Lateral Stability of Long Span Girders from a Producers Perspective

Steven Walker, PE

Knife River – Western Oregon Division

KNIFE RIVER
AN MDU RESOURCES COMPANY

Presentation Outline

- Lateral Stability Literature
- If You Build It They Will Come
- Lateral Stability Basics
- CALTRANS Sections
- Bridge Design Details
- Girder Bracing
- Bracing Examples
- Erection Examples

KNIFE RIVER
AN MDU RESOURCES COMPANY

Lateral Stability – References

- Laszlo and Imper, “Handling and Shipping of Long Span Bridge Beams,” PCI Journal, Vol. 32, No. 6, Nov-Dec 1987, pp 86-101.
- Robert F. Mast, PE, " Lateral Stability of Long Prestressed Concrete Beams - Part 1," PCI Journal, Vol. 34, No. 1., Jan-Feb 1989, pp. 34-53.
- Robert F. Mast, PE, " Lateral Stability of Long Prestressed Concrete Beams - Part 2," PCI Journal, Vol. 38, No. 1., Jan-Feb 1993, pp. 70-88.

KNIFE RIVER
AN MDU RESOURCES COMPANY

Girder Stability - Literature

- Chris D. Hill, John S. Dick and Maher K. Tadros, “PCI Advisory on I-Girder Stability during Handling and Construction.” Safety and Serviceability, Aspire Magazine, Winter 2009 Issue, pp 38-40.

www.aspirebridge.org

KNIFE RIVER
AN MDU RESOURCES COMPANY

Times are changing

Throughout the years a common question is often asked "How long can you make it?"

Photo Courtesy Of Jon Grafton

KNIFE RIVER
AN MDU RESOURCES COMPANY

If you will build it they will come

Prestressed precast concrete bridge girders are increasing in span due to improvements in:

- Concrete Strengths
- Stressing Beds
- Shipping Equipment
- Cranes

KNIFE RIVER
AN MDU RESOURCES COMPANY

Concrete Strengths

ODOT's
- 7,000 psi Transfer
- 9,000 psi 28 day

KRC's
- 15,000 psi 28 day

KNIFE RIVER
AN MDU RESOURCES COMPANY

Stressing Beds

KNIFE RIVER
AN MDU RESOURCES COMPANY

Shipping Equipment

KNIFE RIVER
AN MDU RESOURCES COMPANY

Bigger Cranes

- 80 Ton Single Pick

KNIFE RIVER
AN MDU RESOURCES COMPANY

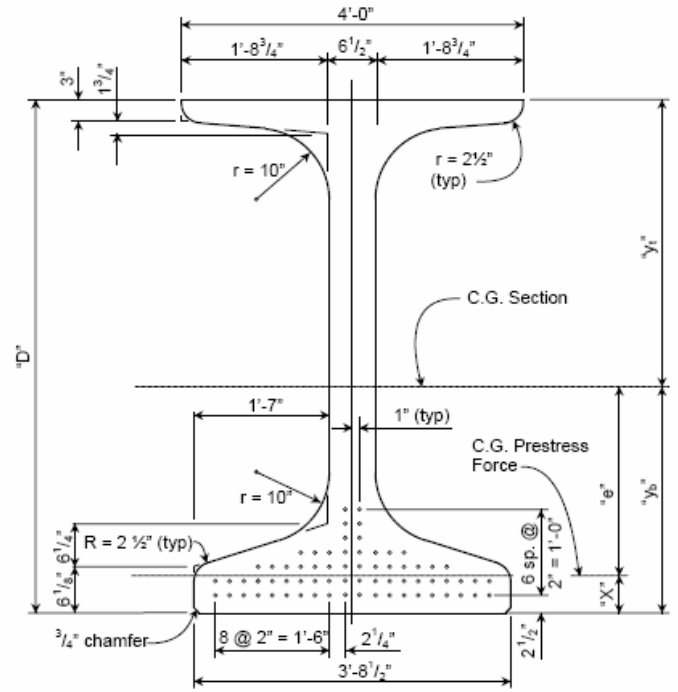
Oregon's BT90 Girder

KNIFE RIVER
AN MDU RESOURCES COMPANY

CALTRANS “SUPER” Girder

- 200 Foot Plus Spans

CALTRANS PRETENSIONED “SUPER” GIRDER



SECTION PROPERTIES

Size (ft-in)	"D" (in)	A (in^2)	I (in^4)	"y_b" (in)	"y_t" (in)	S_b (in^3)	S_t (in^3)	r (in)	w (lb/ft)
3'-0"	36	797	131 480	15.79	20.21	8 327	6 506	12.84	830
3'-6"	42	836	194 940	18.27	23.73	10 670	8 215	15.27	871
4'-0"	48	875	273 010	20.79	27.21	13 132	10 033	17.66	911
4'-6"	54	914	366 470	23.35	30.65	15 694	11 956	20.02	952
5'-0"	60	953	476 050	25.95	34.05	18 345	13 981	22.35	993
5'-6"	66	992	602 500	28.57	37.43	21 089	16 097	24.64	1033
6'-0"	72	1031	746 560	31.23	40.77	23 905	18 311	26.91	1074
7'-0"	84	1109	1 090 400	36.62	47.38	29 776	23 014	31.36	1155
8'-0"	96	1187	1 513 400	42.09	53.91	35 955	28 072	35.71	1236
9'-0"	108	1265	2 021 200	47.62	60.38	42 444	33 474	49.97	1318
10'-0"	120	1343	2 619 600	53.21	66.79	49 231	39 221	44.17	1399

KNIFE RIVER
AN MDU RESOURCES COMPANY

Let The Challenge Begin

The Engineer of Record typically designs the composite girder in its final, fully braced configuration.

The production, handling, shipping, and erection responsibilities rest with the manufacture and erection contractor.

The Engineer of Record must ensure the girder can be fabricated, shipped, and erected. Talk to your local precaster during the early design phase.

KNIFE RIVER
AN MDU RESOURCES COMPANY

Things Are Going To Happen!!

KNIFE RIVER
AN MDU RESOURCES COMPANY

Engineering Challenges

- Lateral Stability Analysis
- Pushing The Limits
- Modified Sections

KNIFE RIVER
AN MDU RESOURCES COMPANY

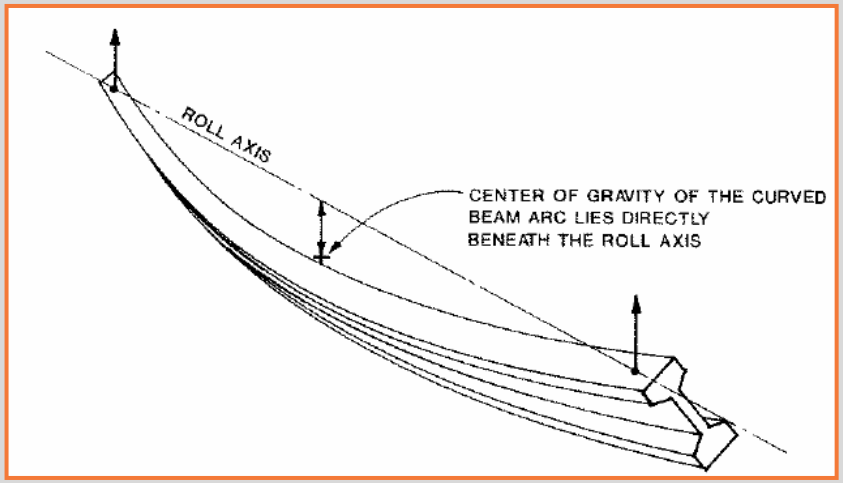
Lateral Stability

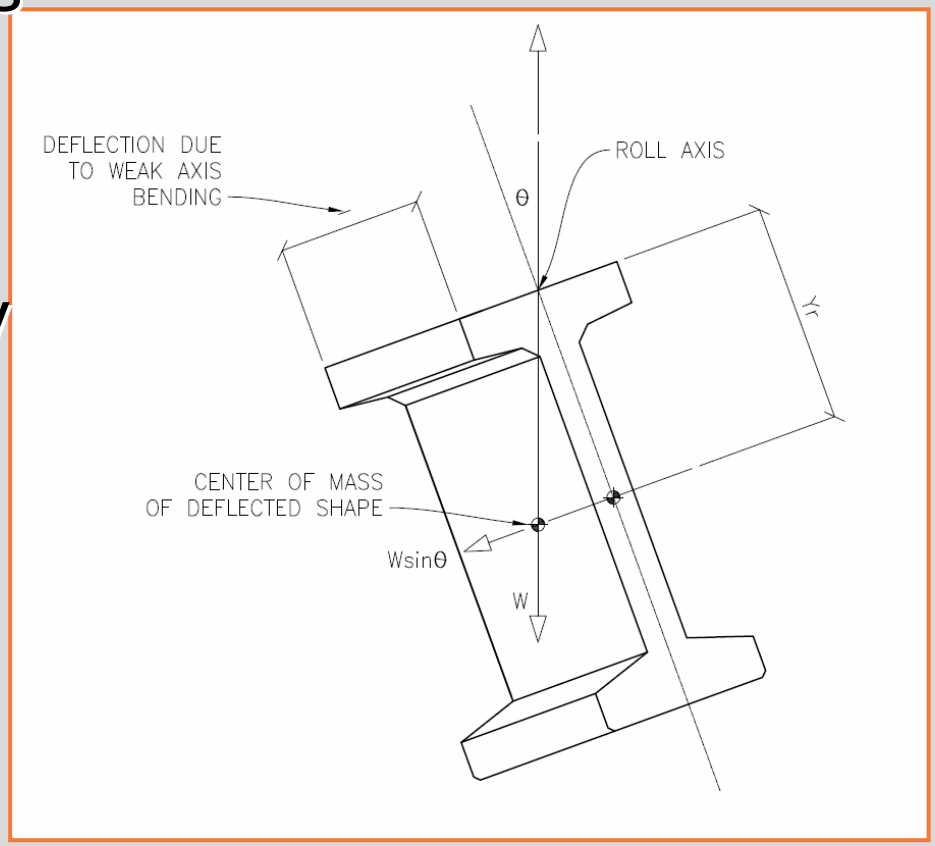
The girder is safe to handle during all handling configurations.

Factor of Safety against lateral buckling instability. Recommended 1.5 minimum according to Dr. Mast.

Lateral Stability

- Girder Section Properties
- Lifting Geometry
- Material Properties
- Level of Prestressing
- Initial Lateral Eccentricity

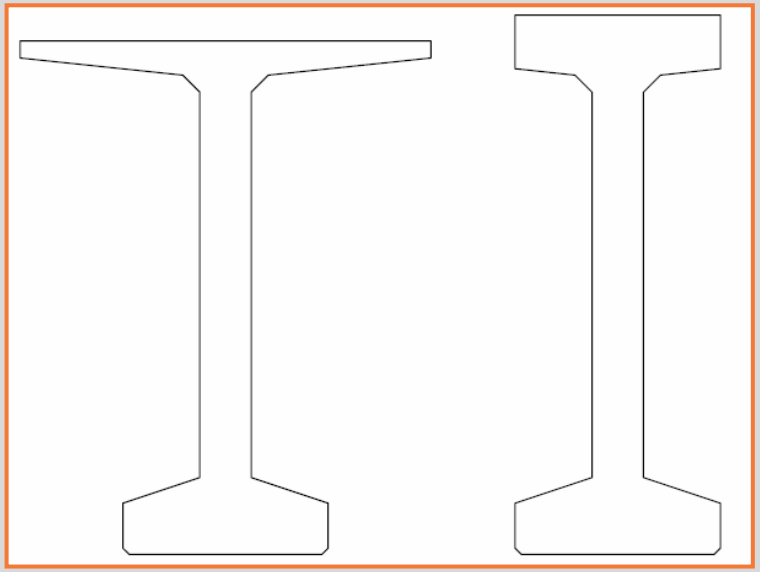


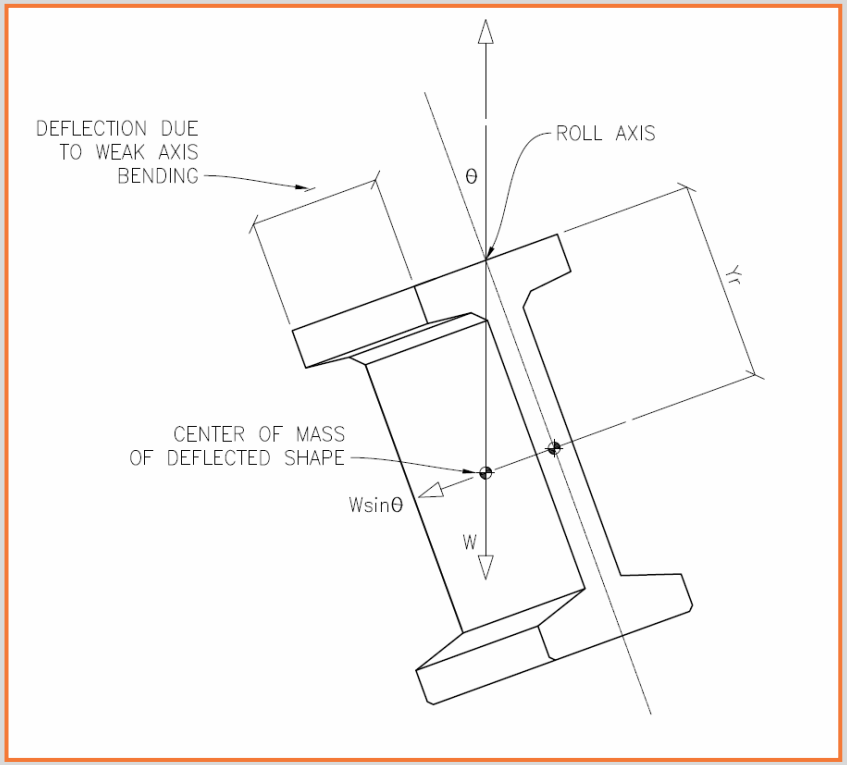


KNIFE RIVER
AN MDU RESOURCES COMPANY

Girder Section Properties

- Weak Axis Stiffness (Iy)
- Girder Height

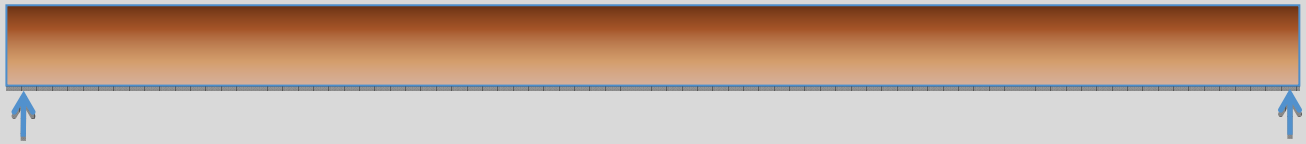




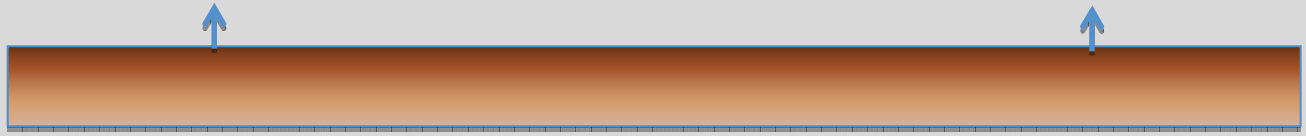
KNIFE RIVER
AN MDU RESOURCES COMPANY

Lifting Geometry

Engineer Designs it to be resting on the girder ends.

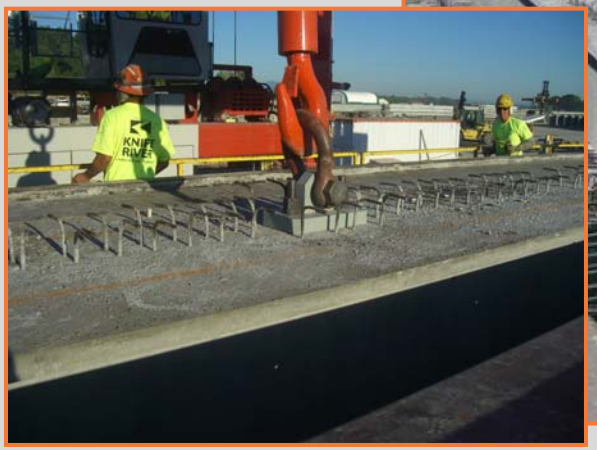


In order for the girder to be stable the lifting points are moved towards midspan.



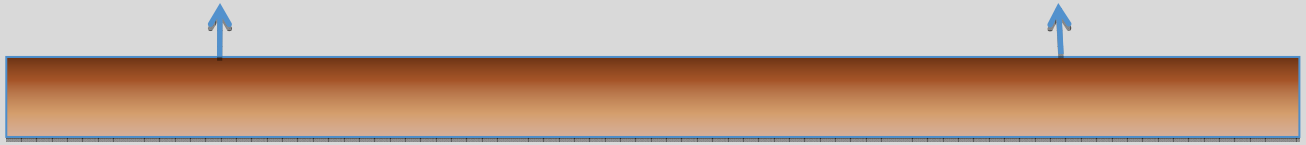
KNIFE RIVER
AN MDU RESOURCES COMPANY

Lifting Geometry



KNIFE RIVER
AN MDU RESOURCES COMPANY

Material Properties

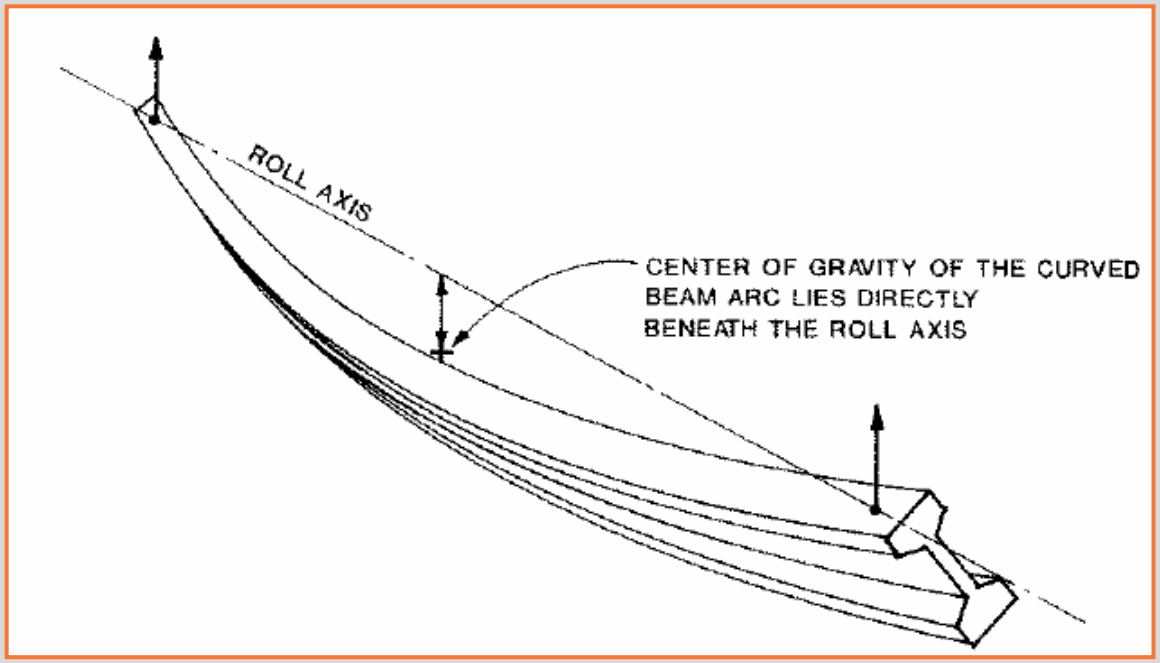


- Less Dead Load Moment
- Increases Compressive Stresses
- Top Post Tensioned Strand

KNIFE RIVER
AN MDU RESOURCES COMPANY

Initial Lateral Eccentricity

- ¼” For Strand Placement
- 1/16” Per 10 Feet of Sweep
- ¼” Offset For Lifting Eyes



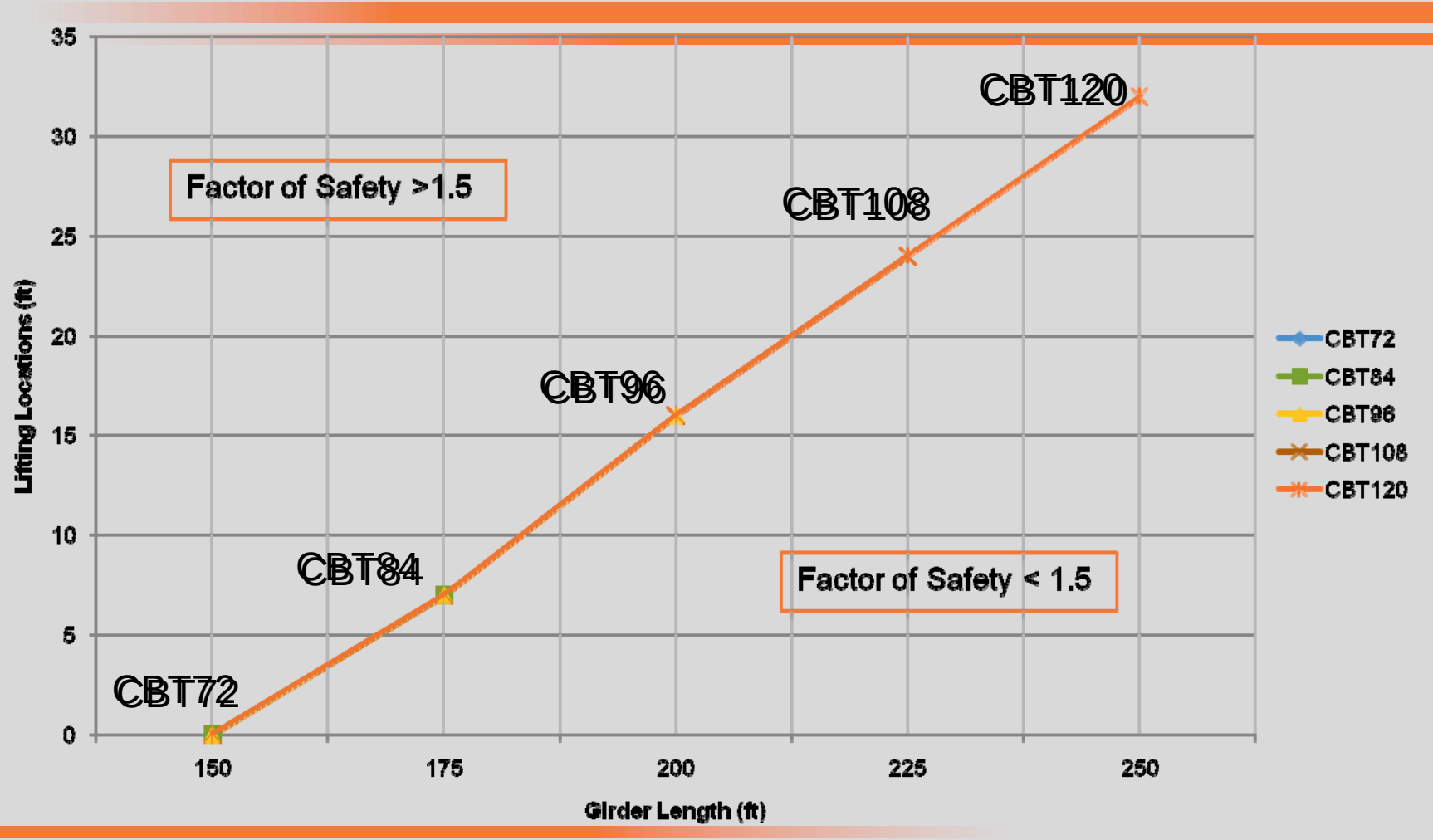
KNIFE RIVER
AN MDU RESOURCES COMPANY

Assumptions

- CBT72, CBT84, CBT96, CBT108, & CBT120
- Span To Depth Ratio = 25
- 150 ft To 250 ft Girder Lengths
- f'_{ci} = 7,000 psi
- Maximized Strand Pattern, $\mathbf{s}_b = 0.6*f'_{ci}$
- Minimum Factor of Safety of 1.5

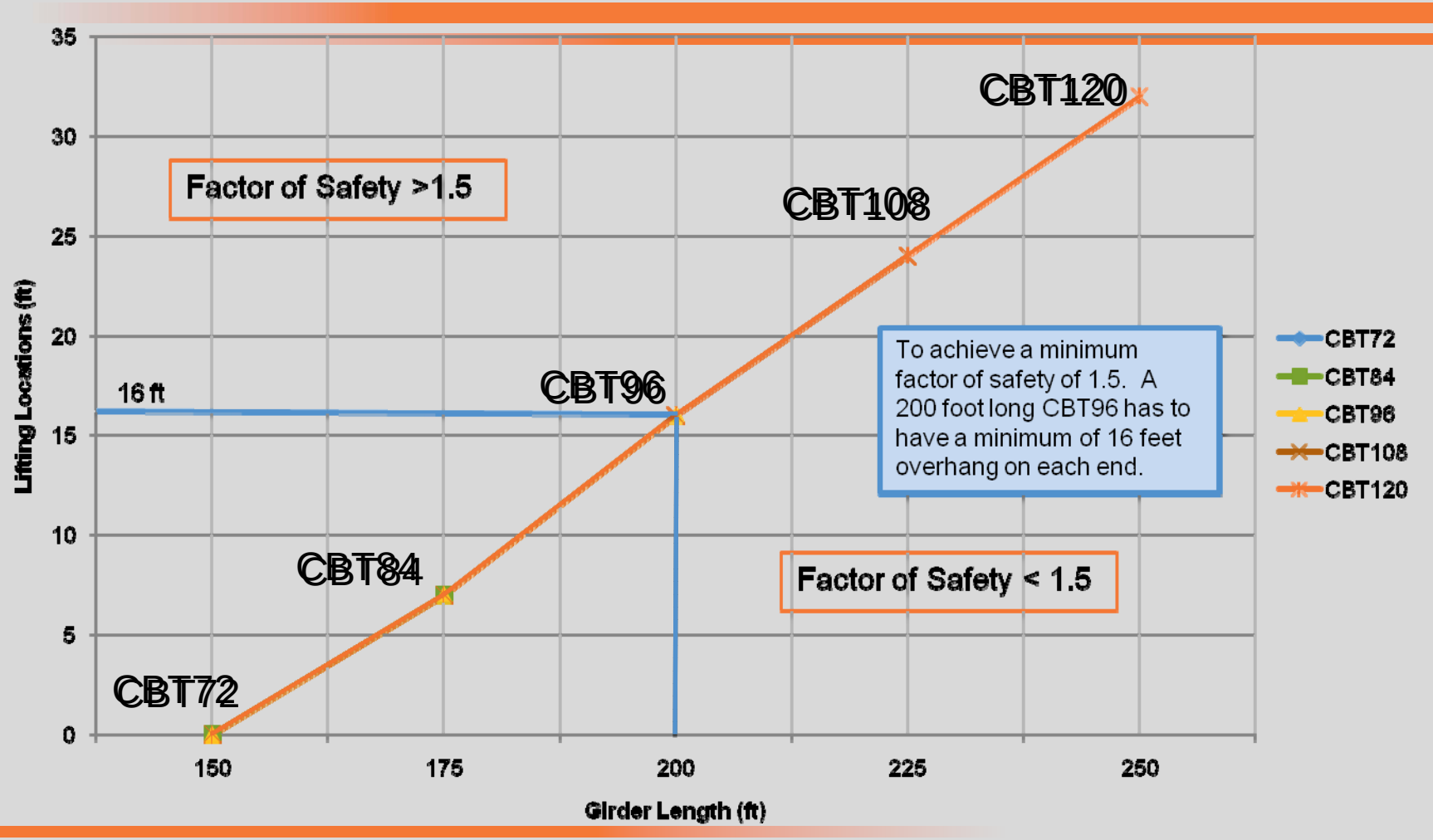
KNIFE RIVER
AN MDU RESOURCES COMPANY

Lateral Stability of CALTRANS Girders



KNIFE RIVER
AN MDU RESOURCES COMPANY

Lateral Stability of CALTRANS Girders



KNIFE RIVER
AN MDU RESOURCES COMPANY

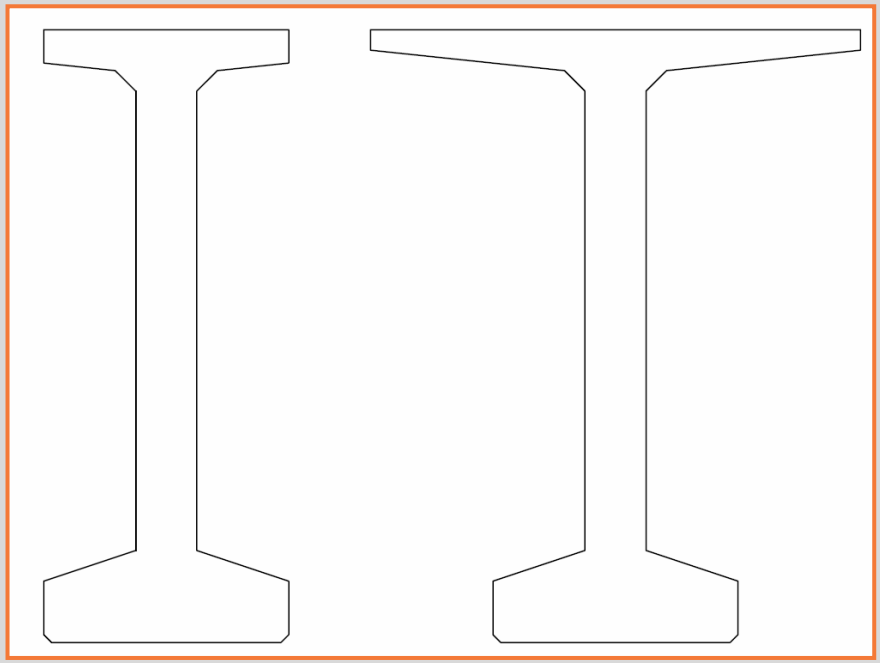
Tricks of the Trade

- Top Post Tensioned Strand
- Increased Lifting Eye Height
- Lifting Brackets
- Additional Lifting Eyes

KNIFE RIVER
AN MDU RESOURCES COMPANY

Modified Sections

- Truncated Flanges



F.S. = 1.09

F.S. = 1.85

KNIFE RIVER
AN MDU RESOURCES COMPANY

Nebraska – Bunking Locations

KNIFE RIVER
AN MDU RESOURCES COMPANY

Erection Challenges

- Picking Locations
- Erection Techniques
- Bearing Systems
- Bracing

KNIFE RIVER
AN MDU RESOURCES COMPANY

Bearing Systems

Tall Narrow Bearing Systems

KNIFE RIVER
AN MDU RESOURCES COMPANY

Erection Techniques

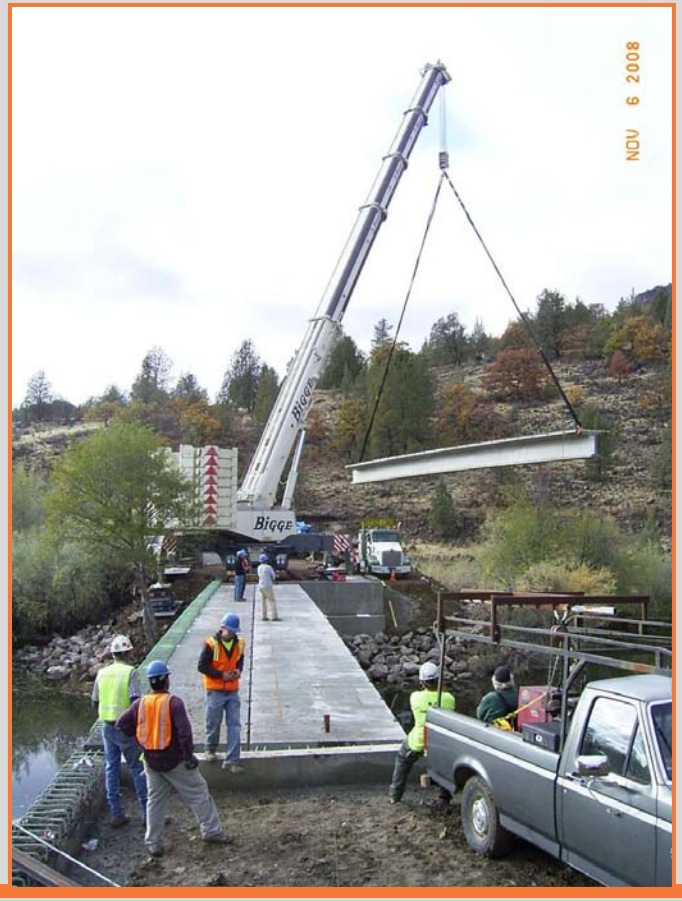
- Two Cranes
- Single Crane
- Passing
- Launching
- Combination

KNIFE RIVER
AN MDU RESOURCES COMPANY

Two Cranes

KNIFE RIVER
AN MDU RESOURCES COMPANY

Single Crane



KNIFE RIVER
AN MDU RESOURCES COMPANY

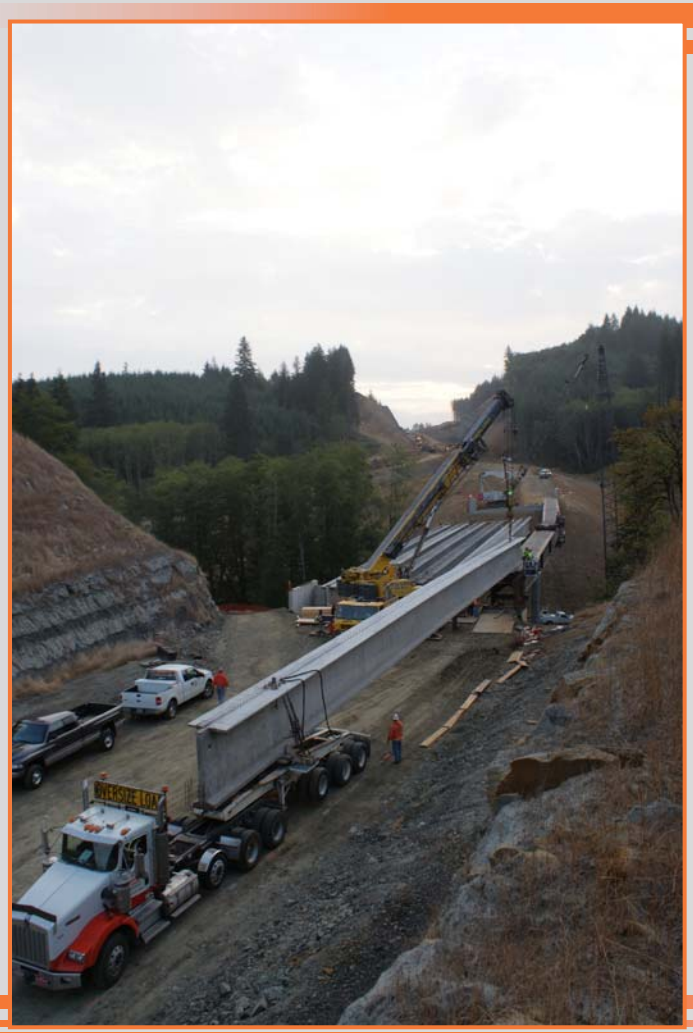
Load Passing

KNIFE RIVER
AN MDU RESOURCES COMPANY

Launching

KNIFE RIVER
AN MDU RESOURCES COMPANY

Combination



KNIFE RIVER
AN MDU RESOURCES COMPANY

Combination

KNIFE RIVER
AN MDU RESOURCES COMPANY

Combination

KNIFE RIVER
AN MDU RESOURCES COMPANY

Combination

KNIFE RIVER
AN MDU RESOURCES COMPANY

Bracing

KNIFE RIVER
AN MDU RESOURCES COMPANY

Bracing

KNIFE RIVER
AN MDU RESOURCES COMPANY

Room for Improvement

KNIFE RIVER
AN MDU RESOURCES COMPANY

Summary

- Ensure the girder can be constructed, shipped, and erected.
- Engineering Details
  - Bearing System (utilize full width of flange)
  - Temporary Bearing System (oak blocking)
- Precast Manufacturer
  - Lifting and Bunking Points
  - Temporary Prestressing
  - Product Weight

KNIFE RIVER
AN MDU RESOURCES COMPANY

Summary

- Shipping
  - Coordinate with Precaster
  - Bunking locations may be modified based on permitting and trucking configuration
- Erection
  - Site conditions
  - Number of cranes
  - Passing and launching considerations
  - Bracing schemes

KNIFE RIVER
AN MDU RESOURCES COMPANY

The End

KNIFE RIVER
AN MDU RESOURCES COMPANY