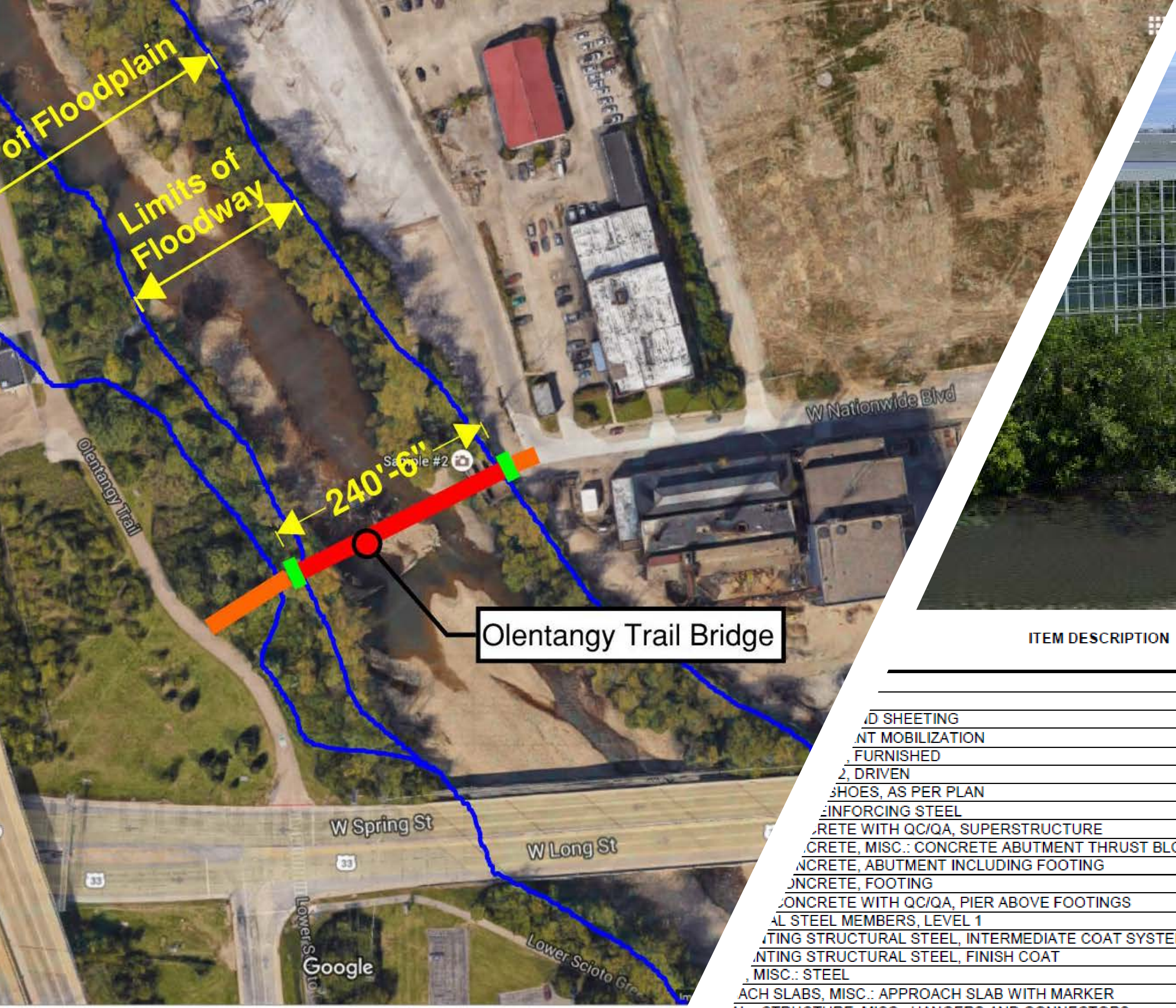
Design and Construction of the Olentangy Trail – Arena District Connector Bridge

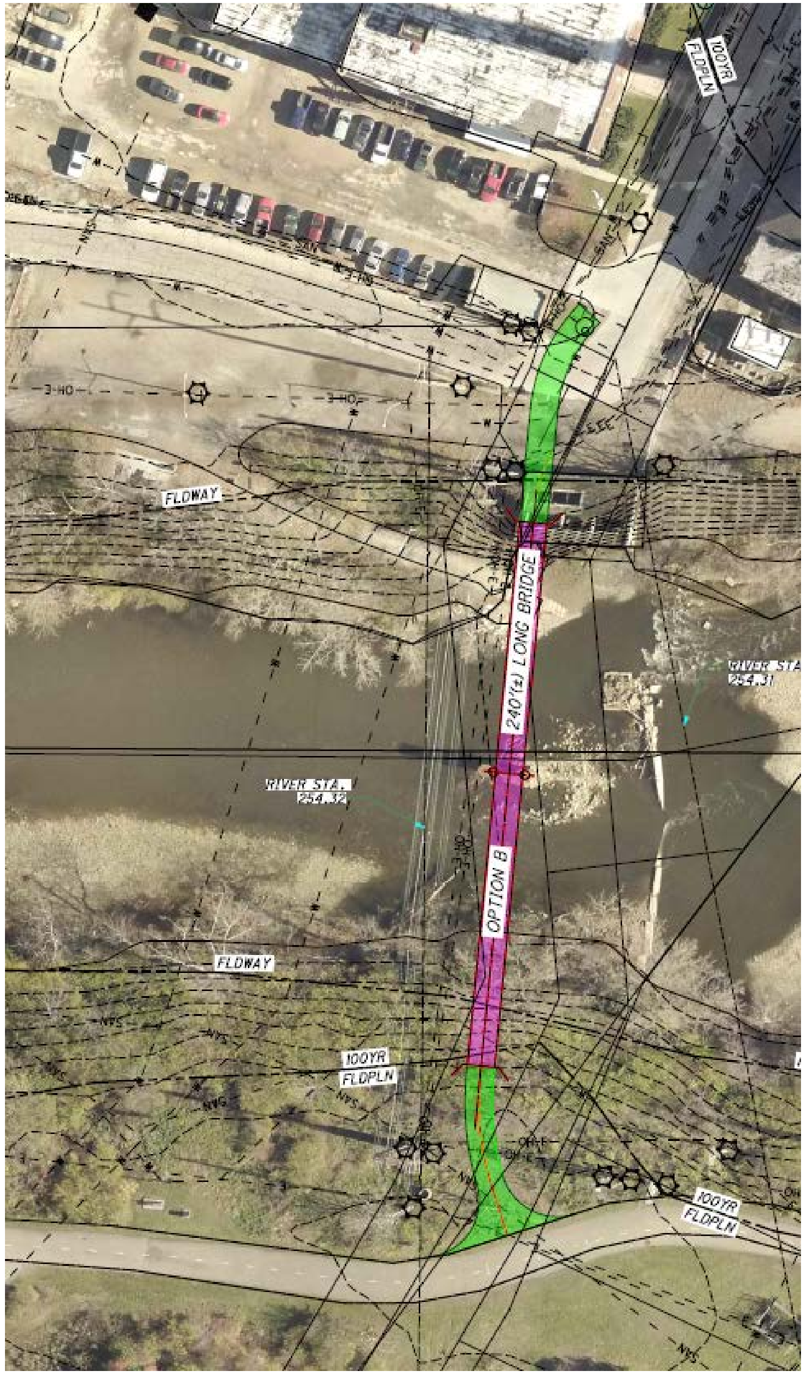
Presenters:
John Shanks, PE
Travis Butz, PE

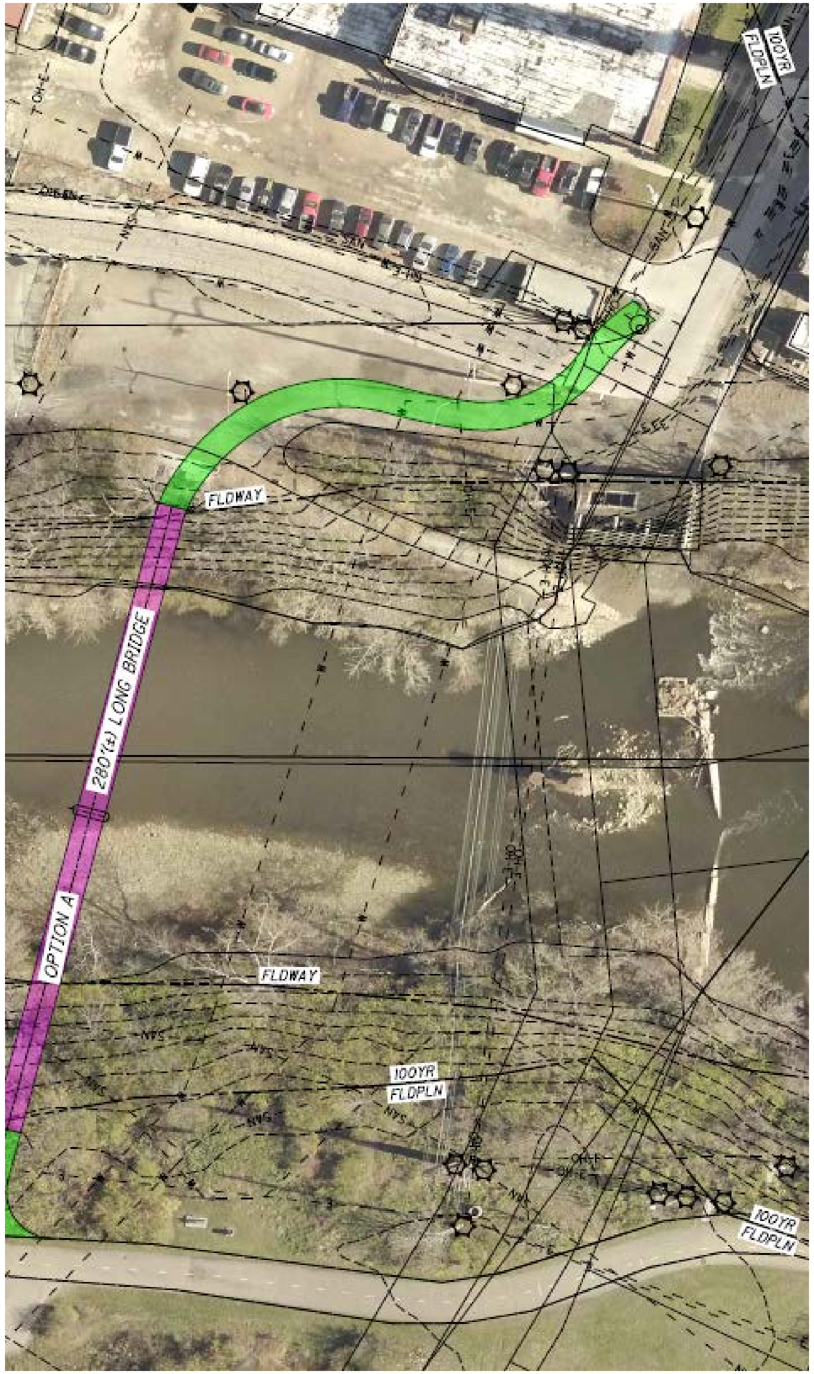
BURGESS & NIPLE

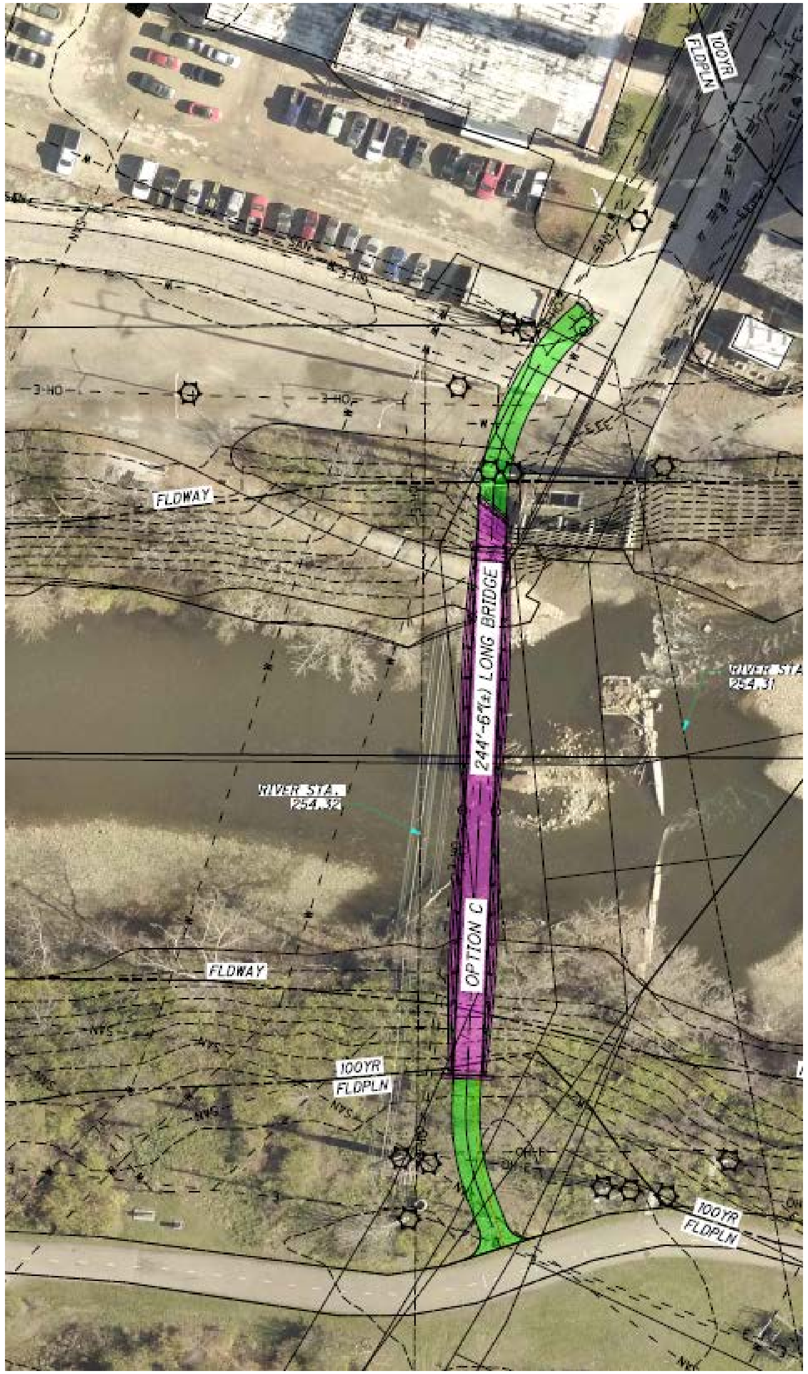


ITEM DESCRIPTION	TOTAL QUANTITY	UNIT	2017 UNIT PRICE	TOTAL 2017 CONSTRUCTION COST
	0	EACH	$0.00	$0
...D SHEETING	1	LS	$30,000.00	$30,000
...NT MOBILIZATION	1	LS	$20,000.00	$20,000
..., FURNISHED	1780	FT	$32.09	$57,110
...2, DRIVEN	1580	FT	$13.18	$20,820
...SHOES, AS PER PLAN	42	EACH	$99.51	$4,190
...EINFORCING STEEL	53440	LB	$1.07	$57,270
...RETE WITH QC/QA, SUPERSTRUCTURE	78	CY	$975.78	$75,640
...CRETE, MISC.: CONCRETE ABUTMENT THRUST BLOCKS	129	CY	$530.00	$68,500
...NCRETE, ABUTMENT INCLUDING FOOTING	67	CY	$572.92	$38,340
...ONCRETE, FOOTING	32	CY	$479.21	$15,330
...CONCRETE WITH QC/QA, PIER ABOVE FOOTINGS	83	CY	$1,113.52	$92,790
...AL STEEL MEMBERS, LEVEL 1	62020	LB	$1.68	$104,350
...NTING STRUCTURAL STEEL, INTERMEDIATE COAT SYSTEM OZEU	7640	SF	$3.62	$27,670
...NTING STRUCTURAL STEEL, FINISH COAT	7640	SF	$3.02	$23,040
..., MISC.: STEEL	550	FT	$275.00	$151,250
...ACH SLABS, MISC.: APPROACH SLAB WITH MARKER	43	SY	$250.00	$10,750
...AL - STRUCTURE, MISC.: HANGERS AND CONNECTORS	73560	LB	$2.50	$183,900
...CIAL - STRUCTURE, MISC.: GLULAM BRIDGE MEMBER	8	EACH	$58,900.00	$471,200
	0	EACH	$0.00	$0
			Subtotal:	$1,452,150
		Contingency %:	20%	$290,430
			TOTAL COST:	$1,742,580



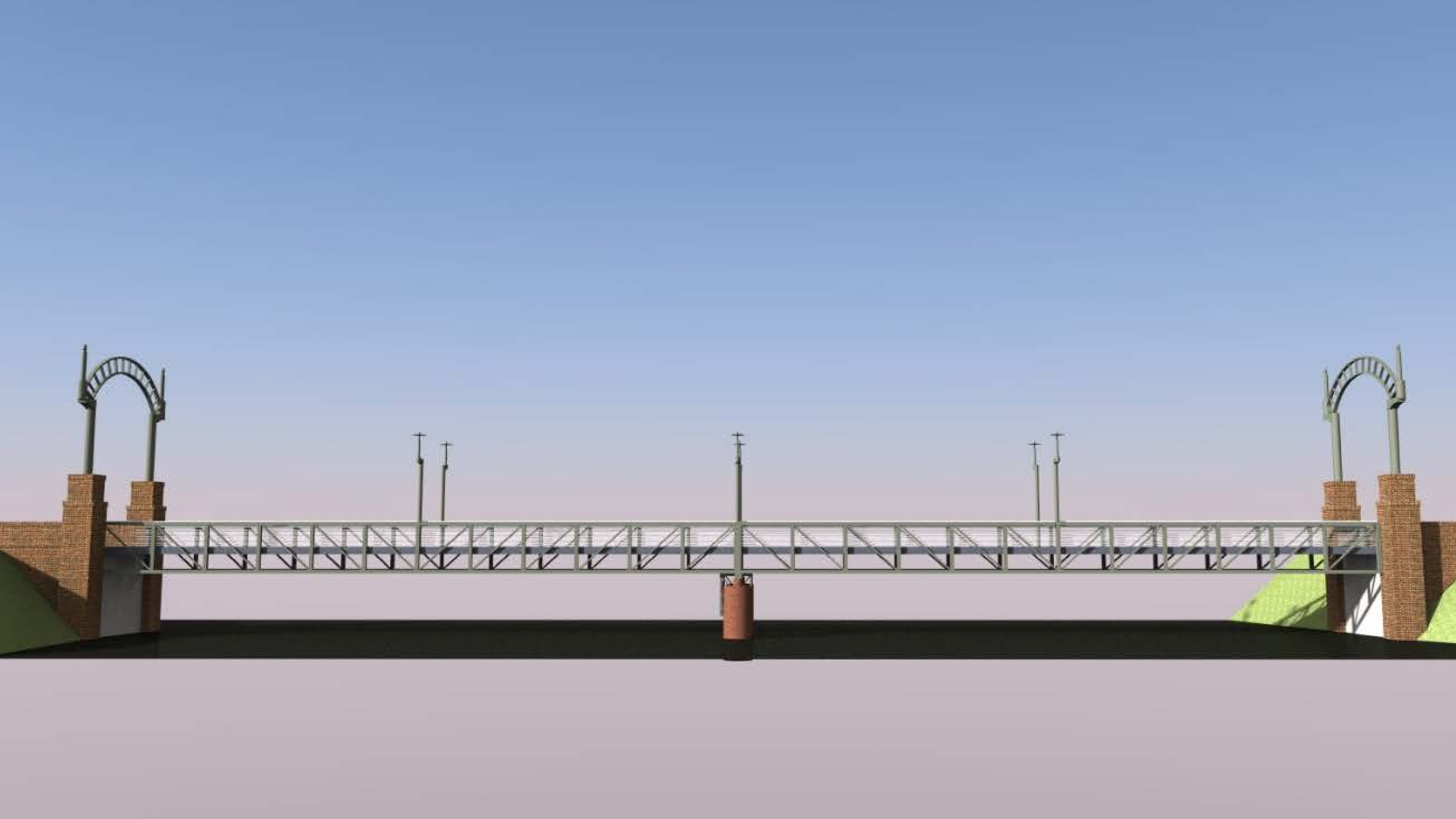

100YR FLDPLN
FLDWAY
240'(±) LONG BRIDGE
RIVER STA. 254.32
OPTION B
FLDWAY
100YR FLDPLN
100YR FLDPLN


100YR FLDPLN
FLDWAY
280'(±) LONG BRIDGE
OPTION A
FLDWAY
100YR FLDPLN
100YR FLDPLN

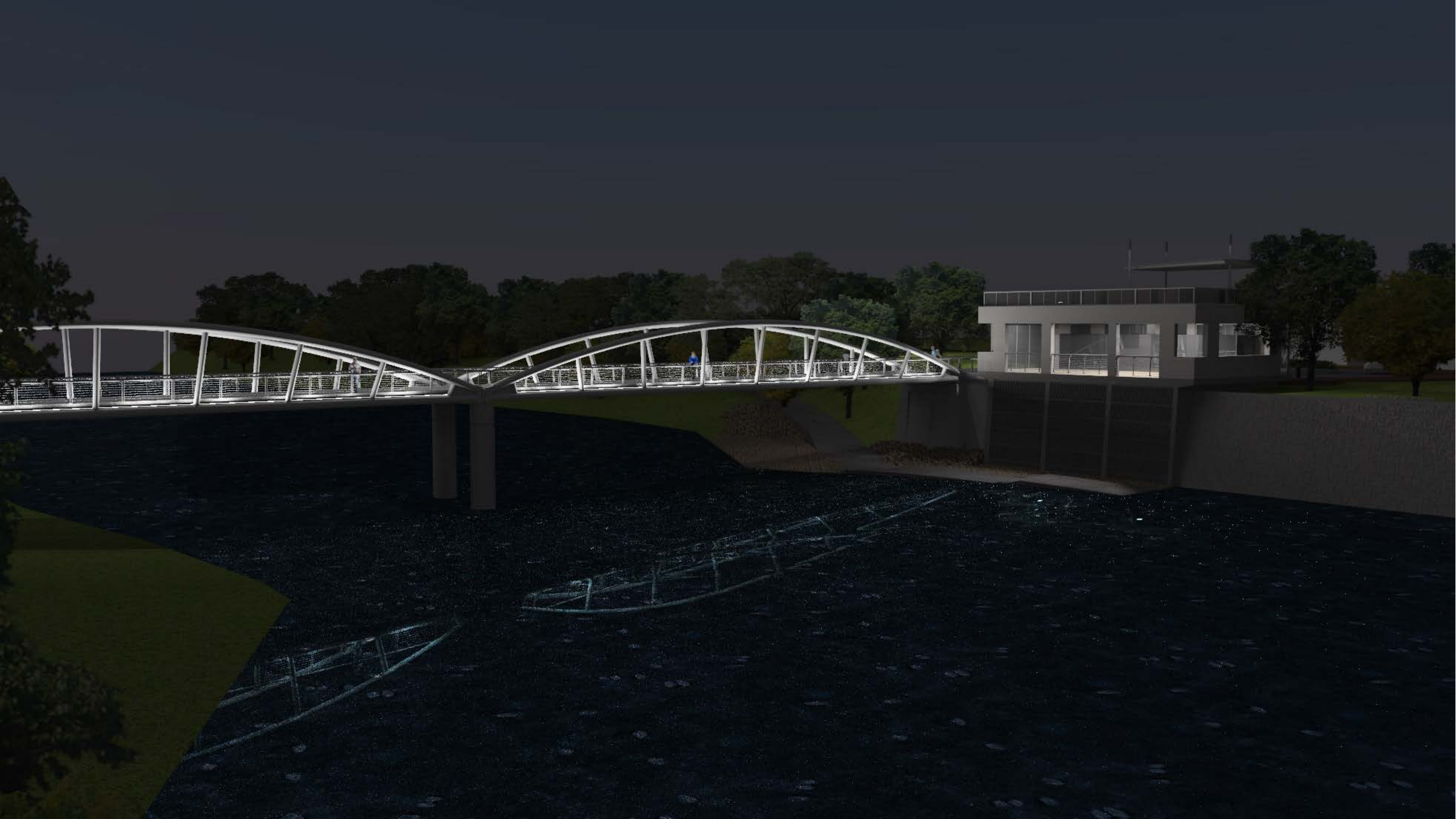

100YR FLDPLN
FLDWAY
244'-6"(±) LONG BRIDGE
RIVER STA. 254.32
OPTION C
FLDWAY
100YR FLDPLN
100YR FLDPLN


MUNICIPAL LIGHT PLANT

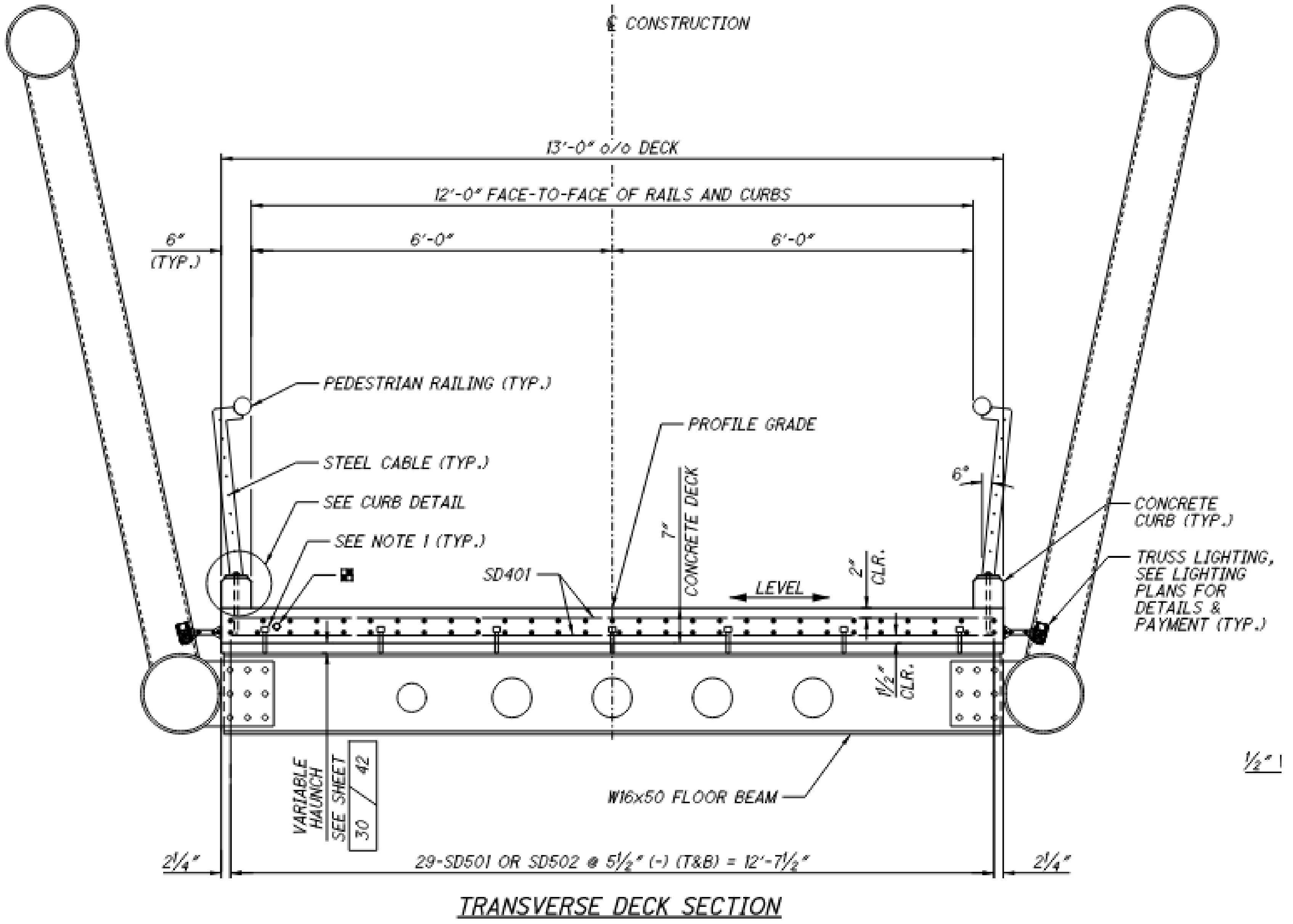

HUNTINGTON PARK
HOME PLATE ENTRY

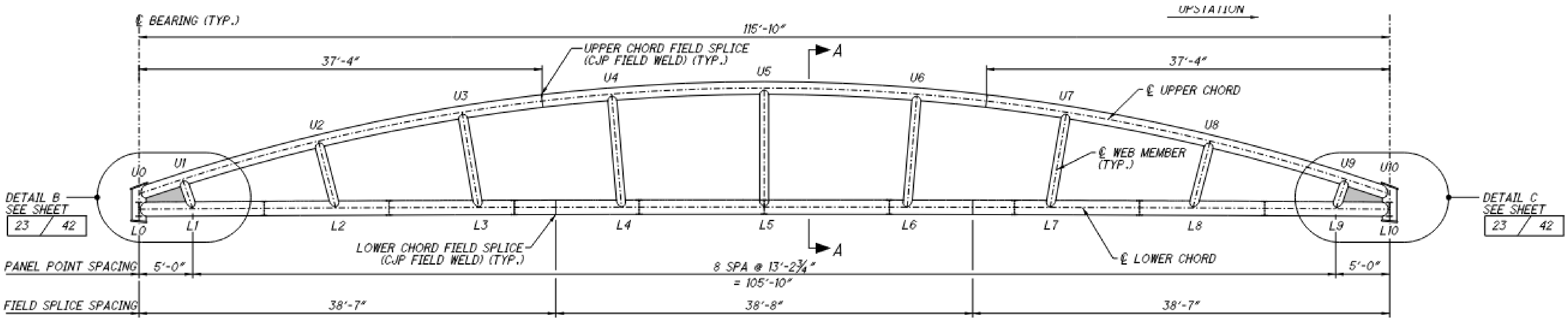



96
TICKETING
SW
GATE

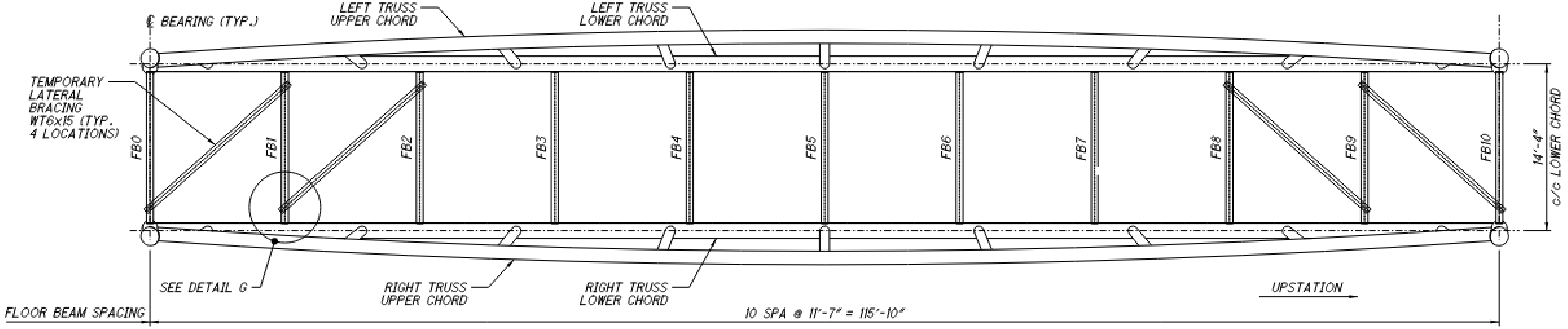


- Inclined Vierendeel trusses using round HSS sections
- Floorbeams are I-beams, field bolted moment connections to trusses
- Conventional composite concrete deck on SIP forms, span between floorbeams
- Variable deck haunch included to control the deck profile
- Deck is flat in cross section, positive drainage achieved by longitudinal grade





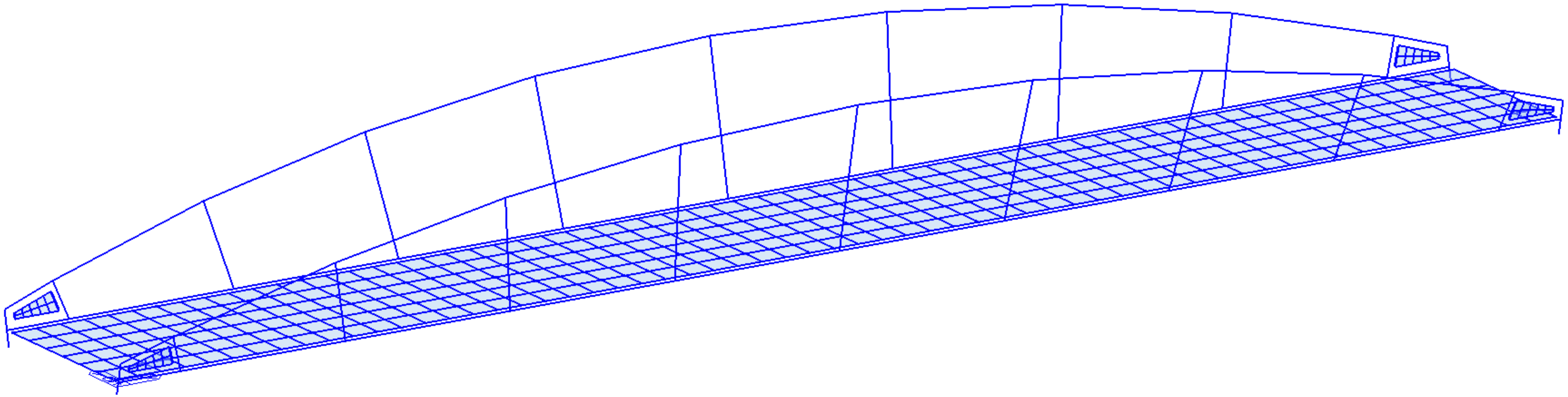
TRUSS ELEVATION

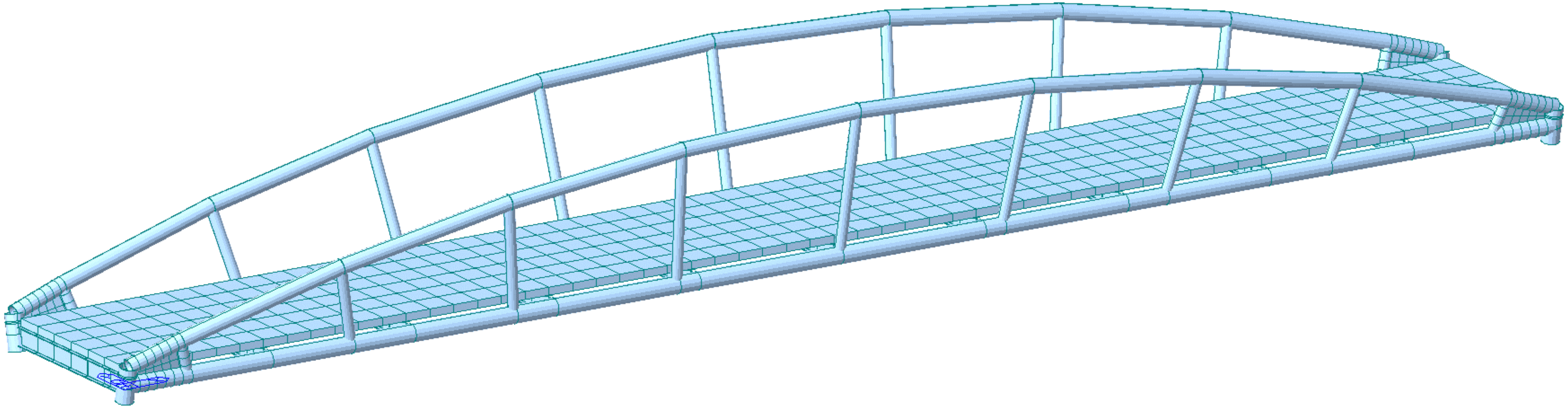


TRUSS PLAN

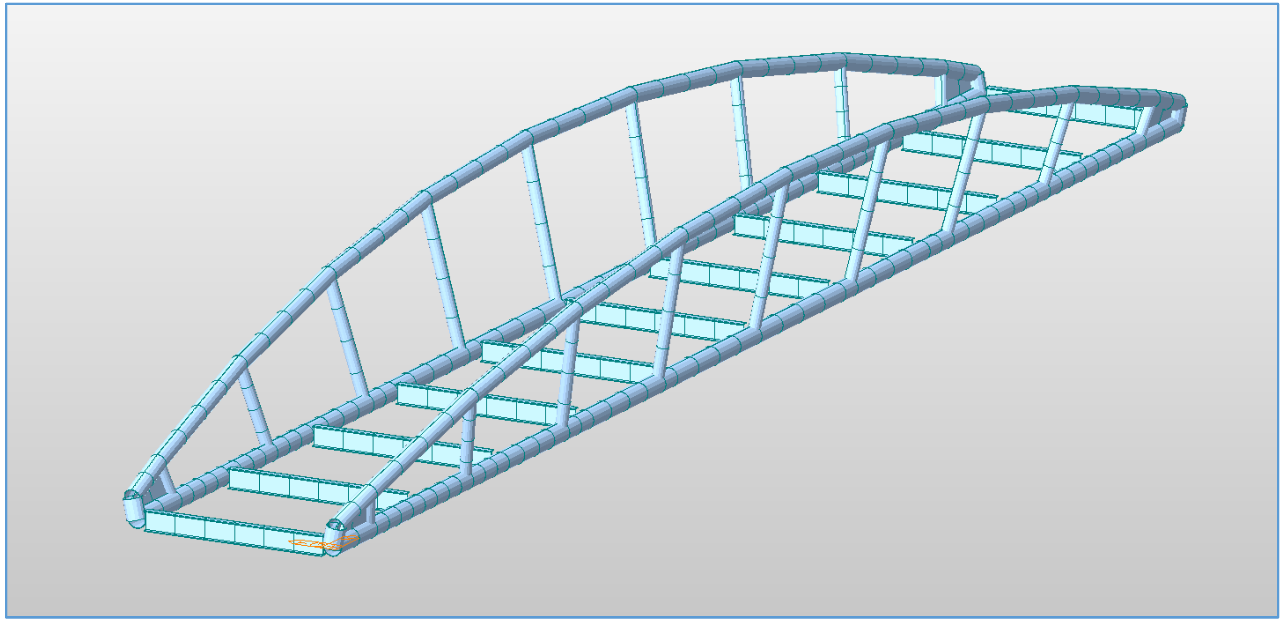
- Vierendeel truss is a moment frame with fully welded connections
- End panels are filled with welded web plates to help resolve the forces at the ends of the bridge
- Trusses were designed to come out in 3 pieces, connected by CJP field welds
- Ohio Structures constructed the truss lines full length in the shop, eliminated filed splices

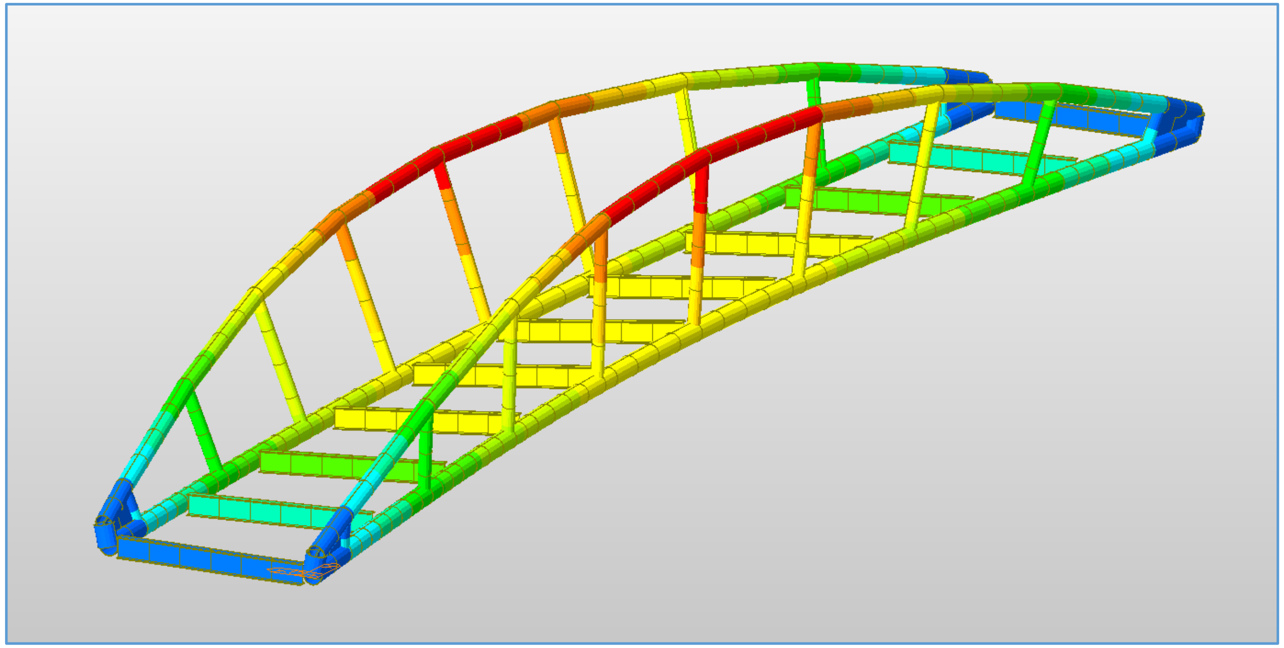
- Midas Civil used to calculate member forces
- Beam elements for truss members & floorbeams, shell elements for deck and web plates
- Multi-stage analysis examined deck construction, wind before & after the deck is placed



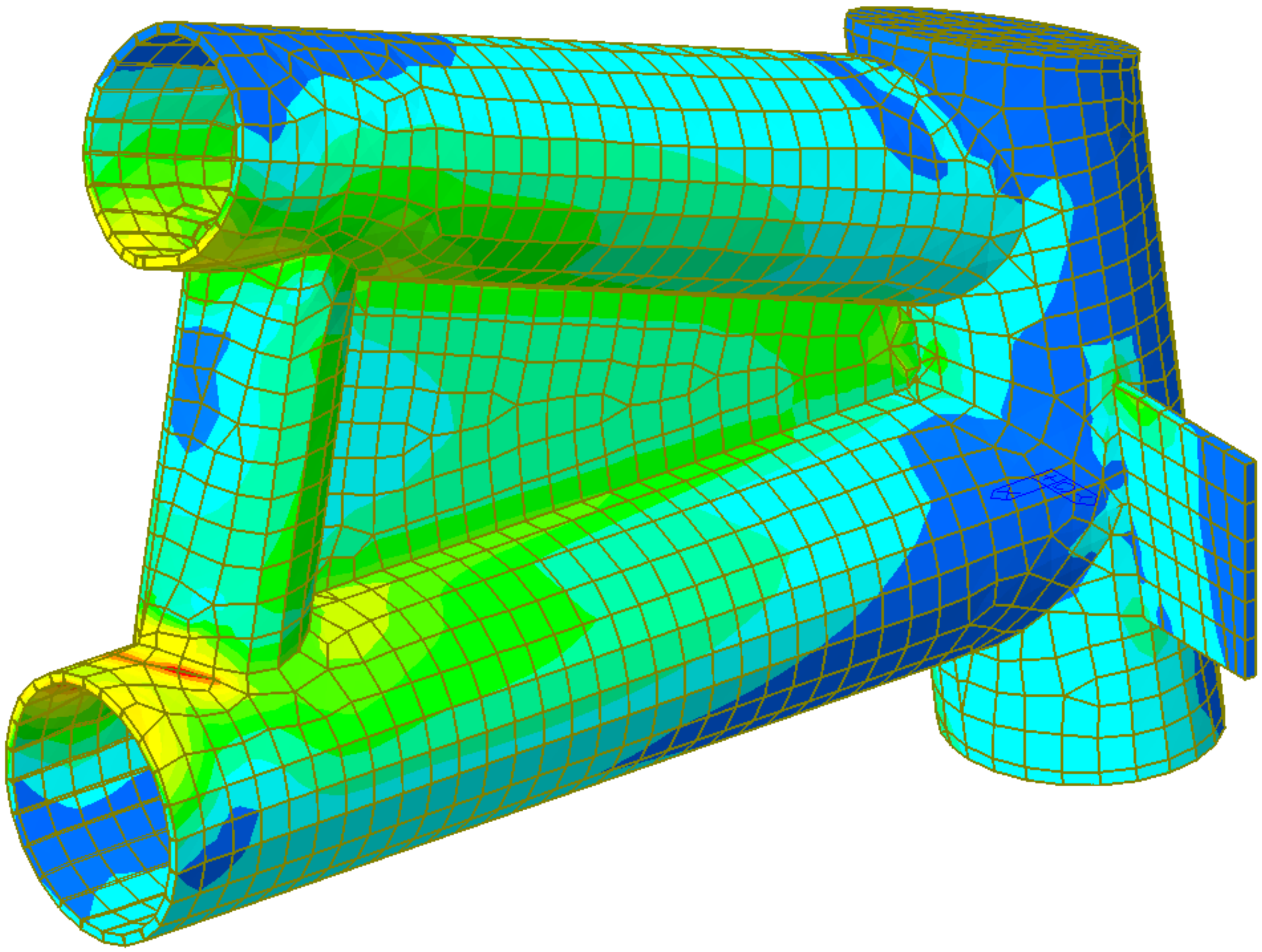


- Upper chord is braced by the bending stiffness of the truss web members
- Linear & nonlinear buckling analysis for construction and final conditions
- Considered the combined effects of wind, vertical loads



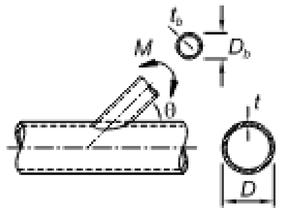
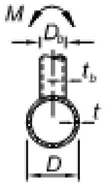


- Detailed analysis of the end panel to examine crushing / local buckling of the tube sections
- Tube members and plates modeled using shell elements
- Nonlinear analysis, verified factored stresses remained below yield limits



- Tubular truss members are generally controlled by the design of the connections
- Not in AASHTO
- Covered in Chapter K of AISC Specification for Structural Steel Buildings

TABLE K4.1
Available Strengths of Round HSS-to-HSS Moment Connections

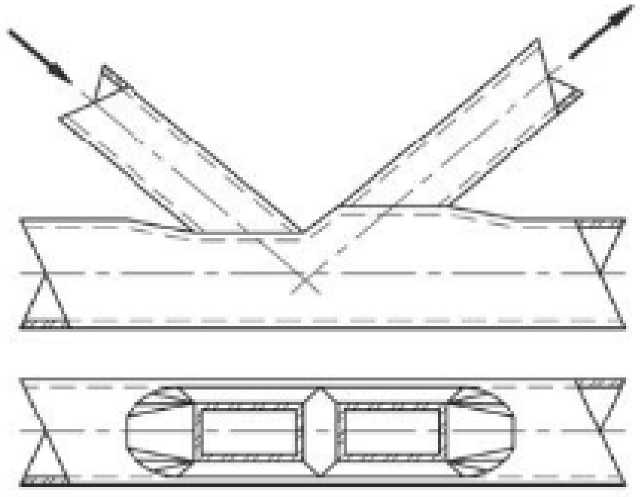
Connection Type	Connection Available Flexural Strength
Branch(es) Under In-Plane Bending T-, Y- and Cross-Connections 	Limit State: Chord Plastification $M_{n\text{-}ip}\sin\theta = 5.39F_y t^2\gamma^{0.5}\beta D_b Q_f$ (K4-1) $\phi = 0.90$ (LRFD) $\Omega = 1.67$ (ASD)
	Limit State: Shear Yielding (punching), when $D_b < (D - 2t)$ $M_{n\text{-}ip} = 0.6F_y t D_b^2\left(\frac{1+3\sin\theta}{4\sin^2\theta}\right)$ (K4-2) $\phi = 0.95$ (LRFD) $\Omega = 1.58$ (ASD)
Branch(es) Under Out-of-Plane Bending T-, Y- and Cross-Connections 	Limit State: Chord Plastification $M_{n\text{-}op} = \frac{F_y t^2 D_b}{\sin\theta}\left(\frac{3.0}{1-0.81\beta}\right)Q_f$ (K4-3) $\phi = 0.90$ (LRFD) $\Omega = 1.67$ (ASD)
	Limit State: Shear Yielding (punching), when $D_b < (D - 2t)$ $M_{n\text{-}op} = 0.6F_y t D_b^2\left(\frac{3+\sin\theta}{4\sin^2\theta}\right)$ (K4-4) $\phi = 0.95$ (LRFD) $\Omega = 1.58$ (ASD)

For T-, Y- and cross-connections, with branch(es) under combined axial load, in-plane bending, and out-of-plane bending, or any combination of these load effects:

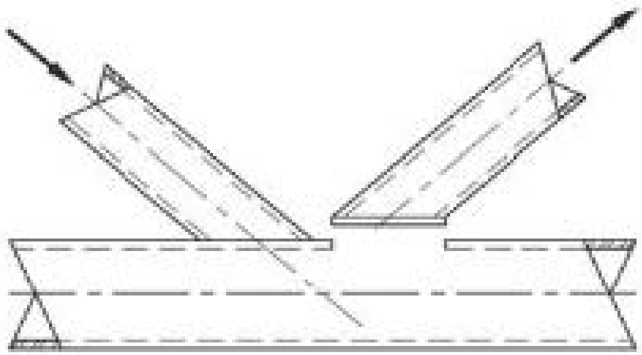
LRFD: $\left[P_u/(\phi P_n)\right] + \left[M_{r\text{-}ip}/(\phi M_{n\text{-}ip})\right]^2 + \left[M_{r\text{-}op}/(\phi M_{n\text{-}op})\right] \le 1.0$ (K4-5)

ASD: $\left[P_a/(P_n/\Omega)\right] + \left[M_{r\text{-}ip}/(M_{n\text{-}ip}/\Omega)\right]^2 + \left[M_{r\text{-}op}/(M_{n\text{-}op}/\Omega)\right] \le 1.0$ (K4-6)

ϕP_n = design strength (or P_n/Ω = allowable strength) obtained from Table K3.1
$\phi M_{n\text{-}ip}$ = design strength (or $M_{n\text{-}ip}/\Omega$ = allowable strength) for in-plane bending
$\phi M_{n\text{-}op}$ = design strength (or $M_{n\text{-}op}/\Omega$ = allowable strength) for out-of-plane bending
$M_{r\text{-}ip}$ = $M_{u\text{-}ip}$ for LRFD; $M_{a\text{-}ip}$ for ASD
$M_{r\text{-}op}$ = $M_{u\text{-}op}$ for LRFD; $M_{a\text{-}op}$ for ASD

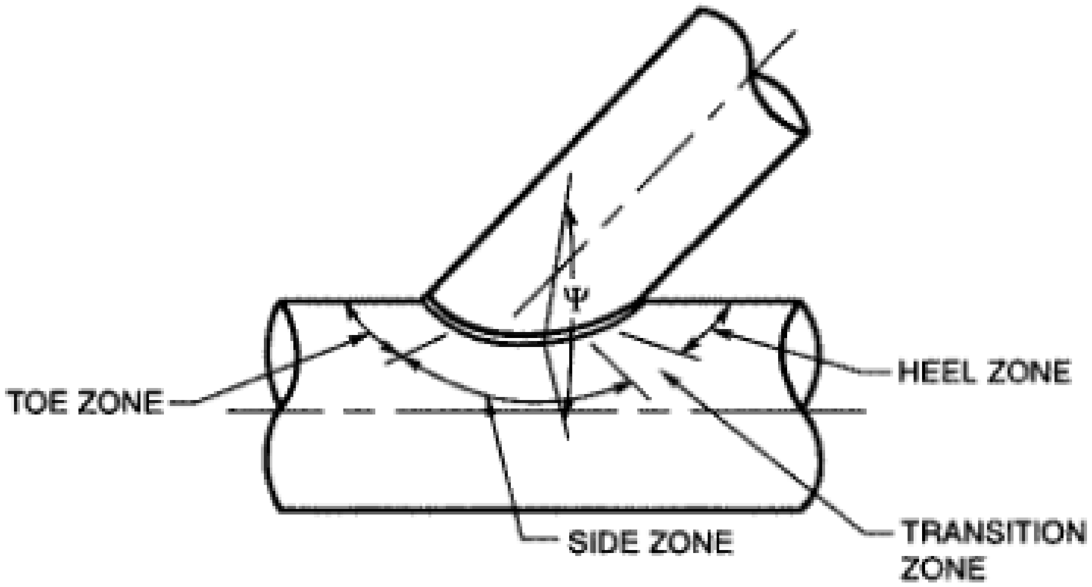


(a) Chord wall plastification.

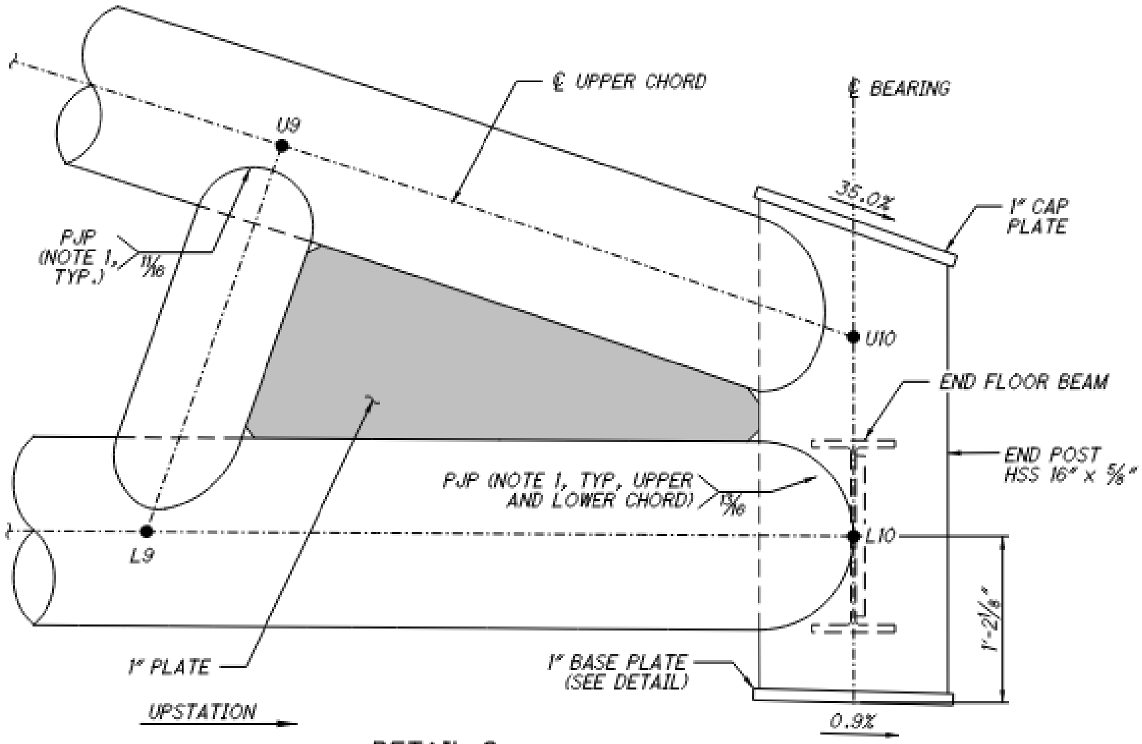


(b) Shear yielding (punching) of the chord.

- Welding of tubular members is not covered in AWS D1.2 (Bridge Welding Code)
- Requirements are in chapter 9 of AWS D1.1 (Structural Welding Code)
- Figure 9.11 deals with PJP welds of tubular members



(A) CIRCULAR CONNECTION



DETAIL C

NOTES:

1. PARTIAL PENETRATION GROOVE WELDS BETWEEN TUBULAR MEMBERS SHALL BE PERFORMED ACCORDING TO AWS D1.1 (2015) FIGURE 9.11. SEE GENERAL NOTES FOR ADDITIONAL WELDING AND TESTING REQUIREMENTS.

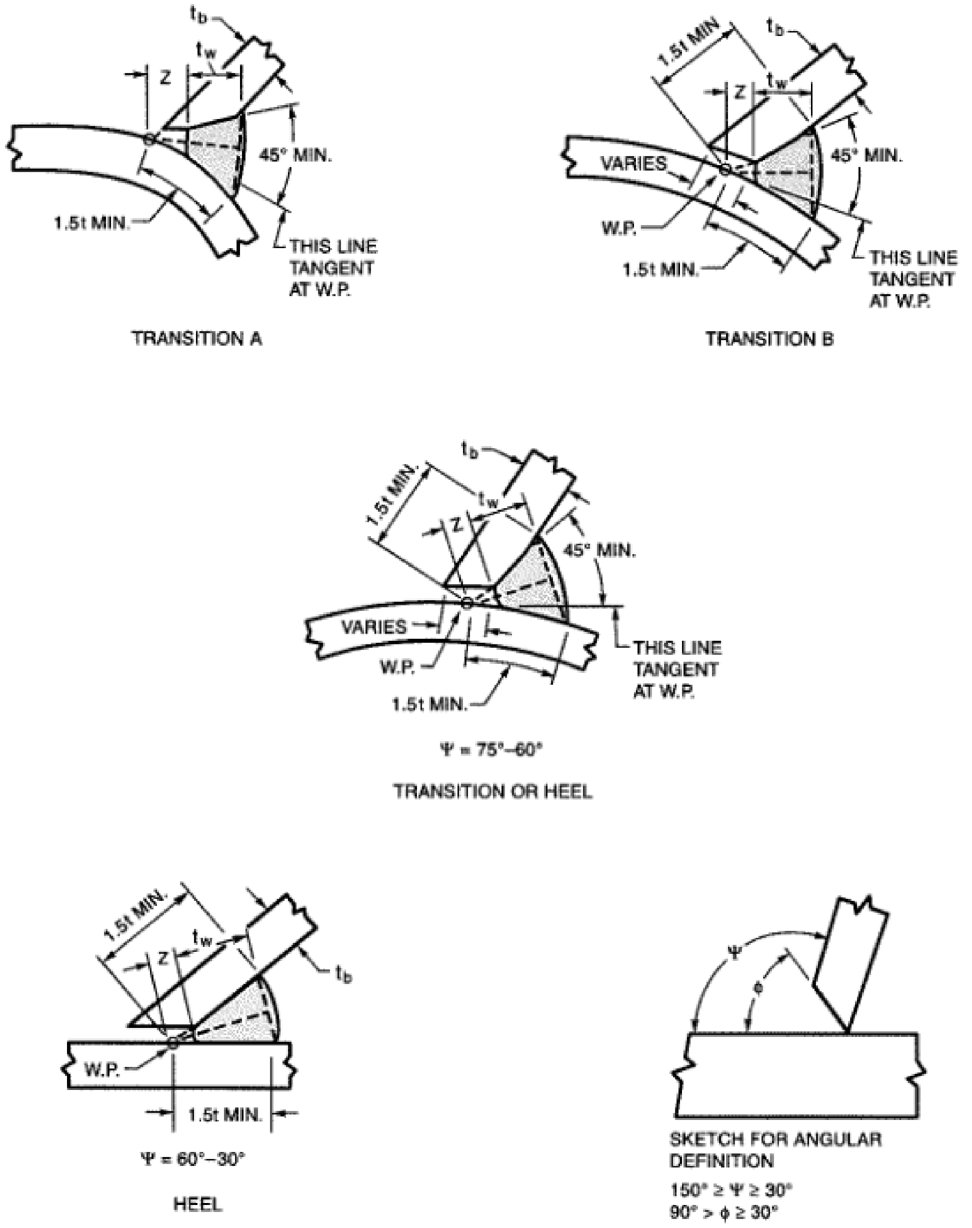
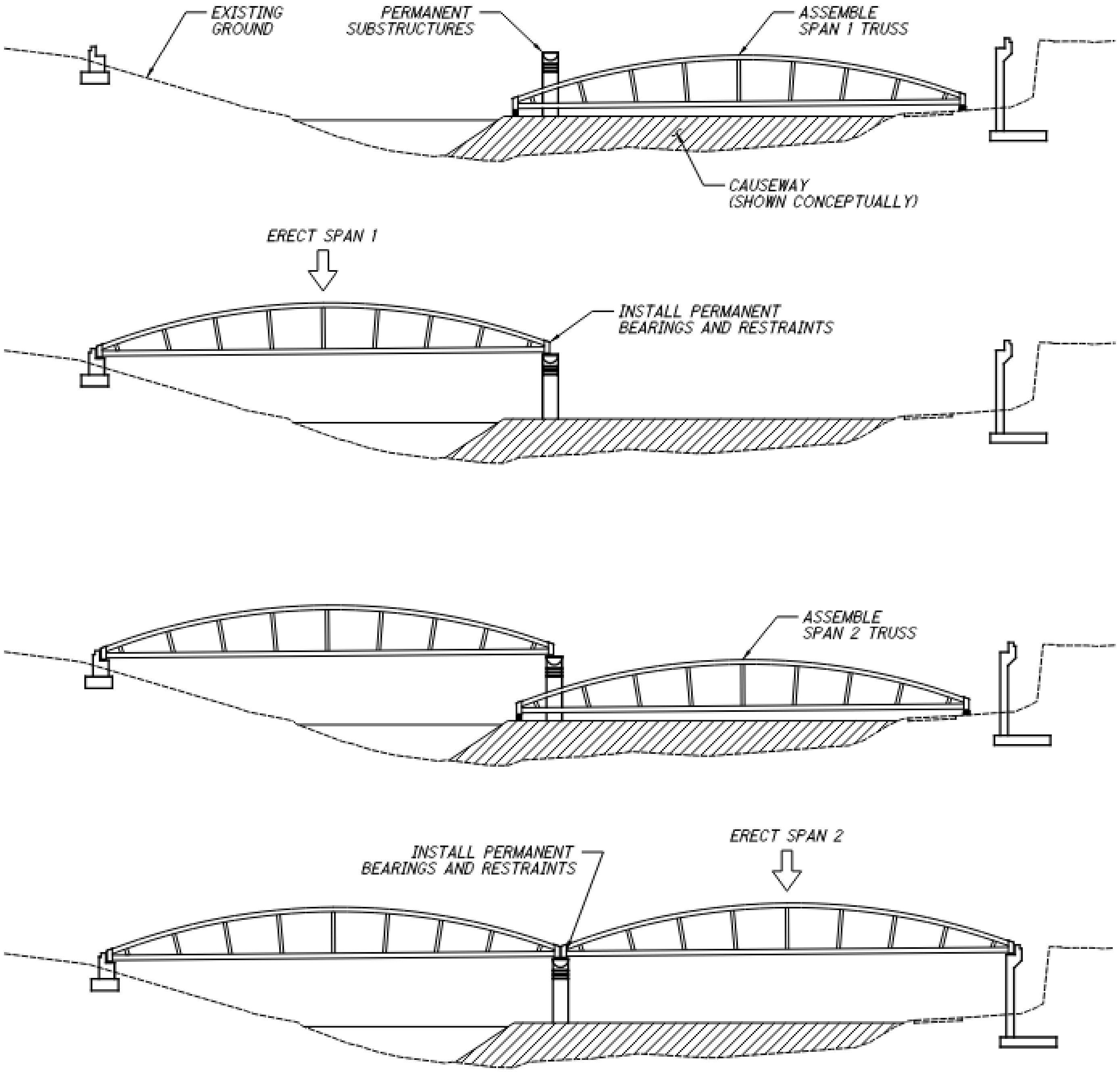


Figure 9.11 (Continued)—Prequalified Joint Details for PJP T-, Y-, and K-Tubular Connections (see 9.10.1)

- Trusses would be assembled on the ground, lifted into place as a unit
- Temporary lateral bracing is required for the lift, to carry wind loads until the deck is placed
- Contractor had the option to place the deck forms before erecting the truss




GORBEL
2 TON
HOBART


AF 120
ANDERSON
WENNING
AF 120


GROVE
OVERSIZED LOAD
CAT
CAT
24562


WLL 80,000 LB


CAPITAL CITY
CAPITAL CITY


MACK
578
CAUTION


COLUMBUS


COLUMBUS


Confluence Park now Astor Park

Questions?

Bridge	$1.76 M
Lighting	$0.26 M
Total Project	$2.63 M