Structural Element Erection Bracing

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Construction & Maintenance
Overview

- **Temporary Structures**
  - Bracing
  - Shoring

- **Authority and Liabilities regarding contractor’s safety critical work**
  - Items 5 and 441
    - TxDOT Engineers
    - TxDOT Inspectors

- **Resources**
  - Design Manuals
    - TxDOT
    - ASSHTO
  - Standards
  - BRG Division
Topics

• **Concrete**
  – Prestress “I”-Beams
    • Types (All)
  – Prestress “U”-Beams
    • Types U

• **Structural Steel**
  – Rolled “W” Shape
    • W18 thru W40
  * Plate Girders “I” - Section
Why?
Safety Concerns

- Public

On the roadway.
Safety Concerns

- Workers (TxDOT & Contractor)

On the job.
Safety Concerns

- Workers (TxDOT & Contractor)
Safety Concerns

- Workers (TxDOT & Contractor)
Concrete Beams
Concrete Beams

• MEBR (C) Standard
  – Prestress Concrete “I”-Beams
    • Types A, B, C, IV, 72, Tx 28 thru Tx 70
    • Type A, B issues
  • MEBR (U) Standard
    – Prestress Concrete “U”-Beams
      • Types U
Jan. 2005

Updated Jan. 2005
Typical Bracing

- 1998 Standard
1998 Standard
Prestressed "U"-Beams

MINIMUM BLOCKING OF EXTERIOR U-BEAM

Required minimum blocking of exterior fiber must be in place before pouring of fiber concrete. Leave blocking in position for at least 10 days or until otherwise relieved of the Contractor's convenience.

MINIMUM BEAM BRACING

Load two No. 6 bars at each end of each beam to be used. A minimum of 6 bars is required either on either side of the beam. This reinforcement is in addition to the shear reinforcement required. It is placed before any pouring of the diaphragm panels.

Load No. 6 bars to the maximum capacity of the exterior beam and exterior bay after stress in beam bars has been released and prior to pouring exterior concrete. This reinforcement is in addition to that shown for the concrete diaphragms.

GENERAL NOTES:

Systems shown No. or bracket may vary shown due to varying conditions. Load bars at each end of each beam is the maximum capacity of the beam and the beam should be placed before any pouring of the diaphragm panels. Use of these systems shall be at the Contractor's discretion and the responsibility for the accuracy of the bracing and the safety of the structure.

Texas Department of Transportation
Bridge Division

MINIMUM ERECTION AND BRACING REQUIREMENTS
PRESTRUC U-BEAM SPANS

MEBR (U)
Short Span Bridges

• Short Span
  – Type A or B
Short Span Bridges

- 3’ Overhang Typ.

TYPICAL TRANSVERSE SECTION
Type “IV” Beam

Type “A” Beam
Before Deck Placement

BID-WELL 4800
≈ 14,000 Lbs.

GOMACO C-450
≈ 11,000 Lbs.

8”
After Deck Placement
Beam Rotation
Beam Rotation
Beam Rotation
HAULING & ERECTION:
The Contractor’s attention is directed to the possible lateral instability of prestressed concrete beams and girders over 130’ long, especially during hauling and erection. The use of the following methods to improve stability is encouraged: Locate lifting devices at the maximum practical distance from beam ends; use external lateral stiffening devices during hauling and erection; lift with vertical lines using two machines; and take care in handling to minimize inertial and impact forces.

CROSS BRACING DETAIL

Supplemental horizontal bracing required for slab placement. See Horizontal Bracing Details.
Supplemental Horizontal Bracing
Supplemental Horizontal Bracing
Supplemental Horizontal Bracing

Note 7 “Tight fit (Typ)”
Structural Steel Beams
Structural Steel Beams

- Rolled “W” Shape “I”- Beams
  - W18 thru W40
- * Plate Girders “I” - Section
Rolled “W” Shape “I”- Beams

- Mainly Straight
- W18 Thru W40
- SBBR(S)
Steel "W" Shape Beams

II. Structural Steel Beams
A. "W" Beams
1. Mainly Straight
W 18 Through W 40
2. SBBR (S)

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Erection and Slab Placement Bracing

[Diagram showing details of erection and slab placement bracing]

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TABLE A

<table>
<thead>
<tr>
<th>Beam Type</th>
<th>Live Load (kips)</th>
<th>Dead Load (kips)</th>
<th>Unit Weight (psf)</th>
<th>Material Grade</th>
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</thead>
<tbody>
<tr>
<td>W18 &amp; W21</td>
<td>10.5</td>
<td>20.5</td>
<td>144</td>
<td>A36</td>
</tr>
<tr>
<td>W25</td>
<td>16.5</td>
<td>22.5</td>
<td>144</td>
<td>A36</td>
</tr>
<tr>
<td>W30 &amp; W35</td>
<td>16.5</td>
<td>22.5</td>
<td>144</td>
<td>A36</td>
</tr>
<tr>
<td>W35 &amp; W40</td>
<td>20.5</td>
<td>24.5</td>
<td>144</td>
<td>A36</td>
</tr>
</tbody>
</table>

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General Notes:

- Permanent splice plates shall be placed immediately after erection of each beam.
- Intermediate bracing shall remain in place until tied concrete has attained 50% of its compressive strength (3,000 psi).
- Steel plates are considered auxiliary to structural steel members.

[Diagram showing details of permanent splice plates and reinforced concrete beams]

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Texas Department of Transportation

Erection and Bracing Requirements

Steel Beam Spans

SBBR

[Diagram showing details of steel beam spans]
Steel Structures - Misc.

- May need to design supplemental temporary bracing for slab placement on steel I-girders
- Standard does not address slab placement bracing - it assumes the diaphragms will do the job
- Some bolted channel diaphragms won’t do the job
6” Slab

Bolted Channel Diaphragms

27” deep beam rotated 2”
1 1/4” dia holes for 1” dia bolts

C12x 20.7
1/2 x 2 steel bar

4x4 wedged tight

20’ O.C.
Plate Girders “I” Section
Plate Girders “I” Section
Plate Girders

• Characteristics
  – Tall Beams (Composite Section)
    • Composite Section
    • TxDOT (3:1)
    • ASSHTO up to (6:1)
  – Long Span (less bents)
  – High in elevation (3rd, 4th level)
  – Curved
  – Ramps (Smaller Radii)
  – Metropolitan Areas
    • Populated
    • High Traffic
Plate Girders

TxDOT “Bridge Design Manual”

“Erection Issues”

“Girder sections tend to be unstable during erection if the top flange plate is too narrow. Composite design tends to make the top flange narrow. Erection procedures, including falsework and girder support while welding or bolting splices, require close coordination with the contractor.

Erection is especially critical for curved girder units. Accurate analysis of deflections and stresses during erection stages is very complicated and time consuming. The tendency is to rely on judgment until trouble occurs. Except for a few notable mistakes, Texas has managed to get its curved girders erected without significant mishap. Close coordination between field and design personnel is vital.”
Plate Girders

Tall Beams

- Composite Section
- TxDOT (3:1)
- ASSHTO up to (6:1)
Plate Girders

- Long Span (less bents)
- High in elevation (3rd, 4th level)
Plate Girders

- Straight
Plate Girders

- Curved
Plate Girders

- Metropolitan Areas
  - Populated
  - High Traffic
Plate Girders

- Massive Equipment
- Numerous Worker
Plate Girders
Plate Girders
Plate Girders
Structural Steel

Submit 2 copies of erection drawings in accordance with Item 5, “Control of the Work,” before erection of railroad underpasses, trusses, field-spliced (welded or bolted) girders, arches, or other members for which erection drawings are required on the plans. Submit an additional copy of the drawings for railroad underpasses. Erection drawings are not required for rolled I-beam units unless otherwise noted on the plans.
441.3.A.6.a. Erection Drawings. (Cont.)

Clearly indicate at least:

• procedures;
• sequence of work;
• equipment to be used;
• location of falsework, erection cranes, and holding cranes;
• falsework design details;
• girder lifting points;
• adjacent structures loaded; and
• requirements for releasing cranes during erection that differ from the requirements of this Item or those shown on the plans.

If site conditions differ from those assumed for these drawings, revise the drawings to reflect the actual conditions before continuing the erection work.
ITEM 5
CONTROL OF THE WORK
5.1. Authority of Engineer. The Engineer has the authority to observe, test, inspect, approve, and accept the work. The Engineer decides all questions about the quality and acceptability of materials, work performed, work progress, Contract interpretations, and acceptable Contract fulfillment. The Engineer has the authority to enforce and make effective these decisions. The Engineer acts as a referee in all questions arising under the terms of the Contract. The Engineer’s decisions will be final and binding.
ITEM 5
CONTROL OF THE WORK (Cont.)

5.2. Plans and Working Drawings. When required, provide working drawings to supplement the plans with all necessary details not included on the Contract plans. Prepare and furnish working drawings in a timely manner and obtain approval, if required, before the beginning of the associated work. For all working drawing submittal requirements, the Engineer may allow electronic and other alternative submission procedures. Have a licensed professional engineer sign, seal, and date the working drawings as indicated in Table 1.
**Table 1**  
**Signature and Approval Requirements for Working Drawings**

<table>
<thead>
<tr>
<th>Working Drawings For</th>
<th>Requires Licensed Professional Engineer’s Signature, Seal, and Date</th>
<th>Requires Departmental Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Alternate or optional designs submitted by Contractor</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Supplementary shop and fabrication drawings for structural items</td>
<td>No unless required on the plans</td>
<td>See applicable Item</td>
</tr>
<tr>
<td>3. Contractor-proposed temporary facilities that affect the public safety, not included on the plans</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>4. Form and falsework details</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bridges, retaining walls, and other major structures</td>
<td>Yes unless otherwise shown on the plans</td>
<td>No¹</td>
</tr>
<tr>
<td>Minor structures</td>
<td>No unless otherwise shown on the plans</td>
<td>No</td>
</tr>
<tr>
<td>5. Erection drawings</td>
<td>Yes</td>
<td>No¹</td>
</tr>
<tr>
<td>6. Contractor-proposed major modifications to traffic control plan</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

¹ The Engineer may require that the Contractor have a licensed professional engineer certify that the temporary works are constructed according to the sealed drawings.
HORIZONTALLY CURVED I-GIRDERS:

Unless shown otherwise on the erection drawings, support girder sections such that the mid-ordinate of the girder does not exceed 1.2’ between support points. See "Curved Girder Erection Support Detail". Brace girders at all supports. Do not remove temporary supports until continuous girders are supported by at least three permanent supports, cross-frames or diaphragms are fully installed, and splices are completed.

When using the support plate details shown on this standard, as a minimum, use a support near the center of the girder section until the splice is completed.
Structural Steel

1.2’ Max
mid-ordinate between permanent and/or temporary supports

chord between supports

CURVED GIRDER ERECTION SUPPORT DETAIL
Structural Steel

- **Sequence**
  - Beams ID Numbers
  - Splices
  - Starting end

- **Procedure**
  - Number and capacity of cranes
  - Crane setup locations
  - Beam pickup points
  - Beam hooks capacities
  - False Bent locations
  - Etc.

- **Load Calculations**
  - Each section of beam
  - Shoring capacity
  - Crane
    - Capacity
    - location
    - Boom Angles
    - Brand and Type
Resources

- TxDOT - Standard Spec. 2004
- TxDOT - Standard MEBR (S)
- TxDOT - Bridge Design Manual
- TxDOT – BRG – Field Ops., Const. & Maint.

Questions?
Questions?