

PRECAST CONCRETE BOX CULVERTS

Discussion Items:

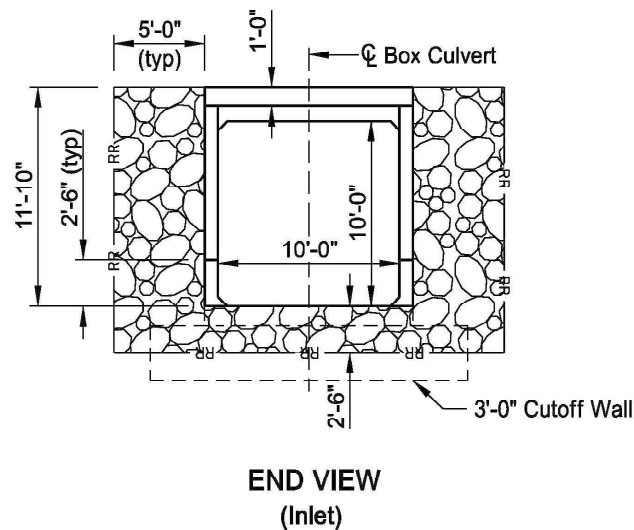
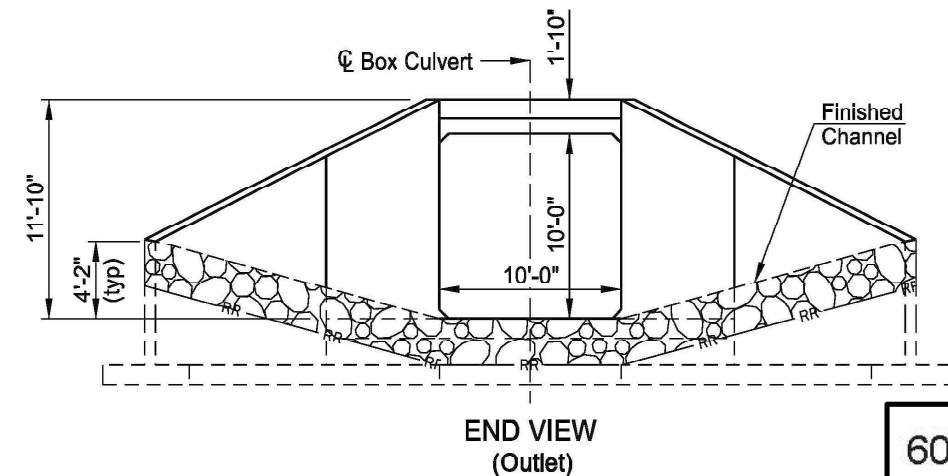
- Design & Detail Changes
- End Section Design & Details
- Use of Embedded Lift Anchors
- Use of Single Cell vs. Double Cell Boxes
- Skewed Box Culvert End Section Details
- Fill Placement Between Adjacent Barrels
- Box Culvert Backfill Details

Jeff Rensch, PE
NDDOT BRIDGE DESIGN SECTION



PRECAST CONCRETE BOX CULVERTS DESIGN & DETAIL CHANGES

PAST PRACTICE – Contractor/Fabricator Design & Rating



606 PRECAST BOX CULVERT DESIGN: Design the box culvert and box culvert end sections in accordance with the AASHTO LRFD Bridge Design Specifications, 9th Edition. Design for HL-93 live load and a fill height of 17 ft over the box culvert.

Load rate the box culvert in accordance with both the NDDOT Load Rating Manual and the AASHTO Manual for Bridge Evaluation, 2018 Edition, incorporating the latest Interim Revisions. Provide a box culvert design to achieve a rating factor greater than or equal to 1.0 for the design, legal, and permit trucks at the specified fill height.

Include with the work drawing submittals a Load Rating Report sealed by a ND registered PE, and an AASHTOWare BrR Model of the structure in XML format.

PRECAST CONCRETE BOX CULVERTS

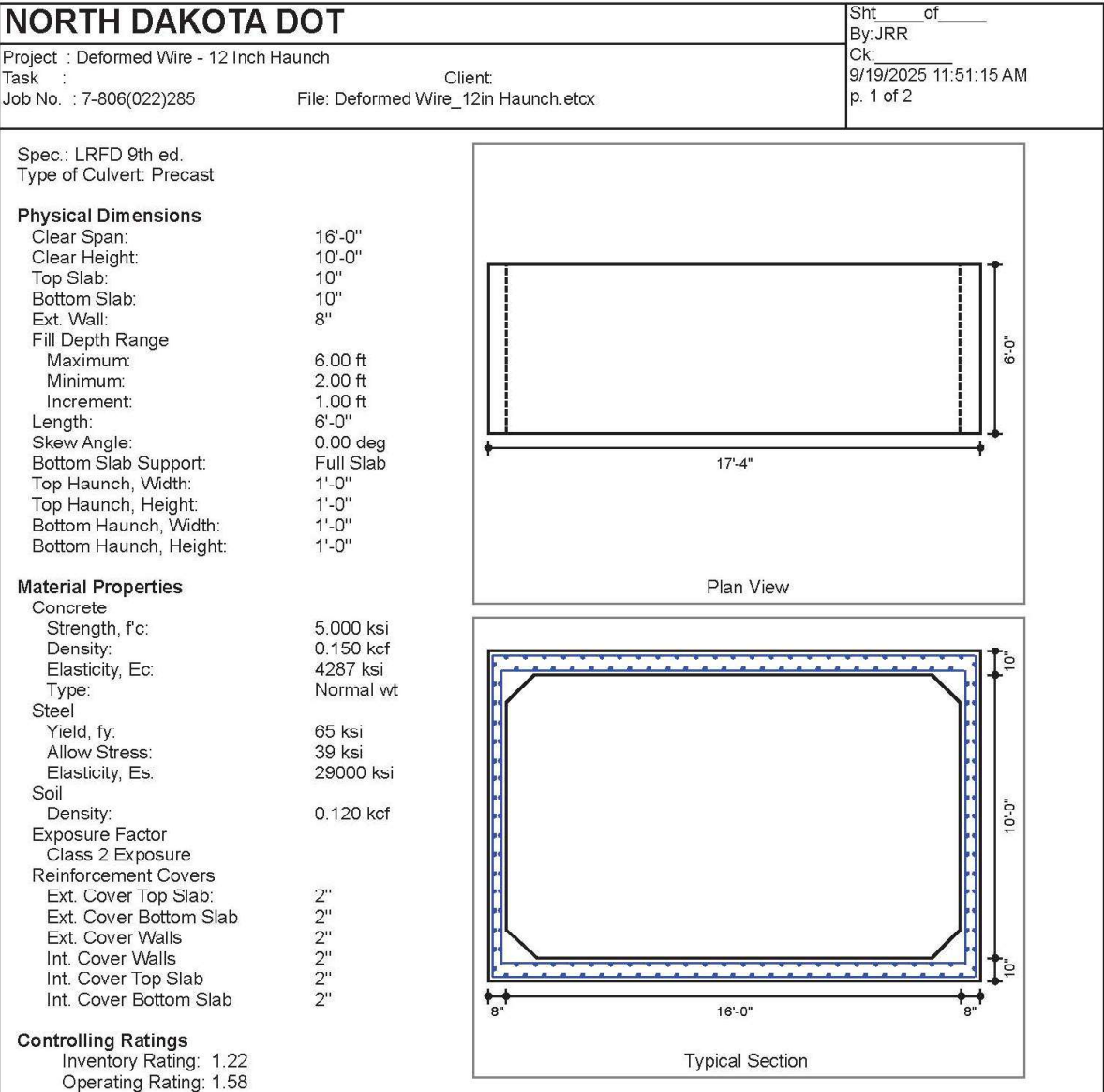
DESIGN & DETAIL CHANGES

NEW PROCESS

Nearing Completion for 3 Internal Projects

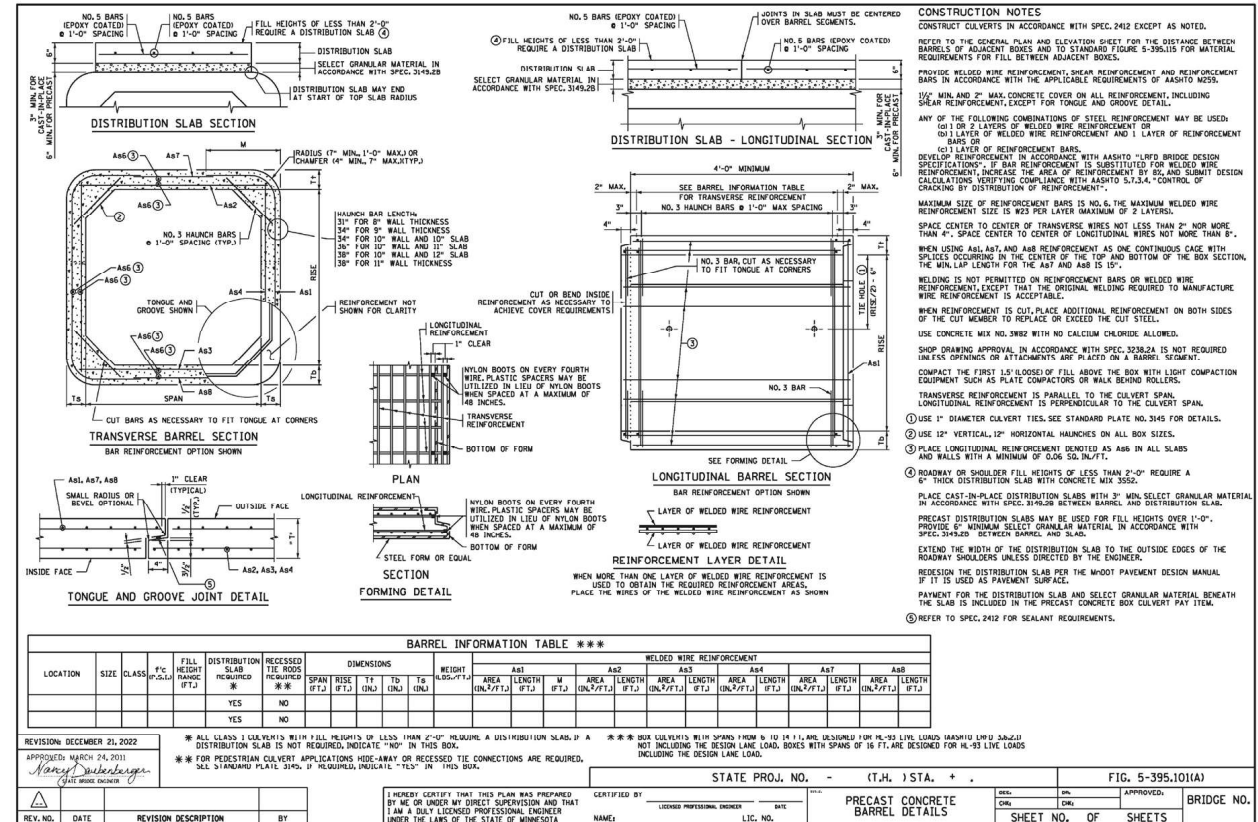
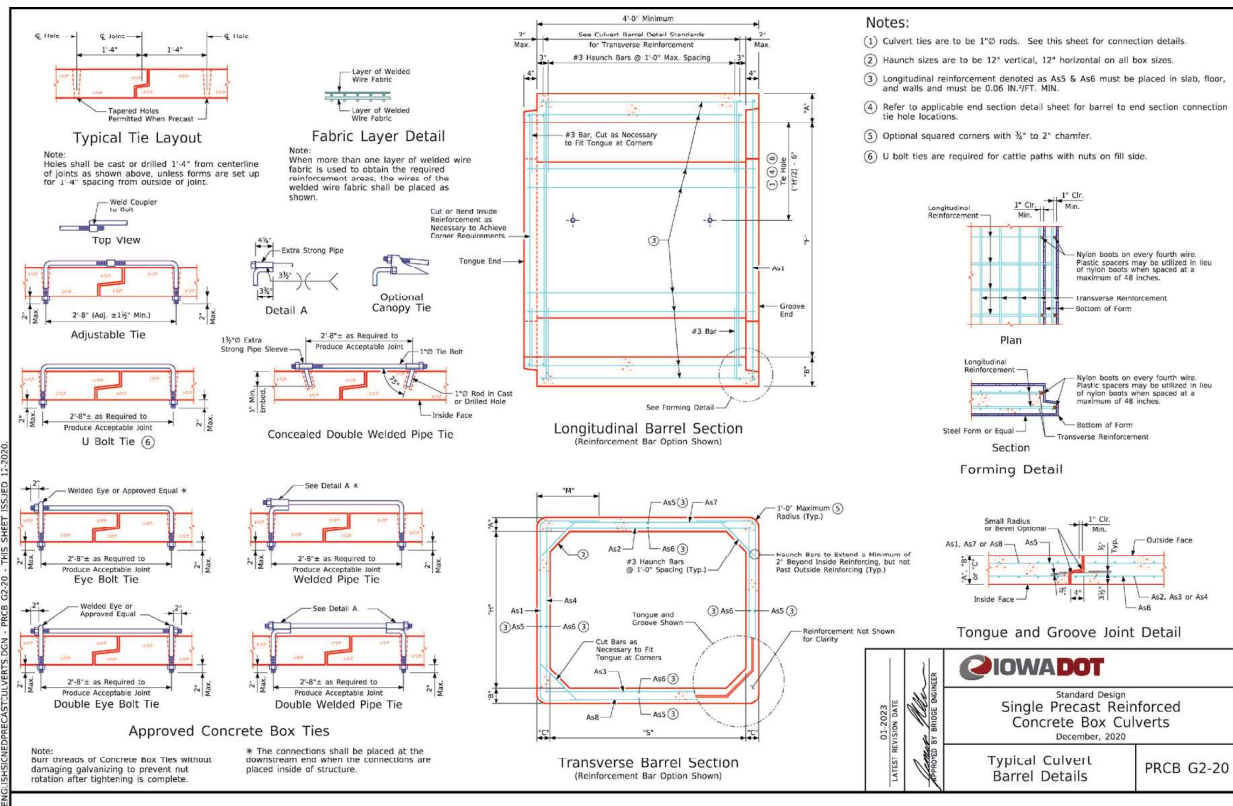
Full Design & Rating by EOR for Contract Plans

- Design per AASHTO LRFD 9th Ed.
- Utilizing Eriksson Culvert Design Software
- Fill Ht. Range used for Design listed on the Plans
- Design for Concrete $f'_c = 5$ ksi
Increase to 6 ksi if required for shear
- Design utilizing WWR with $f_y = 65$ ksi
- Design for soil density = 120 pcf
Min $E_H = 30$ pcf
Max $E_H = 60$ pcf



NEW PROCESS

- MnDOT & IaDOT used as References



NORTH
Dakota | Transportation
Be Legendary.

PRECAST CONCRETE BOX CULVERTS

DESIGN & DETAIL CHANGES

23 U.S.C. § 407 Documents
NDDOT Reserves All Objections

STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	SS-7-806(022)285	170	4

NOTES:

Provide Grade 65 welded wire reinforcement conforming to AASHTO M 336. The maximum wire size per layer is D25 or W25. Provide a maximum of 2 layers of welded wire reinforcement. If 2 layers of welded wire reinforcement are used to obtain the required area of reinforcement, place the layers as shown in the "Reinforcement Layer Detail."

Provide Grade 80 reinforcement meeting Section 612 for any bar reinforcement incorporated into the structure. Do not exceed size 6 bar reinforcement within the structure.

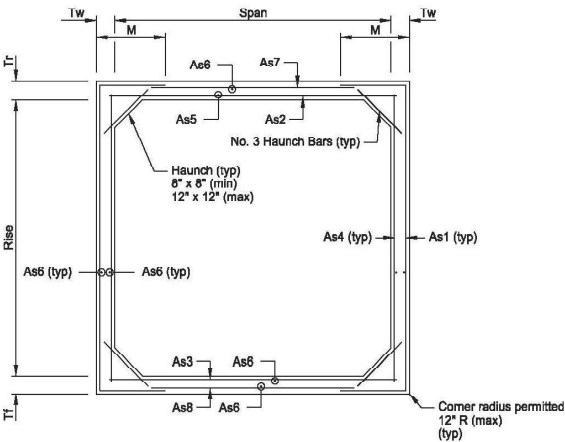
Provide 1½" minimum concrete cover on all reinforcement except for as detailed in the "Tongue and Groove Joint Detail."

If bar reinforcement is substituted for welded wire reinforcement, increase the area of reinforcement by 8% and submit design calculations verifying compliance with AASHTO 5.7.3.4 "Control of Cracking by Distribution Reinforcement."

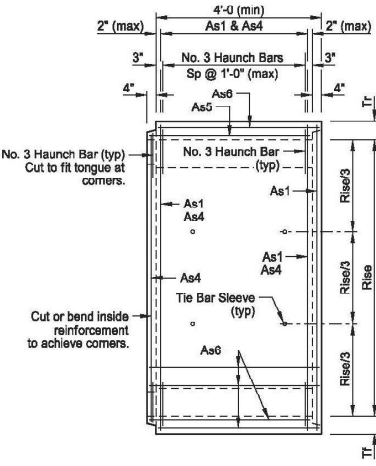
Develop reinforcement in accordance with AASHTO LRFD Bridge Design Specifications.

Space transverse wires not greater than 4" nor less than 2" measured center to center. Space longitudinal wires not greater than 8" nor less than 4" measured center to center.

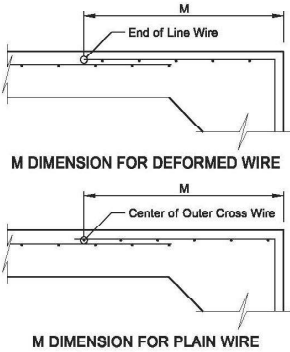
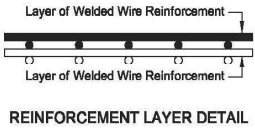
The M dimension shown is designated to the end of line wire for deformed welded wire reinforcement and to the center of the outermost cross wire for plain welded wire reinforcement. Adjust the length of As1 steel provided to ensure the minimum M dimension is provided. See details on this sheet.



TRANSVERSE BARREL SECTION

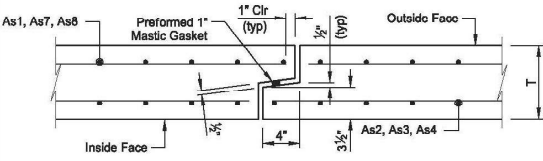


LONGITUDINAL BARREL SECTION

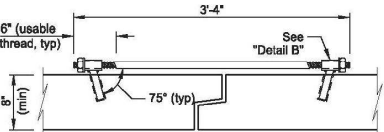


BARREL INFORMATION TABLE																						
STRENGTH F _C (KSI)	FILL HEIGHT RANGE (F)	DIMENSIONS					WEIGHT (LBS/FT)	WELDED WIRE REINFORCEMENT														
								As1			As2		As3		As4		As5	As6	As7		As8	
		SPAN	RISE	T _r	T _f	T _w		A _{HEA} (IN ² /FT)	LENGTH	M	A _{HEA} (IN ² /FT)	LENGTH	A _{HEA} (IN ² /FT)	LENGTH	A _{HEA} (IN ² /FT)	LENGTH	A _{HEA} (IN ² /FT)	A _{HEA} (IN ² /FT)	LENGTH	A _{HEA} (IN ² /FT)	LENGTH	
5.00	2-6	16'-0"	10'-0"	10"	10"	8"	6635	0.81	18'-4"	3'-7"	1.29	18'-6"	1.35	18'-6"	0.2	10'-6"	0.08	0.08	0.24	13'-4"	0.24	13'-4"

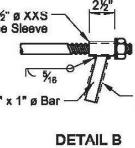
The information provided in the Barrel Information Table assumes square corners, 12" x 12" haunches, and concrete density of 150 pcf.



TONGUE AND GROOVE JOINT DETAIL



HIDDEN TIE BAR DETAIL



DETAIL B

This drawing is preliminary and not for construction or implementation purposes.

TOBACCO GARDEN CREEK	
BARREL SECTION & REINFORCING STEEL TABLE	
DRAWING NO.	1806-300.993-4

NDDOT BARREL DETAIL SHEET

- Intend to continue to permit flexibility
- Shop Dwg submittal still required
- Deviations from Plan details will be handled with Shop Dwg review

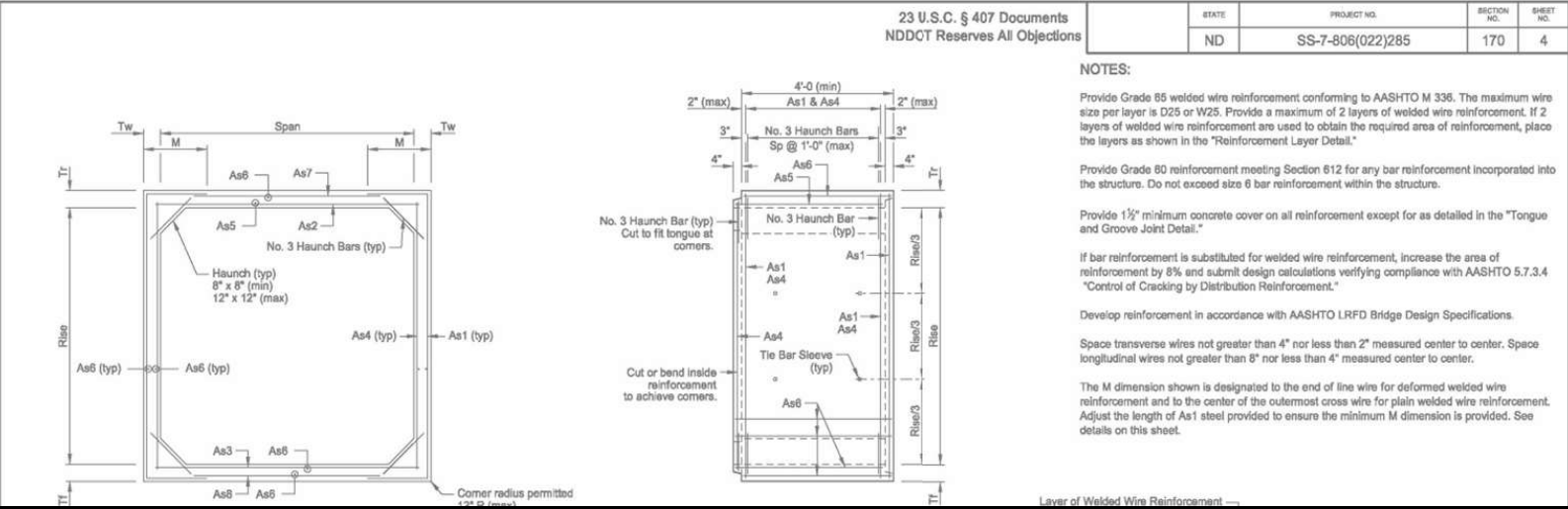
NORTH
Dakota

Transportation

Be Legendary.

PRECAST CONCRETE BOX CULVERTS

DESIGN & DETAIL CHANGES

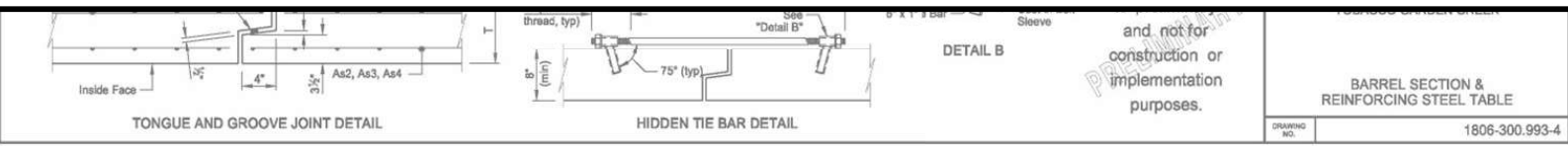


BARREL INFORMATION TABLE

- Req'd Concrete Design Strength
- Design Fill Height Range
- Min Thickness of Top Slab, Bottom Slab, & Walls
- Min Req'd Reinf Area & Length (WWR)

BARREL INFORMATION TABLE																						
STRENGTH f _c (KSI)	FILL HEIGHT RANGE (FT)	DIMENSIONS					WEIGHT (LBS/FT)	WELDED WIRE REINFORCEMENT														
								As1			As2		As3		As4		As5	As6	As7		As8	
		SPAN	RISE	Tr	Tf	Tw		AREA (IN2 / FT)	LENGTH	M	AREA (IN2 / FT)	LENGTH	AREA (IN2 / FT)	LENGTH	AREA (IN2 / FT)	LENGTH	AREA (IN2 / FT)	AREA (IN2 / FT)	AREA (IN2 / FT)	LENGTH	AREA (IN2 / FT)	LENGTH
5.00	2 - 6	16'- 0"	10'- 0"	10"	10"	8"	6635	0.81	18'- 4"	3'- 7"	1.29	16'- 6"	1.35	16'- 6"	0.2	10'- 6"	0.06	0.06	0.24	13'- 4"	0.24	13'- 4"

The information provided in the Barrel Information Table assumes square corners, 12" x 12" haunches, and concrete density of 150 pcf.



PRECAST CONCRETE BOX CULVERTS DESIGN & DETAIL CHANGES

23 U.S.C. § 407 Documents

STATE

PROJECT NO.

SECTION NO.

SHEET NO.

NOTES:

Provide Grade 65 welded wire reinforcement conforming to AASHTO M 336. The maximum wire size per layer is D25 or W25. Provide a maximum of 2 layers of welded wire reinforcement. If 2 layers of welded wire reinforcement are used to obtain the required area of reinforcement, place the layers as shown in the "Reinforcement Layer Detail."

Provide Grade 60 reinforcement meeting Section 612 for any bar reinforcement incorporated into the structure. Do not exceed size 6 bar reinforcement within the structure.

Provide 1½" minimum concrete cover on all reinforcement except for as detailed in the "Tongue and Groove Joint Detail."

If bar reinforcement is substituted for welded wire reinforcement, increase the area of reinforcement by 8% and submit design calculations verifying compliance with AASHTO 5.7.3.4 "Control of Cracking by Distribution Reinforcement."

Develop reinforcement in accordance with AASHTO LRFD Bridge Design Specifications.

Space transverse wires not greater than 4" nor less than 2" measured center to center. Space longitudinal wires not greater than 8" nor less than 4" measured center to center.

The M dimension shown is designated to the end of line wire for deformed welded wire reinforcement and to the center of the outermost cross wire for plain welded wire reinforcement. Adjust the length of As1 steel provided to ensure the minimum M dimension is provided. See details on this sheet.

BARREL NOTES

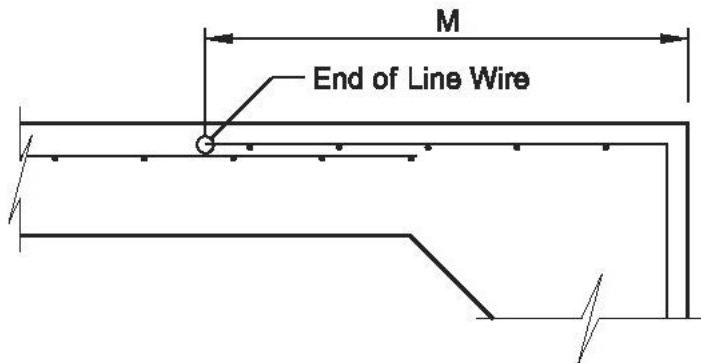
- Reinforcement Requirements
- Min Clear Cover = 1 ½"
- Substitution of Grade 60 rebar is permitted. 8% increase to area is required.
- Use of Plain Wire or Deformed Wire WWR is currently permitted.

NORTH
Dakota

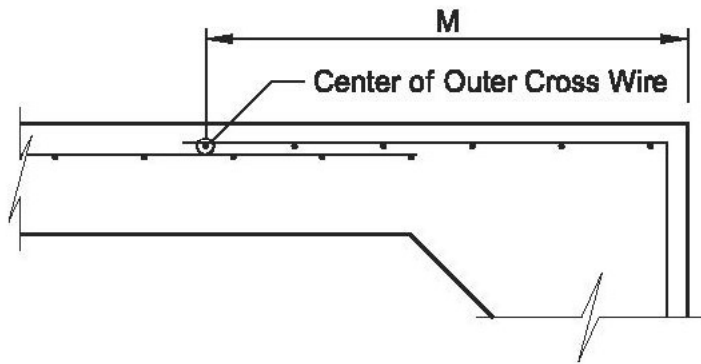
Be Legendary.

Transportation

PRECAST CONCRETE BOX CULVERTS DESIGN & DETAIL CHANGES



M DIMENSION FOR DEFORMED WIRE

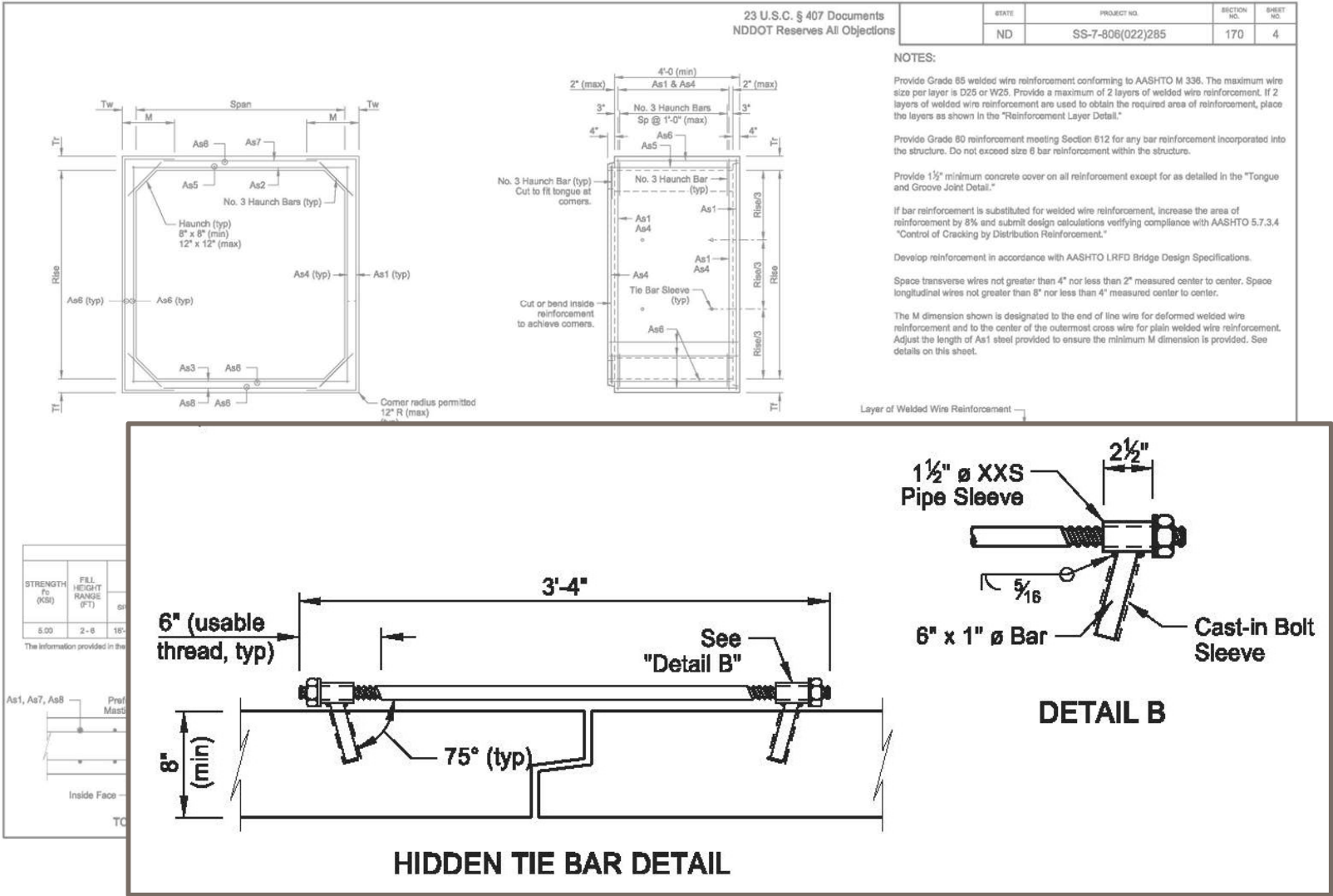


M DIMENSION FOR PLAIN WIRE

WWR: PLAIN WIRE vs DEFORMED WIRE

- Both are permitted to be used
- Development Length and Lap Length are calculated differently for each
- ACI 318 defines these lengths differently:
 - Deformed Wire is defined to end of Line Wire
 - Plain Wire is defined to center of outermost Cross Wire
- This difference affects M-Dimension and length of AS1 reinforcement
- Neither MnDOT nor IaDOT appear to address this distinction
- NDDOT process is to calculate required M-Dimension for both wire types and show the largest on the plans. Will then provide detail to define how the M-Dimension is intended to be measured.
- Will require adjustment to length of AS1 steel required if Plain Wire is used.
- Open to feedback and suggestions from Fabricators.

PRECAST CONCRETE BOX CULVERTS DESIGN & DETAIL CHANGES



Box Culvert Tie Detail

- Hidden Tie detail required for box culverts
- Requirement for tack weld was eliminated
- Requirement to provide lock washer or upset threads after installation will also be eliminated

PRECAST CONCRETE BOX CULVERTS DESIGN & DETAIL CHANGES

		23 U.S.C 407 NDDOT Reserves All Objections	STATE	PROJECT NO.	SECTION NO.	SHEET NO.
			ND	SS-7-806(022)285	170	2

NOTES

100

SCOPE OF WORK: Work at this site consists of removing an existing structure and building a new quad barrel 16' x 10' precast concrete box culvert.

202

REMOVAL OF STRUCTURE: The existing structure was constructed in 1979 as a two-span, prestressed concrete T-beam bridge with an overall length of 72 ft and a clear roadway width of 32 ft. Include all work required to remove the bridge, guardrail, and timber piling to 1 ft below foundation fill in the contract unit price for "Removal of Structure."

606

JOINTS: Provide joints in accordance with Section 606.E.3, with the exception that a 12" minimum width waterproof membrane is allowable around the exterior surfaces of the box culvert walls and roof. Tie all joints in accordance with the details provided in the plans.

606

PRECAST COMPONENTS: Provide lift anchors designed to safely lift, handle, ship, and place precast components. Holes cast through the roof, floor, or walls of the precast components will not be permitted unless the weight of components exceed the rated capacity of industry available lift anchor systems. If lift holes are required due to segment weight, plug all lift holes after installation with polymer plugs and seal the outside of the precast component using 12" x 12" min sized waterproof membrane centered on each lift hole. Galvanize all lift anchors or lift hole pipe sleeves permanently incorporated into precast concrete components in accordance with Section 854.

606

PRECAST SECTION DESIGN: The precast concrete structure has been detailed to utilize 4 single lines of precast barrel segments and end sections. Substitution of precast double barrel segments will not be permitted for this project.

The Barrel Information Table provided in the plans lists the minimum required dimensions and reinforcement. Alternate designs using dimensions or reinforcement areas less than those listed in the table will not be permitted. Substitution of precast segments using roof, floor, or wall thicknesses larger than those listed in the table will be permitted with approval by the Engineer.

606

PRECAST END SECTIONS. Fabricate and install the precast cutoff walls at the outlet end of the structure with a stagger matching the detail shown in the plans. Transverse (perpendicular to the flow line) and longitudinal (parallel to the flow line) components are required to form a complete cutoff wall. Provide a system to connect the cutoff walls at the end sections using ¾" min diameter rebar dowels spaced at 2'-0" max.

Fabricate and install the precast parapet wall at the outlet end of the structure with the layout shown on the plans. Provide a system to connect the parapet wall to the structure using ¾" min diameter rebar dowels spaced at 2'-0" max.

Include all costs to fabricate and install the cutoff wall and parapet in the price bid for Precast RCB End Sections.

606

PRECAST SEGMENT LAYOUT: Provide a distance of 1'-0" between separate precast units. Fill the gap between sections with a controlled density backfill consisting of cement, water, pozzolanic materials, and aggregate per the mix design provided. Use material that is fluid on placement to flow around and fill voids in the backfill area. The mix design yields approximately one cubic yard of controlled density backfill. Mix the material continuously during pumping or placement to keep the solution from separating.

Mix Design:

Material	Weight
Cement	175 lbs
Fly Ash	175 lbs
Water	375 lbs (45 gallons)
Fine Aggregate	2600 lbs

Include all costs to furnish and place the controlled density backfill in the price bid for Precast RCB Culvert.

The Barrel Information Table provided in the plans lists the minimum required dimensions and reinforcement. Alternate designs using dimensions or reinforcement areas less than those listed in the table will not be permitted. Substitution of precast segments using roof, floor, or wall thicknesses larger than those listed in the table will be permitted with approval by the Engineer.

606 PRECAST SECTION DESIGN

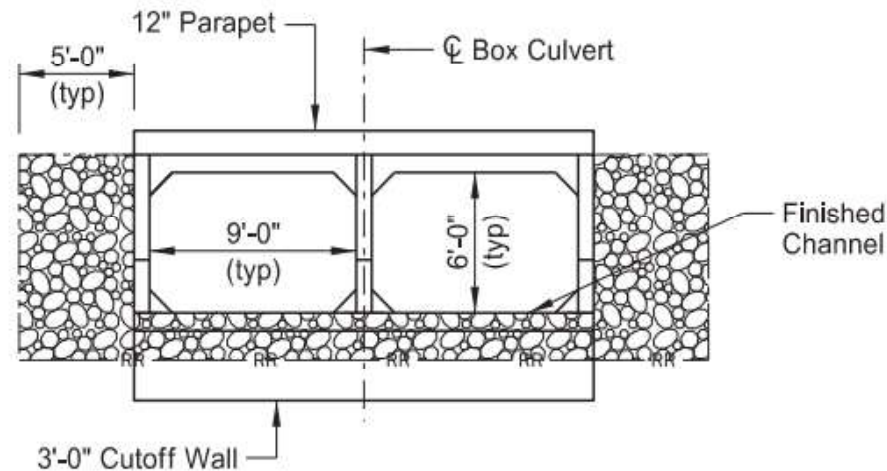
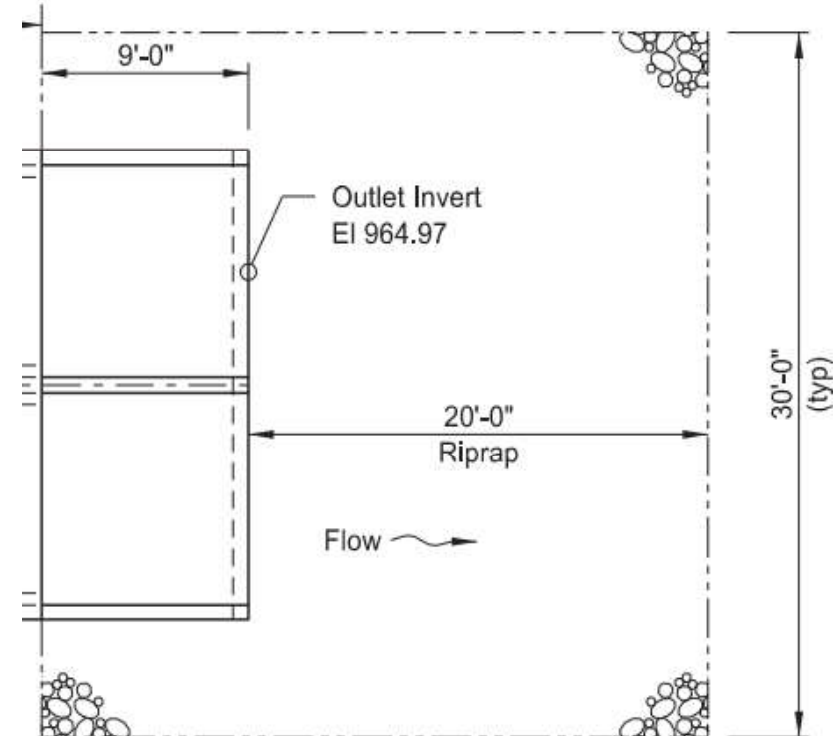
- Member thickness and/or reinforcement areas less than shown in the plans will not be permitted.
- Use of reinforcement areas larger than shown on the plans will be permitted.
- Use of member thicknesses larger than shown on the plans will be permitted with approval by the Engineer. May require additional steel to meet min reinforcement requirements.

The Barrel Information Table provided in the plans lists the minimum required dimensions and reinforcement. Alternate designs using dimensions or reinforcement areas less than those listed in the table will not be permitted. Substitution of precast segments using roof, floor, or wall thicknesses larger than those listed in the table will be permitted with approval by the Engineer.

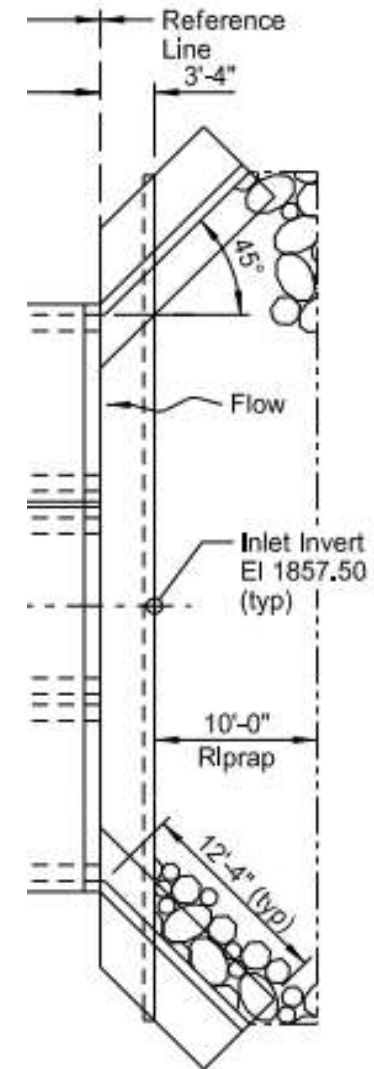
PRECAST CONCRETE BOX CULVERTS END SECTION DESIGN & DETAILING

FLARED WINGS vs PARALLEL WINGS

- NDDOT has already moved to use of parallel wings for most situations:
 - Easier to fabricate
 - Easier to install
 - Easier to extend in the future
- Flared wings are still needed and specified for unique situations.



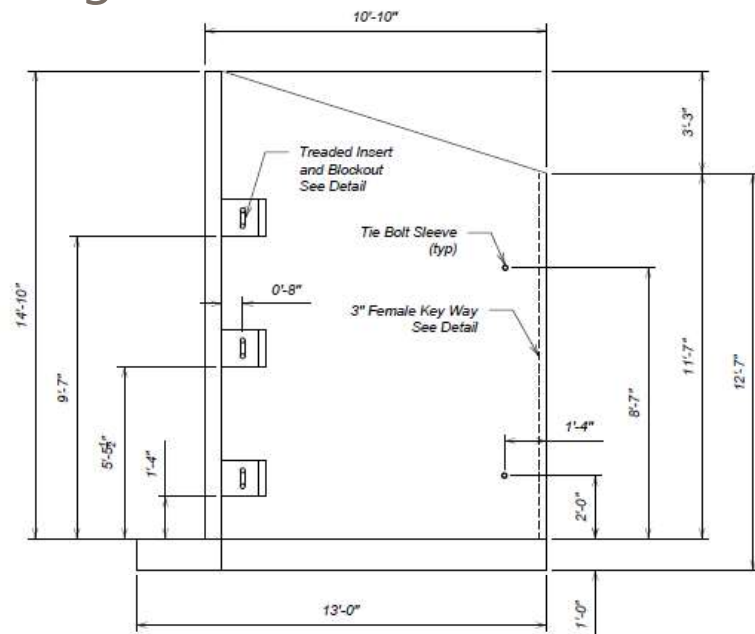
END VIEW



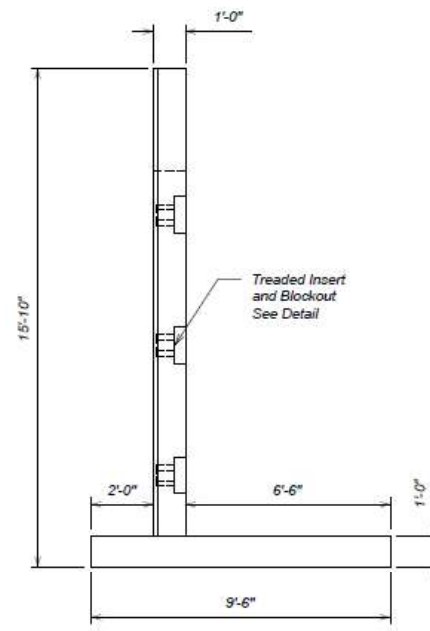
PRECAST CONCRETE BOX CULVERTS END SECTION DESIGN & DETAILING

FLARED WINGS

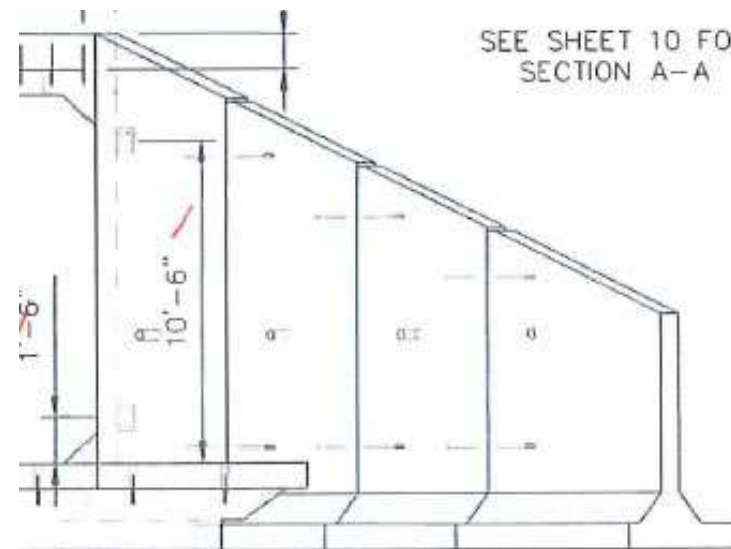
- Different Fabricators use different systems.
- This will still be permitted
- Flared wings will not be designed and detailed in the Contract Plans
- Fabricator design will still be required
- Intend to develop a Special Provision to provide better design guidance to be followed in the future



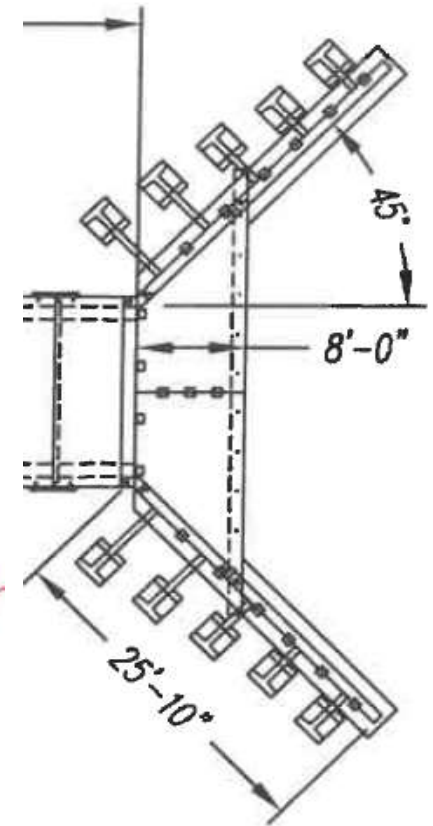
ELEVATION VIEW



SIDE ELEVATION VIEW



SEE SHEET 10 FOR
SECTION A-A



PRECAST CONCRETE BOX CULVERTS EMBEDDED LIFT ANCHORS

- Use of embedded lift anchors is preferred
- May be situations that still require the use of lift holes.
- Use of holes cast through the box for lifting will still be permitted
- In either case, steel components cast into the box culvert will need to be galvanized.



PRECAST CONCRETE BOX CULVERTS

EMBEDDED LIFT ANCHORS

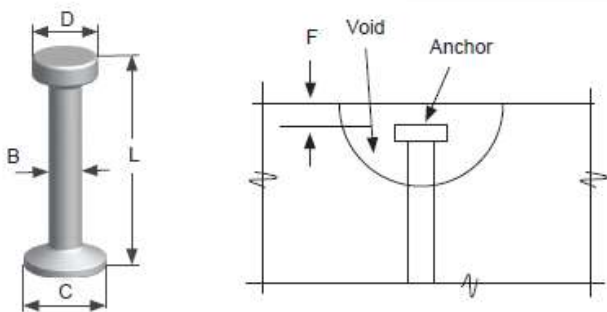
GENERAL TYPES

- CONAC A-ANCHORS
- CONAC DR-ANCHORS
- Other systems available
- Capacity appears to be limited by top slab thickness

DR System

DR Anchors

Economical and effective method for backstripping or face lifting in tension. The system code is stamped on the head of each anchor to match with the correct lifting unit. Stocked in hot dip galvanized; mill finish available on request.



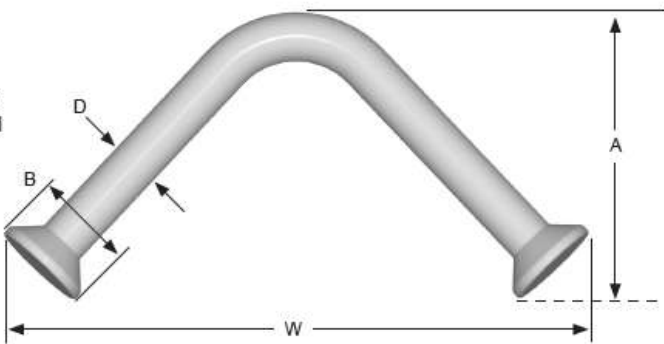
Lifting Systems

A-Anchor System



14 and 18 MM A-Anchors

CONAC A-Anchors are available in standard finish galvanized and self color.



ITEM CODE	SLAB MIN. THICKNESS	SWL TENSION	SWL AT 90° SHEAR	END DISTANCE
4CA12	4"	2600	4000	9"
4CA14	4"	3500	5400	9"
5CA14	5"	5500	8500	10"
5CA18	5"	6000	9300	10"
6CA14	6"	6500	10100	12-1/2"
6CA18	6"	7500	11600	12-1/2"
8CA18	8"	13000	20000	15-1/2"

Note: Safe working loads based on approximate 4:1 safety factor with a minimum concrete strength of 4,000 psi. For use as pulling iron load may be increased by up to 33% with a Safety Factor of 3:1.

ITEM CODE	DEPTH (A)	ANCHOR WIDTH (W)	BODY DIA. (D)	BASE DIA. (B)	PANEL DEPTH
4CA12	3-1/4"	5-1/8"	1/2"	1-3/16"	4"
4CA14	3-1/8"	6-5/16"	9/16"	1-3/16"	4"
5CA14	3-3/4"	8-1/4"	9/16"	1-3/16"	5"
5CA18	3-3/4"	8-11/16"	11/16"	2"	5"
6CA14	4-3/4"	10-9/16"	9/16"	1-9/16"	6"
6CA18	4-3/4"	9-1/16"	11/16"	2"	6"
8CA18	6-3/4"	12-1/4"	11/16"	2"	8"

CONAC A-Anchors are available in Stainless Steel 316 upon request.

PRECAST CONCRETE BOX CULVERTS EMBEDDED LIFT ANCHORS

LIFT ANCHOR CAPACITY

- Design guidance appears to assume 4 lift points, with only 3 engaged and utilized for lift capacity check.
- Varies by anchor – appears the SWL for many lift anchors installed into a 10" slab is generally 8 tons or less
- **NDDOT will NOT be providing design or details for lift anchors in the plans. SWL for any system utilized will have to be checked by Fabricator.**
- NDDOT intends to provide the plan note shown.

606 PRECAST COMPONENTS: Provide lift anchors designed to safely lift, handle, ship, and place precast components. Holes cast through the roof, floor, or walls of the precast components will not be permitted unless the weight of components exceed the rated capacity of industry available lift anchor systems. If lift holes are required due to segment weight, plug all lift holes after installation with polymer plugs and seal the outside of the precast component using 12" x 12" min sized waterproof membrane centered on each lift hole. Galvanize all lift anchors or lift hole pipe sleeves permanently incorporated into precast concrete components in accordance with Section 854.

PRECAST CONCRETE BOX CULVERTS

LIFT HOLES

LIFT HOLE REQUIREMENTS

- Lift Holes to be plugged with polymer plugs
- Install waterproof membrane after plugging
- All components to be galvanized

606 PRECAST COMPONENTS: Provide lift anchors designed to safely lift, handle, ship, and place precast components. Holes cast through the roof, floor, or walls of the precast components will not be permitted unless the weight of components exceed the rated capacity of industry available lift anchor systems. If lift holes are required due to segment weight, plug all lift holes after installation with polymer plugs and seal the outside of the precast component using 12" x 12" min sized waterproof membrane centered on each lift hole. Galvanize all lift anchors or lift hole pipe sleeves permanently incorporated into precast concrete components in accordance with Section 854.



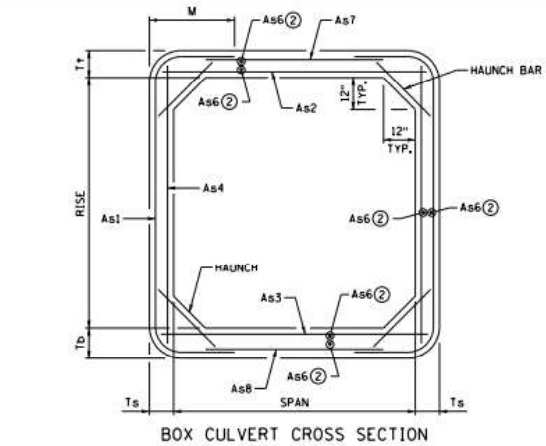
PRECAST CONCRETE BOX CULVERTS

FUTURE CHANGES

FUTURE STEPS

- Provide Design Guide to Consultants for future NDDOT and Local Projects. Wish to standardize the process for all future projects.
- Likely to see a mix of projects in future bid lettings until process is finalized and guidance can be distributed for use.
- Ultimate goal is to develop standard designs for single cell precast concrete box culverts. No timeline for development.

								REINFORCEMENT REQUIREMENTS ①										
SIZE SPAN x RISE (ft.)	CLASS	f'c (psi)	FILL HEIGHT RANGE (ft.)	T+ (in.)	Tb (in.)	Ts (in.)	WEIGHT (lbs./ft.)	As1			As2		As3		As4		As7/As8	
								As	LENGTH	M	As	LENGTH	As	LENGTH	As	LENGTH	As	LENGTH
6x4	1	5000	<3	8	8	8	2575	0.29	10'-2"	2'-8"	0.36	6'-6"	0.30	6'-6"	0.20	4'-6"	0.20	4'-6"
	2	5000	3 - 9	8	8	8	2575	0.24	10'-2"	2'-8"	0.27	6'-6"	0.28	6'-6"	0.20	4'-6"	0.20	4'-6"
	3	5000	9 - 25	8	8	8	2575	0.52	10'-2"	2'-8"	0.59	6'-6"	0.60	6'-6"	0.20	4'-6"	0.20	4'-6"
6x5	1	5000	<3	8	8	8	2775	0.26	11'-2"	2'-8"	0.40	6'-6"	0.35	6'-6"	0.20	5'-6"	0.20	4'-6"
	2	5000	3 - 9	8	8	8	2775	0.22	11'-2"	2'-8"	0.30	6'-6"	0.31	6'-6"	0.20	5'-6"	0.20	4'-6"
	3	5000	9 - 25	8	8	8	2775	0.46	11'-2"	2'-8"	0.64	6'-6"	0.66	6'-6"	0.20	5'-6"	0.20	4'-6"
6x6	1	5000	<3	8	8	8	2975	0.24	12'-2"	2'-8"	0.43	6'-6"	0.39	6'-6"	0.20	6'-6"	0.20	4'-6"
	2	5000	3 - 9	8	8	8	2975	0.20	12'-2"	2'-8"	0.32	6'-6"	0.34	6'-6"	0.20	6'-6"	0.20	4'-6"
	3	5000	9 - 25	8	8	8	2975	0.41	12'-2"	2'-8"	0.67	6'-6"	0.69	6'-6"	0.20	6'-6"	0.20	4'-6"
8x4	1	5000	<3	9	10	8	3325	0.43	10'-8"	2'-10"	0.38	8'-6"	0.38	8'-6"	0.20	4'-6"	0.24	6'-3"
	2	5000	3 - 8	9	10	8	3325	0.36	10'-8"	2'-10"	0.35	8'-6"	0.36	8'-6"	0.20	4'-6"	0.24	6'-3"
	3	5000	8 - 17	9	10	8	3325	0.59	10'-8"	2'-10"	0.60	8'-6"	0.61	8'-6"	0.20	4'-6"	0.24	6'-3"
	4	5000	17 - 25	9	10	8	3325	0.85	10'-8"	2'-10"	0.83	8'-6"	0.85	8'-6"	0.20	4'-6"	0.24	6'-8"
8x5	1	5000	<3	9	10	8	3525	0.38	11'-8"	2'-10"	0.42	8'-6"	0.43	8'-6"	0.20	5'-6"	0.24	6'-3"
	2	5000	3 - 8	9	10	8	3525	0.31	11'-8"	2'-10"	0.39	8'-6"	0.41	8'-6"	0.20	5'-6"	0.24	6'-3"
	3	5000	8 - 17	9	10	8	3525	0.51	11'-8"	2'-10"	0.65	8'-6"	0.68	8'-6"	0.20	5'-6"	0.24	6'-3"
	4	5000	17 - 25	9	10	8	3525	0.74	11'-8"	2'-10"	0.91	8'-6"	0.93	8'-6"	0.20	5'-6"	0.24	6'-4"
8x6	1	5000	<3	9	10	8	3725	0.35	12'-8"	2'-10"	0.46	8'-6"	0.47	8'-6"	0.20	6'-6"	0.24	6'-3"
	2	5000	3 - 8	9	10	8	3725	0.28	12'-8"	2'-10"	0.41	8'-6"	0.44	8'-6"	0.20	6'-6"	0.24	6'-3"
	3	5000	8 - 17	9	10	8	3725	0.46	12'-8"	2'-10"	0.69	8'-6"	0.72	8'-6"	0.20	6'-6"	0.24	6'-3"
	4	5000	17 - 25	9	10	8	3725	0.66	12'-8"	2'-10"	0.96	8'-6"	0.99	8'-6"	0.20	6'-6"	0.24	6'-3"
8x7	1	5000	<3	9	10	8	3925	0.31	13'-8"	2'-10"	0.49	8'-6"	0.51	8'-6"	0.20	7'-6"	0.24	6'-3"
	2	5000	3 - 8	9	10	8	3925	0.26	13'-8"	2'-10"	0.43	8'-6"	0.47	8'-6"	0.20	7'-6"	0.24	6'-3"
	3	5000	8 - 17	9	10	8	3925	0.42	13'-8"	2'-10"	0.72	8'-6"	0.75	8'-6"	0.20	7'-6"	0.24	6'-3"
	4	5000	17 - 25	9	10	8	3925	0.60	13'-8"	2'-10"	0.99	8'-6"	1.02	8'-6"	0.20	7'-6"	0.24	6'-3"
8x8	1	5000	<3	9	10	8	4125	0.29	14'-8"	2'-10"	0.52	8'-6"	0.54	8'-6"	0.20	8'-6"	0.24	6'-3"
	2	5000	3 - 8	9	10	8	4125	0.24	14'-8"	2'-10"	0.45	8'-6"	0.49	8'-6"	0.20	8'-6"	0.24	6'-3"
	3	5000	8 - 17	9	10	8	4125	0.39	14'-8"	2'-10"	0.73	8'-6"	0.77	8'-6"	0.20	8'-6"	0.24	6'-3"
	4	5000	17 - 25	9	10	8	4125	0.55	14'-8"	2'-10"	1.01	8'-6"	1.04	8'-6"	0.20	8'-6"	0.24	6'-3"
10x4	1	5000	<3	9	10	8	3800	0.66	10'-8"	2'-10"	0.50	10'-6"	0.48	10'-6"	0.20	4'-6"	0.24	8'-3"
	2	5000	3 - 7	9	10	8	3800	0.55	10'-8"	2'-10"	0.47	10'-6"	0.48	10'-6"	0.20	4'-6"	0.24	8'-3"
	3	5000	7 - 15	9	10	8	3800	0.90	10'-8"	2'-10"	0.78	10'-6"	0.79	10'-6"	0.20	4'-6"	0.24	8'-10"
	4	6000	15 - 25	10	10	8	3950	1.33	11'-9"	3'-4"	1.17	10'-6"	1.19	10'-6"	0.20	4'-6"	0.24	8'-11"
10x5	1	5000	<3	9	10	8	4000	0.59	11'-8"	2'-10"	0.56	10'-6"	0.54	10'-6"	0.20	5'-6"	0.24	8'-3"
	2	5000	3 - 7	9	10	8	4000	0.50	11'-8"	2'-10"	0.52	10'-6"	0.54	10'-6"	0.20	5'-6"	0.24	8'-3"
	3	5000	7 - 15	9	10	8	4000	0.79	11'-8"	2'-10"	0.86	10'-6"	0.88	10'-6"	0.20	5'-6"	0.24	8'-6"
	4	6000	15 - 25	10	10	8	4150	1.15	12'-3"	3'-1"	1.29	10'-6"	1.31	10'-6"	0.20	5'-6"	0.24	8'-11"
10x6	1	5000	<3	9	10	8	4200	0.54	12'-8"	2'-10"	0.61	10'-6"	0.59	10'-6"	0.20	6'-6"	0.24	8'-3"
	2	5000	3 - 7	9	10	8	4200	0.45	12'-8"	2'-10"	0.56	10'-6"	0.59	10'-6"	0.20	6'-6"	0.24	8'-3"
	3	5000	7 - 15	9	10	8	4200	0.71	12'-8"	2'-10"	0.92	10'-6"	0.94	10'-6"	0.20	6'-6"	0.24	8'-3"
	4	6000	15 - 25	10	10	8	4350	1.02	12'-10"	2'-10"	1.37	10'-6"	1.40	10'-6"	0.20	6'-6"	0.24	8'-11"
10x7	1	5000	<3	9	10	8	4400	0.50	14'-4"	3'-2"	0.66	10'-6"	0.63	10'-6"	0.20	7'-6"	0.24	7'-8"
	2	5000	3 - 7	9	10	8	4400	0.42	13'-8"	2'-10"	0.59	10'-6"	0.63	10'-6"	0.20	7'-6"	0.24	8'-3"
	3	5000	7 - 15	9	10	8	4400	0.65	13'-8"	2'-10"	0.97	10'-6"	1.00	10'-6"	0.20	7'-6"	0.24	8'-3"
	4	6000	15 - 25	10	10	8	4550	0.92	13'-9"	2'-10"	1.43	10'-6"	1.46	10'-6"	0.20	7'-6"	0.24	8'-8"
10x8	1	5000	<3	9	10	8	4600	0.46	14'-8"	2'-10"	0.69	10'-6"	0.66	10'-6"	0.20	8'-6"	0.24	8'-3"
	2	5000	3 - 7	9	10	8	4600	0.39	14'-8"	2'-10"	0.62	10'-6"	0.66	10'-6"	0.20	8'-6"	0.24	8'-3"
	3	5000	7 - 15	9	10	8	4600	0.60	14'-8"	2'-10"	1.00	10'-6"	1.04	10'-6"	0.20	8'-6"	0.24	8'-3"
	4	6000	15 - 25	10	10	8	4750	0.85	14'-9"	2'-10"	1.52	10'-6"	1.57	10'-6"	0.20	8'-6"	0.24	8'-5"
10x9	1	5000	<3	9	10	8	4800	0.43	15'-8"	2'-10"	0.73	10'-6"	0.70	10'-6"	0.20	9'-6"	0.24	8'-3"
	2	5000	3 - 7	9	10	8	4800	0.36	15'-8"	2'-10"	0.65	10'-6"	0.70	10'-6"	0.20	9'-6"	0.24	8'-3"
	3	5000	7 - 15	9	10	8	4800	0.56	15'-8"	2'-10"	1.03	10'-6"	1.07	10'-6"	0.20	9'-6"	0.24	8'-3"
	4	6000	15 - 25	10	10	8	4950	0.79	17'-1"	3'-6"	1.54	10'-6"	1.60	10'-6"	0.20	9'-6"	0.24	6'-11"
10x10	1	5000	<3	9	10	8	5000	0.42	16'-8"	2'-10"	0.77	10'-6"	0.74	10'-6"	0.20	10'-6"	0.24	8'-3"
	2	5000	3 - 7	9	10	8	5000	0.42	16'-8"	2'-10"	0.68	10'-6"	0.73	10'-6"	0.20	10'-6"	0.24	8'-3"
	3	5000	7 - 15	9	10	8	5000	0.56	18'-0"	3'-6"	1.05	10'-6"	1.09	10'-6"	0.22	10'-6"	0.24	6'-11"
	4	6000	15 - 25	10	11	9	5575	0.74	18'-4"	3'-7"	1.34	10'-6"	1.43	10'-6"	0.22	10'-6"	0.27	6'-11"

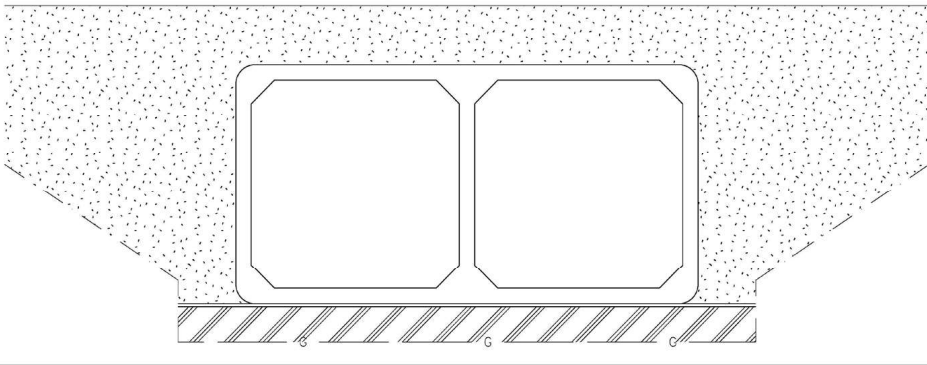


- GENERAL NOTES**
- SEE STANDARD FIG. 5-395.100(A) FOR BASIS OF DESIGN. FILL HEIGHT IS DEFINED AS THE DISTANCE FROM THE TOP OF THE CULVERT TO THE TOP OF THE PAVEMENT OR TO TOP OF FILL IF THERE IS NO PAVEMENT.
- DESIGNS FOR FILL HEIGHTS GREATER THAN SHOWN IN THE TABLES ARE AVAILABLE FROM THE MNDOT BRIDGE OFFICE.
- SEE STANDARD FIG. 5-395.101(A) AND FIG. 5-397.101(B) FOR ADDITIONAL INFORMATION. TRANSVERSE REINFORCEMENT IS PARALLEL TO THE CULVERT SPAN. LONGITUDINAL REINFORCEMENT IS PERPENDICULAR TO THE CULVERT SPAN.
- IF THE FILL HEIGHT RANGE EXTENDS INTO MORE THAN ONE CLASS, USE THE CLASS WITH THE LARGEST STEEL AREA. CHECK MAXIMUM AND MINIMUM FILL HEIGHTS OVER THE FULL AREA OF ROADWAY AND SHOULDERS.
- ROADWAY OR SHOULDER FILL HEIGHTS OF LESS THAN 2'-0" REQUIRE A DISTRIBUTION SLAB. EXTEND THE WIDTH OF THE DISTRIBUTION SLAB TO THE OUTSIDE EDGES OF THE ROADWAY SHOULDERS UNLESS DIRECTED BY THE ENGINEER.
- USE CONCRETE MIX 3552 FOR THE DISTRIBUTION SLAB.
- PLACE 6" THICK CAST-IN-PLACE DISTRIBUTION SLABS WITH NO. 5 BARS AT 1'-0" TRANSVERSELY AND NO. 5 BARS AT 1'-0" LONGITUDINALLY. EPOXY COAT ALL DISTRIBUTION SLAB REINFORCEMENT. CENTER DISTRIBUTION SLAB JOINTS OVER BARREL SEGMENTS. PROVIDE 3" MIN GRANULAR MATERIAL IN ACCORDANCE WITH SPEC. 3149.2B BETWEEN BARREL AND DISTRIBUTION SLAB.
- PRECAST DISTRIBUTION SLABS WITH THE SAME REINFORCEMENT MAY BE USED FOR FILL HEIGHTS OVER 1'-0". CENTER DISTRIBUTION SLAB JOINTS OVER BARREL SEGMENTS. PROVIDE 6" MIN GRANULAR MATERIAL IN ACCORDANCE WITH SPEC. 3149.2B BETWEEN BARREL AND DISTRIBUTION SLAB.
- REDESIGN DISTRIBUTION SLAB PER THE MNDOT PAVEMENT DESIGN MANUAL IF IT IS USED AS PAVEMENT SURFACE.
- CULVERT WEIGHT IS BASED ON 150 P.C.F. WITH A HAUNCH SIZE OF 12 INCHES.
- ① REINFORCEMENT AREAS ARE IN SQUARE INCHES PER LINEAL FOOT OF BARREL. ALL REINFORCEMENT LENGTHS AND AREAS ARE MINIMUM REQUIREMENTS. REINFORCEMENT REQUIREMENTS ARE FOR WELDED WIRE REINFORCEMENT WITH MINIMUM SPECIFIED YIELD STRESS OF 65 ksi. IF BAR REINFORCEMENT IS SUBSTITUTED FOR WELDED WIRE REINFORCEMENT, INCREASE THE AREA OF REINFORCEMENT BY 8%, AND SUBMIT DESIGN CALCULATIONS VERIFYING COMPLIANCE WITH AASHTO 5.7.3.4 "CONTROL CRACKING BY DISTRIBUTION OF REINFORCEMENT".
- ② PLACE LONGITUDINAL REINFORCEMENT DENOTED AS As6 IN ALL SLABS AND WALLS WITH A MINIMUM OF .06 IN²/FT.

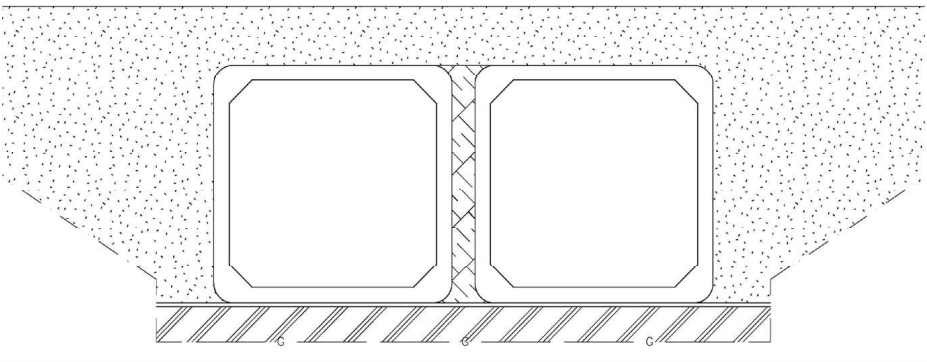
PRECAST CONCRETE BOX CULVERTS

USE OF SINGLES VS DOUBLES

Fabricated as a Double



Fabricated as Pair of Singles



PAST PRACTICE – Multi-Line Boxes

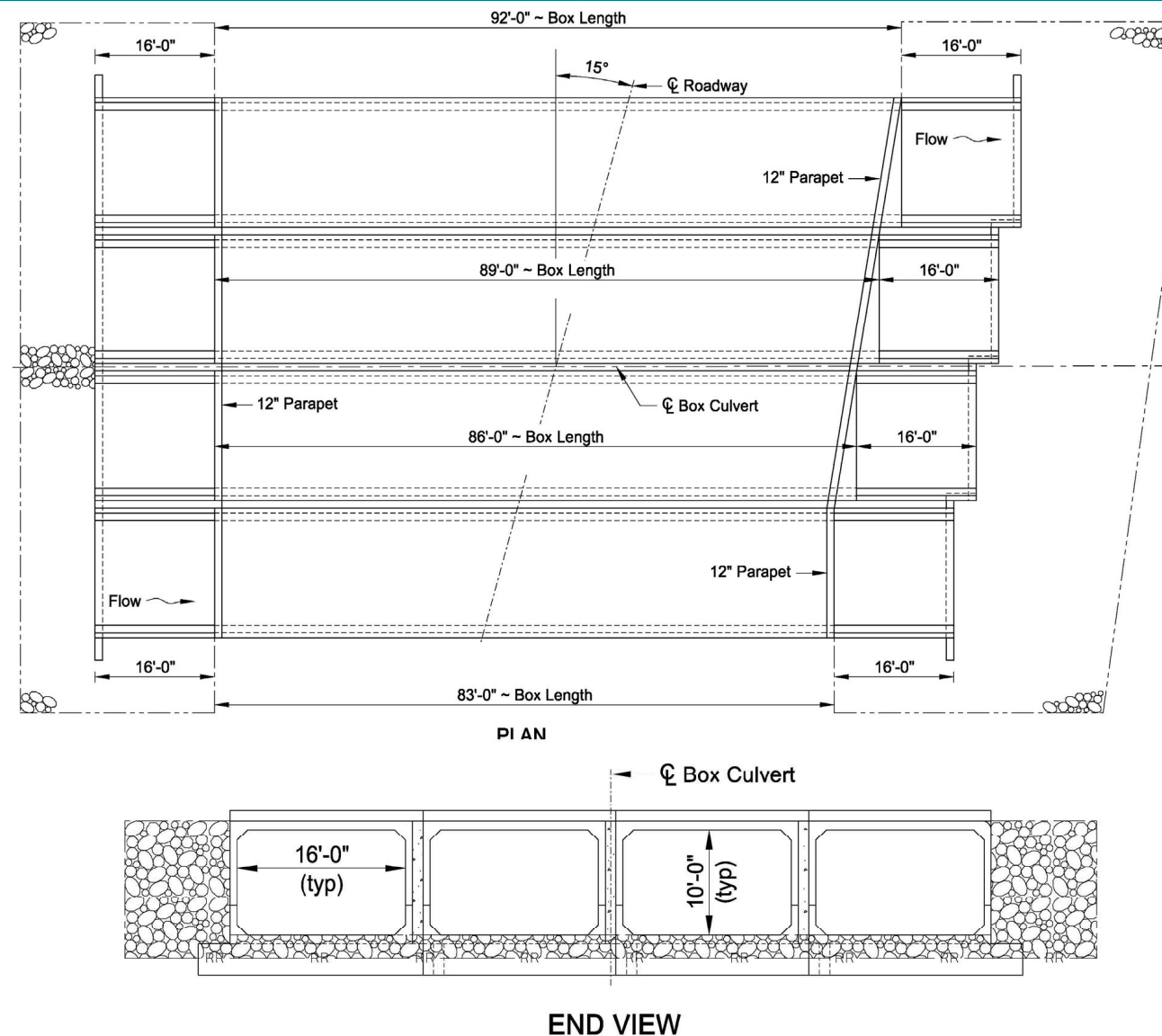
- Show a precast double cell box in the Plans
- Provide a note in the Plans permitting substitution of single cell boxes with no adjustment to bid quantity or prices
- Provide detail in the Plan for backfill between barrels

606 PRECAST SECTION: Tie the precast barrel and precast end sections together with 1"Ø tie bolts as shown on Standard Drawing D-714-22. A lock nut or lock washer may be provided in lieu of tack welding as shown in the standard drawings. Place ties in the exterior walls of each precast segment. Use two ties per exterior wall joint, located at the one-third points of the wall's clear height.

As an alternative to the double-cell precast segment, two single-cell precast segments may be provided. This provision also applies to the end sections. This substitution will be made at no additional cost to the project.

PRECAST CONCRETE BOX CULVERTS

USE OF SINGLES VS DOUBLES



Future Projects

Will start requiring single line boxes on some projects - No substitution of doubles

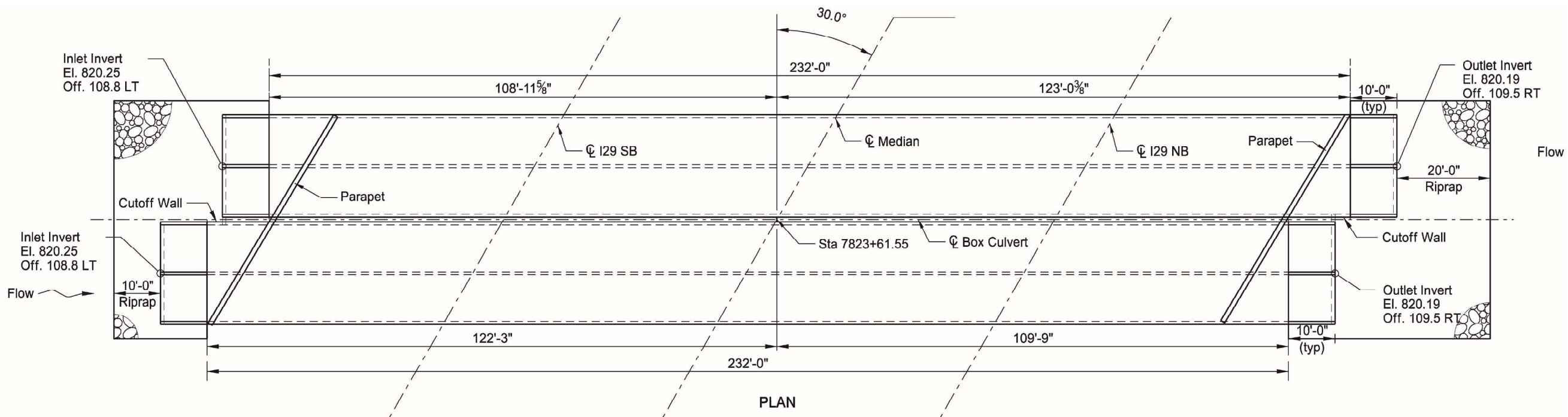
Projects With:

- Large Span Boxes – 14' & 16' Spans
 - Limit size & weight for handling, shipping, installation
 - Less prone to damage during installation
 - Tighter joints after installation
- Skewed Ends:
 - Square end sections require stagger between adjacent lines of box
 - Singled reduce stagger distance between adjacent lines

PRECAST CONCRETE BOX CULVERTS END SECTIONS FOR SKEWED CROSSINGS

GRAND FORKS DISTRICT

- Quad 10x6 precast box @ 30 degree skew
- Detailed and constructed as pair of double cell boxes
- Approx. 13 foot stagger at termination of end sections



PRECAST CONCRETE BOX CULVERTS END SECTIONS FOR SKEWED CROSSINGS

CONSTRUCTION

- Parapet skewed to match Roadway CL
- Didn't allow for proper backfill along wing

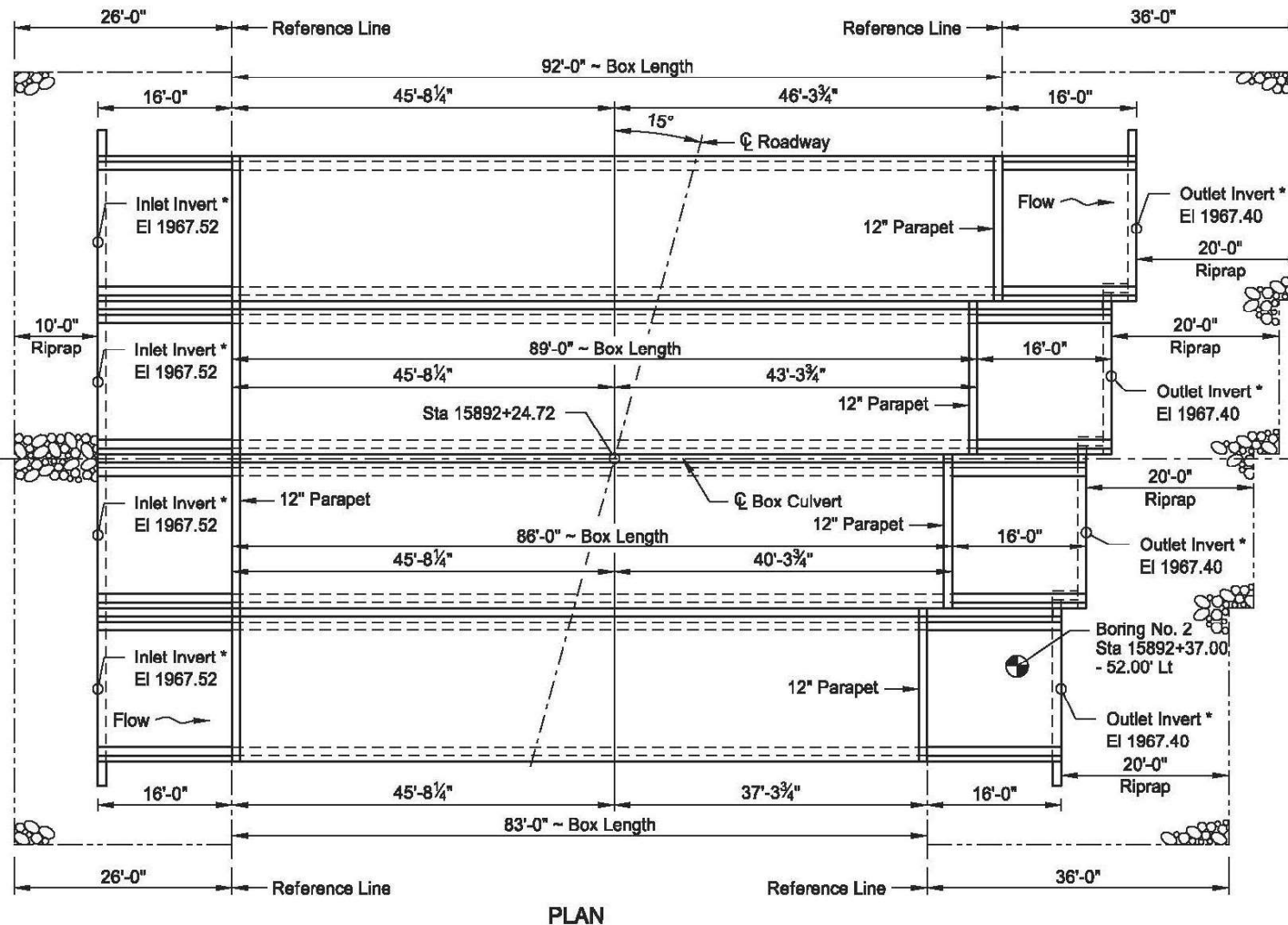


FINISHED STRUCTURE

- Parapet breaks to match end section
- Rock added to cover top of boxes



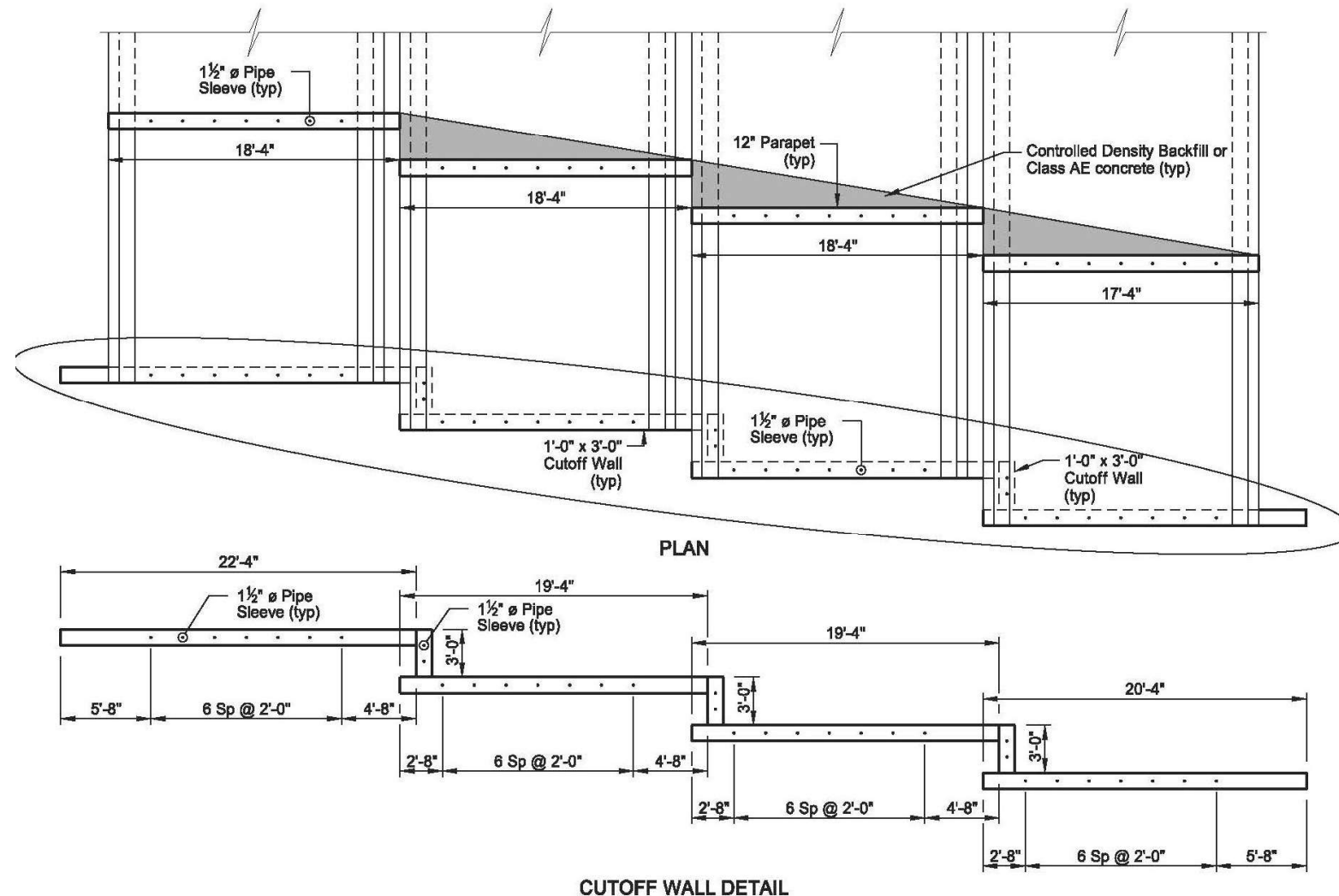
PRECAST CONCRETE BOX CULVERTS END SECTIONS FOR SKEWED CROSSINGS



USE OF SINGLES

- Quad 16x10 precast box @ 15 degree skew
- Designed and detailed as 4-lines of single cell boxes
- Substitution of double cell boxes will not be permitted
- Stagger limited to 3 feet at termination of end sections

PRECAST CONCRETE BOX CULVERTS END SECTIONS FOR SKEWED CROSSINGS



PARAPET DETAILS

- Fabricated square to ends of barrels
- Contractor to construct concrete or CDF topping over roof after installation
- Topping not required for strength
- 7-day cure on topping not required

CUTOFF WALL DETAILS

- Fabricated to match stagger of end sections
- Short segments required to be installed parallel to flow direction

PRECAST CONCRETE BOX CULVERTS FILL BETWEEN ADJACENT LINES OF BOX

OLD CDF DETAIL

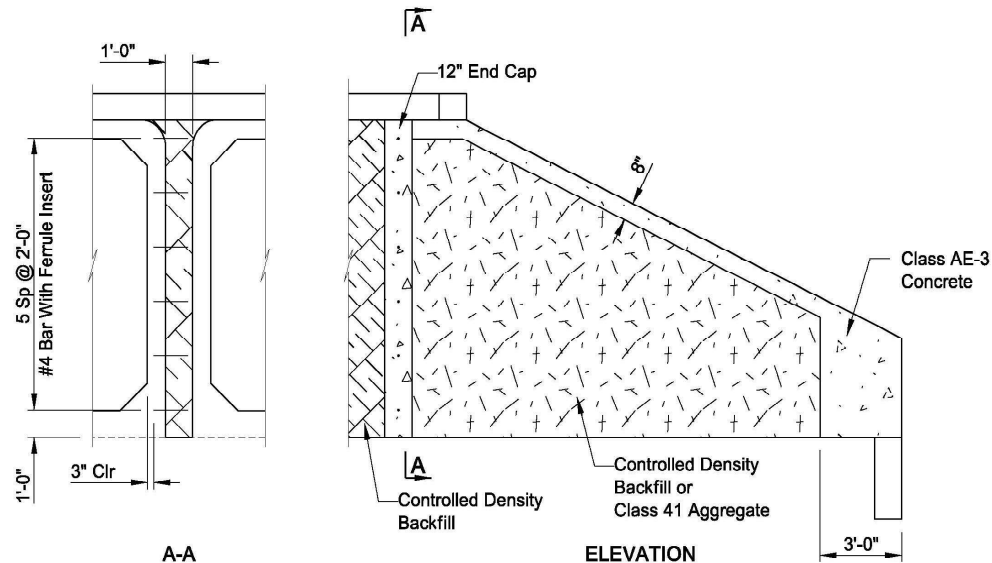
1. 12" End Cap – Non-Shrink Grout & Rebar Anchors
2. CDF Between Barrels
3. CDF or Class 41 between Wings
4. Concrete Cap – Top and Ends of Wings

NOTES:

The intent of this detail is to show only the placement of the controlled density backfill between adjacent barrels. The representation of the size of barrels is arbitrary.

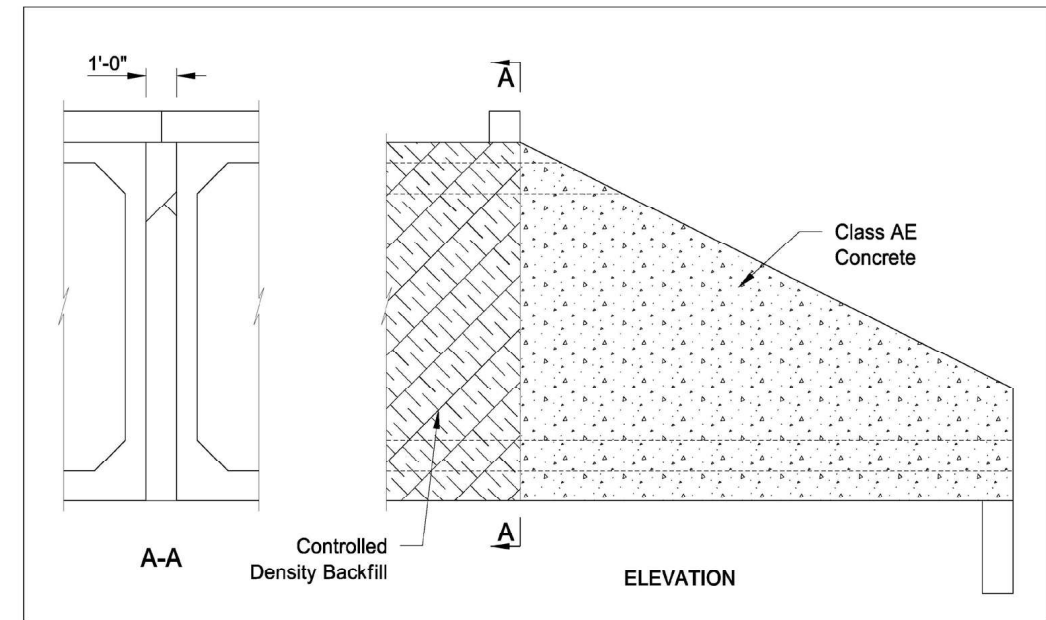
Embed the #4 bar 6" into the side of one of the box culvert end sections maintaining a 3" minimum clearance from the other box culvert. Spacing measured 1'-0" from bottom of box and spaced at 1'-0" up the front face.

Install the #4 bars according to the manufacturer's recommendations, with a high strength adhesive specifically intended for concrete anchorage and that meets the requirements of Section 806.02.



NEW CDF DETAIL

1. CDF Between Barrels
2. Concrete Between Wings



PRECAST CONCRETE BOX CULVERTS FILL BETWEEN ADJACENT LINES OF BOX

OLD CDF MIX DESIGN

910 CONTROLLED DENSITY BACKFILL: Controlled density backfill consists of cement, water, fly ash and aggregate at the ratio specified below. Place controlled density backfill as shown in the plans. Mix the material continuously during pumping or placement to keep the solution from separating.

Mix Design:

<u>Material</u>	<u>Weight</u>
Cement	75 lbs
Fly Ash	125 lbs
Water	417 lbs (50 gallons)
Fine Aggregate	2600 lbs

Include the controlled density backfill and materials used for the 12" cap in the price bid for "DbI 16Ft X 10Ft Precast RCB Culvert."

NEW CDF MIX DESIGN

606 PRECAST SEGMENT LAYOUT: Provide a distance of 1'-0" between separate precast units. Fill the gap between barrel segments with a controlled density backfill consisting of cement, water, pozzolanic materials, and aggregate per the mix design provided. Use material that is fluid on placement to flow around and fill voids in the backfill area. The mix design yields approximately one cubic yard of controlled density backfill. Mix the material continuously during pumping or placement to keep the solution from separating.

Mix Design:

<u>Material</u>	<u>Weight</u>
Cement	175 lbs
Fly Ash	175 lbs
Water	375 lbs (45 gallons)
Fine Aggregate	2600 lbs

Include all costs to furnish and place the controlled density backfill in the price bid for Precast RCB Culvert.

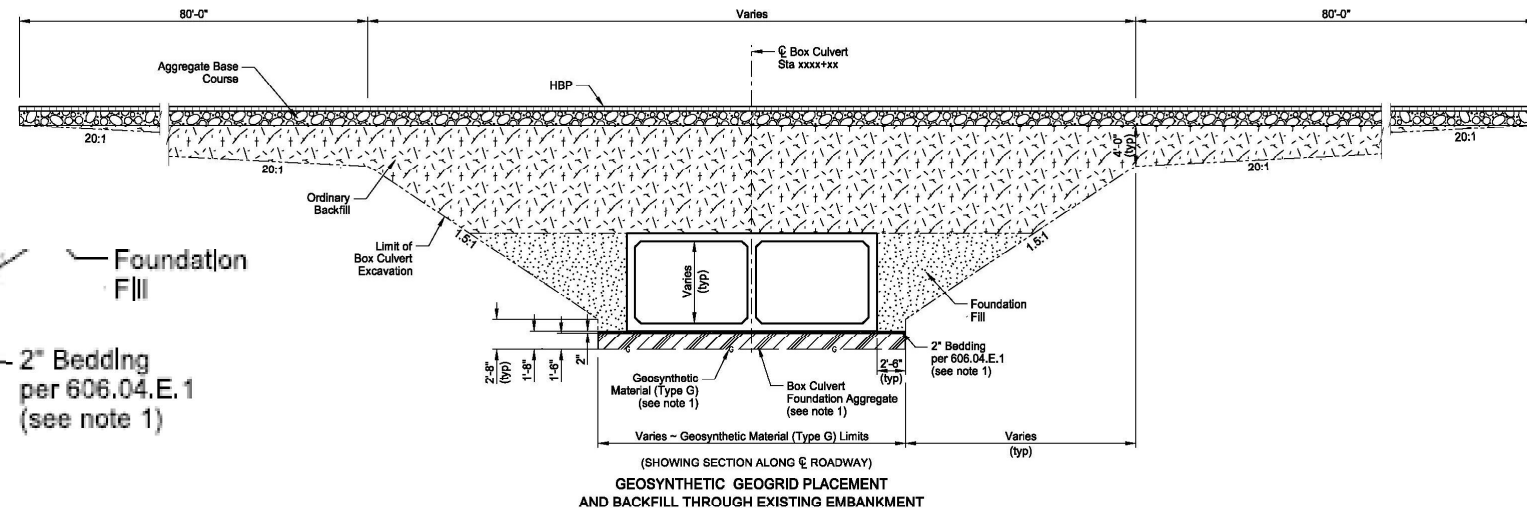
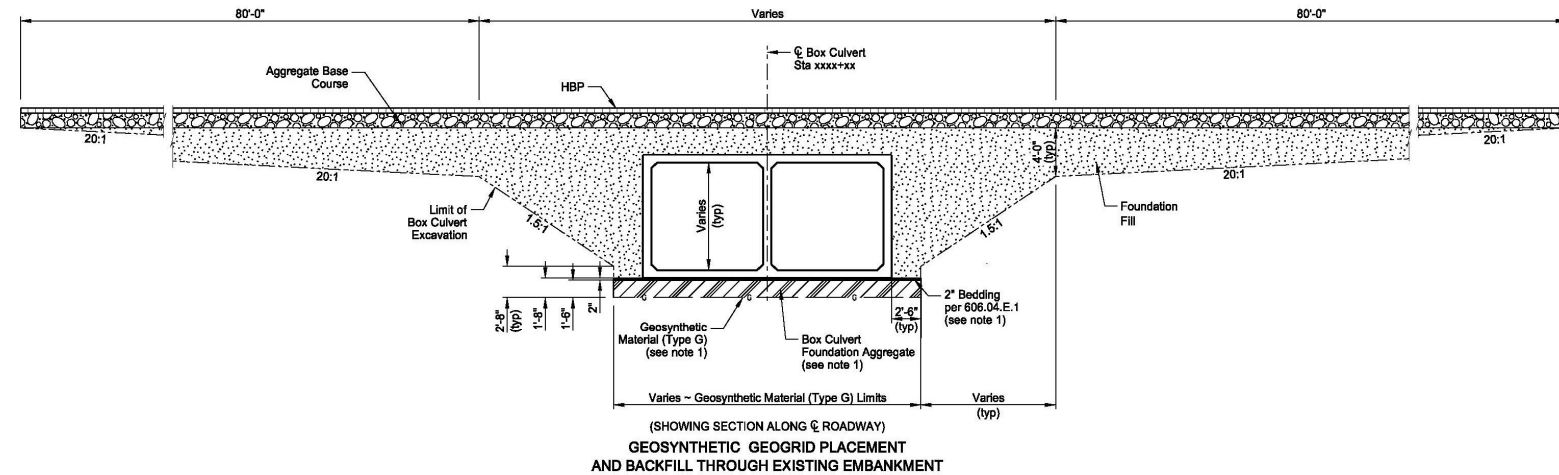
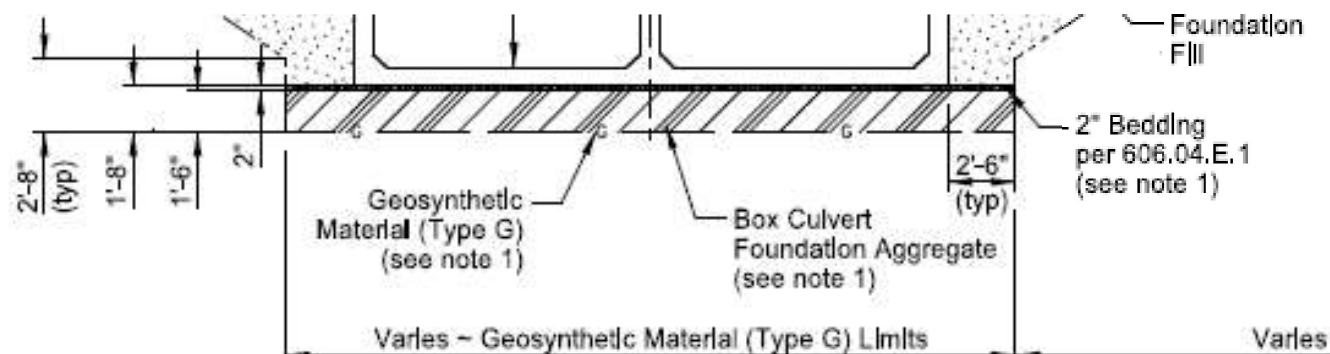
Fill the gap between end sections with Class AE concrete meeting Section 602.03 B.

Include all costs to furnish and place the Class AE concrete in the price bid for Precast RCB End Sections.

PRECAST CONCRETE BOX CULVERTS BACKFILL DETAILS

CURRENT DETAILS

- Separate details for shallow and deep fill situations
- At Contractor request, both details incorporate new Box Culvert Foundation Aggregate into the bedding detail



PRECAST CONCRETE BOX CULVERTS BACKFILL DETAILS

ADDITIONAL GUIDANCE FOR CONTRACTORS

SHALLOW FILL BACKFILL DETAIL

- Wish to provide a 3D model to better define limits of Foundation Fill and Bedding.
- Model will be cut to Roadway Model Dirt Grade to accurately reflect construction limits and material quantities.
- Working towards providing this model as part of Supplemental Design Data provided for a project.

