp from Lake Shore Drive (LSD). This portion of the interchange is also known as Structure 1501. This procedure, prepared for S&J Construction Company (S&J), demonstrates the stability of the girders during erection and adequacy of the cranes and rigging. The erection procedure and associated drawings for the Stage I construction are included in Appendix A, and the Stage II procedure and drawings are in Appendix B. Calculations of girder stability and rigging, prepared by WJE, are enclosed in Appendix C.

This overall project will consist of the construction of three outbound bridge structures (016-1501, 016-1504, and 016-1505). These bridge structures are constructed using multi span continuous steel girders separated into units. This procedure evaluates the erection of bridge structure 016-1501, which consists of nine (9) girder lines and each girder line is composed of nine (9) girder sections. This bridge utilizes staged construction where Girder Lines 5 through 1 will be erected in Stage I and Girder Lines 6 through 9 will be erected in Stage II. Each stage of the attached erection procedure considers that the bridge will be erected from west to east and each stage consists of five phases. Phase 1 will erect the steel girders from the west abutment to Field Splice 1-2, Phase 2 will erect the steel girders from Field Splice 1-2 to Field Splice 1-4, Phase 3 will erect the steel girders from Field Splice 1-4 to Field Splice 1-6, Phase 4 will erect the steel girders from Field Splice 1-6 to Field Splice 1-8, and Phase 5 will erect the girders from Field Splice 1-8 to the east abutment.

It is our understanding that three Shuttlelift 7755 cranes (or equivalent) will be used during each phase to erect the steel girders of this bridge. This erection procedure considers these cranes will be operated in motion in order to move girders from the loading truck to their final positions. Capacity charts available to WJE for this crane state that the charts are for reference only and must not be used for lifting purposes. Prior to the steel erection, S&J shall confirm that the actual crane to be used will be operated within the Manufacturer's specifications and has adequate capacity to operate using the pick weights and radii shown on the drawings in Appendices A and B.

We would like to reiterate the following items stated in the attached erection procedure:

- Contractor shall notify WJE if the conditions vary from those shown in this submittal.
- The cranes shall never be operated in a manner that will exceed their rated capacity at any radius as specified by the manufacturer.
- The cranes shall be set up on a firm, level, and uniformly supporting surface. As a result, this may require the installation of compacted fill or other modifications to the construction site at the locations where the cranes will be positioned, and these modifications shall be coordinated between the contractor and the erector to be in conformance with the crane manufacturer’s requirements.
- The cranes shall maintain a safe working distance from all overhead power lines or other utilities, if present, and this distance shall be as recommended by the crane manufacturer and the utility company.
- When pick and carry methods are used, the crane shall travel slowly and cautiously on a firm and level supporting surface.
- Lifting operations shall not be performed if wind gusts exceeding 25 MPH are anticipated or observed.
- All bolts shall be installed snug tight during erection, unless noted otherwise.
- Bolts installed in permanent connections shall be in accordance with the Contract Documents.

The table below shows the acceptable crane boom configurations for this procedure. The Shuttlelift 7755 cranes will also be used to set the cross frames in all phases of this erection.

| Crane | Counter-weight | Max. Radius | Max. Pick Weight | Girder Section | Girder Lines | Acceptable Boom Extensions |
|-------------------------------|-----------------------|--------------------|-------------------------|-----------------------|---------------------|-----------------------------------|
| (2) Shuttlelift (22-ton) 7755 | None (on rubber) | 14 ft | 21,227 lbs. | 1 | 1 - 9 | Any |
| (2) Shuttlelift (22-ton) 7755 | None (on rubber) | 12 ft | 37,777 lbs. | 2 | 1 - 9 | Any |
| (2) Shuttlelift (22-ton) 7755 | None (on rubber) | 6 ft | 43,423 lbs. | 3 | 1 - 9 | Any |
| (2) Shuttlelift (22-ton) 7755 | None (on rubber) | 12 ft | 37,777 lbs. | 4 | 1 - 9 | Any |
| (2) Shuttlelift (22-ton) 7755 | None (on rubber) | 14 ft | 22,524 lbs. | 5 | 1 - 9 | Any |
| (2) Shuttlelift (22-ton) 7755 | None (on rubber) | 14 ft | 30,478 lbs. | 6 | 1 - 9 | Any |
| (2) Shuttlelift (22-ton) 7755 | None (on rubber) | 14 ft | 24,386 lbs. | 7 | 1 - 9 | Any |
| (2) Shuttlelift (22-ton) 7755 | None (on rubber) | 14 ft | 30,478 lbs. | 8 | 1 - 9 | Any |
| (2) Shuttlelift (22-ton) 7755 | None (on rubber) | 16 ft | 21,847 lbs. | 9 | 1 - 9 | Any |

It should be noted that we have not reviewed the structural adequacy and stability of the girders and cross frames to support subsequent loading from protective shielding, construction equipment, the weight of formwork and concrete, or any other cases not specifically described herein. We have also not provided prescriptive guidance for final detailing to meet the requirements of the Contract Documents.

We recommend that the proposed procedure be reviewed in detail with field personnel prior to erecting the steel superstructure. Any changes to the procedure must be reviewed and approved by an Illinois Licensed Structural Engineer.

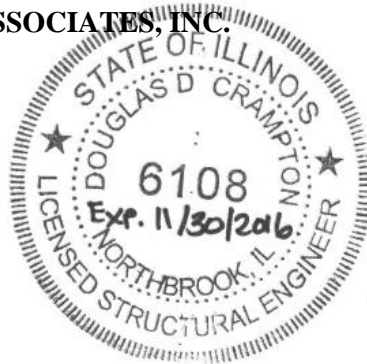
We appreciate the continued opportunity to be of service to S&J Construction. Please call if you have any questions.

Sincerely,

WISS, JANNEY, ELSTNER ASSOCIATES, INC.



Douglas D. Crampton, P.E., S.E.
Licensed Structural Engineer
Illinois No. 6108



Attachments

APPENDIX A: STAGE I ERECTION PROCEDURE AND DRAWINGS

ERECTION PROCEDURE STAGE I

I-55 Outbound Over Lake Shore Drive Structure 016-1501

January 15, 2016
Page 1 of 10

The erection of the structural steel for SN 016-1501 of the Outbound I-55 Bridge over Lake Shore Drive in Chicago, Illinois, will be performed over the course of two (2) stages, and each stage will consist of five (5) phases. Stage I will be completed over several days and will utilize three Shuttlelift 7755 (or equivalent) cranes.

General Notes

1. Contractor shall notify WJE if the conditions vary from those shown in this submittal.
2. All bearings will be installed before erection begins. Elevations at bearings will be verified prior to erection.
3. The splices may be prepped on the ground prior to erection. Prepping will include the installation of bolts through the splice plates and one girder section. Some bolts may be removed during erection to install pins for alignment purposes. A minimum of 50% of the holes shall be filled with bolts and alignment pins.
4. For the purposes of this erection procedure, when mating a splice in the air, each side of the splice shall have a minimum of 50% of the holes filled with bolts and alignment pins prior to releasing load from the crane.
5. For the purposes of this erection procedure, the specified cross frames shall be installed with a minimum of three bolts installed snug tight at each corner of the cross frame prior to releasing load from the crane. For cross frames installed after the girder is erected, a minimum of three snug tight bolts shall be installed in each corner of the cross frame.
6. Temporary braces to the adjacent existing structure shall be installed perpendicular to the length of the girder, when viewed in plan.
7. All cranes shall be operated within the radii and capacities shown on the erection drawings. The cranes shall never be operated in a manner that will exceed their rated capacity at any radius as specified by the manufacturer.
8. Crane capacities shown are for "front rated", which means the crane boom is directly over the front of the crane ± 15 degree maximum rotation toward the side.
9. Cranes shall be on fully extended outriggers when picking beam sections off delivery trucks.
10. When pick and carry methods are used, the crane shall travel slowly and cautiously on a firm and level supporting surface. Follow crane manufacturer's recommendations for pick and carry operations, including tire condition, tire inflation, and travel speed.
11. The cranes shall be set up on a firm, level, and uniformly supporting surface. As a result, this may require the installation of compacted fill or other modifications to the construction site at the locations where the cranes will be positioned, and these modifications shall be coordinated between the contractor and the erector to be in conformance with the crane manufacturer's requirements.
12. The cranes shall maintain a safe working distance from all overhead power lines or other utilities, if present, and this distance shall be as recommended by the crane manufacturer and the utility company.
13. No hoisting of loads shall occur over open traffic lanes.

14. The steel erection shall not be performed if wind gusts exceeding 25 MPH are anticipated or observed, or wind gusts/speeds exceed the maximum operating speed specified by the crane manufacturer.
15. If a Shuttlelift 7755 is not in use during a certain step in the erection procedure, it may be used to erect the bearings, cross frames, and temporary bracing. This may be set up in multiple locations and shall always be set up on level and stable ground, and operate within the capacities identified in the manufacturer's specifications.
16. After the erection of each girder and installation of temporary braces and/or cross frames, the girder shall be aligned and plumb before disconnecting from the crane.
17. All bolts shall be installed snug tight during erection, unless noted otherwise. Bolts installed in permanent connections shall be in accordance with the Contract Documents. Final detailing shall be performed after all steel has been erected and all bolts have been installed.
18. Girders shall be blocked at the piers and abutments to prevent lateral movement of the girder and maintain proper geometry.
19. Temporary platforms, lagging, shielding, or other loads shall not be applied to the structure until all girders have been erected and all bolts in all diaphragms and splices have been installed to a minimum of snug tight.
20. At the start of each Phase, the first 3 girder lines (Girders 5, 4 and 3) must be completed and all cross frames installed (minimum of three bolts installed snug tight at each corner) prior to the end of the first erection shift. However, it is permissible for the erection shift to end after Girders 5 and 4 are erected provided all the following conditions are met:
 - a. All cross frames are installed between girders 5 and 4 with a minimum of three bolts installed snug tight at each corner.
 - b. Maximum forecast wind speed for the interval between the end of the first shift and the anticipated erection of Girder 3 is no greater than 50 MPH, and no thunderstorms are forecast.
 - c. The erector must monitor the forecast every 6 hours. If the forecast or observed conditions change such that the above assumptions are no longer valid, the erector shall notify the erection engineer to determine appropriate supplemental support (e.g. hold crane, temporary cabling) as required.
21. Subsequent erection shifts can end any time after all erection steps of a given girder line have been completed, and further weather monitoring is not required, provided that all cross frames have been installed with a minimum of three bolts installed snug tight at each corner.
22. For purposes of this erection narrative, the following terminology will be used:

Phase 1

- Girder Section 1 West Abutment to Field Splice 1-1
- Girder Section 2 Field Splice 1-1 to Field Splice 1-2

Phase 2

- Girder Section 3 Field Splice 1-2 to Field Splice 1-3
- Girder Section 4 Field Splice 1-3 to Field Splice 1-4

Phase 3

- Girder Section 5 Field Splice 1-4 to Field Splice 1-5
- Girder Section 6 Field Splice 1-5 to Field Splice 1-6

Phase 4

- Girder Section 7 Field Splice 1-6 to Pier 1-7
- Girder Section 8 Field Splice 1-7 to Pier 1-8

Phase 5

- Girder Section 9 Field Splice 1-8 to Pier 5W

The erection sequence will be performed as follows:

Stage I, Phase 1: West Abutment to Field Splice 1-2

- For this phase, Cranes A, B, and C will be placed on level and stable ground to the south of Span 1W for each day of steel erection as shown on Sheets S-3 through S-5.
- The girders to be erected in this stage and phase are Girder Lines 5 through 1, from the west abutment to Field Splice 1-2 (FS1-2).
- The first 2 girder lines must be completed with all cross frames installed prior to the end of the first erection shift, and weather monitoring shall be performed as described above.
- Subsequent erection shifts in this phase can end any time after all erection steps of a given girder line have been completed.

Girder 5

1. Cranes A and B will pick Section 1 of Girder Line 5 (shown on Sheet S-3) using rigging as shown on Sheet S-2.
2. Once the girder section is picked and rigging properly adjusted, Girder Section 1 will be hoisted into position and placed on the bearing installed on the west abutment.
3. At this time, temporary bracing angles and clamps shall be connected to the existing adjacent structure as shown on Sheet S-17 at the locations specified on Sheet S-3.
4. Once the temporary bracing has been completely installed and the girder has been blocked at the bearing to prevent lateral movement, Crane A can slowly disconnect from the girder. Crane B shall remain in place to support the east end of the girder.
5. Cranes A and C will pick Section 2 of Girder Line 5 (shown on Sheet S-4) using rigging as shown on Sheet S-2. Once the girder section is picked and rigging properly adjusted, Girder Section 2 will be hoisted into position and mated with Girder Section 1 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
6. Once the girders have been mated, the crane will land the girder line on the bearing installed on Pier 1W.
7. With the cranes still holding the weight of the girders resting on the bearings, the splice connection shall be completed.
8. Concurrent with the work on the splice connection, temporary bracing angles and clamps shall be installed at Pier 1W as shown on Sheet S-17.
9. Once the bracing has been completely installed and the girder blocked at each bearing to prevent lateral movement of the girder, the cranes can disconnect from the girder.

Girder 4

1. Cranes A and B will pick Section 1 of Girder Line 4 (shown on Sheet S-5) using rigging as shown on Sheet S-2.
2. Once the girder section is picked and rigging properly adjusted, Girder Section 1 will be hoisted into position and placed on the bearing installed on the west abutment.
3. At this time, cross frames at locations specified on Sheet S-5 (noted by a *) shall be installed between Girder 5 and Girder 4.
4. Once the required cross frames have been installed and the girder blocked at the bearing to prevent lateral movement of the girder, Crane A can slowly disconnect from the girder. Crane B shall remain in place to support the east end of the girder.

5. Cranes A and C will pick Section 2 of Girder Line 4 (shown on Sheet S-5) using rigging as shown on Sheet S-2. Once the girder section is picked and rigging properly adjusted, Girder Section 2 will be hoisted into position and mated with Girder Section 1 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
6. Once the girders have been mated, the crane will land the girder line on the bearing installed on Pier 1W.
7. With the cranes still holding the weight of the girders resting on the bearings, the splice connection shall be completed.
8. Concurrent with the work on the splice connection, cross frames at locations specified on Sheet S-5 shall be installed between Girder 5 and Girder 4.
9. Once the required cross frames have been installed and the girder blocked at the supports to prevent lateral movement of the girder, the cranes can disconnect from the girder.
10. Next, all cross frames between Girders 5 and 4 will be installed.

Girder 3 through Girder 1

1. Girders 3 through 1 will be installed in a similar manner as Girder 4. The cranes shall be positioned as shown on Sheet S-5.
2. After all girders and cross frames have been erected in Phase 1, all remaining bolts in the cross frames and splices will be installed to a minimum of snug tight.

Stage I, Phase 2: Field Splice 1-2 to Field Splice 1-4

- For this phase, Cranes A, B, and C will be placed on level and stable ground to the south of Span 2W for each day of steel erection as shown on Sheets S-6 through S-8.
- The girders to be erected in this stage and phase are Girder Lines 5 through 1, from Field Splice 1-2 (FS1-2) to Field Splice 1-4 (FS1-4).
- The first 2 girder lines must be completed with all cross frames installed prior to the end of the first erection shift, and weather monitoring shall be performed as described above.
- Subsequent erection shifts in this phase can end any time after all erection steps of a given girder line have been completed.

Girder 5

1. Cranes A and B will pick Section 3 of Girder Line 5 (shown on Sheet S-6) using rigging as shown on Sheet S-2.
2. Once the girder section is picked and rigging properly adjusted, Girder Section 3 will be hoisted into position and mated with Girder Section 2 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
3. At this time, temporary bracing angles and clamps shall be connected to the existing adjacent structure as shown on Sheet S-17 at the locations specified on Sheet S-6.
4. Once the temporary bracing has been completely installed, Crane A can slowly disconnect from the girder. Crane B shall remain in place to support the east end of the girder.
5. Cranes A and C will pick Section 4 of Girder Line 5 (shown on Sheet S-7) using rigging as shown on Sheet S-2. Once the girder section is picked and rigging properly adjusted, Girder

Section 4 will be hoisted into position and mated with Girder Section 3 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.

6. Once the girders have been mated, the crane will land the girder line on the bearing installed on Pier 2W.
7. With the cranes still holding the weight of the girders resting on the bearings, the splice connection shall be completed.
8. Concurrent with the work on the splice connection, temporary bracing angles and clamps shall be installed at Pier 2W as shown on Sheet S-17.
9. Once the bracing has been completely installed and the girder blocked at each bearing to prevent lateral movement of the girder, the cranes can disconnect from the girder.

Girder 4

1. Cranes A and B will pick Section 3 of Girder Line 4 (shown on Sheet S-8) using rigging as shown on Sheet S-2.
2. Once the girder section is picked and rigging properly adjusted, Girder Section 3 will be hoisted into position and mated with Girder Section 2 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
3. At this time, cross frames at locations specified on Sheet S-8 (noted by a *) shall be installed between Girder 5 and Girder 4.
4. Once the required cross frames have been installed, Crane A can slowly disconnect from the girder. Crane B shall remain in place to support the east end of the girder.
5. Cranes A and C will pick Section 4 of Girder Line 4 (shown on Sheet S-8) using rigging as shown on Sheet S-2. Once the girder section is picked and rigging properly adjusted, Girder Section 4 will be hoisted into position and mated with Girder Section 3 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
6. Once the girders have been mated, the crane will land the girder line on the bearing installed on Pier 2W.
7. With the cranes still holding the weight of the girders resting on the bearings, the splice connection shall be completed.
8. Concurrent with the work on the splice connection, cross frames at locations specified on Sheet S-8 shall be installed between Girder 5 and Girder 4.
9. Once the required cross frames have been installed and the girder blocked at the supports to prevent lateral movement of the girder, the cranes can disconnect from the girder.
10. Next, all cross frames between Girders 5 and 4 will be installed.

Girder 3 through Girder 1

1. Girders 3 through 1 will be installed in a similar manner as Girder 4. The cranes shall be positioned as shown on Sheet S-8.
2. After all girders and cross frames have been erected in Phase 1, all remaining bolts in the cross frames and splices will be installed to a minimum of snug tight.

Stage I, Phase 3: Field Splice 1-4 to Field Splice 1-6

- For this phase, Cranes A, B, and C will be placed on level and stable ground to the south of Span 3W for each day of steel erection as shown on Sheets S-9 through S-11.
- The girders to be erected in this stage and phase are Girder Lines 5 through 1, from Field Splice 1-4 (FS1-4) to Field Splice 1-6 (FS1-6).
- The first 2 girder lines must be completed with all cross frames installed prior to the end of the first erection shift, and weather monitoring shall be performed as described above.
- Subsequent erection shifts in this phase can end any time after all erection steps of a given girder line have been completed.

Girder 5

1. Cranes A and B will pick Section 5 of Girder Line 5 (shown on Sheet S-9) using rigging as shown on Sheet S-2.
2. Once the girder section is picked and rigging properly adjusted, Girder Section 5 will be hoisted into position and mated with Girder Section 4 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
3. At this time, temporary bracing angles and clamps shall be connected to the existing adjacent structure as shown on Sheet S-17 at the locations specified on Sheet S-9.
4. Once the temporary bracing has been completely installed, Crane A can slowly disconnect from the girder. Crane B shall remain in place to support the east end of the girder.
5. Cranes A and C will pick Section 6 of Girder Line 5 (shown on Sheet S-10) using rigging as shown on Sheet S-2. Once the girder section is picked and rigging properly adjusted, Girder Section 6 will be hoisted into position and mated with Girder Section 5 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
6. Once the girders have been mated, the crane will land the girder line on the bearing installed on Pier 3W.
7. With the cranes still holding the weight of the girders resting on the bearings, the splice connection shall be completed.
8. Concurrent with the work on the splice connection, temporary bracing angles and clamps shall be installed at Pier 3W as shown on Sheet S-17.
9. Once the bracing has been completely installed and the girder blocked at each bearing to prevent lateral movement of the girder, the cranes can disconnect from the girder.

Girder 4

1. Cranes A and B will pick Section 5 of Girder Line 4 (shown on Sheet S-11) using rigging as shown on Sheet S-2.
2. Once the girder section is picked and rigging properly adjusted, Girder Section 5 will be hoisted into position and mated with Girder Section 4 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
3. At this time, cross frames at locations specified on Sheet S-11 (noted by a *) shall be installed between Girder 5 and Girder 4.

4. Once the required cross frames have been installed, Crane A can slowly disconnect from the girder. Crane B shall remain in place to support the east end of the girder.
5. Cranes A and C will pick Section 6 of Girder Line 4 (shown on Sheet S-11) using rigging as shown on Sheet S-2. Once the girder section is picked and rigging properly adjusted, Girder Section 6 will be hoisted into position and mated with Girder Section 5 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
6. Once the girders have been mated, the crane will land the girder line on the bearing installed on Pier 3W.
7. With the cranes still holding the weight of the girders resting on the bearings, the splice connection shall be completed.
8. Concurrent with the work on the splice connection, cross frames at locations specified on Sheet S-11 shall be installed between Girder 5 and Girder 4.
9. Once the required cross frames have been installed and the girder blocked at the supports to prevent lateral movement of the girder, the cranes can disconnect from the girder.
10. Next, all cross frames between Girders 5 and 4 will be installed.

Girder 3 through Girder 1

1. Girders 3 through 1 will be installed in a similar manner as Girder 4. The cranes shall be positioned as shown on Sheet S-11.
2. After all girders and cross frames have been erected in Phase 1, all remaining bolts in the cross frames and splices will be installed to a minimum of snug tight.

Stage I, Phase 4: Field Splice 1-6 to Field Splice 1-8

- For this phase, Cranes A, B, and C will be placed on level and stable ground to the south of Span 4W for each day of steel erection as shown on Sheets S-12 through S-14.
- The girders to be erected in this stage and phase are Girder Lines 5 through 1, from Field Splice 1-6 (FS1-6) to Field Splice 1-8 (FS1-8).
- The first 2 girder lines must be completed with all cross frames installed prior to the end of the first erection shift, and weather monitoring shall be performed as described above.
- Subsequent erection shifts in this phase can end any time after all erection steps of a given girder line have been completed.

Girder 5

1. Cranes A and B will pick Section 7 of Girder Line 5 (shown on Sheet S-12) using rigging as shown on Sheet S-2.
2. Once the girder section is picked and rigging properly adjusted, Girder Section 7 will be hoisted into position and mated with Girder Section 6 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
3. At this time, temporary bracing angles and clamps shall be connected to the existing adjacent structure as shown on Sheet S-17 at the locations specified on Sheet S-12.
4. Once the temporary bracing has been completely installed, Crane A can slowly disconnect from the girder. Crane B shall remain in place to support the east end of the girder.

5. Cranes A and C will pick Section 8 of Girder Line 5 (shown on Sheet S-13) using rigging as shown on Sheet S-2. Once the girder section is picked and rigging properly adjusted, Girder Section 8 will be hoisted into position and mated with Girder Section 7 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
6. Once the girders have been mated, the crane will land the girder line on the bearing installed on Pier 4W.
7. With the cranes still holding the weight of the girders resting on the bearings, the splice connection shall be completed.
8. Concurrent with the work on the splice connection, temporary bracing angles and clamps shall be installed at Pier 4W as shown on Sheet S-17.
9. Once the bracing has been completely installed and the girder blocked at each bearing to prevent lateral movement of the girder, the cranes can disconnect from the girder.

Girder 4

1. Cranes A and B will pick Section 7 of Girder Line 4 (shown on Sheet S-14) using rigging as shown on Sheet S-2.
2. Once the girder section is picked and rigging properly adjusted, Girder Section 7 will be hoisted into position and mated with Girder Section 6 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
3. At this time, cross frames at locations specified on Sheet S-14 (noted by a *) shall be installed between Girder 5 and Girder 4.
4. Once the required cross frames have been installed, Crane A can slowly disconnect from the girder. Crane B shall remain in place to support the east end of the girder.
5. Cranes A and C will pick Section 8 of Girder Line 4 (shown on Sheet S-14) using rigging as shown on Sheet S-2. Once the girder section is picked and rigging properly adjusted, Girder Section 8 will be hoisted into position and mated with Girder Section 7 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
6. Once the girders have been mated, the crane will land the girder line on the bearing installed on Pier 4W.
7. With the cranes still holding the weight of the girders resting on the bearings, the splice connection shall be completed.
8. Concurrent with the work on the splice connection, cross frames at locations specified on Sheet S-14 shall be installed between Girder 5 and Girder 4.
9. Once the required cross frames have been installed and the girder blocked at the supports to prevent lateral movement of the girder, the cranes can disconnect from the girder.
10. Next, all cross frames between Girders 5 and 4 will be installed.

Girder 3 through Girder 1

1. Girders 3 through 1 will be installed in a similar manner as Girder 4. The cranes shall be positioned as shown on Sheet S-14.
2. After all girders and cross frames have been erected in Phase 1, all remaining bolts in the cross frames and splices will be installed to a minimum of snug tight.

Stage I, Phase 5: Field Splice 1-8 to Pier 5W

- For this phase, Cranes A and B will be placed on level and stable ground to the south of Span 5W for each day of steel erection as shown on Sheets S-15 through S-16.
- The girders to be erected in this stage and phase are Girder Lines 5 through 1, from Field Splice 1-8 (FS1-8) to Pier 5W.
- The first 2 girder lines must be completed with all cross frames installed prior to the end of the first erection shift, and weather monitoring shall be performed as described above.
- Subsequent erection shifts in this phase can end any time after all erection steps of a given girder line have been completed.

Girder 5

1. Cranes A and B will pick Section 9 of Girder Line 5 (shown on Sheet S-15) using rigging as shown on Sheet S-2.
2. Once the girder section is picked and rigging properly adjusted, Girder Section 9 will be hoisted into position and mated with Girder Section 8 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
3. Once the girder sections have been mated, the cranes will land the girder line on the bearing installed on Pier 5W.
4. With the cranes still holding the weight of the girder resting on the bearing, temporary bracing angles and clamps shall be connected to the existing adjacent structure as shown on Sheet S-17 at the locations specified on Sheet S-15.
5. Once the bracing has been completely installed and the girder blocked at each bearing to prevent lateral movement of the girder, the cranes can disconnect from the girder.

Girder 4

1. Cranes A and B will pick Section 9 of Girder Line 4 (shown on Sheet S-16) using rigging as shown on Sheet S-2.
2. Once the girder section is picked and rigging properly adjusted, Girder Section 9 will be hoisted into position and mated with Girder Section 8 in the air just above its approximate final location. The girders will be considered mated when the splice plates are in their design position on each girder and a sufficient number of bolts and pins are installed to ensure proper alignment of the splice plates and girder sections.
3. Once the girder sections have been mated, the cranes will land the girder line on the bearing installed on Pier 5W.
4. With the cranes still holding the weight of the girder resting on the bearing, the cross frames at locations specified on Sheet S-16 shall be installed between Girder 5 and Girder 4.
5. Once the cross frames have been installed and the girder blocked at each bearing to prevent lateral movement of the girder, the cranes can disconnect from the girder.
6. Next, all cross frames between Girders 5 and 4 will be installed.

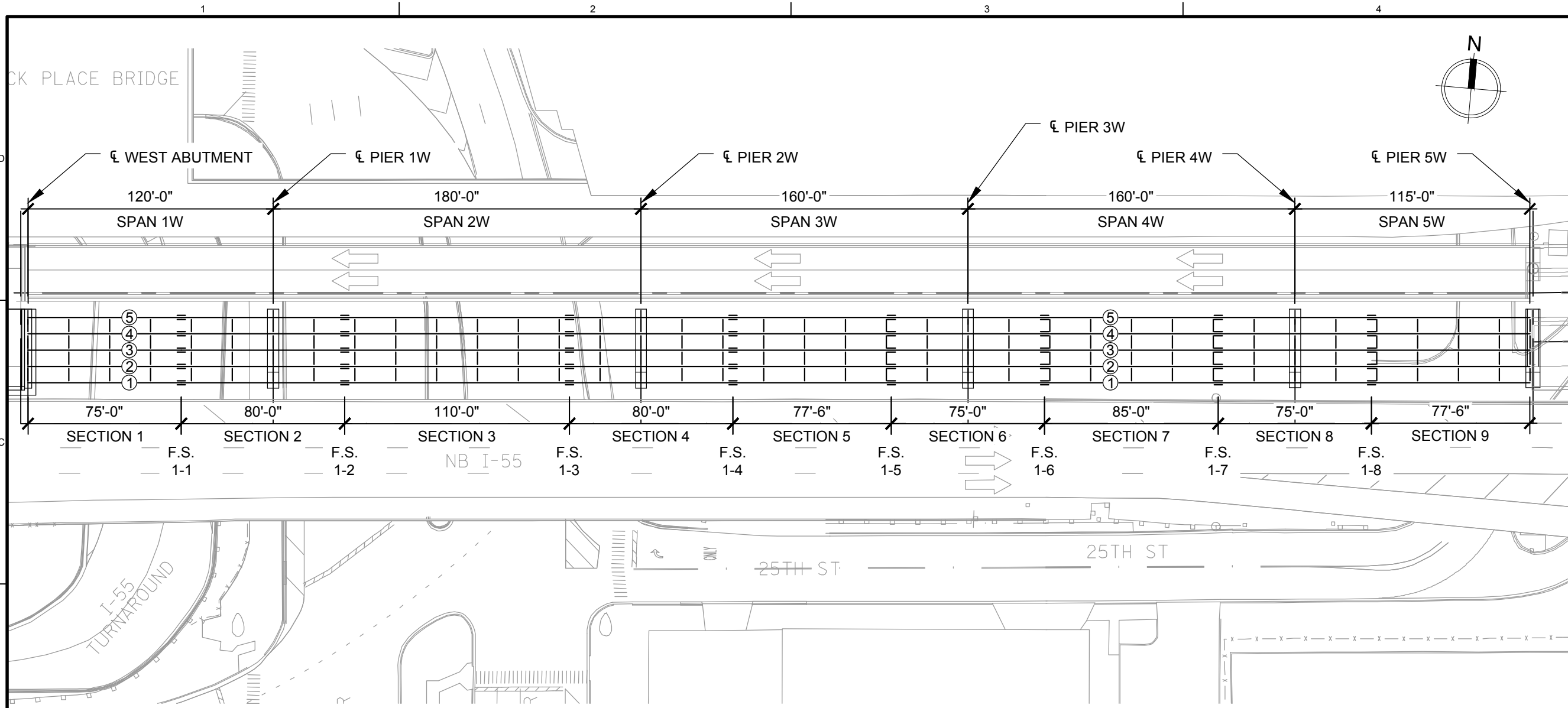
Girder 3 through Girder 1

1. Girders 3 through 1 will be installed in a similar manner as Girder 4. The cranes shall be positioned as shown on Sheet S-16.
2. After all girders and cross frames have been erected in Phase 5, all remaining bolts in the cross frames and splices will be installed to a minimum of snug tight.

Final Detailing

After all girders are erected as described above, final detailing shall be completed in accordance with the Contract Plans.

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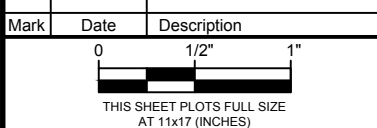
Project
I-55 and Lake Shore Drive Interchange Reconstruction (Outbound Structures)
S.N. 016-1501

Client
S & J Construction
4245 166th Street
Oak Forest, IL 60452

GENERAL NOTES

1. **STRUCTURAL STEEL MATERIALS FOR BRACING AT ABUTMENTS, PIERS AND MIDSPAN:**
 - a. STRUCTURAL STEEL ANGLES SHALL CONFORM TO THE REQUIREMENTS OF ASTM A36 (Fy=36 ksi).
 - b. STRUCTURAL STEEL PLATE SHALL CONFORM TO ASTM A570 GRADE 50 (Fy=50ksi).
 - c. STRUCTURAL STEEL WT SECTIONS SHALL CONFORM TO ASTM A992 (Fy=50ksi).
 - d. HIGH STRENGTH BOLTS, NUTS AND WASHERS SHALL CONFORM TO AASTHO M164 (ASTM A325), TYPE 1. STANDARD HOLES (BOLT DIAMETER + 1/16") SHALL BE USED FOR ALL HOLES IN THE TEMPORARY BRACING MEMBERS.
 - e. ALL WELDING FOR TEMPORARY BRACING SHALL BE IN ACCORDANCE WITH AWS D1.5.

2. **ERECTION PROCEDURE:**
 - a. THE ERECTION OF THE STEEL SUPERSTRUCTURE SHALL NOT BE PERFORMED IF WIND GUSTS EXCEEDING 25 MPH ARE FORECASTED OR OBSERVED.
 - b. ALL BOLTS SHALL BE INSTALLED SNUG TIGHT DURING ERECTION.
 - c. THE RIGGING USED FOR ALL GIRDERS SHALL BE AS SHOWN ON S-2.
 - d. THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING THE WEIGHT OF EACH LIFT AND ENSURING THE STABILITY OF EACH MEMBER DURING ALL STAGES OF ERECTION.
 - e. ANY DEVIATIONS FROM THIS PROCEDURE SHALL BE APPROVED BY WJE.
 - f. SEE NARRATIVE FOR MORE DETAILED ERECTION PROCEDURE



| | |
|-------------|-------------|
| Project No. | 2015.4852.1 |
| Date | 1/14/16 |
| Drawn | JJZ |
| Checked | DDC |
| Scale | N.T.S. |

STAGE 1
GENERAL NOTES AND
SITE LAYOUT

Sheet Title

Sheet No. **S-1**

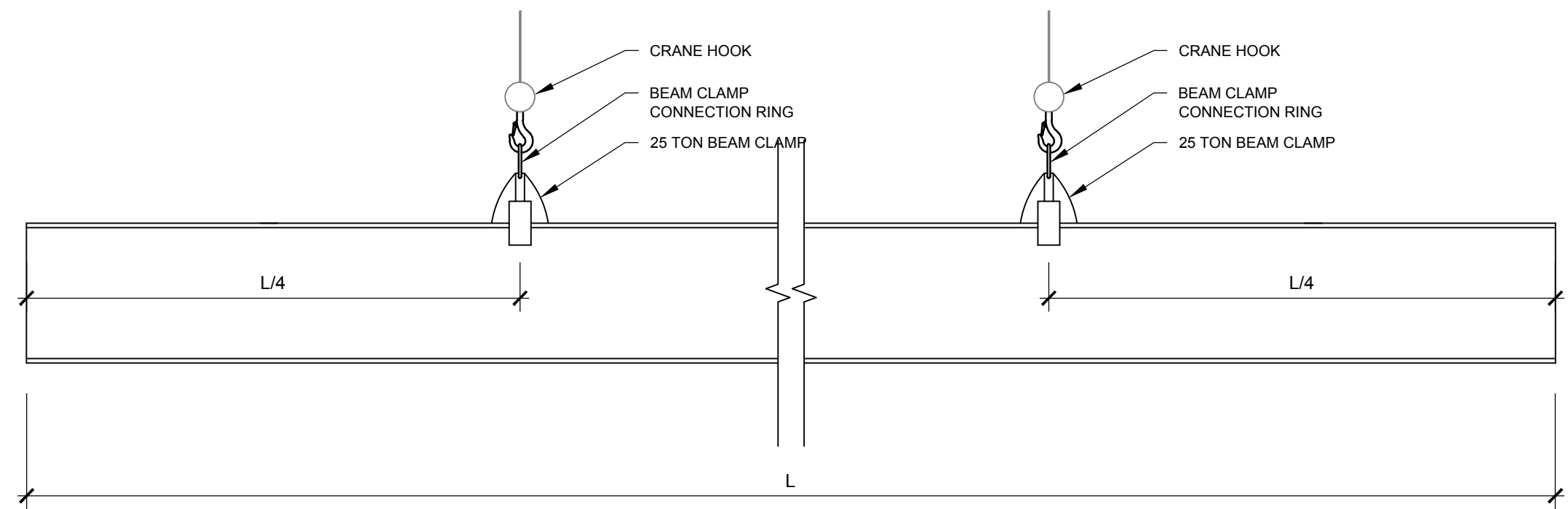
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1 2 3 4

D
C
B
A

| SECTION | | L | L/4 |
|---------|----------------------|---------------------------------------|---------------------------------------|
| 1 | W. ABUTMENT TO FS1-1 | 75' - 8 ³ / ₈ " | 18' - 11" |
| 2 | FS1-1 TO FS1-2 | 80' - 0" | 20' - 0" |
| 3 | FS1-2 TO FS1-3 | 110' - 0" | 27' - 6" |
| 4 | FS1-3 TO FS1-4 | 80' - 0" | 20' - 0" |
| 5 | FS1-4 TO FS1-5 | 77' - 6" | 19' - 4 ¹ / ₂ " |
| 6 | FS1-5 TO FS 1-6 | 75' - 0" | 18' - 9" |
| 7 | FS1-6 TO FS 1-7 | 85' - 0" | 21' - 3" |
| 8 | FS1-7 TO FS1-8 | 75' - 0" | 18' - 9" |
| 9 | FS1-8 TO E. ABUTMENT | 78' - 2 ³ / ₈ " | 19' - 6 ¹ / ₂ " |

NOTE:
L/4 CAN BE ADJUSTED ±18" TO AVOID CROSS FRAME LOCATIONS

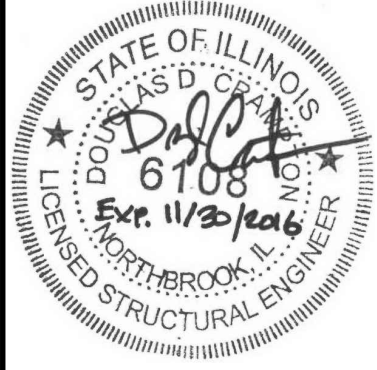


1
S-2 RIGGING FOR ALL GIRDER SECTIONS

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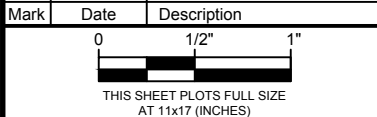


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(Outbound Structures)
S.N. 016-1501

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| Mark | Date | Description |
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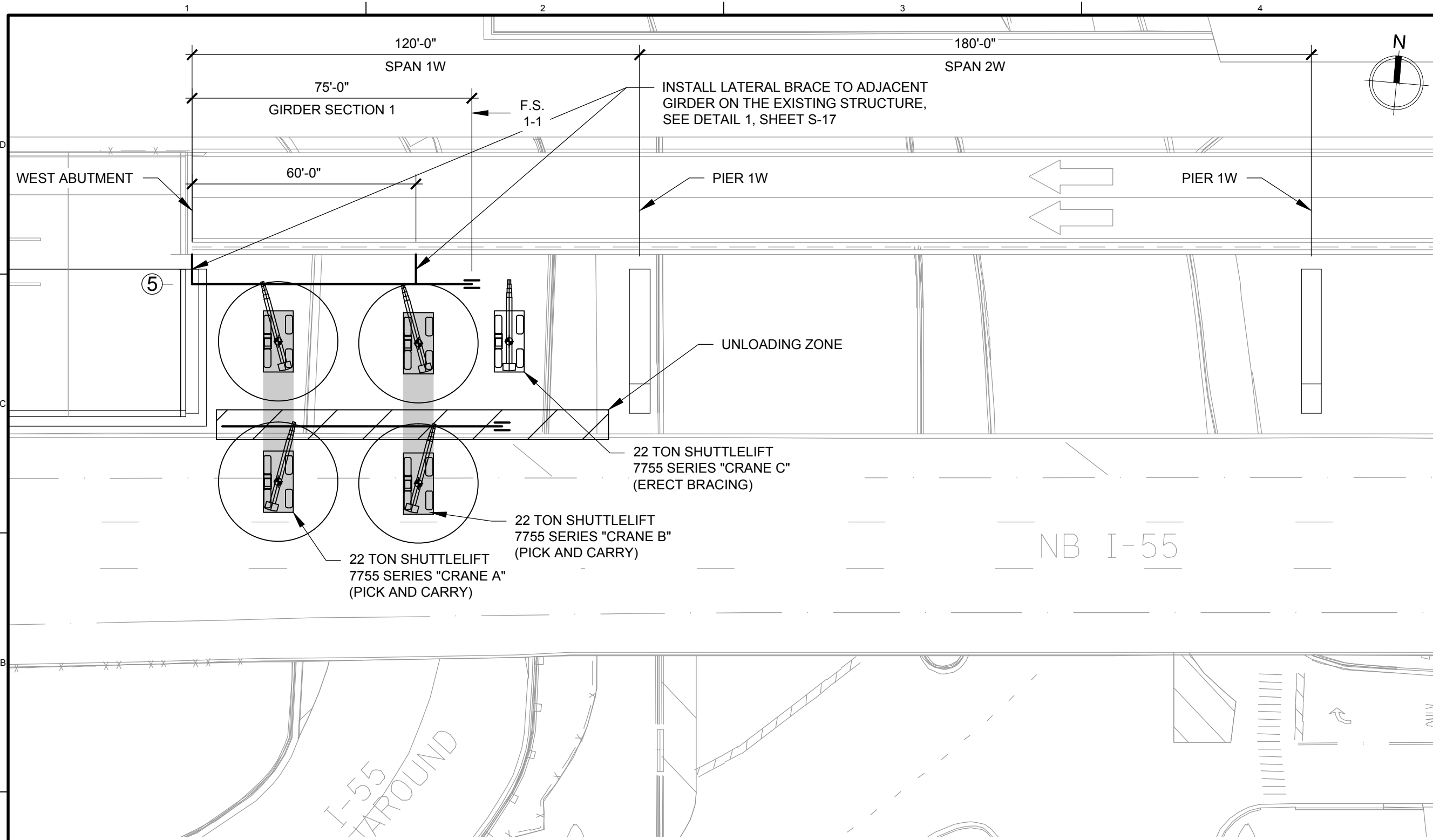
Project No. 2015.4852.1
Date 1/14/16
Drawn JJZ
Checked DDC
Scale N.T.S.

STAGE I
RIGGING

Sheet Title

Sheet No. **S-2**

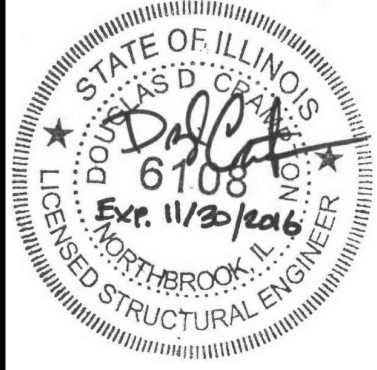
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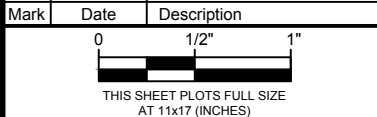


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Date **1/14/16**
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Checked **DDC**
Scale **N.T.S.**

STAGE I
SPAN 1W
PLAN VIEW - 1

Sheet Title

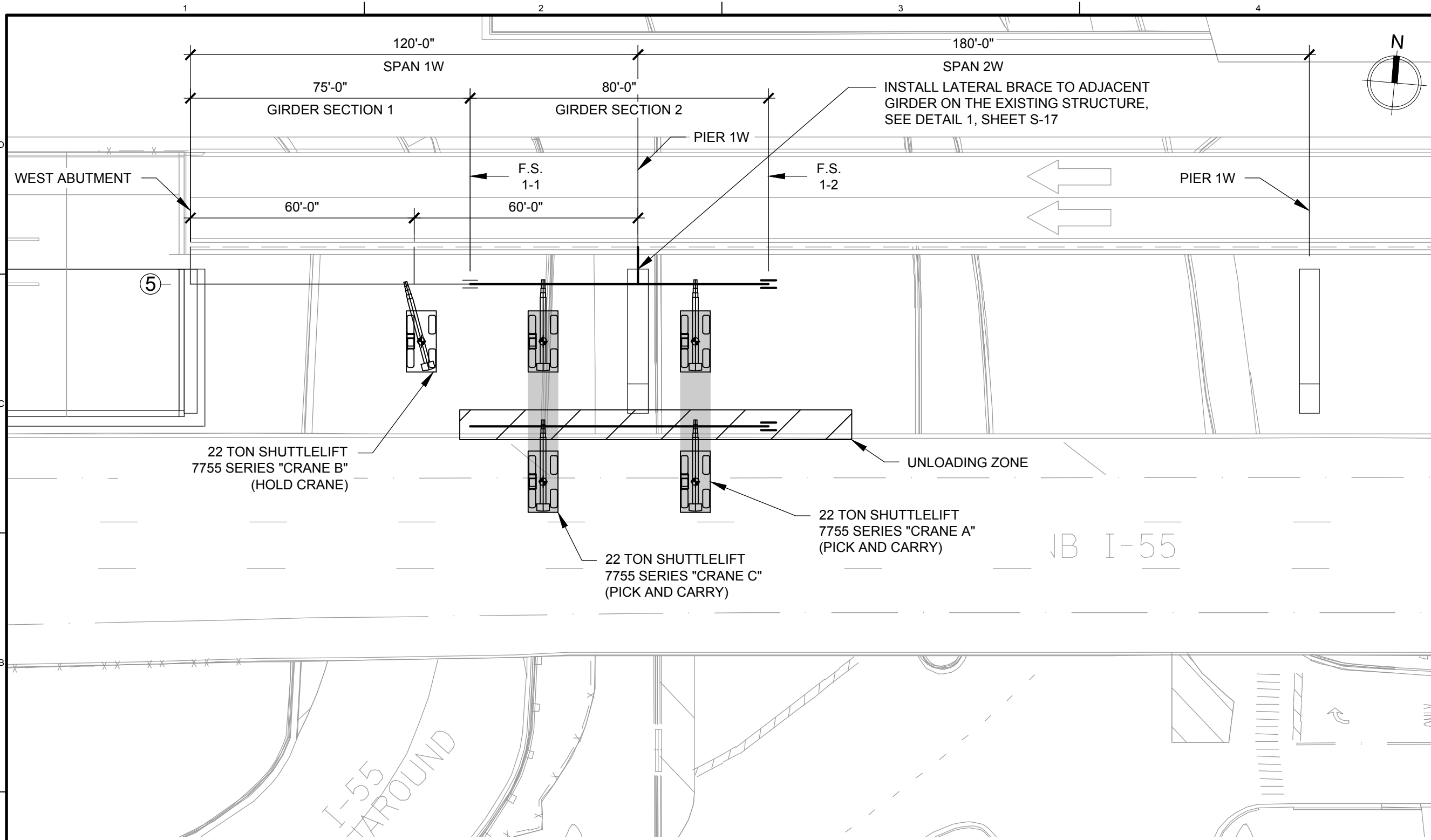
Sheet No. **S-3**

- NOTES:**
- CRANE SHALL BE ON FULLY EXTENDED OUTRIGGERS WHEN PICKING BEAM SECTIONS OFF DELIVERY TRUCK



| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|-------------------------------------|---------------------|----------------|---------------------|----------------|--------------|--|
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 21,277 LBS | 1 | 5 | 15,500 LBS x 2 = 31,000 LBS ALL BOOM LENGTHS ACCEPTABLE |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | | | | |

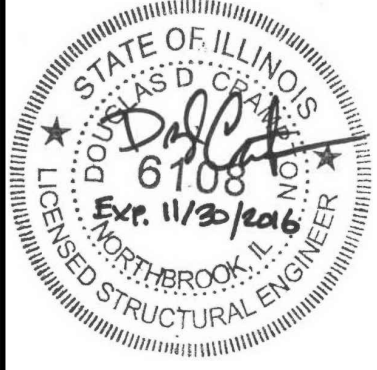
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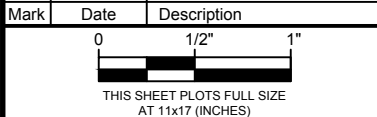


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STAGE I
SPAN 1W
PLAN VIEW - 2

Sheet Title

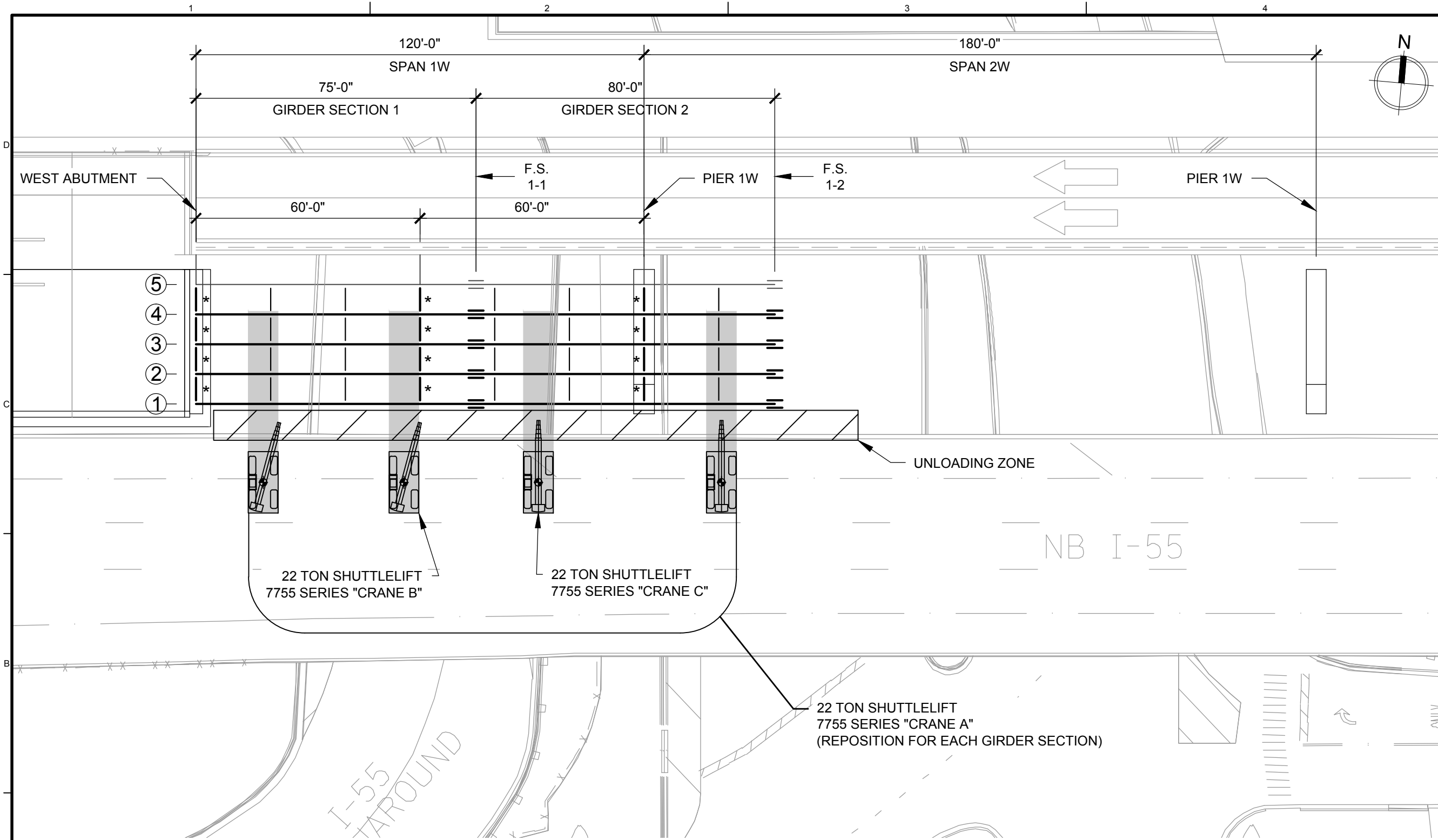
Sheet No. **S-4**

- NOTES:**
- CRANE SHALL BE ON FULLY EXTENDED OUTRIGGERS WHEN PICKING BEAM SECTIONS OFF DELIVERY TRUCK

FULL LANE CLOSURE

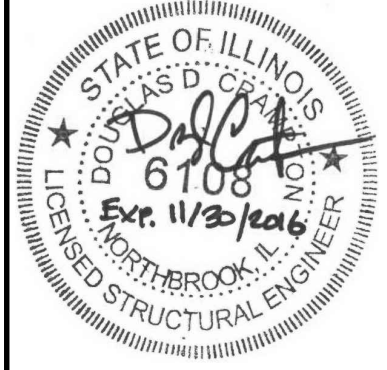
| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|----------------------------------|------------------|----------------|---------------------|----------------|--------------|--|
| C | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 12 FT | 37,777 LBS | 2 | 5 | 19,600 LBS x 2 = 39,200 LBS ALL BOOM LENGTHS ACCEPTABLE |
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 12 FT | | | | |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 14,289 LBS (HOLD) | 1 | 5 | 15,500 LBS ALL BOOM LENGTHS ACCEPTABLE |

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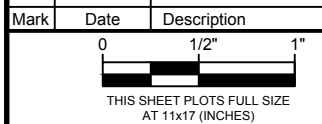
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Date **1/14/16**
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Scale **N.T.S.**

**STAGE I
SPAN 1W
PLAN VIEW - 3**

Sheet Title

Sheet No.

S-5

NOTES:

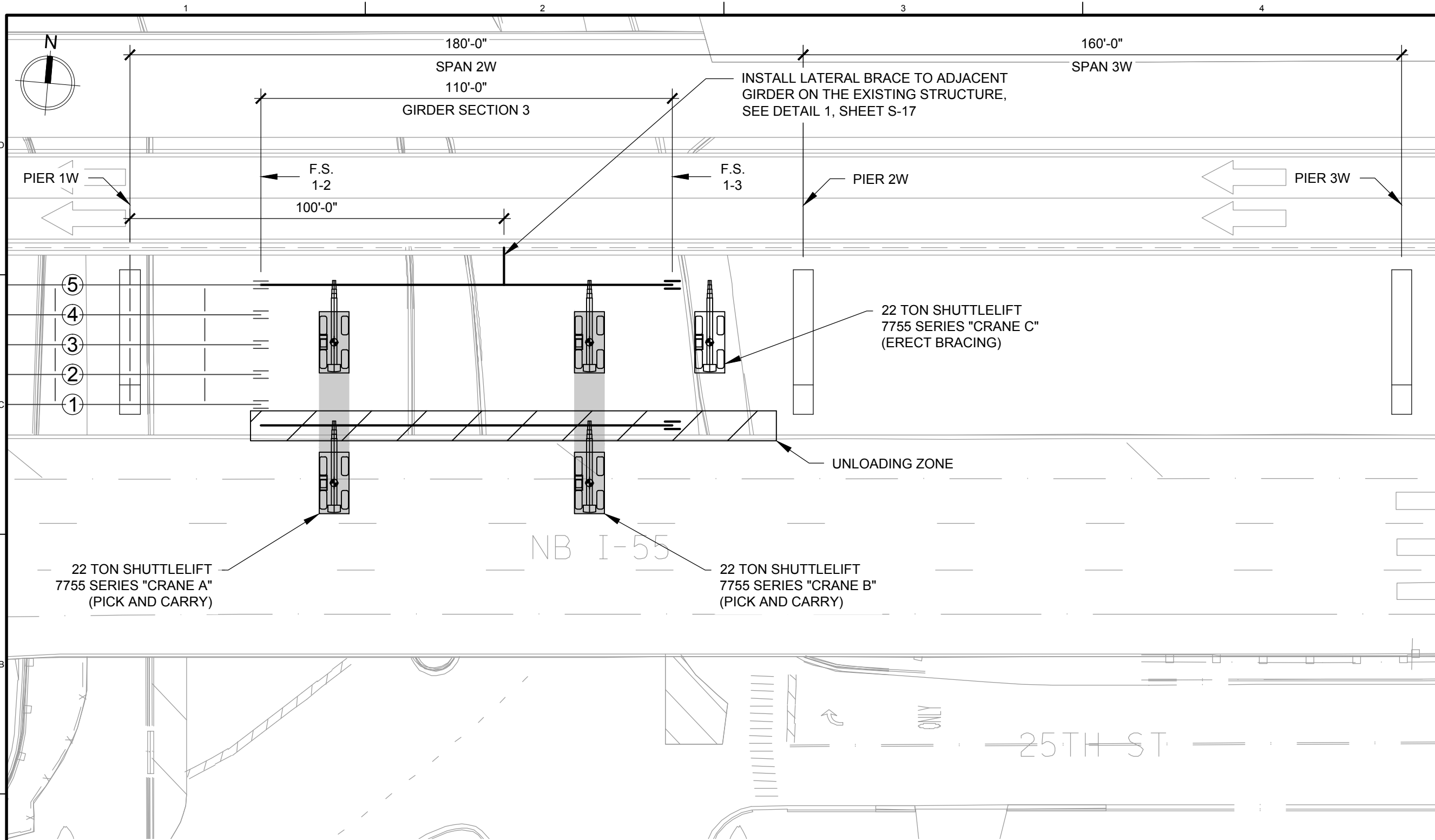
1. CRANE SHALL BE ON FULLY EXTENDED OUTRIGGERS WHEN PICKING BEAM SECTIONS OFF DELIVERY TRUCK

* CROSS FRAMES REQUIRED FOR THE PURPOSE OF ERECTION

FULL LANE CLOSURE

| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|----------------------------------|------------------|----------------|---------------------|----------------|--------------|--|
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 21,277 LBS | 1 | 4 THRU 1 | 15,500 LBS x 2 = 31,000 LBS ALL BOOM LENGTHS ACCEPTABLE |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | | | | |
| C | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 12 FT | 37,777 LBS | 2 | 4 THRU 1 | 19,600 LBS x 2 = 39,200 LBS ALL BOOM LENGTHS ACCEPTABLE |
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 12 FT | | | | |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 14,289 LBS (HOLD) | 1 | 4 THRU 1 | 15,500 LBS ALL BOOM LENGTHS ACCEPTABLE |

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NOTES:

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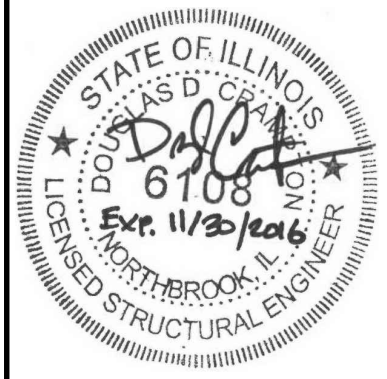
FULL LANE CLOSURE

| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|-------------------------------------|---------------------|----------------|---------------------|----------------|--------------|--|
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 8 FT | 43,423 LBS | 3 | 5 | 28,000 LBS x 2 = 56,000 LBS ALL BOOM LENGTHS ACCEPTABLE |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 8 FT | | | | |

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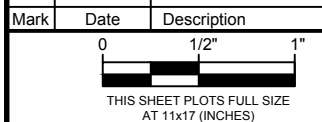
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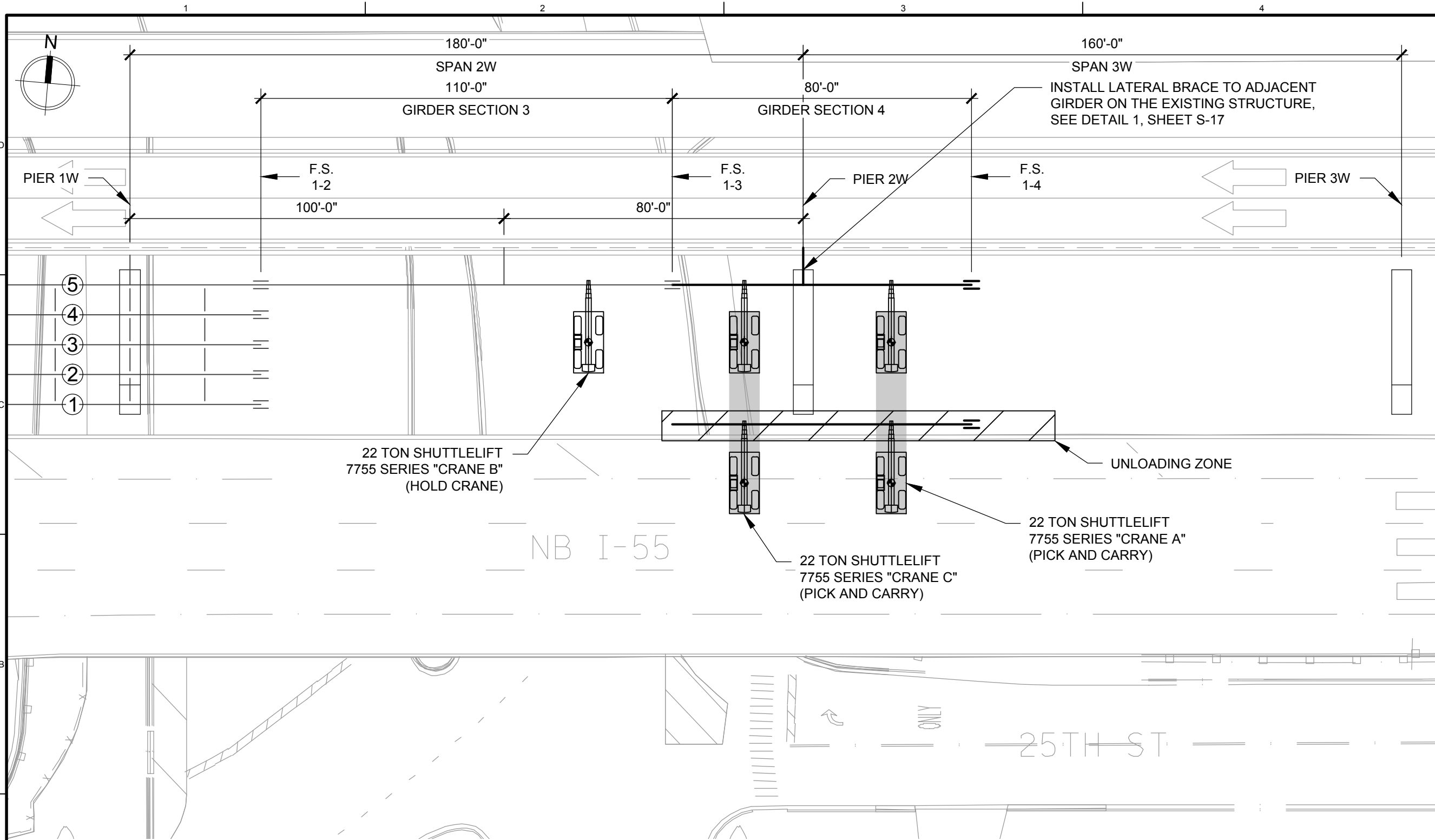
STAGE I
SPAN 2W
PLAN VIEW - 1

Sheet Title

Sheet No.

S-6

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NOTES:

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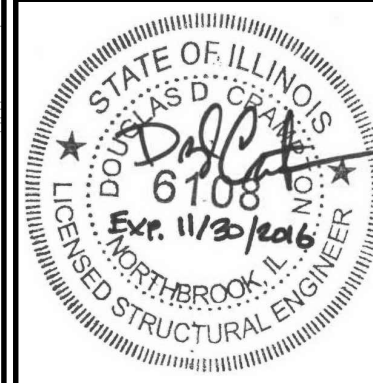
FULL LANE CLOSURE

| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|----------------------------------|------------------|----------------|---------------------|----------------|--------------|--|
| C | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 12 FT | 37,777 LBS | 4 | 5 | 19,600 LBS x 2 = 39,200 LBS ALL BOOM LENGTHS ACCEPTABLE |
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 12 FT | | | | |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 6 FT | 28,901 LBS (HOLD) | 3 | 5 | 30,000 LBS ALL BOOM LENGTHS ACCEPTABLE |

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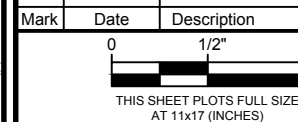
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Interchange Reconstruction
(Outbound Structures)
S.N. 016-1501

Client
S & J Construction
4245 166th Street
Oak Forest, IL 60452



Project No. 2015.4852.1

Date 1/14/16

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Scale N.T.S.

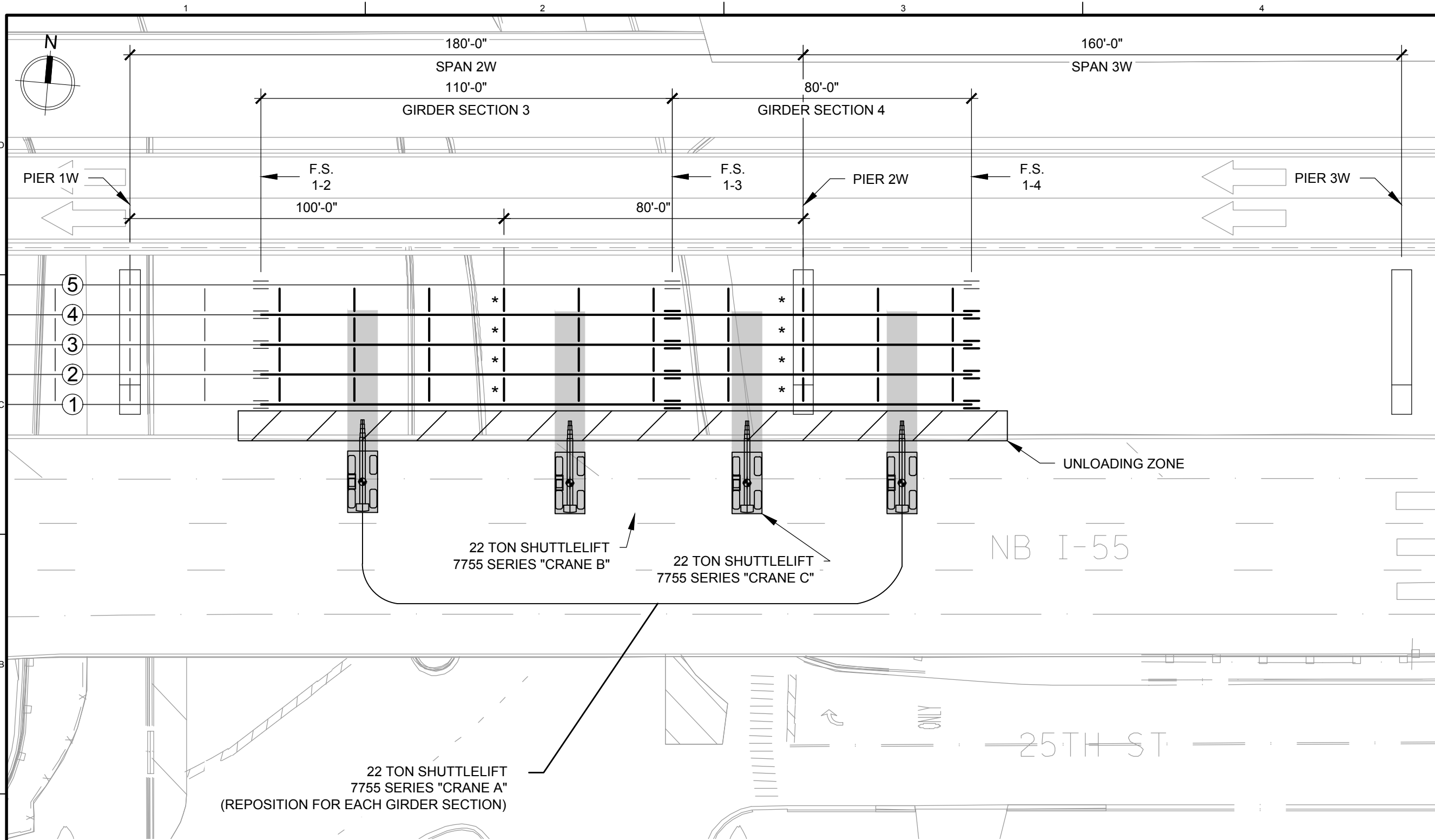
STAGE I
SPAN 2W
PLAN VIEW - 2

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S-7

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NOTES:

1. CRANE SHALL BE ON FULLY EXTENDED OUTRIGGERS WHEN PICKING BEAM SECTIONS OFF DELIVERY TRUCK

* CROSS FRAMES REQUIRED FOR THE PURPOSE OF ERECTION

FULL LANE CLOSURE

| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|----------------------------------|------------------|----------------|---------------------|----------------|--------------|--|
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 8 FT | 43,423 LBS | 3 | 4 THRU 1 | 28,000 LBS x 2 = 56,000 LBS ALL BOOM LENGTHS ACCEPTABLE |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 8 FT | | | | |
| C | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 12 FT | 37,777 LBS | 4 | 4 THRU 1 | 19,600 LBS x 2 = 39,200 LBS ALL BOOM LENGTHS ACCEPTABLE |
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 12 FT | | | | |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 6 FT | 28,901 LBS (HOLD) | 3 | 4 THRU 1 | 30,000 LBS ALL BOOM LENGTHS ACCEPTABLE |

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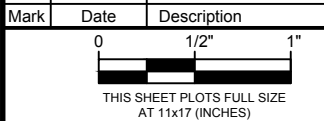
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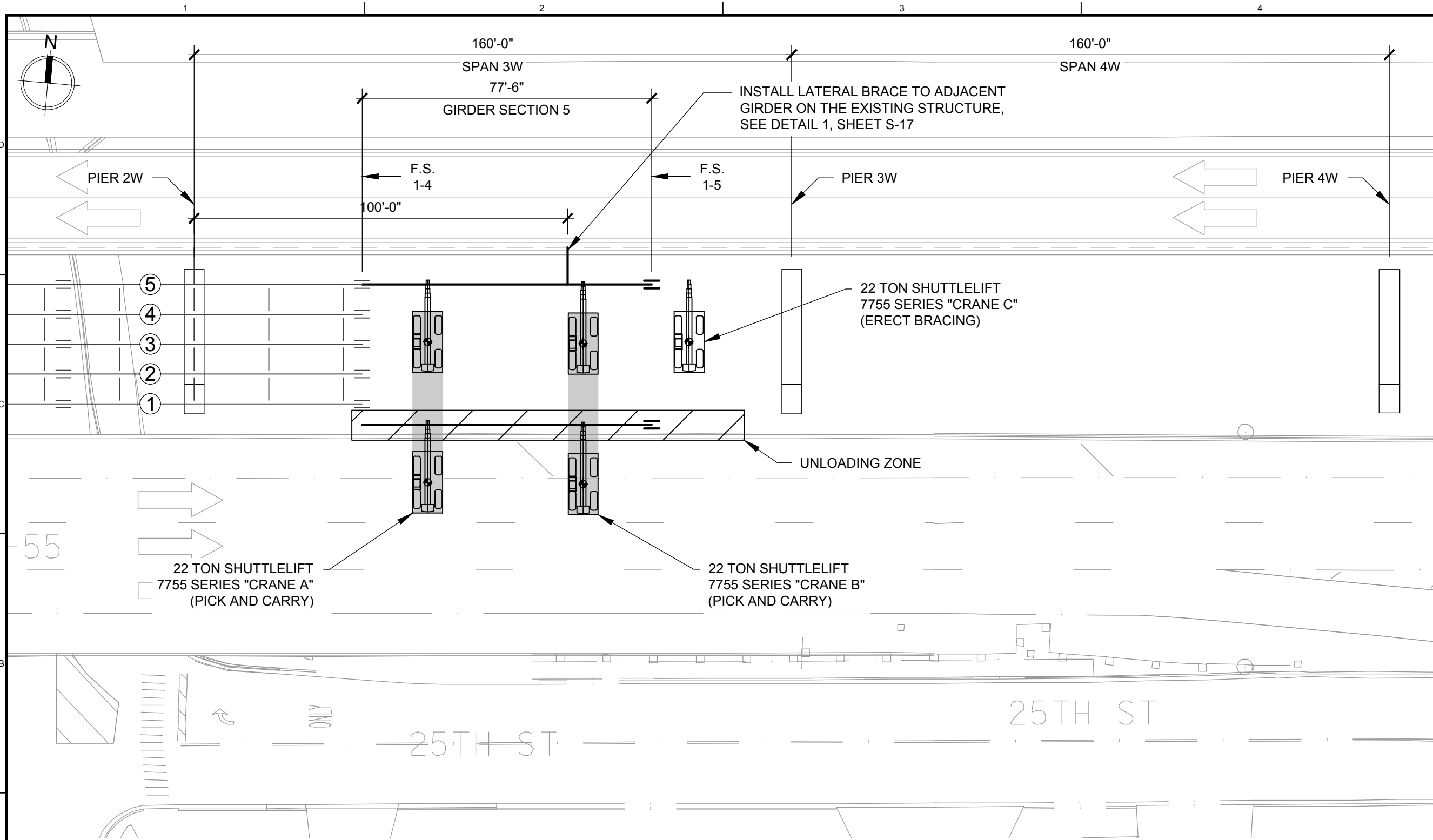
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SPAN 2W
PLAN VIEW - 3

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NOTES:

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FULL LANE CLOSURE

| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|-------------------------------------|---------------------|----------------|---------------------|----------------|--------------|--|
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 22,524 LBS | 5 | 5 | 15,500 LBS x 2 = 31,000 LBS ALL BOOM LENGTHS ACCEPTABLE |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | | | | |

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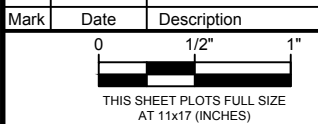
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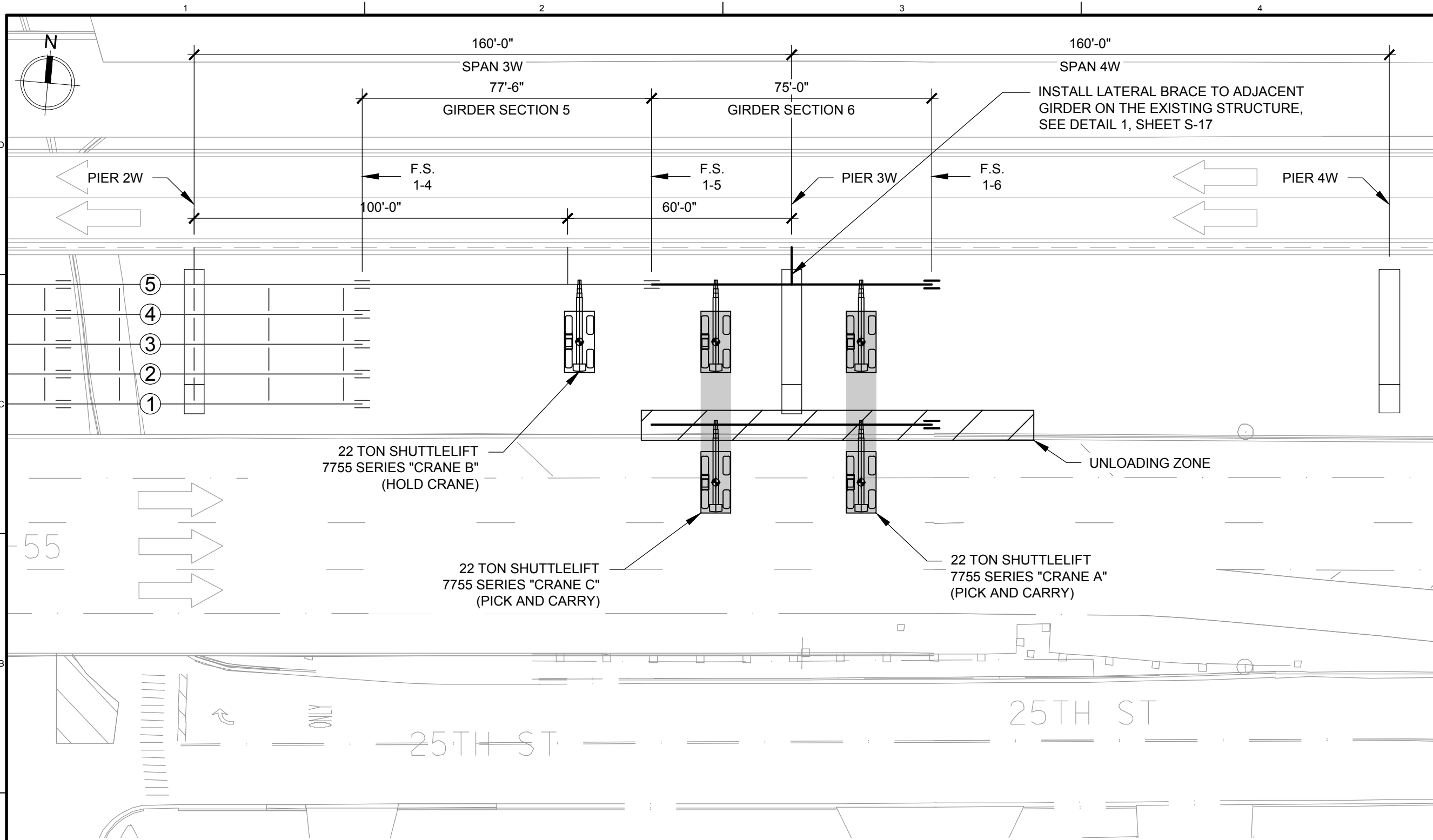
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SPAN 3W
PLAN VIEW - 1

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S-9

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NOTES:

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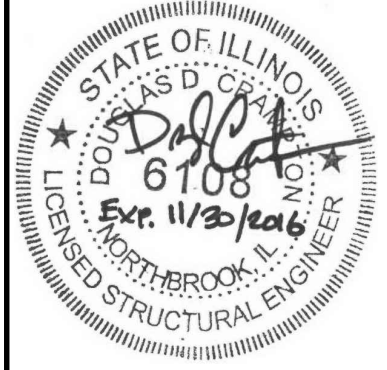
FULL LANE CLOSURE

| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|----------------------------------|------------------|----------------|---------------------|----------------|--------------|--|
| C | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 30,478 LBS | 6 | 5 | 15,500 LBS x 2 = 31,000 LBS ALL BOOM LENGTHS ACCEPTABLE |
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | | | | |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 13,801 LBS (HOLD) | 5 | 5 | 15,500 LBS ALL BOOM LENGTHS ACCEPTABLE |

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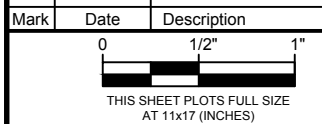
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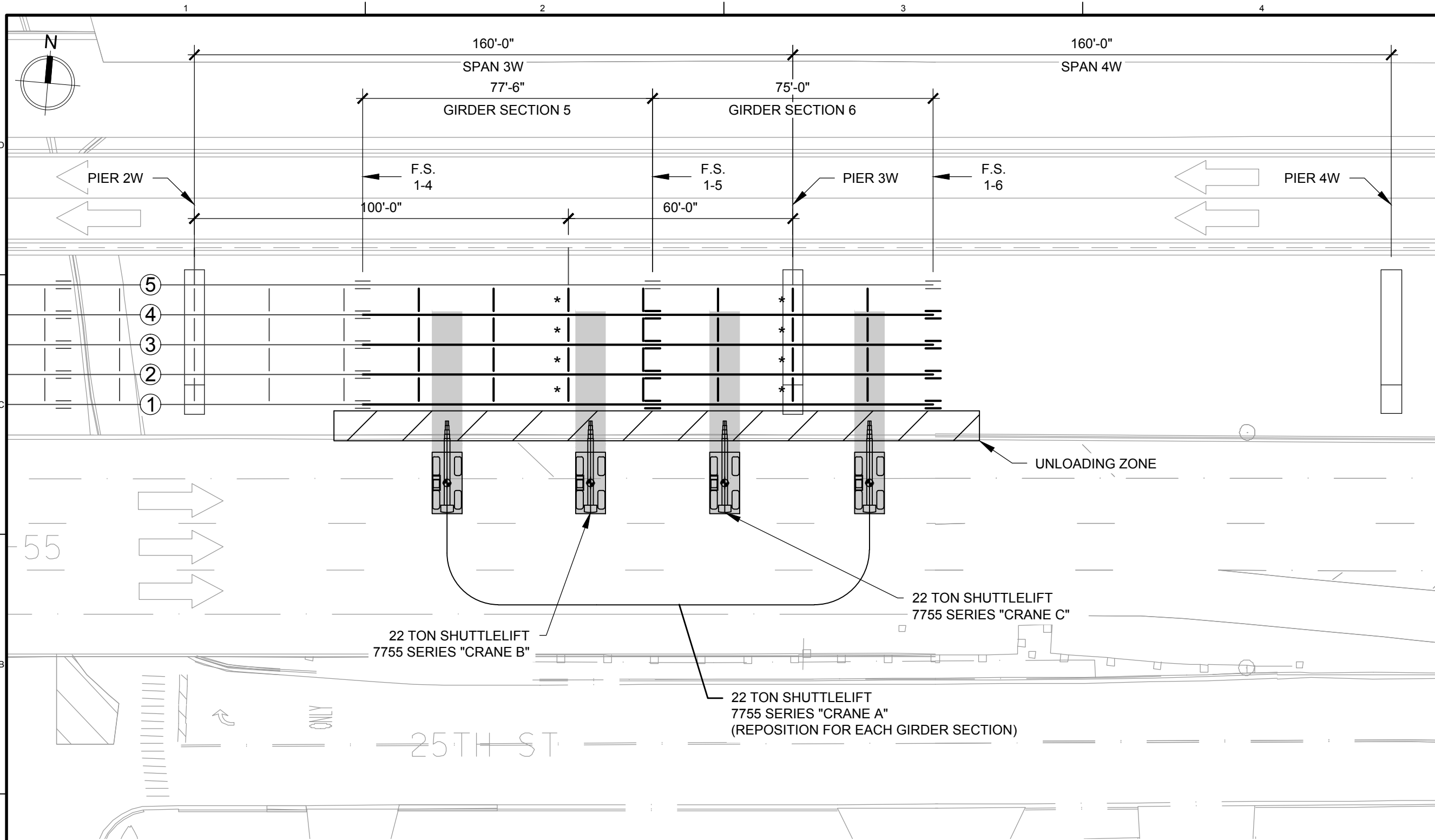
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 - CROSS FRAMES REQUIRED FOR THE PURPOSE OF ERECTION
- FULL LANE CLOSURE

| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|----------------------------------|------------------|----------------|---------------------|----------------|--------------|--|
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 22,524 LBS | 5 | 4 THRU 1 | 15,500 LBS x 2 = 31,000 LBS ALL BOOM LENGTHS ACCEPTABLE |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | | | | |
| C | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 30,478 LBS | 6 | 4 THRU 1 | 15,500 LBS x 2 = 31,000 LBS ALL BOOM LENGTHS ACCEPTABLE |
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | | | | |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 13,801 LBS (HOLD) | 5 | 4 THRU 1 | 15,500 LBS ALL BOOM LENGTHS ACCEPTABLE |

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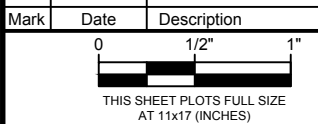
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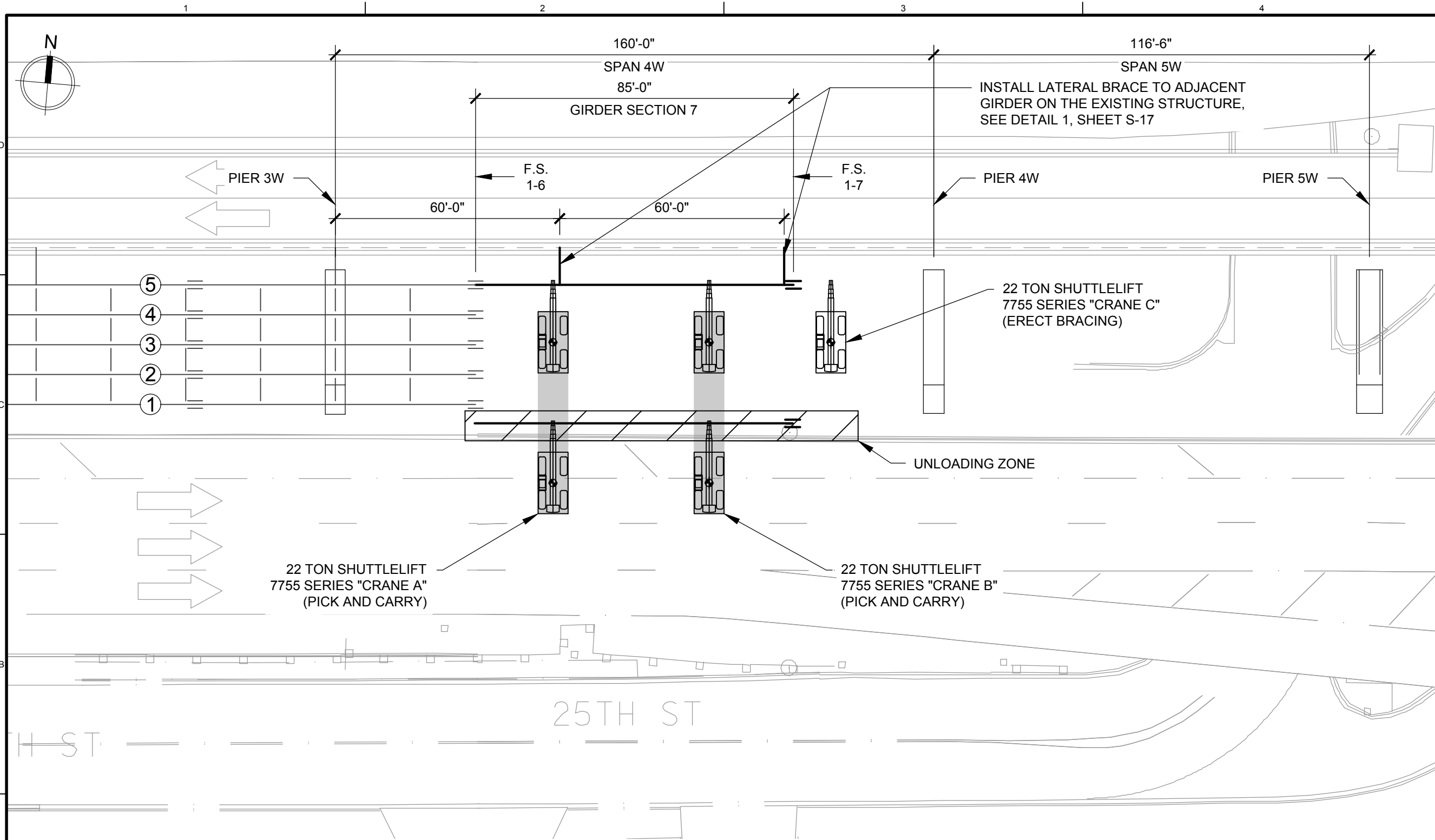
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SPAN 3W
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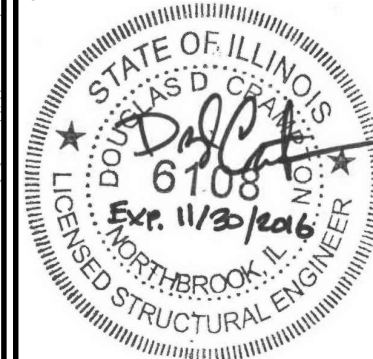
FULL LANE CLOSURE

| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|-------------------------------------|---------------------|----------------|---------------------|----------------|--------------|--|
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 24,386 LBS | 7 | 5 | 15,500 LBS x 2 = 31,000 LBS ALL BOOM LENGTHS ACCEPTABLE |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | | | | |

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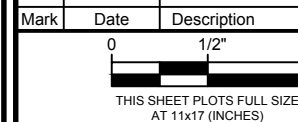
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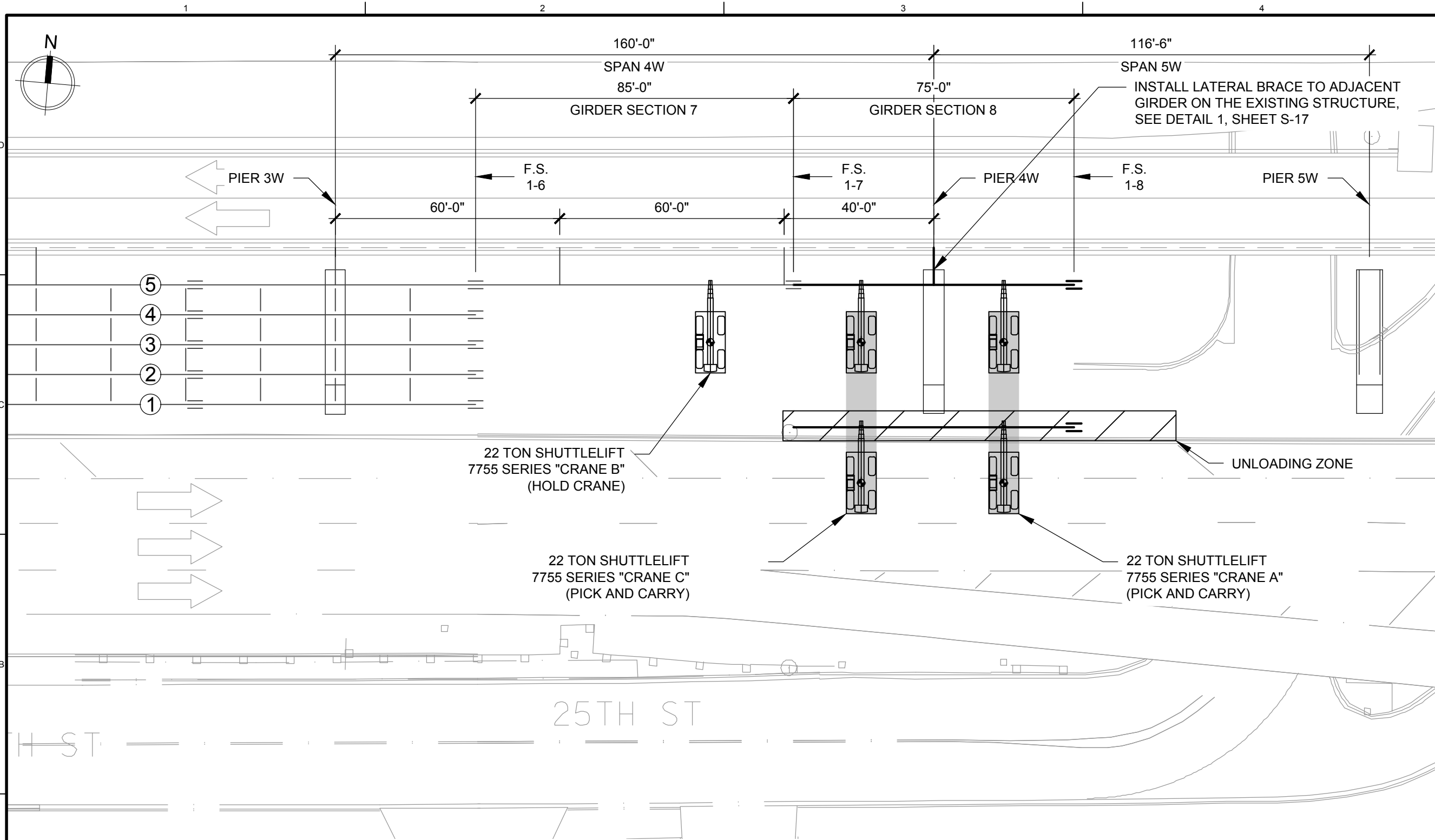
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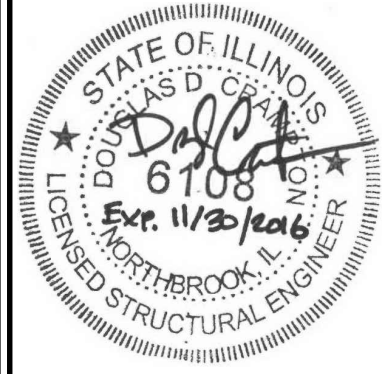
FULL LANE CLOSURE

| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|----------------------------------|------------------|----------------|---------------------|----------------|--------------|--|
| C | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 30,478 LBS | 8 | 5 | 15,500 LBS x 2 = 31,000 LBS ALL BOOM LENGTHS ACCEPTABLE |
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | | | | |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 15,419 LBS (HOLD) | 7 | 5 | 15,500 LBS ALL BOOM LENGTHS ACCEPTABLE |

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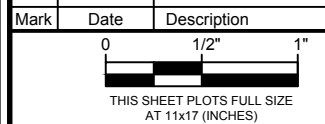
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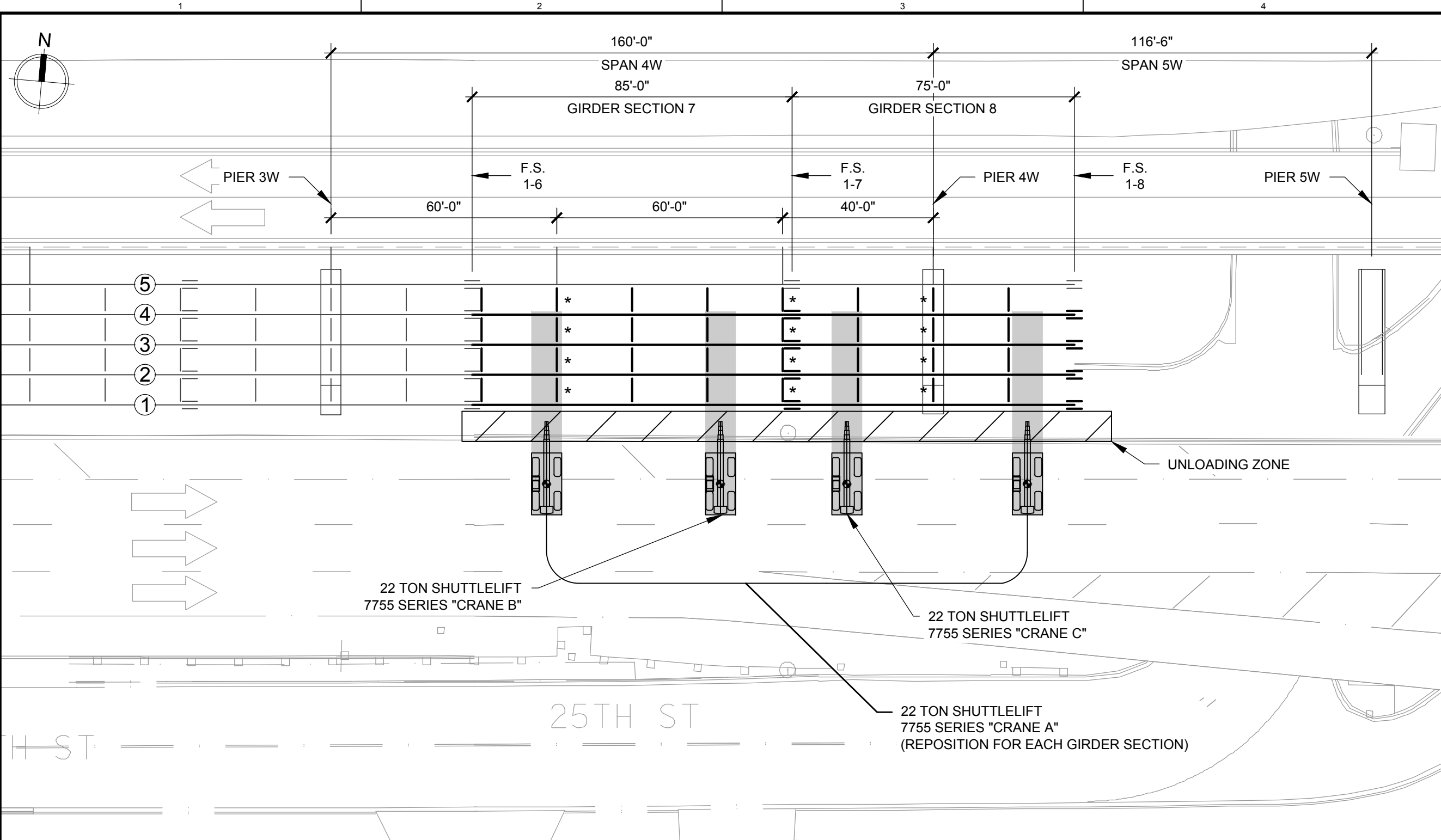
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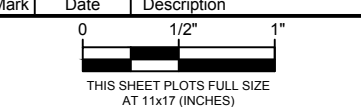


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STAGE I
 SPAN 4W
 PLAN VIEW - 3

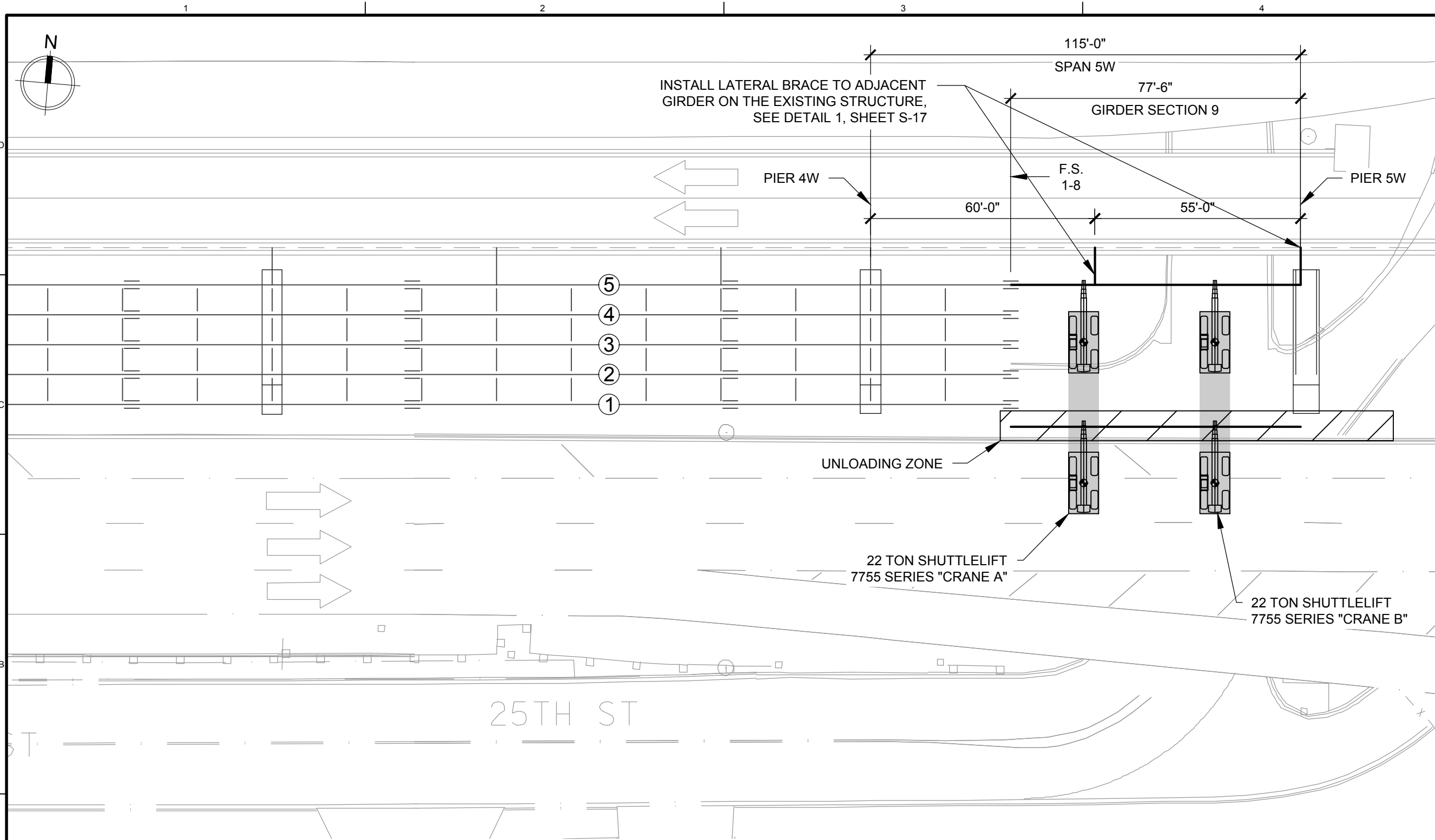
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- NOTES:**
- CRANE SHALL BE ON FULLY EXTENDED OUTRIGGERS WHEN PICKING BEAM SECTIONS OFF DELIVERY TRUCK
- * CROSS FRAMES REQUIRED FOR THE PURPOSE OF ERECTION
- FULL LANE CLOSURE

| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|----------------------------------|------------------|----------------|---------------------|----------------|--------------|--|
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 24,386 LBS | 7 | 4 THRU 1 | 12,400 LBS x 2 = 24,800 LBS ALL BOOM LENGTHS ACCEPTABLE |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | | | | |
| C | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 30,478 LBS | 8 | 4 THRU 1 | 15,500 LBS x 2 = 31,000 LBS ALL BOOM LENGTHS ACCEPTABLE |
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | | | | |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 14 FT | 15,419 LBS (HOLD) | 7 | 4 THRU 1 | 15,500 LBS ALL BOOM LENGTHS ACCEPTABLE |

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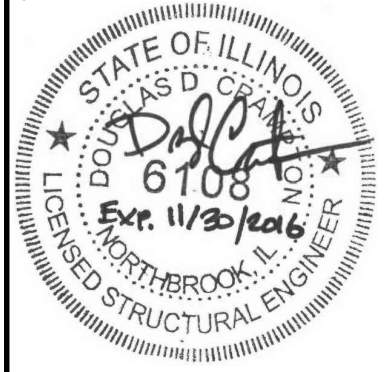
FULL LANE CLOSURE

| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|-------------------------------------|---------------------|----------------|---------------------|----------------|--------------|--|
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 16 FT | 21,847 LBS | 9 | 5 | 12,400 LBS x 2 = 24,800 LBS ALL BOOM LENGTHS ACCEPTABLE |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 16 FT | | | | |

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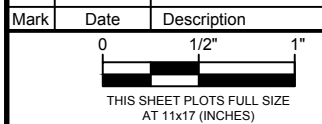
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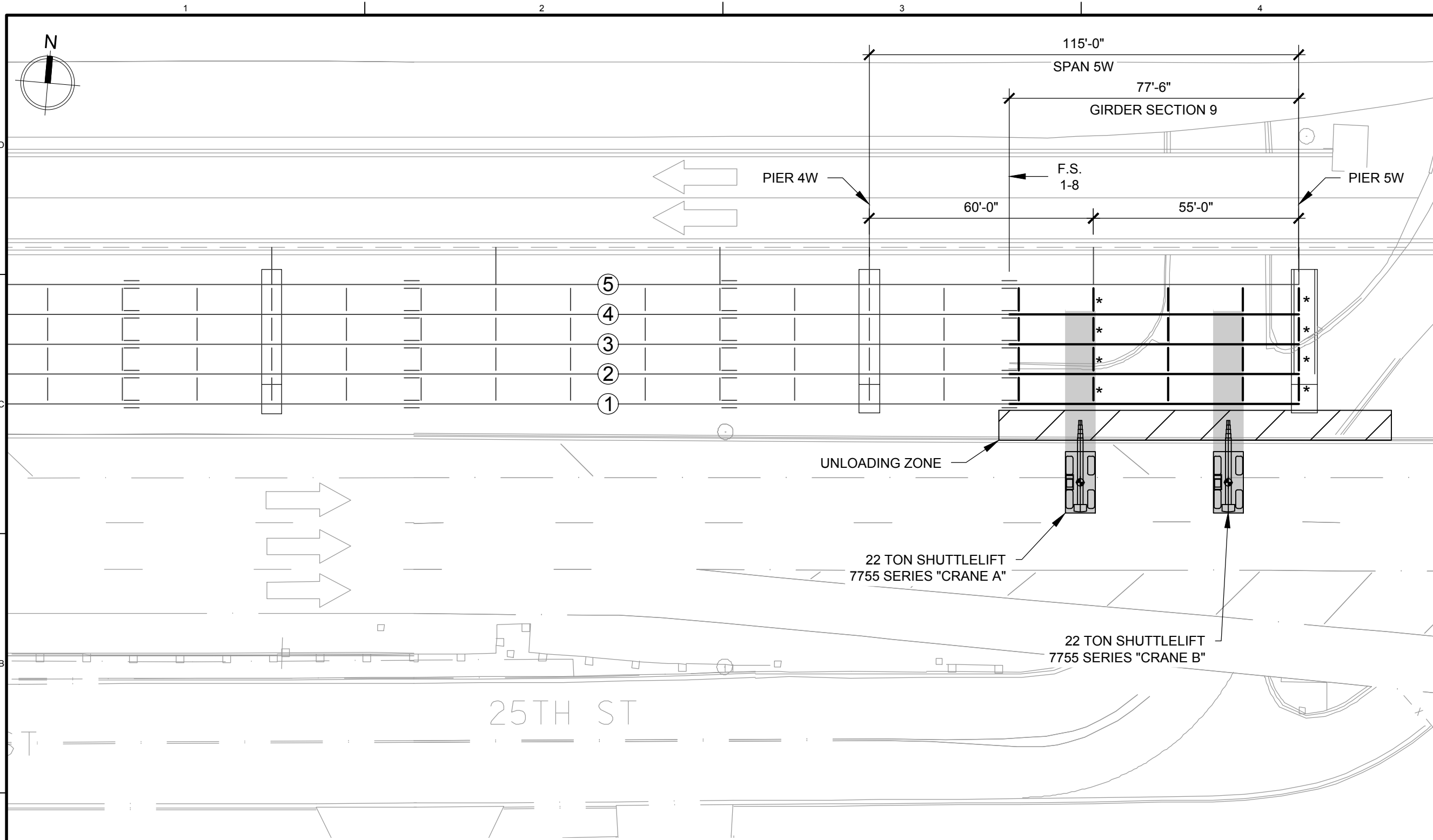
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SPAN 5W
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S-15

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FULL LANE CLOSURE

| | CRANE | COUNTER-WEIGHT | MAXIMUM RADIUS | MAXIMUM PICK WEIGHT | GIRDER SECTION | GIRDER LINES | ACCEPTABLE BOOM LENGTHS AND CAPACITIES |
|---|-------------------------------------|---------------------|----------------|---------------------|----------------|--------------|--|
| A | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 16 FT | 21,847 LBS | 9 | 4 THRU 1 | 12,400 LBS x 2 = 24,800 LBS ALL BOOM LENGTHS ACCEPTABLE |
| B | SHUTTLELIFT (22-TON) 7700 SERIES | NONE (ON RUBBER) | 16 FT | | | | |

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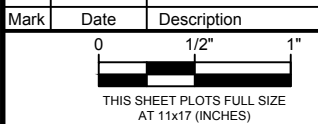
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Scale **N.T.S.**

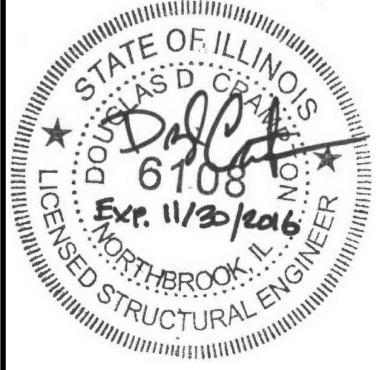
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4245 166th Street
Oak Forest, IL 60452

| | | |
|--|--|--|
| | | |
| | | |
| | | |
| | | |
| | | |

| Mark | Date | Description |
|------|------|-------------|
| 0 | 1/2" | 1" |

THIS SHEET PLOTS FULL SIZE AT 1/16" (INCHES)

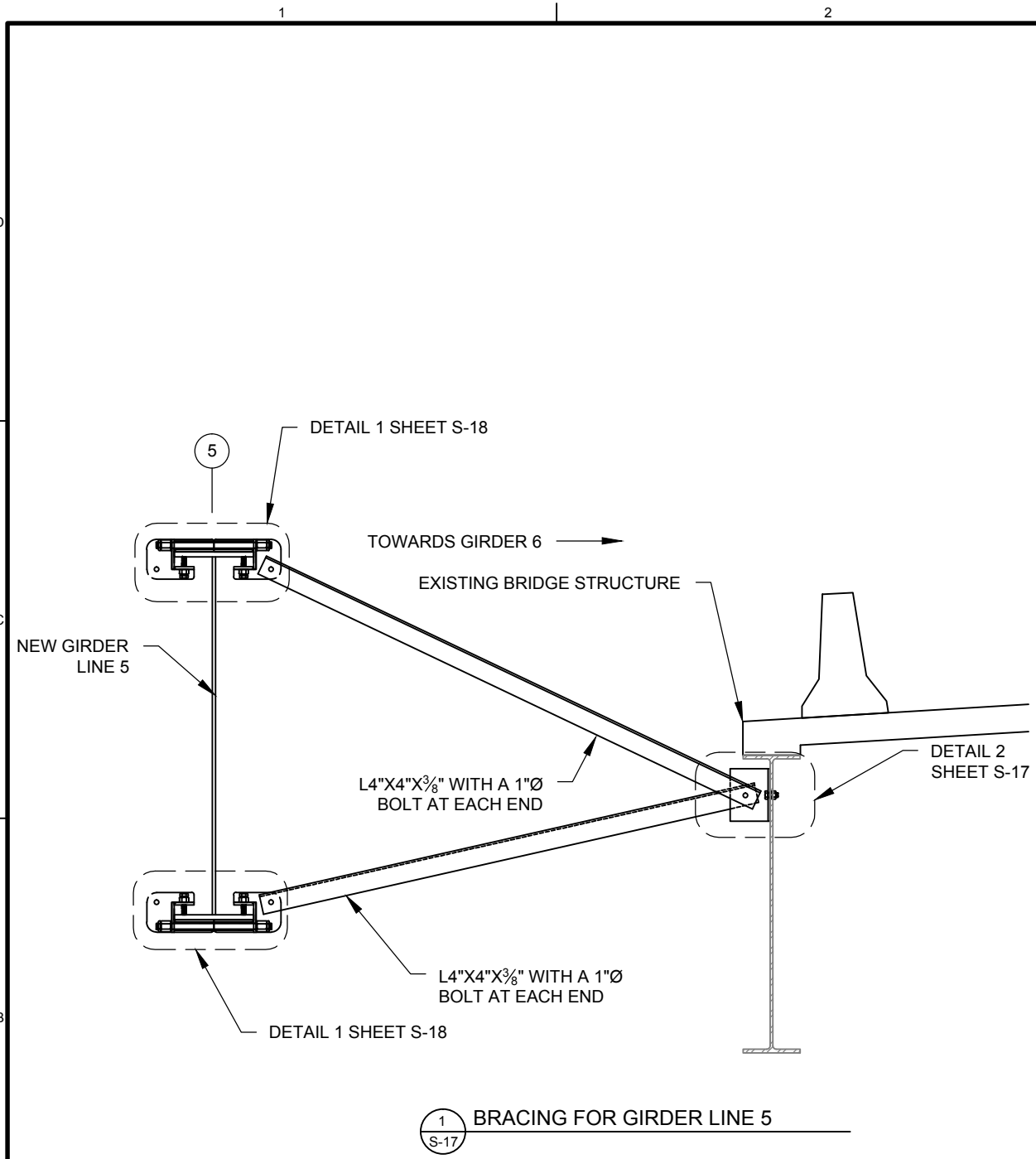
| | |
|-------------|-------------|
| Project No. | 2015.4852.1 |
| Date | 1/14/16 |
| Drawn | JJZ |
| Checked | DDC |
| Scale | N.T.S. |

**STAGE I
BEAM BRACING DETAILS**

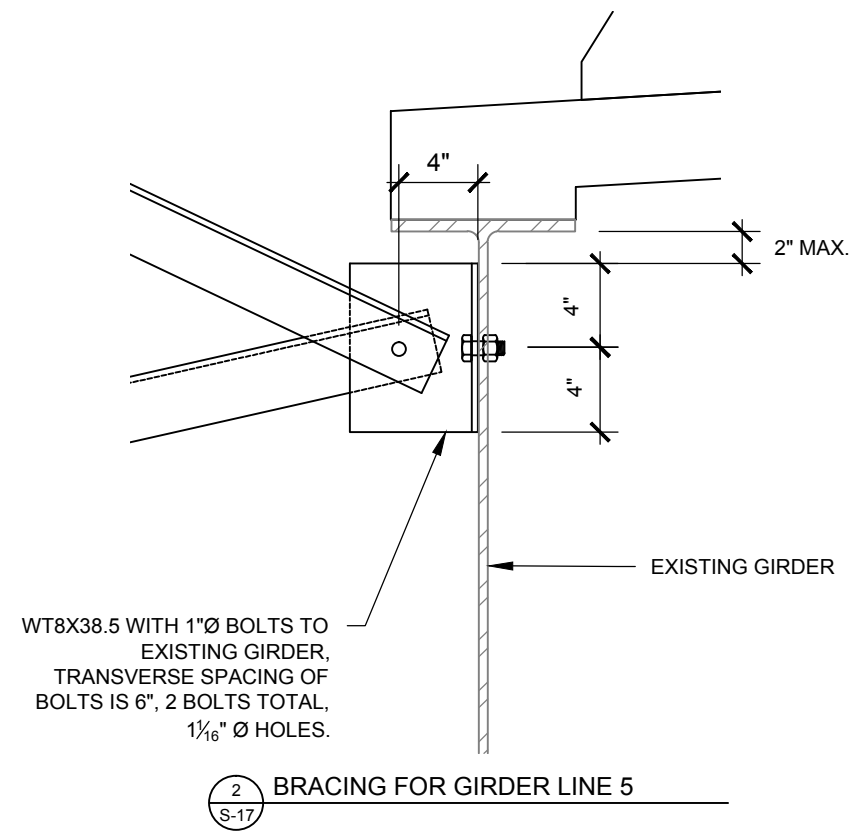
Sheet Title

S-17

Sheet No.

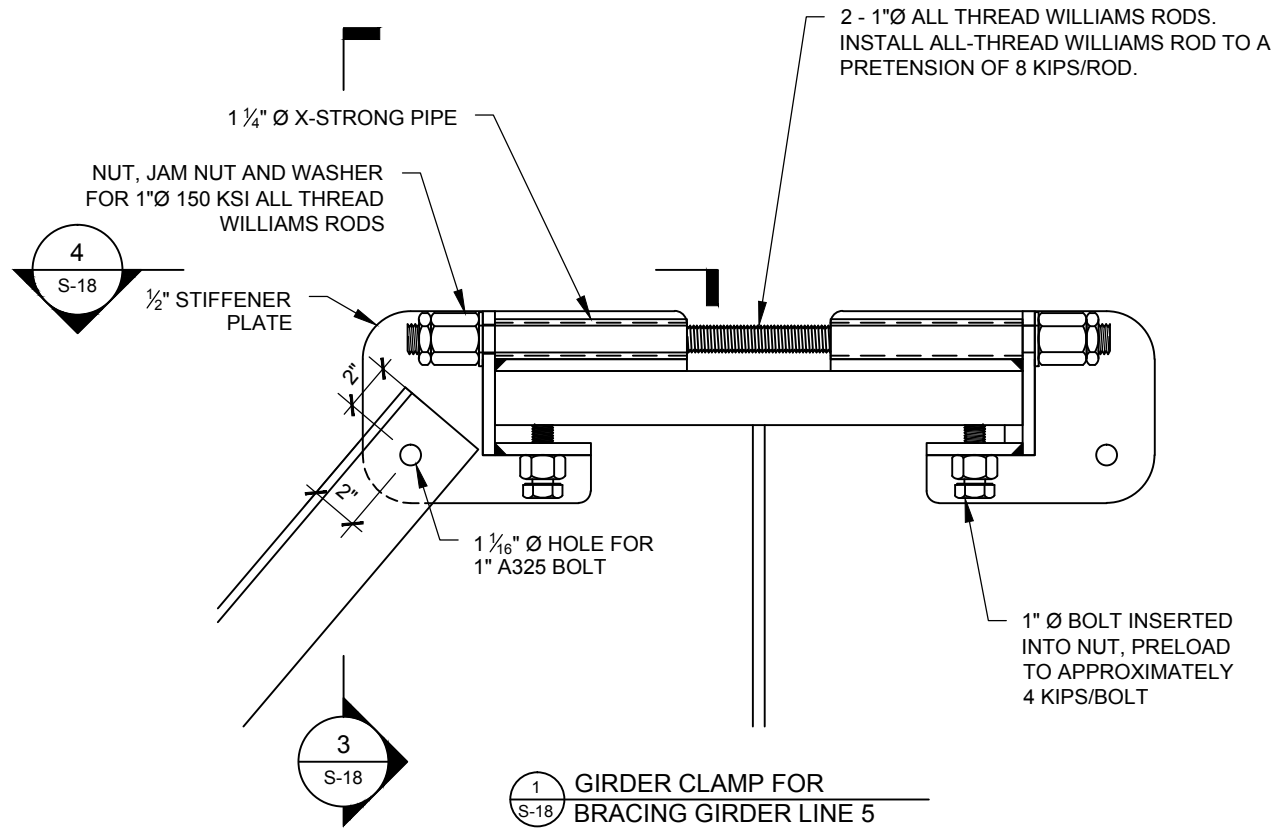


- NOTES:
- BRACING ANGLES SHALL HAVE MAXIMUM ANGLE OF 45° MEASURED FROM THE HORIZONTAL.
 - MAXIMUM LENGTH OF BRACING ANGLE SHALL BE 12 FEET.
 - ANGLES SHALL BE INSTALLED PERPENDICULAR TO THE LENGTH OF THE GIRDER, WHEN VIEWED IN PLAN.

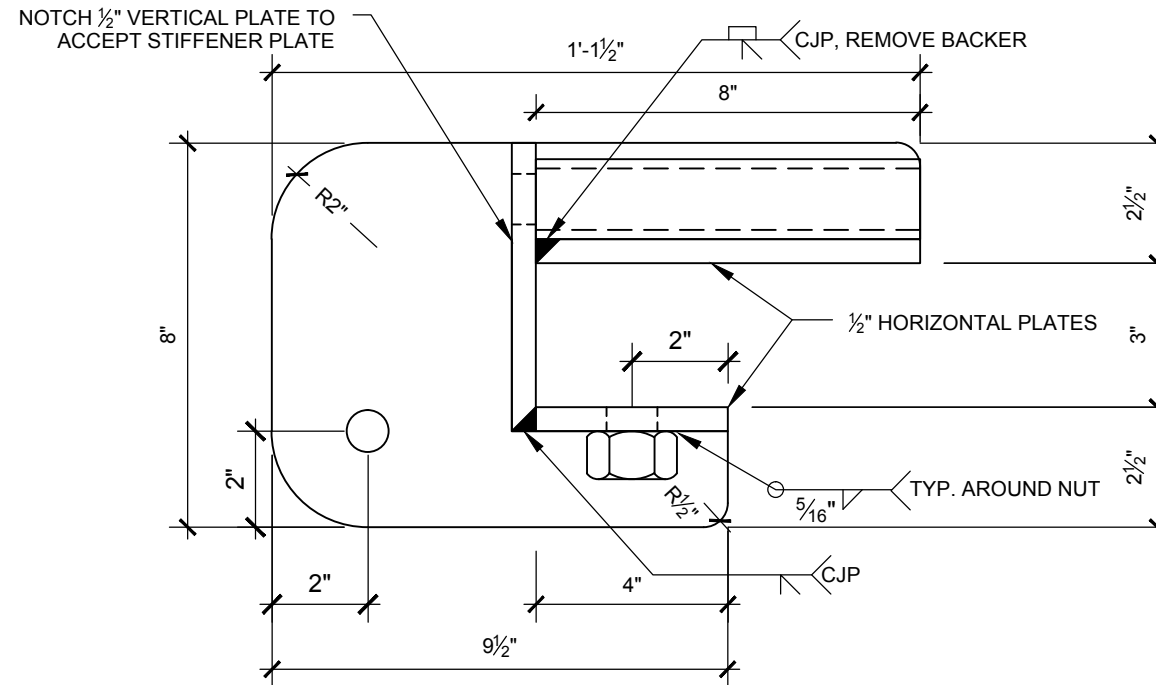


- NOTES:
- BRACING SHALL BE INSTALLED PERPENDICULAR TO THE PLANE OF THE GIRDER WEB (PARALLEL TO THE DIAPHRAGM LINES), WHEN VIEWED IN PLAN.
 - THE CENTERLINE OF THE BRACE/CLAMP SHALL BE INSTALLED WITHIN 6 INCHES OF THE DIAPHRAGM CONNECTION PLATE ON GIRDER LINE 5.
 - THE ACTUAL LENGTH OF THE BRACE MEMBERS SHALL BE VERIFIED IN THE FIELD, BUT SHALL NOT EXCEED 12 FEET.
 - MAXIMUM EDGE DISTANCE IN THE BRACING ANGLE SHALL BE 2" MEASURED FROM THE CENTER OF THE HOLD TO ANY EDGE.

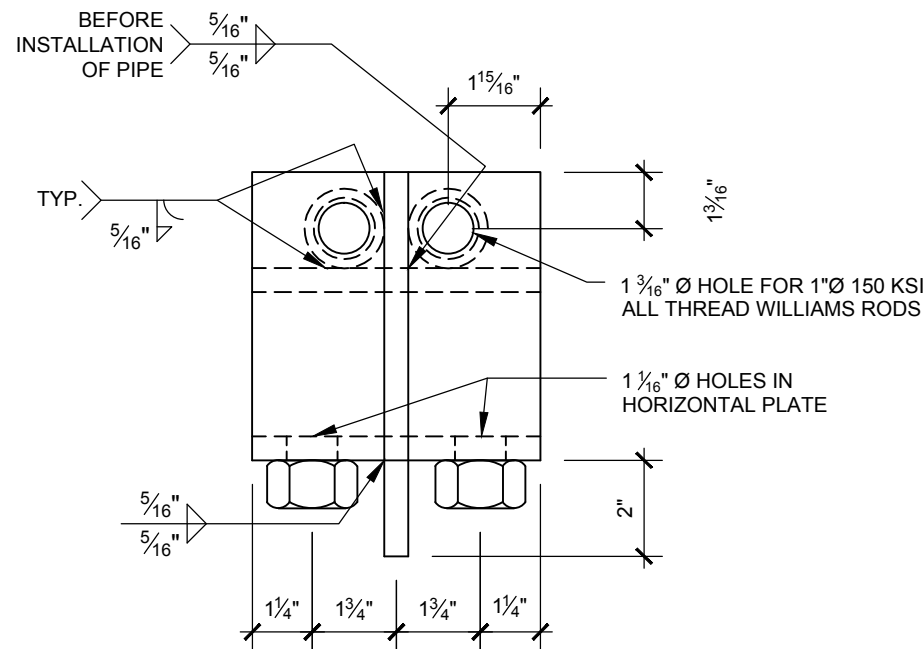
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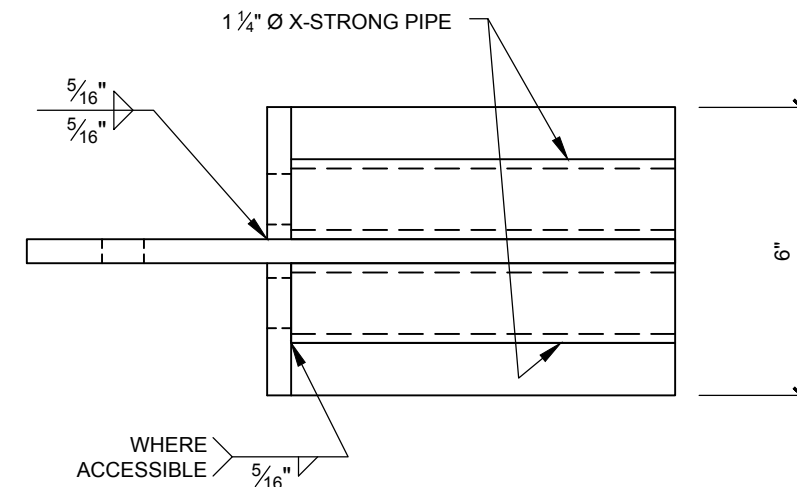
1 GIRDER CLAMP FOR BRACING GIRDER LINE 5



2 GIRDER CLAMP FOR BRACING GIRDER LINE 5



3 END VIEW OF GIRDER CLAMP

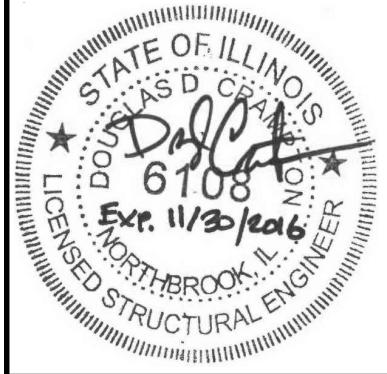


4 TOP VIEW OF GIRDER CLAMP

WJE ENGINEERS ARCHITECTS MATERIALS SCIENTISTS

Wiss, Janney, Elstner Associates, Inc.
330 Pfingsten Road
Northbrook, Illinois 60062
847.272.7400 tel | 847.291.4813 fax
www.wje.com

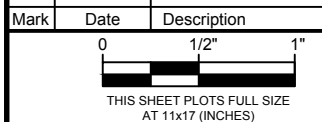
Headquarters & Laboratories: Northbrook, Illinois
Atlanta | Austin | Boston | Chicago | Cleveland | Dallas | Denver | Detroit
Honolulu | Houston | Los Angeles | Minneapolis | New Haven | New York
Princeton | San Francisco | Seattle | Washington, D.C.



Consultant

Project
I-55 and Lake Shore Drive
Interchange Reconstruction
(Outbound Structures)
S.N. 016-1501

Client
S & J Construction
4245 166th Street
Oak Forest, IL 60452



Project No. 2015.4852.1
Date 1/14/16
Drawn JJZ
Checked DDC
Scale N.T.S.

STAGE I
GIRDER CLAMP DETAILS

Sheet Title

Sheet No.

S-18

APPENDIX B: STAGE II ERECTION PROCEDURE AND DRAWINGS

Stage II narrative and drawings omitted for brevity

APPENDIX B: WJE CALCULATIONS

Structural Calculations omitted for brevity

7700 Series


**product
guide**

features

- 22 ton (19.9 mt) capacity 360° on outriggers @ 8.5 ft. (2.6m) radius
- 15 ton (13.6 mt) deck carrying capacity
- 15 ton (13.6 mt) on rubber capacity
- 43 ft. (13.1m) 3-section boom or 67 ft. (20.43m) 5-section boom
- 17 ft. (5.18m) offsettable swingaway extension
- 130 bhp (97.0 kW) Cummins QSB4.5L (Tier III) diesel engine

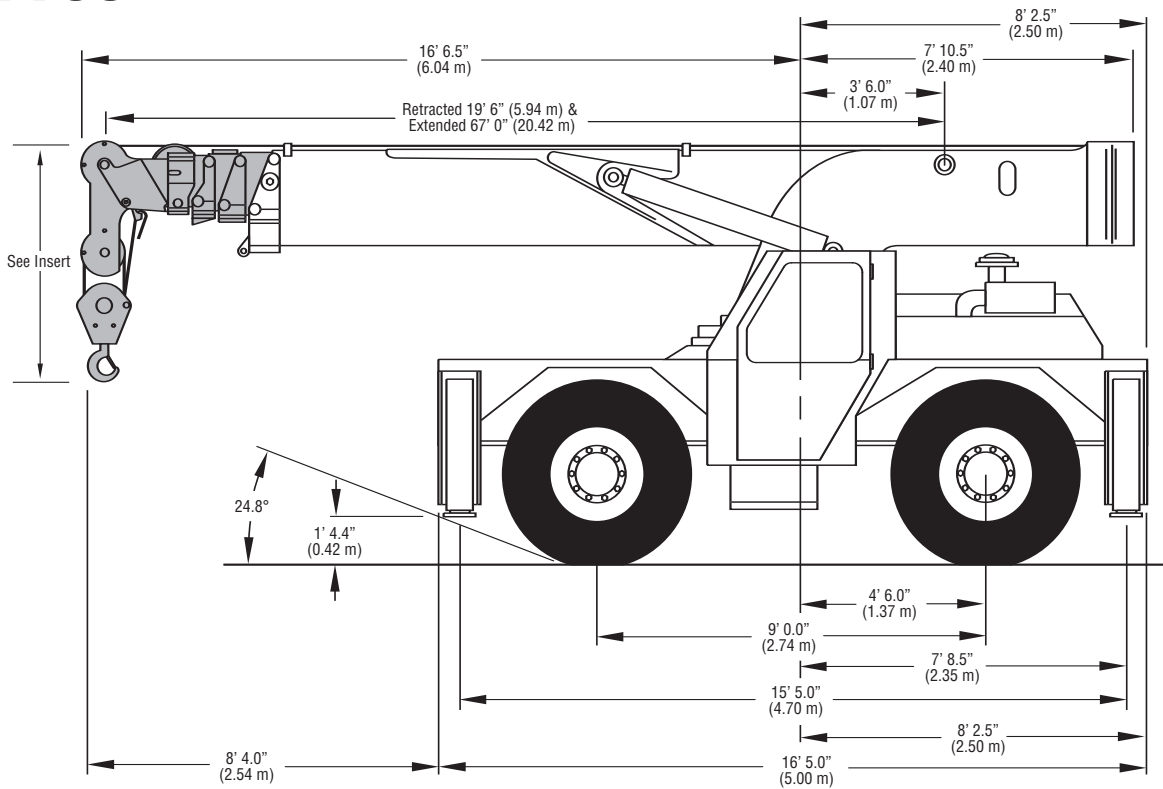


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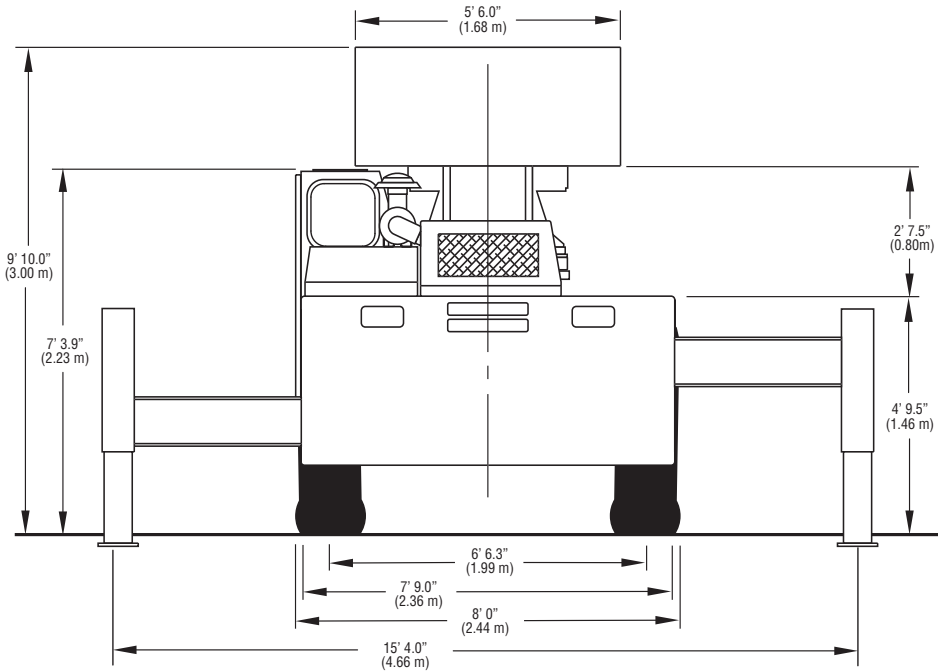
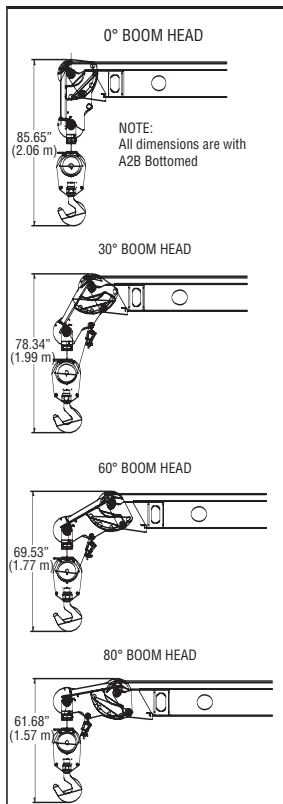
Features
2
Specifications
3
7755
Dimensions
5
7755
Working Range
6
Load Chart
7
7755
Range Diagram
8
Load Chart
9

dimensions

7755



5

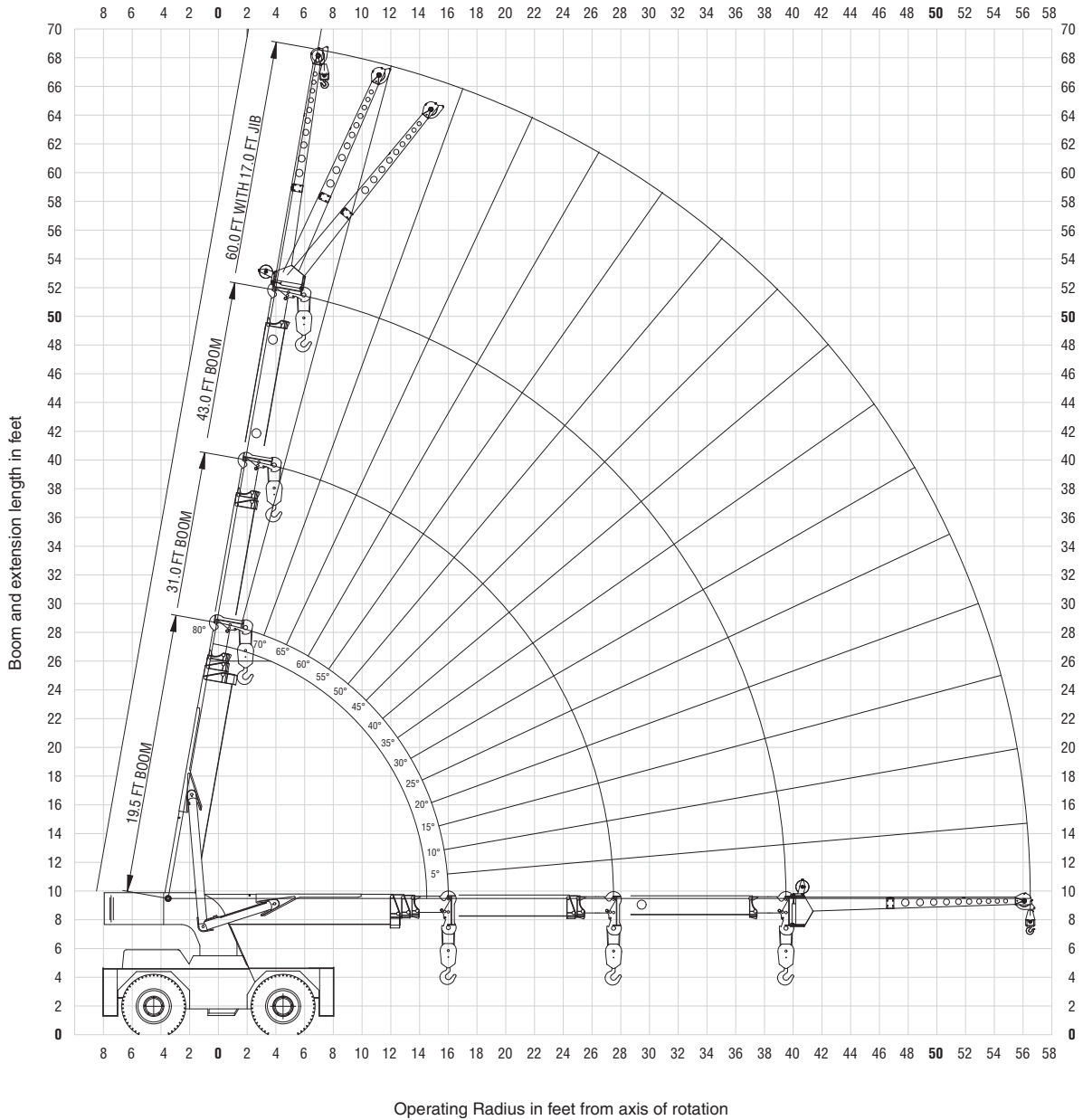


7700 Series

range diagram

7755 (3-section boom)

6



7700 Series

THIS CHART IS ONLY A GUIDE AND SHOULD NOT BE USED TO OPERATE THE CRANE. The individual crane's load chart, operating instructions and other instructional plates must be read and understood prior to operating the crane.

load chart

7755 (3-section boom)

7

| MAIN BOOM LOAD RATINGS ON OUTRIGGERS Extended and Down 360° or Retracted and Down Front/Rear | | | | | | | | MAIN BOOM LOAD RATINGS ON OUTRIGGERS Retracted and Down 360° | | | | | | | | | | | | | |
|---|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|---|------------------------|------------------------|----------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| Radius (ft) | 19.5 ft Boom | | 20.5-30 ft Boom | | 31 ft Boom | | 32-42 ft Boom | | 43 ft Boom | | Radius (ft) | 19.5 ft Boom | | 20.5-30 ft Boom | | 31 ft Boom | | 32-42 ft Boom | | 43 ft Boom | |
| | Boom Angle (deg) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) | | Boom Angle (deg) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) | Rated Load (lbs) |
| 8.5 | 58 | 44000 | 26500 | 71 | 26500 | 25400 | 76 | 25400 | 8.5 | 58 | 31000 | 26500 | 71 | 26500 | 25400 | 76 | 25400 | | | | |
| 10 | 52 | 40000 | 31600 | 68 | 31600 | 28000 | 74 | 28000 | 10 | 52 | 24000 | 22300 | 68 | 22300 | 22000 | 74 | 22000 | | | | |
| 12 | 44 | 33800 | 30500 | 64 | 30500 | 25000 | 72 | 25000 | 12 | 44 | 17200 | 16300 | 64 | 16300 | 16300 | 72 | 17000 | | | | |
| 14 | 33 | 28500 | 28500 | 59 | 28500 | 22600 | 69 | 22600 | 14 | 33 | 13300 | 12500 | 59 | 12500 | 12500 | 69 | 13600 | | | | |
| 16 | 0 | 24900 | 24900 | 55 | 25700 | 20000 | 66 | 20000 | 16 | 0 | 10200 | 9800 | 55 | 9800 | 9800 | 66 | 11100 | | | | |
| 18 | - | - | 22800 | 50 | 22800 | 17900 | 63 | 17900 | 18 | - | - | 7900 | 50 | 7900 | 7900 | 63 | 9100 | | | | |
| 20 | - | - | 20200 | 45 | 20200 | 16100 | 60 | 16100 | 20 | - | - | 6500 | 45 | 6500 | 6500 | 60 | 7500 | | | | |
| 22 | - | - | 17800 | 39 | 17800 | 14600 | 56 | 14600 | 22 | - | - | 5300 | 39 | 5300 | 5300 | 56 | 6200 | | | | |
| 24 | - | - | - | 31 | 15360 | 13300 | 53 | 13300 | 24 | - | - | 4300 | 31 | 4300 | 4300 | 53 | 5200 | | | | |
| 26 | - | - | - | 22 | 13250 | 12300 | 49 | 12300 | 26 | - | - | 3500 | 22 | 3500 | 3500 | 49 | 4400 | | | | |
| 27.5 | - | - | 11600 | 0 | 11600 | 11600 | 47 | 11600 | 27.5 | - | - | 2900 | 0 | 2900 | 2900 | 47 | 3900 | | | | |
| 30 | - | - | - | - | - | 9900 | 42 | 10500 | 30 | - | - | - | - | - | 2600 | 42 | 3200 | | | | |
| 32 | - | - | - | - | - | 8800 | 37 | 9800 | 32 | - | - | - | - | - | 2300 | 37 | 2700 | | | | |
| 34 | - | - | - | - | - | 7800 | 32 | 8700 | 34 | - | - | - | - | - | 1900 | 32 | 2300 | | | | |
| 36 | - | - | - | - | - | 7100 | 26 | 7800 | 36 | - | - | - | - | - | 1750 | 26 | 1900 | | | | |
| 39.5 | - | - | - | - | - | 6400 | 0 | 6400 | 39.5 | - | - | - | - | - | 1400 | 0 | 1400 | | | | |

| Radius (ft) | MAIN BOOM ON RUBBER | |
|----------------|--------------------------|-------------------------|
| | Any Boom Length | |
| | Front Rating (lbs) | 360° Rating (lbs) |
| 6 | 30000 | 21000 |
| 8 | 28000 | 17900 |
| 10 | 25000 | 15000 |
| 12 | 19600 | 12400 |
| 14 | 15600 | 9900 |
| 16 | 12700 | 7700 |
| 18 | 10300 | 6300 |
| 20 | 8300 | 4900 |
| 22 | 6800 | 3900 |
| 24 | 5800 | 3100 |
| 26 | 4900 | 2500 |
| 28 | 4200 | 2100 |
| 30 | 3700 | 1800 |
| 32 | 3300 | 1550 |
| 34 | 3000 | 1300 |
| 36 | 2700 | 1100 |
| 38 | 2500 | 950 |
| 40 | 2200 | 800 |

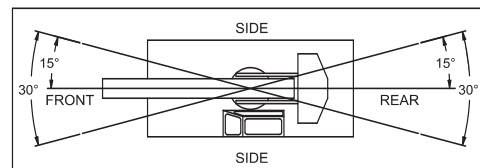
| Main Boom Angle (deg) | 17 FT JIB CAP. ON EXT. OUTRIGGERS (lbs) | | |
|--------------------------------|---|--------|--------|
| | Jib Offset Angle | | |
| | 0 deg | 15 deg | 30 deg |
| 80 | - | 5000 | 3500 |
| 75 | 7500 | 4400 | 3100 |
| 70 | 6100 | 3900 | 2800 |
| 65 | 5000 | 3500 | 2550 |
| 60 | 4300 | 3150 | 2350 |
| 55 | 3800 | 2850 | 2200 |
| 50 | 3400 | 2600 | 2100 |
| 45 | 3050 | 2400 | 2000 |
| 40 | 2800 | 2250 | 1950 |
| 35 | 2600 | 2150 | 1900 |
| 30 | 2400 | 2080 | 1830 |
| 25 | 2300 | 2050 | - |
| 20 | 2200 | 2000 | - |
| 15 | 2100 | 1950 | - |
| 10 | 2050 | - | - |
| 5 | 2020 | - | - |
| 0 | 2000 | - | - |

SHADED AREAS ARE GOVERNED BY STRUCTURAL STRENGTH, DO NOT RELY ON TIPPING.

OPERATION OF THIS EQUIPMENT IN EXCESS OF RATING CHARTS AND DISREGARD OF INSTRUCTIONS IS DANGEROUS AND VOIDS WARRANTY.

MAXIMUM PERMISSIBLE SINGLE LINE PULL = 11,000 lbs

HOIST ROPE: 5/8" diameter
6 x 19 XIPS IWRC BRIGHT
Min. req'd breaking strength = 38,500 lbs



- The rated loads are the maximum lifting capacities as determined by operating radius, boom length, and boom angle. The operating radius is the horizontal distance from a projection of the axis of rotation to the supporting surface, before loading, to the center of vertical hoist line or tackle with load applied.
- Rated load columns for discrete boom lengths apply when actual boom length is within +/- 1.0 ft of discrete length. For other boom lengths, use appropriate intermediate boom length column.
- For operating radius not shown, use load rating of next larger radius.
- The rated loads shown on outriggers do not exceed 85% of actual tipping. The rated loads shown on rubber do not exceed 75% of actual tipping. These ratings are based on freely suspended loads with the crane leveled, standing on a firm, uniform supporting surface. Practical working loads depend on supporting surface, operating radius and other factors affecting stability. Hazardous surroundings, climatic conditions, experience of personnel and proper handling must all be taken into account by the operator.
- The weights of all load handling devices such as hooks, hook blocks, slings, etc., except the hoist rope, shall be considered as part of the load. See reduction chart.
- Ratings on outriggers are for either outriggers fully extended and down or fully retracted and down. Ratings for outriggers fully retracted and down will apply for any intermediate outrigger setting.
- Ratings on rubber depend on tire capacity, condition of tires and proper inflation pressure (110 psi). Loads on rubber may be transported at a maximum speed of 2.5 mph on a smooth hard level surface with boom retracted to the shortest length possible and centered over front. For 360° ratings on rubber, rear axle oscillation locks must be in place. Do not use jib with crane on rubber.
- The maximum combined total boom and deck load is 20,000 lbs. The maximum deck load only is 30,000 lbs.
- Do not induce any external side loads to boom or jib.

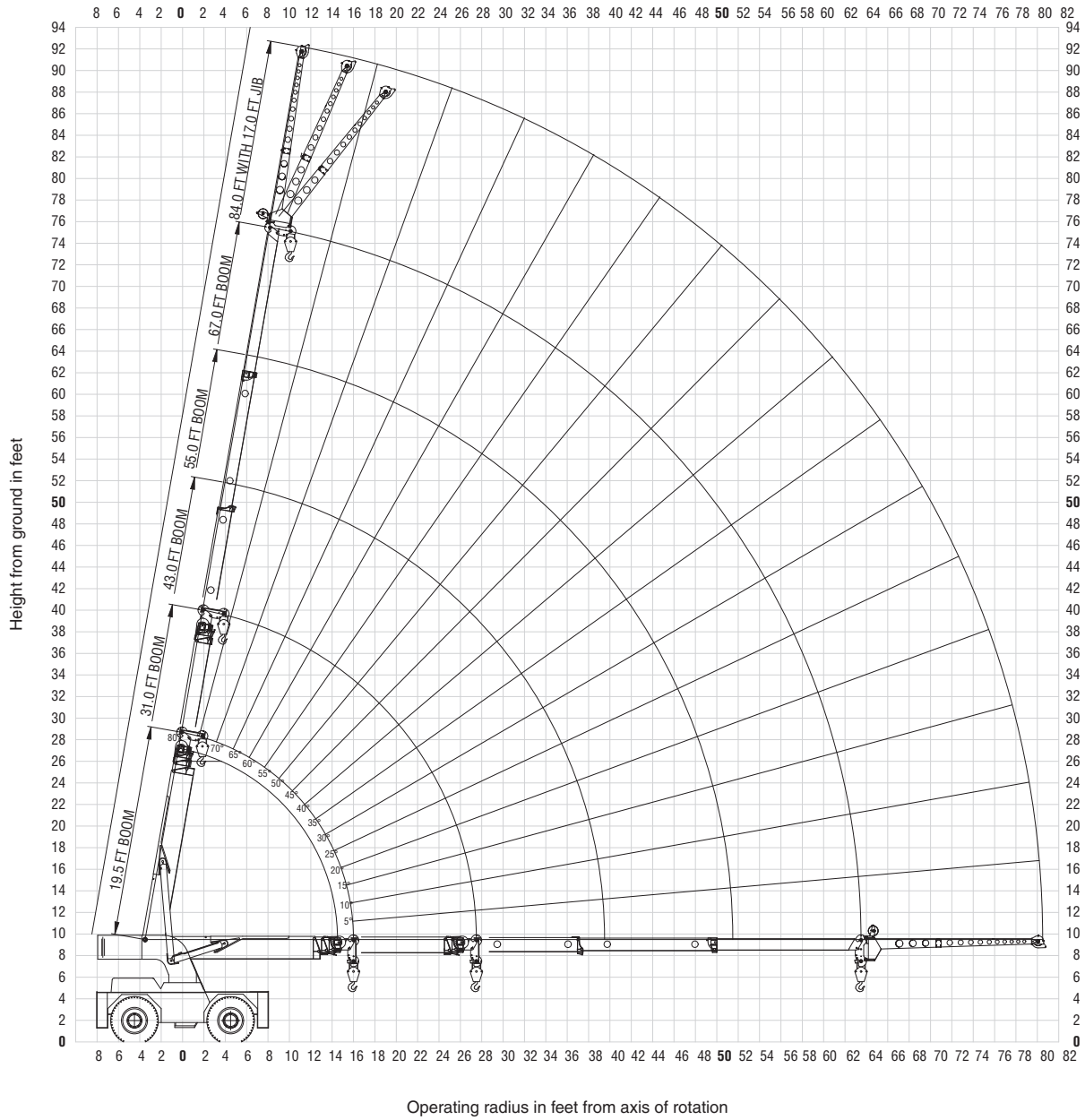
| | RATING REDUCTIONS FOR LOAD HANDLING DEVICES INSTALLED (lbs) | |
|--------------|---|----------|
| | FROM MAIN BOOM | FROM JIB |
| MAIN BLOCK | 400 | N/A |
| HOOK & BALL | 100 | 100 |
| JIB STOWED | 0 | N/A |
| JIB DEPLOYED | 500 | 0 |

THIS CHART IS ONLY A GUIDE AND SHOULD NOT BE USED TO OPERATE THE CRANE. The individual crane's load chart, operating instructions and other instructional plates must be read and understood prior to operating the crane.

range diagram

7755 (5-section boom)

8



7700 Series

THIS CHART IS ONLY A GUIDE AND SHOULD NOT BE USED TO OPERATE THE CRANE. The individual crane's load chart, operating instructions and other instructional plates must be read and understood prior to operating the crane.

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Fax: +82 2 3439 0405

Philippines

Makati City

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Niella Tanaro

Portugal

Baltar

Fânzeres

Slovakia

Saris

U.S.A.

Manitowoc

Port Washington

Shady Grove



Constant improvement and engineering progress make it necessary that we reserve the right to make specification, equipment and price changes without notice. Illustrations shown may include optional equipment and accessories, and may not include all standard equipment.

Crosby® Clamp-Co Beam Clamps

CCBC



Crosby Clamp-Co Beam Clamps provide an efficient method for handling wide flange beam sections and plate girders. When lifting, these beam clamps grip the beam at three points, and when properly balanced and safely guided, the beam can be handled even if the clamp is slightly off center lengthwise.

- Capacities: 5 Tons to 35 Tons
- Eliminates the need for slings, chokers, and spreader bars.
- When applied to load, the tongs automatically open and slide under the flange of the beam.
- Center plate and gripping tongs work together - the heavier the beam, the greater the clamping pressure.
- Model "NS" clamps have a recessed base to accept studs welded to the beam surface.
- Individually Proof Tested to 2 times the Working Load Limit with certification.
- Finish - Red Paint.
- All sizes are **RFID EQUIPPED**.

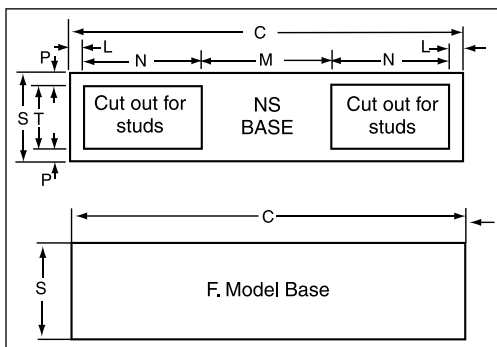
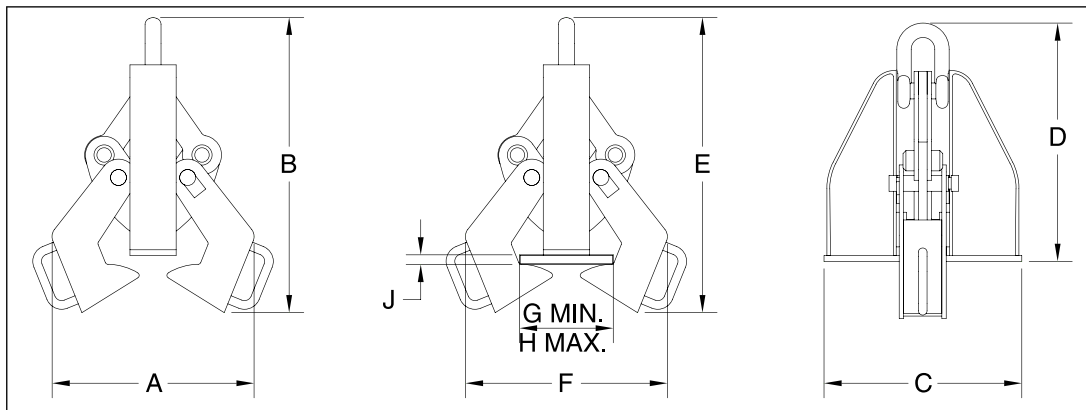


NOTE: Control the beam at all times. Beams should be gripped as near the center as possible. Snubbing lines at each end must be used to control excessive twisting or swinging, and to guide the beam to its proper place. Each lifting situation may have a specific demand which should be addressed before lifting.

Beam Clamps

| Model No. | CCBC-500 Stock No. | Working Load Limit (Tons)* | Flange Grip Range (in.) | | Weight Each (lbs.) | Dimensions (in.) | | | | | | | | | |
|-----------|--------------------|----------------------------|-------------------------|-----------|--------------------|------------------|-------|-------|-------|-------|-------|-------|-------|------|--|
| | | | Width | Thickness | | A | B | C | D | E | F | G | H | J | |
| F-5 | 2732000 | 5 | 4 - 10 | .5 - 1 | 70.0 | 9.50 | 26.00 | 12.00 | 20.00 | 25.50 | 16.00 | 4.00 | 10.00 | 1.00 | |
| F-15 | 2732009 | 15 | 7 - 17 | .5 - 2 | 153 | 15.50 | 34.00 | 17.00 | 27.00 | 34.50 | 25.00 | 7.00 | 17.00 | 2.00 | |
| NS-15 | 2732018 | 15 | 7 - 17 | .5 - 2 | 153 | 15.50 | 34.00 | 17.00 | 27.00 | 34.50 | 25.00 | 7.00 | 17.00 | 2.00 | |
| F-25 | 2732027 | 25 | 16 - 24 | 1 - 3 | 290 | 23.00 | 48.00 | 22.25 | 36.00 | 53.00 | 37.25 | 16.00 | 24.00 | 3.00 | |
| NS-25 | 2732036 | 25 | 16 - 24 | 1 - 3 | 290 | 23.00 | 48.00 | 22.25 | 36.00 | 53.00 | 37.25 | 16.00 | 24.00 | 3.00 | |
| F-35 | 2732045 | 35 | 16 - 36 | 1.63 - 4 | 519 | 30.00 | 64.00 | 27.50 | 48.00 | 58.00 | 53.00 | 16.00 | 36.00 | 4.00 | |
| NS-35 | 2732054 | 35 | 16 - 36 | 1.63 - 4 | 519 | 30.00 | 64.00 | 27.50 | 48.00 | 58.00 | 53.00 | 16.00 | 36.00 | 4.00 | |

* Maximum Proof Load is 2 times the Working Load Limit and design factor based on EN13155 and ASME B30.20.
NOTE: : For beam clamps larger than 35 Tons, please contact the Crosby Special Engineered Products Department.



| Base Stock No. | Base Dimensions (in.) | | | | | | |
|----------------|-----------------------|-----|------|------|-----|------|------|
| | C | L | M | N | P | S | T |
| F-5 | 13.50 | - | - | - | - | 3.00 | - |
| F-15 | 17.00 | - | - | - | - | 4.00 | - |
| NS-15 | 17.00 | .50 | 6.50 | 4.50 | .75 | 4.00 | 2.50 |
| F-25 | 22.25 | - | - | - | - | 5.50 | - |
| NS-25 | 22.25 | .75 | 7.75 | 6.50 | .75 | 5.50 | 4.00 |
| F-35 | 27.50 | - | - | - | - | 6.00 | - |
| NS-35 | 27.50 | .75 | 9.00 | 8.50 | .75 | 6.00 | 4.50 |

APPENDIX C

**CONSTRUCTION INSPECTOR'S CHECKLIST
FOR
STRUCTURAL STEEL BOLTING**

The installation of fasteners in bridge connections is a critical element in the proper behavior of the structure. All connections are to be installed, tightened and inspected in accordance with the latest issue of the Specifications for Structural Joints using A325 or A490 Bolts for slip critical connections as issued by the Research Council on Structural Connections of the Engineering Foundation. The pertinent parts of this specification are discussed in detail in Section 500 of the Construction Manual. While its use is not required, this checklist is provided to give the inspector a quick overview of the requirements. Before beginning any fastener installation the inspector should read and be familiar with all of the requirements for the type of fastener used. If your answer to any of the following questions is no, STOP and review the required information before continuing.

1. PRE-INSTALLATION INSPECTION

Have you read Section 505 of the Standard Specifications, the Supplemental Specifications, the Special Provisions and Section 500 of the Construction Manual? _____

Are all fasteners being stored in their original containers so that they are protected from dirt and moisture or intermixing of lots? Lids should be on and the containers not stored under plastic. _____

Do all delivered fastener assemblies have approved manufacturer's markings? Markings should be on the containers, not just the lids. (505.04)(f)(3)(f)(1) _____

CONTAINER INFORMATION REQUIREMENTS:

- A. Manufacturer identification
- B. Contents
- C. Component lot numbers (verify with MCTR)
- D. R-C lot number

Have you received the required certifications from the mill, the manufacturer and/or distributor? (505.04)(f)(3)(f)(2) _____

MILL TEST REPORT (MTR) 505.04(f)(3)(e)(1)

- A. From steel producer on their form
- B. One report for each component
- C. Report must contain following:
 - 1. Heat number
 - 2. Chemical analysis
 - 3. Location where melted and manufactured
 - 4. Location where tests conducted
 - 5. Date of tests

MANUFACTURER CERTIFIED TEST REPORT (MCTR) 505.04(f)(3)(e)(2)

- A. From each component manufacturer to document any tests they performed
- B. Report must contain the following:

- 1. Mill heat numbers (verify with MTR)
- 2. Manufacturer lot number (verify with container)
- 3. Test results

| | | | |
|----------------------------|---|-----------------------|-------------|
| BOLT | A. Proof load test minimum values: | 1/2 in. bolt | 12,050 lbs. |
| | | 5/8 in. bolt | 19,200 lbs. |
| | | 3/4 in. bolt | 28,400 lbs. |
| | | 7/8 in. bolt | 39,250 lbs. |
| | | 1 in. bolt | 51,500 lbs. |
| | B. Wedge tensile test (10° with no head failures 1/4 in. to 1 in.) (6° with no head failures over 1 in.) minimum values: | 1/2 in. bolt | 17,050 lbs. |
| | | 5/8 in. bolt | 27,100 lbs. |
| | | 3/4 in. bolt | 40,100 lbs. |
| | | 7/8 in. bolt | 55,450 lbs. |
| | | 1 in. bolt | 72,700 lbs. |
| C. Hardness test | ≤ to 1 in. bolt | min. 24RC | max. 34RC |
| | > 1 in. bolt | min. 19RC | max. 31RC |
| D. Galvanization thickness | | min. 2 ml. | max. 6 ml. |
| E. R-C test | <ul style="list-style-type: none"> 1. Component lot number 2. R-C lot number 3. Location and date of tests | | |
| NUT | A. Proof load test minimum values: | 1/2 in. nut | 20,450 lbs. |
| | | 5/8 in. nut | 32,550 lbs. |
| | | 3/4 in. nut | 48,100 lbs. |
| | | 7/8 in. nut | 66,550 lbs. |
| | | 1 in. nut | 87,250 lbs. |
| B. Hardness test | C and C3 nuts | B78 to C38 | |
| | DH and 2H nuts | C24 to C38 | |
| C. Galvanization thickness | | min. 2 ml. | max. 6 ml. |
| WASHER | A. Hardness test | black and mech. galv. | C38 to C45 |
| | | hot dip galv. | C26 to C45 |
| | B. Galvanization test | min. 2 ml. | max. 6 ml. |

- 4. Certification statement

DISTRIBUTOR CERTIFIED TEST REPORT (DCTR) 505.04(f)(3)(e)(3)

- A. Prepared by distributor
- B. Documents R-C tests they performed and lot numbers assigned
- C. Must contain the following:
 - 1. Manufacturer lot numbers (verify with MCTR)
 - 2. R-C test results
 - 3. Location and date of tests
 - 4. R-C lot numbers
 - 5. Certification statement

NOTE: Galvanized fastener assemblies must have all physical tests performed after galvanization. Therefore the test results could be on either the MCTR or the DCTR depending on who had the components coated.

Do all containers have an ILL OK stamp on them or have you received a letter from the Bureau of Materials and Physical Research approving the fasteners? If not, have you sent the required samples to Materials for testing? No installation should begin until you have received the results. _____

Do all delivered fasteners have lubrication? Black fasteners should be oily to the touch; galvanized nuts should have a visible tinted lubricant on them. (505.04)(f)(4)(g)(2a & b), 1006.08 _____

Has the contractor supplied a tension calibrating device? The device must have been calibrated within the last year and the calibration results must be included. The device must be capable of testing the following minimum bolt lengths (505.04)(f)(2):
5/8" and 3/4" : 2"
7/8" : 2.25"
1" : 2.5" _____

Have you performed rotational capacity tests on two assemblies from each rotational capacity lot and recorded the results? (505.04)(f)(3)(g)(1) _____

INSPECTION DURING INSTALLATION

Has the contractor demonstrated that the procedure to be used by the bolting crew will provide the required tension in a tension calibrating device? Does each bolting crew member fully understand the tightening procedure to be used? (505.04)(f)(2) _____

Are only enough fasteners that can be used during a work shift being removed from storage and are all unused fasteners being returned to storage in their original containers at the end of each work shift? _____

Are all of the holes in the splices and field connections being filled with bolts before any bolt tightening is begun? On continuous span beams no bolt tightening shall begin until the entire length is in place. (505.04)(f)(2) _____

Are all fasteners in a connection being brought to snug tight before final tightening is begun? Snug tight should bring all the plies of a connection into _____

contact with each other. Start at the most rigid part (near the center) of the connection and work toward the free edges. (505.04)(f)(2) _____

Are all fasteners being brought to the required minimum tension in accordance with the Specifications? Start at the most rigid part (near the center) of a connection and work toward the free edges. (505.04)(f)(2) _____

If at any time during installation you suspect the level of lubrication of the fastener has changed, are you conducting additional rotational capacity testing? _____

Are you monitoring the installation to assure that the installation method is being properly applied? _____

Are you inspecting each completed connection as required by the specification for the type of fastener used? _____

Galvanized and A490 bolts can not be reused. A325 black bolts may be reused if allowed by your supervisor. Additional tightening is not considered reuse. _____

TURN-OF-THE-NUT METHOD

After snug tightening has each bolt or socket been marked so that the required turn can be verified? (505.04)(f)(2)(d) _____

Is the unturned element being prevented from turning? _____

If impact wrenches are being used, are they of sufficient capacity so that the required turn is being performed in approximately 10 seconds? _____

Is tightening progressing from the most rigid part (near the center) to the free edges? _____

Are all bolts being tightened using the required turn of the nut? _____

Are you visually checking the match marks to ensure that each fastener has been turned the amount necessary to achieve the required minimum tension? (505.04)(f)(2)(d)(2) _____

TWIST-OFF BOLTS

Following the snug tightening operation, are all fasteners being tightened until the control or indicator element is twisted off? (505.04)(f)(2)(b) _____

Is tightening progressing from the most rigid part (near the center) to the free edges? (505.04)(f)(2) _____

Are you monitoring the tightening operation to ensure that the proper procedure is routinely being followed? _____

Are you visually checking that each control or indicator element has sheared? _____

Are you tapping each fastener with a hammer to ensure there are no loose fasteners? _____

Is the Contractor cleaning and painting the exposed end? Cleaning may be accomplished with a wire brush or power tool. Painting shall consist of one coat (5.0 mils minimum thickness) of an approved high-build aluminum epoxy mastic. (505.04)(f)(2) _____

LOCK PIN AND COLLAR

Following the snug tightening operation, are all fasteners being tightened until the control or indicator element is broken off? (505.04)(f)(2)(c) _____

Is tightening progressing from the most rigid part (near the center) to the free edges? (505.04)(f)(2) _____

Are you monitoring the tightening operation to ensure that the proper procedure is routinely being followed? _____

Are you visually checking that each control or indicator element has broken? Are you randomly measuring the collar dimensions to ensure they are within the allowable tolerances shown in the manufacturer's table? (505.04)(f)(2)(c) _____

Is the Contractor cleaning and painting the exposed end? Cleaning may be accomplished with a wire brush or power tool. Painting shall consist of one coat (5.0 mils minimum thickness) of an approved high-build aluminum epoxy mastic. (505.04)(f)(2) _____

DIRECT TENSION INDICATORS

Following the snug tightening operation, are you checking that the number of spaces in which a 0.005 inch gage is refused does not exceed the allowable value? (505.04)(f)(2)(a)(2) _____

Is tightening progressing from the most rigid part (near the center) to the free edges? (505.04)(f)(2) _____

Are you monitoring the tightening operation to ensure that the proper procedure is routinely being followed? _____

Are you visually checking that all gaps are not completely closed? (505.04)(f)(2)(a)(2) _____

Are you checking that the number of spaces in which a 0.005 inch gage is refused is equal to or greater than the allowable value? (505.04)(f)(2)(a)(2) _____

The test procedure, as detailed in Section 500 of the Construction Manual, should be followed when filling out this form. One worksheet shall be filled out for each rotational capacity lot number used on the project.

County _____

Section _____

Route _____

District _____

Contract No. _____

Job No. _____

Project _____

1. Bolt Grade: A325 A490

2. Assigned R-C LOT NUMBER: _____

Bolt

Nut

Washer

3. Manufacturer: _____

Lot Number: _____

4. Bolt Diameter: _____ Inch

Bolt Length: _____ Inches

| | Sample I | Sample II |
|--|-----------------------------|-----------------------------|
| 5. Measured Tension | _____ kips | _____ kips |
| 6. Measured Torque | _____ ft - lbs | _____ ft - lbs |
| 7. Maximum Permitted Torque (see back) | _____ ft - lbs | _____ ft - lbs |
| | <input type="checkbox"/> OK | <input type="checkbox"/> OK |
| after twice the installation rotation: | | |
| 8. Measured Tension | _____ kips | _____ kips |
| 9. Minimum Tension (see back) | _____ kips | _____ kips |
| | <input type="checkbox"/> OK | <input type="checkbox"/> OK |
| 10. Verify Thread Condition | <input type="checkbox"/> OK | <input type="checkbox"/> OK |

Tested by: _____

Witnessed by: _____

Date: _____

Location: _____

Rotational Capacity Maximum Torque (step 7 on front side)

| 3/4 Inch | | 7/8 Inch | |
|-----------------|--------|-----------------|--------|
| Tension | Torque | Tension | Torque |
| kips | ft-lbs | kips | ft-lbs |
| 28 | 437 | 39 | 711 |
| 29 | 453 | 40 | 729 |
| 30 | 469 | 41 | 747 |
| 31 | 484 | 42 | 766 |
| 32 | 500 | 43 | 784 |
| 33 | 516 | 44 | 802 |
| 34 | 531 | 45 | 820 |
| 35 | 547 | 46 | 839 |
| 36 | 562 | 47 | 857 |
| 37 | 578 | 48 | 875 |
| 38 | 594 | 49 | 893 |
| 39 | 609 | 50 | 911 |
| 40 | 625 | 51 | 930 |
| 41 | 641 | 52 | 948 |
| 42 | 656 | 53 | 966 |
| 43 | 672 | 54 | 984 |
| 44 | 688 | 55 | 1003 |
| 45 | 703 | 56 | 1021 |
| 46 | 719 | 57 | 1039 |
| 47 | 734 | 58 | 1057 |
| 48 | 750 | 59 | 1076 |
| 49 | 766 | 60 | 1094 |
| 50 | 781 | 61 | 1112 |
| | | 62 | 1130 |
| | | 63 | 1148 |
| | | 64 | 1167 |
| | | 65 | 1185 |

Minimum Measured Tension (step 9 on front side)

| | A325 bolt | A490 bolt |
|----------|-----------|-----------|
| 3/4 inch | 32 | 40 |
| 7/8 inch | 45 | 56 |

State of Illinois
Department Of Transportation

**CONSTRUCTION INSPECTOR'S CHECKLIST
FOR
BRIDGE SUPERSTRUCTURES**

While its use is not required, this checklist has been prepared to provide the field inspector a summary of easy-to-read step-by-step requirements relative to the proper construction of all cast-in-place concrete bridge decks ([Section 503](#)). The following questions are based on and referenced to information found in the [Standard and Supplemental Specifications, Highway Standards](#), appropriate sections of the Construction Manual ("CM"), the Manual of Test Procedures for Materials ("MTPM") and the [Project Procedures Guide](#) ("PPG").

1. PREPARATION PRIOR TO SUPERSTRUCTURE CONSTRUCTION

a. Office Review (General Items)

- (1) Have you thoroughly reviewed the Contract [Special Provisions, Plans and the Standard and Supplemental Specifications](#)? _____
- (2) Have you computed the volume of BS Concrete (see Art.1020.04) and the weight (mass) of Reinforcement Bars for comparison with the quantity shown in the bill of materials? This will help familiarize you with the plans, find plan errors prior to starting construction, and satisfy part of your documentation requirements. (Note: This is not a documentation requirement if Form [BC 981](#), Agreement On Accuracy of Plan Quantities is jointly signed.) _____
- (3) Have you reviewed the [Project Procedure Guide](#) ("PPG") for minimum testing requirements? _____
- (4) If this contract contains the Recurring Special Provision for Quality Control/Quality Assurance (QC/QA) of Concrete Mixtures, have you reviewed the QC/QA special provision and discussed its requirements with the district Materials office? In addition, has the district Materials office approved the contractor's Quality Control Plan? _____
- (5) Have you determined what material must be inspected prior to incorporation into the work and what material certifications are required? (See [PPG Attachment 3](#)) _____
- (6) Have you reviewed the appropriate sections of the Construction Manual (CM): [Section 500](#), the CM [Documentation Section](#), the CM [Forms Section](#), Construction Memorandum Nos. [39, 45, 64, 72, 73, 74 and 78](#), and the [Project Procedures Guide](#) (PPG)? _____

- (7) If this contract contains the Structural Assessment Reports special provision (SARs), have the submittal requirements been fulfilled? (Note per the SAR special provision, separate portions of work may be covered by separate SARs. Thus there may be various SAR submittals at various times.) _____
 - (8) Have approved final shop drawings been received and are they available for reference when products are delivered to the jobsite? _____
 - (9) If required by Materials, has the Contractor supplied additional elastomeric bearing assemblies for testing? (See Art. 1083.04, Art. 521.09) _____
- b. Office Review (Precast Prestressed Concrete items – Prior to jobsite Delivery)
- (1) Have you reviewed the [Manual for Fabrication of Precast Prestressed Concrete Products](#)? In particular see Section 1.2 and Appendix A for maximum allowable dimensional tolerances, Section 3.5 for allowable damage and repairs, and Appendix A for procedures to remedy unacceptable products. The Manual for Fabrication of Precast Prestressed Concrete Products can be found at <http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Materials/Precast-Prestress/ppcfabricationmanual2013.pdf> _____
 - (2) Have you verified with the District Materials Engineer if any product was declared unacceptable and if a remedy for the unacceptable product has been approved? If a remedy for any product declared unacceptable has been approved, obtain a copy of the “Notice of Unacceptable Product at Plant or Jobsite” form ([BMPR PS02](#)) and the remedy approval notification for the project file. _____
 - (3) Have you verified with the District Materials Engineer if the fabricator has developed an alternate transportation loading configuration (in lieu of the configuration specified in Std. Spec. Art. 504.06 (c)? (Note, Art. 504.06 (c) may not apply in all cases because of the length and depth of the beams, the transportation route to deliver the beams, or other circumstances.) If the fabricator has developed an alternate transportation loading configuration, its design should be sealed by a licensed Illinois structural engineer and approved by the Bureau of Bridges and Structures. The approved transportation loading configuration is to be used for checking the location of bolsters or other supports. _____

c. Field Review

- (1) Are you checking the bearing seat elevations before and after each abutment or pier pour? Errors caught at this stage can often be corrected by grinding, shimming or adjusting elevations. _____
- (2) Are you laying out bearing lines on top of abutments and piers for beam erection and checking span lengths between abutments and piers? _____
- (3) Are the bearing areas on supporting masonry being finished within allowable tolerances? Improperly finished, deformed or irregular bearing areas shall be ground smooth, filled or otherwise corrected to within allowable tolerances to provide even bearing on the seats. (See Art. 503.15(c), 505.08(a), 505.08(f) and CM Division 500) _____
- (4) Are you inspecting the material as it is delivered to the jobsite for evidence of inspection (See PPG Attachment 3), that the material has not been damaged due to mishandling subsequent to inspection and that it is being properly stored? _____

2. BEAM ERECTION

a. Pre-Erection (General Items)

- (1) If this contract contains the Structural Assessment Reports special provision (SARs), has the erection SAR been approved? _____
- (2) Have you had a pre-erection meeting with the Contractor to discuss the erection plan, bolting requirements, jobsite samples, job site testing and test equipment, etc. as applicable? (This is not a contract requirement, but is highly recommended.) _____
- (3) Do you have proper evidence of inspection for all materials to be used? (See PPG Attachment 3) _____

b. Pre-Erection (Structural Steel items)

- (1) Before starting erection, has the Contractor submitted an erection plan detailing the proposed methods of erection and the amount, location(s) and type(s) of equipment to be used? Has the plan been approved by the Engineer? (See Art. 505.08(e)) (Note, if the contract contains the SARs special provision, the special provision holds over Art. 505.08(e) See Art. 105.05) _____
- (2) If falsework is needed for the erection process, has the Contractor submitted erection falsework plans for review, or

has the submittal been waived by the Engineer? (See Art. 505.08(d)) (Note, if the contract contains the SARs special provision, the special provision holds over Art. 505.08(d) See Art. 105.05)

c. Pre-Erection (Precast Prestressed Concrete items – Arrival at jobsite before unloading)

(1) Does the product have an ILL OK stamp? If the product doesn't have the ILL OK stamp, issue a notice of unacceptable product ([BMPR PS02](#)) to the contractor and contact the District Materials Engineer. (See Art. 106.02 for additional guidance regarding unacceptable materials and Section 3.6.3 of the [Manual for Fabrication of Precast Prestressed Concrete Products](#) for more information on the ILL OK stamp.)

(2) Are the bolsters or other supports at the correct location, per Std. Spec. Art. 504.06 (c) or an approved alternate (project specific) loading configuration, for transporting the product? If bolsters or supports are located incorrectly, subsequent inspection will be required to verify that the product did not incur crack damage. It is recommended the product be returned to the Producer for this inspection. If it is not feasible to return the product to the Producer, access to the entire beam is required for inspection. Note, it may not be feasible (or possible) to perform this inspection after the product is placed in its final location. Thus, an immediate inspection will likely be required. This immediate inspection may delay the contractors operation.

3. Were wood blocks or other suitable material, per Std. Spec. Art. 504.06 (c), placed under the tie chains (by the supplier) to prevent chipping the concrete during transport? If shipping damage is identified, issue a notice of unacceptable product ([BMPR PS02](#)) to the contractor.

d. Structural Fasteners

(1) Have you reviewed the Inspectors Checklist for [Structural Steel Bolting](#) and Construction Manual [Section 500](#)?

(2) Have the high strength bolts, nuts and washers been fabricated domestically from domestically produced steel (See Art. 106.01)?

(3) Does the shipment of fastener assemblies have the required evidence of materials inspection? (See PPG Attachment 3)

If bolting hardware has not have the required evidence of materials inspection, are you obtaining three bolts of each size and length and three nuts and washers of each size, per lot,

and submitting them to the BMPR for testing? (See PPG Attachment 3) _____

(4) Has the Contractor given you the Mill Test Report(s), Manufacturer Certified Test Report(s), and (if applicable) the Distributor Certified Test Report(s) for each Rotational Capacity (RC) lot delivered to the job site? (See Art. 505.04(f)(3)f.2) _____

(5) Has the Contractor supplied a calibration device capable of indicating bolt tension to perform the Rotation Capacity (RC) tests and field verification tests? (See Art. 505.04(f)(2) and 505.04(f)(3)g.1) _____

(6) Has the Contractor supplied a calibrate dial inspection torque wrench (See Art. 505.04(f)(2) and 505.04(f)(3)g.1) _____

(7) Have you performed the field RC tests on two fastener assemblies (except Lock-pin and Collar type fasteners) of each RC Lot delivered to the job site? (See Art. 505.04(f)(3)g.1, CM Sec. 500 – Procedure for Performing Rotational Capacity Test) _____

(8) Has the Contractor supplied a representative sample of not less than 3 fasteners of each diameter, length and grade to be checked in the supplied calibration device at the job site? If any fastener fails to meet the required minimum tension, the lot it was taken from will be rejected. (See Art. 505.04(f)(2), CM Sec. 500 – Procedure for Installation and Tightening of High Strength Fasteners) _____

(9) Has each bolting crew demonstrated understanding of the procedural requirements for the fastener system selected by the Contractor? (See Art. 505.04(f)(2), and CM Div. 500) _____

(10) Are bolts, nuts, and washers from each Rotational Capacity (RC) lot being shipped in the same container? (Note, when there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers.) (See Art. 505.04(f)(3)f.1) _____

(11) Is each container permanently marked with the RC lot number, both on the container and on the lid? (See Art. 505.04(f)f.1) _____

e. Structural Steel

(1) Are inaccessible areas being painted prior to erection (bottom and top of bearings, back of beams and diaphragms, top flange in non-shear stud areas, etc.)? (See Art. 506.04(f), 506.04(g), 506.05 and Special Provisions) _____

- (2) Are beams and diaphragms being handled properly to keep damage to the prime coat to a minimum? (See Art. 505.08(c)) _____
- (3) Once bolting hardware is opened is it being stored out of the weather or in sealed watertight containers or bags? _____
- (4) Are the galvanized nuts lubricated with a tinted dry lubricant and plain bolts, nuts and washers lightly lubricated prior to installation? If not is an acceptable lubricant being applied before tightening? (See Art. 505.04(f)(3)g.2) _____
- (5) During erection of all structural steel members on continuous spans, are the splices being filled with a minimum of 25% bolts and 25% drift pins? No splice connection shall be tightened (snug tightened or final tightened) until the entire continuous length is in place on the substructure to permit the alignment of the beams to be at the plan profile and grade.. (See Art.505.08(h) & CM Div. 500) _____
- (6) Is the Contractor using the following procedure to complete the installation of the fasteners at each splice and field connection:
 - (a) Is the Contractor removing all drift pins and filling all holes in the splice with 100% finger-tight bolts? (See Art. 505.08(h)) _____
 - (b) Do all high-strength bolts have a hardened washer under the element (nut or bolt head) turned in tightening? (See Art. 505.04(f)(2)) _____
 - (c) Are the fasteners in all holes of the connection initially brought to a snug tight condition, progressing systematically from the most rigid part of the connection to the free edges in a manner minimizing relaxation of the previously tightened fasteners? (See Art. 505.04(f)(2)) _____
 - (d) If using the Turn-of-Nut Method, is the contractor performing a minimum of two cycles of systematic snug tightening for connections with 25 mm (1 in.) and thicker plates to minimize relaxation of previously tightened fasteners prior to final tightening? (See Art. 505.04(f)(2)d.1) _____
 - (e) After all fasteners in the connection are snug tight, is the Contractor fully tightening the fasteners progressing systematically from the center most rigid part of the connection to its free edges? (See Art. 505.04(f)(2)) _____
- (7) Have you verified that all fasteners have been installed to the minimum required tension? (See Article 505.04(f)(2), CM Div. 500 – General Procedure for Inspection of High Strength

Fasteners Installation, and Construction Inspector’s Checklist for High Strength Bolting) _____

- (8) Is the Contractor aware that no field welding or flame cutting will be allowed on beams or girders without permission of the Engineer? (See Art. 505.08(n), and bridge plan general notes) _____

f. Precast, Prestressed Concrete – Unloading and Handling

- (1) Is the Contractor fully engaging all the lifting loops as shown on the shop drawings? Never allow the contractor to lift a product without fully engaging all the lifting loops as shown on the shop drawings. Be advised that extra lifting loops may be used by the Producer at the plant because of their handling equipment. These loops are supposed to be removed at the plant, but sometimes they are not. Thus, it is important to review the shop drawings. (See Art. 504.06(d) and CM Div. 500) _____

- (2) Is the contractor utilizing an adequate spreader beam and slings to prevent the development of detrimental horizontal forces in the product? Note, the minimum sling angle should be shown on PPC beam plan sheet(s). (See Art. 504.06(d) and CM Div. 500) _____

g. Precast, Prestressed Concrete – After Placement at the jobsite

- (1) Have you Examined beams for excessive sweep (i.e. horizontal curvature)? This should be performed during or as soon as practicable after placement. Be advised that as the sun shines on the beams it will cause temperature differentials that may cause the beams to temporarily warp. Thus, it may be necessary to examine the beams for sweep early in the morning when temperature differentials are minimized. (See dimensional tolerance information provided in Section 1.2.4 and Appendix A of the Manual for Fabrication of Precast Prestressed Concrete Products. In rare instances, beams may be in tolerance for sweep but still cannot be placed properly. In this situation it is important to contact the Bureau of Bridges and Structures.) _____

- (2) Have you examined beams for unusual camber (i.e. vertical curvature)? Unusual camber includes no camber, negative camber, excessive differential camber with adjacent deck beams and excessive camber contributing to thin wearing surfaces on deck beams or negative fillets on I – Beams/Bulb T – Beams. (See Art. 504.06(d), CM Div. 500 and Manual for Fabrication of Precast Prestressed Concrete Products – Appendix A – “Procedure to remedy an unacceptable prestressed product at the jobsite”) _____

- (3) Have you examined the product for cracks, per Section 3.5 of the [Manual for Fabrication of Precast Prestressed Concrete Products](#), using a crack comparator and tape measure? (Do not drill, or allow drilling, into PPC products without prior consultation with the Bureau of Bridges and Structures.) As an aid to the inspection, it is suggested to spray the concrete surface with water to help locate cracks. If cracks not exceeding the Department's limits are located, verify if repairs per Section 3.5.6 of the [Manual for Fabrication of Precast Prestressed Concrete Products](#) were performed. This may be seen visually or you can contact the Department's QA plant inspector. If cracks exceeding the Department's limits are located, issue a notice of unacceptable product ([BMPR PS02](#)) to the contractor. _____
- (4) Have you verified no chips, spalls, or other damage occurred to the concrete during handling at the jobsite? It is not uncommon for beam torsion (twisting) to occur during handling which may cause damage or spalling of concrete. If handling damage is identified, issue a notice of unacceptable product ([BMPR PS02](#)) to the contractor. _____

Note. When a notice of unacceptable product ([BMPR PS02](#)) is issued, follow the "procedure to remedy an unacceptable prestressed product at the jobsite" outlined in Appendix A of the [Manual for Fabrication of Precast Prestressed Concrete Products](#).

h. Bearings

- (1) Are bearings being handled properly to prevent damage? This is particularly important for Type II bearings, since the stainless steel and Teflon sliding surfaces are very easily damaged. _____
- (2) Are all bearing sliding surfaces clean before installation and kept clean after installation? _____
- (3) If Type II Elastomeric, Type III Elastomeric, or High Load Multi-Rotational bearings are utilized are they being adjusted to center vertically over bearing and base plates at 10 °C (50 ° F)? (See bridge plan detail) _____
- (4) If Type II Elastomeric, Type III Elastomeric, or High Load Multi-Rotational bearings are utilized are their anchor bolt holes being drilled after bearings are in place? (See bridge plan note and Art. 521.06) _____
- (5) After anchor bolts are installed, have you check the upper ends of the bolts to verify proper embedment? Anchor bolt lengths should leave the exposed end projecting between 12 mm (1/2 in.) and 50 mm (2 in.) above the top of the nut. (See Art. 521.06) _____

- (6) Have all bearing side retainers been secured in place prior to forming the bridge deck? (See Art. 505.08(f)) _____

3. PRE-DECKING

a. Fillets

- (1) Are you marking each beam at the fillet intervals as shown in the plans and preparing a field book for elevation shots? _____
- ((2) Are fillet elevations being shot after all structural fasteners in a continuous steel span are final tightened? _____
- (3) Are fillet elevations being shot before forms have been placed? The weight of the forming wood is not taken into account by the deflection diagram. _____
- (4) Are you consulting with the supervising field engineer if there are negative or excessive positive fillets? The deck grades may require adjustment. Fillets in excess of 6 in. (150 mm) may require additional reinforcement – contact the Bureau of Bridges & Structures if excessive fillets have not already been addressed in the plans. Without reinforcement, shear studs must extend at least 2 in. (50 mm) into the deck. _____
- (5) Are you marking fillets in 3 mm (1/8 inch) increments at each location? _____

b. Inspection of Delivered Epoxy Coated Reinforcement Bars

- (1) Are all the systems used for handling padded at the contact areas? (Art. 508.03 and Reinforcement Bars – Storage and Protection Special Provision)
- (2) Are bars being protected from mechanical injury and deterioration by exposure? (See 508.03 and Reinforcement Bars – Storage and Protection Special Provision) _____
- (3) Is storage on wooden or padded steel cribbing? (Art. 508.03 and Reinforcement Bars – Storage and Protection Special Provision) _____
- (4) Are rebars from a certified plant? Compare the identification marking on bars with the latest list of certified plants, from BMPR. Reject all rebars from non-certified plants. <http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Specialty-Lists/Highways/Materials-&-Physical-Research/Metals/rebardowelproducers.pdf> _____
- (5) Is the epoxy coating applicator on the approved list of certified epoxy coating plants? (See Reinforcement Bars Special Provision)

<http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Specialty-Lists/Highways/Materials-&-Physical-Research/Metals/rebardowelproducers.pdf>

- (6) Do rebars conform to the plan shape and dimensions? _____
- (7) Although rebars will be in bundles, are you making a preliminary check for damaged epoxy coating? Total damage greater than 2 percent of the bar surface in any 1 ft. (300 mm) of length of the bar or greater than 5 percent of the bar surface area covered with patching material shall be rejected. Scars greater than 1/16 sq. in. (40 sq. mm) can be repaired after placed in the deck mat. (See Art. 508.05) _____

4. DECKING FOR CONCRETE PLACEMENT

a. Screed Rail Installation and No Weld Areas

- (1) Are you prohibiting the welding to or drilling or cutting holes in beams/girders? (See Art. 503.06 and bridge plan general note) _____
- (2) Is the Contractor obtaining permission before making any field welding not specified in the contract documents? Contact the Bureau of Bridge & Structures. (See bridge plan general note – "No welding allowed anywhere", and Art. 505.08(n)) _____

b. Forms

- (1) Are forms set to correct fillet height? _____
- (2) Are form dimensions correct? _____
- (3) Are forms clean, braced, tight and sufficiently rigid to prevent distortion? Are you rejecting any forms that are not acceptable for reuse? (Art. 503.06) _____
- (4) Are forms (adjacent to surfaces that will be exposed to view) being treated with form oil prior to rebar placement? (See Art. 503.06) _____
- (5) Is all forming hardware that is to be incorporated into the deck galvanized or epoxy coated? (Art. 503.06(b)) _____
- (6) Are all joints tight to prevent concrete leakage onto beams or girders? (See Art. 503.07) _____

c. Cantilever Forming Brackets

If the Contractor uses cantilever forming brackets on exterior beams or girders, are the following procedures being complied with to prevent beam rotation and a possible thin deck (Art. 503.06(b))? _____

- (1) Is the resulting force of the leg brace bearing on the web within 6 inches (150 mm) from the bottom flange of the beam or girder? (Art. 503.06(b)(1)) _____
- (2) Is the top of the exterior steel beams or girders tied together with a minimum No. 4 (No. 13) epoxy coated reinforcement, or equivalent at no greater than 4 ft. (1.2 m) centers if the finishing machine rails are on the outside of the watertable, or 8 ft. (2.4 m) centers if the finishing machine rails are on the top flange of the exterior beams? On stage construction, where cantilever brackets are used on only one exterior line of beams or girders, this line shall be tied to the opposite exterior line. Cross frames on steel girders which do not have a top strut shall not be considered a tie. (See Art. 503.06(b)(2)) _____
- (3) If steel beams 27 inches or shallower are utilized are you following special details outlined on the bridge plan base sheet SB-1. Note, the finishing machine rail must be on the beam and the tie bars and blocking are to be at 4 ft. (1.2 m) centers. _____
- (4) Are the tie bars being placed at no greater than 8 ft. (2.4 m) centers on precast, prestressed concrete (PPC) I-beams and bulb-tees regardless of where the finishing machine rails are placed? On stage construction, where cantilever brackets are used on only one exterior line of beams or girders, this line shall be tied to the opposite exterior line. (See Art. 503.06(b)(2)) _____
- (5) Are tie bars being placed parallel to the transverse reinforcement? (See Supp. Spec. partial revision to Art. 503.06) _____
- (6) Are tie bars being placed no lower than the bottom transverse reinforcement or no higher than the top transverse reinforcement? Special brackets and/or reworking existing brackets may be required to maintain proper placement. (See Supp. Spec. partial revision to Art. 503.06) _____
- (7) Is each tie bar furnished with an approved tie bar stabilizing system consisting of adjustable end clips, lag studs, and turnbuckles? Are the end clips and lag studs sufficiently rigid so as not to deflect during the deck pour? (See Supp. Spec. partial revision to Art. 503.06) _____
- (8) Are you prohibiting welding to the structural steel, stud shear connectors, or reinforcement bars protruding from PPC beams for the installation of the tie bar stabilizing system? (See Supp. Spec. partial revision to Art. 503.06) _____
- (9) After installation, are the tie bars tensioned with turnbuckles until the bars do not vary from a straight line from center of end clip to center of opposite end clip? For decks with cross

slopes, it may be necessary to anchor the ties on the exterior girders and on the girders adjacent to the cross slope crown. (See Art. 503.06(b)(2) and Supp Spec. partial revision to Art. 503.06)

- (10) Are hardwood 4 inch x 4 inch (100 mm x 100 mm) blocks or material of an equivalent strength being wedged between webs of exterior and first interior beams within 6 inches (150 mm) of the bottom flanges at each location where the top of the beams are tied together? (Art. 503.06 (b)(3))

d. Shear Studs

- (1) As soon as the fillet heights are determined are you providing the Contractor with a list of the number and length of studs necessary to provide the required minimum 2 inch (50 mm) deck embedment? (See bridge plan detail)
- (2) Are you checking the Contractor’s layout of the stud locations versus plan locations?
- (3) Are you prohibiting stud welding when the flange surface is wet or the base metal temperature is below 0 °F (-17 °C) (without preheating the metal)? (See Art. 505.08(m)(2))
- (4) Is each stud location being prepared by grinding, lightly, parallel to the beams longitudinal axis to remove mill scale and heavy rust? (See Art. 505.08(m)(2))
- (5) Is the operator making the required 45° bend test? (See Art. 505.08(m)(3))
- (6) Are you making a 45° bend test with a heavy hammer on about 1% of the studs per beam? (See Art. 505.08(m)(3))
- (7) Are you testing suspect studs by bending the stud 15° opposite the deficiency and bending it back vertically then rejecting studs showing visual stress? (Art. 505.08(m)(3)) (It is recommended you “ping” each stud with the hammer.)
- (8) Are you requiring defective studs to be removed and replaced with a new stud in the same location as the defective stud, after properly grinding the vacated area to a smooth flush condition or filling pullout of metal in the vacated area with weld metal using the shielded-metal arch process and low-hydrogen electrodes. (See Art. 505.08(m)(3))

NOTE: This method of repairing defective studs is appropriate only in positive moment areas. For defective studs near piers, contact the Bureau of Bridges and Structures.

e. Reinforcement Bar Placement

(1) Are all reinforcement bars tied securely in place? Are epoxy coated rebars being tied with plastic or epoxy coated tie wire? (Floating or sticking rebars into wet concrete shall not be allowed.) (See Art. 508.05) _____

(2) Are all rebar intersections being tied? Alternate intersection tying will be allowed when spacing is less than 1 ft. (300 mm) in each direction. (See Art. 508.05) _____

(3) When epoxy coated rebars are specified to be cut in the field, are they being sawed or sheared and the cut ends painted with epoxy? (Flame cutting is not permitted.) _____

Note: "spray can" epoxy repair will not satisfy ASTM D 3963 [m1] (See Art. 508.04)

(4) Are epoxy coated rebars handled properly to prevent damage to the rebar coating? (Use rope slings, no dragging or dropping permitted.) (Art. 508.03) _____

(5) Are all rebar laps of the specified length (plans will show splice length) and contact spliced? (See Art. 508.06) _____

(6) Are the reinforcement bar chairs epoxy coated and at the required spacing? (See Art. 508.05) _____

Bottom bars - Continuous chairs at 3 ft.-3 inches (1 m) maximum spacing _____

Top bars - Continuous chairs at 3 ft. (900 mm) maximum spacing, or individual chairs at 2 ft. (600 mm) x 3 ft. (900 mm) maximum spacing. _____

(7) Are the rebars in the tops of slabs being securely held in place by plastic or epoxy coated No. 9 (3.8 mm) wire ties, or other devices fastened to the structural steel, falsework, or other structural component? (Every 25 ft. (7.6 m) longitudinally and 15 ft. (4.5 m) transversely) (See Art. 508.05) _____

(8) After epoxy coated rebars are in place, are you inspecting the rebars for damage to the coating and requiring the Contractor to repair all scars greater than 1/4 by 1/4 in. (6 x 6 mm)? (See Art. 508.05) _____

(9) Are rebars being rejected that have either a total damage greater than 2% of the bar surface in each 1 ft. (300 mm) length of bar or greater than 5 percent of the bar surface area covered with patching material? (See Art. 508.05) _____

(10) For longitudinal or transverse joints in the deck with rebars protruding through the pour, has the Contractor constructed a platform outside the joint, above the protruding bars, and supported on the lower slab form? Personnel will not be permitted to stand or walk on the projecting reinforcement bars until the concrete has hardened. (See Art. 503.09) _____

f. Screed Rails

(1) Are you checking the screed rail elevation from the fillet points and checking the rail for a smooth curve through all the grade points by eyeballing? _____

g. Longitudinal Bonded Construction Joints

(1) Are the longitudinal bonded construction joint forms being set at the required location? With the approval of the Engineer, the Contractor may be allowed to pour the deck out-to-out. (See Art. 503.09) _____

(2) Is the grade of the longitudinal construction joint form, or the temporary screed bars, being set with an instrument and check measured against the designed deck slab thickness? _____

h. Deck Drainage Openings

(1) Are required drainage openings in the proposed deck at the proper location, elevation and positioned so as to prevent the discharge of drainage water against any portion of the structure, or directly onto any railroad, highway, or unprotected earth below? Make sure the floor drains and scuppers are not unintentionally placed partially under the parapet location. Note that the edge of the deck is moved 2 in. (50 mm) if the parapet slip form option is used. (See Art. 503.11) _____

i. Expansion Joints

(1) When plates, angles or other structural shapes are specified, are they set to correct position, elevation and rigidly attached to bulkheads set to provide plan opening at 50 °F (10 °C) prior to concrete placement? (See Art.503.10(c) and bridge plan detail) _____

(2) If temporary expansion joint bulkheads are attached to adjacent deck slabs or abutments for support, is the Contractor cutting the attachments as soon as the concrete has set to prevent joint damage due to horizontal expansion? _____

5. PRE-POUR MEETING

Prior to (preferably the day before) placement of deck concrete, a meeting will be held with the Contractor to review the following deck placement procedures (see Attachment 1 for sample pre-pour meeting agenda):

a. Mix

(1) Have you discussed the properties of the proposed concrete mix (retarder, strength, water/cement ratio, etc.) with the District Materials Engineer and the Contractor? _____

(2) Have you discussed with the Contractor the air, slump and strength requirements for deck concrete and the location for a suitable site to run tests? _____

b. Concrete Delivery

(1) Is the delivery commitment from the ready mix supplier adequate so that the operations of placing and finishing will be continuous? (See Art. 503.07, Art. 1020.11(d)(9)) _____

(2) Does the Contractor have sufficient equipment and labor to maintain continuous concrete placement operation between expansion or construction joints specified? (See Art. 503.16) _____

c. Pumped Concrete (Construction [Memorandum No. 74](#))

(1) Is the Contractor aware mortar used to provide initial lubrication for the line shall be wasted and not allowed to be placed in the deck? The wasted mortar shall not be placed in any stream or drainage way. _____

(2) Is the Contractor aware when the horizontal placement method is used, the line shall have a piece of plywood placed under each pipe joint to prevent damage to the epoxy coated rebars and to catch concrete which oozes from the line when the joint is disconnected? Concrete dropping onto rebars shall be removed. It sets up rapidly and if paved over creates a weak spot in the deck. _____

(3) Will the pump be at lower elevation than the concrete trucks to facilitate discharge from the truck without excessive water additions? Constructing near level ramps or excavating an area for the pump is helpful. _____

(4) Is the Contractor aware no water shall be added to the pump hopper. If water is added, to remove a line blockage etc..., this concrete must be wasted. _____

(5) Is the Contractor aware the use of aluminum pipes or tubes is strictly prohibited. (See Art. 503.07) _____

- (6) Does the discharge end of the pump have attached either an "S" shaped flexible or rigid conduit, a 90 degree elbow with a minimum of 10 ft. (3 m) of flexible conduit placed parallel to the deck, or a similar configuration approved by the Engineer? (See Art. 503.07 and CM Section 500) _____
- (7) Is the contractor aware the mortar factor shall not exceed 0.86? (See PCC Level III Technician Course – Manual of Instructions for Design of Concrete Mixes) _____
- (8) Has the procedure to establish a correction factor for air content loss (or gain) in the pump been discussed? At least the first three truck loads should be tested before and after the pumping to establish the correction factor. It should be rechecked every 50 cu. yd. (40 m³) or as conditions change. _____

d. Finishing Equipment & Requirements

- (1) On skewed multi-beam/girder bridges (with skew angle exceeding 45°, or skew angle exceeding 30° and pour width to span length ratio exceeding 0.8) are you checking the bridge plan general notes to determine if the deck concrete must be placed and finished parallel to the skew? _____
- (2) Does the finishing machine transversely finish the surface with either a rotating cylinder(s) or a longitudinal oscillating screed? (See Art. 503.16(a)(1) and 1103.13(a)) _____
- (3) Is the finishing machine in good mechanical condition and the crown checked? _____
- (4) Does the fogging equipment satisfy specification requirements and is it in good working order? (See Art. 5013.16, 1103.13(a), and 1103.17(k)) _____
- (5) Has the "dry" run been made to check rebar clearance? (See Art. 508.05, Art. 1103.13(a)) _____
- (6) Are adequate foot bridges for finishing, texturing and applying cotton mat curing blankets and available for the concrete finishers? (See Art. 503.16, 1020.13(a)(5), 1103.17(d)). _____
- (7) Are there enough vibrators to adequately consolidate the concrete? (See Art. 503.07) _____
- (8) Are the vibrators equipped by the manufacturer with a non-metallic head? Slip-on covers are not allowed. (See Art. 1103.17(a)) _____
- (9) Are long handled floats not less than 3 ft. (1 m) in length and 6 in. (150 mm) in width or hand operated floats not less than 10

ft. (3 m) in length and 6 in. (150 mm) in width provided? (Art. 503.16(a)(1)) _____

(10) Is a burlap or artificial turf carpet drag being furnished for the initial surface texturing? (Art. 503.16(a)(3)) _____

(11) Where longitudinal joints or transverse joints are constructed, will platforms supported on the lower slab form be constructed so workers will not be permitted to stand or walk on projecting reinforcement bars? (See Art. 503.09) _____

(12) If the Engineer determines workability cannot be obtained, will a device be available to apply water to the deck in a fine mist? (See Art. 503.16(a)(1)) _____

(13) Has the Contractor provided temperature, relative humidity, and wind speed measuring equipment? (See Art. 503.16) _____

(14) Is the contractor aware leakage through forms onto beams or girders shall not be allowed to harden and shall be removed while in a plastic state. _____

e. Manpower

Will the Contractor have adequate supervision and enough manpower to place and finish the deck concrete and place curing covering in the specified manner? Has the Contractor designated a person responsible for placing the curing covering? (See Art. 503.16 and 1020.13(a)(5)) _____

f. Deficiency Checklist

Have you informed the Contractor of any deficiencies not previously taken care of? (Forms, reinforcement, epoxy touch up, grade, equipment etc.) _____

g. Curing

(1) Are there adequate cotton blankets, soaker hoses and white polyethylene sheeting (or burlap-polyethylene blankets) on the jobsite to cure the deck? (See Art. 503.17 and 1020.13(a)(5)) _____

(2) Does the contractor have an adequate water supply available on the job site? (See Art. 503.17 and 1020.13(a)(5)) _____

(3) Is the contractor prepared to immediately wet the cotton mats upon placement? (See Art. 503.17 and 1020.13(a)(5)) _____

h. Pour Sequence

Is the contractor aware, if they plan to deviate from the pouring sequence shown in the bridge plans or add a pouring sequence (i.e. add longitudinal or transverse construction joints not shown in the plans) they must submit a proposal in writing? The proposal requires approval from the Bureau of Bridges and Structures. (See Construction Memo. 07-64)

6. **CONCRETE DECK PLACEMENT**

a. Revolution Requirements for Truck Mixers

(1) Are you immediately inspecting the batch counter on all arriving truck mixers to ensure that the required number of revolutions at mixing speed has been obtained? (See Art. 1020.11(a)(2) and 1020.11(a)(5))

(2) Does the number fit within the allowable number of revolutions shown in the table below?

| 60 Mixing Revs. Req'd. (Simultaneous Charging) | | 70 Mixing Revs. Req'd. (Separate Charging) | | | |
|---|-----|---|-----|-----|-----------------|
| Time | | | | | |
| Minutes | Min | Max | Min | Max | |
| 10 | 60 | 119 | 70 | 119 | |
| 15 | 66 | 144 | 72 | 144 | Agitating Speed |
| 20 | 76 | 169 | 82 | 169 | 2-5 rev/min. |
| 25 | 86 | 194 | 92 | 194 | |
| 30 | 96 | 219 | 102 | 219 | Mixing Speed |
| 35 | 106 | 244 | 112 | 244 | 5-16 rev/min. |
| 40 | 116 | 269 | 122 | 269 | |
| 45 | 126 | 294 | 132 | 294 | |
| 50 | 136 | 319 | 142 | 319 | |
| 55 | 146 | 344 | 152 | 344 | |
| 60 | 156 | 369 | 162 | 369 | |

Whenever water or admixtures are added to the truck at the jobsite or the revolutions on the truck are not within the above chart, an additional 40 revolutions at mixing speed shall be put on the truck. (See Art. 1020.11(a)(2) _____

b. Time of Haul

(1) If the temperature of the air or concrete is 18 °C (65 °F) or higher, is a retarding admixture being used? (See Art. 1020.05(b)(1)) _____

(2) Is all concrete which is being hauled in truck mixers or truck agitators being deposited within 60 minutes^{1,2} from the time stamped on the tickets? (See Art. 1020.11(a)(7)) _____

Note 1: When the concrete temperature at point of discharge is below 65 °F (18 °C), the allowable haul time is 90 minutes. (See Art. 1020.11(a)(7))

When the concrete temperature at point of discharge is at or above 65 °F (18 °C), retarding admixture must be used, which brings the maximum haul time up to 90 minutes. (See Art. 1020.05(b)(1), and Art. 1020.11(a)(7))

(3) If central-mixed concrete is being hauled in nonagitator trucks, is the concrete being deposited within 30 minutes? (See Art. 1020.11(a)(7)) _____

c. Concrete Temperature

Are temperature checks of the plastic concrete being taken? The allowable limits for structural concrete are 50 °F (10 °C) to 90 °F (32 °C). When insulated forms or blankets are used: 50 °F (10 °C) to 80 °F (25 °C). (See Art. 1020.14(b)) _____

d. Air Content Determination

Allowable air content in place = (5% - 8%) (See Art. 1020.04)

(1) Is an air content test (per MTPM) made on every load? (See Sampling Schedule 3 Non-QC/QA Concrete in the PPG, Construction Memo. 07-74, and QC/QA of Concrete Mixtures Recurring Special Provision Schedule B note 9/) _____

(2) Is an air content test (per MTPM) made when mix water or air entrainment admixture is added at the jobsite? _____

Note: A slump test, and air test is required when a strength specimen is made. (See Sampling Schedule 3 Non-QC/QA Concrete in the PPG and QC/QA of Concrete Mixtures Recurring Special Provision Schedule B note 8/)

- (4) If a pump or conveyor is used for placement, is an air loss correction factor being established and used according to the following (See Construction Memo. 07-74 and QC/QA of Concrete Mixtures Recurring Special Provision):
- (a) Test the first three truck loads delivered before and after transport by the pump or conveyor.
 - (b) Once the correction factor is determined, it shall be rechecked after an additional 50 cu yd (40 m³) is pumped, or an additional 100 cu yd (80 m³) is conveyed.
 - (c) The correction factor should also be rechecked when significant changes in temperature, distance, pump or conveyor arrangement, etc., have occurred.
 - (d) The air content should be near the midpoint of the range, after the correction factor has been applied. If the air content is not near the midpoint, adjustments are needed at the plant. If air content tests indicate significant air loss, the problem should not be solved by increasing the air content above the upper specification limit. A lower slump concrete or change in pump arrangement can cause less air loss. Thus, the air content at the discharge end could exceed the upper specification limit. The best alternative is to reduce air loss by changing the pump arrangement, or by making minor mix adjustments at the plant.
 - (e) Record the actual test results. For before and after tests used to establish the correction factor, record both sets of tests, but report only the on-the-deck tests to the MISTIC system. Once the correction factor has been established, record the air tests results at the truck, as well as the correction factor used in accepting the truck's air content, but report only the corrected air content to the MISTIC system.
 - (f) If the correction factor is 3 percent or more the Contractor shall take corrective action to reduce the loss of air content during transport by the pump or conveyor.

e. Slump Test

Allowable slump = 2 - 4 in. (50 - 100 mm) for Class BS without high-range water reducing admixture. (See Art. 1020.04)

The maximum slump may be increased to 7 in. (175 mm) when a high range water-reducing admixture is used. (See Art. 1020.04 note 4)

- (1) On non-QC/QA jobs, is a slump test (per MTPM) made at least once each 50 cu. yd. (40 m³) min.? (See Sampling Schedule 3 Non-QC/QA Concrete in the PPG)

(2) Is a Slump test made (per MTPM) when mix water is added at the jobsite? _____

Note: A slump test and air test is required when a strength specimen is made. (See Sampling Schedule 3 Non-QC/QA Concrete in the PPG and QC/QA of Concrete Mixtures Recurring Special Provision Schedule B note 8/)

On QC/QA jobs, the sampling and testing frequency is in accordance with the QC/QA of Concrete Mixtures Recurring Special Provision.

f. Water/Cement Ratio Control

Has the Proportioning Technician or QC personnel at the plant communicated to you and the jobsite QC personnel, the permissible amount of water which can be added at the jobsite without exceeding the allowable water/cement ratio for the concrete mix? The specification requirement for a 4-inch (100 mm) slump still remains in effect and must be considered when adding water. (Art. 1020.04) _____

g. Adding Water or Admixture to Trucks at Jobsite

When water or admixtures are added to the ready-mix truck at the jobsite, is the concrete to be mixed 40 additional revolutions at mixing speed to assure proper mixing? Concrete that is modified at the jobsite after testing so as to alter test results significantly, shall be re-tested for acceptance. (See Art. 1020.11(a)(2)) _____

h. Strength Test

On non-QC/QA jobs are either concrete test beams or cylinders being cast at the site of work and the following requirements met? (Art.1020.09) _____

(1) Modulus of Rupture (6 x 6 x 30 in. (150 x 150 x 750 mm) beam):

Cast 2 beams per pour. (Sampling Schedule 3, Non-QC/QA Concrete in the PPG) _____

Are the beams being made, cured, and tested in accordance with the methods given in the Manual of Test Procedures for Materials (MTPM)? _____

Designed flexural strength = 675 p.s.i (4,650 kPa) in 14 days. (See Art. 1020.04). Record beam tests in "Field Record Book of Modulus of Rupture Tests of Concrete Beams," Form LW-3. _____

(2) Compressive Strength 6 in. (150 mm) diameter x 12 in. (300 mm) cylinder: Cast 2 cylinders in lieu of each beam, i.e. 4 cylinder per pour. (See Sampling Schedule 3 Non-QC/QA Concrete in the PPG) _____

Are the cylinders being made, cured, and tested in accordance with the MTPM? _____

Designed compressive strength = 4000 p.s.i. (27,500 kPa) in 14 days (See Art. 1020.04)

Note: Submit MISTIC Form MI-655 - "P. C. Concrete Strengths," to the District Materials Engineer

It is highly recommended to make additional beam or cylinder test specimens, in case of damage to specimens or low strength test results.

i. Concrete Delivery Tickets

(1) Are all truck tickets being collected and retained? _____

(2) Do concrete tickets show section number, time of batch, batch quantity, truck number, etc.? _____

The QC/QA Recurring Special Provision requires the following information to be recorded on each delivery ticket or in a bound hardback field book: initial/final revolution counter reading, at the jobsite, if the mixture is truck mixed; time discharged at the jobsite; total amount of each admixture added at the jobsite; and total amount of water added at the jobsite.

(3) Are you recording on each truck ticket the inspector's initials, the results of air/slump tests, concrete temperature checks, time of discharge, water or admixtures added, drum revolutions of transit mix trucks upon arrival and strength specimens taken? _____

(4) Are all jobsite air, slump, water or admixture additions and beam test results being submitted to the proportioning technician daily for posting on MISTIC Form [MI 654](#), Concrete, Air, Slump Quantity and Form [MI 655](#), P. C. Concrete Strengths. _____

j. Placing Concrete

(1) Is the concrete being bucketed, conveyed, pumped or otherwise placed in such a manner as to avoid segregation and is not being allowed to drop more than 5 ft. (1.5 m)? (See Art. 503.07) _____

Note: All skewed multi-beam/girder bridges, not just those required to be struck off and finished parallel to the skew per a bridge plan general note, should have the concrete placed parallel to the skew provided plasticity throughout the screeding operation and the uniformity of the tining can be maintained satisfactorily.

- (2) If the distance between the placement of concrete and the covering of the finished concrete nears 35 ft. (10.7 m), or 25 ft. (7.6 m) for deck widths greater than 50 ft. (15 m), are you ensuring placement of concrete is halted until the curing operation catches up? (See Art. 503.16) _____
- (3) Are you checking the evaporation rate based on measurements of air temperature, humidity, and wind speed? _____
- (4) When the evaporation rate is 0.1 lb/sq ft/hour (0.5 kg/sq m/hour) or greater, or when required by the Engineer, is the fogging equipment in operation? (See Art. 503.16) _____
- (5) Is the fogging equipment functioning properly and not accumulating water on the surface of the concrete. _____
- (6) If there is a delay of more than ten minutes during concrete placement, is wet burlap used to protect the concrete until operations resume? (See Art. 503.16) _____
- (7) Is the contractor removing all concrete leakage onto beams or girders while the leakage is in a plastic state? (See Art. 503.07) _____

k. Consolidation

- (1) Is all concrete being compacted with hand operated spud vibrators immediately after it has been placed? (See Art. 503.07) Over-vibration causes segregation and loss of entrained air. _____
- (2) At expansion angles or expansion joint blockouts is the concrete being vibrated through the vent holes to release as much trapped air as possible? _____

l. Strike-Off and Finishing

- (1) Is the finishing machine in proper adjustment and producing the specified surface? _____
- (2) If a vibratory screed is being utilized in lieu of a power driven finishing machine is bridge deck pour width less than 16 ft.? The vibrator must shut off when the speed is stopped so air will not be vibrated out of the concrete and excess mortar will not be brought to the surface. (See Art. 503.16(a)(1)) _____

Note: A vibrating screed may be used when the bridge deck pour is wider than 16 ft. with permission of the Central Bureau of Construction. (See Construction Memo. 07-73) _____

- (3) Are you ensuring that the concrete surface at parapets, curbs, sidewalks and medians is struck off during the deck pour and

that excess concrete, mortar, or paste from the finishing process is not discarded into these areas? (See Art. 503.16(a)(1)) _____

m. Depth Checks

- (1) Are you checking the deck thickness and rebar depth at frequent intervals behind the finishing machine and recording these measurements in your deck pour field book? _____
- (2) If deck thickness or rebar depth deficiencies are found, is the Contractor immediately notified so corrective action can be taken? _____

n. Longitudinal Finishing and Testing

- (1) Is the contractor testing the entire surface for trueness with a 10 ft. (3 m) straightedge and correcting any depressions or high areas? (See Art. 503.16(a)(2)) _____

Note: The Contractor may, at their option, transversely float the entire surface with a hand-operated float having blades not less than 10 ft (3 m) in length and 6 in. (150 mm) in width. If the Contractor chooses to transversely float the entire surface with the 10 ft (3 m) hand float and surface corrections are made, straightedge testing while finishing will not be required.

- (2) Are you prohibiting long handled floats with short length blades 3 ft. (1 m) from being used over the entire deck surface? These floats should only be used when necessary to smooth and fill in porous or open-textured areas as these floats create bumps in the deck surface. (See Art. 503.16(a)(1)) _____

o. Controlling Finish Water

- (1) Are you prohibiting water from being applied to the deck surface unless it can be demonstrated that workability cannot be obtained? (Art. 503.16(a)(1)) _____
- (2) If water is permitted is it being applied in a fine mist from a sprayer and not by brushes or other methods which concentrates water? (Art. 503.16(a)(1)) _____

p. Surface Texturing

- (1) Is the deck surface being textured with either a burlap or artificial turf carpet drag (parallel to the centerline of the roadway) in the plastic state? (See Art. 503.16(a)(3)a.) _____
- (2) After the required curing and protection, is the deck being grooved, by a mechanical saw device, perpendicular to the centerline of the roadway? (See Art. 503.16(a)(3)b.) _____

- (3) Is the grooving being stopped 1 ft. (300 mm) from the face of the curbs or parapets and 2 in. ± 1 in. (50 mm ± 25 mm) from deck drains and expansion joints? (See Art. 503.16(a)(3)b.) _____
- (4) Is slurry being picked up continuously, with vacuum equipment, during the deck grooving operation and disposed of offsite according to Art. 202.03? (See Art. 503.16(a)(3)b.) _____
- (5) Is the deck being flushed with water as soon as possible to remove any slurry material not collected by the vacuum? Discharge into any stream or drainage way is prohibited. (See Art. 503.16(a)(3)b.) _____

q. Curing Bridge Decks

Per Art. 1020.13(a)(5) Wetted Cotton Mat Method:

- (1) Is a separate foot bridge available for the placement of the cotton mats? _____
- (2) Is the Contractor placing dry or damp cotton mats as soon as the surface of the concrete has been finished and textured? Are the mats being placed in a manner which will not mar the concrete surface? _____
- (3) Are you ensuring the distance between placement of the concrete and the placement of the cotton mats does not exceed the allowable distances of 35 ft (10.7 m) (or 25 ft. (7.6 m) for pour widths greater than 50 ft. (15 m)). (See Art. 503.16) _____
- (4) Immediately after placement, are the cotton mats being wetted thoroughly with a gentle spray of water? Are the mats maintained in a wetted condition until the soaker hoses can be placed? _____
- (5) When the concrete has hardened sufficiently, are soaker hoses being placed at a maximum 4 ft. (1.2 m) spacing? _____
- (6) After placement of the soaker hoses, are the cotton mats being covered with white polyethylene sheeting or burlap-polyethylene blankets? _____
- (7) For areas inaccessible to the cotton mats, is curing being done using the burlap method as per Art. 1020.13(a)(3)? _____

r. Bonded Construction Joints

- (1) Is the surface of the existing concrete (or hardened concrete from the first pour) being properly prepared in accordance with Art. 503.09(b)? _____

Is the surface being prepared by washing with water under pressure or by sandblasting to expose clean, well bonded aggregate? _____

Note: Removal of cement paste from the first pour may be facilitated by coating the form of the first pour with approved surface retarder, or applying surface retarder directly to the exposed surface of the first pour. _____

(2) Has the prepared surface of the existing concrete been wetted and maintained in a dampened condition for a minimum of one hour before the application of new concrete? (See Art. 503.09(b)) _____

(3) Immediately before placing the new concrete, is any excess water being removed? (See Art. 503.09(b)) _____

s. Protection

Is all deck concrete which is placed during the winter period (Dec. 1 thru March 15) being protected in accordance with one of the following methods? _____

(1) Method I. The concrete and forms completely covered with insulating material enclosed on sides and edges with an approved waterproof liner. (Art. 1020.13(d)(1)) _____

(2) Combination Method I & II. The top of the deck shall be covered with insulating material. The sides and bottom of the deck shall be enclosed in adequate housing for 7 days. The air surrounding the concrete shall be kept between 50 °F (10 °C) and 80 °F (27 °C). (See Art. 1020.13(d)(1)&(2)) _____

Note: If the concrete is placed outside the winter period and the forecast for temperature is below 45 °F (7 °C), (or the actual temperature drops below 45 °F (7 °C)) and the concrete is less than 72 hours old the concrete shall be protected as above. (Art. 1020.13(d))

t. Parapets and Railings

(1) General

(a) Are you not allowing placement of concrete parapets until the deck forms have been removed? Note deck forms cannot be removed until the deck concrete has attained the required flexural strength and the 7 day curing period is complete. (See Art. 503.16(b), 503.06, and 1020.13) _____

(b) Are you checking the locations for all expansion joints, handrail post bolts, and chamfer strips before

permitting the Contractor to place concrete? (See Art. 503.16(b)(2)) _____

(c) Has the deck surface under the parapet been properly prepared for a horizontal bonded joint? Is the prepared surface soaked for an hour before the pour, and is excess water being removed immediately prior to placing concrete? (See Art. 503.09) _____

(2) Formed Parapets and Railings

(a) Are you ensuring all forms have good surface quality? Air pockets vibrated out of the concrete tend to cling even more to the sloped surfaces of parapet forms and a rough form surface worsens this situation. _____

(b) Are you checking the forms prior to placement to ensure they are of the correct dimension, tight fitting, and properly aligned? (Art. 503.16(b)(2)) _____

(c) Are you ensuring the proper clearance from the faces of the concrete? _____

(d) Is the contractor placing the concrete in continuous horizontal layers and thoroughly vibrating the concrete in each layer to ensure internal consolidation and minimize air pockets and honeycombing on the surface of the parapet? (Art. 503.07) _____

(e) Are you rechecking the alignment of forms and grade of the top chamfer strips immediately after the placing of concrete in the forms to ensure all corners in the finished work shall be true, sharp and clean cut? (See Art. 503.16(b)(2)) _____

(f) Are the parapets being cured 7 days with the waterproof paper, polyethylene sheeting, wetted burlap or wetted cotton mat method? (See Art. 1020.13) _____

(See also Art. 1020.13 table note 8/regarding non-traffic surfaces receiving a protective coat according to Art. 503.19)

(g) Are all depressions resulting from the removal of ties, rods or bolt anchorages and all air pockets or rough places larger than 1/2 in. (13 mm) being carefully and neatly pointed with matching mortar? (Art. 503.15) _____

(h) Are all parapet and railing surfaces that will be exposed to view after completion of the work being given a normal finish consisting of the removal of all fins, rough spots, stains, hardened mortar or grout, and form lines

by rubbing with a #16 carborundum stone or equal?
(See Art. 503.15(a))

If the surface of concrete is oil-stained, or is otherwise not of uniform color, it may require cleaning utilizing a grout rub. The grout shall be 1 part cement (from the original source) to 1½ parts fine sand with sufficient water to produce a grout with the consistency of thick paint. At the end of the cleaning operation there shall be no visible film of grout remaining.
(See Art. 503.15(a))

(3) Slip Formed Parapets (General)

(a) Is there a bridge plan general note stating slipformed parapets are not allowed? If there is a bridge plan general note stating slipformed parapets are not allowed, under no circumstance is slipforming to be allowed.

(b) Is the "Slipform Parapet" special provision included in the contract? If the contract does not contain either the slipform parapet special provision or a general note prohibiting slipformed parapets, contact the Central Bureau of Construction to determine if slipforming should be allowed as an alternate method of construction.

(4) Slipform Parapet (See Slipform Parapet Special Provision)

(a) Is the rebar cage tied at all bar intersections? This is necessary to maintain rigidity during concrete placement. The contractor may use additional epoxy coated stiffening reinforcement bars to prevent movement of the reinforcement cage subject to your approval. Significant movement of the cage during slipforming will be cause for immediately ceasing the slipforming operation.

(b) Are you checking the slipform equipment to make sure the proper dimensions will be placed?

In particular, are you making sure the breakline between the base of the parapet and upper portion of the parapet on the face of the parapet does not exceed the plan dimension? This dimension is critical.

(c) Does the slipform machine have automatic horizontal and vertical grade control?

- (d) Has the contractor performed a dry run for the full distance of the anticipated pour, checking for the proper clearance between the rebar and the slipform? _____
- (e) Are the ends of the parapet formed and the forms securely braced? Are parapet sections at light standards formed for a minimum distance of 4 ft (1.2 m) on each side of the discontinuity? _____
- (f) Is the slipform machine running at speeds within the specification limits? _____
- (g) Is the vertical surface at the base of the barrier (within 3 in. of the deck) being troweled true after passage of the slipform machine? Hand finishing of minor sporadic surface defects may be allowed? _____

 Any visible indication that less than specified cover of concrete over the reinforcing bars has been obtained, or of any cracking, tearing or honeycombing of the plastic concrete, or any location showing diagonal or horizontal cracking will be cause for rejection of the parapet section in which they are found.
- (h) Is the specified clearance between the rebar and the slipform being maintained without external force throughout the pour? _____

 If proper clearance cannot be maintained without external force, the slipform operation shall stop until the rebar cage is adjusted to obtain the proper clearance.
- (i) Are you checking that the rebar cage is not moving longitudinally during the slipform operation? _____

 Excessive movement of the rebar cage during the slipform operation shall be cause for removal and replacement of the affected section.
- (j) Is the actual longitudinal alignment within tolerance? _____
- (k) Are abrupt changes in actual longitudinal alignment of 1/2 in. in 10 ft. (13 mm in 3 m) being removed and replaced? _____
- (l) Are all surfaces being checked with a 10 ft. (3 m) straight edge furnished and used by the Contractor as the concrete is extruded from the slipform? _____
- (m) Are variations greater than 1/4 in. in 10 ft. (6 mm in 3 m) being corrected immediately? Continued variations in the barrier surface exceeding 1/4 in. in 10 ft. (6 mm

in 3 m) will not be permitted and remedial action shall immediately be taken to correct the problem. _____

(n) Are any deformations or bulges remaining after initial set being removed by grinding after the concrete has hardened? _____

(o) Is the parapet being cured according to the special provision? _____

(p) Have random cores been taken to verify the quality of the slipform parapet? _____

u. Surface Variations

(1) At the end of the curing or protection period, are you testing the surface of the deck with a 16 ft. (5 m) straightedge? (See Art. 503.16(a)(4)) _____

(2) Are variations greater than 3/16 in. (5 mm) being removed by grinding or cutting? (See Art. 503.16(a)(4)) _____

v. Expansion Joints

(1) Neoprene Expansion Joint Installation

(a) Are the concrete surfaces on which the joint sets, dry, clean and free of dirt, grease, loose concrete and contaminants? (See Art. 520.07) _____

(b) Is the concrete surface level and sound (no broken or spalled concrete) with adjacent joint seats in a common plane with each other? If not are the surfaces corrected by grinding or other approved procedures? (See Art. 520.07) _____

(c) Are neoprene surfaces in contact with the adhesive/sealant bedding compound cleaned with acceptable solvent prior to installation and is the adhesive/sealant applied over the entire blockout? (See Art. 520.07) _____

(d) Are nuts torqued to 65 ft.-lbs. (90 Nm) and after 24 hours of initial installation are the nuts retorqued to 65 ft.-lbs. (90 Nm)? (See Art. 520.07) _____

(e) Are bolt wells, joints between units, around connecting bolts and cavity plugs cleaned and sealed in a neat manner? (See Art. 520.07) _____

(f) Upon completion of the joint, are uneven end butt connections being ground flush? (See Art. 520.07) _____

- (2) Preformed Elastomeric Compression Joint Seals
 - (a) Is the seal installed with suitable hand or machine tools and secured in place in a clean joint with approved adhesive which covers both sides of the seal in contact with the sides of the joint? (See Art. 520.06) _____
 - (b) Is the seal installed in one continuous piece with no more than one manufacturer's splice? (See Art. 520.06) _____
- (3) Preformed Elastomeric Strip Seals
 - (a) Is the steel extrusion cavities being kept clean and dry until the strip seal is placed? (See Art. 520.08) _____
 - (b) Are the "locking ears" portion of the strip seal gland being coated (and installed) with an adhesive/lubricant in 5 ft. (1.5 m) maximum intervals to ensure the adhesive/lubricant does not dry prior to installation? (See Art. 520.08) _____

w. Protective Coat

- (1) Is PROTECTIVE COAT, when specified, being applied to the entire top surface of the bridge deck, hubguards and to the tops and inside vertical faces of the sidewalk, parapets, end posts, and wings? (See Art. 503.19) _____
- (2) Is the protective coat being applied in two applications at 50 sq. yds. per gal. (11m²/L)? (See Art. 503.19) _____
- (3) Is the protective coat being applied when the temperature is above 40 °F (4 °C)? (See Art. 503.19) _____
- (4) Is the protective coat being applied on clean, dry concrete, which is at least 14 days old, after bridge deck grooving but before the bridge deck is marked ? Note there should be a 48 hour drying period since the last rain (See Art. 503.19) _____

x. Field Painting of Structural Steel

Is the steel being cleaned, spot painted and given the application of the additional paint coatings required by the contract? (Art. 506.05) _____

7. **DOCUMENTATION OF FINAL CONTRACT QUANTITIES**

CONCRETE STRUCTURES- Cubic Yard (Cubic Meters)

CONCRETE SUPERSTRUCTURE - Cubic Yards Cubic Meters

REINFORCEMENT BARS - Pounds (Kilograms)

REINFORCEMENT BARS, EPOXY COATED - Pounds (Kilograms)

BAR SPLICERS - Each

a. Are computations based on plan dimensions in a permanent file to verify plan quantities? _____

If your computations are not reasonably close to plan quantity, within 0.3 cu. yd. (0.2m³) for Concrete and 10 lbs. (4.5 kg) for Reinforcement Bars are your calculations being checked by another person to verify the revised quantity? _____

Are you indicating in your records that the structure was "Built to plan dimensions." Otherwise, are you showing revised dimensions? _____

Are you computing the weight of reinforcing bars using the theoretical weight as listed in Art. 508.07? _____

b. In lieu of all of the above, do you have a jointly-signed Form [BC 981](#) agreeing to plan quantities for appropriate pay items to document the final pay quantity? _____

PROTECTIVE COAT - Square Yards (Square Meters)

NEOPRENE EXPANSION JOINT - Foot (Meter)

PREFORMED JOINT SEAL - Foot (Meter)

PREFORMED JOINT STRIP SEAL - Foot (Meter)

a. Have field measurements of all applicable pay items been taken? _____

Have the field measurements and computations been retained in a permanent file? _____

b. In lieu of all of the above, do you have a jointly-signed Form [BC 981](#) agreeing to plan quantities for appropriate pay items to document the final pay quantity? _____

FURNISHING STRUCTURAL STEEL - Lump Sum

ERECTING STRUCTURAL STEEL - Lump Sum

FURNISHING & ERECTING STRUCTURAL STEEL - Lump Sum

FURNISHING & ERECTING STRUCTURAL STEEL - Pounds (Kilograms)*

*This pay item is used for minor pay items of structural steel such as expansion dams on concrete bridges or miscellaneous steel for the repair of existing structures. The pounds (kilograms) of structural steel shall be determined using the approved shipping weight (mass) or by measuring on an approved platform scale (unless the quantity is less than 10,000 lb. (4500 kg)). (See Art. 505.12)

Designers are supposed to include the weight of bolts, nuts, and washers in the estimated structural steel quantity calculation

ELASTOMERIC BEARING ASSEMBLY – Each

ANCHOR BOLTS - Each

FURNISHING & ERECTING PRECAST, PRESTRESSED CONCRETE I-BEAMS (Depth Specified) - Foot (Meter)

FURNISHING & ERECTING PRECAST, PRESTRESSED CONCRETE BULB T-BEAMS (Depth Specified) - Foot (Meter)

PRECAST, PRESTRESSED CONCRETE DECK BEAMS (Depth Specified) - Foot (Meter)

In determining the total length to be paid for, the specified overall length of the individual beams will be used.

In lieu of measured quantities, do you have a jointly-signed Form [BC 981](#) agreeing to beam plan quantities to document the final pay quantity? (See Art. 504.07).

DECK PREPOUR MEETING AGENDA

(Rev. 3/1/09)

Length _____ Width _____

Date: _____

Time: _____

Contact: _____

AGENDA

What is the scheduled date of the pour? _____ Time? _____

1. DISCUSS PLAN NOTES AND SPECIAL PROVISIONS**a. Pour Sequence Concerns**

The addition of a pour sequence (i.e. the addition of longitudinal or transverse joints) or use of a pour sequence that differs from a pour sequence shown in the contract plans must be approved by Bureau of Bridges and Structures.)

b. QC/QA Concrete – discuss roles relating to control of materials and construction.**2. EQUIPMENT**

a. Bidwell? _____ Gomaco? _____ Screed? _____

(1) Discuss auger height (1/8 to 1/4" above roller)

(2) Discuss roller (1/8" higher in back)

(3) Discuss roller rotation

(4) Is equipment in good working order?

b. Skew Placement Concerns

(1) >45 degrees (or >30 degrees with pour width to span length ratio exceeding 0.8); check bridge plan general notes for special finishing requirements

(2) <45 degrees

(3) Have proper adjustments been made to the finishing machine

a. Heavily skewed decks should be finished from leading end to trailing end.

b. Finishing should be from low side to high side of superelevated decks.

c. Dry Run Concerns

- | | | |
|-----|--|------|
| (1) | check rebar clearance | Inch |
| (2) | check deck thickness | Inch |
| (3) | check deck drain clearance | Inch |
| (4) | check for rail deflection | |
| (5) | check fogging system for performance (verify all nozzles work, shut-off system functions and nozzles do not leak.) Nozzles should not point straight down. | |
| (6) | check rebar for ties, epoxy touch ups, etc. | |
| (7) | check for hydraulic leaks and other equipment problems | |
| (8) | check rail supports to ensure stability | |

d. Fogging System Concerns

Note: Fogging is required unless evaporation rate is less than 0.1 lb/sq.ft./hr. Fogging increases humidity at deck surface. Fogging reduces plastic and dry shrinkage cracking caused by high temperature, low humidity, and high wind.

- (1) Use Portland Cement Association's publication "Design and Control of Concrete Mixtures" – section on plastic shrinkage cracking to determine the evaporation rate.
- (2) Repair leaks to avoid ponding water
- (3) Fogging system should be in accordance with Art. 1103.17(k) (No baptizing!)

e. Foot Bridges – minimum 2 required

- (1) Finishers
- (2) Burlap / Artificial Turf Carpet Drag and Curing

f. Plastic Texture

Burlap or artificial turf carpet should be dragged parallel to centerline of roadway.

g. Air Meter Concerns

- (1) Have the air meters been calibrated and correlated?

- (2) Are there a backup air meters that have been calibrated and correlated?

Correlation should include all primary and secondary/backup meters from the plant, contractor and state. All meters should read within 0.9%

h. Concrete Pump Concerns

- (1) Waste initial mortar in approved location (not the deck or water way)
- (2) Plywood under all pipe joints
- (3) No water hosed into hopper
- (4) No aluminum pipes
- (5) Air test required at both ends to determine air loss correction factor (first 3 loads + every additional 50 cu. yd.)
- (6) Required "S" shaped outlet or 90 degree elbow and hose; Purpose to control air loss, prevent segregation, and reduce the potential for damage to epoxy coated reinforcement
- (7) What is backup/breakdown procedure? (i.e. bucket or additional pump)

i. Mix Concerns

- (1) Air Content decreases as boom angle decreases
- (2) Temperature Control

j. Concrete Conveyor Concerns

- (1) Adequate covering to collect spilled concrete
- (2) DO NOT run conveyor out over placed concrete (spillage)
- (3) Avoid reinforcement bar damage from conveyor supports and conveyor section stacking

k. 10 foot straight edges...how many?

- l. Floating entire surface with 10' float optional, – Floating entire surface with 3' float is not allowed

m. Bonded Construction Joints

- (1) First Pour-finish smooth, spray retarder on joint surface within 30 minutes after concrete placement
- (2) Next Day- Pressure wash to expose aggregate
- (3) Second Pour- wet first pour joint surface and keep damp for at least one hour prior to second pour

n. Phone Concerns

- (1) Is a phone available to call the ready-mix plant?
- (2) Is adequate service/signal available for cell phones?
- (3) What is the ready-mix plant phone number?

o. Vibrator Concerns

- (1) Do all vibrators have non-metallic heads coated by the manufacturer (BDE)?
- (2) Slip-on head covers are not allowed.
- (3) Are back-up vibrators available and approved?

3. FRAMING, RAILS AND REBAR

a. Cantilever Forming Bracket Concerns

- (1) Leg brace of cantilever bracket shall bear on the web within 6" of bottom flange
- (2) #4 epoxy tie bars required @ 4' to 8' c-c (4' max. when finishing machine rails are located outside exterior steel beams/girders)
- (3) Place ties between top and bottom layers of deck reinforcement. For decks with cross slopes, it may be necessary to anchor the ties on the exterior girders and on the girders adjacent to the cross slope crown.
- (4) Draw ties taut until tie bar does not vary from a straight line.
- (5) Use fabricated brackets to anchor ties (no welding to studs or PPC beam reinforcement bars)
- (6) Alternate tie procedures must be submitted for approval with design calculations and detailed plans
- (7) Cable not allowed (too much elongation)
- (8) 4x4's required between exterior and first interior beams at tie locations
- (9) All accessories being permanently incorporated should be epoxy coated or galvanized
- (10) Coat forms with form oil prior to placing reinforcement

b. Reinforcement Bar Concerns

- (1) Discuss epoxy coating inspection procedure
- (2) Repair nicks and cuts

- (3) Cut skew rebar...Shear cut – No flame cutting allowed
 - (4) 100% ties? Less than 12"spacing, alternate intersections ok
(Use multiple twists to assure bars stay tied under foot traffic)
 - (5) #9 tiedown wire @ 25' longitudinal & 15' transverse spaces
 - (6) Chairs...continuous 3' bottom or top. 2'x3' spacing for top mat ok
(Top mat chairs are required to be placed on formwork. Not on bottom mat of steel.)
 - (7) Protect epoxy coating
 - (a) Is plywood available?(Best Practice)
 - (b) Avoid using rebars to clean come-alongs and other hand tools
 - (c) Rubber coated vibrators
- c. Rail Support Concerns
- (1) Where are rail supports placed?
 - (2) Avoid rails within pour when possible
(Causes problems with consolidation, hand finishing and delays curing placement)
(Rails must be placed directly on W27 and smaller steel beams)
 - (3) Avoid having to stand in mix to finish
 - (4) How and where are supports attached? (Epoxy? No field welding)
 - (5) What is the center to center distance?
 - (6) Is the rail rigid?
- g. Plywood walkways on 4x4 supports?
- (Walking on projecting reinforcement bars can fracture the concrete after the initial set)

4. **CURING**

- a. Wetted Cotton Mat Method (Required)
 - (1) Do not over finish concrete
 - (2) Cover IMMEDIATELY

- (3) Who is the contractor's supervisor responsible for covering and curing the deck?
 - (4) Do we have adequate dedicated labor?
 - (5) Pre-Wet Cotton Mats (Best Practice) or SOAK immediately.
 - (a) Mats must be thoroughly soaked. Use adequate water.
 - (b) Delayed wetting can cause mats to wick water away.
 - (6) Keep blankets within 35' of finishing machine (25' for decks wider than 50') or stop placement to catch-up.
 - (7) Emphasize timely covering include very beginning of pour
 - (8) Soaker Hoses every 4' max.
 - (9) Is there a continuous water supply-how will it be keep wet overnight/weekend?
 - (10) Cover cotton mats and soaker hoses with white polyethylene sheeting or burlap-polyethylene blankets
- b. Low Air Temperature Protection Concerns
- (1) Required when air temperature is below 45 °F within 72 Hrs. (predicted or actual)
 - (2) Required during Winter Period of December 1 – March 15
 - (3) Review Protection Method 1 and 2
 - (4) Contractor responsible for concrete damage by cold
 - (5) Means for checking concrete temp during curing required

5. **PLACEMENT**

- a. Wet the wood deck prior to concrete placement
- b. Leakage onto beams or girders must be removed when in the plastic state – to avoid damage to primer/paint system
- c. Compressor available to blow off dried concrete
- d. Remove splattered concrete from deck and parapet reinforcement bars – typically with burlap
- e. Reinforcement bars must remain clean of mud
- f. Avoid walking in finished/vibrated concrete
- g. Mortar/Cream Concerns

- (1) Mortar/cream from finishing machine rollers shall be removed from the deck
 - (2) The mortar/cream should not be wasted in sidewalk, median, or parapet areas etc...
- h. Vibrator Insertion Concerns
- (1) Insert vibrators vertical for 3-5 seconds to remove entrapped air, not entrained air
 - (2) Do not drag vibrators – this leads to segregation of mix
 - (3) Do not use vibrators to move concrete
- i. Probe & Record deck thickness
- j. Air & Slump Concerns
- (1) Need test area
 - (2) No fly dumping
 - (3) Test each load
 - (4) Test before and after pumper – have a piece of plywood available for air test on deck
 - (5) What slump do you want at the deck?
 - (6) What air content do you want at the deck?
- k. Plastic Texture Concerns
- (1) Use burlap or artificial turf carpet drag
 - (2) Drag parallel to centerline roadway
- l. Saw Cut Grooving Concerns
- (1) Saw cut groove perpendicular to centerline roadway
 - (2) Pick up slurry
 - (3) Stop grooving 1' from face of curbs and parapets
 - (4) Stop grooving 2" ± 1" from drains and expansion joints
- m. Finishing Concerns
- (1) Do not over hand finish
 - (2) Set Machine Properly

- (3) No need to bull float – (floating entire surface is only permitted with floats 10' long or longer)
- (4) Check with 10 ft. straight edge
- (5) Avoid walking in finished concrete
- n. Emergency Procedures (Delays over 10 minutes)
 - (1) Concrete protection (wetted burlap available)
 - (2) Spare Parts for finishing machine
 - (3) Header available
 - (4) Header locations
- o. Parapet Area Concerns
 - (1) Avoid bidwell slop
 - (2) Rebar need to be cleaned of any splatter
 - (3) Discuss preparation of horizontal joint
- p. Place concrete uniformly - do not spread mix erratically on the deck
- q. If structure is skewed place concrete parallel to skew

6. **DELIVERY OF MIX**

- a. Mix Design Concerns
 - (1) Does the RE have a copy of the approved mix design?
 - (2) Are there any factors which require special construction needs?
 - (a) Long term retarding
 - (b) Pumping - When class BD concrete is to be pumped, the course aggregate gradation shall have a minimum of 45 percent passing the 1/2in. sieve as per article 1004.01(c) note 8/.
 - (c) Specialized concrete
 - (3) Have approved gradation tests been submitted from the plant stockpiles?
- b. Transit or Central Mix Plant
- c. Scheduled time for start of pour?
- d. Material Supply Concerns
 - (1) How much material is going to be needed?

- (2) At what rate?
 - (3) Haul time from plant?
 - (4) Are enough trucks available?
 - (5) Are enough materials available (cement, microsilicia, aggregates)?
- e. Addition of Admixtures Onsite Concerns
- (1) Discuss responsibility for adding admixtures on site
 - (2) Is adequate Air Entrainment Admixture (AEA) and Superplasticizer on site?
 - (3) Know your admixtures
 - (a) Compatability
 - (b) Dosage rates - One Oz. AEA/yd³ normally raises air one percent
 - (c) 40 additional revs before testing
- f. Discuss responsibility for communicating with the plant
- (1) Mix and admixture changes
 - (2) Breakdowns
 - (3) Air Loss
- g. All concrete trucks must have working rev counters and sight tubes. Counters will be reset for each load.
- h. Delivery Ticket Concerns
- (1) Each delivery ticket shall be stamped with the batch time
 - (2) Best practice - Each delivery ticket should include plant test results
 - (3) Best Practice - Each delivery ticket should note the amount of water that can be added on-site
 - (4) Note when strength specimens are made in field
 - (5) Field Personnel should record rev count, time of discharge, total water added and total admixtures added
- i. All trucks will reverse their drums prior to loading.
- j. Discuss truck mixer revolutions
- k. If Type G admixture (superplasticizer with retarder) is used...No retempering will (with water or Type G admixture) be allowed.

- If Type F admixture (superplasticizer) is used...No retempering water will be allowed, Retempering will be with Type F only. Ensure retempering does not bust the maximum water/cement ratio
- I. Discuss use of retarder
 - m. Discuss haul time
 - n. Concrete Temperature Concerns
 - (1) No concrete will be placed with a mix temperature above 90 degrees
 - (2) Correlate all thermometers before pour
 - (3) Is enough ice available if necessary?
 - (4) Water stockpiles
 - (5) Retarder or 50% increase in water reducer required above 85 degrees
 - (6) No concrete will be placed with a mix temperature below 50 degrees
 - (7) Is enough hot water available
 - (8) Do aggregates need to be heated?
 - o. Aggregate gradation and moisture tests shall be ran prior to pour
 - p. Has a Dedicated concrete wash out area been established (with silt fence – best practice)?
 - q. Testing Concerns
 - (1) An air test will be performed on every load at the jobsite.
 - (2) Check slump for loss of workability
 - (3) A wheel barrow shall be available at testing site for obtaining more representative sample. (1/3 to 1/2 full)

7. WEATHER

- a. Hot and/or windy (and/or DRY) Weather Concerns
 - (1) AVOID pouring (prime cause of plastic shrinkage cracking)
 - (2) Fogging system required
 - (3) Pour at night
 - (4) Start very early in the morning
 - (5) Labor fatigue (will enough labor be available?)

b. Rain Concerns

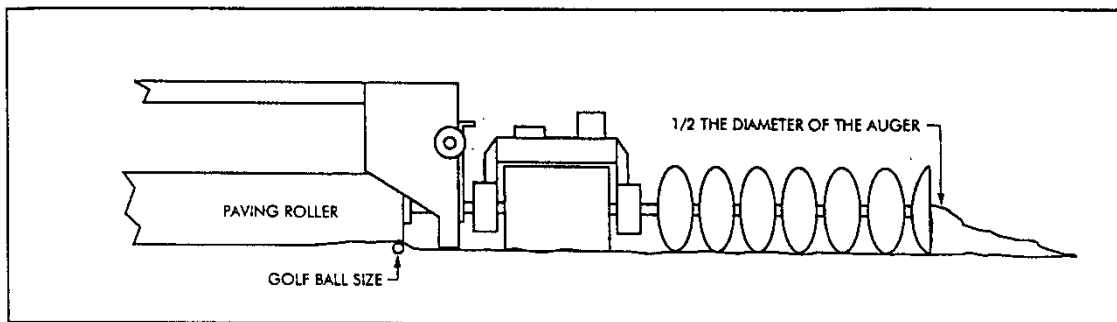
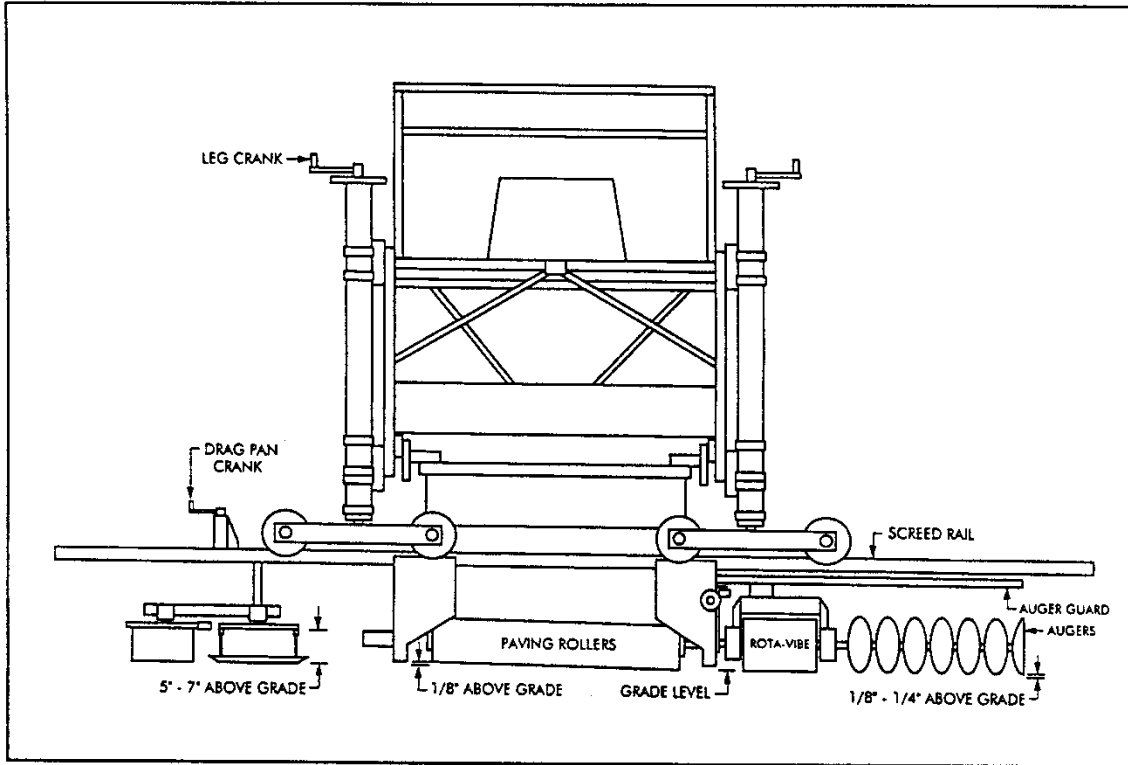
- (1) Check forecast – should we AVOID pouring – why chance removal?
- (2) Who will decide to call off pour?
- (3) When will decision be made to call off pour?
- (4) Rain hitting the surface raises the water/cement ratio and causes scaling, and marring of the surface and ultimately a shorter deck life

8. MISCELLANEOUS CONCERNS

- (1) Review Construction Inspectors Checklist for Bridge Superstructures
- (2) Rules of Thumb?
- (3) Medians and Sidewalks need same attention to detail as rest of the deck
- (4) Discuss stage line joint preparation if applicable

(Excerpt from "Machine Setup, Models 2450-3600-4800 Concrete Paving Machine," Bid-Well, Division of CMI Corporation, Canton, SD)

ADJUST ROLLERS AND DRAG PAN – After the pour has started and the machine has moved out from the end bulkhead or has passed over the bulkhead the full length of the paving roller, raise the back of the machine 1/8 of an inch by turning the leg cranks 1/2 turn counterclockwise (See figures below). This will keep the rear of the paving rollers from digging in and leaving a small ridge of concrete. It may be necessary to readjust the augers, up or down, to obtain or reduce the roll of concrete. Optimum is golf ball size in diameter at the front of the paving roller. As the machine progresses into the pour and clears the bulkhead or end dam, attach the burlap or astrograss drag to the drag pan.

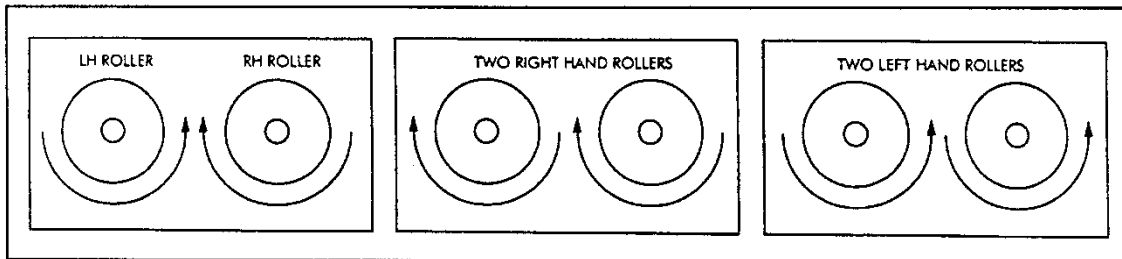


NOTE: The burlap drag should be wet. If new burlap is being used the burlap should soak in water for at least 24 hours. This will remove all oils in the burlap and make it more absorbent.

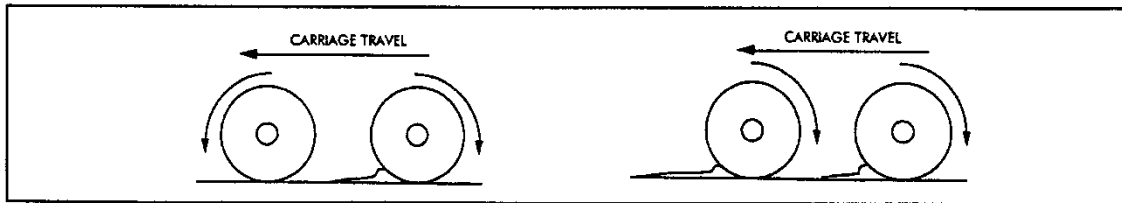
The texture given by the burlap can be easily adjusted. If the burlap is dragging too hard, remove one of the retaining tubes and roll up the burlap so that the drag is not so heavy. If the burlap does not seem to drag enough, increase the length of the burlap so that it hangs down more.

NOTE: If the drag pan H-Frame is too high or the chains are hooked too tight, the pan will have a tendency to hop as it is being dragged across the deck.

ROLLER ROTATION – The two paving rollers can rotate in the same direction (either clockwise or counter-clockwise) or they can rotate in opposite directions (See figure below).

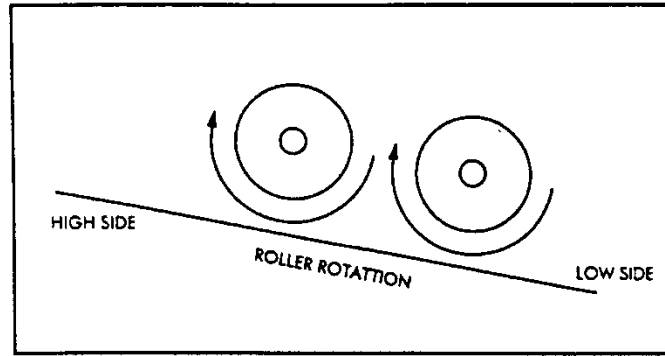


At the beginning of a pour it is recommended that you rotate the rollers in the same direction for the first couple of passes. Using the Roller Directional Valves, position the two valve levers in the same direction. Facing the augers, both rollers turn clockwise when the carriage travels to the left and counterclockwise when the carriage travels to the right. Put the Automatic Roller Reversing Valve in the "Reversing" position. The "Reversing" position will change the roller direction with each pass of the carriage. After a couple passes, change the direction of one roller. Which one will depend on the direction of the carriage travel (See figure below).



Put the Automatic Roller Reversing Valve in the "Non-Reversing" position. The "Non-Reversing" position does not change the roller direction with each pass of the carriage. Facing the augers, the right roller turns clockwise and the left roller turns counterclockwise. This allows the leading roller to consolidate the concrete and the trailing roller to pave the surface. Normally, when pouring a flat bridge deck or slab, this roller rotation will provide the best overall production and sealed finish. However, due to "mix," slump and other concrete variables one roller rotation option may work better than another. The paver's automatic pivot device will keep the excess material that the paving rollers carry moving out the front of the paving rollers instead of trailing off to the rear of the paving rollers. The pivot device can be adjusted for quickness by turning the set screws on the Automatic Roller Reversing Valve.

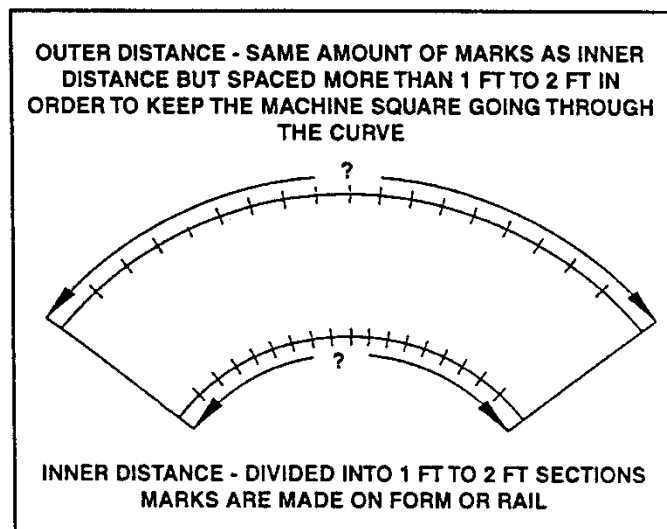
SUPER ELEVATIONS – When paving super elevated slabs, bridge decks or skewed decks both rollers must be turning in the same direction and the Automatic Roller Reversing Valve should be set in the "Non-Reversing" position. The concrete should be pushed from the low side to the high side of the elevation and roll over the concrete going down the super elevation (See figure, p. 30)



The roller direction will depend on the direction of the pour and what side is the high side.

PAVING UP & DOWN GRADES – When paving up a grade, the rear of the paving rollers may need to be raised higher (approximately 1/8" to 1/4"). Raise the back of the machine 1/8 of an inch by turning the leg crank 1/2 turn counterclockwise. The augers may need to be adjusted lower. Adjusting the augers with the Auger Adjusting Crank (Handle). These adjustments will counteract the tendency of excess concrete from moving downhill toward the paving rollers. When paving down a grade, the augers may need to be raised higher to provide the proper amount of concrete to the paving rollers. The rear of the paving rollers may not need to be raised but be sure that there is close to total contact with the deck or slab. When paving down hill, you want maximum surface contact with the concrete but not allow any ridge or line of concrete to come off the rear of the paving rollers.

PAVING CURVES – Given the known length or distance of the inside and outside curve, mark an equal number of spaces on the inner curve (1 to 2 feet in length). Count the number of spaces on the inner curve and mark the same number of spaces on the outer curve. The length of these spaces will vary with the length of the outer curve section (See figure below).



To negotiate the inner curve, the operator will at times place the Machine Direction Control Lever in the neutral position allowing a longer amount of travel for the outer curve and the machine. Keep the front wheels of both the inner and outer ends aligned with the marks placed on the rail or curb.

MACHINE ADVANCEMENT – The advancement of the machine at the end of each pass is based on the rate of concrete being poured. The operator should pace the machine advancement so that the physical placement of the concrete is no more than 6 to 8 feet in front of the machine. Normal advancement of the machine will vary from 3 to 6 inches (up to 12 inches) for each carriage pass. This will insure that fresh concrete will move into the paving rollers before dehydration of the concrete occurs. This is particularly true in hot, windy weather. The decking and sub-base material should also be kept wet in hot, windy weather to aid in the slowing down of the drying process.

CARRIAGE TRAVEL SPEED – At times it may be advantageous to slow down the carriage travel speed. Slowing the carriage travel will allow the paving rollers to have longer contact with the surface. Slowing the carriage travel speed may be beneficial when paving Super Plasticized Concrete or Latex Modified concrete. The carriage speed can be reduced by slowing down the engine or by using the carriage speed control located on the operator's console. The operating speed of the engine should run 2800 to 3200 RPM. At these speeds the carriage will travel approximately 85 to 90 feet per minute transversely across the machine.