National Concrete Bridge Council

2025 NCBC WEBINAR SERIES

Mastering Bridge Geometry: Insights into Precast Concrete Segmental

April 23, 2025

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Update from the National Concrete Bridge Council

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NCBC
National Concrete Bridge Council

The National Concrete Bridge Council

- Is dedicated to promoting quality in concrete bridge industry
- Disseminates information on design, construction and condition of concrete bridges
- Communicates with federal, state DOTs, city and county public works, and consultants

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NCBC Members

National Concrete Bridge Council

ACI

ASBI

CRSI

EIG EPOXY INTEREST GROUP

ESCSI

ICRI CONCRETE REPAIR Restore | Repurpose | Renew

NRMCA

PCI

pti

SFA

wri

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www.nationalconcretebridge.org

NCBC 2025 Webinar Series

**Thursday May 22, 2025: Resilience of Post-Tensioned Box Girders

June 18, 2025: Steel Rebar vs GFRP: Why Steel Still Reigns Supreme for Reinforced Concrete

July 23, 2025: Extending the Service Life of Concrete Using Lightweight Aggregates

August 20, 2025: Introducing Life-365 Service Life Model

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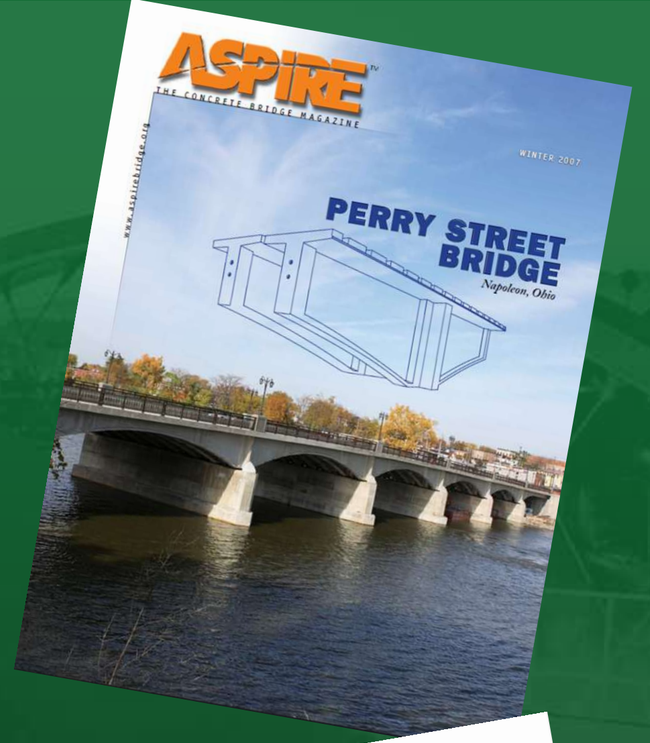
National Concrete Bridge Council

NCBC Resources

- ASPIRE, the concrete bridge magazine, since 2007
- Industry calendar
- Seminars and events
- HPC Bridge Views - a cooperative newsletter with FHWA, since 1999



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www.nationalconcretebridge.org

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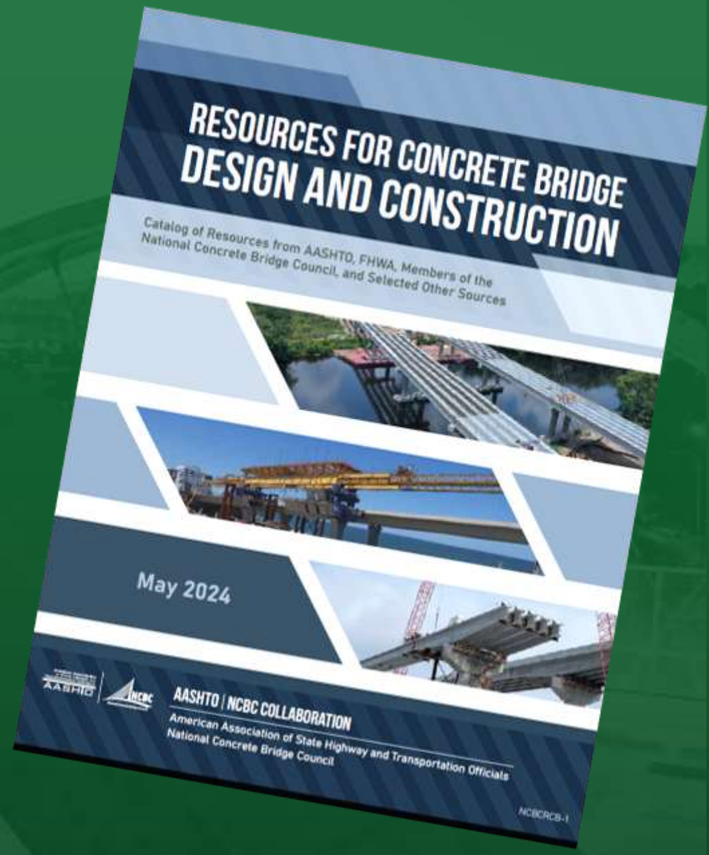
NCBC Resources

Resources for Concrete Bridge Design and Construction Available from AASHTO

https://store.transportation.org/Item/PublicationDetail?ID=5250

for free download



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Industry Events 2025

April 28-May 2: PTI Certification Week, Salt Lake City
May 4-7: PTI Convention, Phoenix, AZ
May 31- June 6: AASHTO COB Meeting, Dallas
July 13-16: International Bridge Conference, Pittsburgh
Aug.19-20: CBEI Concrete Materials for Bridges, Austin

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Continuing Education

NCBC is working with PCI to offer continuing education credits. PCI has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.

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John A. Corven, P.E.

Director of Complex Bridges
Hardesty & Hanover / Corven Engineering

BSCE – University of Florida (1978)
ME – University of Florida (1979)
Complex Bridges for 43 years
70 Major Bridges with $2B Construction Value
Current President of the ASBI
(American Segmental Bridge Institute)

Related Publications:

FDOT New Directions in Post-Tensioning (10 Volumes)
PCI Bridge Manual – Segmental Bridge Chapter 14
FHWA Tendon Installation and Grouting Manual
FHWA Post-Tensioned Box Girder Design Manual
FHWA/PCI Bridge Geometry Manual

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Presentation

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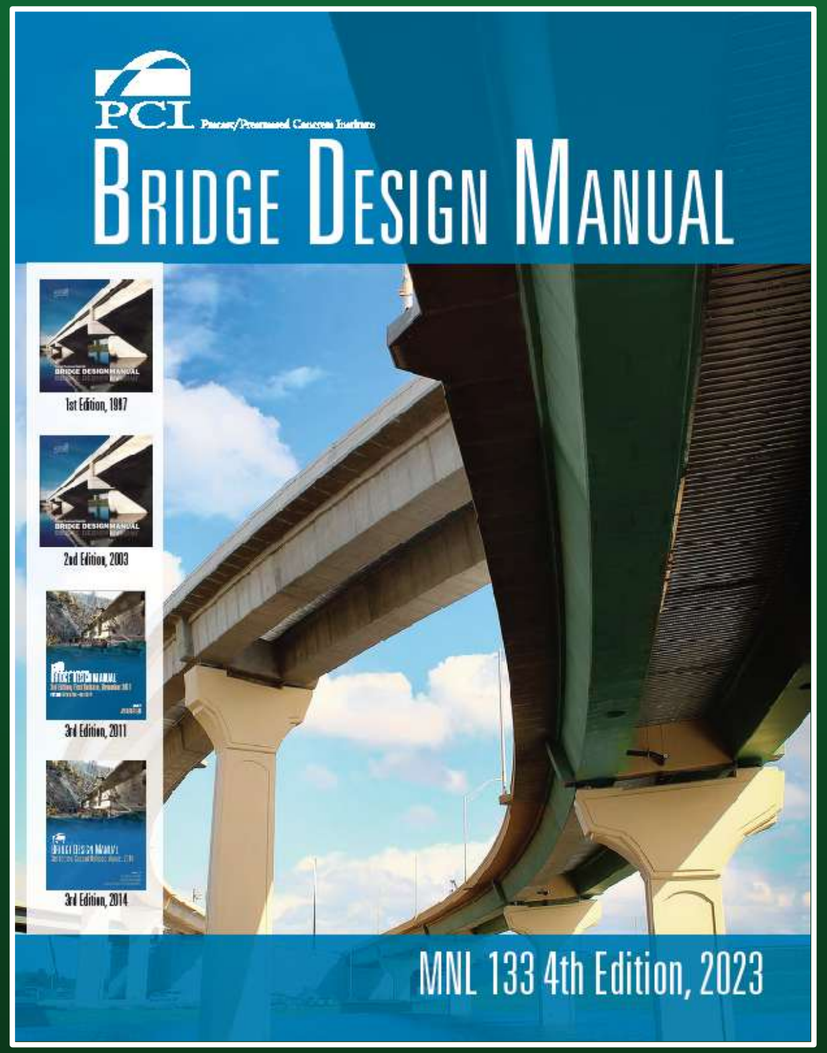
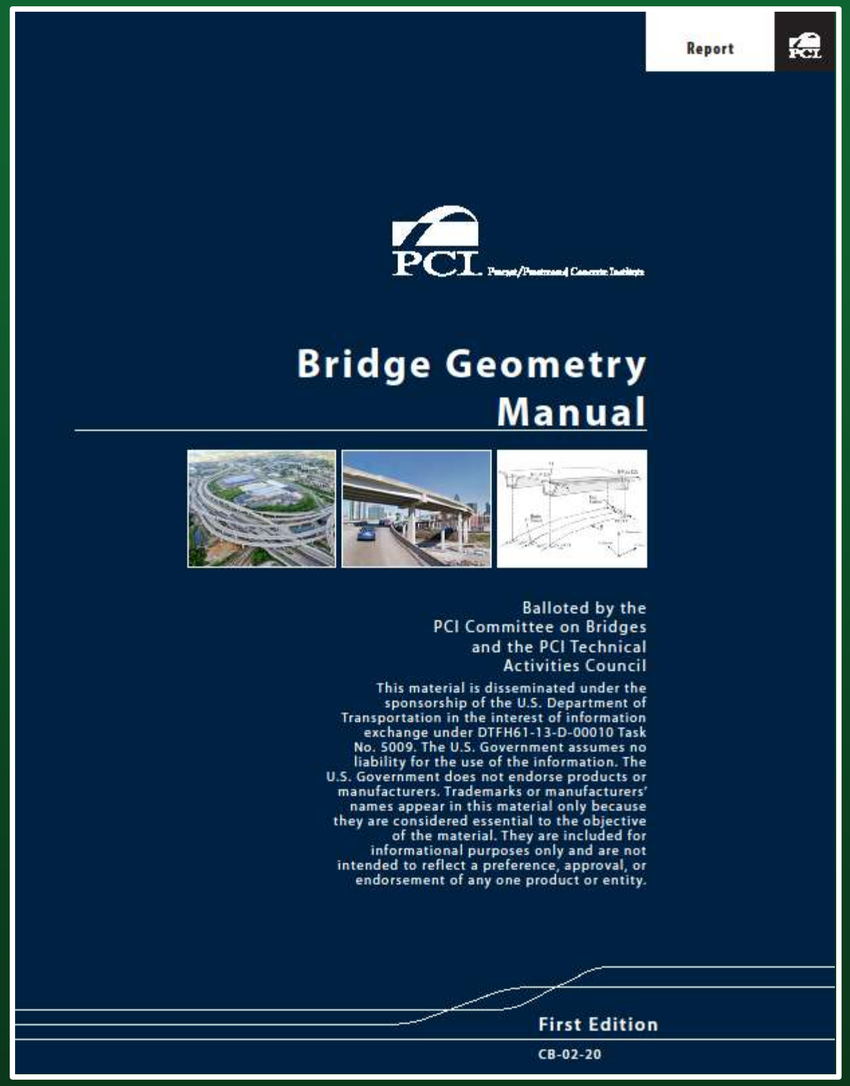
Precast Segmental Bridge Geometry

FHWA/PCI Bridge Geometry Manual – Chapter 14



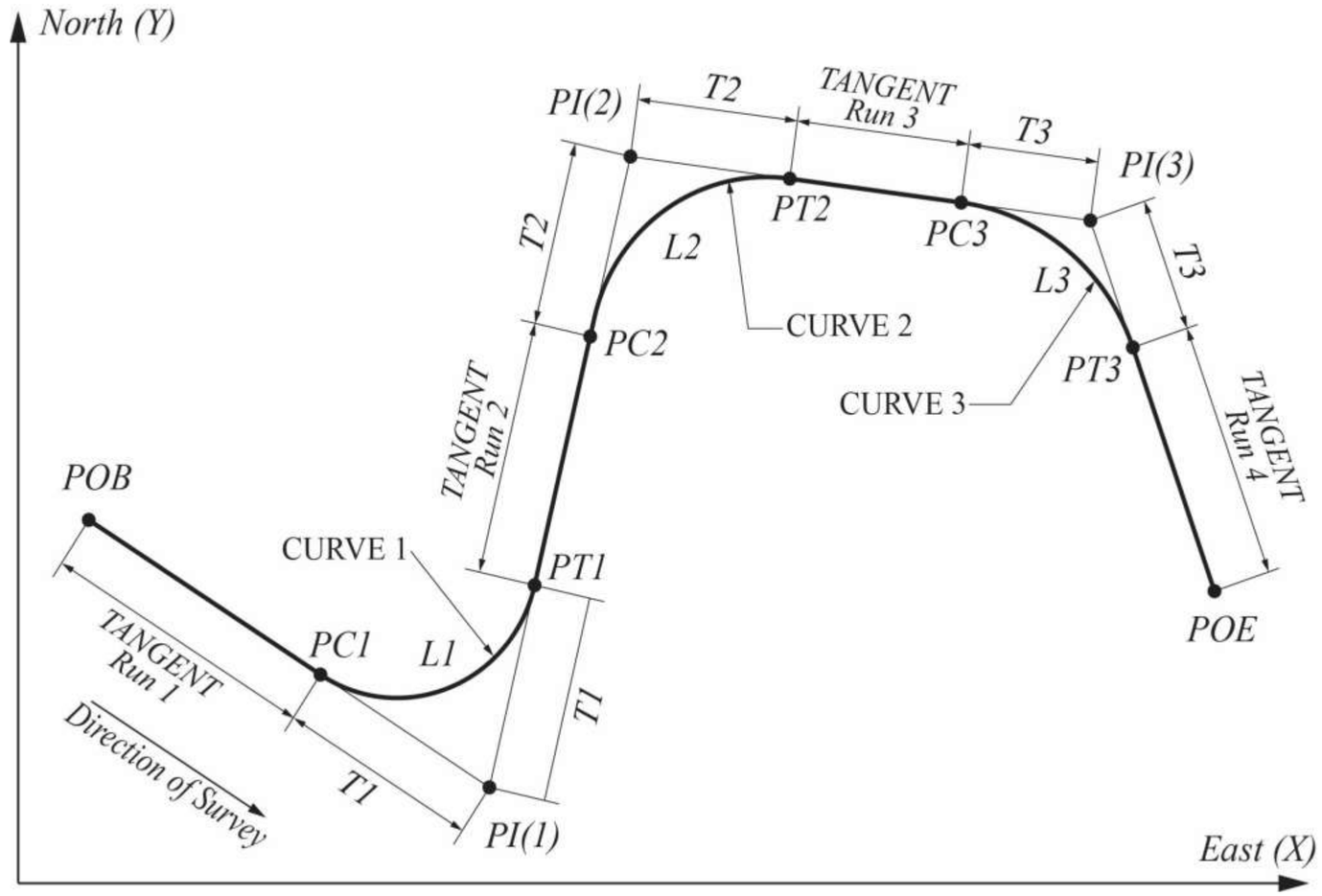
Contents

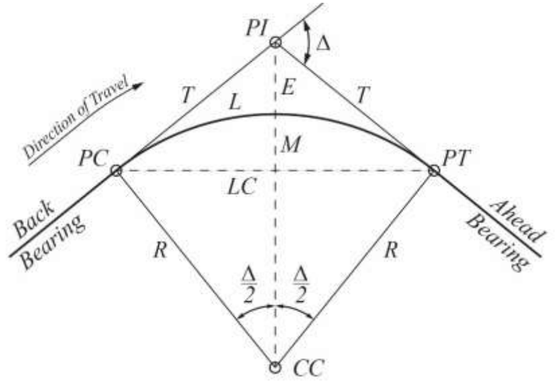
FHWA/PCI Bridge Geometry Manual

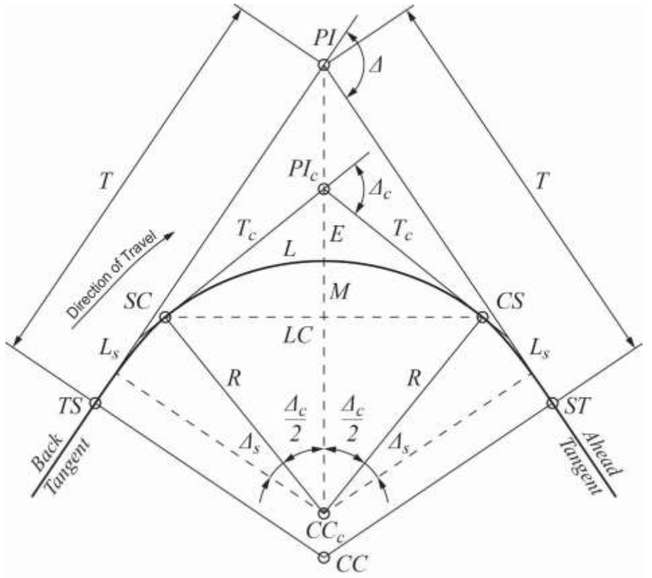


Contents

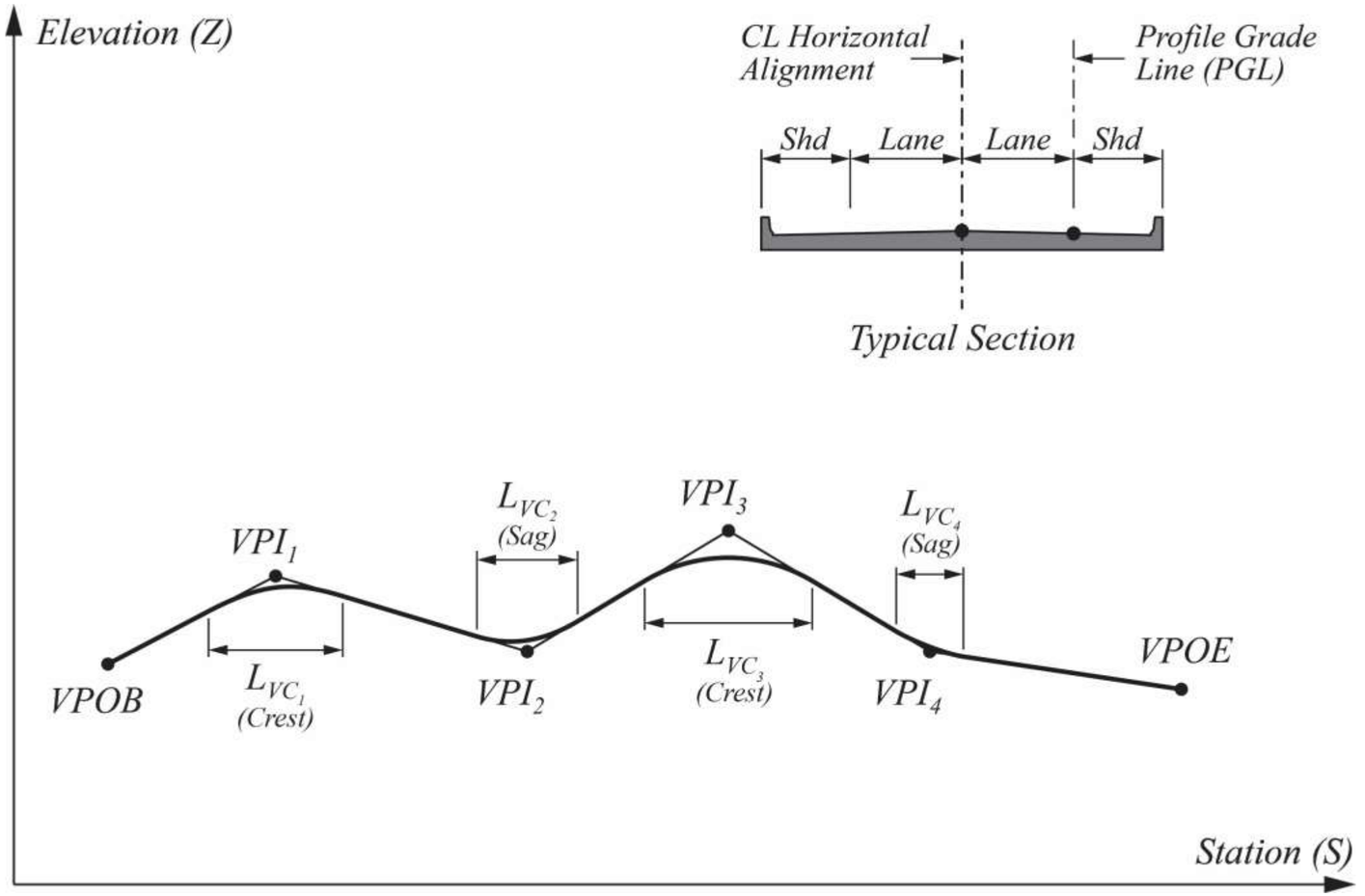
Chapter 2 - Horizontal Alignment

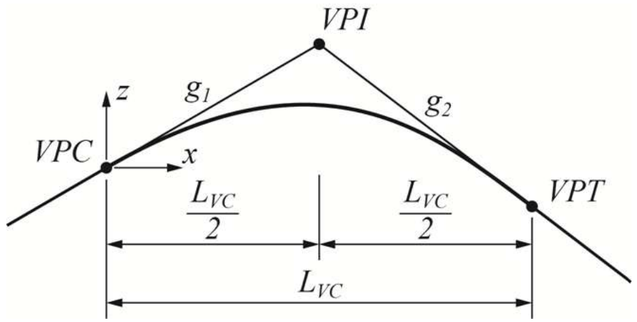






Chapter 3 - Vertical Profile

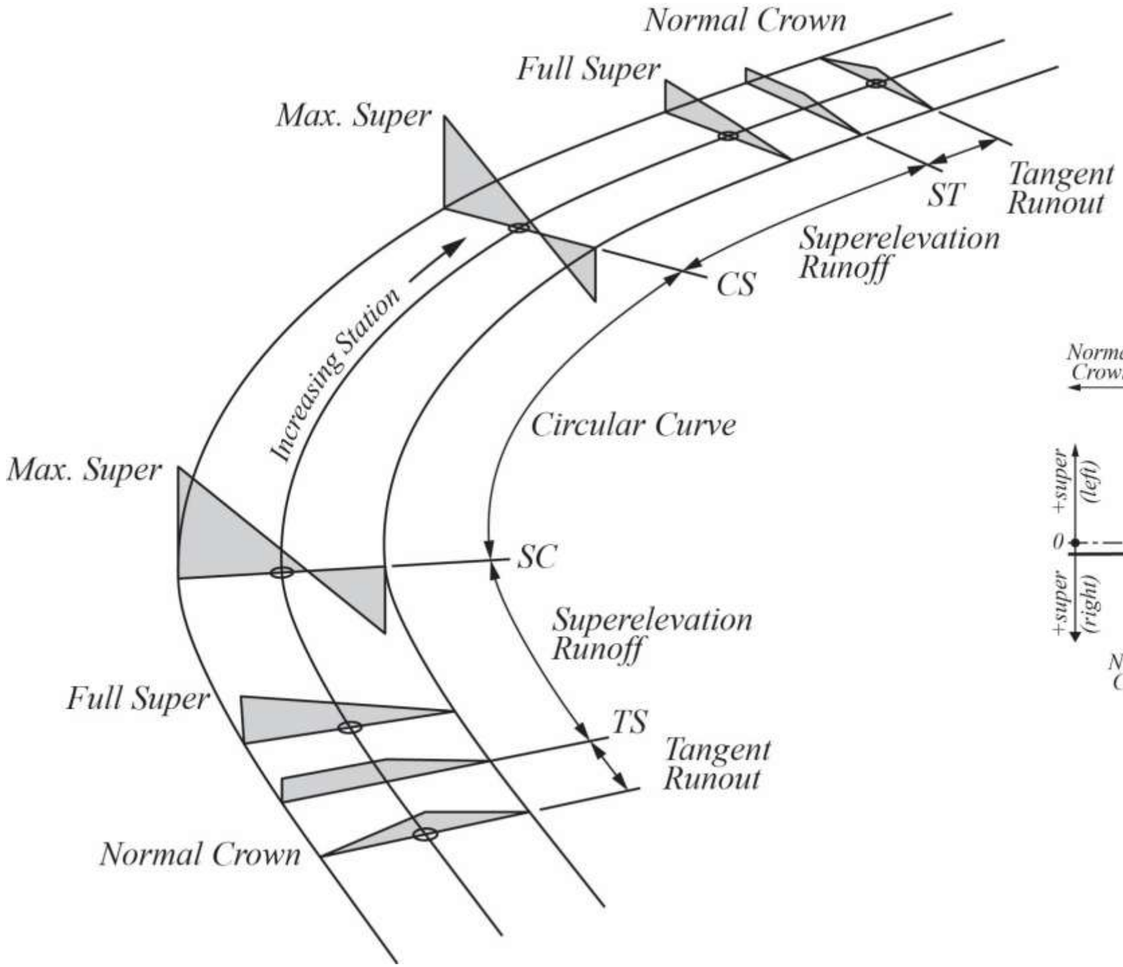


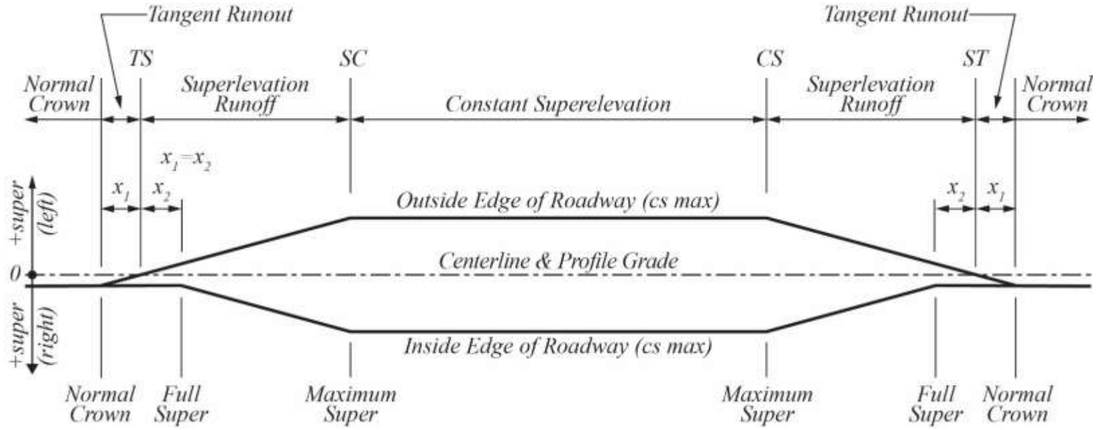


$$g(x) = \left(\frac{g_2 - g_1}{L_{VC}}\right)x + g_1$$

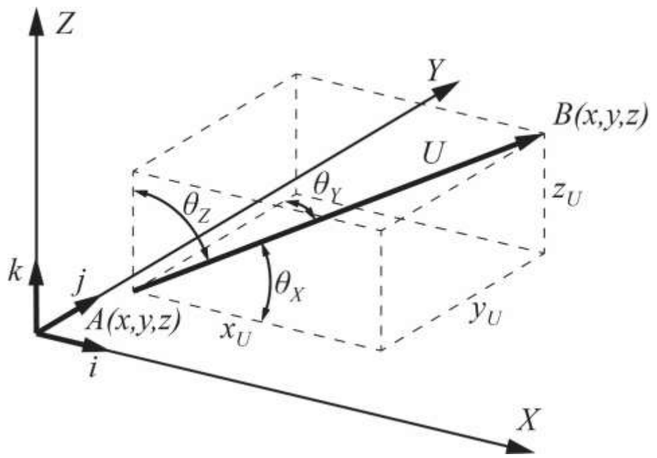
$$Z(x) = \left(\frac{g_2 - g_1}{2L_{VC}}\right)x^2 + g_1 x + E_{VPC}$$

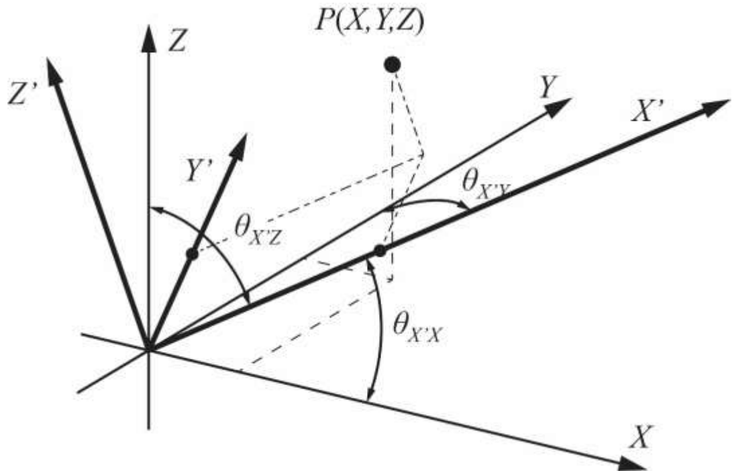
Chapter 4 - Superelevation Variations





Appendix A – Vector Geometry





Transformations

$$[P'] = [T][P]$$

$$[T]^T [P'] = [T]^T [T][P] = [P]$$

Direction Cosines

$$\cos\theta_{UX} = \left(\frac{x_U(1) + y_U(0) + z_U(0)}{|U|(1)} \right) = \frac{x_U}{|U|}$$

$$\cos\theta_{UY} = \left(\frac{x_U(0) + y_U(1) + z_U(0)}{|U|(1)} \right) = \frac{y_U}{|U|}$$

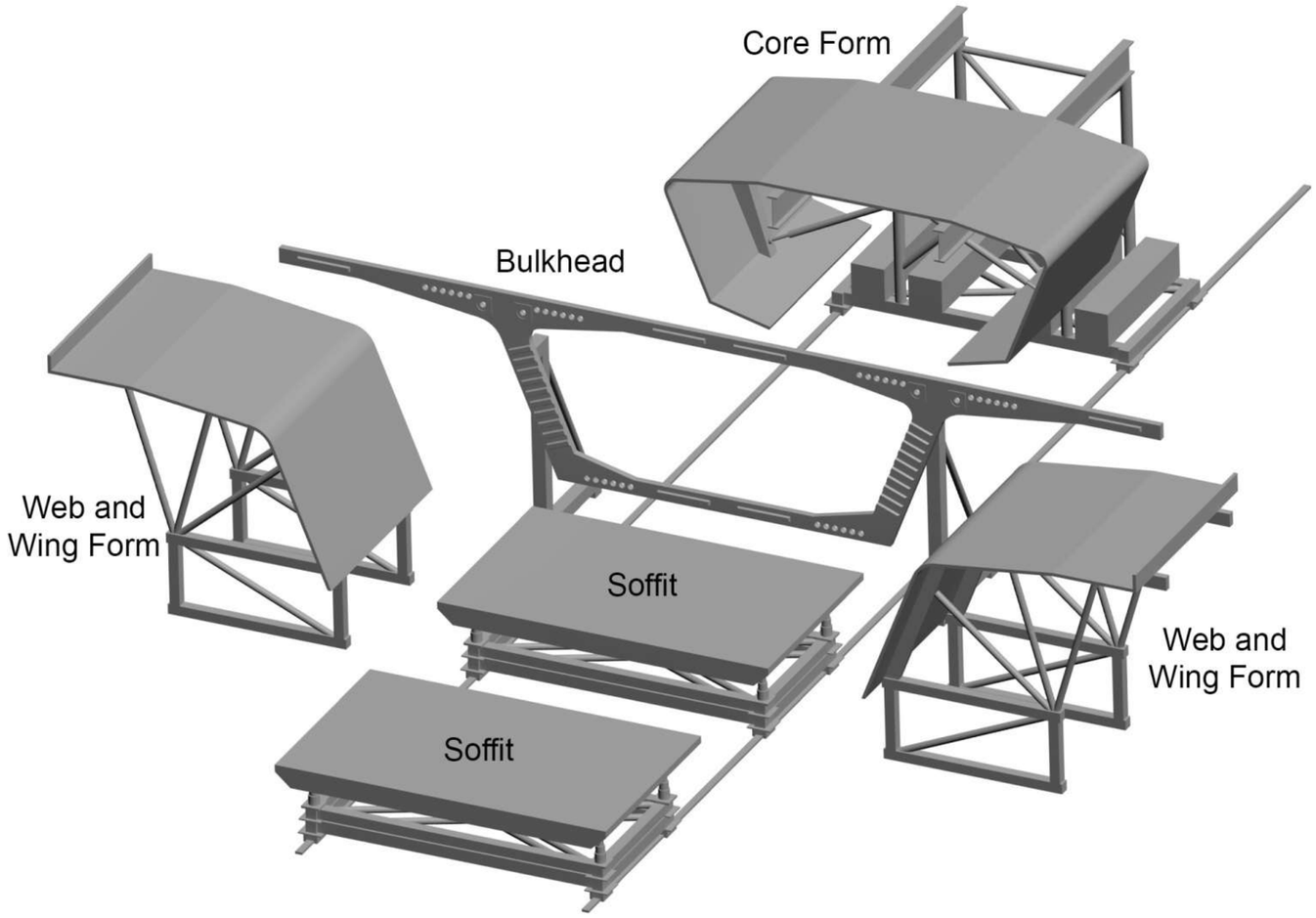
$$\cos\theta_{UZ} = \left(\frac{x_U(0) + y_U(0) + z_U(1)}{|U|(1)} \right) = \frac{z_U}{|U|}$$

Transformation Matrices

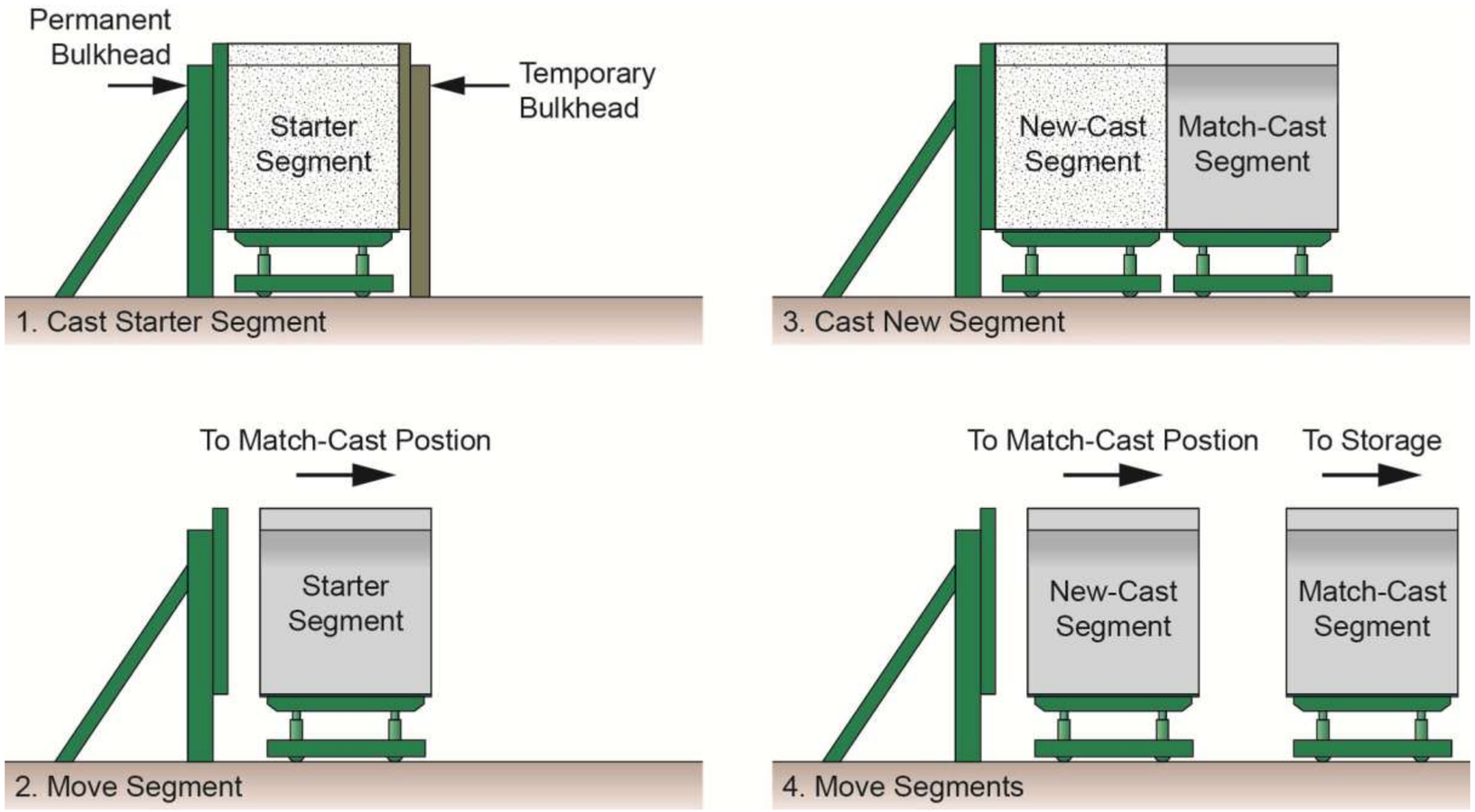
$$[T] = \begin{bmatrix} \cos\theta_{X'X} & \cos\theta_{X'Y} & \cos\theta_{X'Z} \\ \cos\theta_{Y'X} & \cos\theta_{Y'Y} & \cos\theta_{Y'Z} \\ \cos\theta_{Z'X} & \cos\theta_{Z'Y} & \cos\theta_{Z'Z} \end{bmatrix} \qquad [T]^T = \begin{bmatrix} \cos\theta_{X'X} & \cos\theta_{Y'X} & \cos\theta_{Z'X} \\ \cos\theta_{X'Y} & \cos\theta_{Y'Y} & \cos\theta_{Z'Y} \\ \cos\theta_{X'Z} & \cos\theta_{Y'Z} & \cos\theta_{Z'Z} \end{bmatrix}$$

Short-Line Match Casting

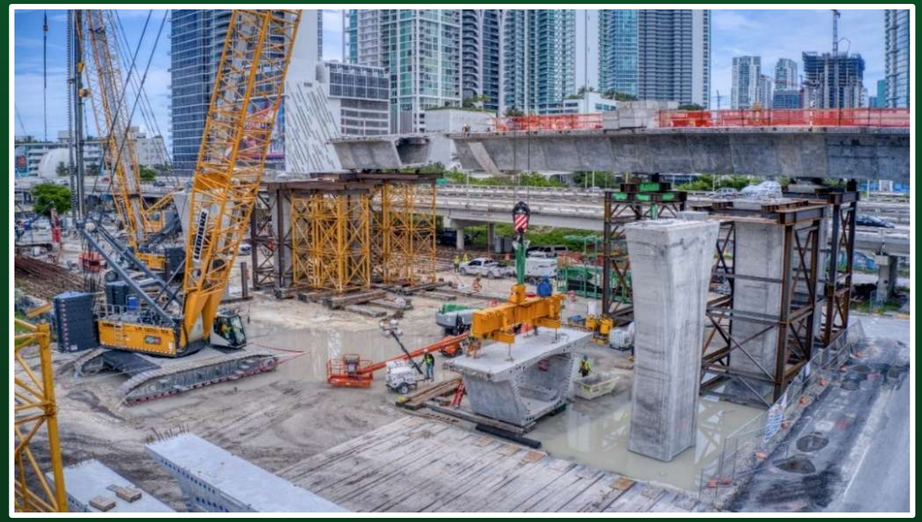
Segment Casting Machine Components



Short-Line Casting Cycoe



Balanced Cantilever Construction



Span-By-Span Construction

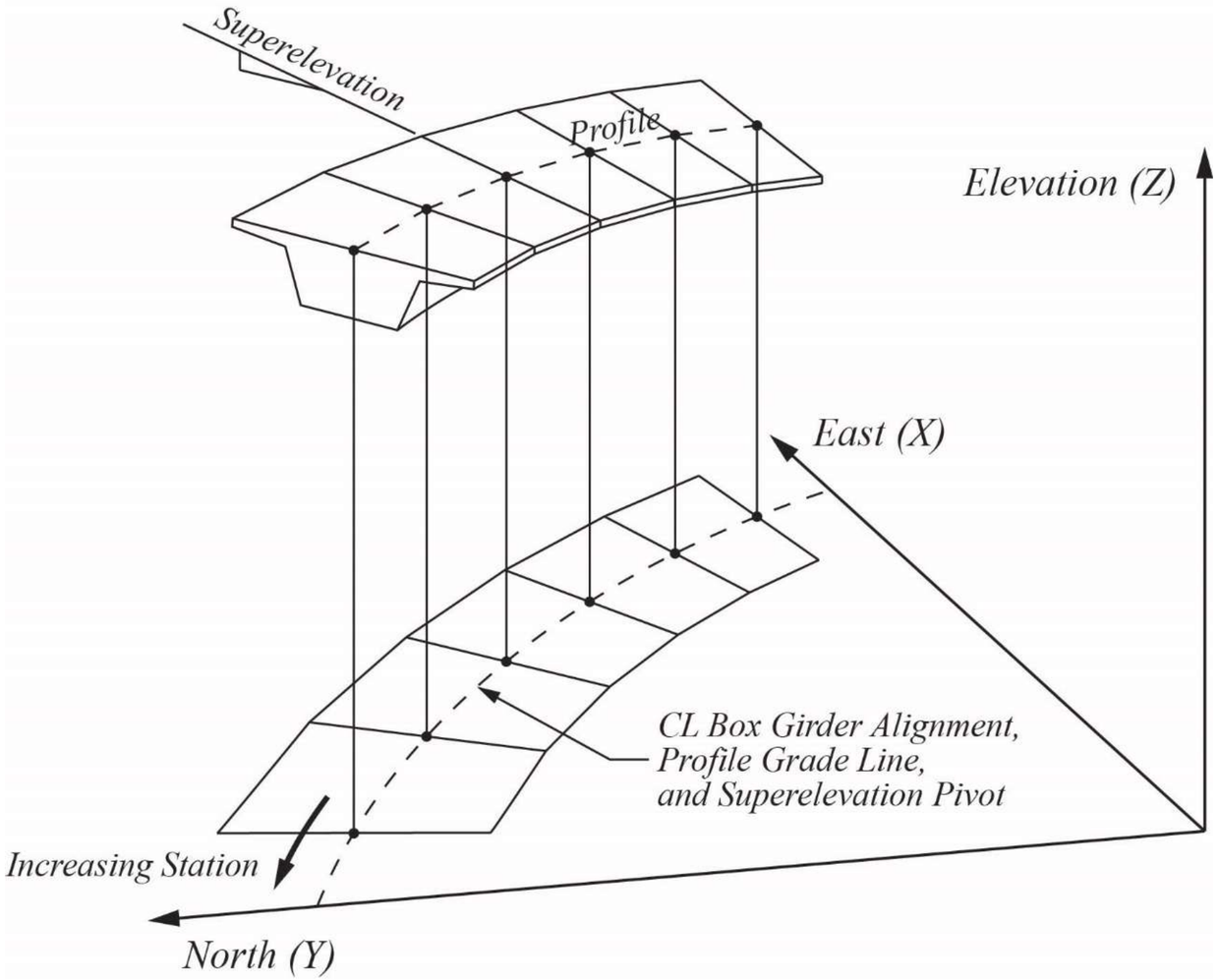
Design Activities

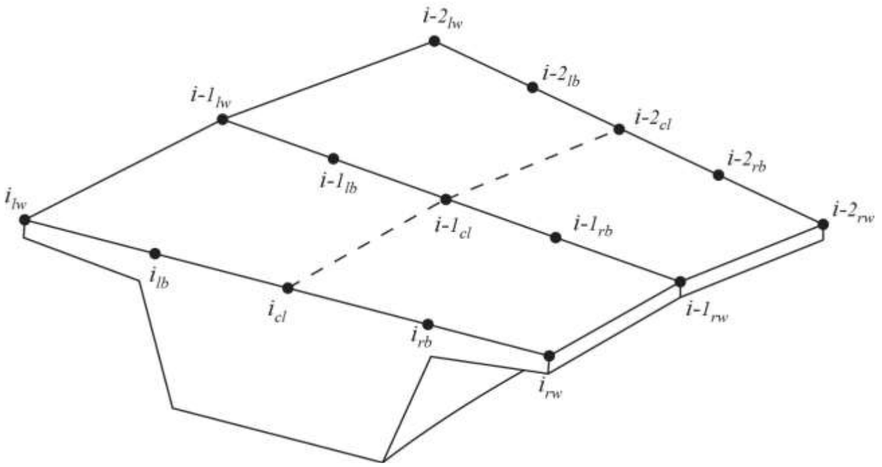
Work by Engineer of Record

Design Activities

1. Global Coordinate Geometry
2. Segment Dimensions
3. Tendon Geometry (External)
4. 3D Analytical Models
5. Bearing Details
6. Pier Heights & Details
7. Foundation Layouts
8. Drainage Details

3D Segment Geometric Definitions

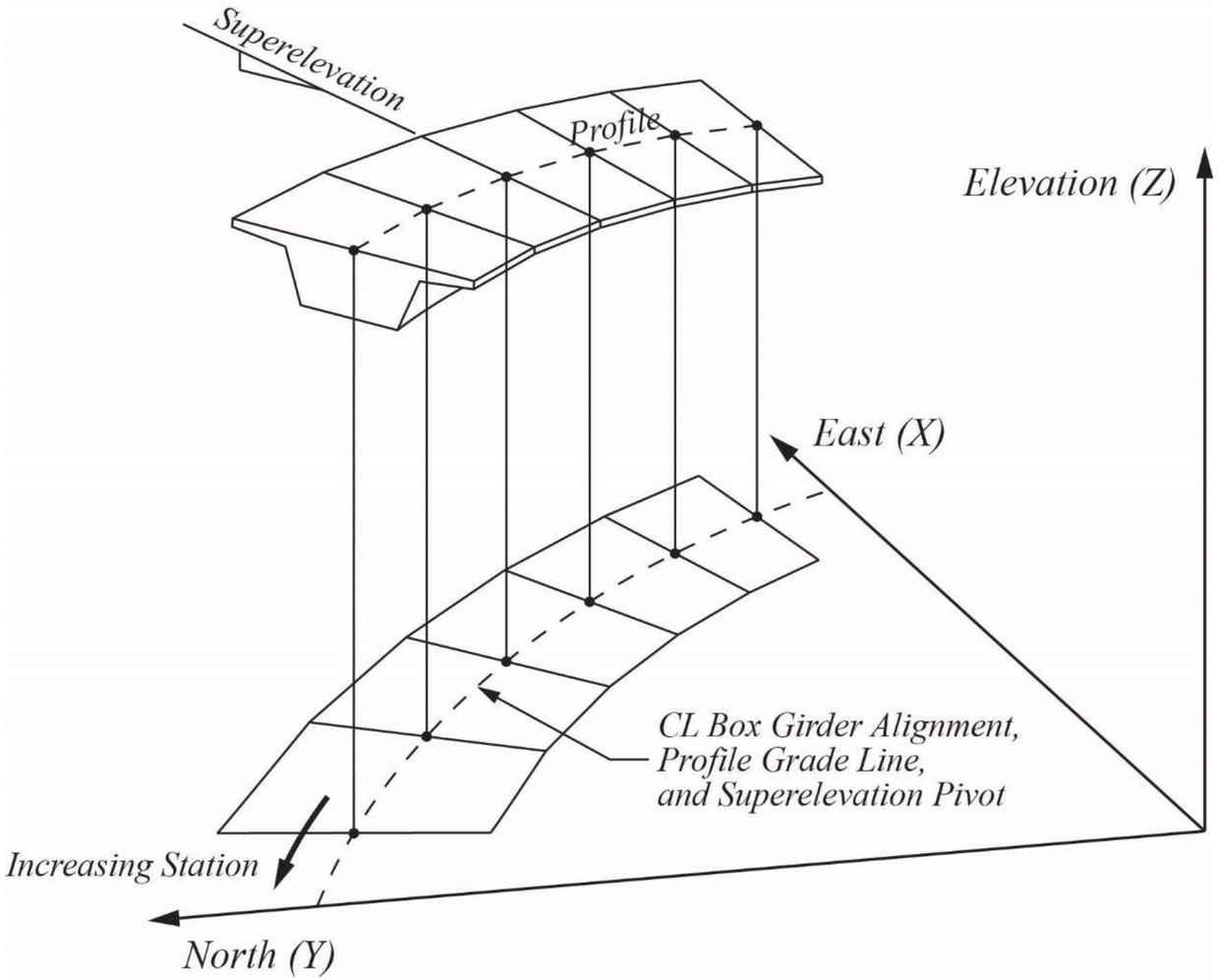




<u>Points</u>

- Centerline
- Left and Right Control Points
- Left and Right Wing Tips

3D Segment Geometric Definitions

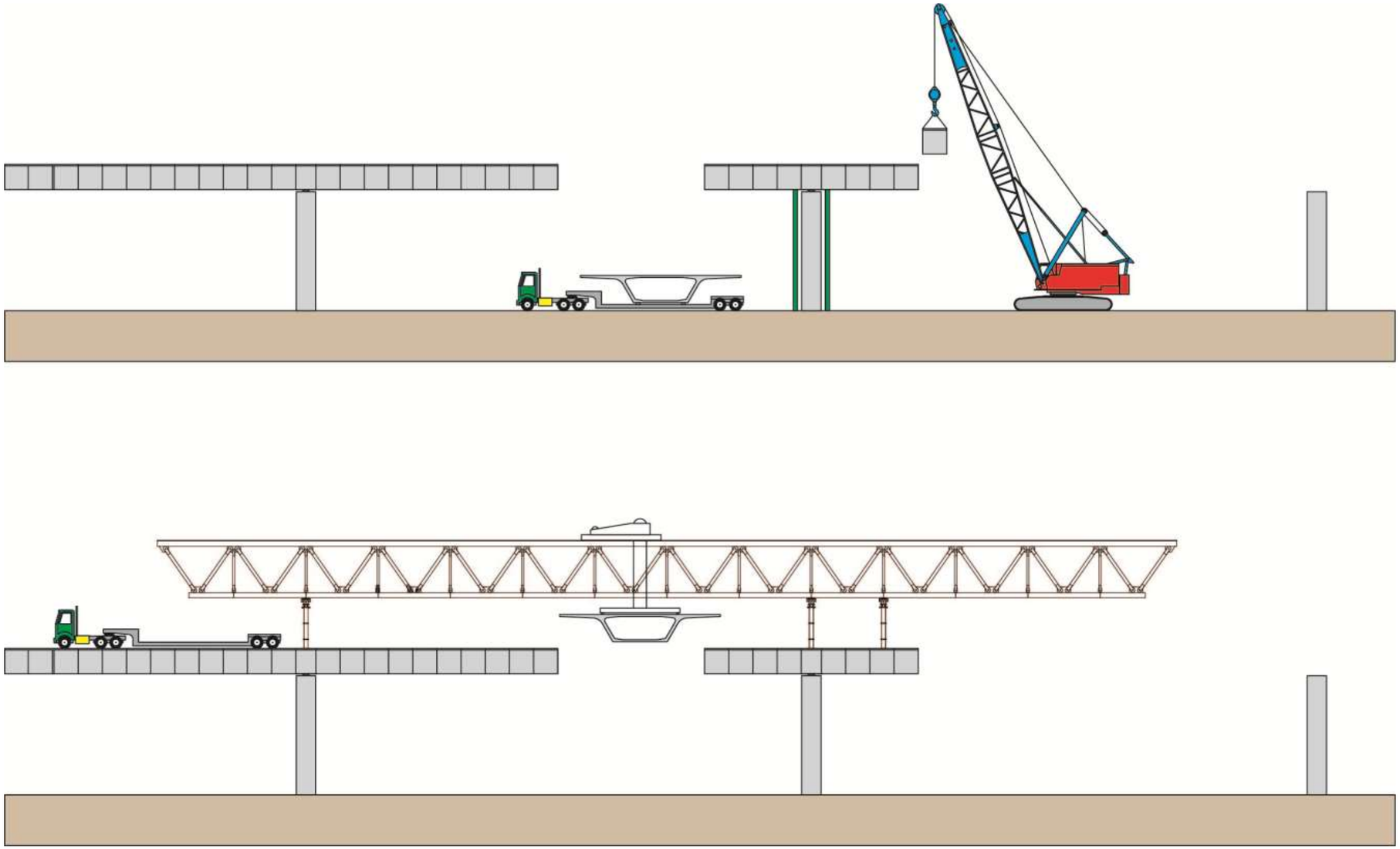


Requirements

- Centerline of segments points fall on the horizontal alignment and vertical profile
- Joints between segments follow the superelevation definition
- Specified chorded length of segments
- Piers maintain their stationing but include an offset

Construction Method Impact on Segment Geometry

Balanced Cantilever Construction



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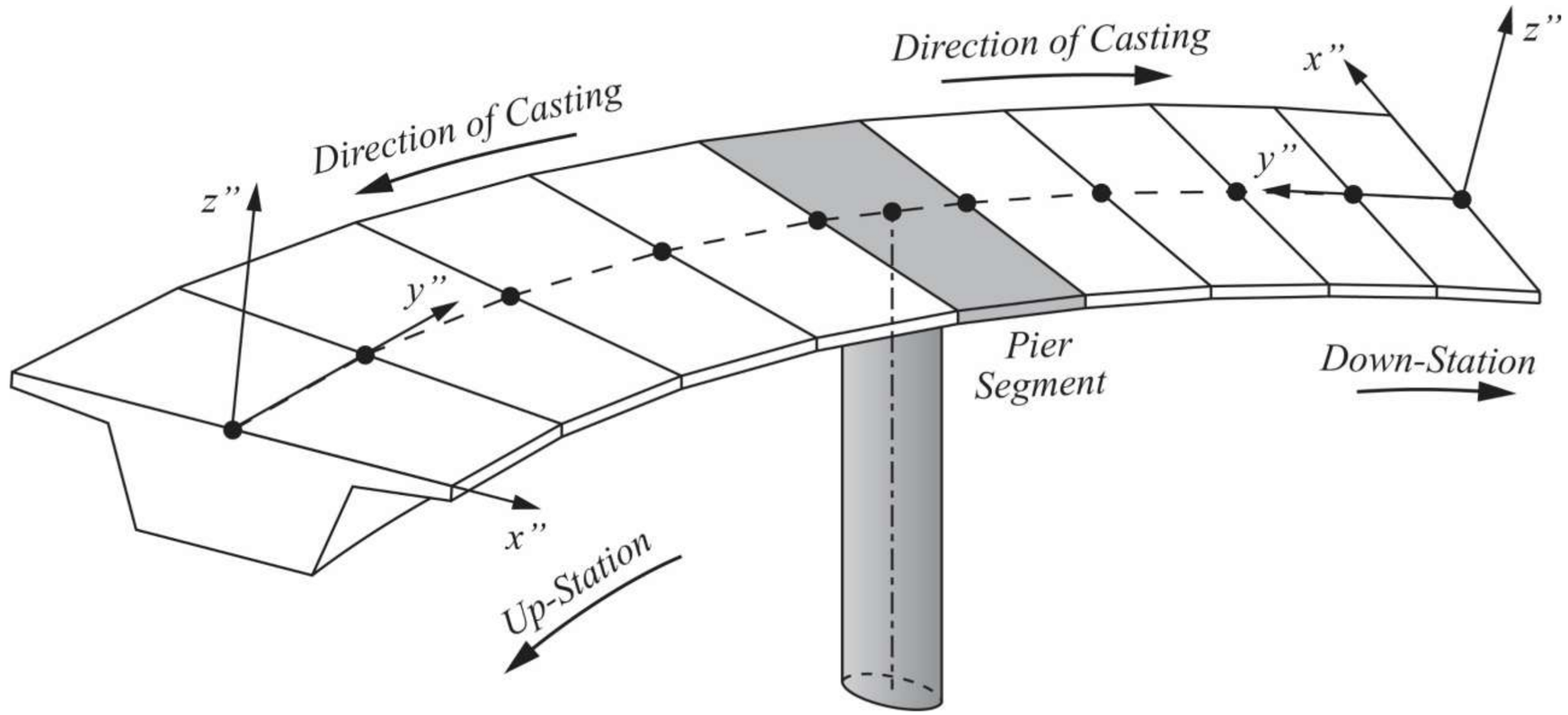
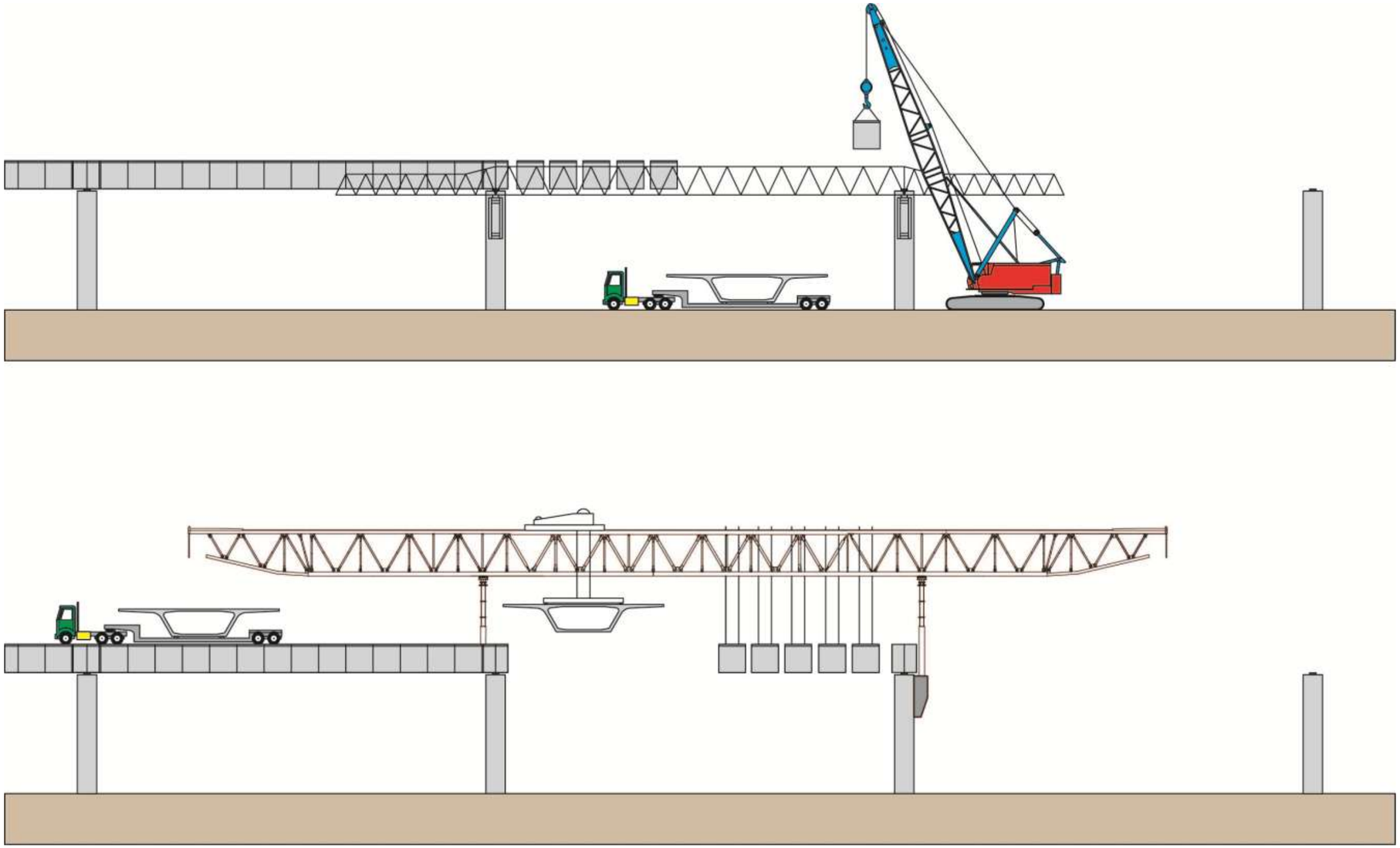
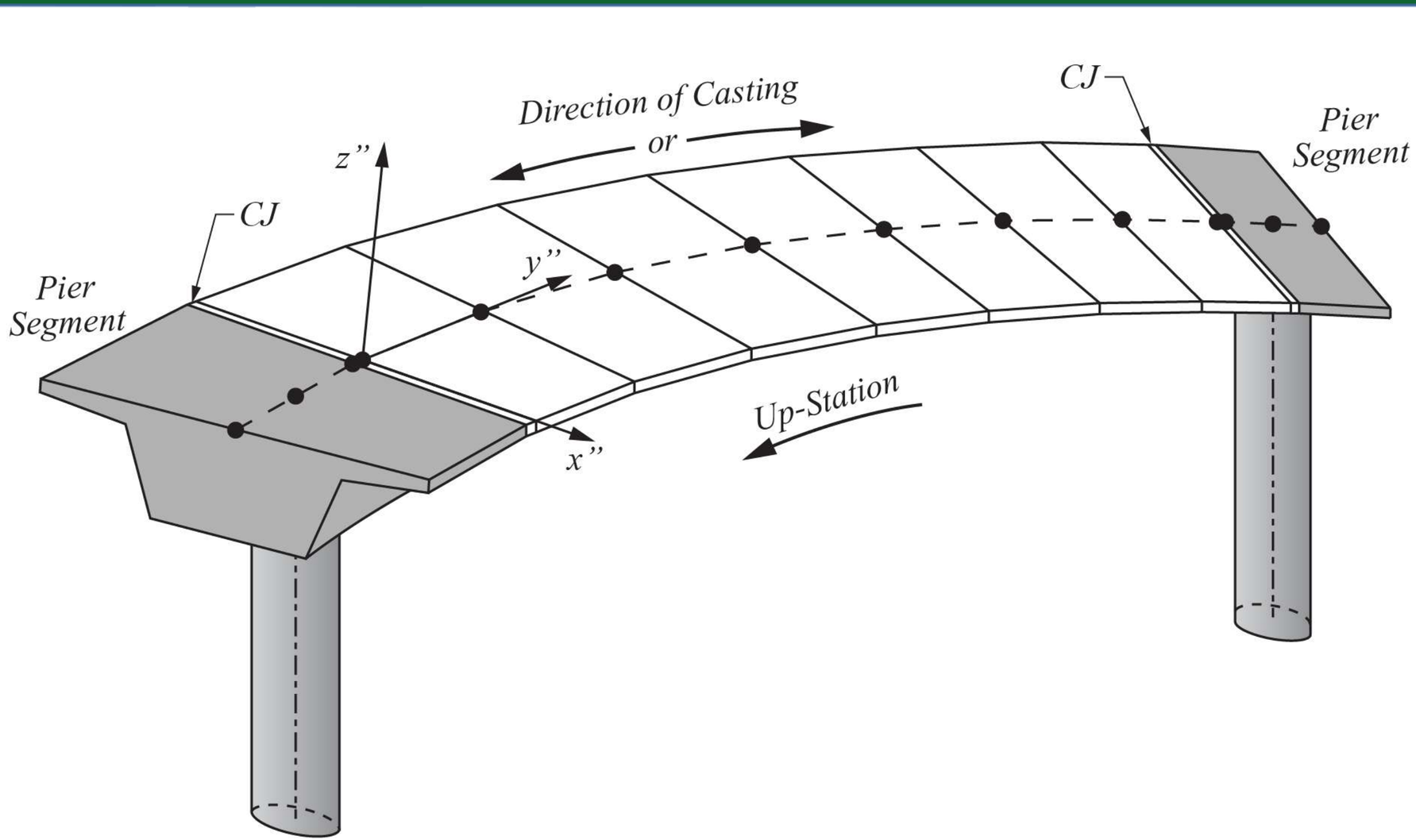


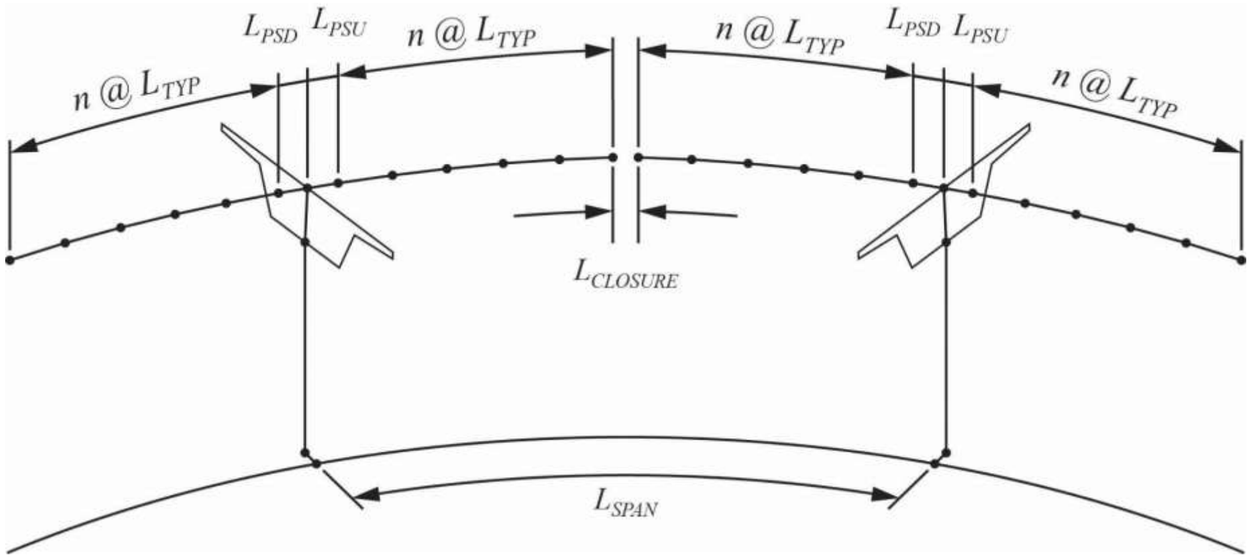
Span-By-Span Construction



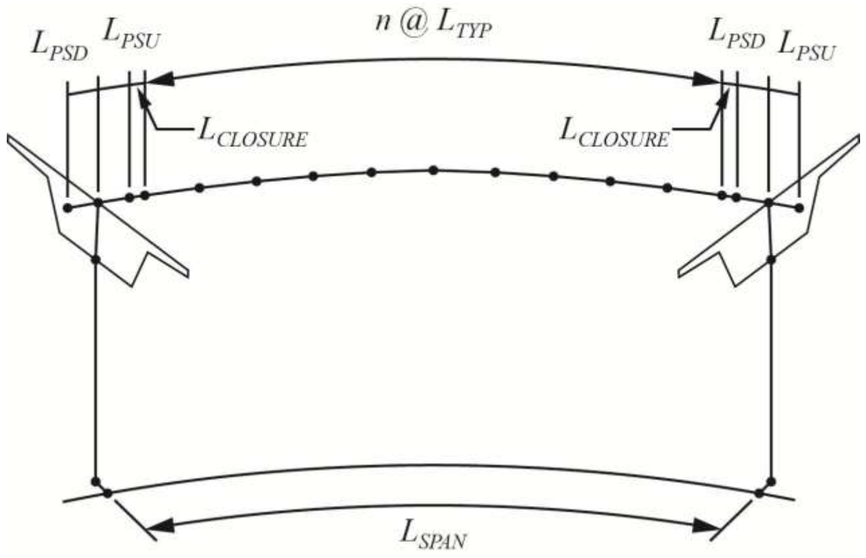
Span-By-Span Construction



Segment Layouts Compared

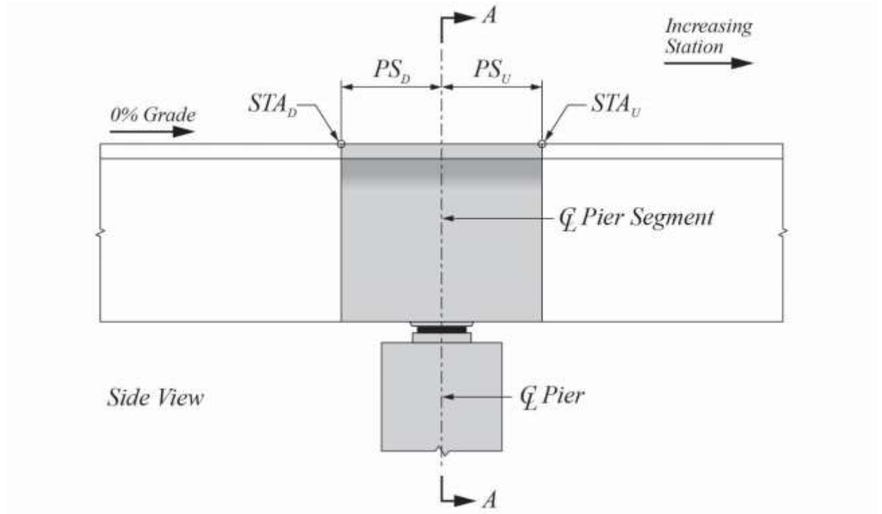


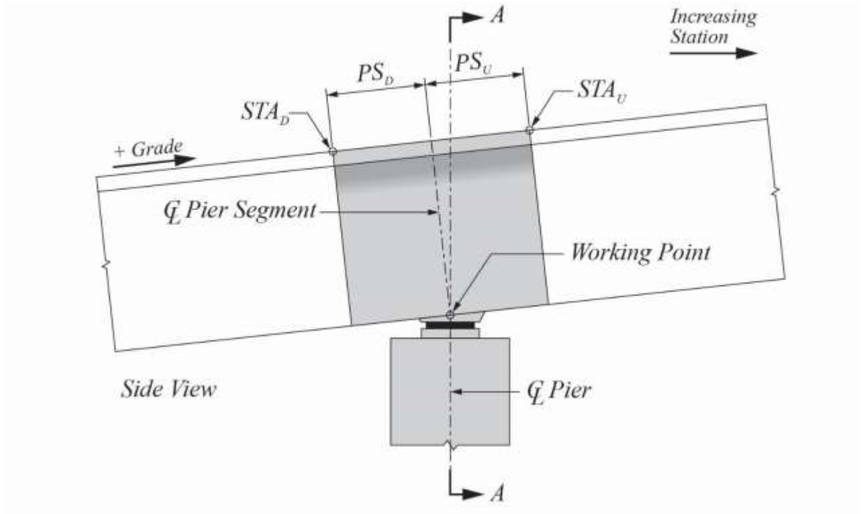
Balanced Cantilever



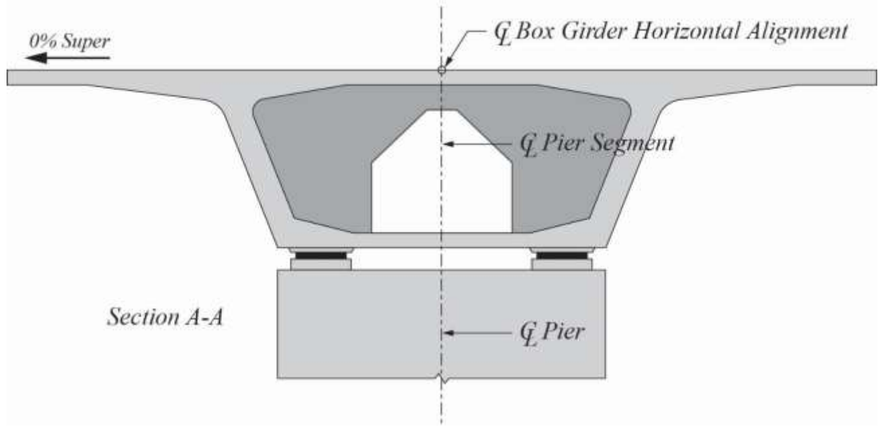
Span-By-Span

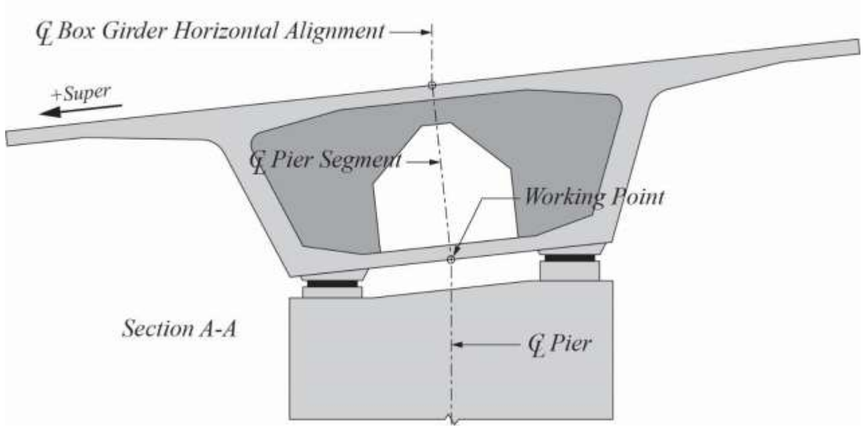
Pier Segment Placement





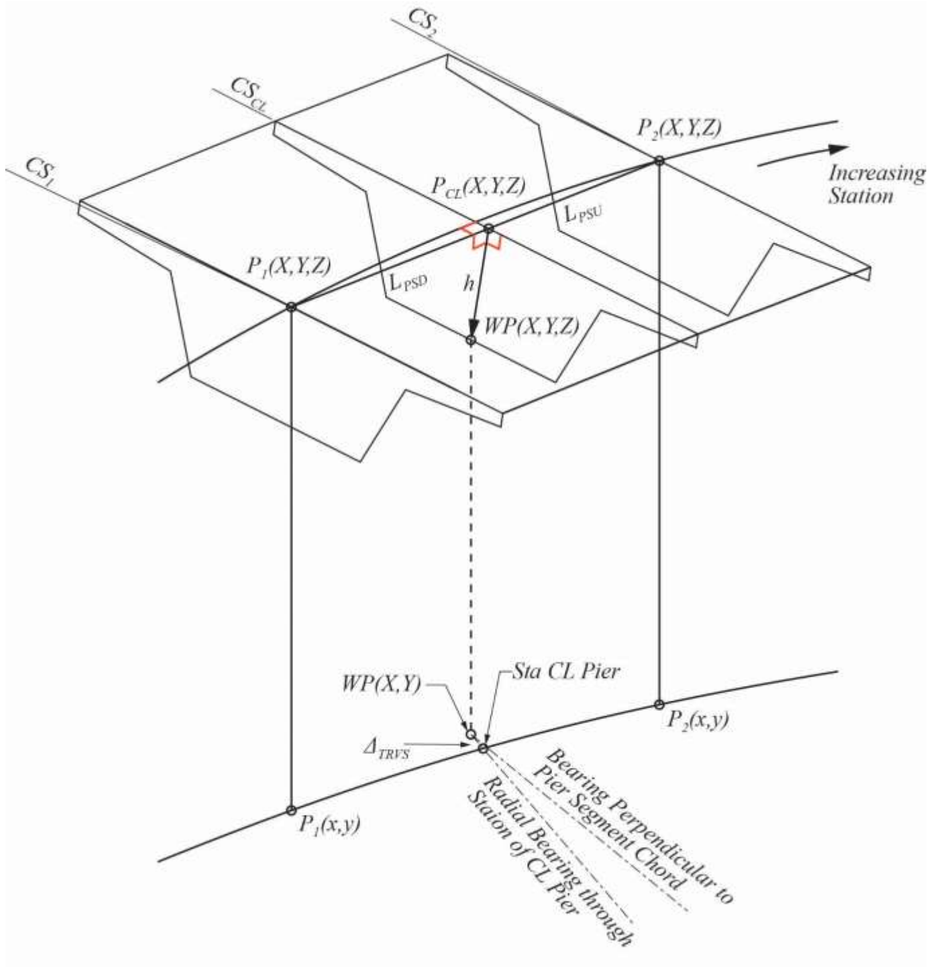
Grade Adjustment

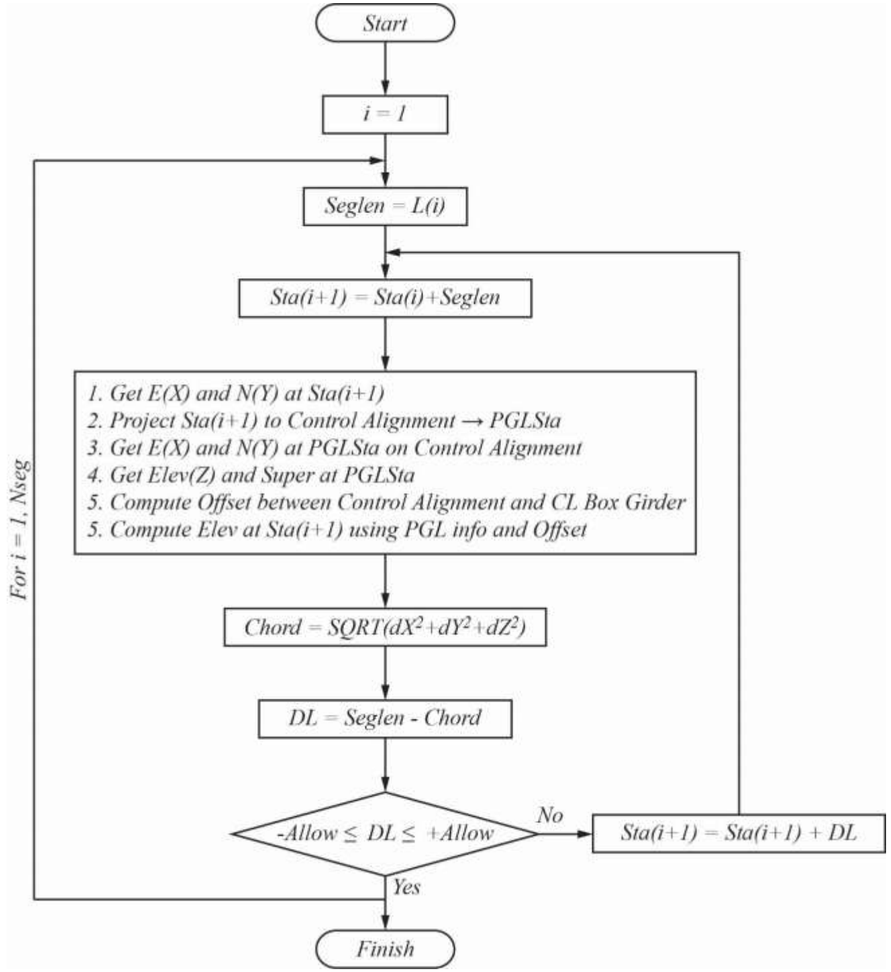




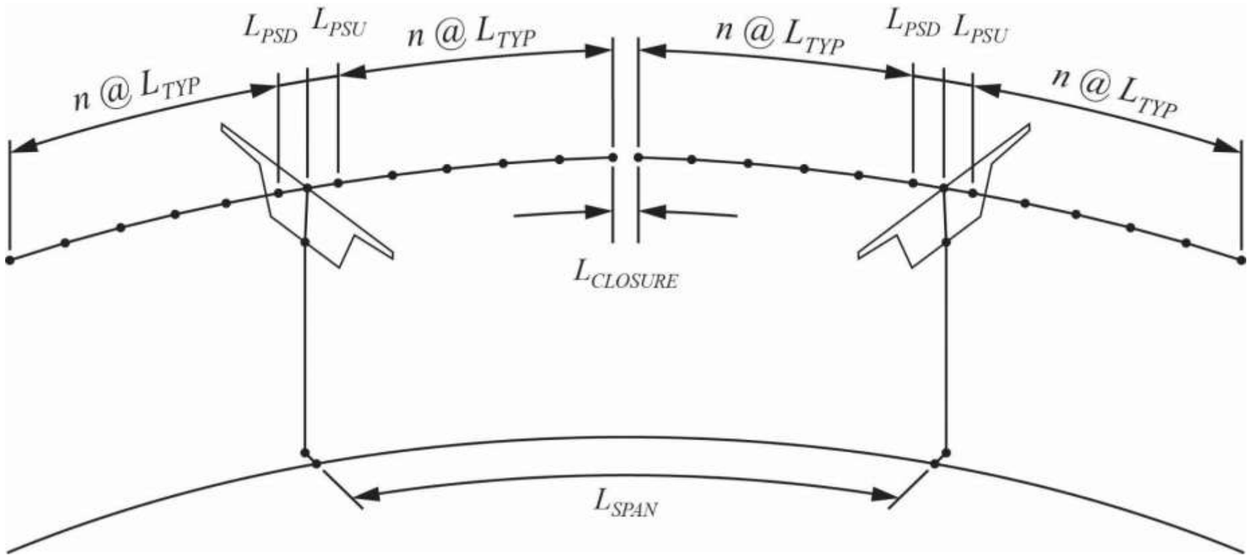
Superelevation Adjustment

Pier Segment Placement

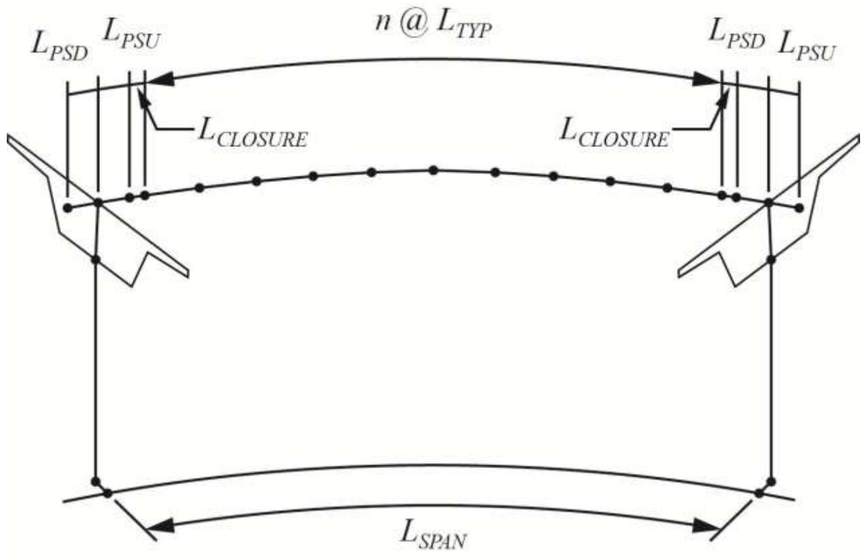




Segment Layouts & Lengths



Balanced Cantilever



Span-By-Span

Foothills Parkway Bridge No. 2

Bridge Length = 790’

Typical Span Length = 180’

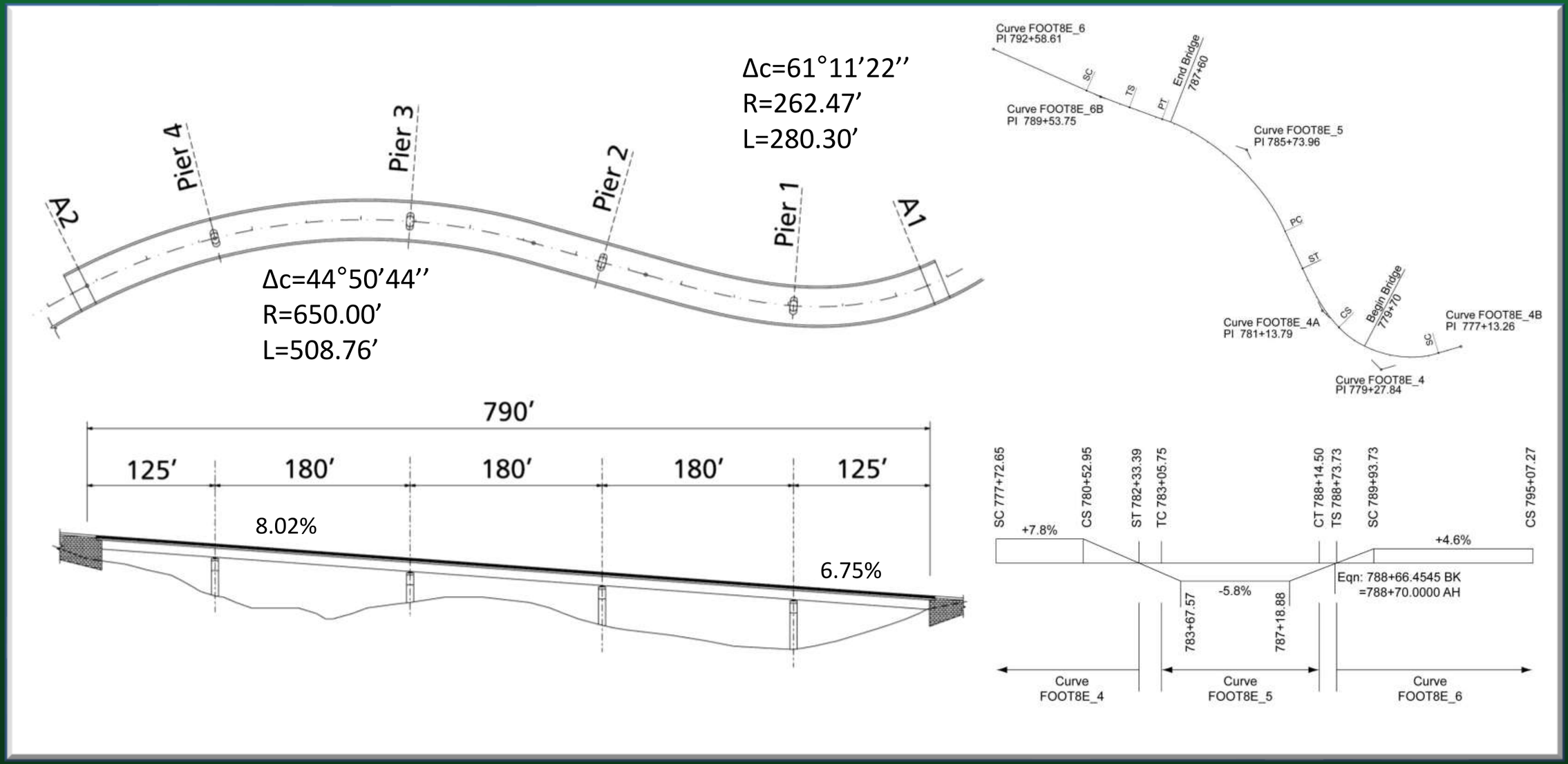
Girder Depth = 10’

Minimum Curve Radius = 262’

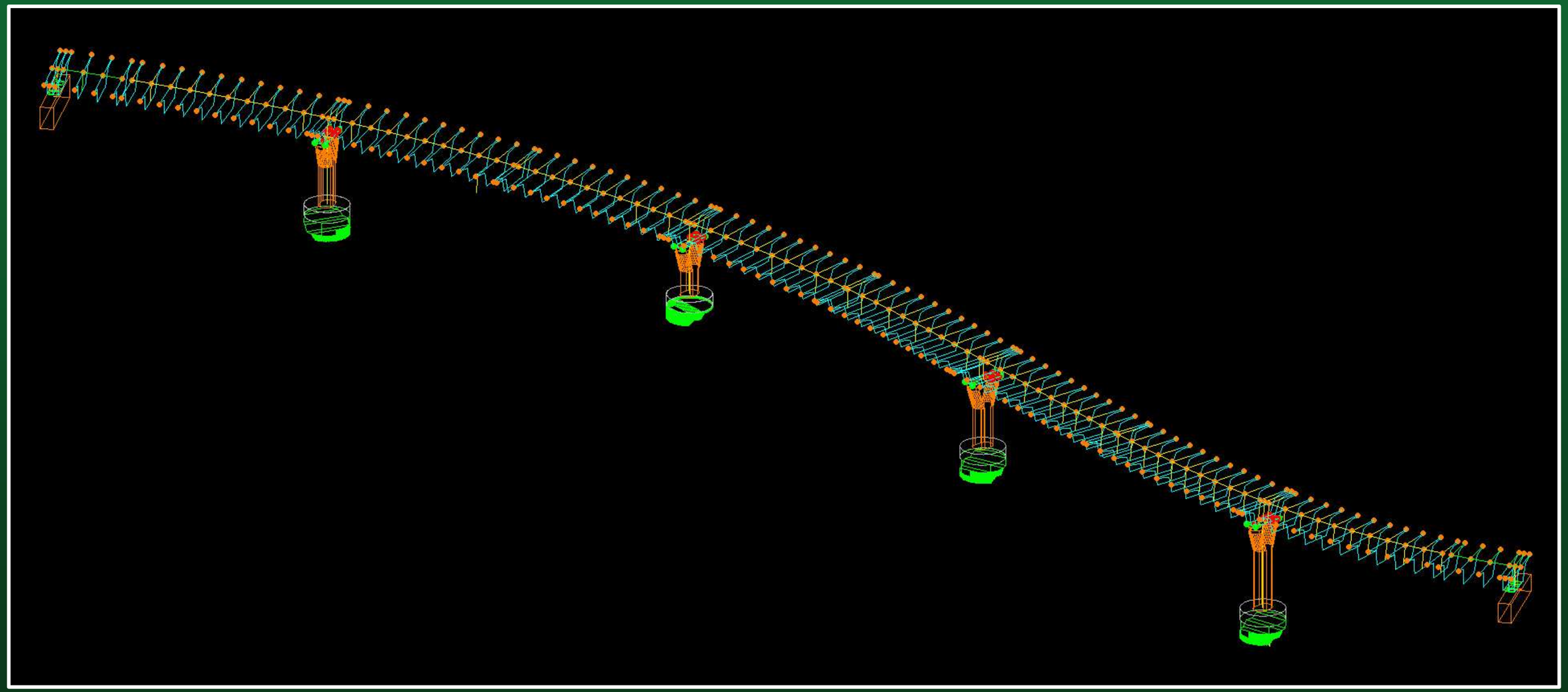
Maximum Grade = 8.02%

Superelevation = -7.8% to +5.8%

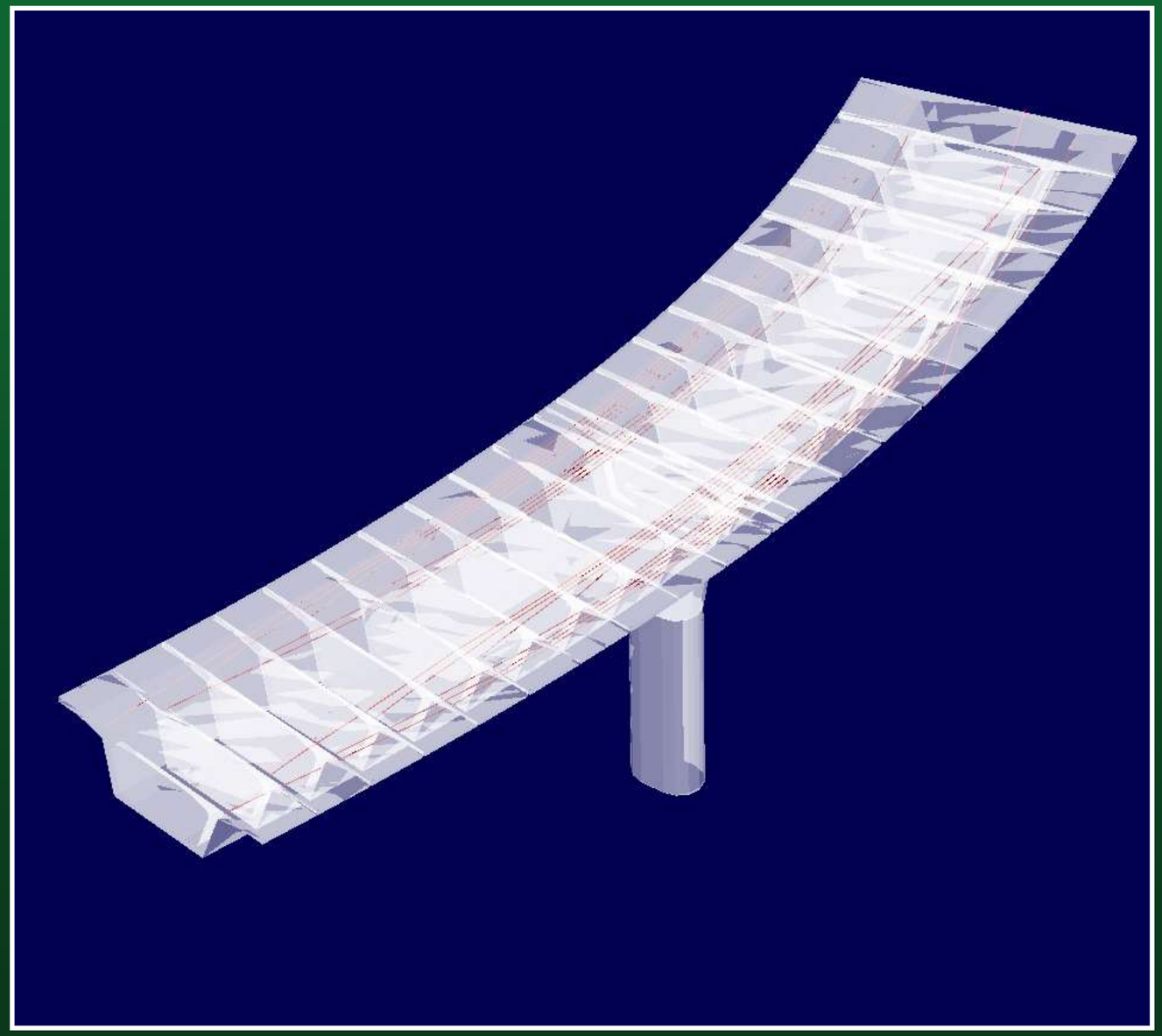
Bridge Layout

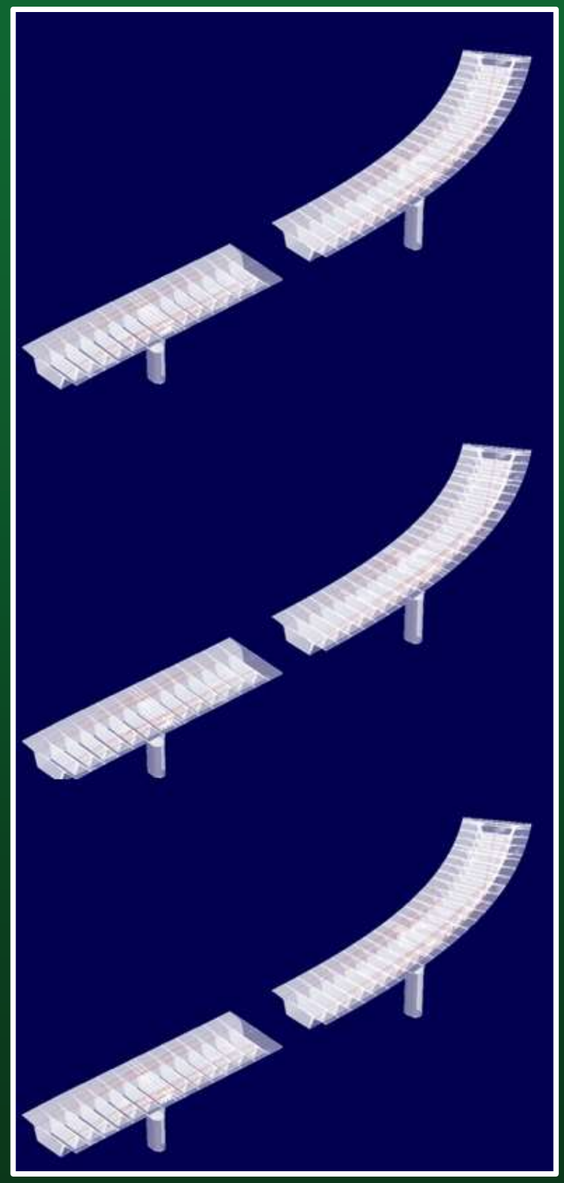


3D Bridge Geometry



Time-Dependent Construction Analyses





Longitudinal External Post-Tensioning

Bearing, Pier and Footing Geometry

Bearings:
- Plinth Corner Dimensions

Piers:
- Bearing Seat Elevations
- Bearing Seat Thicknesses
- Pier Top Elevations
- Pier Top Slope

Footings:
- Coordinates and Offsets

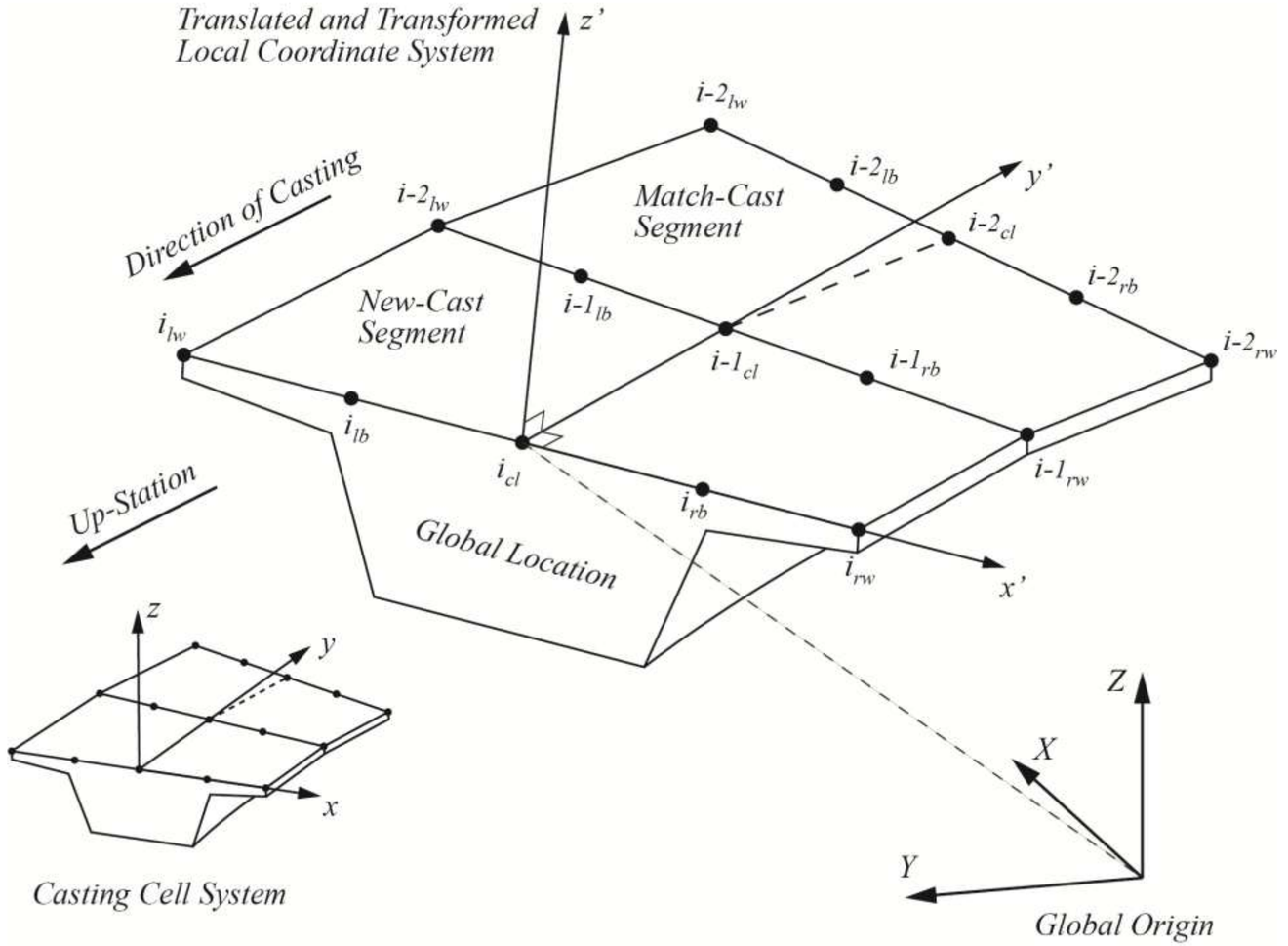
Construction Activities

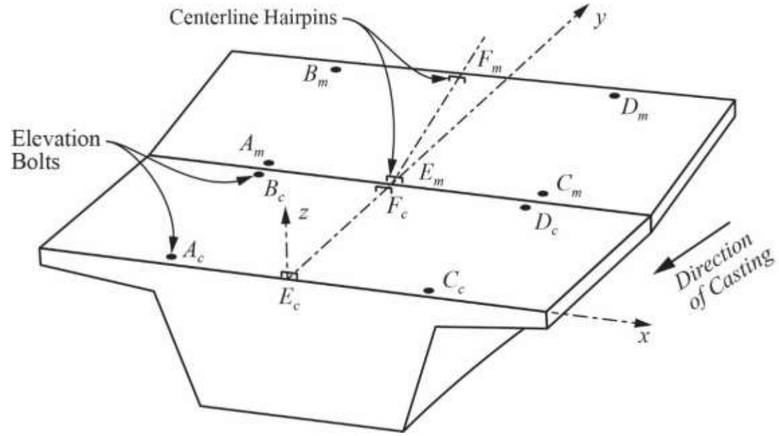
Work by Construction Engineer

Construction Activities

1. Shop Drawings
2. Casting Curves
3. Casting Manual
4. Geometry Control Procedure
5. Daily Set-Up
6. As-Cast Readings
7. Next-Cast Adjustments
8. Final Global Locations

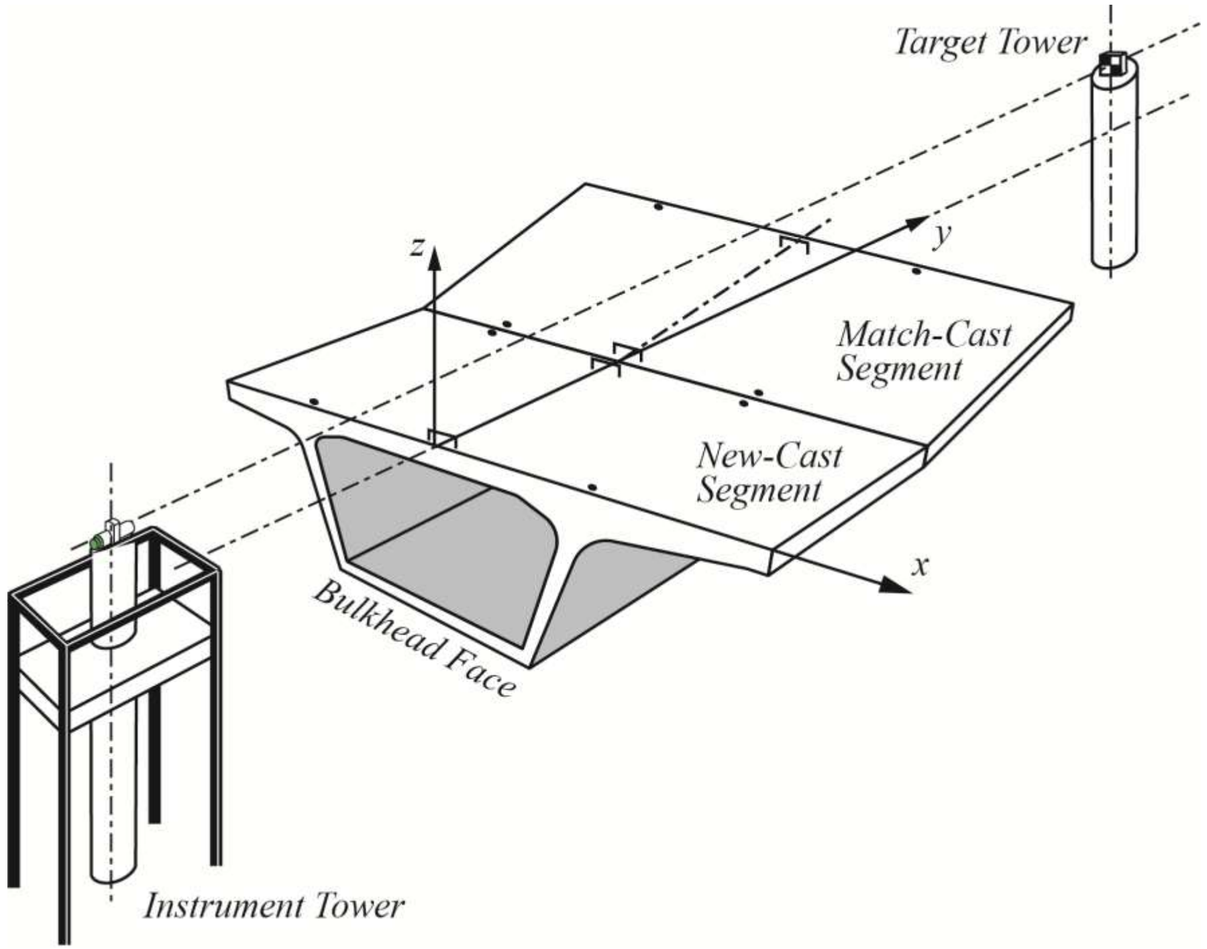
Casting Cell Coordinate Transformations

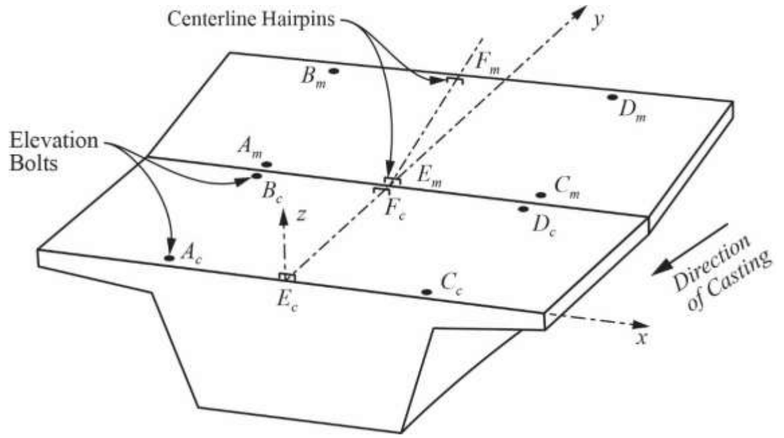




Control Locations

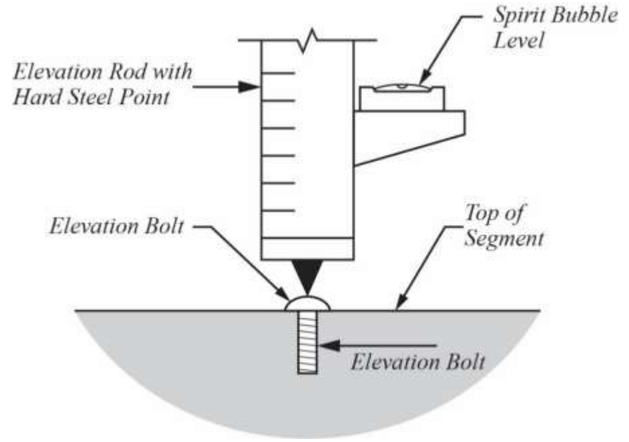
Casting Yard Survey Setup



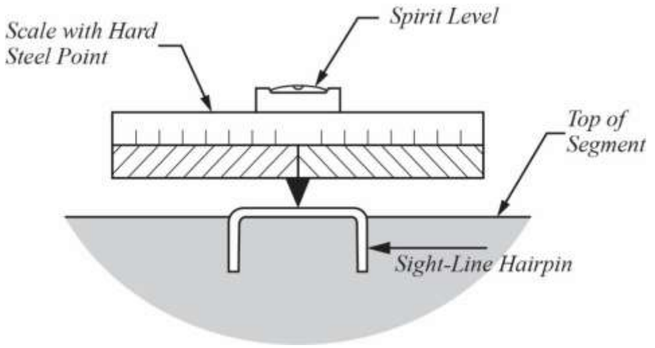


Elevation Bolts &
Alignment Hairpins

Casting Yard Survey Readings

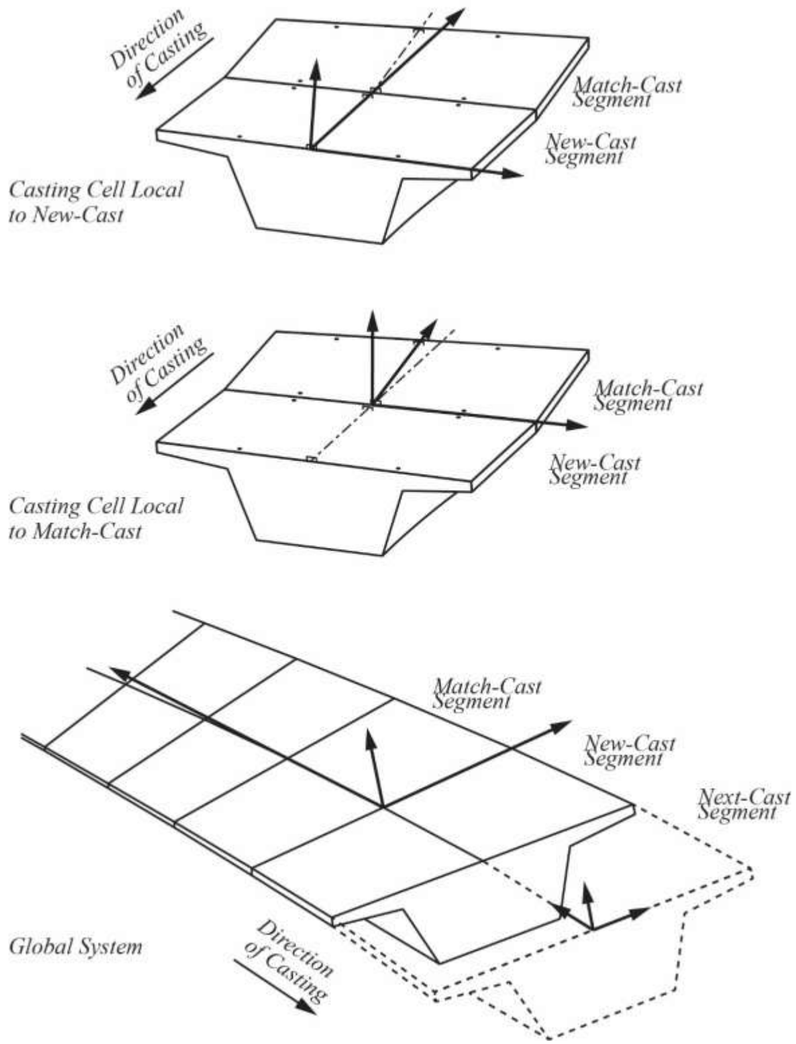


Elevation Bolts



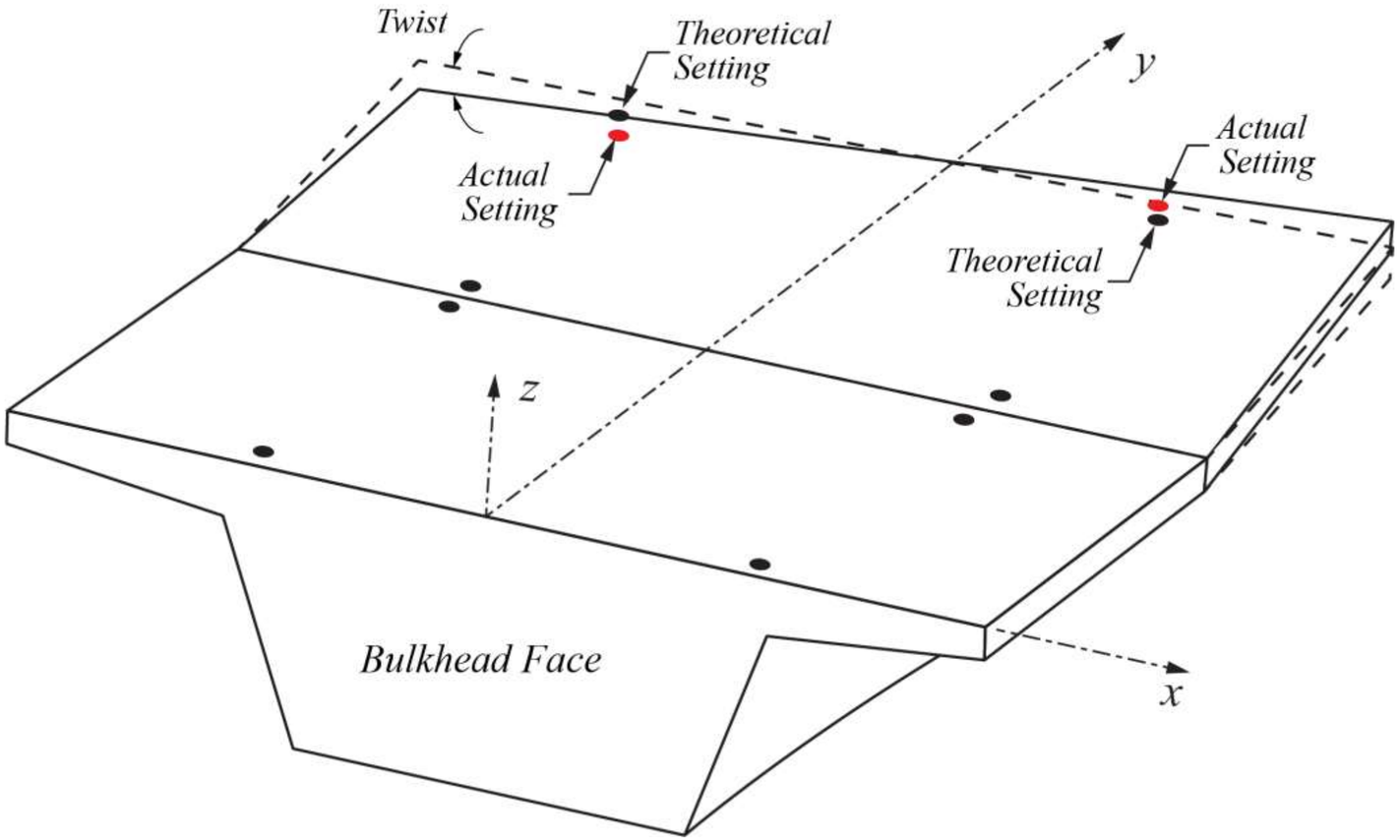
Alignment Hairpins

Geometry Control Calculations – Daily Setups

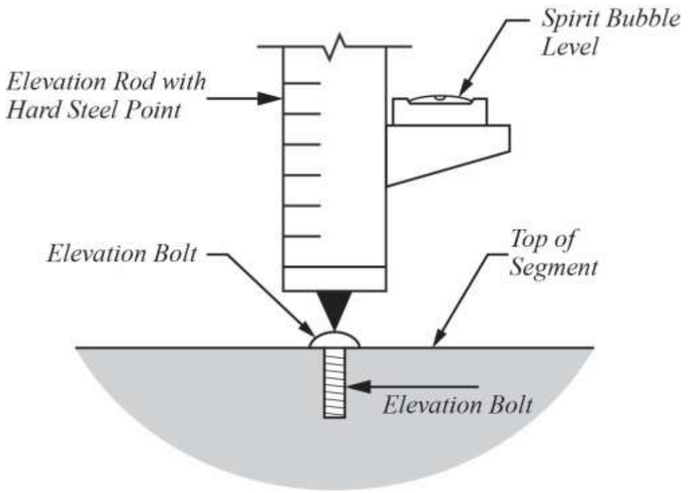


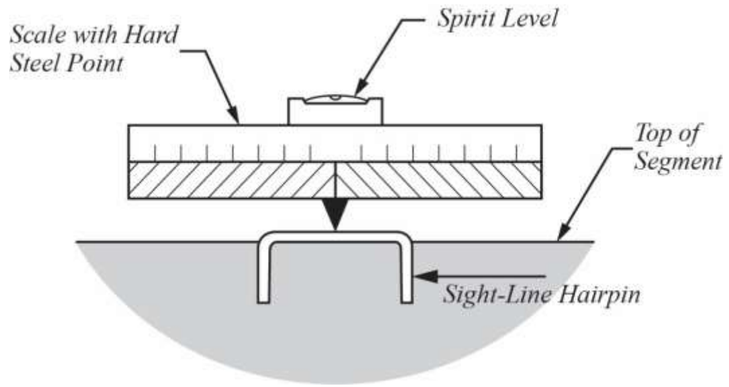
1. Local Cell Coordinates relative to Bulkhead.
2. Transform Local Coordinates to Match-Cast position.
3. Transform New-Cast and Match-Cast to Global.
4. Next Set-Up is New-Cast and Next-Cast to Cell

Twist Measurement & Correction

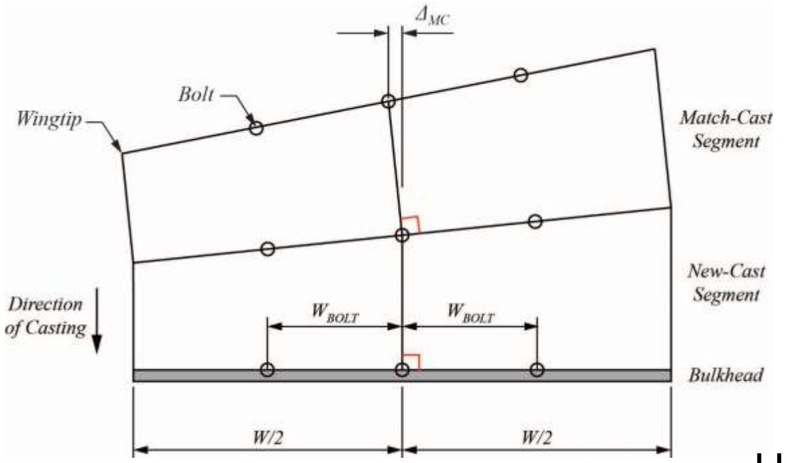


Geometry Control System

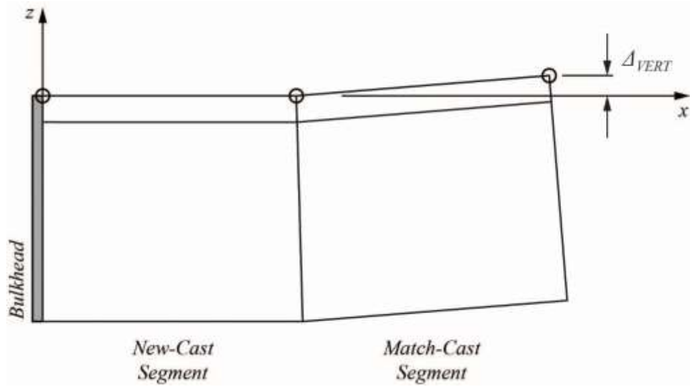




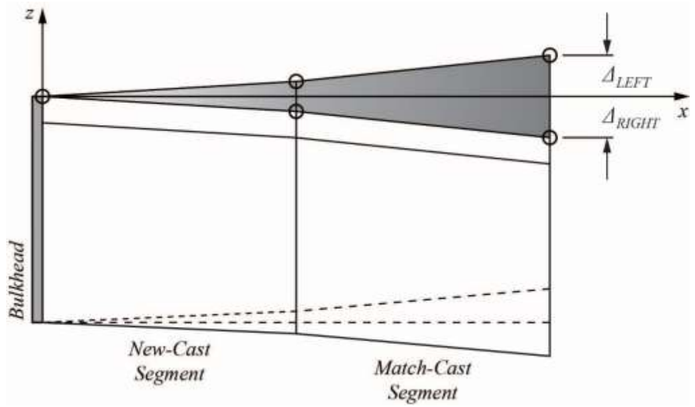
Geometry by Casting Machine Adjustments



Horizontal

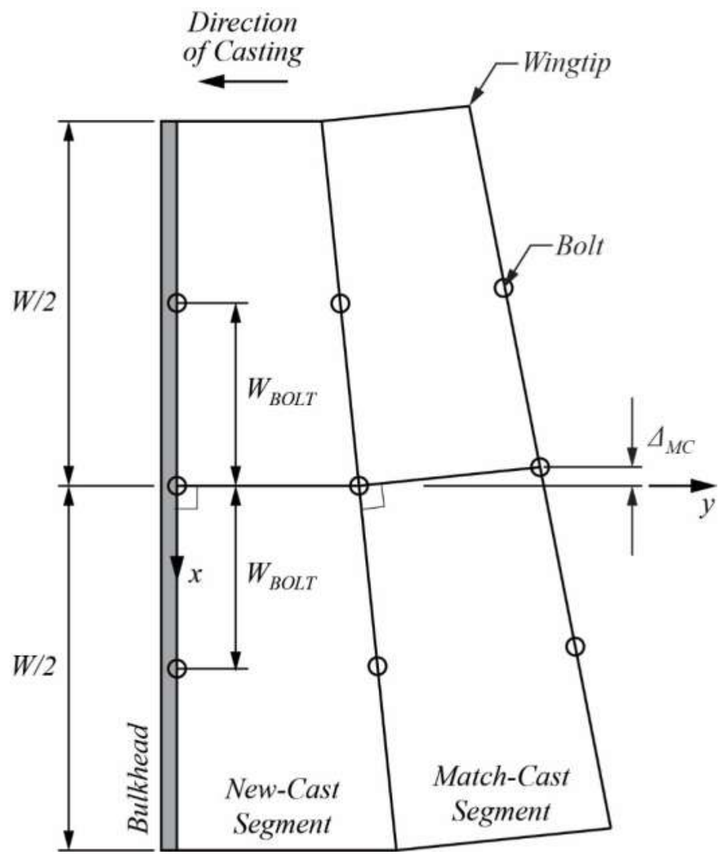


Grade

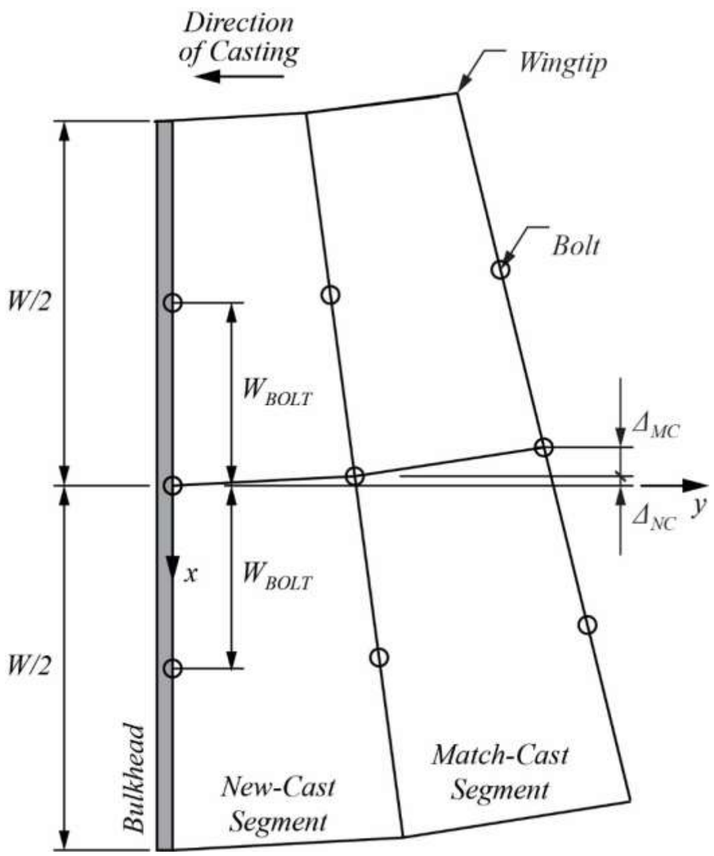


Superelevation

Chorded vs. Radial Segments



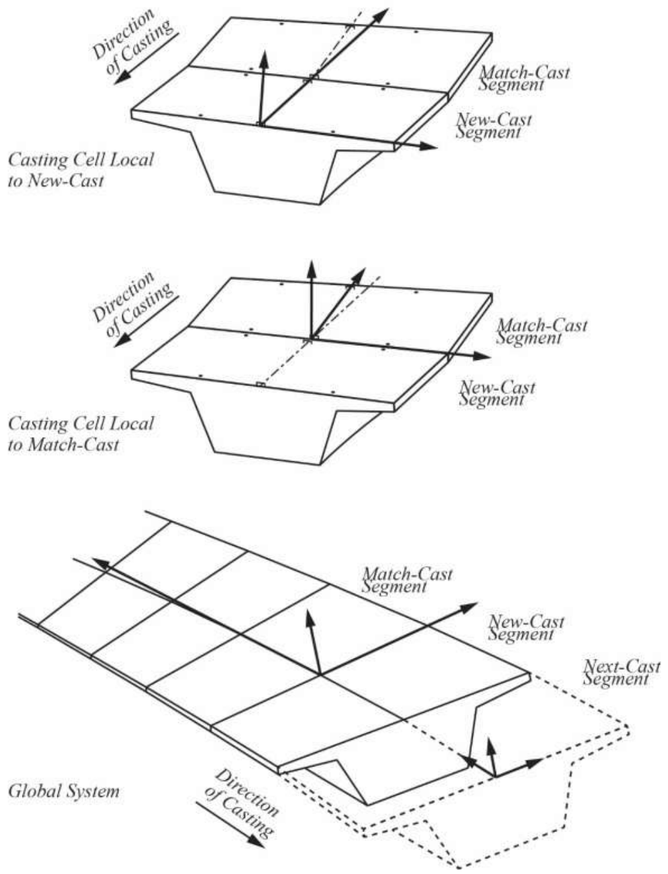
Chorded



Radial

Pier Segment Placement

Geometry Control System



1. Local Cell Coordinates relative to Bulkhead.

2. Transform Local Coordinates to Match-Cast position.

3. Transform New-Cast and Match-Cast to Global.

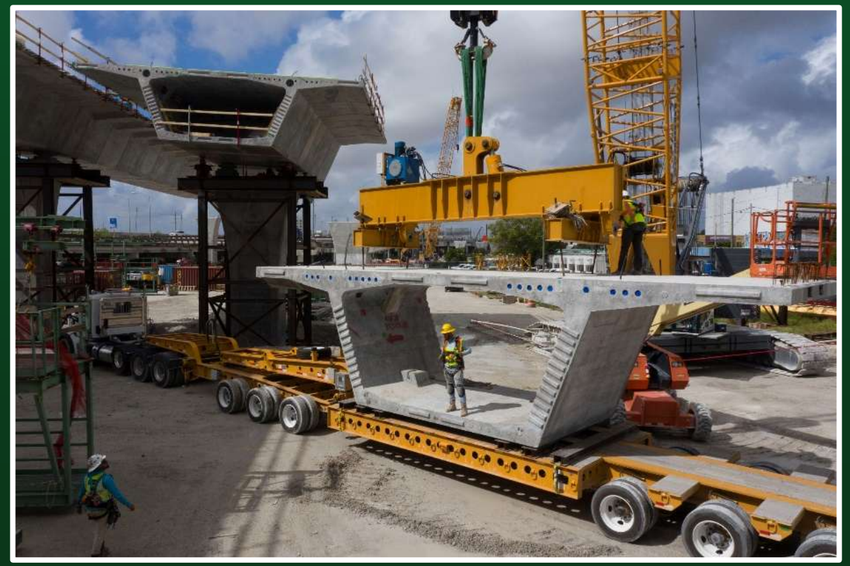
4. Next Set-Up is New-Cast and Next-Cast to Cell

I-395 Segmental Viaducts

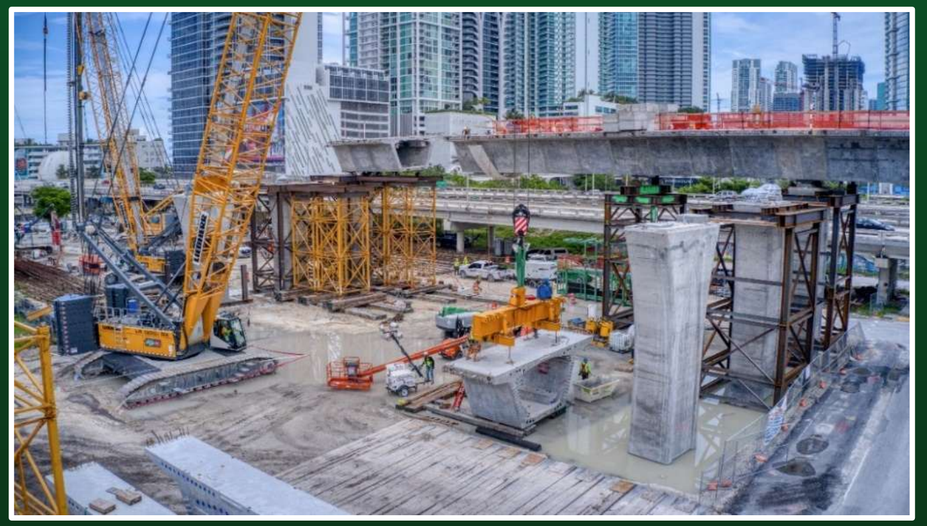
Miami, Florida

- 734,000 sq. ft. of Bridge Deck
- 225 ft. long Typical Span
- Balanced Cantilever Erection
- 3 Precast Segment Types
- Up to 4 Box Girders Joined Transversely to Form Deck

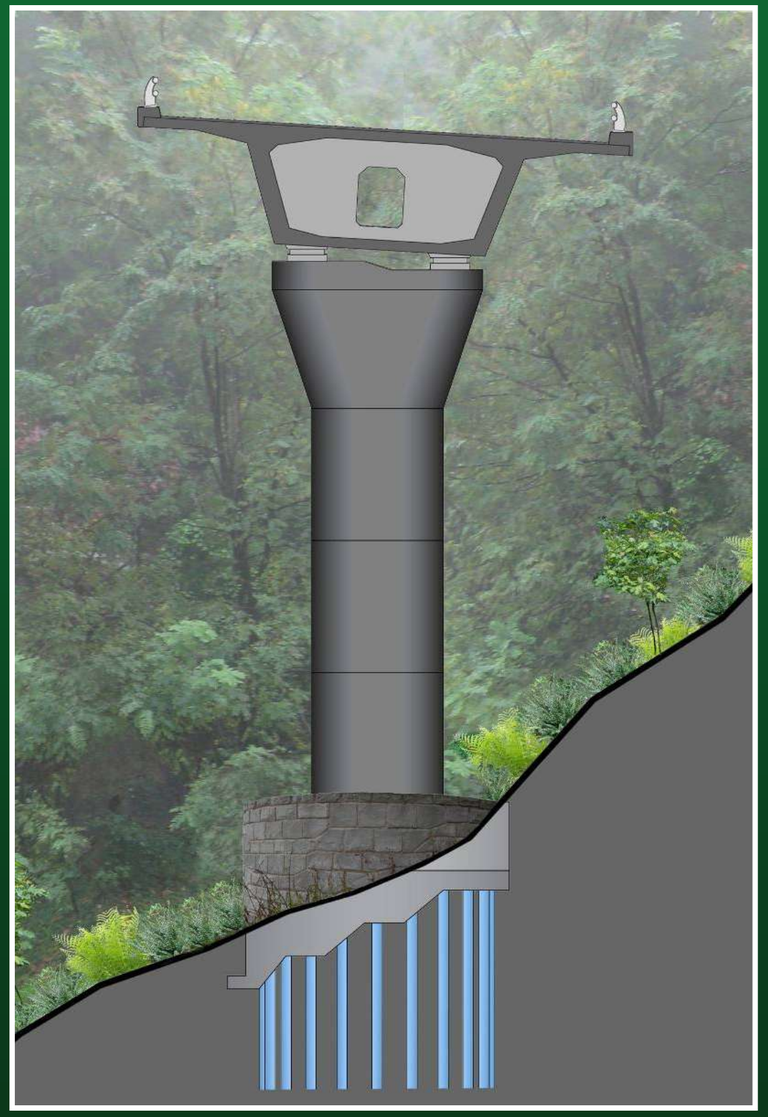
Segment Casting, Storage, and Transportation

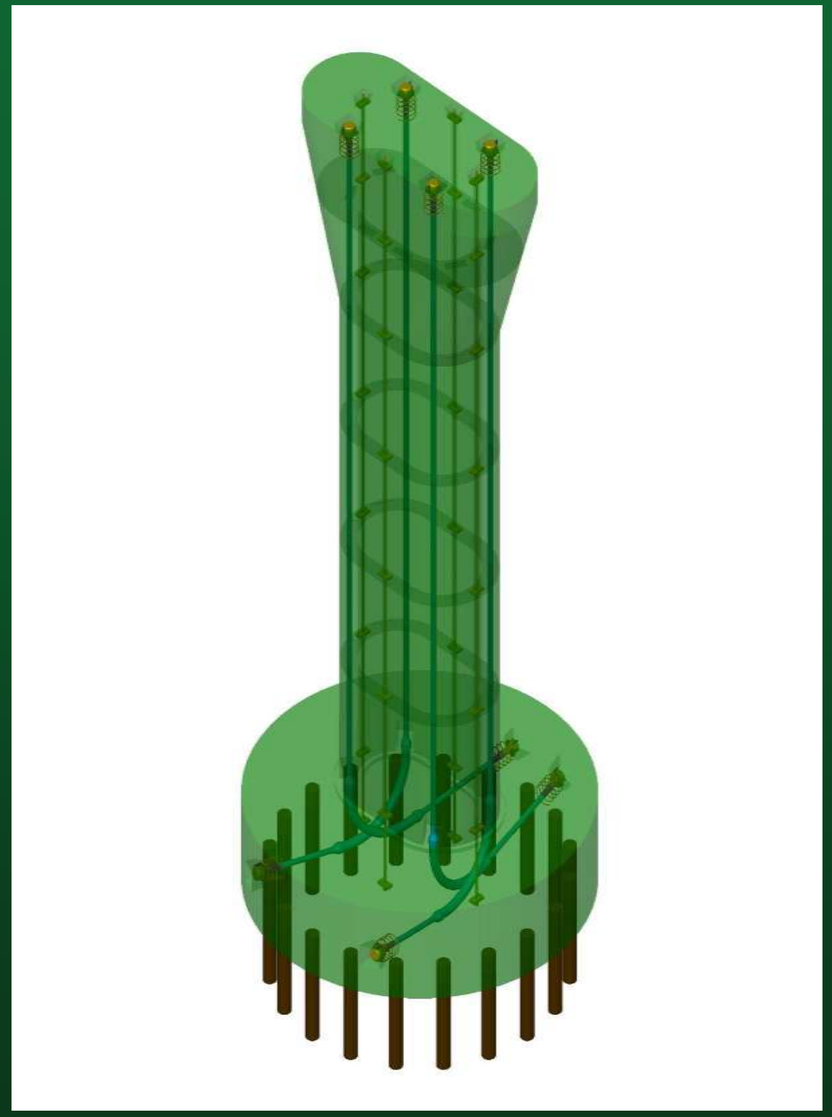


Segment Erection



Precast Segmental Piers





Linn Cove Viaduct

National Concrete Bridge Council

Questions and Answers

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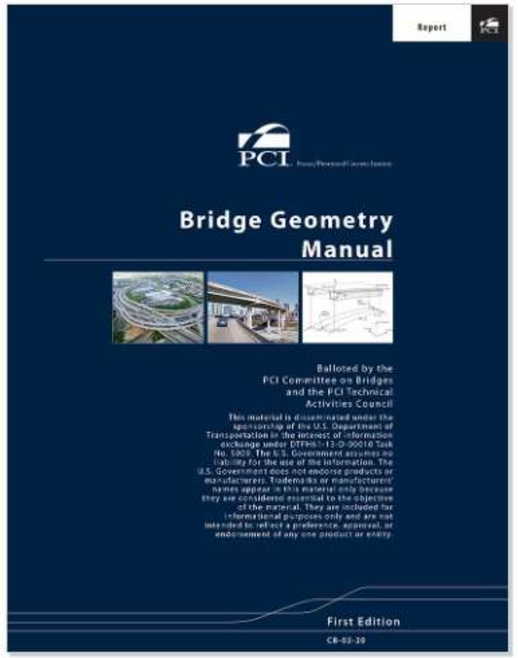

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A Bridge Geometry Manual has been developed as a resource for bridge engineers and CAD technicians. In nine chapters, the manual presents the basics of roadway geometry and many of the calculations required to define the geometry and associated dimensions of bridges. This manual and course materials are not linked to any software tool. The first five chapters are dedicated to the fundamental tools used to establish bridge geometry and the resulting dimensions of bridges. The vector-based approach to locating the North and East coordinates of a point defined by a horizontal alignment is then used to define the geometry of bridges. This manual includes the bridge geometry developed for straight bridges and curved bridges. The geometry of curved bridges using both straight, chorded girders and curved girders is presented.

https://doi.org/10.15554/CB-02-20

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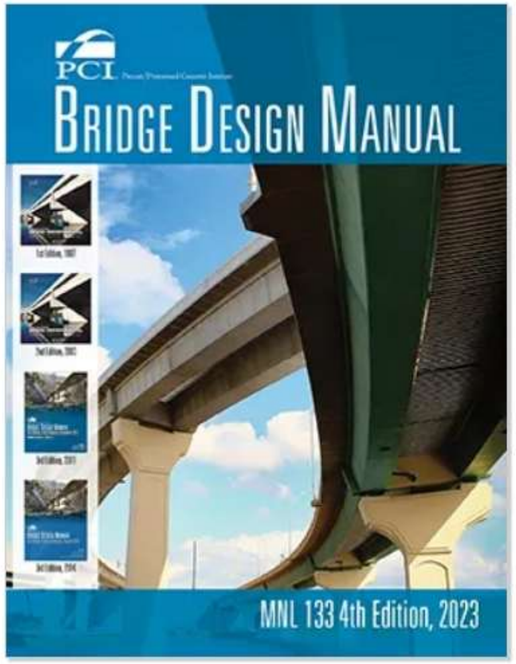
PCI Bridge Design Manual, 4th Edition, 2023



PCI Bridge Design Manual, 4th Edition (MNL-133-23H)

This new edition of the PCI Bridge Design Manual presents both preliminary and final design information for standard beams and most precast and precast, prestressed concrete products and systems used for transportation structures. Load calibration and time-dependent loss computations are extensively discussed, and the manual features updated design examples as well as references to design examples found in the third edition (MNL-133-11).

The fourth edition has been thoroughly revised to explain and amplify the application of the AASHTO LRFD Bridge Design Specifications and to illustrate the effects from shrinkage and creep of the cast-in-place concrete deck. Topics in this comprehensive design manual include background information, strategies for economy, fabrication techniques, design loads, preliminary design tables, design theory, and selected design examples. Chapters also address sustainability, bearings, extending spans, curved and skewed bridges, integral bridges, segmental bridges, additional bridge products, railroad bridges, load rating, repair and rehabilitation, and recreational bridges. Chapters on seismic design and piles will be included in a later printing.

https://doi.org/10.15554/MNL-133-23

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Thank you!

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