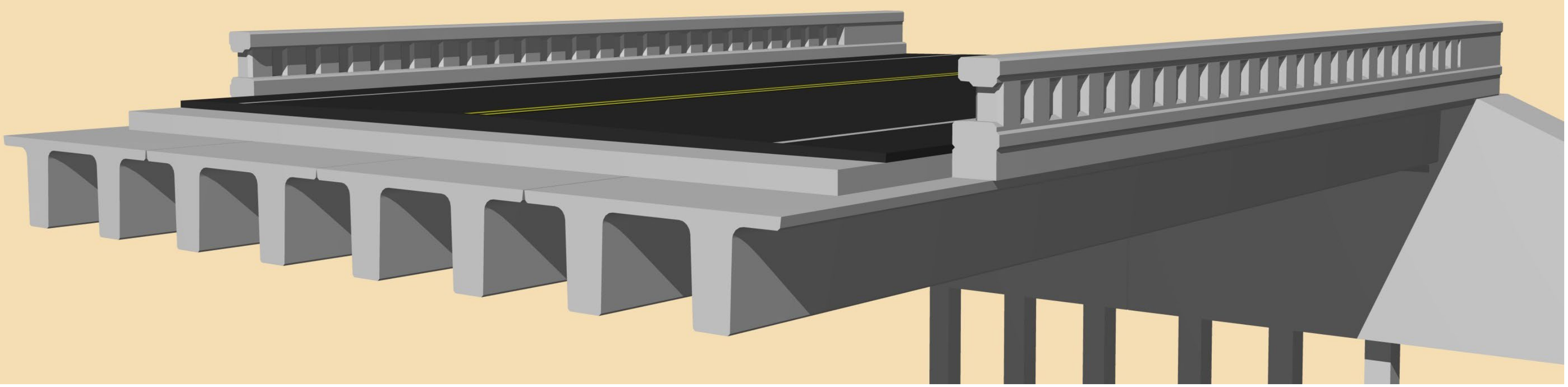
NEXT Beams in Indiana



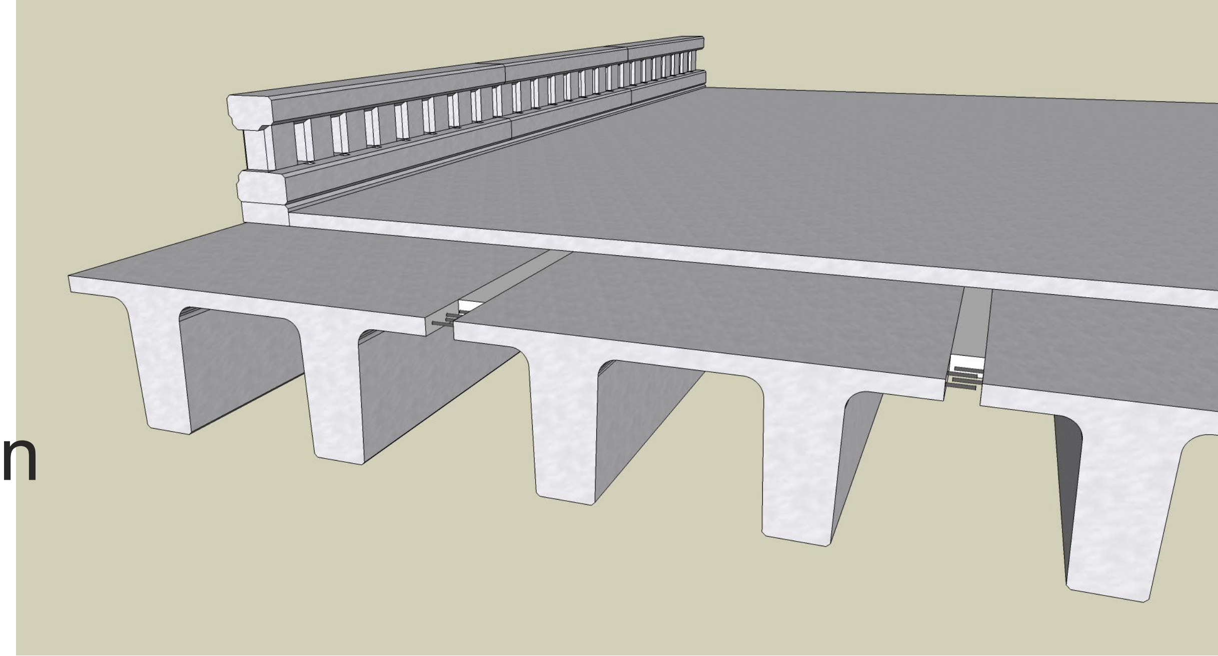
Michael L McCool Jr., P.E.
Pete White, P.E.

February 21, 2023

NEXT Beams in Indiana

Presentation Topics

- Development
- Beam Properties and Details
- Design Tools
- TRB and DOT Design Information
- Photo Examples
- INDOT Pilot Projects



BLN BEAM·LONGEST·NEFF

PCINE Bridge Technical Committee

- Established in 1990
- State DOT’s Engineers, Consultants & Precasters
- Focused on Updating and Developing Regional Standards for ABC Bridge Construction since 2004

Precasters

Rita Seraderian - PCI Northeast

Joe Carrara - J. P. Carrara & Sons

Ben Cota - J. P. Carrara & Sons

Chris Fowler - Oldcastle Precast

Jared Steller - Dailey Precast

Scott Harrigan – Fort Miller

Chris Moore – United Precast

Troy Jenkins - NPP

Consultants

Michael Culmo – CHA Consulting, Inc.

Eric Calderwood - Calderwood Engr.

Vartan Sahakian -Commonwealth Engr.

Darren Conboy - Jacobs Engr.

Ed Barwicki - Lin Associates

State DOT’s

Tim Fields– CTDOT

Bryan Reed - CTDOT

Robert Bulger - Maine DOT

Brian Reeves – Maine DOT

Alex Bardow - MassDOT

Maura Sullivan – MassDOT

Edmund Newton – MassDOT(retired)

Duane Carpenter – NYSDOT

Michael Twiss – NYSDOT

Jason Tremblay –NHDOT

David Scott - NHDOT

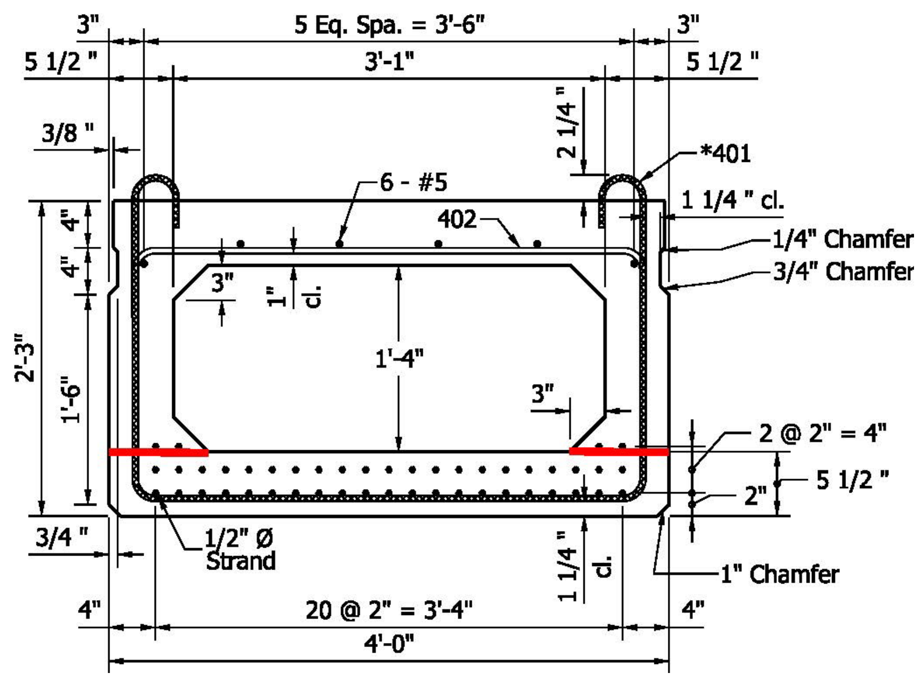
Mike Savella - Rhode Island DOT

Rob Young – Vermont AOT

BLN BEAM·LONGEST·NEFF

Why Develop a New Bridge Section?

- Box Beams have limitations
- Multi-step fabrication process
- Geometric limitations
- Durability concerns
- Closed cells limit inspection



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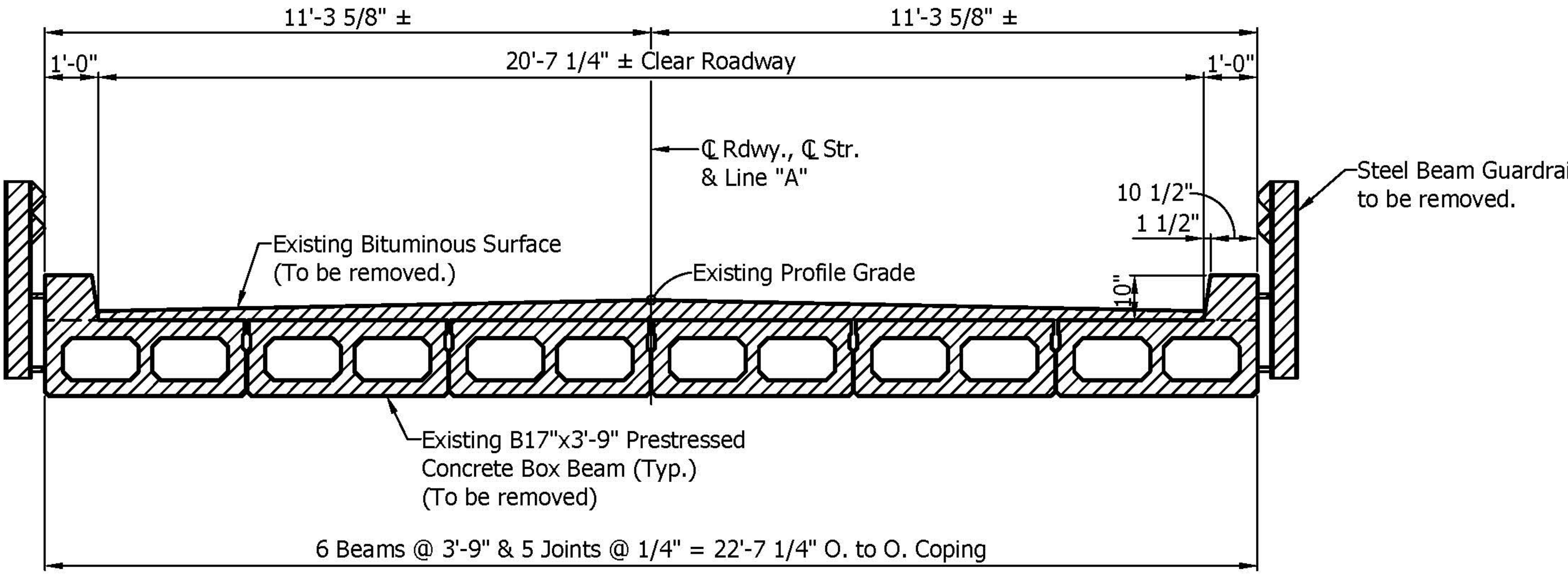
Indiana Adjacent Box Beam Bridges



TYPICAL SECTION - EXISTING

Scale: 3/8"=1'-0"

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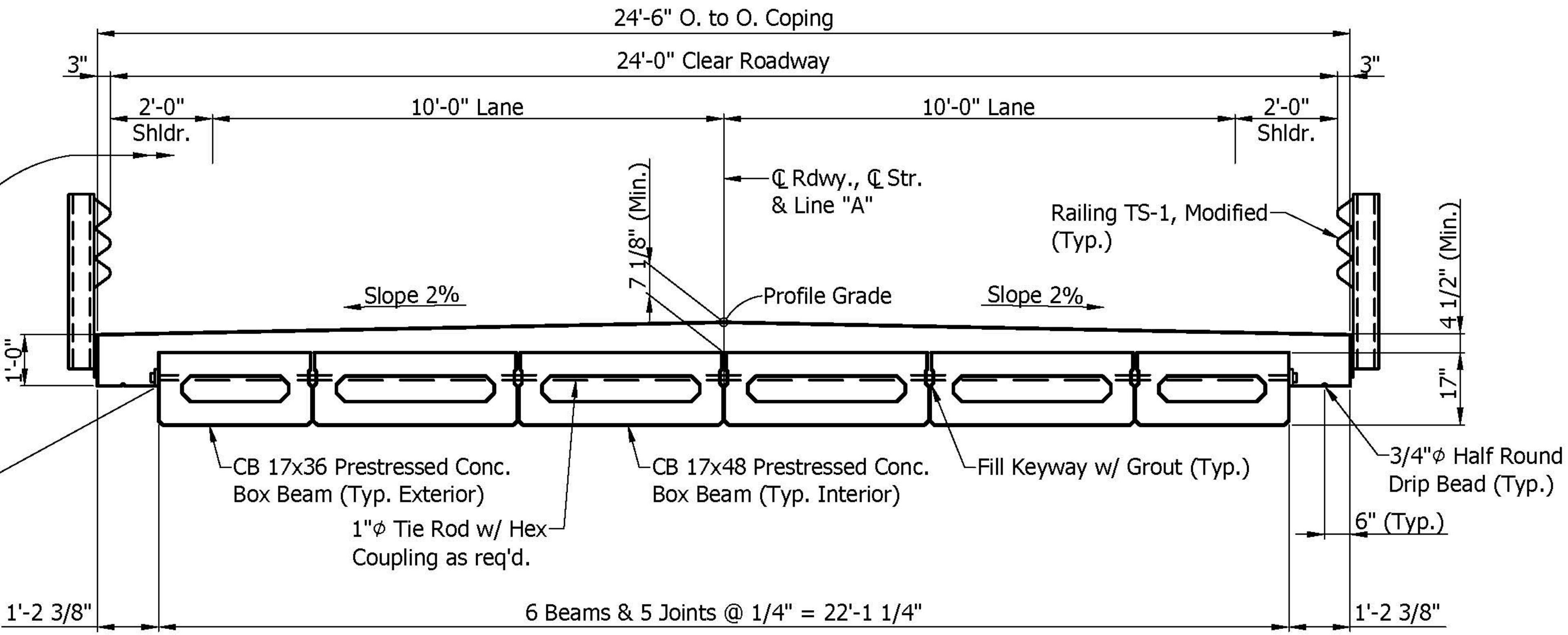
Indiana Adjacent Box Beam Bridges



TYPICAL SECTION - PROPOSED

Scale: 3/8"=1'-0"

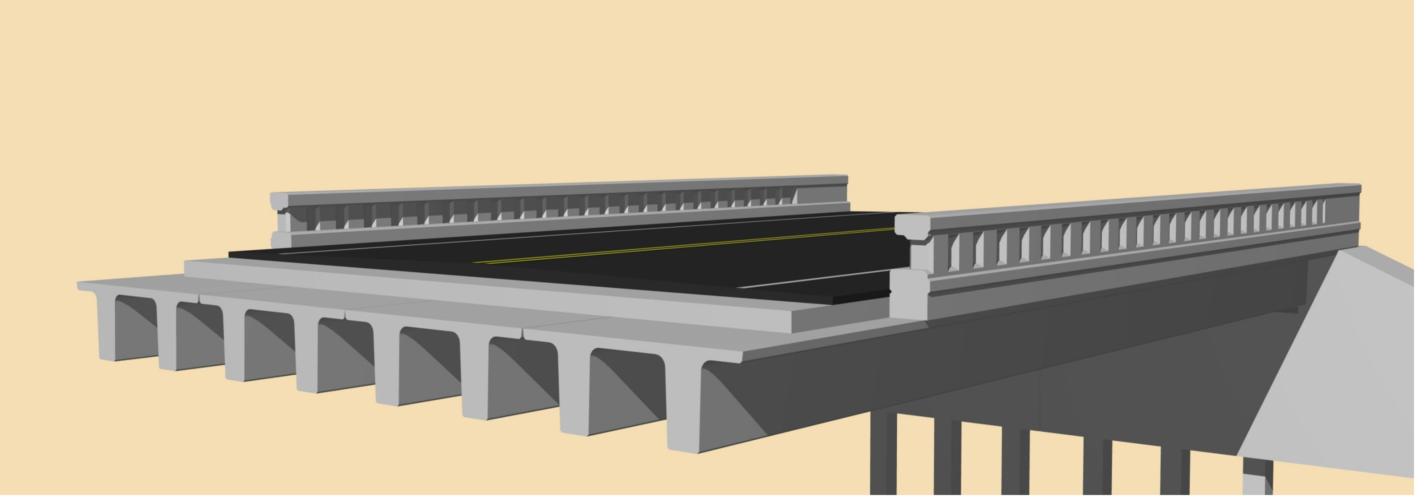
Indiana Adjacent Box Beam Bridges

Indiana Adjacent Box Beam Bridges




Development of the NEXT Beam

- Started in 2006 – Completed in 2008
- Open Double-Tee, Single-Pour Production
- Reduced Fabrication and Installation Cost
- Width varies from 8 ft to 12 ft
- Spans: 20 ft to 80 ft
- Works well for Accelerated Construction (ABC)



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TIMELINE NEXT Beam Developed in 2008

First NEXT Beam Cast

2009

First NEXT F Bridges built York ME and Kittery ME

2010

2 Bridges

7 Bridges

First NEXT D bridges are built in Maine & Vermont MA and NY Build first Bridges

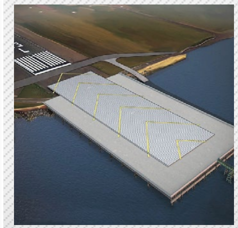
2011

First Curved Flange Project

NJ and RI build their first projects

2012

18 Bridges



Logan Airport uses NEXT beams for Runway Extension and new Airport Viaduct

2011-12

NY built First Lateral Slide

2013

25+ Projects

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Development of the NEXT Beam

- 2015 NEXT Beam Guidelines – Updated w/ NEXT E
- 2021 Second Edition of NEXT Beam Typical Guide Details released

NORTHEAST EXTREME TEE (NEXT) BEAM GUIDE DETAILS

These guidelines and guide details have been developed for the purpose of promoting a greater degree of uniformity among owners, engineers and industry with respect to planning, designing, fabricating and constructing the Northeast Extreme Tee (NEXT) Beam for bridges.

In response to needs determined by Northeast Transportation Agencies, and Prestressed Concrete Producers, the PCI Northeast Bridge Technical Committee prepared these guidelines and guide details to promote uniformity of design and details throughout the region.

The PCI Northeast Bridge Technical Committee Members:

Rita Seraderian	PCI Northeast
Michael Culmo	CHA Consulting, Inc.
Raymond Basar	Connecticut DOT
Bryan Reed	Connecticut DOT
Joel Veilleux	Maine DOT
Richard Meyers	Maine DOT
Taylor Clark	Maine DOT
Alex Bardow	Mass. DOT
Edmund Newton	Mass. DOT (Ret.)
Michael Merlis	Mass. DOT
David Scott	New Hampshire DOT
Jason Tremblay	New Hampshire DOT
Duane Carpenter	NYSDOT
Scott Lagace	NYSDOT
Ramiz Turan	NYSDOT
Adrienne LiBritz-Cooley	NYSDOT
Mike Twiss	NYSDOT (Ret.)
Mike Savella	State of Rhode Island DOT (Ret.)
Stephen Coley	VTRANS
Rob Young	VTRANS
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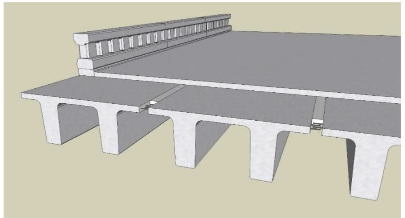
Scott Harrigan	The Fort Miller Co., Inc.
Joe Carrara	J. P. Carrara & Sons
Troy Jenkins	Northeast Prestressed Products
Chris Fowler	Oldcastle Precast
Bruce Miller	Unistress Corp.
James Cutler	Unistress Corp.
Chris Moore	United Concrete Precast
Bill Augustus	United Concrete Precast
Eric Calderwood	Calderwood Eng.
John Byatt	Fuss & O'Neill
Ben Cota	GCP Applied Tech
Paul Moyer	Gill Engineering
Darren Conboy	Jacobs Engineering
Ed Barwicki	Lin Associates
Sergio Brena	University of Mass.



PCI

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Precast/Prestressed Concrete Institute Northeast Covering New England and New York

Report Number:
PCINER-12-NEXT
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By: Precast/Prestressed Concrete Institute Northeast

Northeast Extreme Tee (NEXT) Beam Guide Details
Second Edition 2021
Issue Date: 1/22/2021

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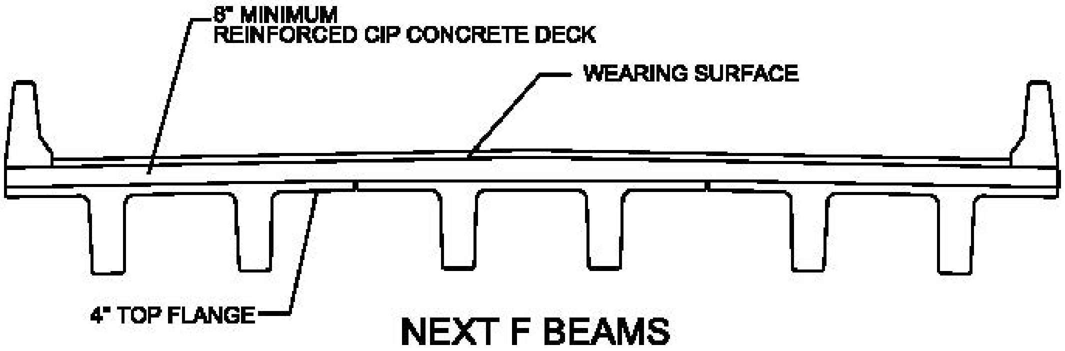
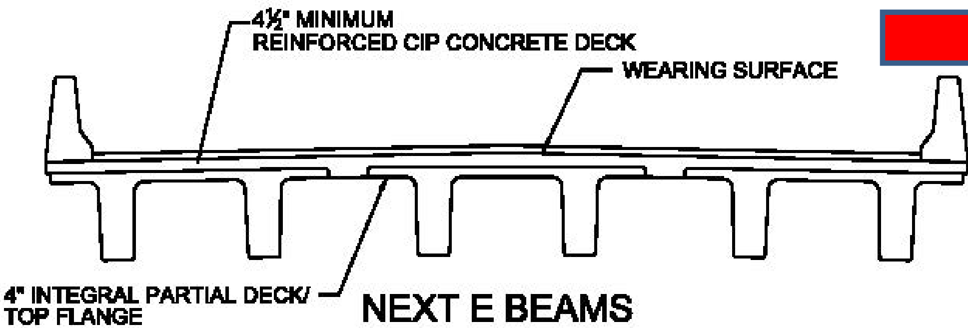
NEXT Beam Shapes



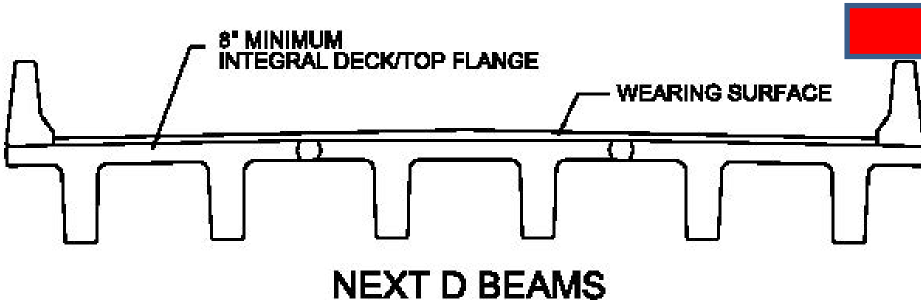
<u>NEXT "F" plus 8" CIP Deck</u>

- No Forming between Flanges
- Easily Accommodates Vertical Curves w/CIP Topping
- Easily Handles Camber Variations between Members



<u>NEXT "E" plus 4" CIP Deck</u>

- Uses Less Topping & Reinforcement
- Flange Connection Made with CIP
- Easily Accommodates Vertical Curve
- Easily Handles Camber Variations between Members

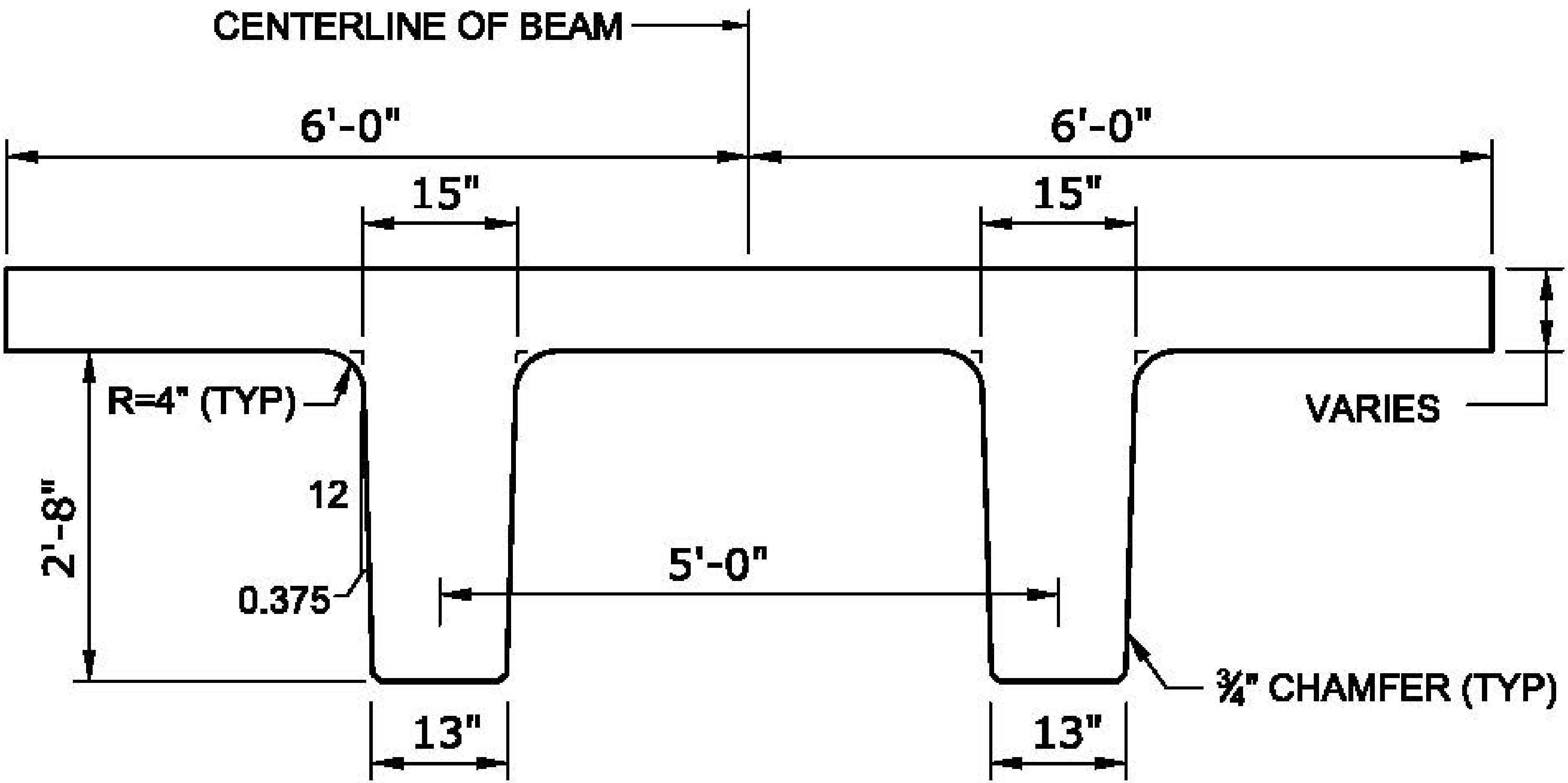


<u>NEXT "D" no CIP Deck</u>

- No CIP Topping/Deck
- Best Section for ABC

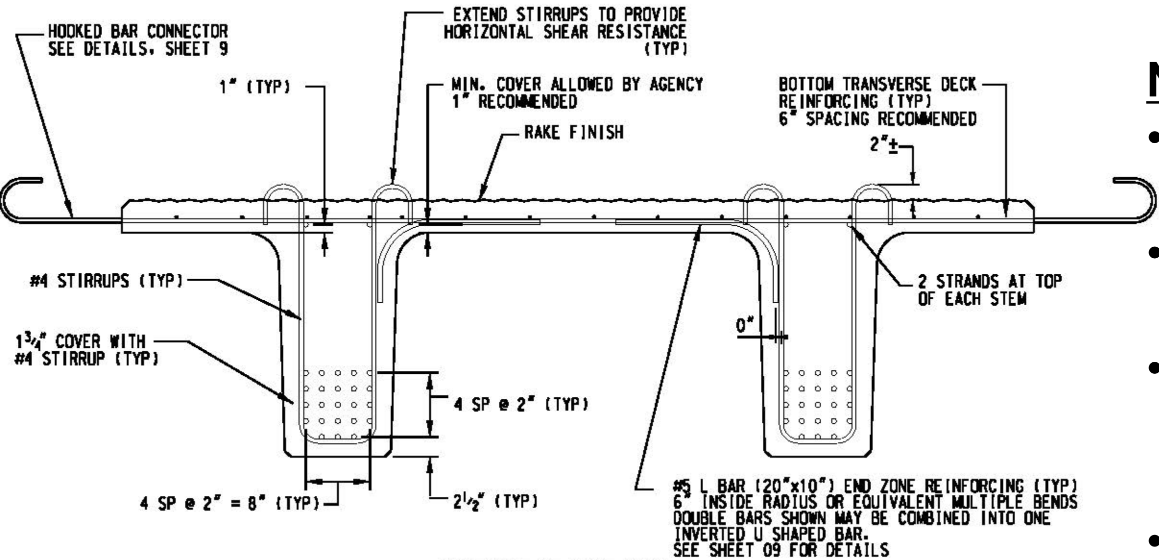
Development of the NEXT Beam

Depth 24" – 36" in 4" increments
Typical Span Range 20' – 80'
Width will vary 8'-0" – 12'-0"



NEXT BEAM DESIGN ENVELOPE

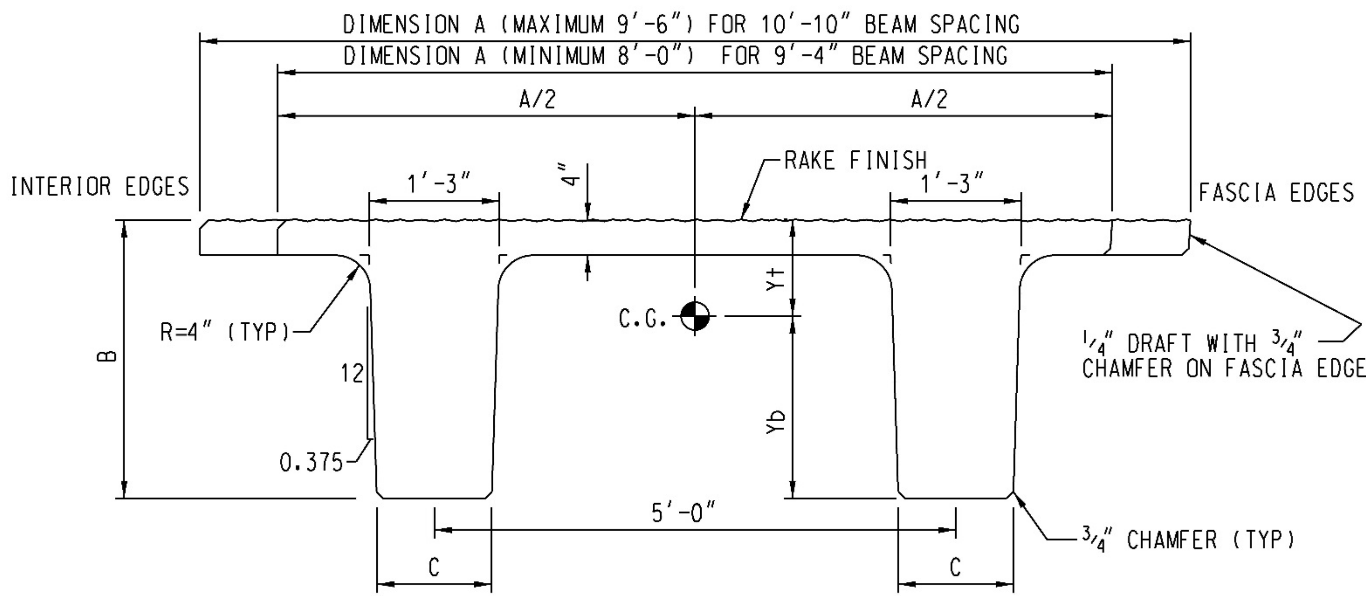
Development of the NEXT Beam



NEXT E BEAM

NEXT "E" BEAM

- Top flange to act as bottom portion of the deck
- Shear reinforcement kept to #4 bars to maximize cover
- Design of deck should be based on conventional CIP concrete deck
- Hook bars in tension are designed



NEXT E BEAM

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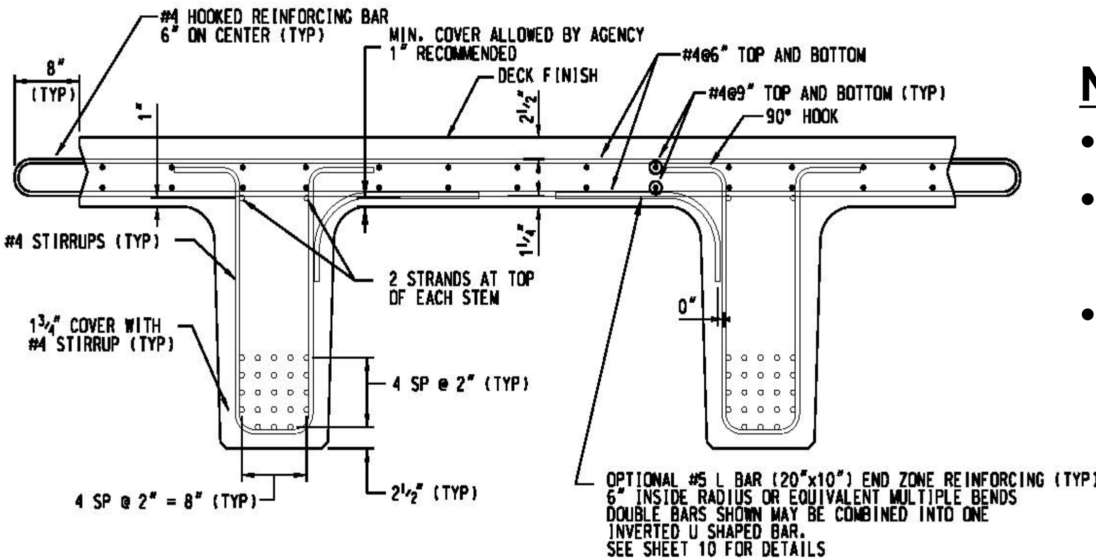
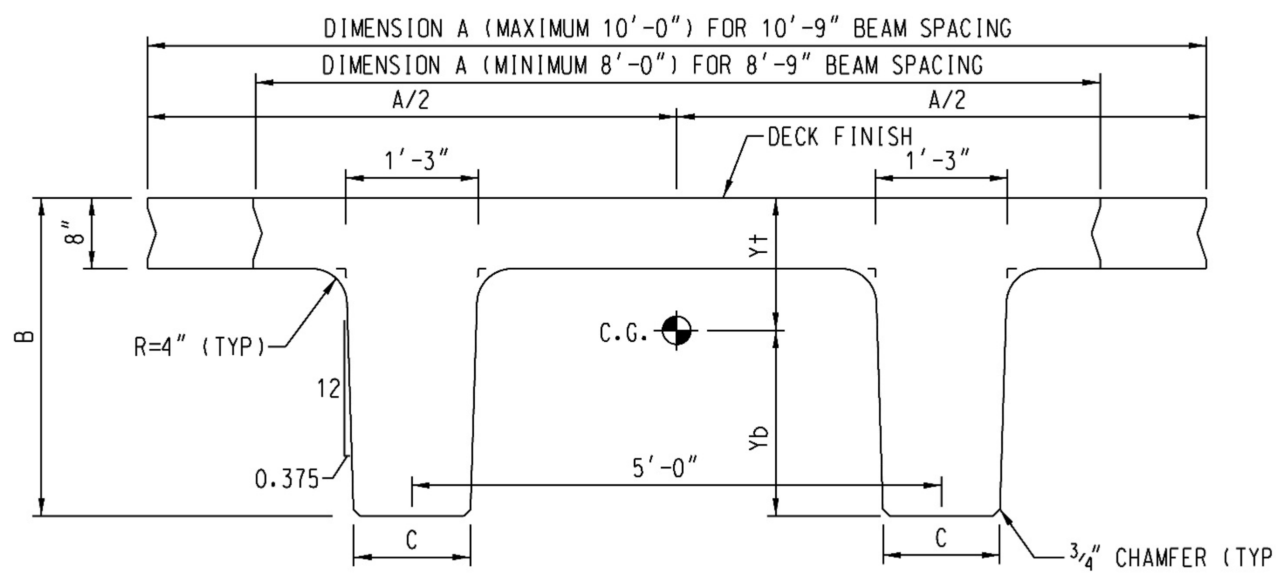
Development of the NEXT Beam



NEXT D BEAM

<u>NEXT "D" BEAM</u>

- Top flange is a structural deck
- Shear reinforcement kept to #4 bars to maximize cover
- Flange connections do not need to be UHPC



NEXT D BEAM

BEAM·LONGEST·NEFF

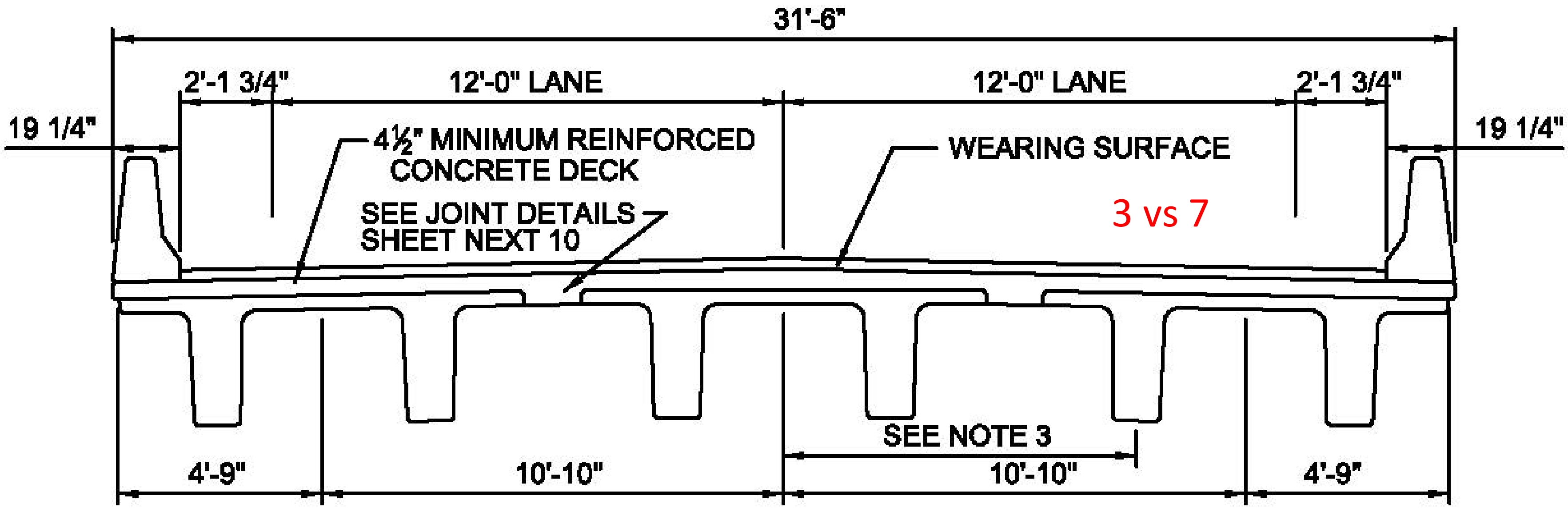
NEXT Beam Properties

NEXT BEAM - SECTION PROPERTIES

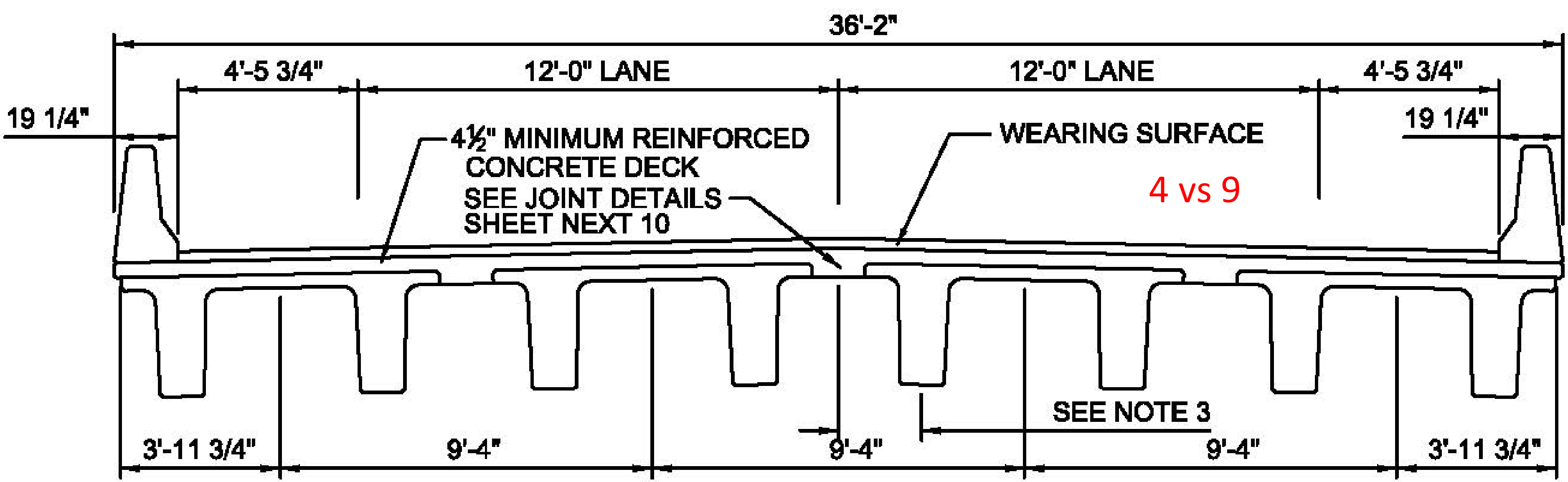
BEAM DESIGNATION	BEAM WIDTH INCHES	BEAM DEPTH INCHES	BASE STEM WIDTH INCHES	AREA IN^2	I IN^4	Yb INCHES	Yt INCHES	St IN^3	Sb IN^3	WEIGHT PLF
	A	B	C			D	E			
MINIMUM WIDTH BEAMS										
NEXT 36 F	95.50	36.00	13.00	1287	160240	21.77	14.23	11261	7361	1341
NEXT 32 F	95.50	32.00	13.25	1182	115813	19.51	12.49	9272	5936	1231
NEXT 28 F	95.50	28.00	13.50	1075	79901	17.24	10.76	7426	4635	1120
NEXT 24 F	95.50	24.00	13.75	966	51823	14.95	9.05	5726	3466	1006
NEXT 36 E	96.00	36.00	13.00	1289	160546	21.79	14.21	11298	7368	1343
NEXT 32 E	96.00	32.00	13.25	1184	116028	19.53	12.47	9305	5941	1233
NEXT 28 E	96.00	28.00	13.50	1078	80042	17.26	10.74	7453	4637	1123
NEXT 24 E	96.00	24.00	13.75	969	51906	14.97	9.03	5748	3467	1009
NEXT 40 D	96.00	40.00	13.00	1667	238087	25.47	14.53	16381	9349	1736
NEXT 36 D	96.00	36.00	13.25	1562	176727	23.03	12.97	13630	7672	1627
NEXT 32 D	96.00	32.00	13.50	1456	126155	20.57	11.43	11039	6132	1517
NEXT 28 D	96.00	28.00	13.75	1347	85684	18.07	9.93	8626	4743	1403
MAXIMUM WIDTH BEAMS										
NEXT 36 F	143.50	36.00	13.00	1479	185525	23.36	12.64	14678	7942	1541
NEXT 32 F	143.50	32.00	13.25	1374	134258	20.98	11.02	12183	6399	1431
NEXT 28 F	143.50	28.00	13.50	1267	92661	18.57	9.43	9826	4990	1320
NEXT 24 F	143.50	24.00	13.75	1158	60045	16.12	7.88	7620	3725	1206
NEXT 36 E	114.00	36.00	13.00	1361	170830	22.44	13.56	12598	7613	1418
NEXT 32 E	114.00	32.00	13.25	1256	123575	20.14	11.86	10419	6136	1308
NEXT 28 E	114.00	28.00	13.50	1150	85300	17.81	10.19	8371	4789	1198
NEXT 24 E	114.00	24.00	13.75	1041	55322	15.45	8.55	6470	3581	1084
NEXT 40 D	120.00	40.00	13.00	1859	258217	26.55	13.45	19204	9724	1936
NEXT 36 D	120.00	36.00	13.25	1754	191497	24.02	11.99	15978	7974	1827
NEXT 32 D	120.00	32.00	13.50	1648	136539	21.44	10.56	12926	6369	1717
NEXT 28 D	120.00	28.00	13.75	1539	92622	18.80	9.20	10072	4926	1603

BEAM·LONGEST·NEFF

NEXT E Beam - Typical Bridge Sections

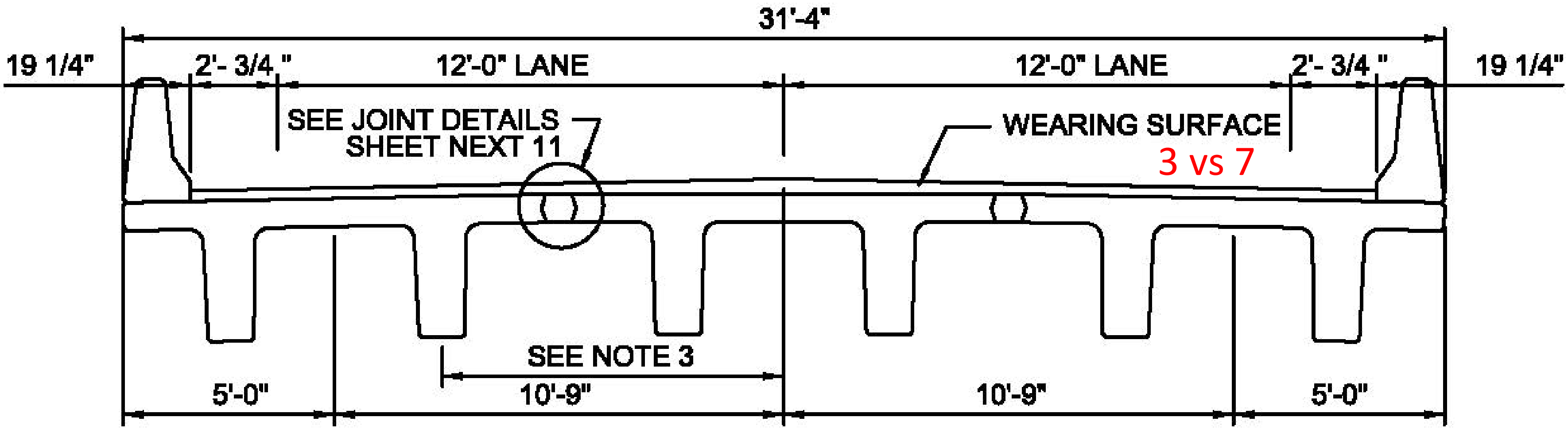


NEXT E BEAMS - MAXIMUM WIDTH BEAMS

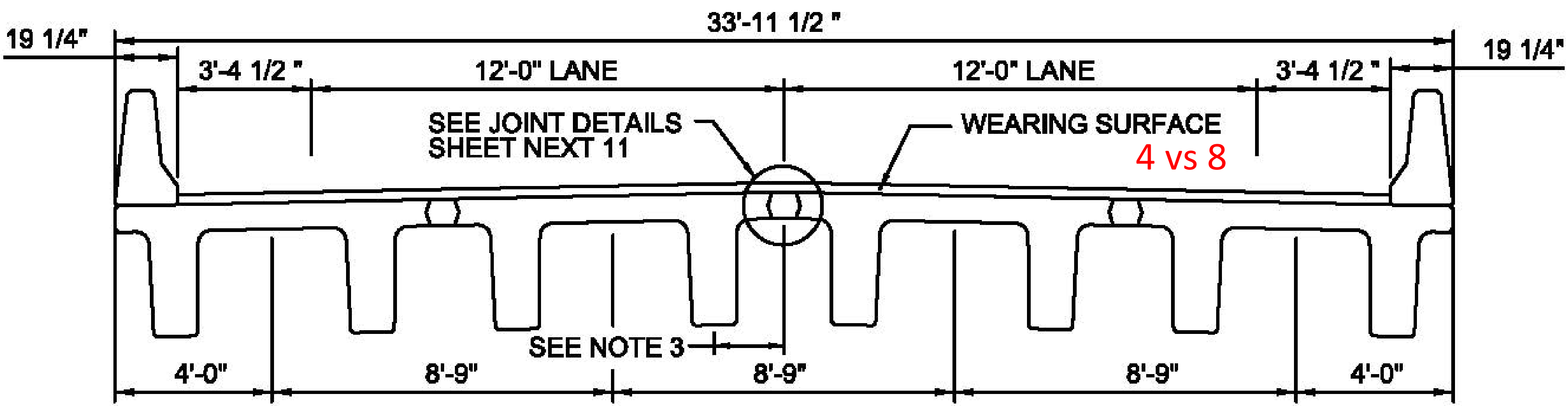


NEXT E BEAMS - MINIMUM WIDTH BEAMS

NEXT D Beam - Typical Bridge Sections



NEXT D BEAMS - MAXIMUM WIDTH BEAMS



NEXT D BEAMS - MINIMUM WIDTH BEAMS

NEXT Beam Span Length Examples

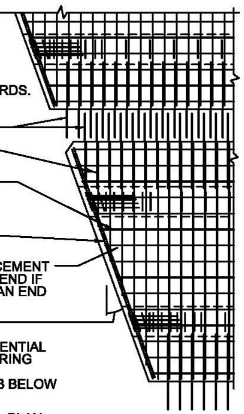
Max Span Length Notes:

- Designs for Cross Sections on previous slides
- AASHTO LRFD 7th Edition
- Barriers at 457 plf and evenly distributed to all beams
- Assumes 3” asphalt wearing surface
- Composite Concrete Strength 4 ksi
- Simply supported beams
- AASHTO Span/Depth Ratios not considered
- Service Limit State Controlled

APPROXIMATE MAXIMUM SPAN LENGTHS				
BEAM TYPE	NOMINAL BEAM WIDTH (FEET)	MAXIMUM SAN LENGTH IN FEET (NUMBER OF STRAND)		
		f'c = 6 ksi	f'c = 8 ksi	f'c = 10 ksi
36F	8	63(32)	81(50)	82(50)
32F	8	58(30)	73(46)	77(50)
28F	8	50(26)	65(42)	71(50)
24F	8	44(24)	56(36)	64(50)
36F	12	54(30)	70(48)	72(50)
32F	12	49(28)	63(44)	68(50)
28F	12	44(26)	56(40)	63(50)
24F	12	37(22)	48(36)	57(50)
36E	8	55(30)	73(48)	75(50)
32E	8	50(28)	65(44)	70(50)
28E	8	42(24)	56(38)	64(50) [1]
24E	8	36(22)	48(34)	58(50) [1]
36E	9.5	52(30)	69(48)	72(50)
32E	9.5	45(26)	61(42)	67(50)
28E	9.5	40(24)	53(38)	61(50) [1]
24E	9.5	34(22)	46(34)	54(48) [1]
40D	8	68(36)	84(50)	86(50)
36D	8	60(32)	79(50) [1]	81(50)
32D	8	52(28)	72(48) [1]	75(50) [1]
28D	8	44(24)	61(42) [1]	68(50) [1]
40D	10	64(36)	79(50)	80(50)
36D	10	56(32)	74(50)	75(50)
32D	10	48(28)	67(48) [1]	70(50) [1]
28D	10	42(26)	57(42) [1]	63(50) [1]

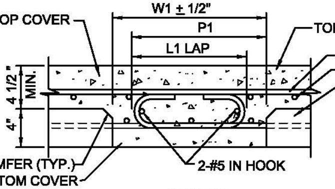
NEXT E Beam – Deck Details

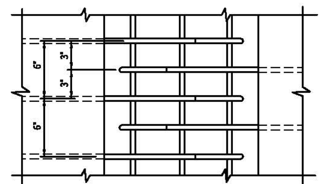
NOTES:
1. DESIGNERS SHOULD CONSULT WITH SEVERAL FABRICATORS FOR LONG SPAN SKEWED BEAMS REGARDING POTENTIAL SHIPPING LIMITATIONS.
2. ACUTE CORNER OVERHANGS MAY REQUIRE SPECIAL DETAILING THAT IS CONSISTENT WITH STATE STANDARDS.



NEXT E BEAM - MAIN DECK REINFORCING DETAILS
SKEWED BEAM ENDS

T = RECOMMENDED TOLERANCE = 0.5" (SEE NOTE 9)
W1 = SPECIFIED JOINT WIDTH, MINIMUM=L1+T+1.5
P1 = HOOK BAR PROJECTION FROM PANEL EDGE = 0.5(W1+L1)+T
L1 = AASHTO HOOK DEVELOPMENT LENGTH (ARTICLE 5.10.8.2.4)

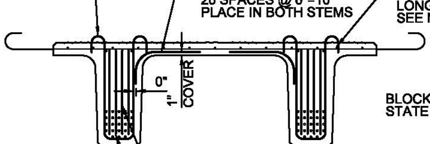




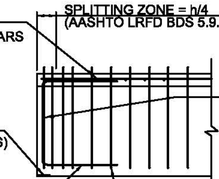
SAMPLE DESIGNS
FOR f'c = 4KSI
#4 DECK BARS W1 = 11 1/2" P1 = 11" L1 = 9 1/2"
#5 DECK BARS W1 = 13 1/2" P1 = 13" L1 = 11 1/2"
FOR f'c = 5KSI
#4 DECK BARS W1 = 10 1/2" P1 = 10" L1 = 8 1/2"
#5 DECK BARS W1 = 12 1/2" P1 = 12" L1 = 10 1/2"

FLANGE CONNECTOR NOTES:
1. CONNECTOR REINFORCING TO BE PLACED ALONG THE ENTIRE SPAN WITH 6" SPACING.
2. FOR SKEWED BRIDGES, PLACE CONNECTOR REINFORCING PERPENDICULAR TO BEAM EDGE. BEND CONNECTOR REINFORCING WITHIN THE FLANGE IN ACUTE CORNERS TO PRODUCE A SQUARE PROJECTION.
3. METHOD OF FORMING CLOSURE POUR TO BE DETERMINED BY THE CONTRACTOR. THE FORMS NEEDS TO BE REMOVABLE AND ABLE TO ACCOMMODATE DIFFERENTIAL CAMBER. FORM SUPPORTS SHOULD NOT PENETRATE THROUGH TOP OF POUR UNLESS APPROVED BY THE ENGINEER. GALVANIZED OR STAINLESS STEEL INSERTS CAST INTO THE UNDERSIDE OF THE BEAM MAY BE USED WITH PERMISSION OF THE OWNER.
4. DESIGNERS ARE RESPONSIBLE FOR THE VERIFICATION OF THE DESIGN OF THIS JOINT. THE BASIS OF THE DESIGN IS THAT THE MINIMUM DEVELOPMENT LENGTH AS SPECIFIED IN AASHTO FOR HOOKED BARS IS EQUIVALENT TO A TENSION LAP SPLICE.
5. THE DIMENSION SHOWN IS APPLICABLE TO A DESIGN WITH THE PARAMETERS LISTED.
6. #4 BARS ARE REQUIRED TO PROVIDE THE MINIMUM CONCRETE COVER SHOWN. IF LARGER BARS ARE USED, A THICKER TOPPING POUR MAY BE REQUIRED IN ORDER TO ACCOMMODATE THE HOOK DIMENSIONS.

NEXT E BEAM - FLANGE CONNECTION DETAILS

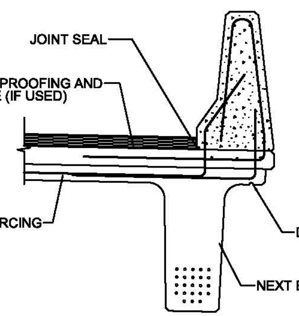


NOTE: h = TOTAL HEIGHT OF MEMBER



NEXT E BEAM - END REINFORCING DETAILS

NOTES:
1. THE BARS SHOWN ARE APPROXIMATELY THE MAXIMUM NUMBER THAT CAN BE FIT WITHIN THE NEXT 24 BEAM. SOME OR ALL OF THESE ADDITIONAL END VERTICAL BARS MAY NOT BE NECESSARY DEPENDING ON THE DESIGN.
2. THE AMOUNT OF SPLITTING REINFORCING MAY BE REDUCED BY DEBONDING STRAND IN THIS AREA. ADDITIONAL SPLITTING REINFORCING SHOULD BE PLACED IN AREAS WHERE DEBONDING IS TERMINATED.
3. PLACE 2-#4 BARS AT THE BEAM END TO CONTROL TOP FLANGE END CRACKING DURING RELEASE AND HANDLING. THE MOST COMMON FORM OF POTENTIAL CRACKING IN THIS AREA IS A SERIES OF VERTICAL HAIRLINE CRACKS THROUGH THE INSIDE RADIUS OF THE TOP FLANGE / BEAM STEM INTERFACE RUNNING PARALLEL TO THE STEM. #5 J BARS AND BOTTOM DECK REINFORCING BARS ARE USED TO SUPPLEMENT THIS REINFORCING. THE TWO J SHAPED BARS SHOWN MAY BE COMBINED INTO ONE INVERTED U SHAPED BAR. THE USE OF A SEMI-INTEGRAL BACKWALL THAT IS CAST IN THE SHOP AS A SECONDARY POUR CAN HELP TO PREVENT THE GROWTH OF THESE CRACKS DURING SHIPPING AND ERECTION. THIS IS RECOMMENDED IF THE SKEW LIMIT IS TO BE EXCEEDED.
4. SPLAY STIRRUPS IN ENDS OF STEM. SEE DETAIL SHEET NEXT 08 FOR THE LAYOUT OF STIRRUPS (SIMILAR TO NEXT F BEAMS).
5. THE DESIGNER SHALL DETAIL ADDITIONAL TOP LONGITUDINAL REINFORCING IN THE TOP FLANGE AT BEAM ENDS IF THE TOP FIBER STRESSES EXCEED 200 PSI (NOTE THAT SOME BRIDGE OWNERS HAVE DIFFERENT STRESS LIMITS IN THIS PORTION OF THE BEAM). THESE BARS ARE USED TO CONTROL TRANSVERSE CRACKING IN THE TOP FLANGE AT RELEASE. THIS REINFORCING SHALL BE DESIGNED IN ACCORDANCE WITH THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (ARTICLE 5.9.2.3.1b). THIS REINFORCING IS FOR CRACK WIDTH AND LENGTH CONTROL, NOT PREVENTION. IF FULLY TENSIONED TOP STRAND ARE INCLUDED IN THE DESIGN, IT IS RECOMMENDED THAT THEY NOT BE USED TO MEET THESE AASHTO PROVISIONS.



NEXT E BEAM - RAILING OPTIONS

NOTES:
1. THIS DETAIL IS SCHEMATIC. ACTUAL DETAIL WOULD NEED TO BE FULLY DESIGNED.
2. MASSDOT CONCRETE BARRIER SHOWN, OTHER BARRIERS SIMILAR.
3. THIS DETAIL CAN BE MODIFIED FOR ANY TYPICAL BARRIER SHAPE INCLUDING RAILINGS WITH CONCRETE CURBS.
4. ALL REINFORCING IN BEAM AND DECK POUR NOT SHOWN.

ISSUE DATE: 01/22/2021	BASIS: AASHTO LRFD BRIDGE DESIGN SPEC. 9th EDTION	SHEET NEXT 10
NEXT E BEAM - DECK DETAILS		

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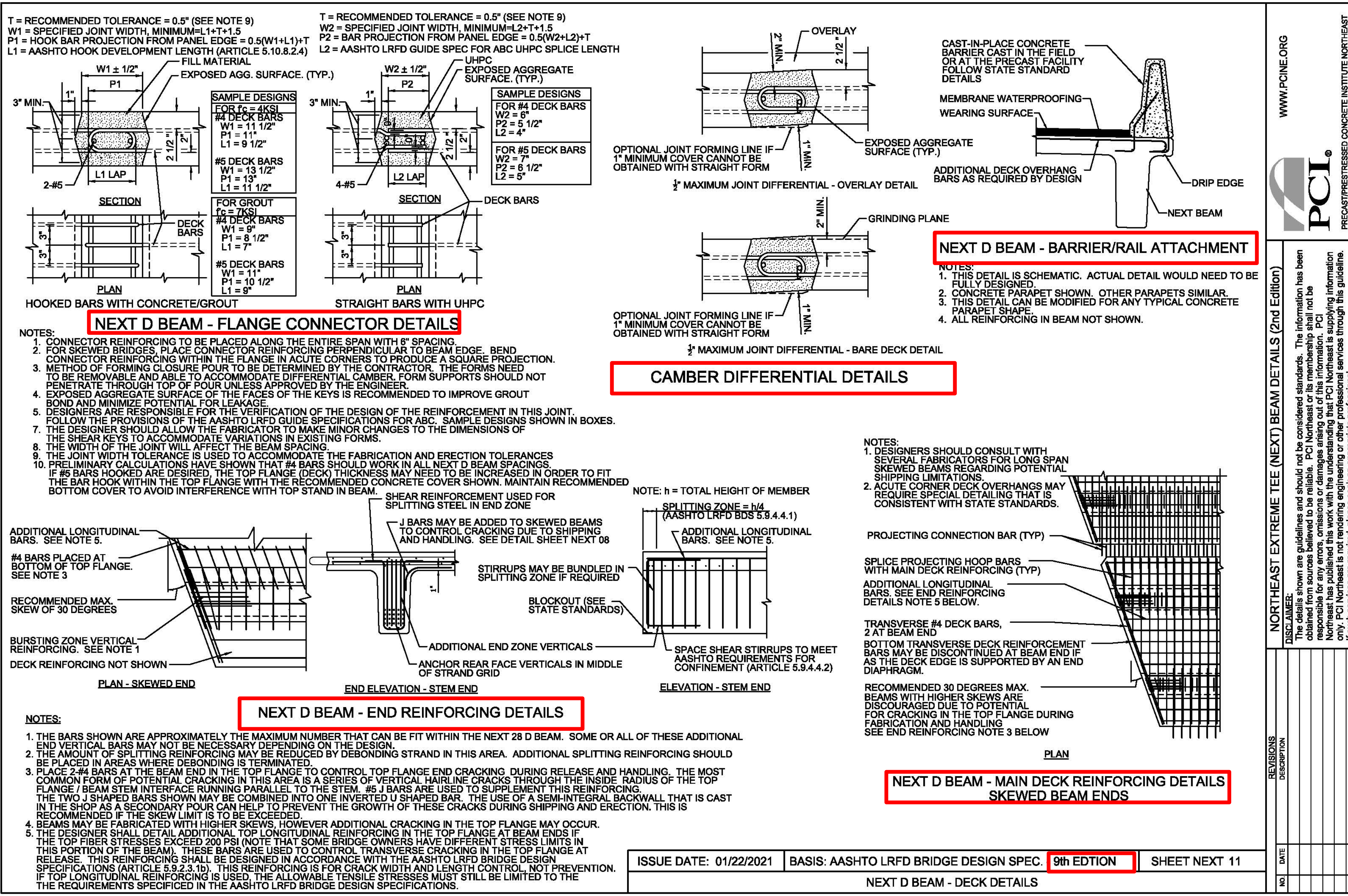
PCI PRECAST/PRESTRESSED CONCRETE INSTITUTE NORTHEAST

NORTHEAST EXTREME TEE (NEXT) BEAM DETAILS (2nd Edition)

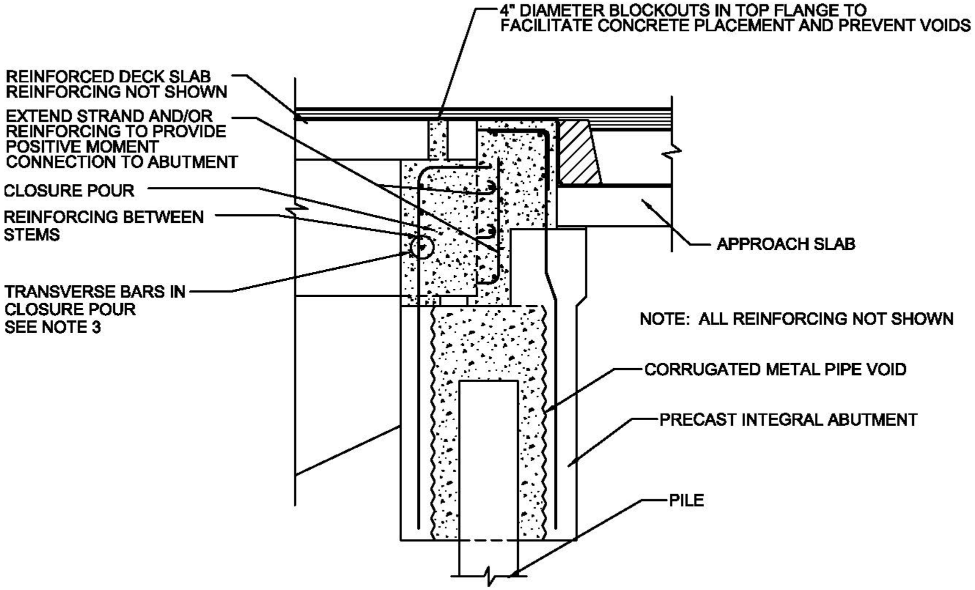
REVISIONS

NO.	DATE	DESCRIPTION

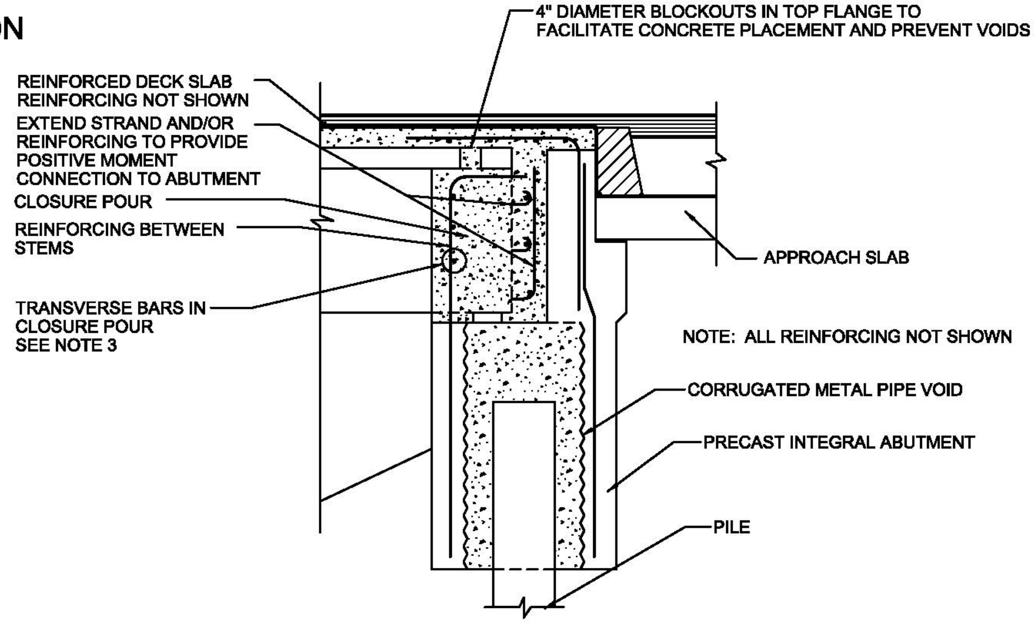
NEXT D Beam – Deck Details



NEXT Beam Details

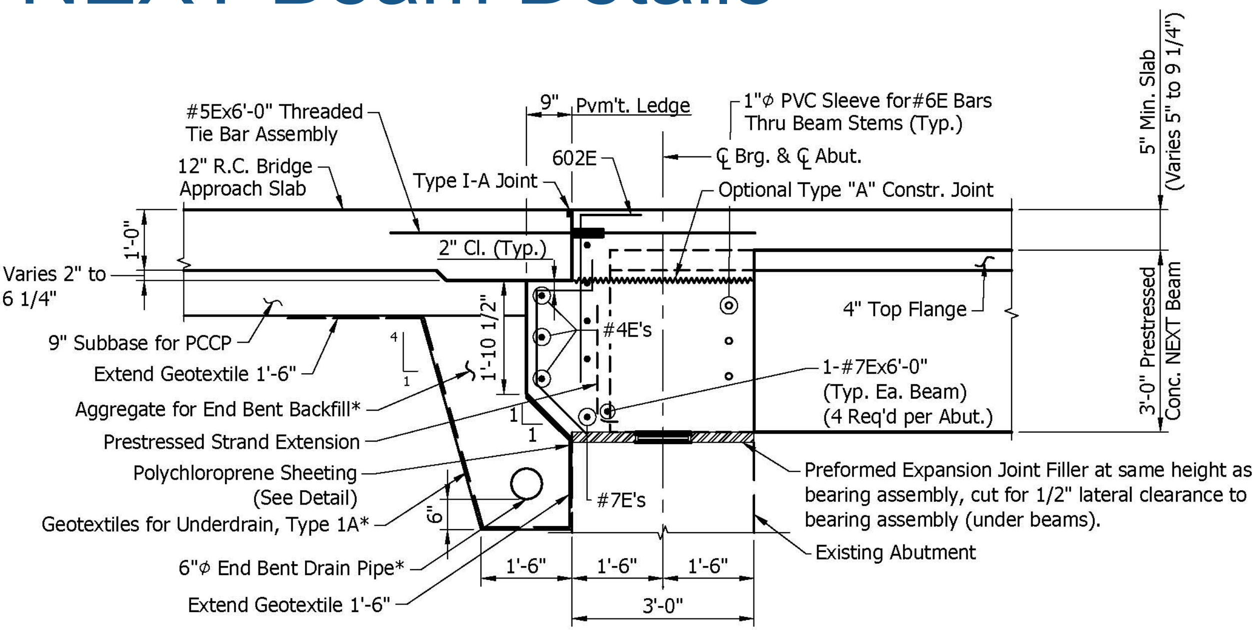


NEXT D - SAMPLE INTEGRAL ABUTMENT SECTION

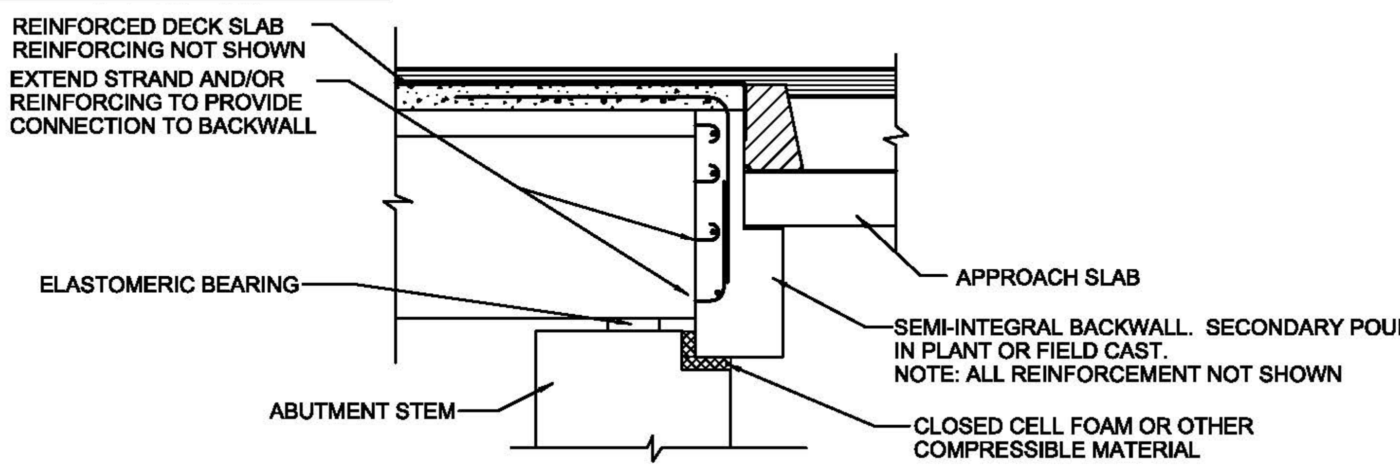


NEXT E - SAMPLE INTEGRAL ABUTMENT SECTION

NEXT Beam Details



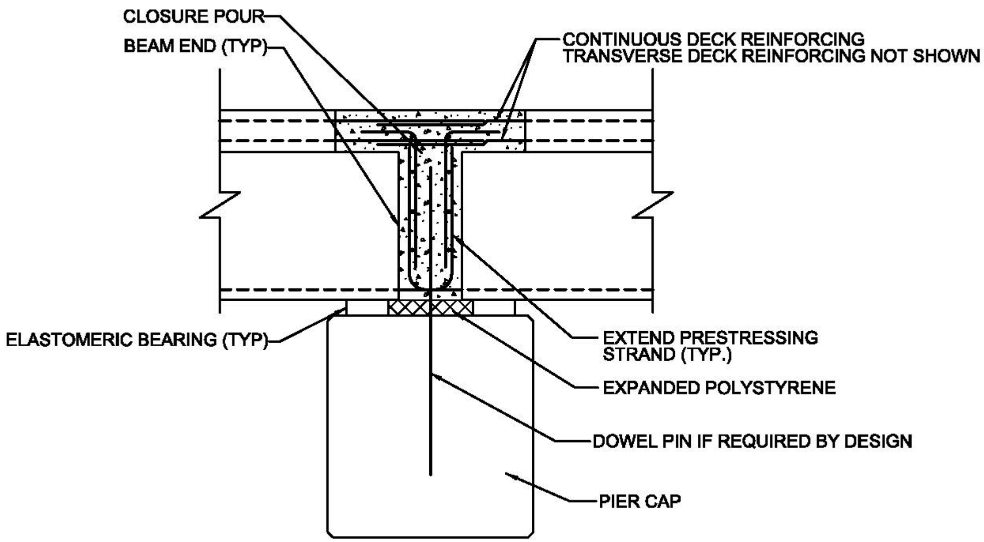
SECTION D-D (AT BEAM STEM)



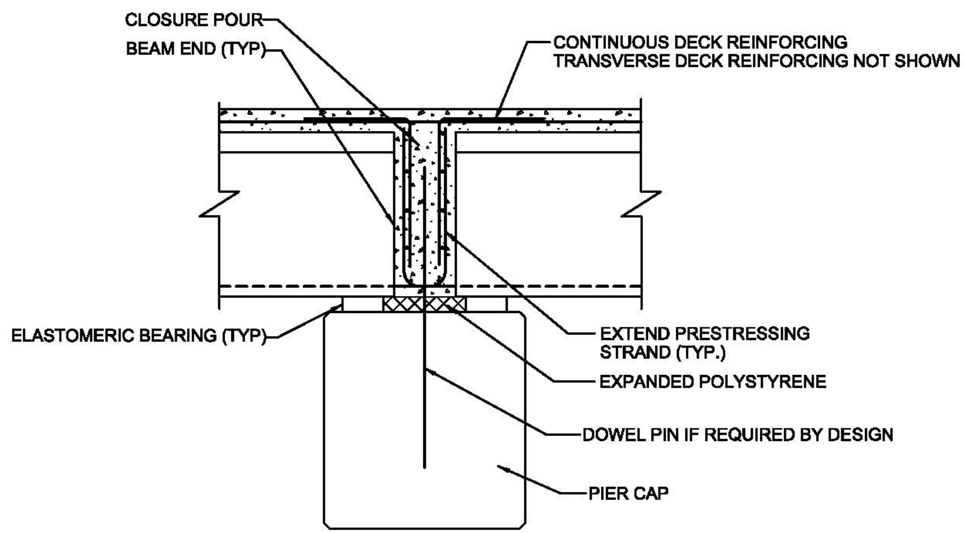
NEXT E - SAMPLE SEMI-INTEGRAL ABUTMENT SECTION

NOTES:
1. THESE DETAILS ARE BASED ON MASSACHUSETTS DEPARTMENT OF TRANSPORTATION STANDARDS FOR TYPE 2 APPROACH SLABS. DETAILS FOR OTHER STATES WILL VARY.

NEXT Beam Details



NEXT D - SAMPLE PIER CONTINUITY DETAIL



NEXT E - SAMPLE PIER CONTINUITY DETAIL

Additional information available at www.pcine.org

PCI Precast/Prestressed Concrete Institute

Northeast Extreme Tee (NEXT) Beam

Technical Resources » Bridge » NEXT Beams

The NEXT Beam was developed by the PCI Northeast Bridge Technical Committee made up of state bridge engineers, consultants and precast manufactures from all six New England states and New York.

The NEXT Beam is designed to be labor-efficient in both the manufacturing plant and on the job site. During fabrication, the absence of draped (harped) strands is a significant advantage. The elimination of deck forming in the field saves significant time during construction while also providing an instant work platform, resulting in a much safer project. NEXT beam bridges are a cost-effective structure which has reduced the overall cost of bridge construction in the Northeast.

Northeast Extreme Tee (NEXT) Beam Guide Details

(Adobe PDF File)

Updated 01/2021 (2nd Ed.) - These guidelines are for NEXT "F", "D" and "E" beams. The guide includes section properties and design details.

History of Significant Changes made to the PCI Northeast NEXT Beam Typical Guide Details

(Adobe PDF File)

Updated 01/2021 (2nd Ed.)

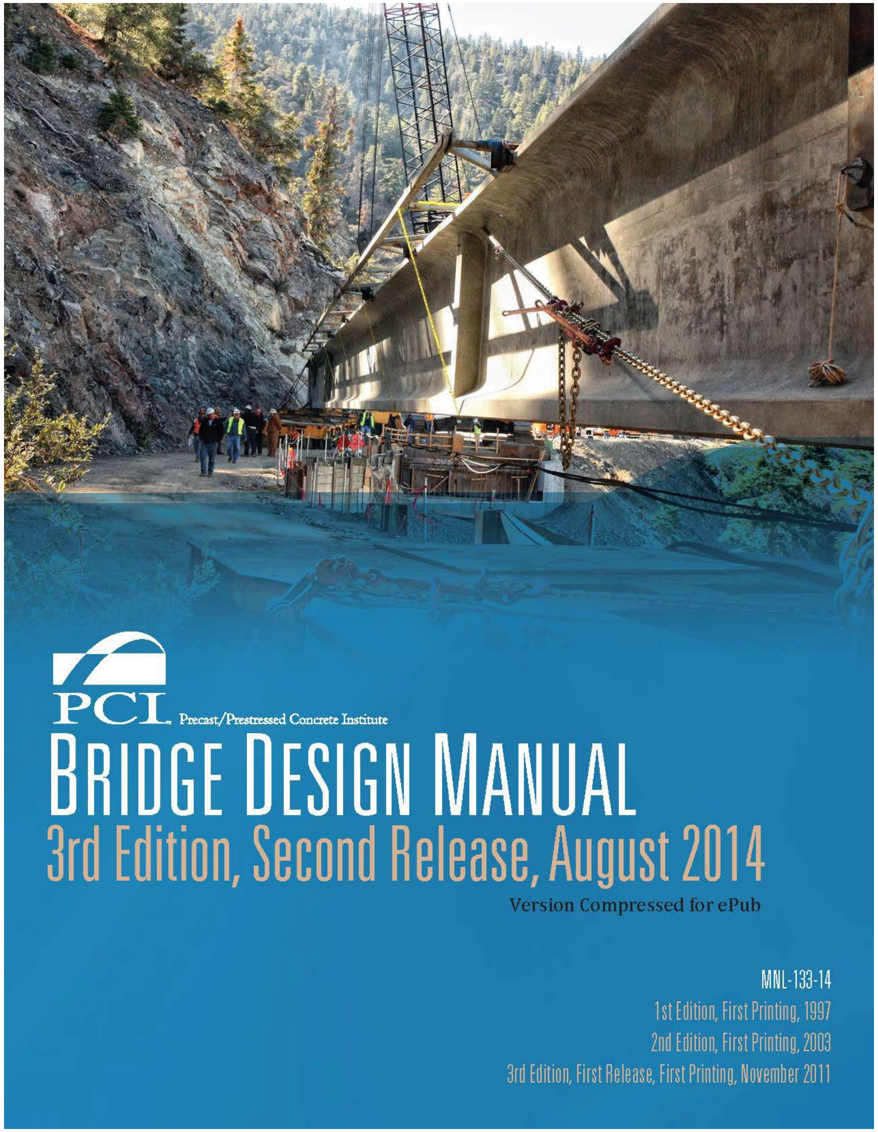
NEXT Beam Frequently Asked Questions

(Adobe PDF File)

PCI BRIDGE DESIGN MANUAL

Chapter 6 – Preliminary Design
- 6.9 Prelim. Design Charts
  - NEXT Type D Beams
  - NEXT Type F Beams
- 6.10 Prelim. Design Data
  - NEXT Type D Beams
  - NEXT Type F Beams

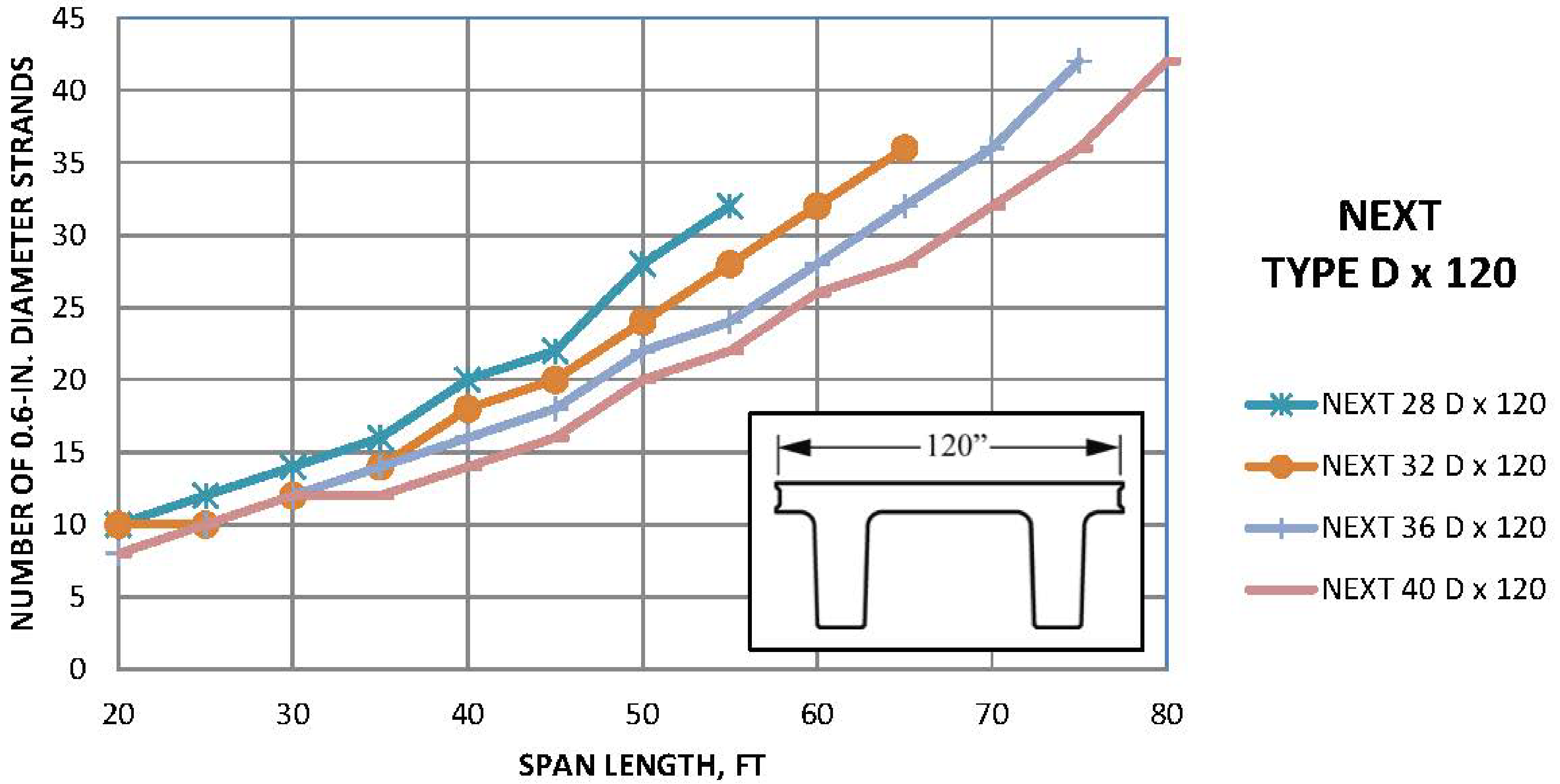
Chapter 9 – Design Examples
- Example 9.7
  - NEXT Type 36 D
  - Single Span
  - Non-Composite Deck
- Example 9.8
  - NEXT Type 36 F
  - Single Span
  - Composite Deck



PCI BRIDGE DESIGN MANUAL

- Preliminary Design Figures

Chart NEXT-3
NEXT Type D x 120 Beams



PCI BRIDGE DESIGN MANUAL

- Preliminary Design Tables

Table NEXT-2
NEXT Beam Type D x 96

Spacing ft	Span ft	Slab Thickness in.	f'_{ci} ksi	No. of Strands	Final Camber in.++	f_b @ $L/2$ ksi	f_t @ $L/2$ ksi	M_u @ $L/2$ ft-kips	M_r @ $L/2$ ft-kips	Control
NEXT Beam 28 D x 8-ft-Wide Exterior Beam										
8	20	0	0.509*	6	-0.01	-0.169	0.386	357	362	Stress
8	30	0	1.601*	10	0.13	-0.046	0.515	672	869	Strength
8	40	0	2.034*	12	0.11	-0.386	0.817	1,061	1,086	Stress
8	50	0	3.473	18	0.50	-0.371	1.102	1,570	1,720	Stress
8	60	0	5.185	26	1.22	-0.327	1.458	2,164	2,467	Stress
8	70	0	6.680	34	1.80	-0.503	1.939	2,831	3,114	Stress
NEXT Beam 28 D x 8-ft-Wide Interior Beam										
8	20	0	1.102*	8	0.05	-0.056	0.436	524	591	Strength
8	30	0	2.120*	12	0.24	-0.060	0.647	922	1,086	Strength
8	40	0	3.056	16	0.52	-0.226	0.951	1,395	1,511	Strength
8	50	0	4.407	22	1.09	-0.372	1.343	2,020	2,109	Stress
8	60	0	6.031	30	2.00	-0.499	1.815	2,742	2,815	Stress

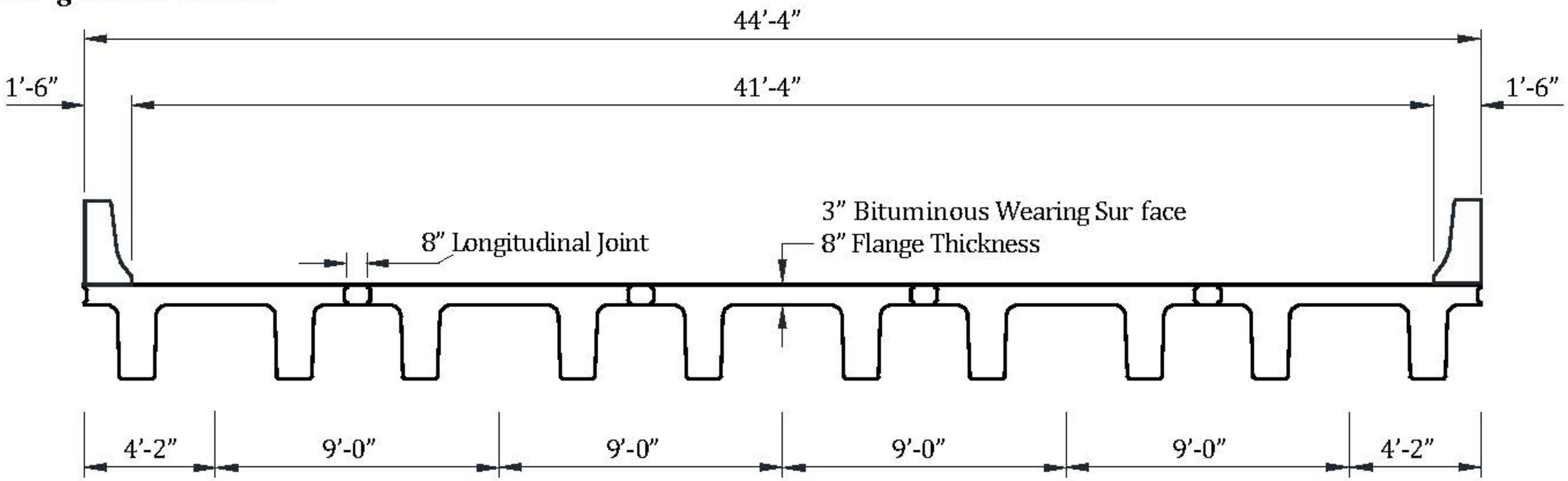
PCI BRIDGE DESIGN MANUAL

9.7 Transformed Sections, Shear General Procedure, Refined Losses

9.7.1 INTRODUCTION

This design example demonstrates the design of an 80-ft, single span, PCI Northeast Extreme double-tee deck bridge with no skew. This example illustrates in detail the design of a typical interior beam at the critical sections in positive flexure, shear, and deflection due to prestress, dead loads, and live loads. The superstructure consists of five beams spaced at 9 ft 0 in. centers, as shown in **Figure 9.7.1-1**. A 3-in.-thick bituminous surfacing will be placed on the beams as a wearing surface. Beams are transversely post-tensioned through the flange of the beams. Design live load is HL-93. The design is accomplished in accordance with *AASHTO LRFD Bridge Design Specifications*, Fifth Edition, 2010, and the 2011 Interim Revisions. Elastic stresses from external loads are calculated using transformed sections. Shear strength is calculated using the general procedure. Time-dependent prestress losses are calculated using the refined estimates.

Figure 9.7.1-1
Bridge Cross Section



NEXT Beam Questions

NEXT Beam Frequently Asked Questions

General Questions

1. **Is the NEXT Beam Proprietary?**
   The NEXT Beam is a regional standard that was developed by the northeast state departments of transportation, consultants, and fabricators. Similar to other standard bridge sections, it is available from multiple fabricators and it is not proprietary.
2. **Who supplies the NEXT Beam?**
   The NEXT Beam is produced by many PCI Certified precast producers. Contact your local PCI Regional Association or local producer.
3. **Is the NEXT Beam acceptable to bridge owner agencies?**
   Yes. The NEXT Beam was developed by a consortium of state bridge engineers from all six New England states and New York and members of the Northeast region of PCI. In addition, many other DOT bridge offices in the United States are using the beam.
4. **Is the NEXT Beam more economical than other bridge systems?**
   The NEXT Beam is efficiently designed to minimize labor in both the manufacturing plant and at the job site. The lack of draped (harped) strands is a significant benefit during fabrication. The elimination of deck forming in the field saves significant time during construction, and also provides an instant platform for work, making for a much safer project. NEXT beam bridges are a cost-effective structure and have reduced the overall cost of building bridges in the Northeast.
5. **What is the difference between the D, E and F Beam?**
   - The ***D Beam (Deck Beam)*** is a beam with an integral full-depth flange that acts as the structural bridge deck. This allows the bridge to be ready for traffic soon after the beams are erected.
   - The ***F Beam (Flange Beam)*** is a beam with a partial-depth flange, which serves as the formwork for a conventional cast-in-place reinforced concrete deck. This results in a monolithic deck surface at the expense of a few extra days of site construction. The top flange of the F Beam eliminates the need for deck forming (including the overhang), which is a tremendous time saver.
   - The ***E Beam (Deck/Flange Beam)*** is a beam that has a top flange that is intended to act as the bottom portion of the structural deck. A reinforced cast-in-place concrete topping is used to complete the structural deck, which will reduce the amount of CIP deck concrete in the field from approximately 8" to 4". The top flange of the NEXT Beam eliminates the need for deck forming (including the overhang),
6. **How do I handle utilities on my bridge?**
   One of the main reasons the NEXT beam was developed was to handle multiple utilities, unlike the box beam, which can only accommodate a few. Utility supports can be coordinated with the Manufacturer and be cast into the beam at the time of fabrication to expedite installation time out in the field.
7. **Are diaphragms required?**
   Intermediate diaphragms are not required for the NEXT Beams. AASHTO LRFD Bridge Design Specifications require diaphragms at the supports where there is a joint in the deck.
8. **What is the recommended bearing type?**
   NEXT Beams are typically supported on reinforced elastomeric bearing pads. Details have been developed and are found on Detail Sheet NEXT 15 of the guidelines. Bearings that can be adjusted vertically may be beneficial for complex geometries. For example, on a skewed bridge with a vertical curve, the support points are out of plane, creating the need for a variable 4-point support system. The adjustable bearing will solve this problem.

Bridge Geometry Questions

1. **What are the typical span lengths and widths?**
   The NEXT Beam can range from a length of 30' to 80' and a nominal width of 8' to 12' for the NEXT F beams, 8' to 10' for the NEXT D Beams and 8' to 9.5' for NEXT E. These span ranges are approximate since they are based on certain design parameters such as parapet weight and overlay options. Actual span capabilities should be checked for each situation based on the actual design parameters. Please consult the attached Detail Sheets.
2. **Can NEXT Beam be used for a skewed bridge?**
   Yes. PCI Northeast recommends a maximum skew for each beam type (AASHTO skew convention) but it may be possible to exceed this value (the largest skew built has been 45 degrees). The concern is with regard to cracking at release in the fabrication plant. Experience with double tee beams has shown the potential for longitudinal cracking in the top flange near the interior stem surfaces. Additional reinforcement has been placed in this region; however, the potential for the development of these cracks is still present and larger skews would mean longer cracks in the end zone. Skewed NEXT D beams general have less cracking than NEXT F or E beams due to the 8" flange and two layers of flange reinforcement. Skewed beams may require special bearing details. See General Question Number 8.
3. **Can the NEXT Beam be used for a curved bridge?**
   The widths of the NEXT Beams can be adjusted readily in fabrication to accommodate gentle curves. The flanges of the exterior NEXT Beams can be curved (in plan) to produce a curved roadway geometry, provided that the flanges fall within the design envelope shown on Detail Sheet NEXT 01.
4. **Can the NEXT Beam be used for a variable width bridge?**
   The widths of the NEXT Beams can be adjusted readily in fabrication to accommodate roadways that are tapered in plan. The flange width of the NEXT Beams can be tapered, creating a slightly 'pie shaped' beam that would be used for splayed layouts.
5. **How do you accommodate roadway profiles with a cambered NEXT Beam?**
   The accommodation of roadway profiles with a cambered NEXT beam can be handled in several ways. The thickness of the deck topping concrete on NEXT E and F Beam bridges can be varied. The thickness of the top flange on Next D Beams can be varied; however, this comes at a higher cost due to the need for more complex forming in the fabrication plant. Another option is to vary the thickness of the overlay (if allowed by state standards) to provide the desired profile. See Profile Details on Detail Sheets NEXT 03 through 05.
6. **How do you accommodate roadway cross slopes and crowns?**
   The beams can be set to match the roadway cross slope. This is not normally done with prestressed I-Beams due to issues with stability. The large lateral stiffness of the NEXT Beam allows for this approach, which greatly simplifies the installation. Roadway crowns can be accommodated at the joints between the beams, or within the topping or overlay. See Detail Sheet NEXT 08.
7. **Is it possible to design NEXT Beam that is narrower than the 8-foot minimum?**
   The 8-foot minimum was set to provide relatively equal stem spacing (within 2 feet), to provide room for inspection access of the stems between the beams, and to avoid impacting the curved fillet on the underside of the top flange. A minor reduction from this minimum can be used with permission from the owner.
8. **Is it possible to design half section single tee using the NEXT Beam Form?**
   It is possible to use a half section for cases where a specific bridge width is required or for bridges were staged construction does not permit full width sections.
9. **Is it possible to step (dap) the bottom of the stem at the support?**
   This should only be done for special situations where the height of the bridge seat must be raised (i.e. low clearance straddle bent). Special care should be exercised in the design to prevent cracking in this critical area. The PCI Design Handbook contains a recommended design procedure for this situation.

Also: Design Questions, Deck and Wearing Surface Questions and Railing Questions

NEXT Beam General Notes

DESIGN AND IMPLEMENTATION GUIDELINES

IT IS THE DESIGNER'S RESPONSIBILITY TO:

1. DESIGN THE BEAM ACCORDING TO THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (9TH ED.) AND THE REQUIREMENTS OF THE OWNER, INCLUDING:
   - NUMBER OF STRAIGHT STRAND AND LAYOUT
   - CHECK DECK REINFORCING IN THE TOP FLANGE AND THE CLOSURE POURS ACCORDING TO THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS. USE THE SAME METHODS AS CAST-IN-PLACE DECKS ASSUMING THAT THE BEAM WEB IS A BEAM LINE.
   - SIZE AND SPACING OF SHEAR REINFORCING
   - BEAM END REINFORCING
   - DECK OVERHANG AND BARRIER REINFORCING
2. CREATE SPECIAL BEAM END DETAILS AS NEEDED, SUCH AS VARYING GEOMETRIC END TREATMENTS, EXTENSIONS OF PRESTRESSING STRAND FOR BEAM ENDS FOR CONTINUITY OF LIVE LOAD, SPECIAL DETAILS FOR INTEGRAL ABUTMENTS, ETC.
3. SPECIFY THE REQUIRED CONCRETE STRENGTHS:
   - RELEASE STRENGTH
   - FINAL STRENGTH
   - STRENGTH OF CONCRETE IN CLOSURE POURS
   - SPEED OF SET
4. CALCULATE CAMBERS AND NOTE THEM ON THE PLANS AT THE FOLLOWING INTERVALS:
   - AT RELEASE
   - 30 DAYS (OR ASSUMED DATE OF INSTALLATION)
   - FINAL
5. INCLUDE THE FOLLOWING NOTE ON THE PLANS:
   THE DESIGN OF SHIPPING AND HANDLING METHODS FOR NEXT BEAMS IS THE RESPONSIBILITY OF THE FABRICATOR. NEXT BEAMS (PARTICULARLY NEXT F AND E BEAMS) ARE SENSITIVE TO LONGITUDINAL TOP FLANGE CRACKING CAUSED BY TWISTING DURING SHIPPING AND HANDLING. THE FABRICATOR SHOULD DEVELOP METHODS THAT MINIMIZE TWISTING OF THE BEAMS. THE SAME LIFTING METHODS SHOULD BE EMPLOYED FOR THE ERECTION OF THE BEAMS AT THE BRIDGE SITE.

GENERAL NOTES

THE BASIS FOR THESE GUIDE DETAILS IS THE AASHTO LRFD BRIDGE DESIG SPECIFICATIONS (9TH EDITION) AND THE AASHTO LRFD GUIDE SPECIFICATIONS FOR ACCELERATED BRIDGE CONSTRUCTION (1ST EDITION).

REINFORCING STEEL: fy = 60,000 PSI (COATING AS PER AGENCY STANDARDS)

PRESTRESSING STRAND: LOW RELAXATION STRAND, 0.6" DIAMETER, AASHTO M 203 GRADE 270

A ½" CONCRETE GRINDING ALLOWANCE FOR CORRECTING UNEVEN ROADWAY SURFACES AT LONGITUDINAL JOINTS MAY BE USED. TO ACCOUNT FOR THIS IN DESIGN, ASSUME LOSS OF ½" OF TOP FLANGE IN THE SECTION PROPERTIES, HOWEVER INCLUDE FULL DECK THICKNESS FOR BEAM WEIGHT.

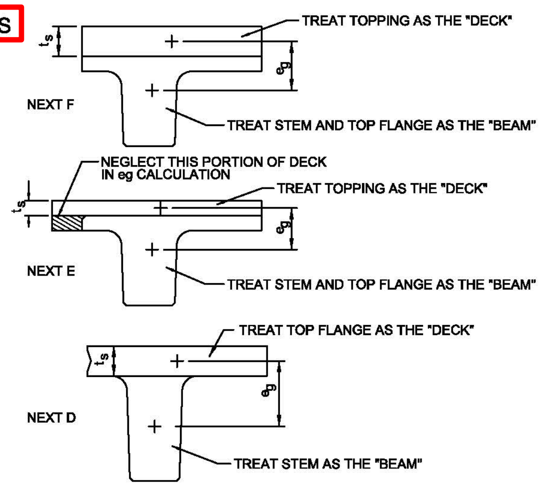
DECK OVERLAYS COMBINED WITH WATERPROOFING MEMBRANES ARE RECOMMENDED FOR THE FOLLOWING REASONS:
- ELIMINATES THE NEED FOR DECK GRINDING
- ACCOUNTS FOR TOP FLANGE DIFFERENTIAL
- PROVIDES ADDITIONAL DECK PROTECTION

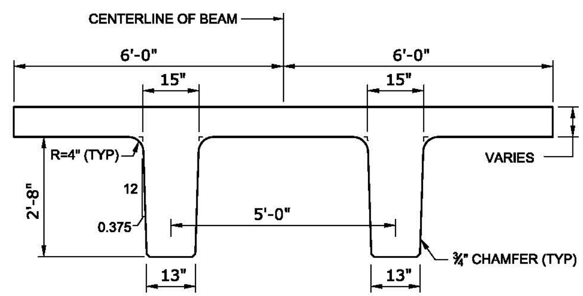
INDEX OF DETAIL SHEETS

LIVE LOAD DISTRIBUTION FACTOR CALCULATIONS

NEXT F AND E BEAMS:
- USE AASHTO CROSS SECTION K (ARTICLE 4.6.2.2.1)
- TREAT EACH STEM AS AN INDIVIDUAL STRINGER (HALF OF TOTAL BEAM SECTION PROPERTIES USED FOR CALCULATION OF I AND A)
- SEE ADJACENT DETAIL FOR CALCULATION OF e_g AND t_s
- USE THE AVERAGE STEM SPACING FOR THE BEAM SPACING TERM IN THE EQUATIONS
- CALCULATE THE DISTRIBUTION FACTORS FOR EACH STEM USING THE TABLES IN ARTICLE 4.6.2.2.2.
- THE APPLICATION OF THE LEVER RULE FOR EXTERIOR STEMS SHALL APPLY
- COMBINE (ADD) THE TWO DISTRIBUTION FACTORS FOR EACH STEM TOGETHER
- APPLY THE COMBINED DISTRIBUTION FACTOR FOR THE DESIGN OF THE ENTIRE NEXT F BEAM

NEXT D BEAMS:
- USE AASHTO CROSS SECTION I (ARTICLE 4.6.2.2.1) ASSUMING THAT THE DECK IS SUFFICIENTLY CONNECTED TO ACT AS A UNIT
- TREAT EACH STEM AS AN INDIVIDUAL STRINGER (HALF OF TOTAL BEAM SECTION PROPERTIES USED FOR CALCULATION OF I AND A)
- ASSUME THAT THE STEM PORTION OF THE BEAM IS THE STRINGER (UP TO THE UNDERSIDE OF THE TOP FLANGE)
- ASSUME THAT THE FLANGE PORTION OF THE BEAM IS THE COMPOSITE DECK (BOTTOM OF TOP FLANGE TO THE TOP OF THE DECK)
- SEE ADJACENT DETAIL FOR CALCULATION OF e_g AND t_s
- USE THE AVERAGE STEM SPACING FOR THE BEAM SPACING TERM IN THE EQUATIONS
- CALCULATE THE DISTRIBUTION FACTORS FOR EACH STEM USING THE TABLES IN ARTICLE 4.6.2.2.2.
- THE APPLICATION OF THE LEVER RULE FOR EXTERIOR STEMS SHALL APPLY
- COMBINE (ADD) THE TWO DISTRIBUTION FACTORS FOR EACH STEM TOGETHER
- APPLY THE COMBINED DISTRIBUTION FACTOR FOR THE DESIGN OF THE ENTIRE NEXT D BEAM





NEXT BEAM DESIGN ENVELOPE

NOTES:
1. THE PURPOSE OF THIS DETAIL IS TO DEFINE THE ENVELOPE THAT CAN BE USED TO DESIGN A NEXT BEAM. THE LOWER PORTION OF THE ENVELOPE DENOTES THE NEXT BEAM FORM THAT CANNOT BE ALTERED.
2. THE VARIABLE WIDTH OF NEXT BEAM IS ACCOMMODATED WITH ADJUSTABLE SIDE FORMS ON THE TOP FLANGE FORM. THE WIDTH OF THE TOP FLANGE CAN BE EXCEEDED; HOWEVER, IT IS NOT RECOMMENDED AS IT WILL REQUIRE SPECIAL FORMING IN THE SHOP (CONTACT FABRICATORS IF THIS IS DESIRED).
3. ANY REASONABLE THICKNESS OF TOP FLANGE CAN BE PROVIDED.
4. DEPTH VARIATIONS ACCOMMODATED BY INSERTS IN THE BOTTOM OF THE STEMS, RESULTING IN MINOR VARIATIONS IN THE WIDTH OF THE BOTTOM OF THE BOTTOM OF THE STEM.
5. LIMITATIONS ON WIDTH FOR NEXT E BASED ON MAXIMUM SHIPPING WIDTH OF 12 FEET (INCLUDING PROJECTING REINFORCING STEEL). SEE DETAIL SHEET NEXT 06.
6. LIMITATIONS ON WIDTH FOR NEXT D BASED ON WEIGHT OF THE BEAM AND THE OVERALL SHIPPING WIDTH OF THE BEAM WITH PROJECTING REINFORCING STEEL. SEE DETAIL SHEET NEXT 06.

ISSUE DATE: 01/22/2021	BASIS: AASHTO LRFD BRIDGE DESIGN SPEC. - 9th EDTION	SHEET NEXT 01
	GENERAL NOTES	

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PCI® PRECAST/PRESTRESSED CONCRETE INSTITUTE NORTHEAST

NORTHEAST EXTREME TEE (NEXT) BEAM DETAILS (2nd Edition)

REVISIONS

NO.	DATE	DESCRIPTION

Additional Design Considerations

Estimate Residual Camber Load for Beam Design

Beam Run Checks same as other Prestress Beams

- **Longitudinal Reinforcing** [AASHTO 5.8.3.5]
- **Pretensioned Anchorage Zones** [AASHTO 5.9.4.4]
- **Max. Spacing Transverse Reinf.** [AASHTO 5.7.2.6]
- **Min. Spacing Reinf. Bars** [AASHTO 5.10.3.1.2]
- **Temperature and Shrinkage** [AASHTO 5.10.6]
- **Min. Area of Interface Shear Reinf.** [AASHTO 5.7.4.2]
- **Tensile Stress Limit** [AASHTO 5.9.2.3.1b-1]

Construction Loading Check of Exterior Flange

- **Dead Load (concrete, coping forms and temporary walkway)**
- **Live Load (normal construction live loads and finishing machine)**
- **Checked sections at web to flange interface**

Top Tension Crack Control

General Rule:

Limit the top tension stresses to 0.2 ksi at release.

Limit Skew to 20 degrees.

Some DOT's allow less tension but special details could allow for more

Bridge beams where minor controlled transverse cracking is acceptable.

AASHTO LRFD Bridge Design Specifications, Article 5.9.4.1.2. AASHTO Table 5.9.4.1.2-1

Management of top tension stresses at beam ends:

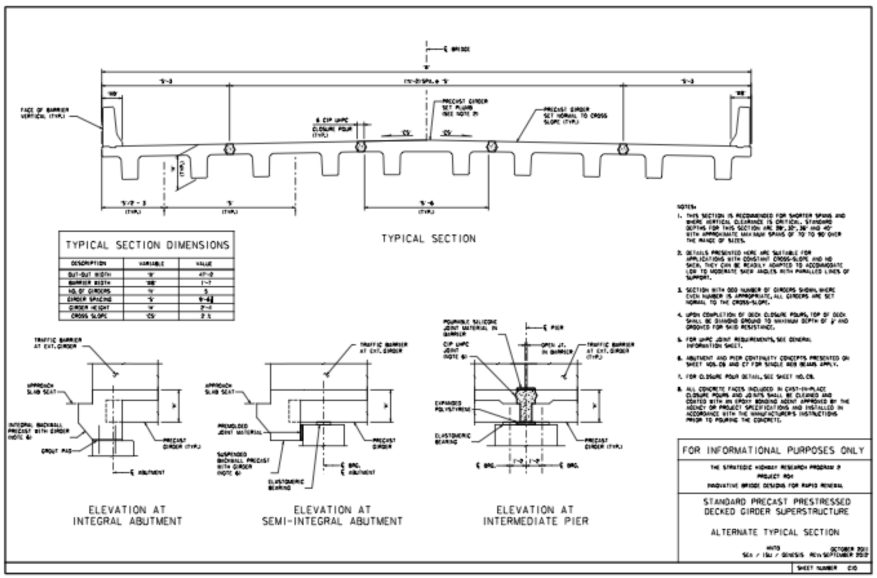
- 25% Debonding
- Bonded top tension reinforcement will not prevent cracks
- Top strands should not be used to fulfill this article
- Spacing of mild reinforcement should be per AASHTO Article 5.7.3.4.

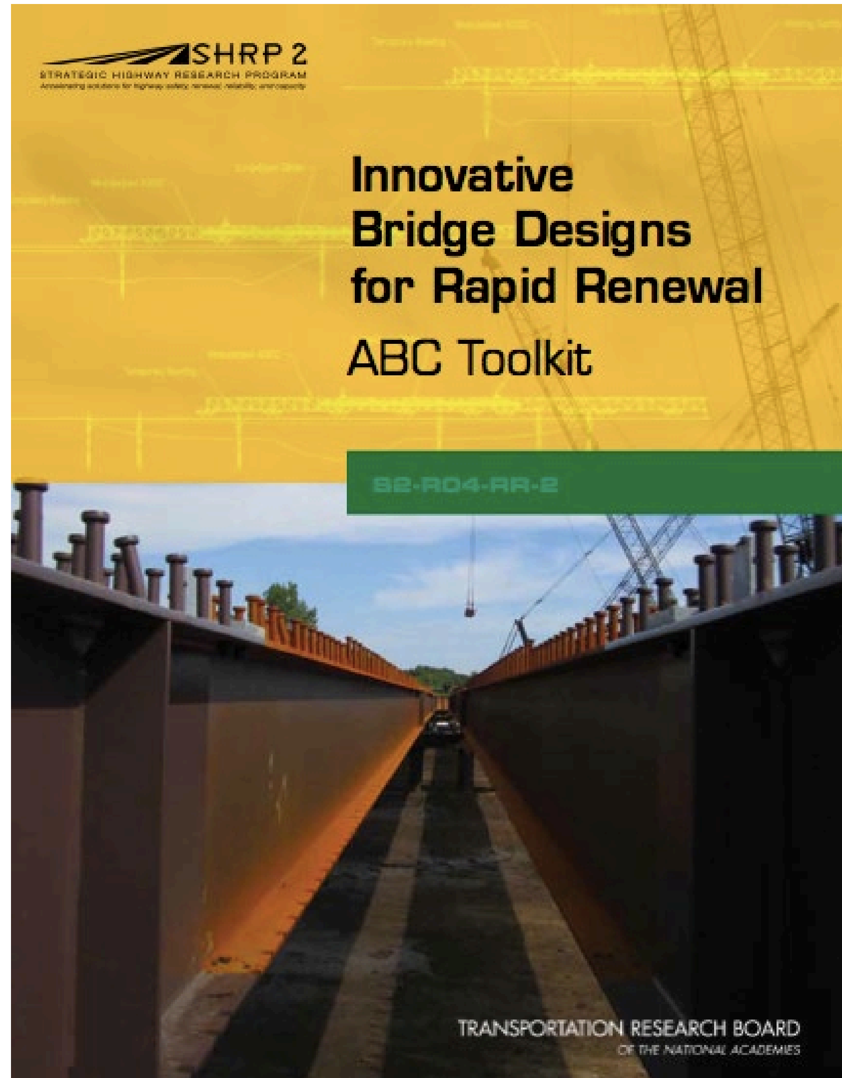
AASHTO LRFD Bridge Design Specifications, Article 5.9.4.1.2.

SHRP2 Research Project

Transportation Research Board Project
SHRP 2 - Innovative Bridge Designs for Rapid Renewal
ABC Toolkit

www.trb.org/main/blurbs/168046.aspx



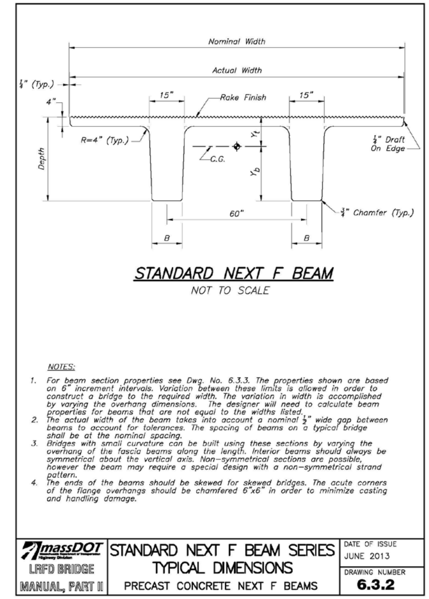


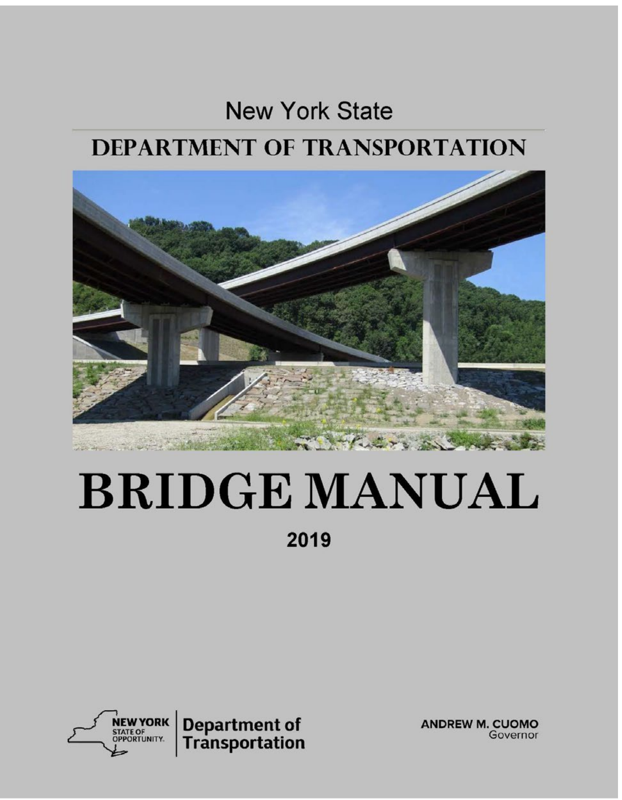
BLN
BEAM·LONGEST·NEFF

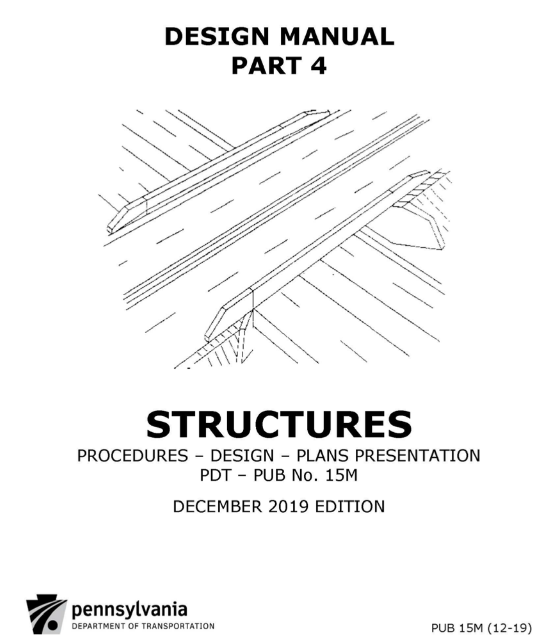
DOT Design Information

Massachusetts, New York and Pennsylvania

- Standard Drawings
- Design Manual Information
- Specifications
- **NYDOT with DGN Files**







NEXT Beam Production

NEXT Beam Production

NEXT Beam Shipping

NEXT Beam Shipping

NEXT Beam Erection

NEXT Beams Erected

Finished NEXT Beam Bridge

South Worthington, MA – Total Precast Built in 60 Days

South Worthington, MA – Total Precast Built in 60 Days

South Worthington, MA – Total Precast Built in 60 Days

South Worthington, MA – Total Precast Built in 60 Days

NEXT Beam Acceptance - States with NEXT Beams

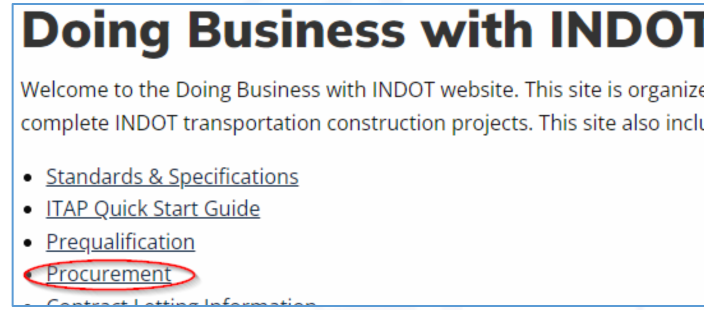
- Massachusetts DOT
- Vermont AOT
- Maine DOT
- Rhode Island DOT
- New Hampshire DOT
- New York State DOT and New York City DOT
- New Jersey DOT
- Delaware DOT
- Pennsylvania DOT
- Virginia DOT
- Connecticut DOT

States with NEXT Beam in Design/Construction:

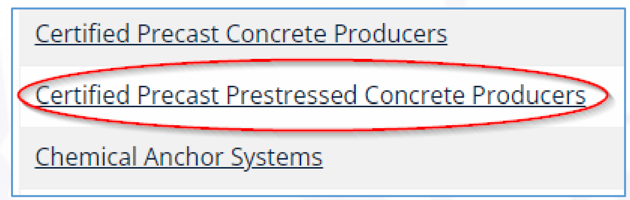
- Indiana DOT

INDOT Pilot Projects

- Beam Procurement
  - INDOT purchased beams for three upcoming construction projects through INDOT Procurement



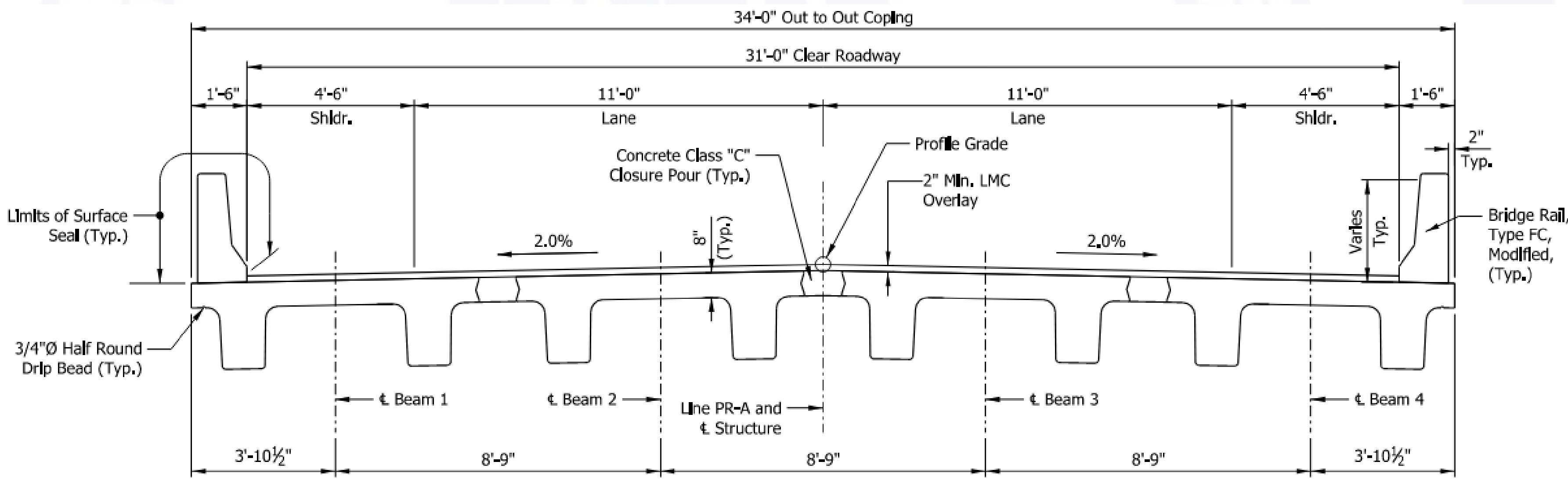
  - Solicited bids from all Certified Precast Prestressed Concrete Producers listed on INDOT's Qualified Source Lists



  - Prestress Service Industries, LLC was issued a purchase order in August 2022

INDOT Pilot Projects

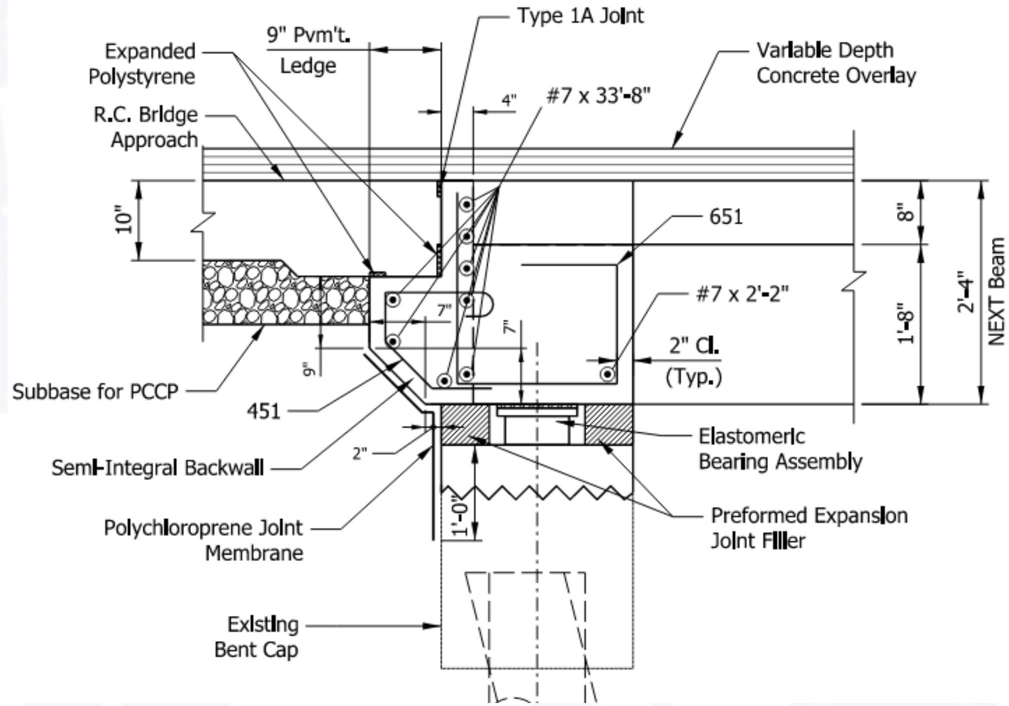
- SR 341 over Dry Run
  - Designer is CHA Consulting, Inc.
  - NEXT 28D Beams
  - 59’-0” Span, 31’-0” Clear Roadway, 0° Skew

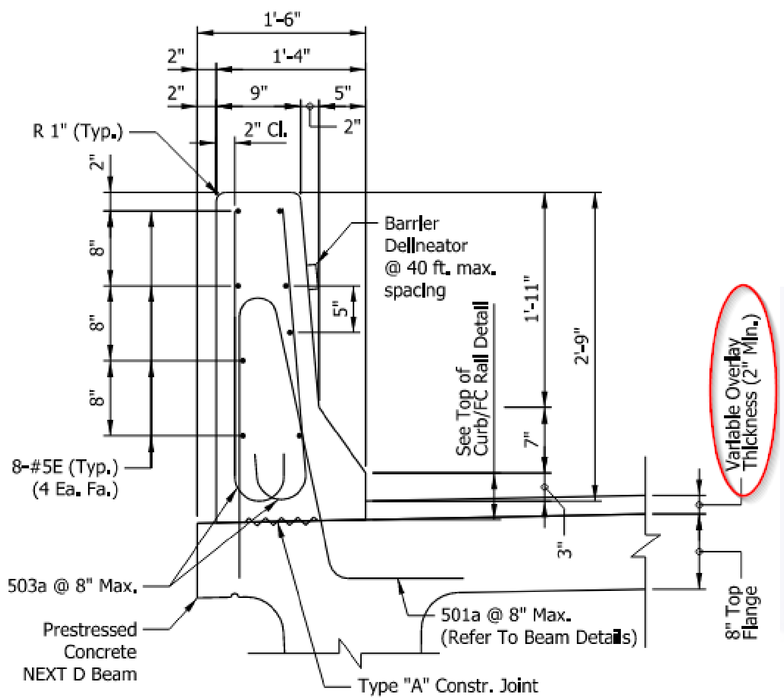


NextLevel INDIANA

INDOT Pilot Projects

- SR 341 over Dry Run
  - Superstructure Replacement
  - Semi-Integral End Bents
  - Variable Depth Concrete Overlay
  - April 12, 2023 Letting

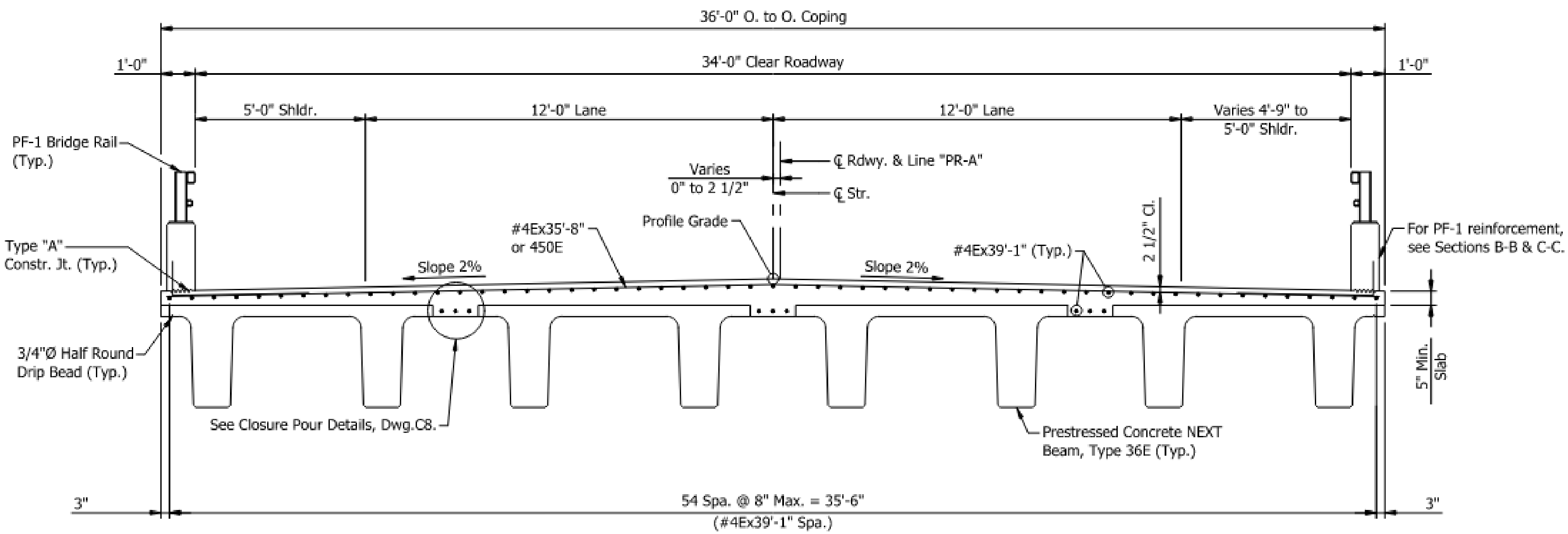




NextLevel INDIANA

INDOT Pilot Projects

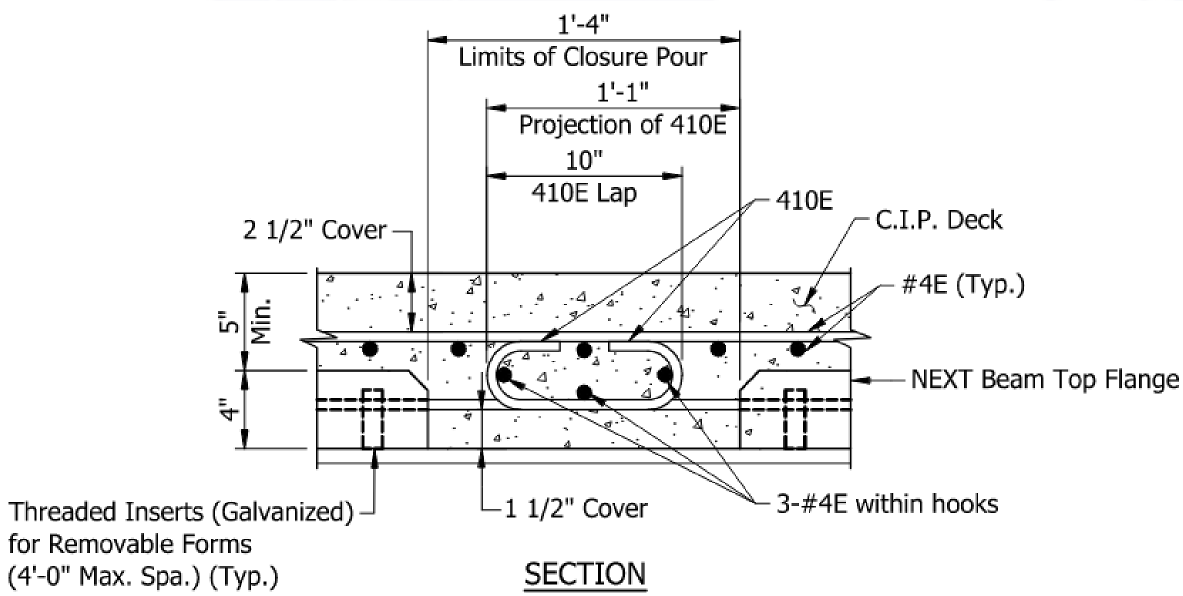
- US 31 over Blue Lick Creek
  - Designer is Beam, Longest and Neff (BLN)
  - NEXT 36E Beams
  - 73’-0” Span, 34’-0” Clear Roadway, 29°33’ Skew



NextLevel INDIANA

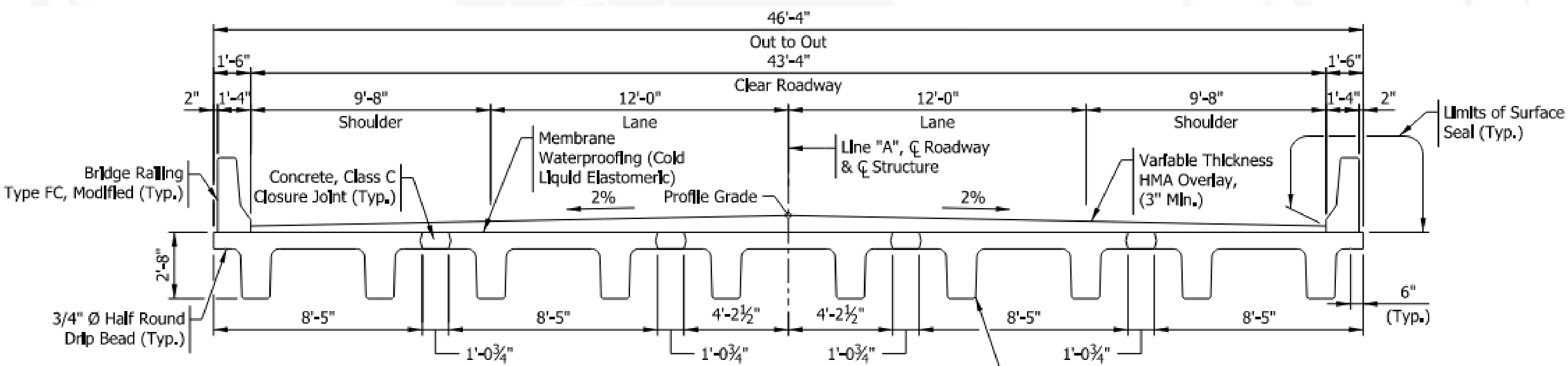
INDOT Pilot Projects

- US 31 over Blue Lick Creek
  - Superstructure Replacement
  - Semi-Integral End Bents
  - Variable Depth Cast-In-Place Deck
  - April 12, 2023 Letting



INDOT Pilot Projects

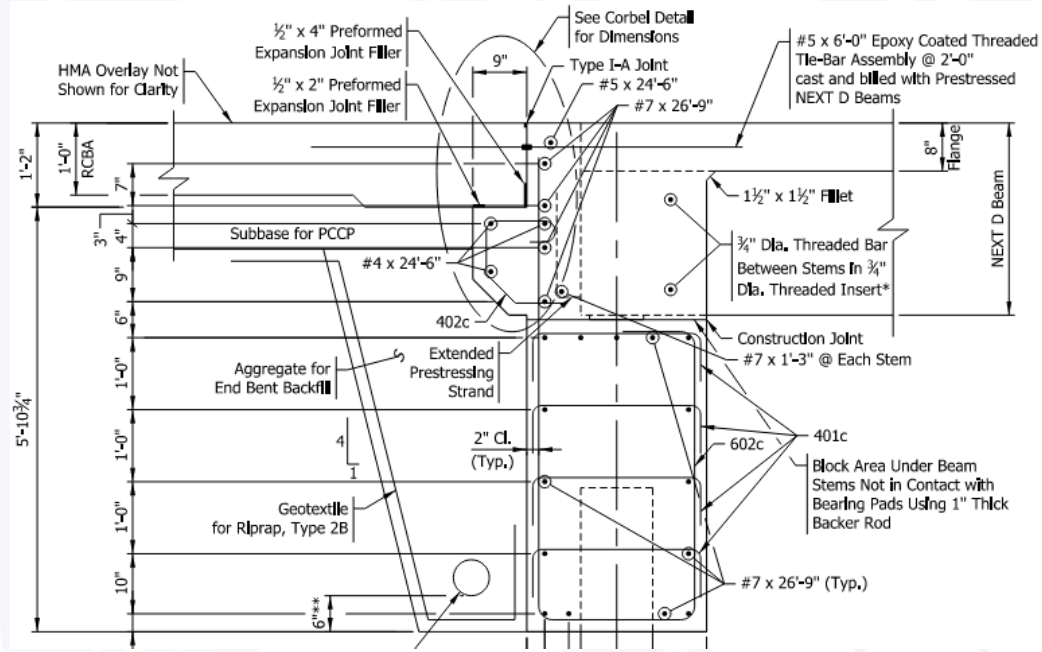
- SR 49 over Ahlgrim Ditch
  - Designer is H.W. Lochner, Inc.
  - NEXT 32D Beams
  - 47’-0” Span, 43’-4” Clear Roadway, 0° Skew

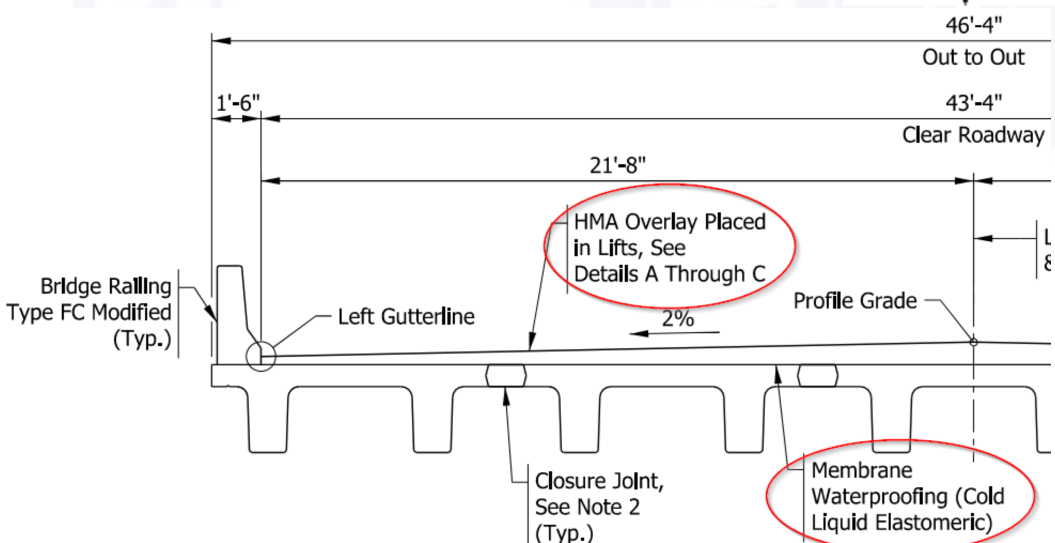


TYPICAL SECTION

INDOT Pilot Projects

- SR 49 over Ahlgrim Ditch
  - Bridge Replacement
  - Integral End Bents
  - Variable Depth HMA Overlay on Spray-Applied Membrane
  - November 15, 2023 Letting





NextLevel INDIANA

INDOT Pilot Projects

- NEXT Beam INDOT Policies & Standards (To-Do List)
  - Indiana Design Manual
    - Typical details refined through pilot projects
    - Chapter 402 – Structure Size and Type
      - 402-5.03 Costs
      - 402-8.02 Superstructure Types
    - Chapter 406 – Prestressed-Concrete Structures
      - 406-12.02 Prestressed-Concrete Member Sections
      - New figures

    - Chapter 409 – Abutment, Bent, Pier, and Bearing
      - 409-2.0 Integral End Bent
      - 409-3.0 Semi-Integral End Bent

PART 4 - STRUCTURAL (BRIDGE DESIGN)

Chapter 402 - Structure Size & Type (Rev. Sep. 2019)

Chapter 403 - Load Analysis & Application (Rev. Feb. 2018)

Chapter 404 - Bridge Deck (Rev. Apr. 2021, Oct. 2022)

Chapter 405 - Reinforced-Concrete Structure (Rev. Oct. 2020, Jun. 2022)

Chapter 406 - Prestressed-Concrete Structure (Rev. Jun. 2021, Sep. 2022)

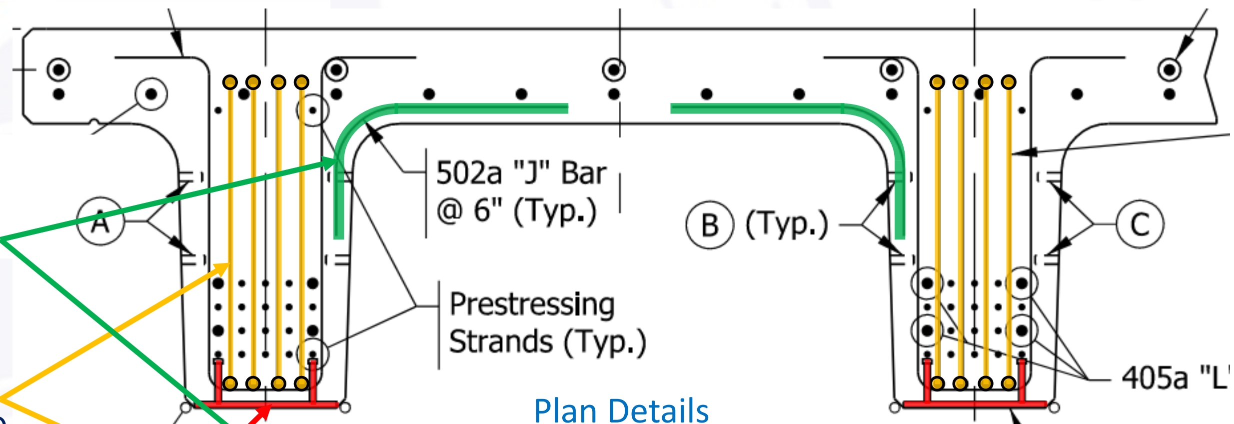
Chapter 407 - Steel Structure (Rev. Apr. 2017)

Chapter 408 - Foundation (Rev. Apr. 2018)

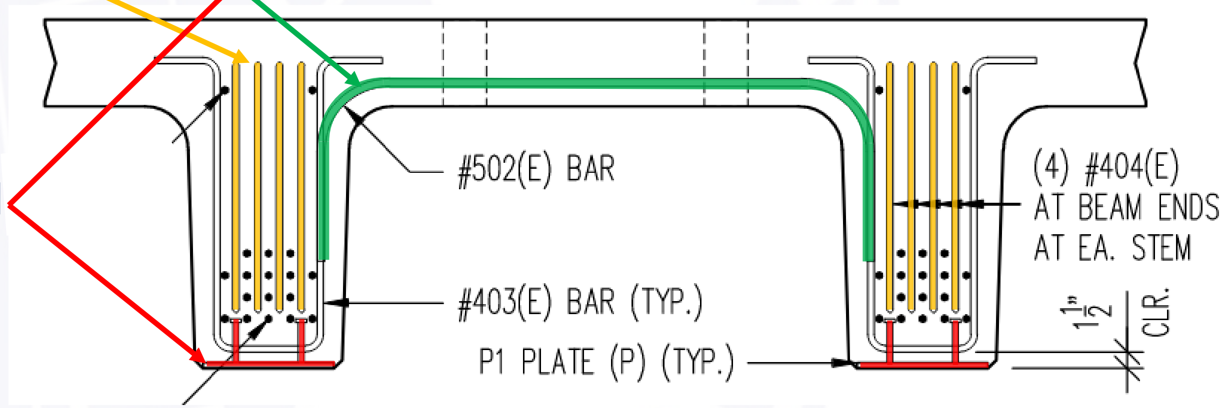
Chapter 409 - Abutment, Bent, Pier, and Bearing (Rev. Apr. 2021)

INDOT Pilot Projects

- Shop Drawing RFI's
  - Combine 2 – 502 bars into a single bar
  - Reduce height of vertical end reinforcement by 2" to avoid congestion
  - Modify embedded plate stud locations to additional clearance



Plan Details

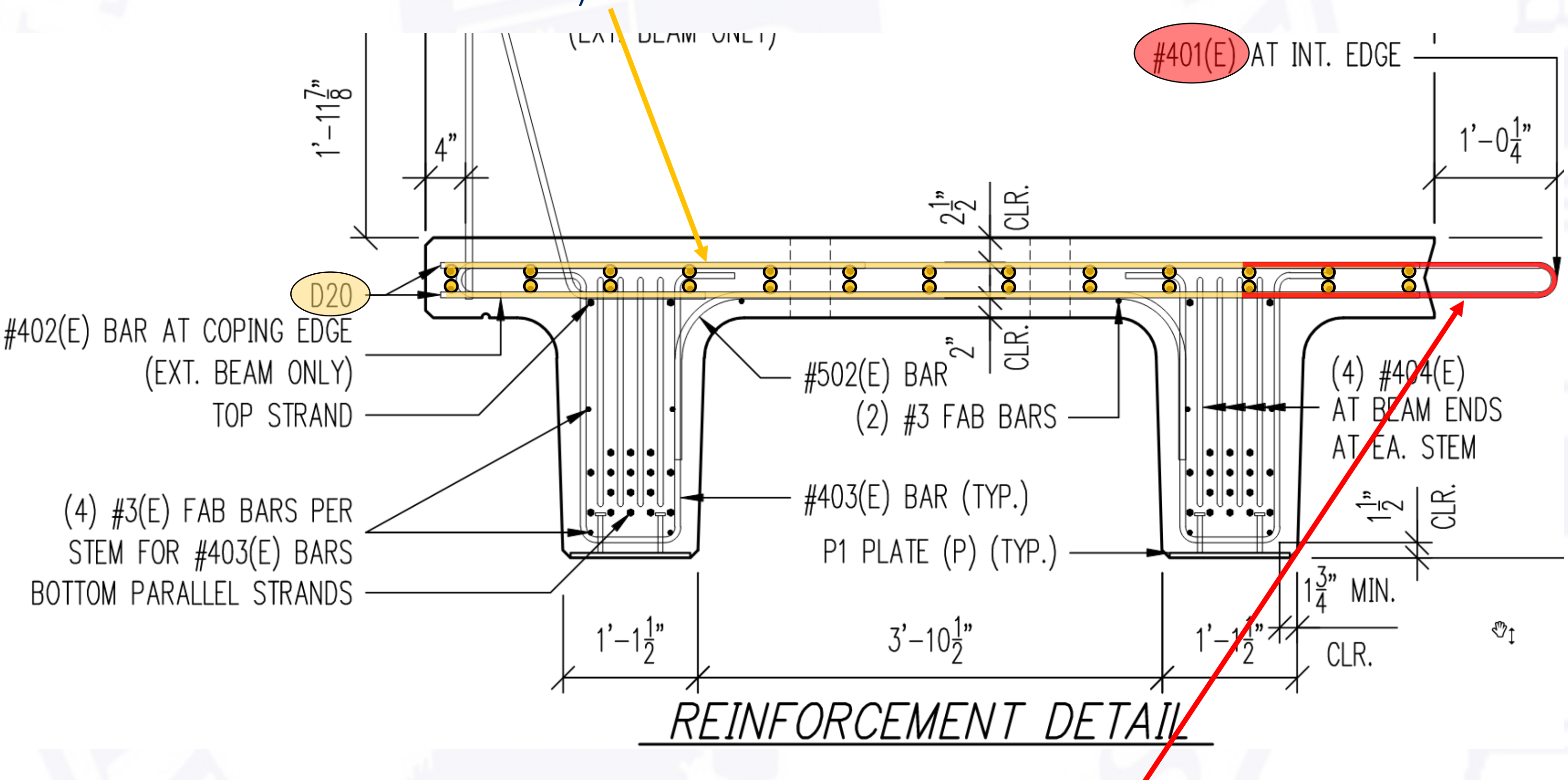


RFI Details

INDOT Pilot Projects

HOT OFF THE PRESS

- Shop Drawing RFI's
  - Utilize WWR in the top slab (Reminder: The IDM now includes details for WWR in prestressed AASHTO and Bulb-Tee beams. Standard Spec Section 737 allows WWR in lieu of conventional reinforcement.)

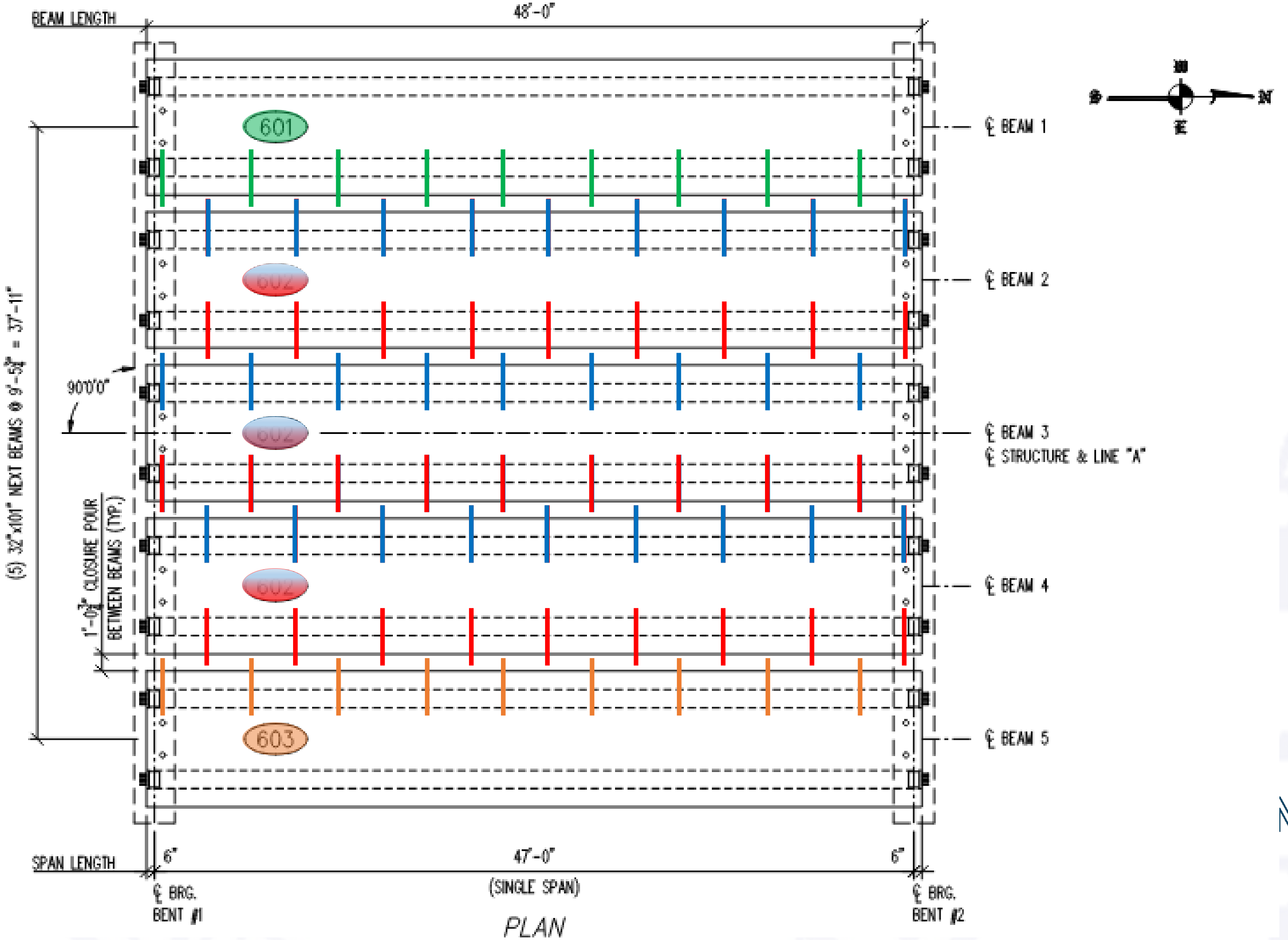


  - Revise the method of staggering closure pour reinforcement

NextLevel INDIANA

INDOT Pilot Projects

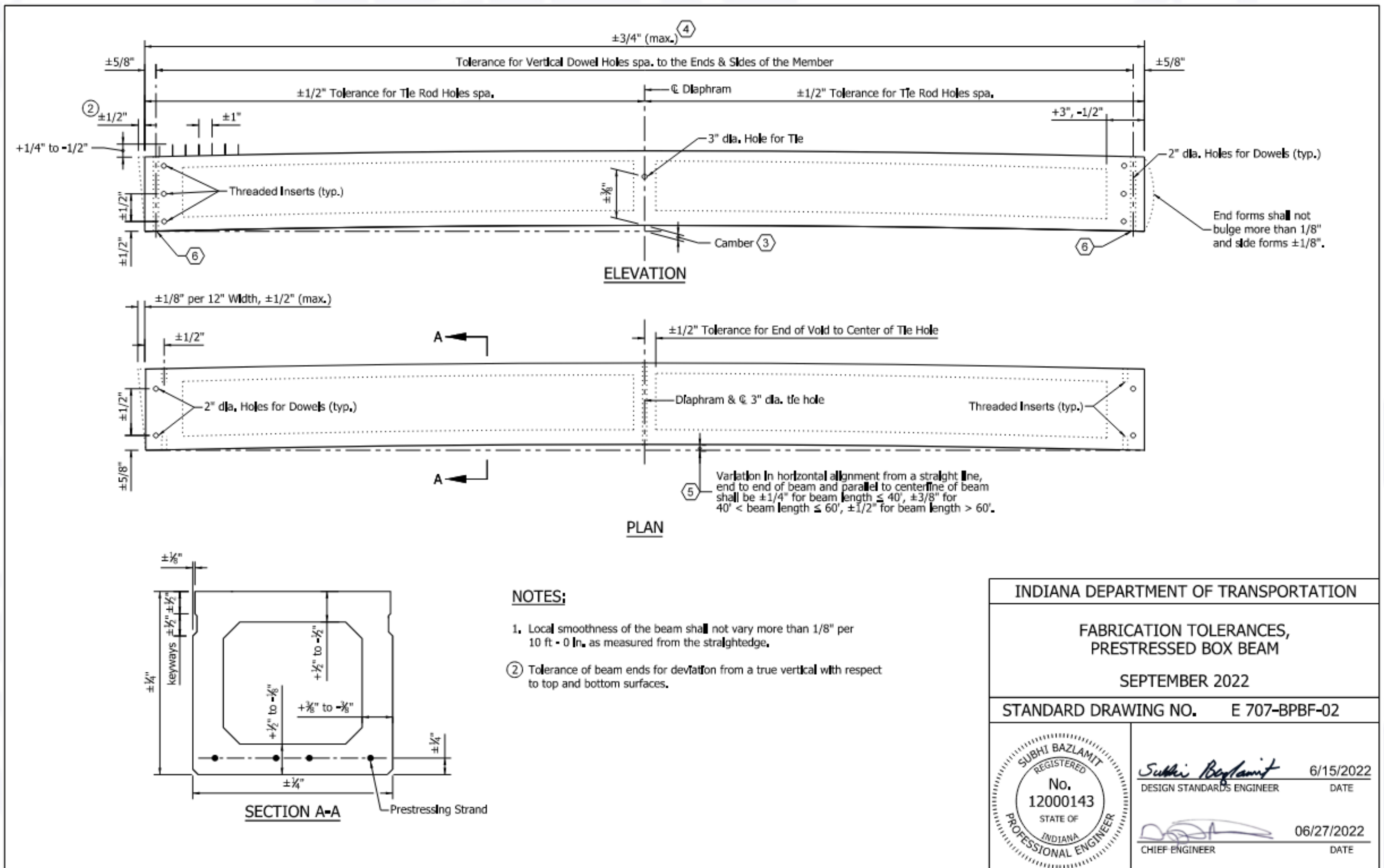
- Shop Drawing RFI's
  - Revise the method of staggering closure pour reinforcement (all int. beams the same)



NextLevel INDIANA

INDOT Pilot Projects

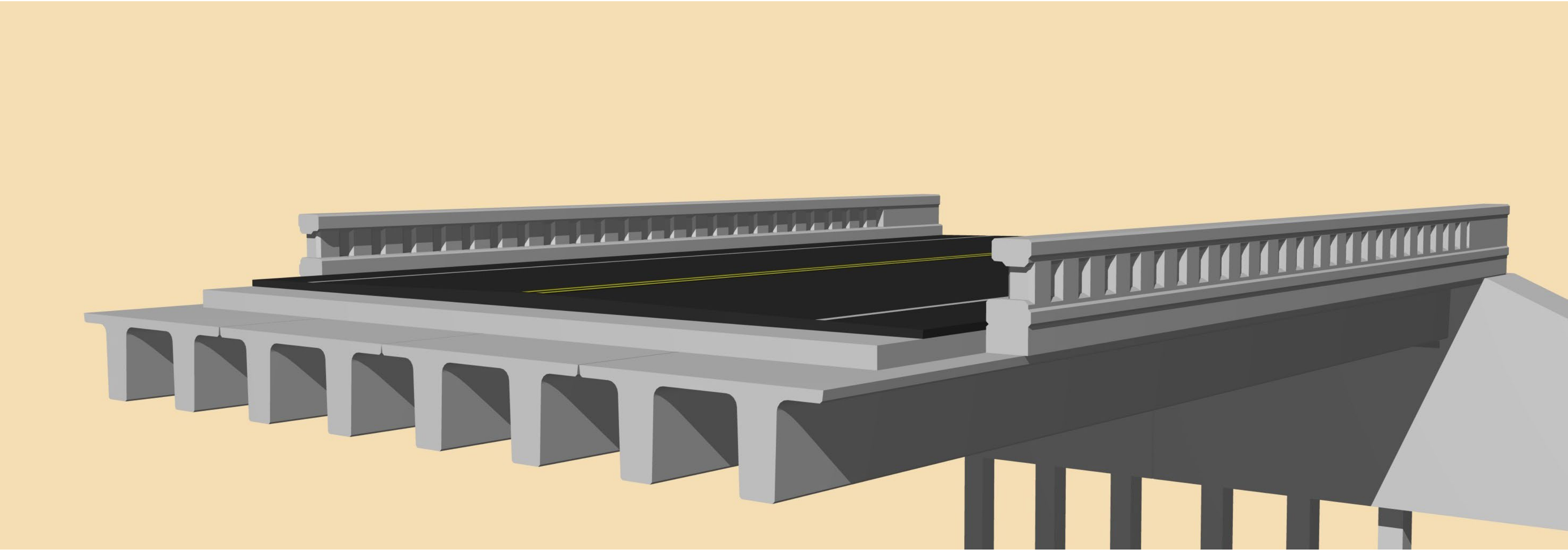
- NEXT Beam INDOT Policies and Standards (To-Do List)
  - INDOT Standard Drawings
    - E 707-BPBF Fabrication Tolerances
    - Anticipated to be consistent with PCI guidance



NextLevel INDIANA

INDOT Pilot Projects

- NEXT Beam INDOT Policies and Standards (To-Do List)
  - INDOT Standard Specifications
    - Section 707 – Precast and Precast, Prestressed Concrete Structural Members
      - 707.08 Handling and Shipping
        - New specifications to minimize twist of beams
        - Four-point lifting with load equalizing devices
      - 707.xx Repairs for Cracking in NEXT Beams
        - Guidelines for Resolution of Non-Conformances in Precast Concrete Bridge Elements by PCI Northeast
      - 707.12 Basis of Payment
        - New Pay Items
          - 707-12xxx STRUCTURAL MEMBER CONCRETE NEXT BEAM xx INCH TYPE x



Questions?