ABC, NEXT beams, & top-down construction

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PCI Gulf South
A Chapter of the Precast/Prestressed Concrete Institute

Accelerated Bridge Construction (ABC)

Basically, there are 3 aspects associated with ABC

- Goals & Initiatives
- Considerations
- Technologies

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Accelerated Bridge Construction (ABC) *Goals & Initiatives*

- Minimize traffic disruptions and/or road closures during bridge construction
  - Reduce user delay-related costs
- Improve work-zone safety
- Improve bridge construction quality and/or durability
- Minimize disruption to environmentally sensitive areas
- Promote standardization
- Take advantage of site accessibility and/or existing right-of-ways
- Reduce construction time
  - Accelerate the overall project
  - Utilize accelerated bridge construction techniques

Accelerated Bridge Construction (ABC) *Considerations*

- High traffic volumes
- Right-of-way
- Environmental
- Time
- Cost
- Construction quality
- Safety
- Mobility Impacts
- Availability of Prefabrication Bridge Elements
- ABC Technologies

- Planning, Design, & Construction
- Site Selection
- Contracting/Procurement /Delivery Methods
- Construction equipment and/or means-and-methods
- Standardization
- Construction Specifications and Materials
- Bridge Program/Management

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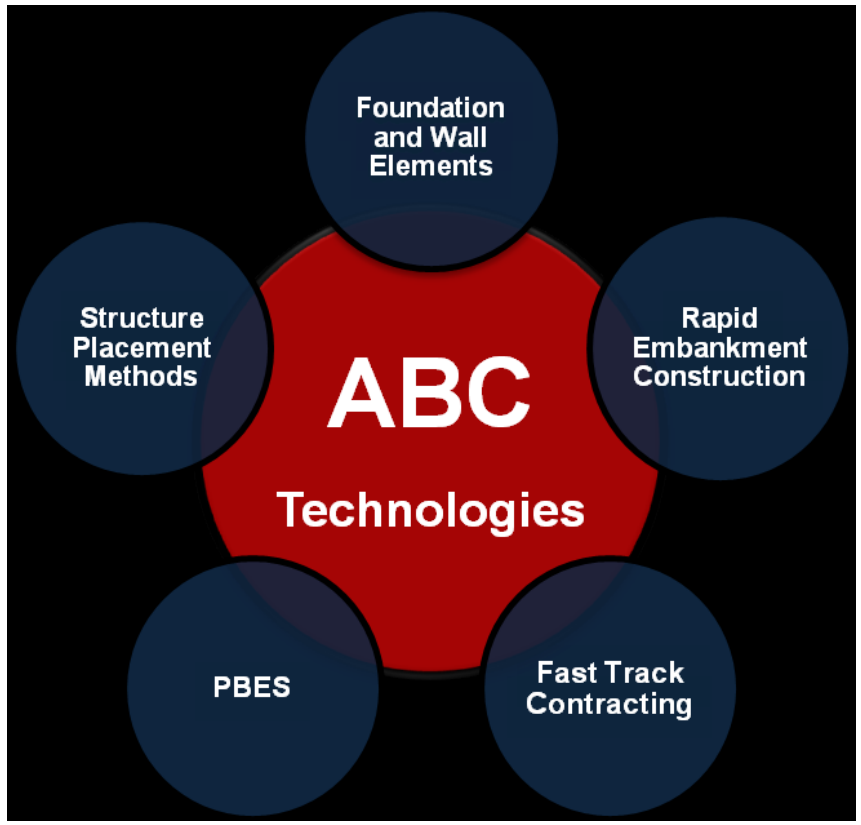
Accelerated Bridge Construction Technologies



Prefabricated Bridge Elements & Systems (PBES)

- *source: FHWA Every Day Counts Initiative from USDOT/FHA Accelerated Bridge Construction Manual (Publication No. HIF-12-013)*

- Prefabricated Bridge Elements and Systems (PBES): PBES are bridge components constructed offsite then brought to the project location, ready to erect. With traditional bridge construction, foundations for piers and abutments must be built first. Pier columns and caps must be built before beams and decks are placed. With PBES, these components can be fabricated concurrently and shipped in as needed. In addition, traditional onsite construction exposes work crews to moving traffic and to working over water or near power lines. Using PBES shortens onsite construction time so that fewer workers need to be exposed to traffic control. It results in durable bridges that can be built faster, more safely, and with fewer traffic delays.

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ABC Resources/Websites

Highways for LIFE (LIFE is an acronym for Long-lasting, Innovative, Fast construction, Efficient, and safe, all characteristics of the ideal highway or bridge construction project)

www.fhwa.dot.gov/publications/publicroads/10janfeb/01.cfm

www.slideinbridgeconstruction.com/

FHWA Center for Accelerating Innovation

http://www.fhwa.dot.gov/innovation/

Every Day Counts (EDC)

www.fhwa.dot.gov/innovation/everydaycounts/

Second Strategic Highway Research Program (SHRP2)

www.fhwa.dot.gov/goshrp2/

FHWA's ABC

www.fhwa.dot.gov/bridge/abc/index.cfm

Slide In Bridge Construction

www.fhwa.dot.gov/construction/sibc/

Florida International University-Accelerated Bridge Construction University Transportation Center

https://abc-utc.fiu.edu/

ALDOT Dothan Bridge Project

www.dothanbridge.com/

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Bridge Retrofits

Owner: Baldwin County Highway Department – Alabama

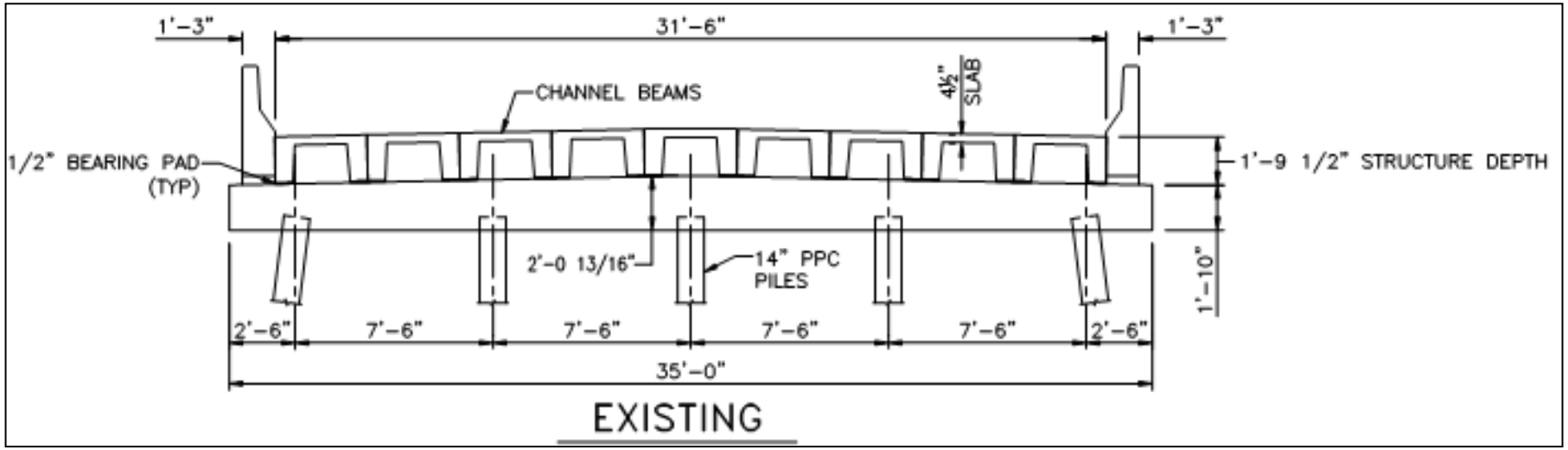
<u>Existing Bridges</u>

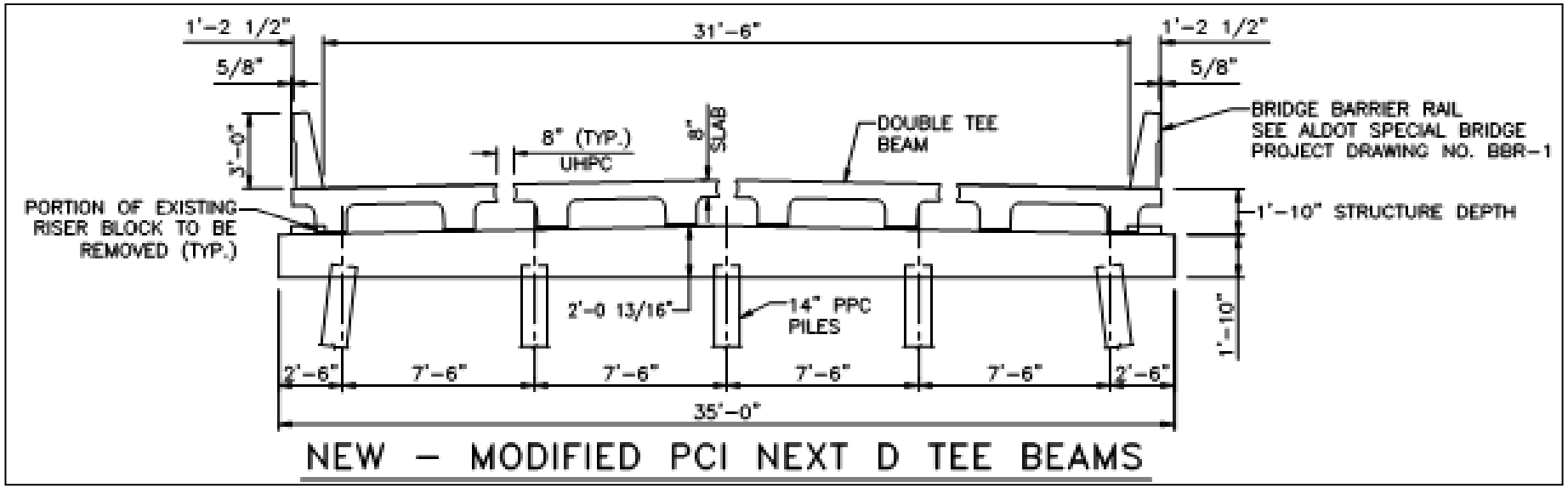
- CR65 Bridge over Turkey Branch, 2-spans at 34-34 ft.
- Doc McDuffie Road Bridge over Wolf Creek, 3-spans at 34-34-34 ft.
- Both bridges have high truck traffic
- Existing bridges were constructed in the late 1990s and early 2000s using reinforced concrete channel beam superstructures that have experienced deterioration of the longitudinal joint in between the reinforced concrete channel beams and damage to channel beam edges

Bridge Retrofits Goals

1. Replace the superstructure and Re-use the Existing Substructures/Bents
2. Consider accelerated construction techniques/solutions
3. Address long-term serviceability and bridge maintenance
4. Maintain existing right-of-way

Details


1'-3"
31'-6"
1'-3"
CHANNEL BEAMS
4½" SLAB
1/2" BEARING PAD (TYP)
1'-9 1/2" STRUCTURE DEPTH
2'-0 13/16"
14" PPC PILES
1'-10"
2'-6"
7'-6"
7'-6"
7'-6"
7'-6"
2'-6"
35'-0"
EXISTING


1'-2 1/2"
31'-6"
1'-2 1/2"
5/8"
5/8"
3'-0"
8" (TYP.) UHPC
8" SLAB
DOUBLE TEE BEAM
BRIDGE BARRIER RAIL SEE ALDOT SPECIAL BRIDGE PROJECT DRAWING NO. BBR-1
PORTION OF EXISTING RISER BLOCK TO BE REMOVED (TYP.)
1'-10" STRUCTURE DEPTH
2'-0 13/16"
14" PPC PILES
1'-10"
2'-6"
7'-6"
7'-6"
7'-6"
7'-6"
2'-6"
35'-0"
NEW – MODIFIED PCI NEXT D TEE BEAMS

CR65 photo showing NEXT beams and precast approach slabs installed

- Thompson Engineering, Engineer of Record
- Blade Construction completed both CR65 and Doc McDuffie bridges Sept/2021
- FORTERRA produced the NEXT beams and precast approach slabs

Doc McDuffie bridge

Additional resources

- David Tomley, P.E., “NEXT Beam Bridge Applications”, 61st Annual Alabama Transportation Conference, February 12, 2018

  http://eng.auburn.edu/files/t2/2018-trans/next-beam-bridge-applications

- FHWA Defines UHPC-class materials as cementitious based composite materials with discontinuous fiber reinforcement, compressive strengths above 21.7 ksi, pre-and post-cracking tensile strengths above 0.72 ksi, and enhanced durability via their discontinuous pore structure.
- Ultra-High Performance Concrete: A State-of-the-Art Report for the Bridge Community
  - https://www.fhwa.dot.gov/publications/research/infrastructure/structures/hpc/13060/13060.pdf
- FHWA-HRT-14-084 (Design and Construction of Field-Cast UHPC Connections)
- FHWA-HRT-11-038 (Ultra-High Performance Concrete)
- FHWA-HRT-14-090 (Bond Behavior of Reinforcing Steel in Ultra-High Performance Concrete)

TxDOT Hemphill County Accelerated Construction Project

Owner: TxDOT
Alternate Design Engineer: Thompson Engineering
Contractor: Webber Construction
Fabricator: Texas Concrete Partners (NEXT beams and precast bent caps)
UHPC: UHPC Solutions & Smart-Up

ENR link:
Innovation and Value Engineering Significantly Reduce Road Closure Times for Bridge Replacements on Remote Texas Panhandle Project ENR Sep 27/Oct 04, 2021 (bnpmedia.com)

http://digital.bnpmedia.com/publication/?i=723232&article_id=4125737&view=articleBrowser&ver=html5

TxDOT BR 2020(634) Project Hemphill County, Texas

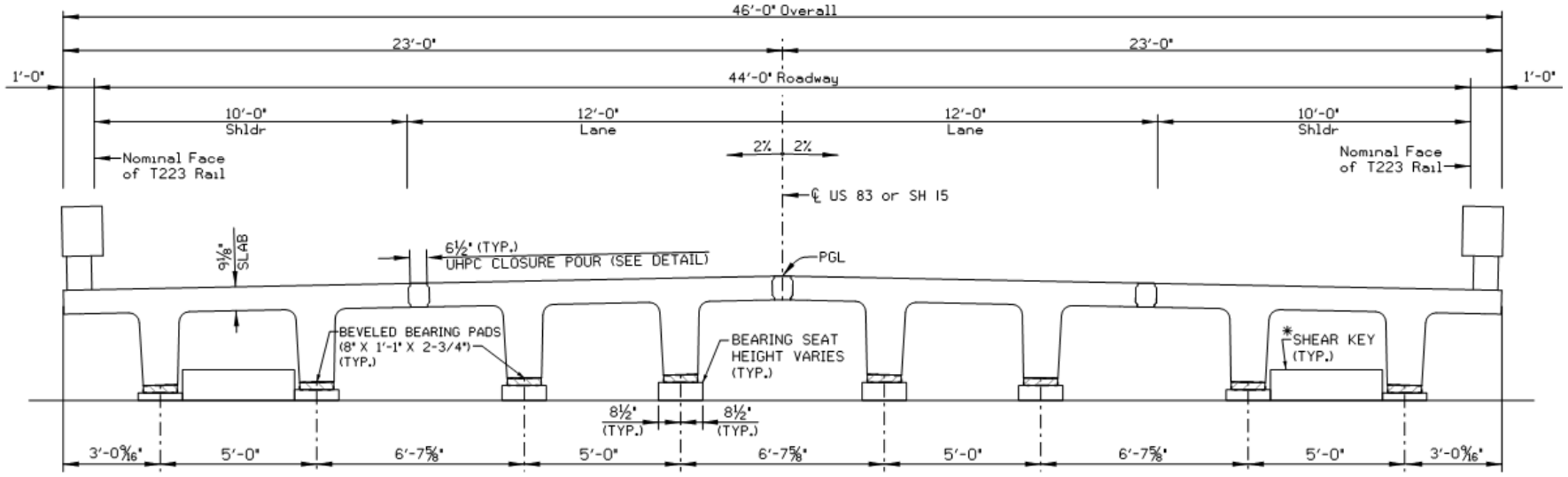
Project includes 5 bridges:

- US83 bridge at West Fork Horse Creek (North); 70-70-60 ft. spans
- US83 bridge at West Fork Horse Creek (South); 70-70-70 ft. spans
- SH15 bridge at Palo Duro Creek; 60-60-60-60-60 ft. spans
- SH15 bridge at Farwell Creek; 70-70 ft. spans
- SH15 bridge at Ivanhoe Creek; 60-60-60-60 ft. spans

- Vehicles Per Day (VPD) in year 2050 range from 800 to 2800
- 75 mph design speed
- Function Class: Arterial

TxDOT BR 2020(634) ABC Project Hemphill County, Texas

Webber Construction together with PCI Producer Member, Texas Concrete Partners, and Thompson Engineering developed an alternative approach using NEXT beams & UHPC for the superstructure replacements and precast interior bent caps.

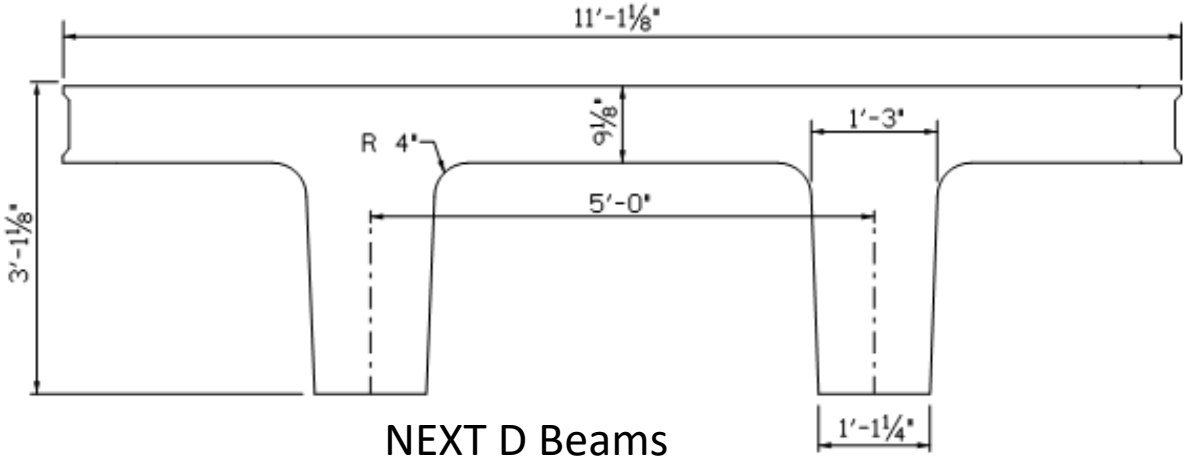


TxDOT BR 2020(634) ABC Project Hemphill County, Texas

- Depth = 37-1/8”
- Top flange width = 11’-1 1/8”
- 30 - 0.6” strands (60 ft. spans)
- 40 - 0.6” strands (70 ft. spans)
- Release strength = 6.0 ksi
- 28-day strength = 8.5 ksi

- The NEXT beam form allows for flexibility in the top flange dimensions to match roadway widths and/or design requirements

- Top flange thickness overbuilt from 8.5” to 9-1/8” to allow for diamond grinding after erection to meet TxDOT’s Ride Quality For Pavement Surfaces requirements (Item 585)



NEXT D Beams

TxDOT BR 2020(634) ABC Project Hemphill County, Texas

- The precast interior bent caps produced using 4.6 ksi concrete strength and lightweight mix using a unit weight of 126 pcf
- Precast caps
  - 50 ft. long
  - 4.5 ft. wide
  - 5.5 ft. tall
  - Weight 85 tons
- The shear blocks and bearing seats poured monolithic with the precast caps

- UHPC Specialty Contractor: UHPC|Solutions and SMARTUP
  - 4-day average compressive strength was 14,170 psi.
  - Epoxy coated rebar pullout resistance over 90,000 psi and black steel rebar pullout resistance of over 104,000 psi for 5-inch embedment. Both met yield strength requirements.

UHPC on site ready-mixer

Joint Configuration

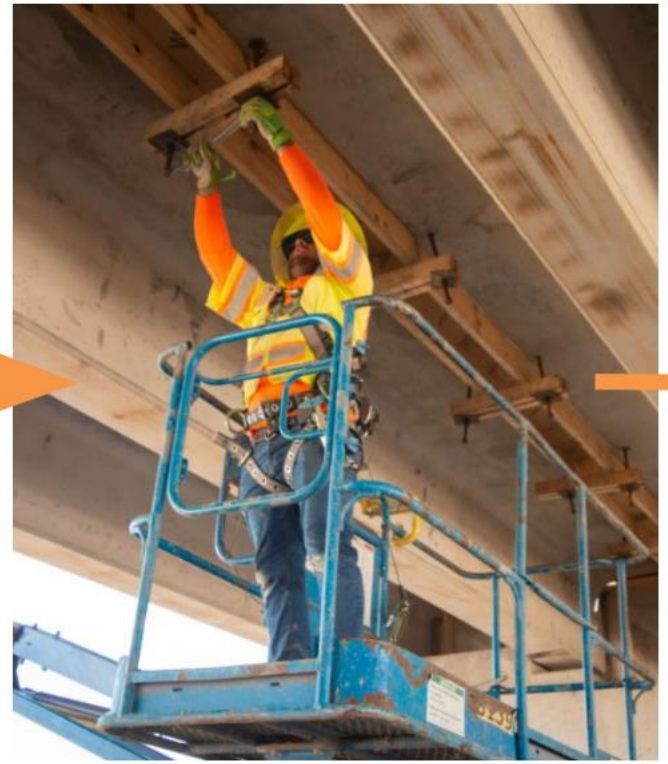
Compared to traditional concrete:

- Connections between precast elements are simplified and smaller
- Volume of UHPC and length of rebar reduced by up to 50%
- Straight rebars develop adequate strength - no bending or headed bars needed
- After prep work, UHPC placement averaged 5-6 hours on each bridge
- No consolidation methods needed - UHPC is self-consolidating and self-leveling
- Connections are possibly strongest part of bridge instead of weakest part

Formwork

UHPC is highly flowable, so the formwork must be made watertight to ensure no loss of material.
Formwork is installed with enough time before UHPC is placed to allow caulk to dry.

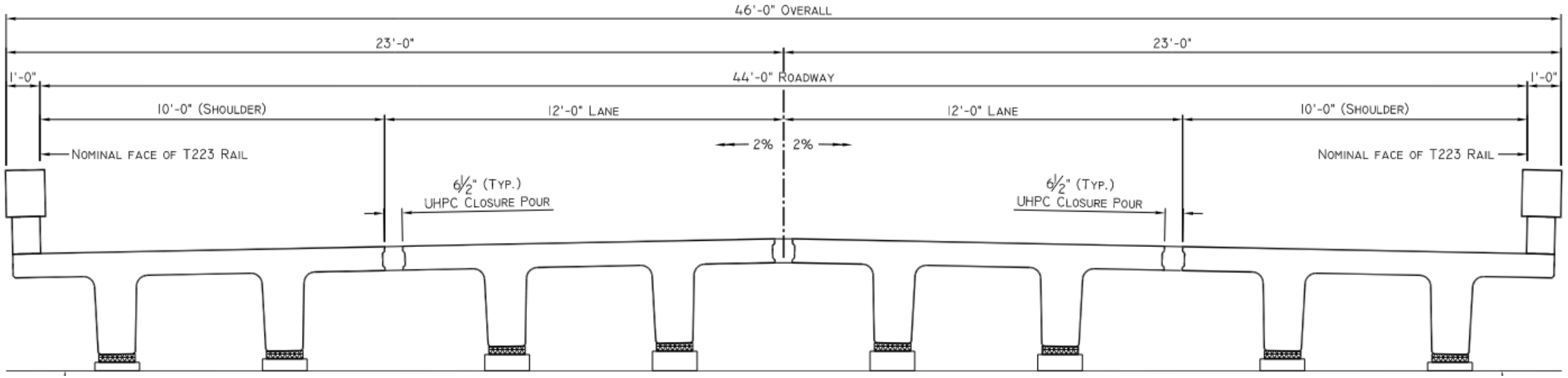
Precaster includes holes for threaded rods used to attach formwork.

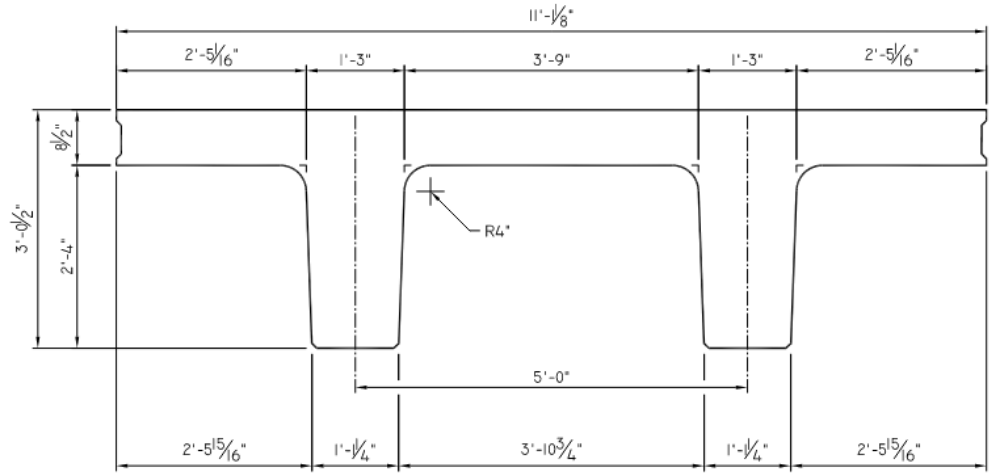


Formwork is securely tightened from underside of bridge.

Caulking the edge between formwork and NEXT beam creates waterproof seal.

Maximum 2-lane transverse section with 10 ft. shoulders using 4-NEXT D beams





NEXT D BEAM (INTERIOR BEAM)
(36.50" x 133.125")

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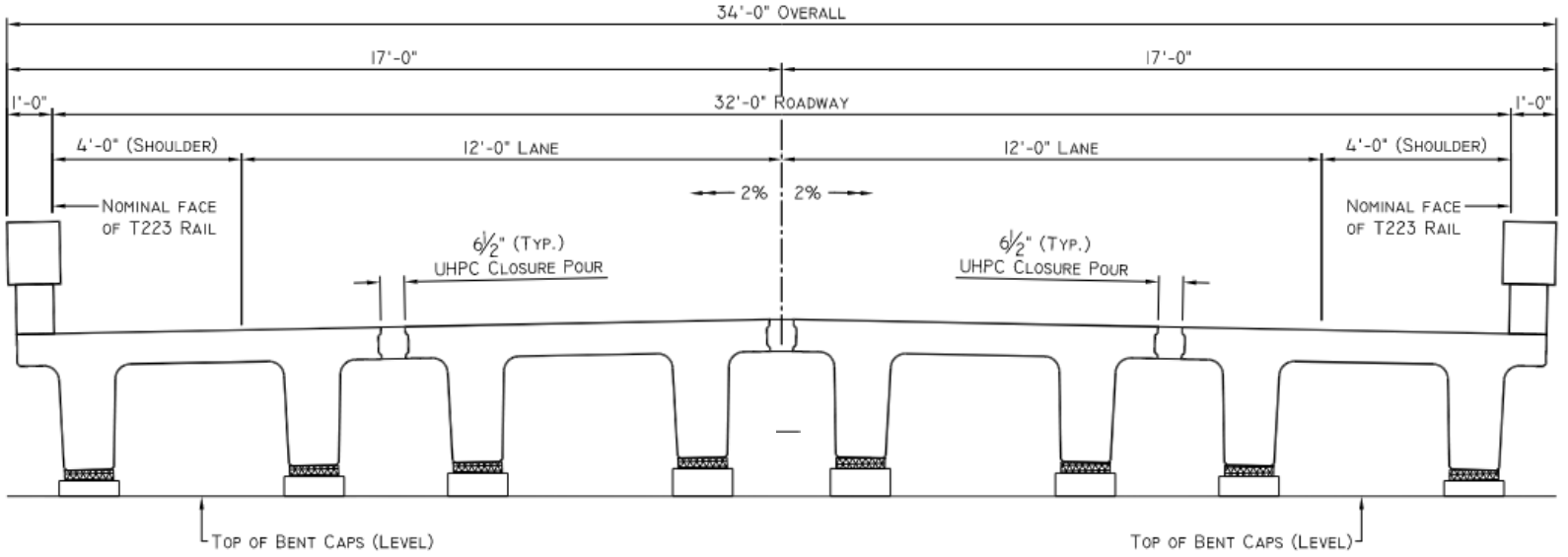
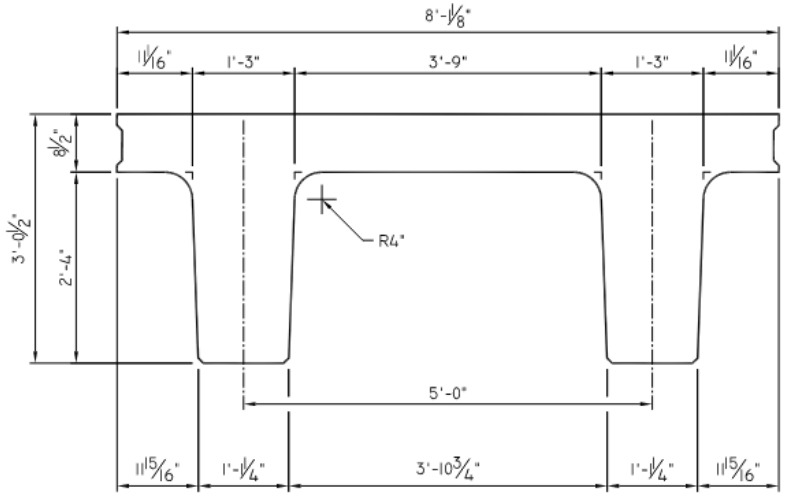
Minimum 2-lane transverse section with 4 ft. shoulders using 4-NEXT D beams





NEXT D BEAM (INTERIOR BEAM)
(36.50" x 97.125")

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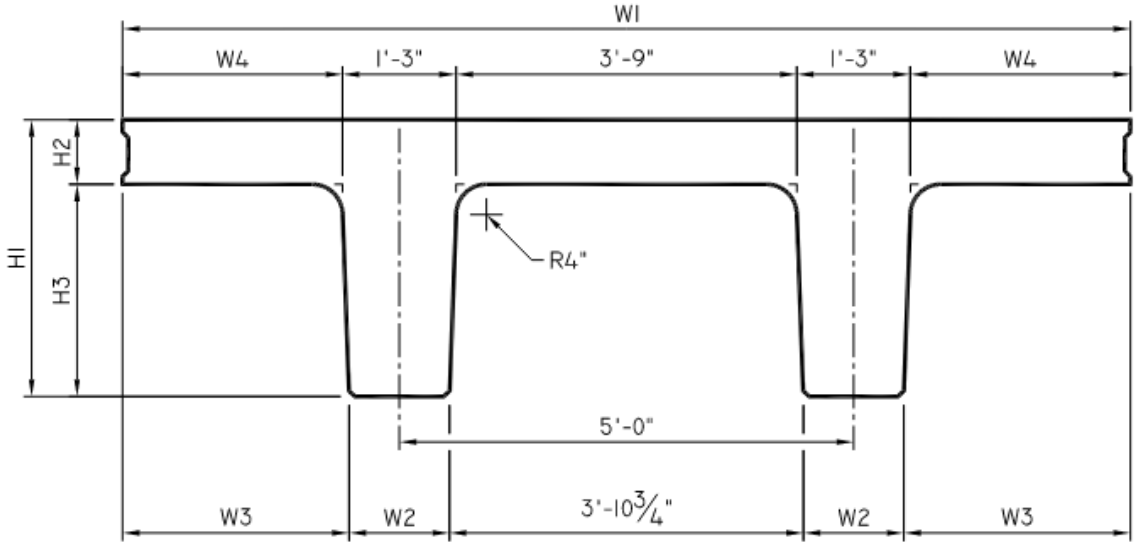
NEXT D beam section dimensions & properties

To facilitate the use of NEXT beams on future projects, the following detail includes the variable dimensions along with several section properties for various beam heights, top flange widths, and top flange thicknesses. Shallower beam heights are available by adding fillers in the stems of the forms. Different top flange widths can be made to accommodate existing roadway widths.



NEXT D BEAM (INTERIOR BEAM)

NEXT D BEAM SECTION PROPERTIES										
BEAM HEIGHT H1	TOP FLANGE THICKNESS H2	STEM HEIGHT H3	TOP FLANGE WIDTH W1	BASE STEM WIDTH W2	FLANGE TO BASE STEM WIDTH W3	FLANGE TO TOP STEM WIDTH W4	AREA ($in.^2$)	CENTER OF GRAVITY	MOMENT OF INERTIA ($in.^4$)	WEIGHT (lb./ft.)
2'-4"	8.00"	1'-8"	8'-1 1/8"	1'-1 3/4"	11 15/16"	11 1/16"	1,352.0	18.11"	86,734	1,475
2'-4 1/2"	8.50"	1'-8"	8'-1 1/8"	1'-1 3/4"	11 15/16"	11 1/16"	1,400.6	18.46"	91,557	1,528
2'-4"	8.00"	1'-8"	11'-1 1/8"	1'-1 3/4"	2'-5 15/16"	2'-5 1/16"	1,640.0	19.14"	96,514	1,789
2'-4 1/2"	8.50"	1'-8"	11'-1 1/8"	1'-1 3/4"	2'-5 15/16"	2'-5 1/16"	1,706.6	19.50"	101,821	1,861
2'-8"	8.00"	2'-0"	8'-1 1/8"	1'-1 1/2"	11 15/16"	11 1/16"	1,461.0	20.61"	127,636	1,593
2'-8 1/2"	8.50"	2'-0"	8'-1 1/8"	1'-1 1/2"	11 15/16"	11 1/16"	1,509.6	20.98"	134,008	1,646
2'-8"	8.00"	2'-0"	11'-1 1/8"	1'-1 1/2"	2'-5 15/16"	2'-5 1/16"	1,749.0	21.83"	142,319	1,907
2'-8 1/2"	8.50"	2'-0"	11'-1 1/8"	1'-1 1/2"	2'-5 15/16"	2'-5 1/16"	1,815.6	22.21"	149,289	1,980
3'-0"	8.00"	2'-4"	8'-1 1/8"	1'-1 1/4"	11 15/16"	11 1/16"	1,568.0	23.07"	178,708	1,710
3'-0 1/2"	8.50"	2'-4"	8'-1 1/8"	1'-1 1/4"	11 15/16"	11 1/16"	1,616.6	23.46"	186,897	1,763
3'-0"	8.00"	2'-4"	11'-1 1/8"	1'-1 1/4"	2'-5 15/16"	2'-5 1/16"	1,856.0	24.45"	199,666	2,024
3'-0 1/2"	8.50"	2'-4"	11'-1 1/8"	1'-1 1/4"	2'-5 15/16"	2'-5 1/16"	1,922.6	24.86"	208,612	2,097
3'-4"	8.00"	2'-8"	8'-1 1/8"	1'-1"	11 15/16"	11 1/16"	1,673.0	25.49"	240,646	1,825
3'-4 1/2"	8.50"	2'-8"	8'-1 1/8"	1'-1"	11 15/16"	11 1/16"	1,721.6	25.91"	250,924	1,878
3'-4"	8.00"	2'-8"	11'-1 1/8"	1'-1"	2'-5 15/16"	2'-5 1/16"	1,961.0	27.04"	269,308	2,139
3'-4 1/2"	8.50"	2'-8"	11'-1 1/8"	1'-1"	2'-5 15/16"	2'-5 1/16"	2,027.6	27.47"	280,550	2,211

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Top-down construction

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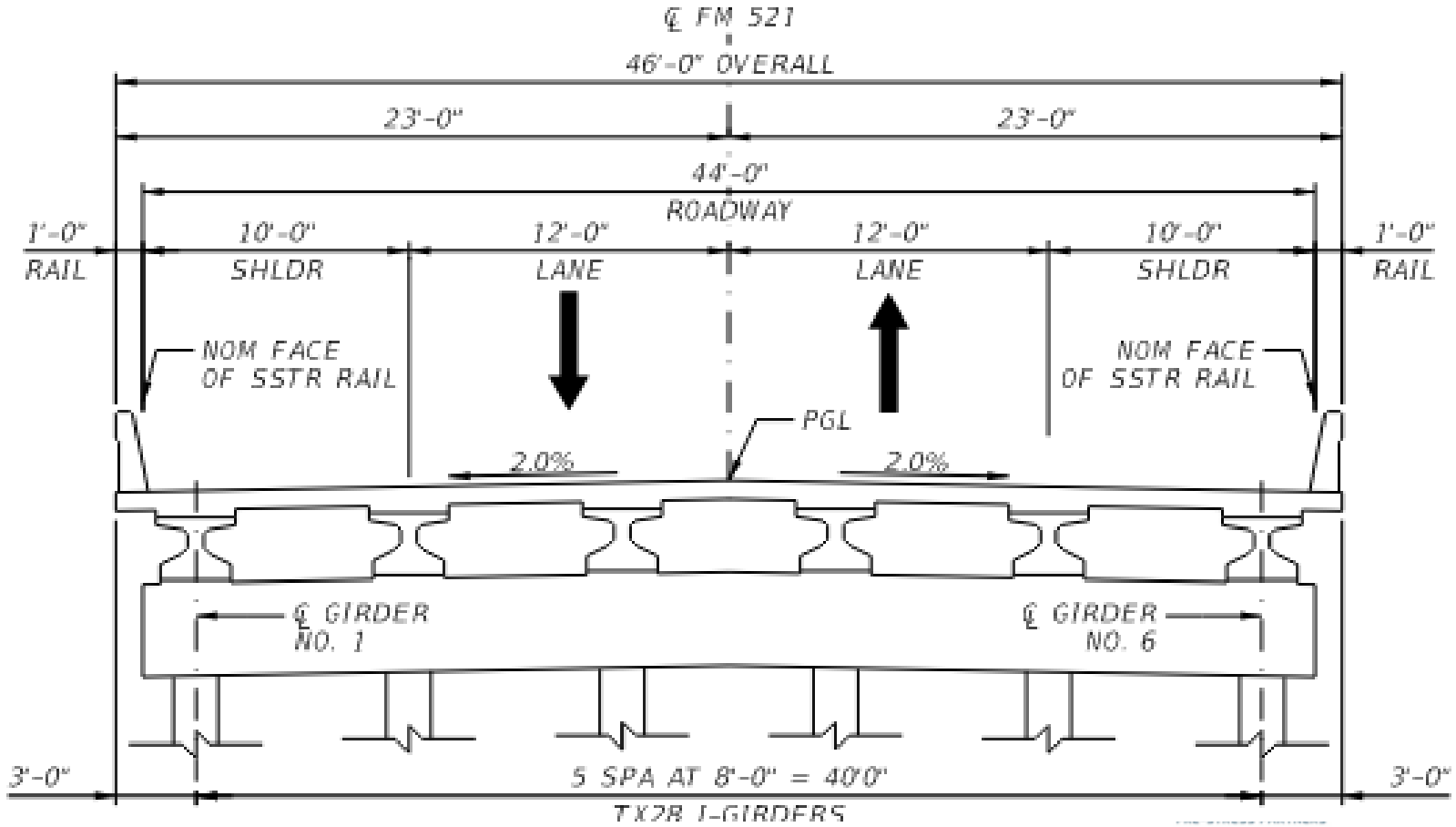
Top-down construction

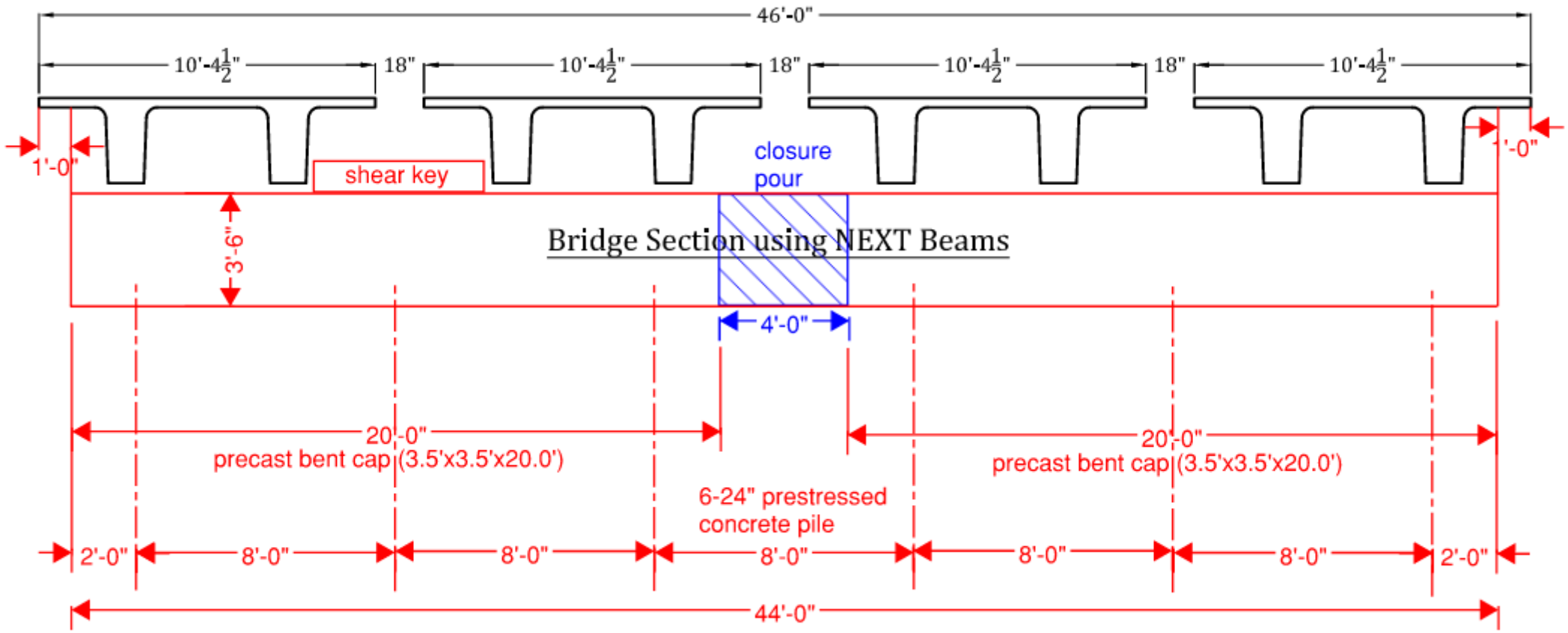
- When crane access prevents conventional construction erection methods or when project sites have environmentally sensitive areas, or the bridge is constructed over water; top-down construction has been utilized by Contractors to erect typically multi-span superstructures using cranes on subsequent spans (placing span 1, then span 2, then span 3, etc.)
- Examples include erection of side-by-side adjacent box beams or NEXT beams that can support cranes during erection of adjoining spans

FM521 bridge over Palacios River

- 6 span bridge

50-70-70-70-70-70 ft.




46'-0"
10'-4½"
18"
10'-4½"
18"
10'-4½"
18"
10'-4½"
1'-0"
shear key
closure pour
1'-0"
3'-6"
Bridge Section using NEXT Beams
4'-0"
20'-0"
precast bent cap (3.5'x3.5'x20.0')
20'-0"
precast bent cap (3.5'x3.5'x20.0')
6-24" prestressed concrete pile
2'-0"
8'-0"
8'-0"
8'-0"
8'-0"
8'-0"
2'-0"
44'-0"