Structures Calculation Guide

Engineering Division
Production Support

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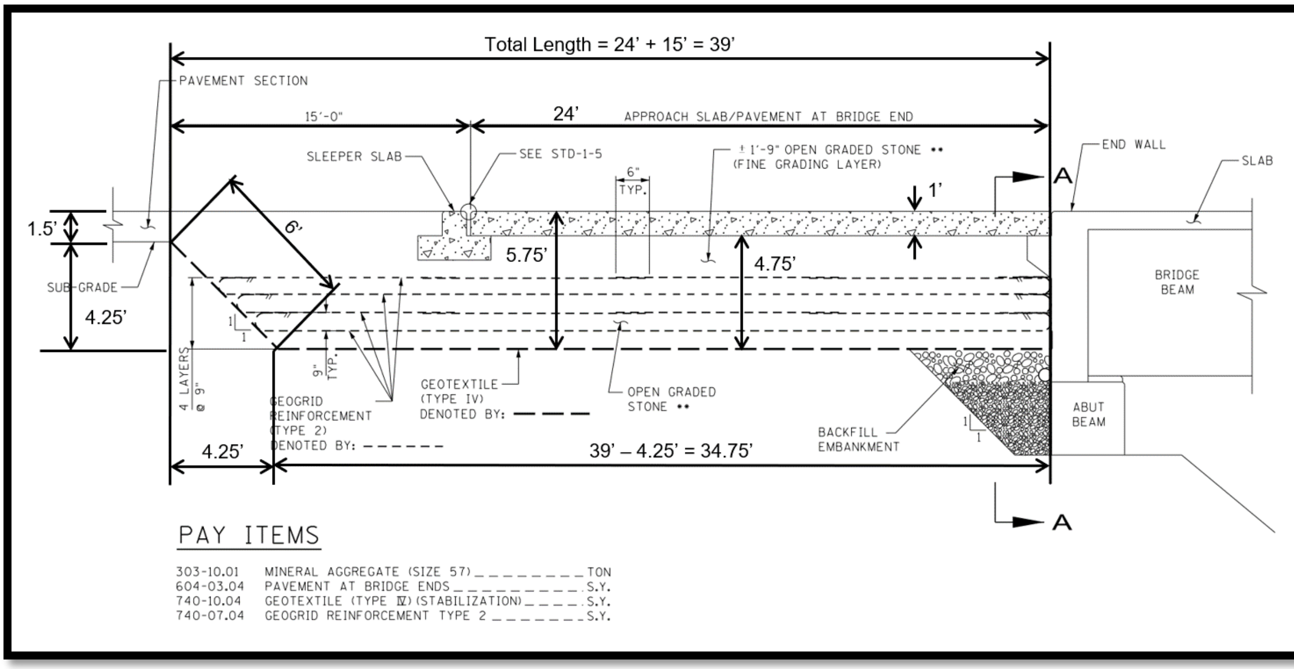
Part 1 – Bridge Ends

Additional roadway quantities are needed for bridge end transitions. Structure Standard Drawings STD-10-2 and STD-10-3 have roadway quantities that are excluded from the structures quantities that need to be calculated separately. Below are those quantities in both standard drawings.

STD-10-2



<u>Assumed Dimensions (These dimensions will vary based on each project):</u>

- Roadway Width = 32' (Two 12' lanes with 4' shoulders)
- Pavement thickness = 1.5'

<u>Standard Dimensions:</u>

- Approach Slab = 24' (From STD-1-5)
- Thickness (From STD-10-2) (NOT including the backfill embankment)
  - 4 layers at 0.75' each = 3'
  - Fine Graded Stone = 1.75'
  - Slab Thickness (From STD-1-5) = 1'
  - Total Thickness = 5.75'

<u>Calculated Dimensions:</u>

- Triangle Area:
  - Total Thickness – Pavement Thickness = Triangle Height
  - 5.75' – 1.5' = 4.25'
- Since the triangle is 1:1, the width = height = 4.25'
  - Length = $\sqrt{4.25^2 + 4.25^2} = 6'$

303-10.01 Mineral Aggregate (Size 57):

24' section: 32' x 24' x 4.75' = 3648 CF = 135.1 CY

15' section: 32' x 15' x 5.75' = 2760 CF = 102.2 CY

Subtract the 1:1 sloped triangle area:

- $32' x \frac{4.25' x\ 4.25'}{2}$ = 289 CF = 10.7 CY

Subtract for Sleeper Slab (cross section area = 4 SF) (From Standard Drawing STD-1-5)

- 32 FT x 4 SF = 128 CF = 4.7 CY

Total = 221.9 CY

x 2 ends = 443.8 CY

x 1.34 TONS/CY = 595 TONS (Based on 32' width)

604-03.04 Pavement at Bridge Ends:

Pavement Width x Approach Slab (Pavement at Bridge End)

32' x 24' = 768 SF = 85.3 SY

x 2 = 171 SY (Based on 32' width)

740-07.04 Geogrid Reinforcement Type 2:

Pavement Width x (Sum of Geogrid Reinforcement Layers)

32' x (35.5' + 36.25' + 37.00' + 37.75') = 4688 SF = 520.9 SY

x2 = 1042 SY (Based on 32' width)

740-10.04 Geotextile (Type IV) (Stabilization):

Pavement Width x (Sum of Geotextile (Type IV))

32' x (6' + 34.75') = 1304 SF = 144.9 SY

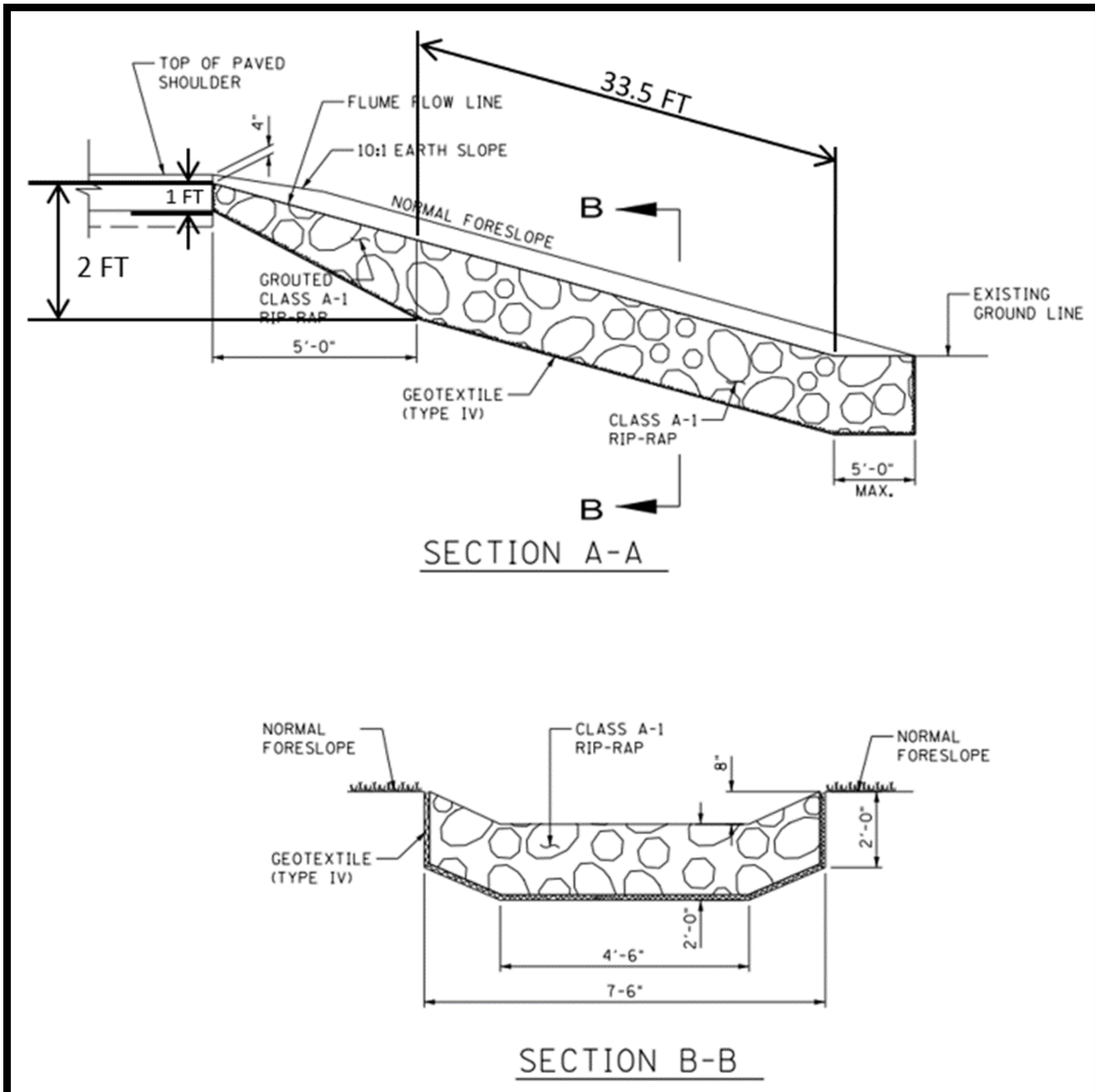
x2 = 290 SY (Based on 32' width)

These quantities will vary depending on the actual dimensions of the roadway.

On Estimated Quantities sheet include this footnote for the quantities calculated for these item numbers:

INCLUDES X FOR BRIDGE ENDS.

STD-10-3



For a slope of 2:1 and height of 15 feet, the length along the slope is 33.5 feet. See below for more details.

Height = 15 ft

Length = 15 ft x 2 = 30 ft (For 2:1 slope)

Length along slope = $\sqrt{(15^2 + 30^2)}$ = 33.5 ft

<u>709-05.06 Machined Rip-Rap (Class A-1):</u>

First 5 FT Grouted section: (See the last Special Note on STD-10-3 for more detail)

Length x (Average Area)

$5' x \frac{[(4.5' x 1') + (3' x 1')] + [(4.5' x 2') + (3' x 2')]}{2}$ = 56.25 CF = 2.1 CY

33.5 FT section:

(Middle volume) + (Tapered volume)

+ (4.5' x 2' x 33.5') + (3' x 2' x 33.5') = 502.5 CF = 18.6 CY

Last 5 FT Max section:

(Middle volume) + (Tapered volume)

+ (4.5' x 2' x 5') + (3' x 2' x 5') = 75 CF = 2.8 CY

Total = 23.5 CY

x 1.75 TONS/CY = <u>42 TONS</u>

<u>740-10.04 Geotextile (Type IV) (Stabilization):</u>

Width:

Middle Width + 2 Sides x (Diagonal length + Height)

4.5' + 2 x (2' + 2') = 12.5 FT

Length:

First 5' Grouted Section + Main section + 5' max section

5' + 33.5' + 5' = 43.5 FT

Total Area:

Total Width x Total Length

12.5' x 43.5' = 543.8 SF= <u>61 SY</u>

These quantities will vary depending on the actual dimensions of the roadway.

On Estimated Quantities sheet include this footnote:

INCLUDES X FOR BRIDGE ENDS

Part 2 – Box Bridge Quantities Calculation (Fill)

Given:

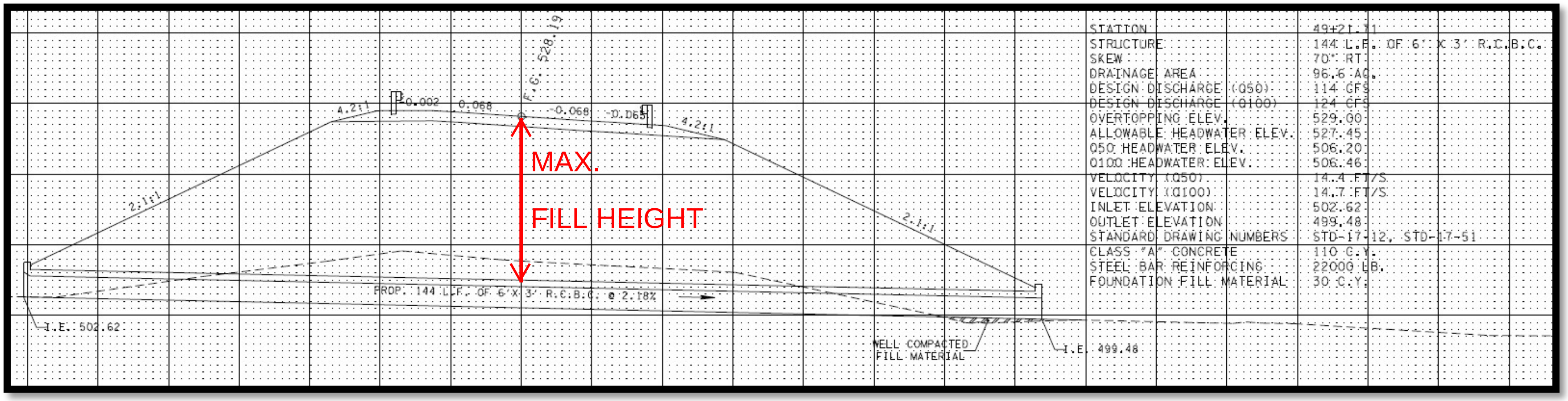
Structure 144 LF of 6’ x 3’ (cell width x cell height) Reinforced Concrete Box Culvert Skew 70°

Maximum Fill Height = 24’

Measure at the center of box culvert from top of slab to final grade

Slope = 2:1

Per Typical Sections in plans



Solution:

Calculate box bridge quantities.

Refer to Standard Drawing STD-17-51

1 @ 6 x 3 REINFORCED CONCRETE BOX BRIDGE																																	
Maximum	Dimensions				Bars TST				Bars TSB				Bars BST				Bars BSB				Bars EWE				Bars EWI				Bars LNT	Bars LND	Bars WS	Concrete	Reinf.
Fill Height ft.	ST in.	SB in.	WT in.	BW ft.	Size	No.	Spacing in.	Length ft.	Size	No.	Spacing in.	Length ft.	Size	No.	Spacing in.	Length ft.	Size	No.	Spacing in.	Length ft.	Size	No.	Spacing in.	Length ft.	Size	No.	Spacing in.	Length ft.	No.	No.	No.	CY/LF	Steel LB/LF
No Fill	8.5	9	8	7.33	4	1	12	6.83	6	2	6	6.83	5	2	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	35	12	4	0.57	142
3	10	10	8	7.33	4	1	12	6.83	6	2	6	6.83	7	1	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	35	12	4	0.63	141
5	8	9	8	7.33	4	1	12	6.83	5	2	6	6.83	5	2	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	0.56	132
10	8	9	8	7.33	4	1	12	6.83	5	2	6	6.83	7	1	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	0.56	132
20	8	9	8	7.33	4	1	12	6.83	6	2	6	6.83	6	2	6	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	0.56	146
30	11	13	8	7.33	4	1	12	6.83	6	2	6	6.83	8	1	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	0.73	143
40	14	15	8	7.33	4	1	12	6.83	6	2	6	6.83	8	1	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	0.85	143
50	16	17	8	7.33	4	1	12	6.83	6	2	6	6.83	8	1	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	0.95	143
60	17	18	8	7.33	4	1	12	6.83	7	2	6	6.83	6	2	6	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	1.00	153

Use table for 1 @ 6 x 3 Box Bridge

Since Maximum Fill Height (FT) = 24 FT, which is between 20 FT and 30 FT in the table, use values for the larger fill height of 30 FT

Therefore,

Concrete = 0.73 CY/LF

Reinforcing Steel = 143 LB/LF

The box bridge is 144 FT long

Concrete = 0.73 CY/LF x 144 FT = 105.12 CY

Reinforcing Steel = 143 LB/LF x 144 FT = 20592 LB

Calculate the wing wall quantities.

Since the skew = 70°, round to the nearest skew value (90°, 75°, 60°, 45°). Use values for skew = 75°.

Refer to Standard Drawing STD-17-12, the quantities given in the tables in Standard Drawing STD-17-12 are for ALL FOUR WINGWALLS

75° SKEW

2:1 SLOPE						
H	WL	hl	WS	hs	CONCRETE (C.Y.)	REINF. STEEL (LBS.)
4	6.00	2.25	4.50	1.75	2.6	641
4.5	6.75	2.50	5.25	2.00	4.7	710
5	7.50	2.75	5.75	2.25	5.5	790
5.5	8.50	3.00	6.50	2.50	6.7	935
6	9.25	3.25	7.25	2.50	7.7	1,019
6.5	10.00	3.75	7.75	2.75	8.9	1,096
7	11.00	4.00	8.50	3.00	10.8	1,408
7.5	11.75	4.25	9.00	3.25	12.1	1,515
8	12.50	4.50	9.75	3.50	13.6	1,626
8.5	13.50	4.75	10.25	3.75	15.3	1,773
9	14.25	5.00	11.00	4.00	18.1	2,646
9.5	15.00	5.50	11.50	4.25	20.0	2,725
10	16.00	5.75	12.25	4.50	22.2	3,018
10.5	16.75	6.00	12.75	4.75	24.2	3,146
11	17.50	6.25	13.50	4.75	28.1	3,503
11.5	18.50	6.50	14.25	5.00	31.3	4,373
12	19.25	6.75	14.75	5.25	33.6	4,638
12.5	20.00	7.25	15.50	5.50	37.0	4,832
13	20.75	7.50	16.00	5.75	42.0	5,744
13.5	21.25	7.75	16.75	6.00	44.8	6,169
14	22.50	8.00	17.25	6.25	48.4	6,454
14.5	23.25	8.25	18.00	6.50	51.5	6,822
15	24.25	8.75	18.50	6.75	58.5	7,370
15.5	25.00	9.00	19.25	7.00	63.9	8,362
16	25.75	9.25	19.75	7.00	67.3	8,778
16.5	26.75	9.50	20.50	7.25	71.8	10,207
17	27.50	9.75	21.00	7.50	78.2	11,200
17.5	28.25	10.00	21.75	7.75	82.6	11,188
18	29.25	10.50	22.50	8.00	88.0	11,667
18.5	30.00	10.75	23.00	8.25	92.4	11,878
19	30.75	11.00	23.75	8.50	104.9	13,387
19.5	31.75	11.25	24.25	8.75	110.2	15,072
20	32.50	11.50	25.00	9.00	116.7	15,803
20.5	33.25	11.75	25.50	9.00	121.6	16,206
21	34.00	12.25	26.25	9.25	136.2	17,837

3:1 SLOPE						
H	WL	hl	WS	hs	CONCRETE (C.Y.)	REINF. STEEL (LBS.)
4	7.25	2.50	5.75	2.25	4.5	691
4.5	8.25	3.00	6.75	2.50	5.7	761
5	9.00	3.25	7.50	2.75	7.2	861
5.5	10.00	3.75	8.25	3.00	8.5	1,017
6	11.00	4.00	9.00	3.25	9.9	1,122
6.5	12.00	4.25	9.75	3.50	11.4	1,207
7	13.00	4.75	10.50	3.75	13.6	1,537
7.5	14.00	5.00	11.25	4.00	15.7	1,672
8	15.00	5.25	12.00	4.25	17.7	1,801
8.5	15.75	5.75	12.75	4.75	19.7	1,987
9	16.75	6.00	13.75	5.00	23.3	3,019
9.5	17.75	6.25	14.50	5.25	25.7	3,112
10	18.75	6.75	15.25	5.50	28.3	3,426
10.5	19.75	7.00	16.00	5.75	31.4	3,627
11	20.75	7.50	16.75	6.00	35.5	4,061
11.5	21.50	7.75	17.50	6.25	39.5	4,904
12	22.50	8.00	18.25	6.50	42.7	5,207
12.5	23.50	8.50	19.00	6.75	46.3	5,388
13	24.50	8.75	19.75	7.00	53.2	6,454
13.5	25.50	9.00	20.75	7.50	55.3	6,892
14	26.50	9.50	21.50	7.75	64.5	7,348
14.5	27.50	9.75	22.25	8.00	68.8	7,780
15	28.25	10.00	23.00	8.25	74.7	8,379
15.5	29.25	10.50	23.75	8.50	79.6	9,359
16	30.25	10.75	24.50	8.75	84.4	9,839
16.5	31.25	11.00	25.25	9.00	92.9	11,836
17	32.25	11.50	26.00	9.25	101.8	12,984
17.5	33.25	11.75	26.75	9.50	107.4	12,925
18	34.00	12.25	27.75	9.75	111.4	13,414
18.5	35.00	12.50	28.50	10.25	119.7	13,702
19	36.00	12.75	29.25	10.50	131.7	15,117
19.5	37.00	13.25	30.00	10.75	142.2	17,331
20	38.00	13.50	30.75	11.00	151.8	18,121
20.5	39.00	13.75	31.50	11.25	158.9	18,687
21	39.75	14.25	32.25	11.50	176.7	20,378

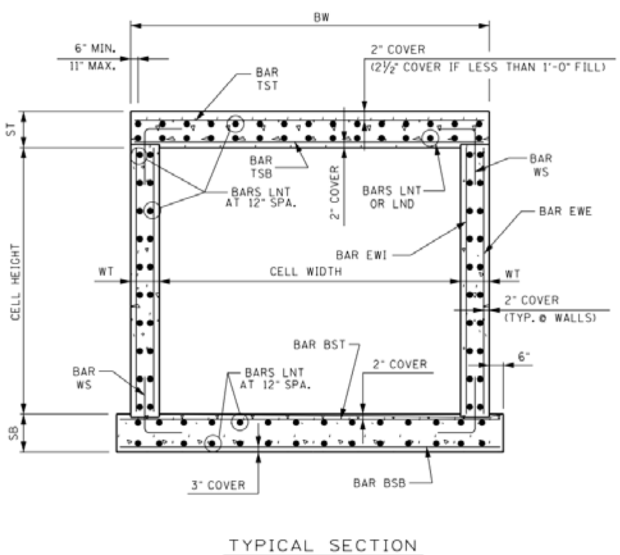
Refer to Standard Drawings STD-17-51 and STD-17-8, use H = 5 FT

H = CELL HEIGHT + +ST + CURB = 3 FT + 11 IN (1 FT/ 12 IN) + 1 FT = 4.92 FT, USE 5 FT

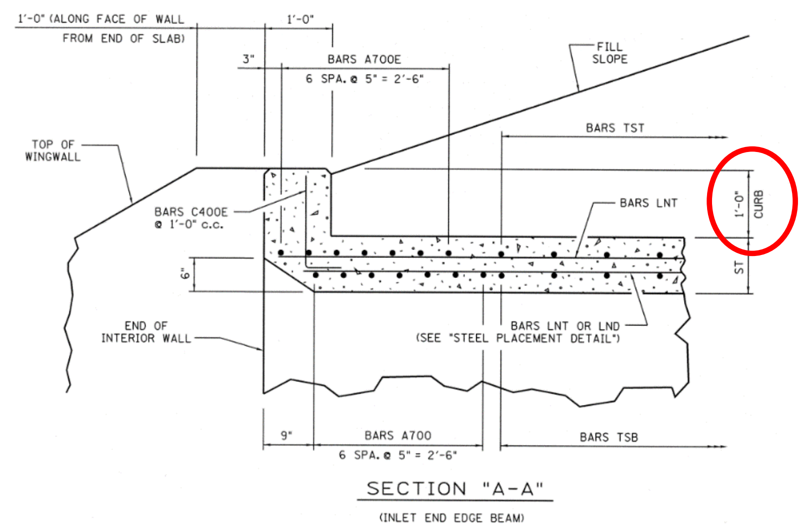
If box bridge has a guardrail, use STD-17-7 instead of STD-17-8.

1 @ 6 x 3 REINFORCED CONCRETE BOX BRIDGE																																	
Maximum	Dimensions				Bars TST				Bars TSB				Bars BST				Bars BSB				Bars EWE				Bars EWI				Bars LNT	Bars LND	Bars WS	Concrete CY/LF	Reinf. Steel LB/LF
Fill Height ft.	ST in.	SB in.	WT in.	BW ft.	Size	No.	Spacing in.	Length ft.	Size	No.	Spacing in.	Length ft.	Size	No.	Spacing in.	Length ft.	Size	No.	Spacing in.	Length ft.	Size	No.	Spacing in.	Length ft.	Size	No.	Spacing in.	Length ft.	No.	No.	No.		
No Fill	8.5	9	8	7.33	4	1	12	6.83	6	2	6	6.83	5	2	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	35	12	4	0.57	142
3	10	10	8	7.33	4	1	12	6.83	6	2	6	6.83	7	1	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	35	12	4	0.63	141
5	8	9	8	7.33	4	1	12	6.83	5	2	6	6.83	5	2	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	0.56	132
10	8	9	8	7.33	4	1	12	6.83	5	2	6	6.83	7	1	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	0.56	132
20	8	9	8	7.33	4	1	12	6.83	6	2	6	6.83	6	2	6	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	0.56	146
30	11	13	8	7.33	4	1	12	6.83	6	2	6	6.83	8	1	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	0.73	143
40	14	15	8	7.33	4	1	12	6.83	6	2	6	6.83	8	1	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	0.85	143
50	16	17	8	7.33	4	1	12	6.83	6	2	6	6.83	8	1	12	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	0.95	143
60	17	18	8	7.33	4	1	12	6.83	7	2	6	6.83	6	2	6	7.83	4	1	12	7.83	4	2	12	3.00	5	2	12	3.00	42	0	4	1.00	153

Use Table from STD-17-51



Use Typical Section from STD-17-51



Use Section "A-A" from STD-17-8

Therefore,

Concrete = 5.5 CY

Reinforcing Steel = 790 LB

The quantitates given in tables in Standard Drawings STD-17-12 are for ALL FOUR WINGWALLS.

Therefore,

TOTAL CONCRETE = 105.12 CY + 5.5 CY = 110.62 CY

TOTAL REINFORCING STEEL = 20592 LB + 790 LB = 21382 LB

NOTE: When necessary, calculate the edge beam and cut-off wall quantities and add total quantities above. See Standard Drawing STD-17-8 and STD-17-6 for more details.

Part 3 – Box Bridge Quantities Calculation (No Fill)

Given:

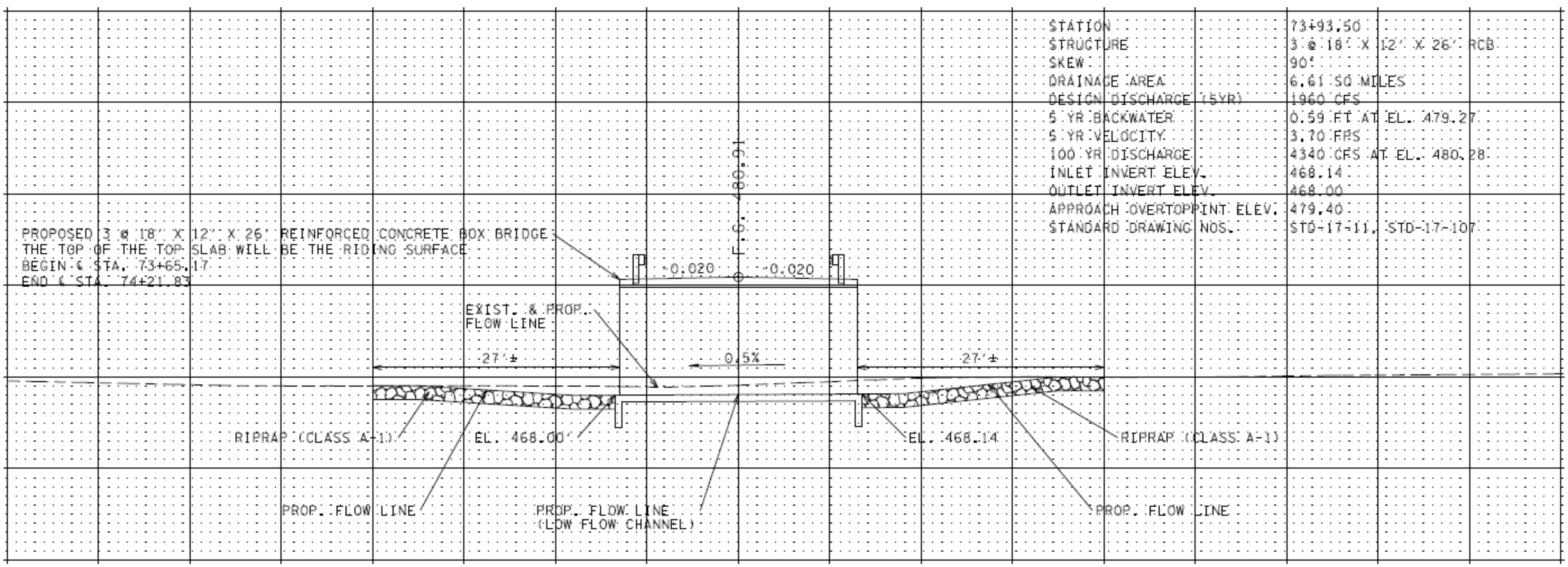
Structure 3 @ 18’x12’x26’ (cell width x cell height x bridge length) Reinforced Concrete Box Bridge Skew 90°

Maximum Fill Height (FT) = No Fill

Since the top of the top slab will be a riding surface, Maximum Fill Height = 0

Slope = 2:1

Per Typical Sections in plans



Solution:

Calculate box bridge quantities.

Refer to Standard Drawing STD-17-107

3 @ 18 x 12 REINFORCED CONCRETE BOX BRIDGE

	Maximum Fill Height ft.	Dimensions ST in.	SB in.	WT in.	IT in.	BW ft.	Bars TST Size	No.	Spacing in.	Length ft.	Bars TSB Size	No.	Spacing in.	Length ft.	Bars BST Size	No.	Spacing in.	Length ft.
Continuous	No Fill	11.5	11	8	8	56.67	8	2	6	56.17	8	2	6	56.17	6	2	6	57.17
	3	15	15	8	8	56.67	11	1	12	56.17	8	2	6	56.17	6	2	6	57.17
	5	16	16	9	8	56.83	11	1	12	56.33	7	2	6	56.33	9	1	12	57.33
	10	20	20	10	8	57.00	11	1	12	56.50	7	2	6	56.50	9	1	12	57.50
Moment Break	20	20	21	12	8	57.33	4	3	12	18.66	11	2	6	56.83	10	2	6	57.83
	30	29	30	15	8	57.83	4	3	12	18.66	10	2	6	57.33	10	2	6	58.33
	40	36	37	17	8	58.17	4	3	12	18.66	10	2	6	57.67	10	2	6	58.67
	50	41	42	19	9	58.67	4	3	12	18.66	10	2	6	58.17	10	2	6	59.17
	60	46	47	20	9	58.83	4	3	12	18.66	10	2	6	58.33	10	2	6	59.33

Maximum Fill Height ft.	Bars BSB Size	No.	Spacing in.	Length ft.	Bars EWE Size	No.	Spacing in.	Length ft.	Bars EWI Size	No.	Spacing in.	Length ft.	Bars IW Size	No.	Spacing in.	Length ft.	Bars LNT No.	Bars LND No.	Bars WS No.	Concrete CY/LF	Reinf. Steel LB/LF
No Fill	7	2	6	57.17	4	2	12	12.00	7	2	12	12.00	5	4	12	12.00	266	108	8	5.15	1477
3	7	2	6	57.17	4	2	12	12.00	7	4	6	12.00	5	4	12	12.00	266	108	8	6.48	1525
5	7	2	6	57.33	4	2	12	12.00	7	4	6	12.00	5	4	12	12.00	322	0	8	6.92	1445
10	8	2	6	57.50	4	2	12	12.00	7	4	6	12.00	5	4	12	12.00	326	0	8	8.43	1522
20	4	3	12	18.66	4	2	12	12.00	8	4	6	12.00	5	4	12	12.00	326	0	8	8.80	1695
30	4	3	12	18.66	4	2	12	12.00	7	4	6	12.00	6	4	12	12.00	326	0	8	12.33	1581
40	4	3	12	18.66	4	2	12	12.00	7	4	6	12.00	5	8	6	12.00	330	0	8	15.07	1617
50	4	3	12	18.66	4	2	12	12.00	7	4	6	12.00	5	8	6	12.00	330	0	8	17.23	1626
60	4	3	12	18.66	4	2	12	12.00	7	4	6	12.00	6	8	6	12.00	330	0	8	19.18	1673

Use table for 3 @ 18 x 12 Box Bridge

Use Maximum Fill Height (FT) = No Fill

Therefore,

Concrete = 5.15 CY/LF

Reinforcing Steel = 1477 LB/LF

The box bridge is 26 FT long

Concrete = 5.15 CY/LF * 26 FT = 133.9 CY

Reinforcing Steel = 1477 LB/LF * 26 FT = 38402 LB

Calculate the wing wall quantities.

Refer to Standard Drawing STD-17-11, the quantities given in the tables in Standard Drawing STD-17-11 are for ALL FOUR WINGWALLS.

90° SKEW

2:1 SLOPE				
H	W	h	CONCRETE (C.Y.)	REINF. STEEL (LBS.)
4	5.00	1.75	3.3	630
4.5	5.75	2.00	4.1	694
5	6.50	2.25	5.3	781
5.5	7.25	2.50	6.3	914
6	8.00	2.75	7.4	1,014
6.5	8.50	3.00	8.4	1,069
7	9.25	3.25	10.1	1,367
7.5	10.00	3.50	11.5	1,486
8	10.75	3.75	13.0	1,607
8.5	11.50	4.00	14.6	1,749
9	12.25	4.25	16.9	2,576
9.5	12.75	4.50	18.4	2,639
10	13.50	4.75	20.4	2,875
10.5	14.25	5.00	23.2	3,091
11	15.00	5.25	26.3	3,494
11.5	15.75	5.50	30.3	4,328
12	16.50	5.75	32.9	4,544
12.5	17.00	6.00	35.1	4,662
13	17.75	6.25	39.4	5,610
13.5	18.50	6.50	42.4	6,003
14	19.25	6.75	45.5	6,260
14.5	20.00	7.00	49.9	6,741
15	20.75	7.25	56.4	7,352
15.5	21.25	7.50	59.4	8,039
16	22.00	7.75	63.2	8,506
16.5	22.75	8.00	67.2	9,812
17	23.50	8.25	73.7	10,799
17.5	24.25	8.50	78.1	10,884
18	24.75	8.75	81.7	11,209
18.5	25.50	9.00	88.3	11,733
19	26.25	9.25	97.7	12,981
19.5	27.00	9.50	102.8	14,737
20	27.75	9.75	108.1	15,265
20.5	28.50	10.00	113.5	15,719
21	29.00	10.25	126.0	17,262

3:1 SLOPE				
H	W	h	CONCRETE (C.Y.)	REINF. STEEL (LBS.)
4	6.25	2.25	4.3	675
4.5	7.25	2.50	5.4	744
5	8.00	3.00	6.9	849
5.5	9.00	3.25	8.3	1,014
6	9.75	3.50	9.5	1,116
6.5	10.50	3.75	10.8	1,180
7	11.50	4.00	13.1	1,520
7.5	12.25	4.50	14.9	1,624
8	13.25	4.75	16.9	1,754
8.5	14.00	5.00	19.5	1,974
9	14.75	5.25	22.2	2,962
9.5	15.75	5.50	24.7	3,082
10	16.50	6.00	27.3	3,342
10.5	17.50	6.25	30.1	3,504
11	18.25	6.50	33.6	3,928
11.5	19.00	6.75	37.5	4,786
12	20.00	7.00	41.9	5,216
12.5	20.75	7.50	45.4	5,394
13	21.75	7.75	52.0	6,412
13.5	22.50	8.00	55.4	6,870
14	23.25	8.25	59.0	7,136
14.5	24.25	8.50	63.3	7,589
15	25.00	9.00	73.3	8,368
15.5	25.75	9.25	77.5	9,299
16	26.75	9.50	82.6	9,820
16.5	27.50	9.75	87.1	11,451
17	28.50	10.00	95.7	12,593
17.5	29.25	10.50	101.2	12,502
18	30.00	10.75	106.4	12,936
18.5	31.00	11.00	118.0	13,630
19	31.75	11.25	129.5	14,977
19.5	32.75	11.50	136.5	17,020
20	33.50	12.00	143.3	17,579
20.5	34.25	12.25	149.6	18,066
21	35.25	12.50	167.3	19,857

Refer to Standard Drawings STD-17-107, use H = 13 FT.

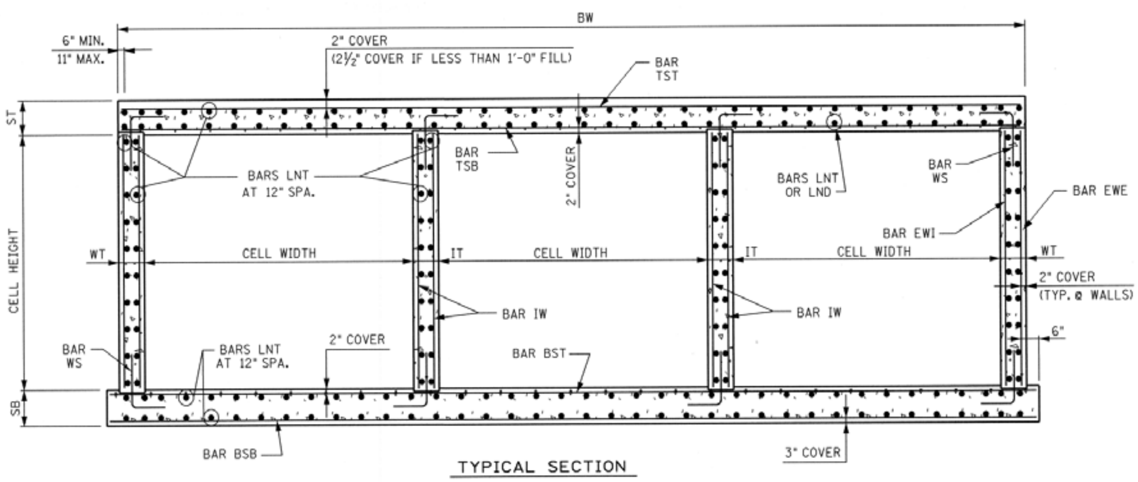
H = CELL HEIGHT + ST = 12 FT + 11.5 IN x (1 FT / 12 IN) = 12.96 FT, USE 13 FT

3 @ 18 x 12 REINFORCED CONCRETE BOX BRIDGE

	Maximum Fill Height ft.	Dimensions ST in.	SB in.	WT in.	IT in.	BW ft.	Bars TST Size	No.	Spacing in.	Length ft.	Bars TSB Size	No.	Spacing in.	Length ft.	Bars BST Size	No.	Spacing in.	Length ft.
Continuous	No Fill	11.5	11	8	8	56.67	8	2	6	56.17	8	2	6	56.17	6	2	6	57.17
	3	15	15	8	8	56.67	11	1	12	56.17	8	2	6	56.17	6	2	6	57.17
	5	16	16	9	8	56.83	11	1	12	56.33	7	2	6	56.33	9	1	12	57.33
	10	20	20	10	8	57.00	11	1	12	56.50	7	2	6	56.50	9	1	12	57.50
Moment Break	20	20	21	12	8	57.33	4	3	12	18.66	11	2	6	56.83	10	2	6	57.83
	30	29	30	15	8	57.83	4	3	12	18.66	10	2	6	57.33	10	2	6	58.33
	40	36	37	17	8	58.17	4	3	12	18.66	10	2	6	57.67	10	2	6	58.67
	50	41	42	19	9	58.67	4	3	12	18.66	10	2	6	58.17	10	2	6	59.17
	60	46	47	20	9	58.83	4	3	12	18.66	10	2	6	58.33	10	2	6	59.33

Maximum Fill Height ft.	Bars BSB Size	No.	Spacing in.	Length ft.	Bars EWE Size	No.	Spacing in.	Length ft.	Bars EWI Size	No.	Spacing in.	Length ft.	Bars IW Size	No.	Spacing in.	Length ft.	Bars LNT No.	Bars LND No.	Bars WS No.	Concrete CY/LF	Reinf. Steel LB/LF
No Fill	7	2	6	57.17	4	2	12	12.00	7	2	12	12.00	5	4	12	12.00	266	108	8	5.15	1477
3	7	2	6	57.17	4	2	12	12.00	7	4	6	12.00	5	4	12	12.00	266	108	8	6.48	1525
5	7	2	6	57.33	4	2	12	12.00	7	4	6	12.00	5	4	12	12.00	322	0	8	6.92	1445
10	8	2	6	57.50	4	2	12	12.00	7	4	6	12.00	5	4	12	12.00	326	0	8	8.43	1522
20	4	3	12	18.66	4	2	12	12.00	8	4	6	12.00	5	4	12	12.00	326	0	8	8.80	1695
30	4	3	12	18.66	4	2	12	12.00	7	4	6	12.00	6	4	12	12.00	326	0	8	12.33	1581
40	4	3	12	18.66	4	2	12	12.00	7	4	6	12.00	5	8	6	12.00	330	0	8	15.07	1617
50	4	3	12	18.66	4	2	12	12.00	7	4	6	12.00	5	8	6	12.00	330	0	8	17.23	1626
60	4	3	12	18.66	4	2	12	12.00	7	4	6	12.00	6	8	6	12.00	330	0	8	19.18	1673

Use Table from STD-17-107



Use Typical Section from STD-17-107

Therefore,

Concrete = 39.4 CY

Reinforcing Steel = 5610 LB

*The quantities given in tables in Standard Drawing STD-17-11 are for **ALL FOUR WINGWALLS**.*

Therefore,

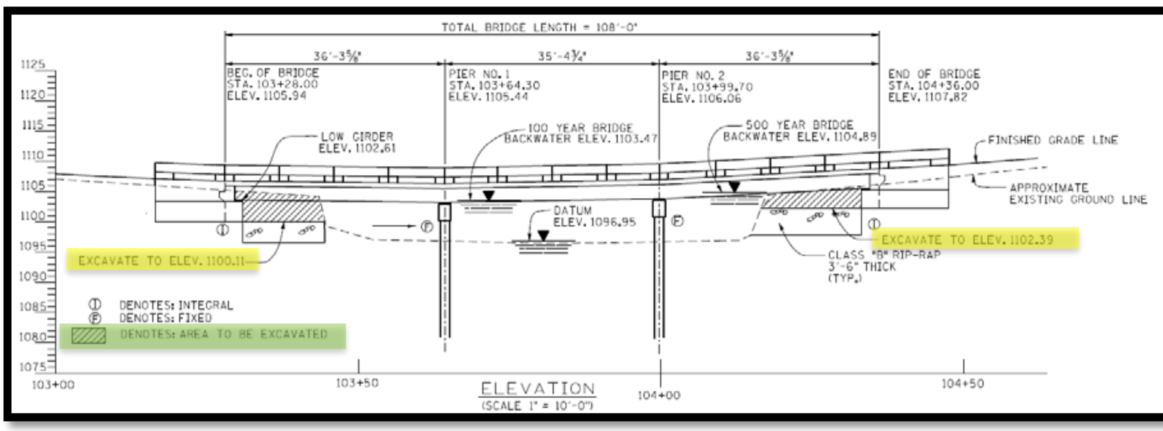
TOTAL CONCRETE = 133.9 CY + 39.4 CY = 173.3 CY

TOTAL REINFORCING STEEL = 38402 LB + 5610 LB = 44012

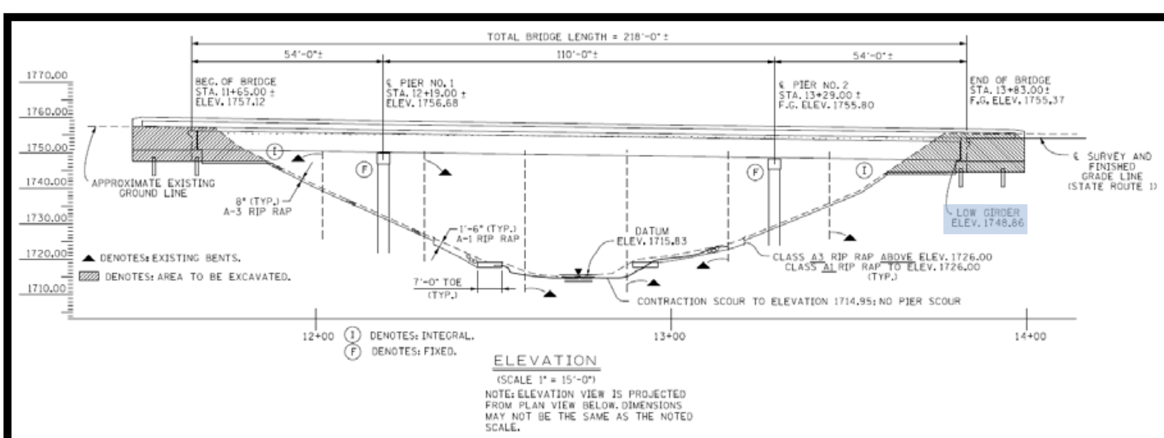
Part 4 – Bridge Earthwork

Bridge excavation may be required for a project that includes a proposed bridge. This part will go into details of the calculations on how much earthwork will be required for the bridge excavation.

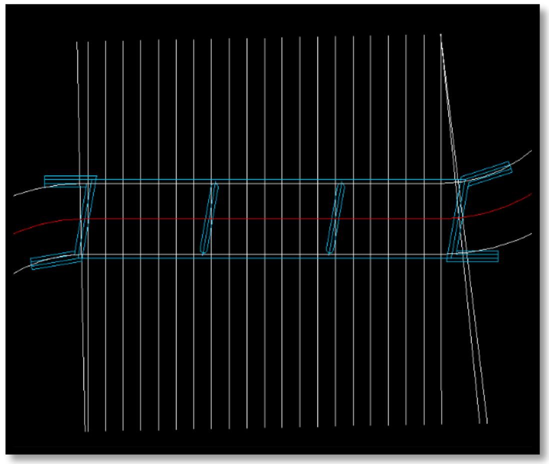
The designer will receive a hydraulic layout from the hydraulics division. This layout will detail any necessary bridge excavation that will be required for a project. If the project includes excavation, the layout will show a shaded area where the excavation will be needed. The excavation elevations will also be shown on the layout. For this project, the excavation at the beginning of the bridge will be to the elevation of 1100.11 and the excavation at the end of the bridge will be to the elevation of 1102.39. These elevations and excavation areas will vary based on project.



NOTE: In some cases, the hydraulic layout will not have the “excavate to this elevation” labeled. The Low-Girder Elevation can be used as a substitute. When using the low girder elevation, an additional 2-feet should be subtracted to allow for room for constructability. This new elevation can be treated as the excavation elevation moving forward in this example. An example of a hydraulic layout with the Low-Girder Elevation is shown below.

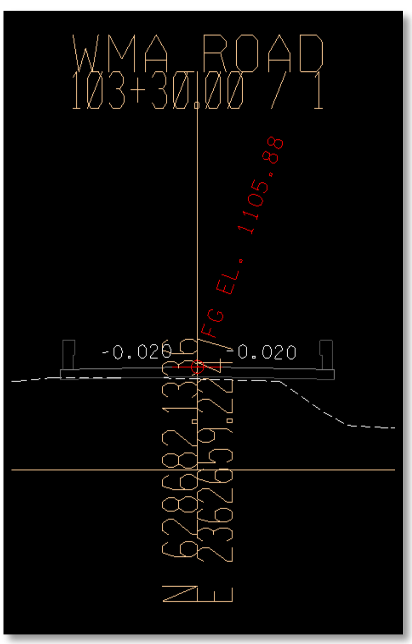


The process of calculating the earthwork includes creating new cross sections of the proposed bridge. The first step is to create a new DGN file for the new pattern lines. In this file, draw pattern lines at 5-foot increments along the proposed bridge stations. In this project, the proposed bridge is from Station 103+28 to Station 104+36.

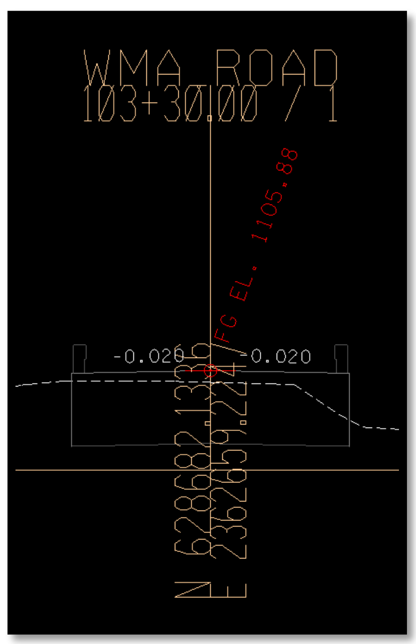


Next, create a new cross section DGN using the XS seed file. In this file, plot the 5-foot incremental cross sections along the proposed bridge. Its critical to understand this is not the same cross section file that is used to determine the project's overall earthwork quantity. The quantity that is calculated in this part have no influence with the project's earthwork quantity.

Looking back at the final hydraulic layout drawing, the beginning bridge excavation elevation is 1100.11. On the cross sections, the elevation of the bottom of the bridge deck need to be moved to the excavation elevation. Starting on Station 103+30, hand manipulate the existing bridge deck and move the line from its original elevation down to the elevation of 1100.11. This process is illustrated in the cross-section figures below.

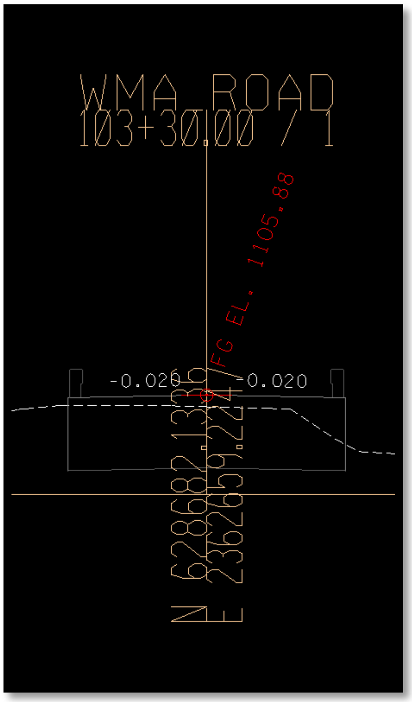


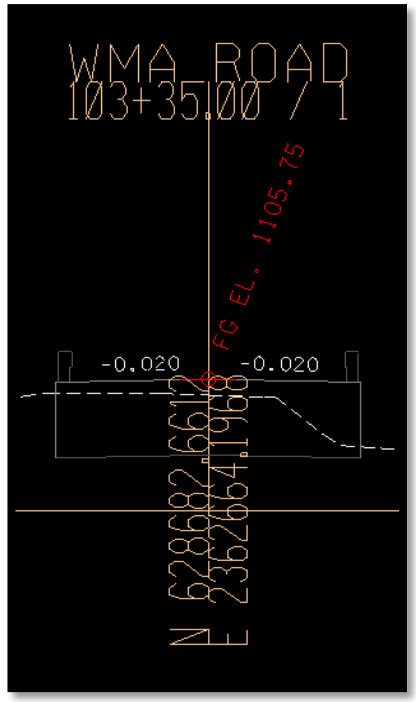
Before

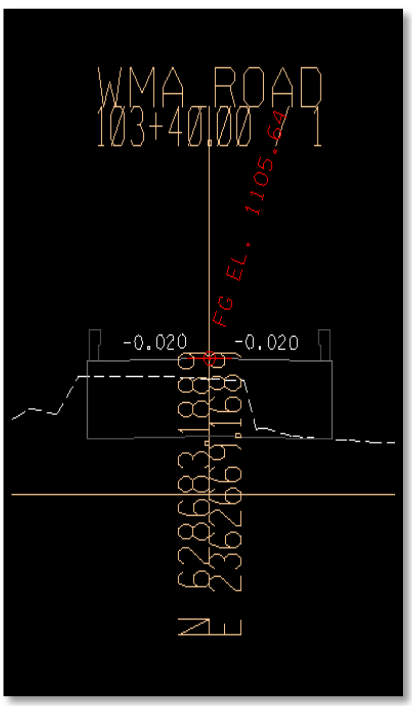


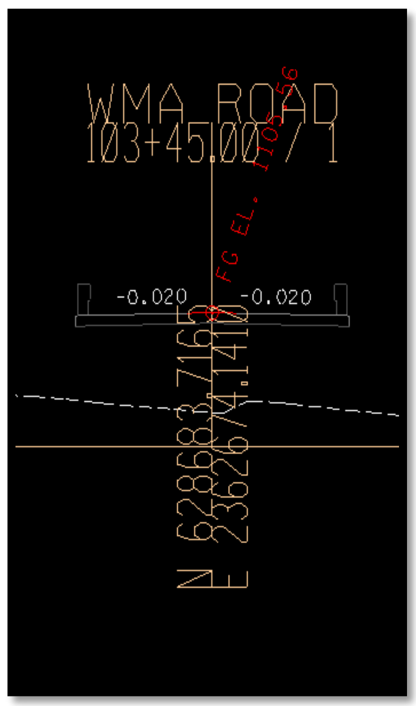
After

Continue this process on each cross section until the existing ground line is below the excavation elevation. The final cross sections should look like the ones in the figures below. These cross sections are only for the beginning of the bridge excavation. The process is the same for the end of the bridge, except for in this example, the excavation elevation is 1102.39.

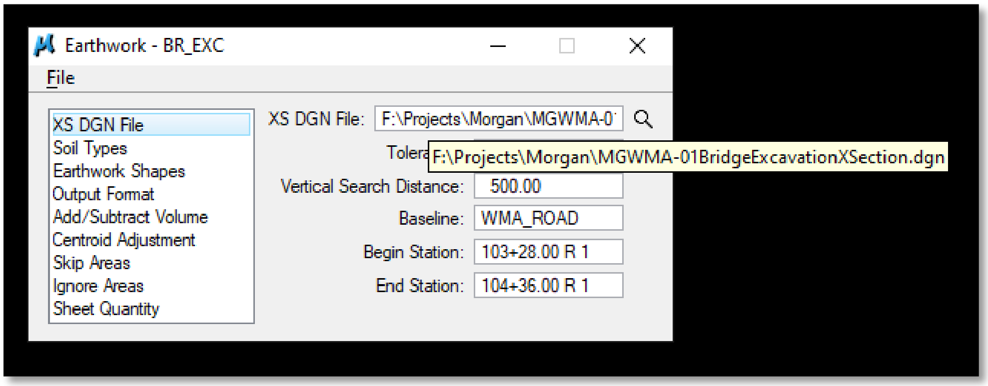




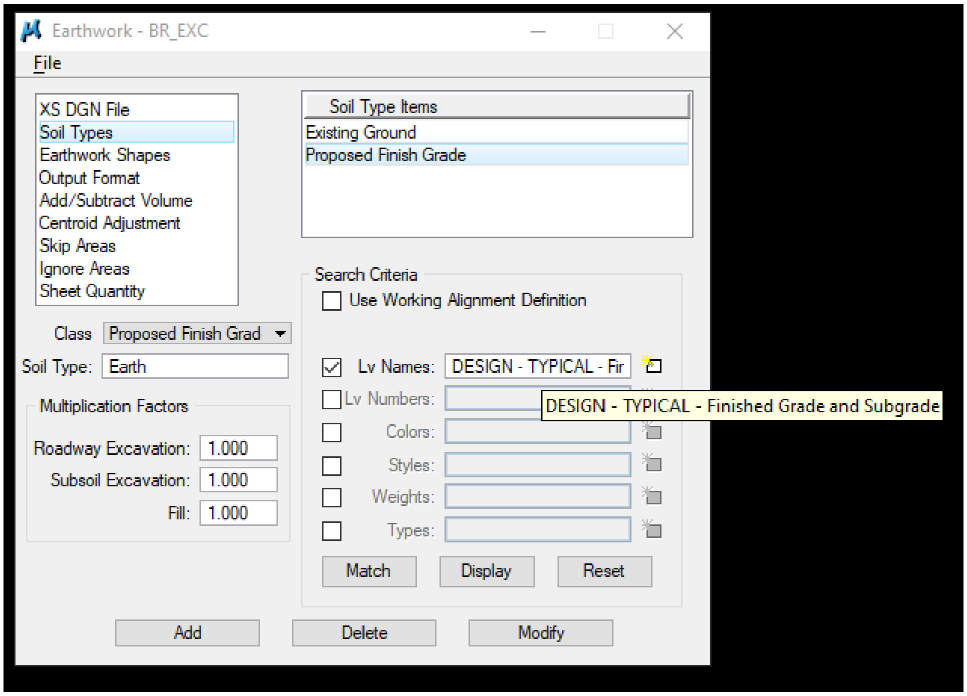




Once you have the bottom of the bridge deck at the excavation elevation for both ends of the bridge, the earthwork can then be ran to determine how much excavation is needed. This process is similar to how the project's overall earthwork is determined with a few minor changes. The earthwork run for the project's overall earthwork can be copied and renamed and then used for the bridge earthwork. The first revision would be to change the XS DGN File to the one that is currently being used and that was created earlier in this section.

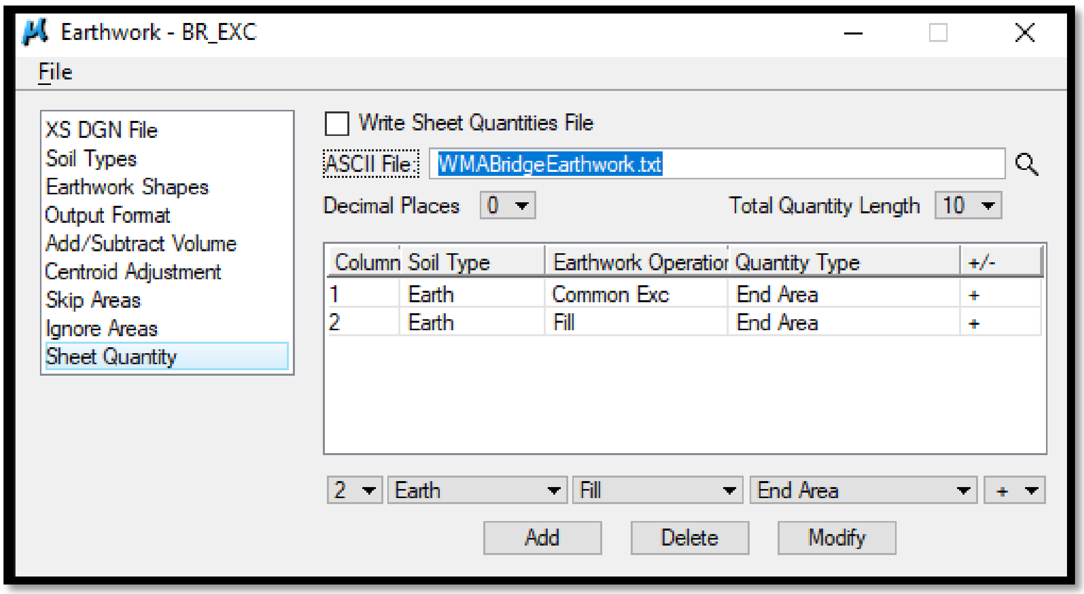


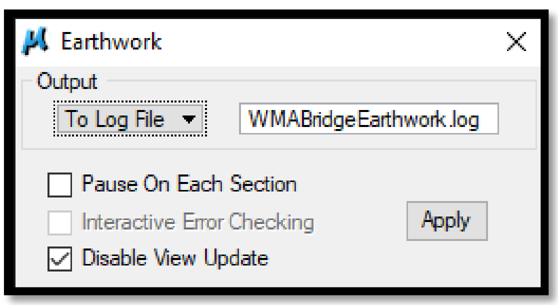
Next, the proposed finish grade soil type needs to be revised. Navigate down to Soil Types and select the Proposed Finish Grade. For simplicity, the level name can be selected and then matched to the level of the bridge deck, this level should be DESIGN – TYPICAL – Finish Grade and Subgrade. The Existing Ground soil type remains the same.



Next, if there was skipped area on the overall project's earthwork file, those need to be revised as well. The skip area and ignore area can be revised to the cross sections that required zero earthwork because the existing ground elevation was below the excavation elevations. For this example, it was from Station 103+45 to Sta. 104+10.

Lastly, in the Sheet Quantity section, the ASCII File name can be revised to be more specific to what is being calculated. The name can be revised to ProjectBridgeEarthwork.txt. The Log File name will need to be revised as well with a similar name.





The earthwork can then be ran to calculate the amount of excavation that will be needed for the bridge excavation. The earthwork output is shown below.

```
            Material Name    End Areas Unadjusted Adjusted  Mult   Mass     Accum      Accum
Station                                Volumes    Volumes   Factor Ordinate Unadj Vol  Adj Vol
                             (sq. ft.) (cu. yd.)  (cu. yd.)                 (cu. yd.)  (cu. yd.)
----------- --------------- --------- ---------- --------- ------ -------- ---------- ----------
 103+28.00 EARTH
                Excavation       7          0          0   1.00                 0          0
                      Fill      17          0          0   1.00       0         0          0

 103+30.00 EARTH
                Excavation     102          4          4   1.00                 4          4
                      Fill       0          1          1   1.00       3         1          1

 103+35.00 EARTH
                Excavation      86         17         17   1.00                21         21
                      Fill       0          0          0   1.00      20         1          1

 103+40.00 EARTH
                Excavation      64         14         14   1.00                35         35
                      Fill       0          0          0   1.00      34         1          1

SKIP STATION RANGE = 103+45.00 to 104+10.00
 104+15.00 EARTH
                Excavation      35         18         18   1.00                53         53
                      Fill       0          0          0   1.00      52         1          1

 104+20.00 EARTH
                Excavation      79         11         11   1.00                64         64
                      Fill       0          0          0   1.00      63         1          1

 104+25.00 EARTH
                Excavation     106         17         17   1.00                81         81
                      Fill       0          0          0   1.00      80         1          1

 104+30.00 EARTH
                Excavation     125         21         21   1.00               102        102
                      Fill       0          0          0   1.00     101         1          1

 104+35.00 EARTH
                Excavation     139         24         24   1.00               126        126
                      Fill       0          0          0   1.00     125         1          1

 104+36.00 EARTH
                Excavation       1          3          3   1.00               129        129
                      Fill      12          0          0   1.00     128         1          1
                  G R A N D   S U M M A R Y    T O T A L S
               Material Name         Unadjusted Adjusted  Mult
                                     Volumes    Volumes   Factor
                                     (cu. yd.)  (cu. yd.)
        --------------------------- ---------  --------- ------
        EARTH
                        Excavation        129        129   1.00
                              Fill          1          1   1.00
                            S P L I T    S U M M A R Y    T O T A L S
                                     XS Quant   XS Quant  Add/Sub Quant Add/Sub Quant
              Material Name          Unadjusted Adjusted  Unadjusted    Adjusted      Mult
                                     Volume     Volume    Volume        Volume        Factor
                                     (cu. yd.)  (cu. yd.) (cu. yd.)     (cu. yd.)
        --------------------------- ---------  --------- ------------ ------------ ------
        EARTH
                        Excavation        129        129            0            0   1.00
                              Fill          1          1            0            0   1.00
```

It can be seen in the figure above that the excavation required is 129 CY. For some projects, a fill quantity may be calculated in this step. If this is the case, the fill quantity can be ignored. For this exercise, only the excavation quantity will be used. This quantity can then be added to the Estimated Grading Quantities Tabulated Block as shown in the figure below.

ESTIMATED GRADING QUANTITIES

DESCRIPTION	UNADJUSTED VOLUMES (CY)		ADJUSTED VOLUMES (CY)
	EXC.	EMB.	EXC.
MAINLINE	352	250	294
SIDE ROADS			
PVT. DRIVES, BUSINESS AND FIELD ENTRANCES			
INDEPENDENT DITCHES			
TEMPORARY CONSTRUCTION EXITS	15		
OTHER (BRIDGE EXCAVATION)	129		
PAVEMENT			
TOPSOIL (EMB.)			
TOPSOIL (EXC.)			
TOPSOIL (TO REPLACE STRIPPED TOPSOIL)		32	

ROCK (C.Y.)		TOTALS (C.Y.)				
EXC.	EMB.	EXC. (UNCL.	EMB. (UNCL.)	EXC (COMMON)	EXC. (AVAIL.)	EXC. (ADJ.)
		496	282	496	414	414

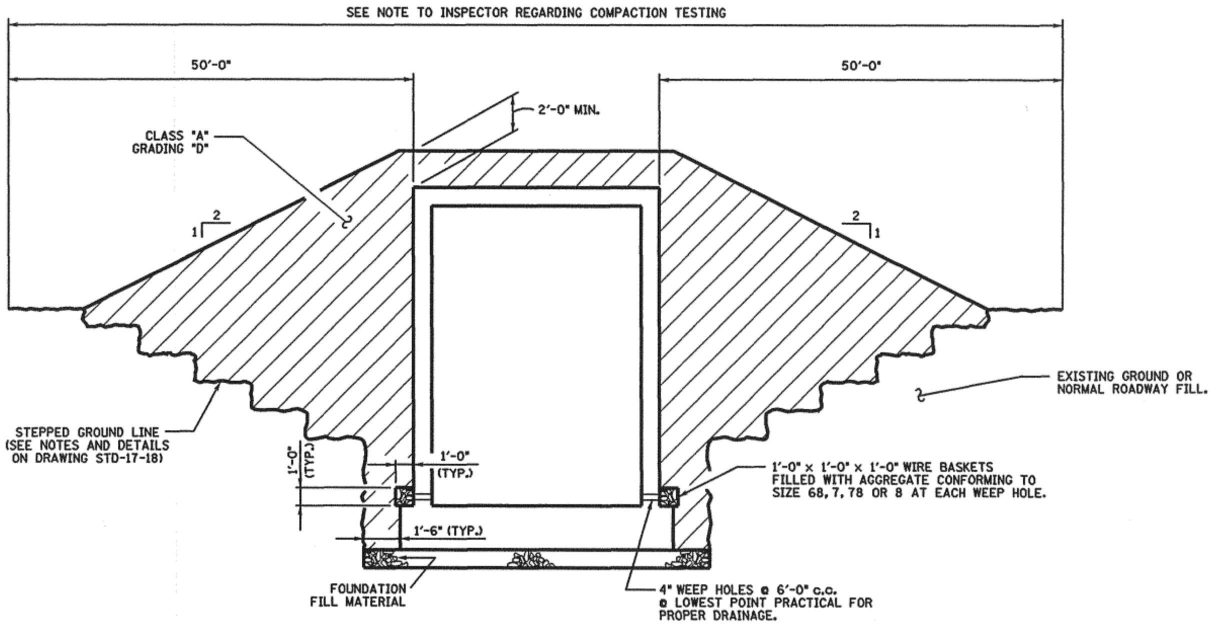
BALANCE SUMMARY

SHRINK = 20 % SWELL = 20 %

EXC.		EMB.
414	VS	-282
AVAILABLE	=	132
WASTE MATERIAL	=	159

Part 5 – Backfill for Box Bridges and Culverts

When a Box Bridge or Culvert is required it may be necessary to excavate the existing channel in order to place the proposed structure. In that case backfill will be needed to fill the excavated area around the proposed structure. See Backfill Placement detail of Standard Structure Drawing STD-17-17 below. This part will illustrate the method for calculating culvert excavation, backfill and foundation fill.

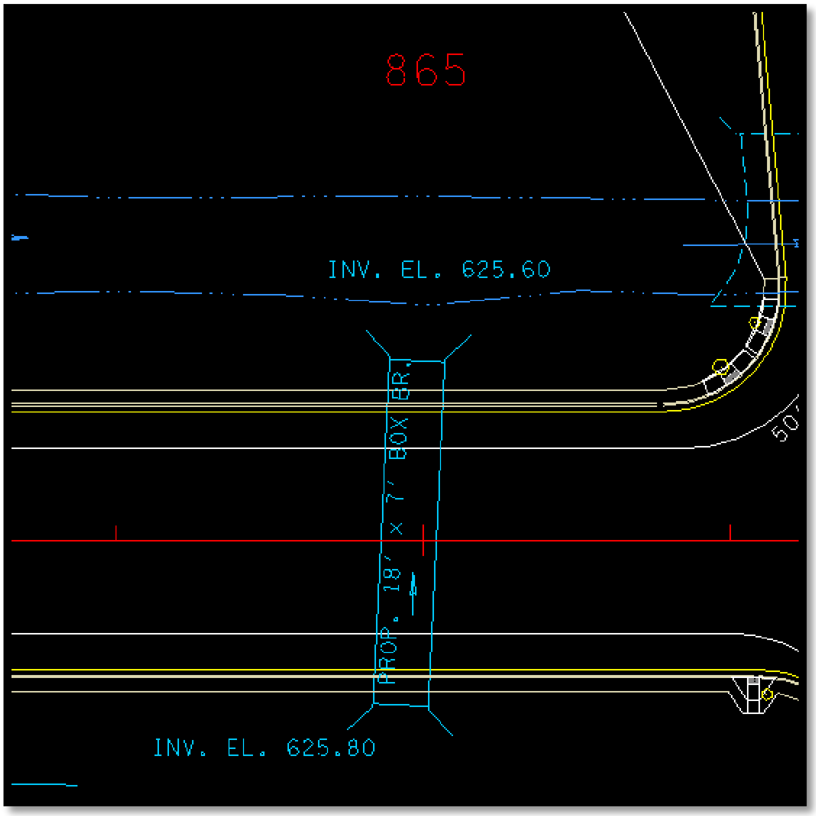


BACKFILL PLACEMENT

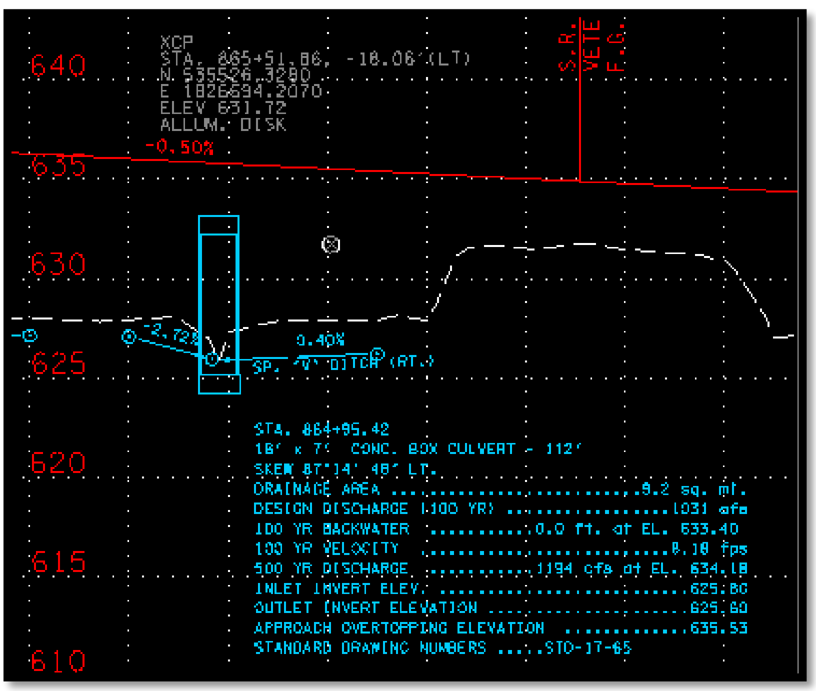
(BOX CULVERT SHOWN; SLAB BRIDGES SIMILAR)

NOTE: CLASS "A" GRADING "D" LIMITS ARE TYPICAL FOR BOX CULVERT OR BRIDGE AND WINGWALLS.

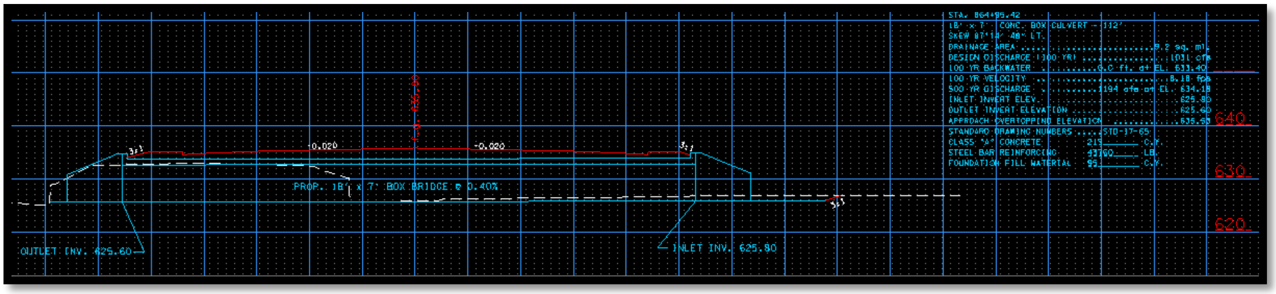
<u>Example:</u> Proposed 18' x 7' Box Bridge located at Sta. 864+95.42. The length of the proposed structure is 112' at skew of 87° 14' 48" Lt.



Plan view of Proposed Box Bridge

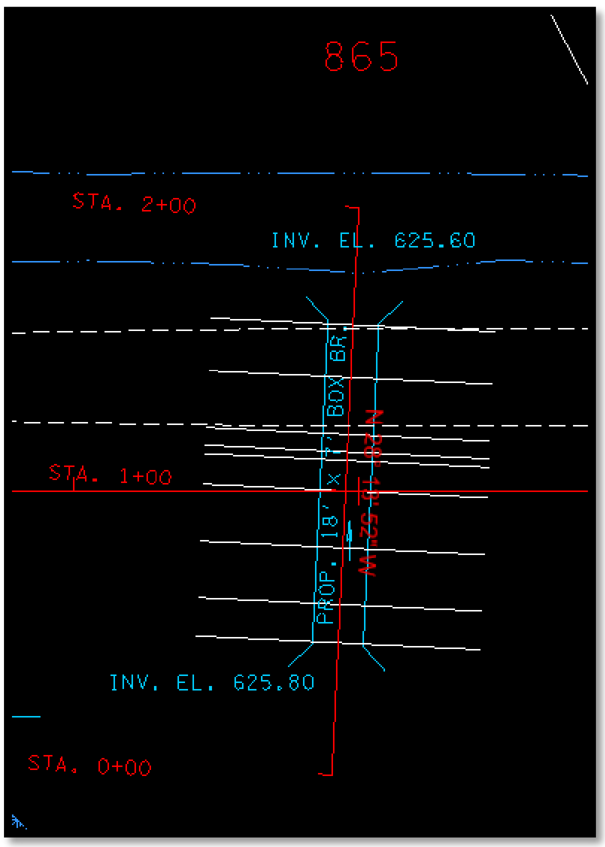


Profile view of Proposed Box Bridge



Culvert section of Proposed Box Bridge

In the Roadway Design Guidelines Section 8-204.02, Figure 8-3 illustrates the limits of culvert excavation for both a box and a slab type bridge. To calculate the excavation and backfill, first it will be necessary to cut cross sections of the existing channel or ground line perpendicular to the center line of the proposed box bridge or culvert.



Plan view of Proposed Box Bridge w/ Pattern Lines

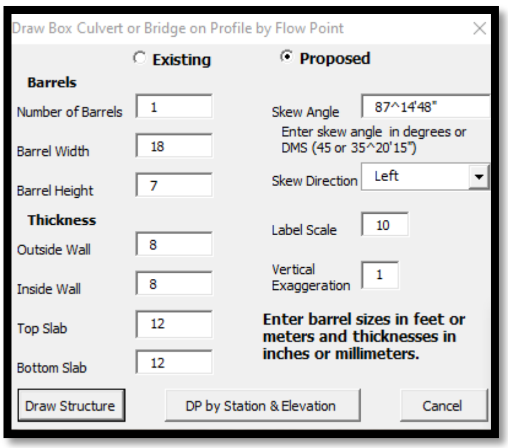
In the figure above, a line has been drawn corresponding to the centerline of the structure. To facilitate the cutting of existing cross sections the red line has been stored as an alignment in Geopak. Pattern lines have been drawn at each end of the culvert and at 20' intervals in between. From the cross section on the previous page, it can be seen that the right edge of the existing roadway is approximately 12.5' left of the proposed roadway centerline. Two additional pattern lines have been drawn on either side of the roadway edge. These pattern lines define where the existing cross section lines will be cut.

Once the cross sections have been cut, from the TDOT menu draw the proposed culvert cell on each cross section (T.D.O.T. > Drainage (Profiles/Culv.Sections) > Draw Box Culvert or Br).

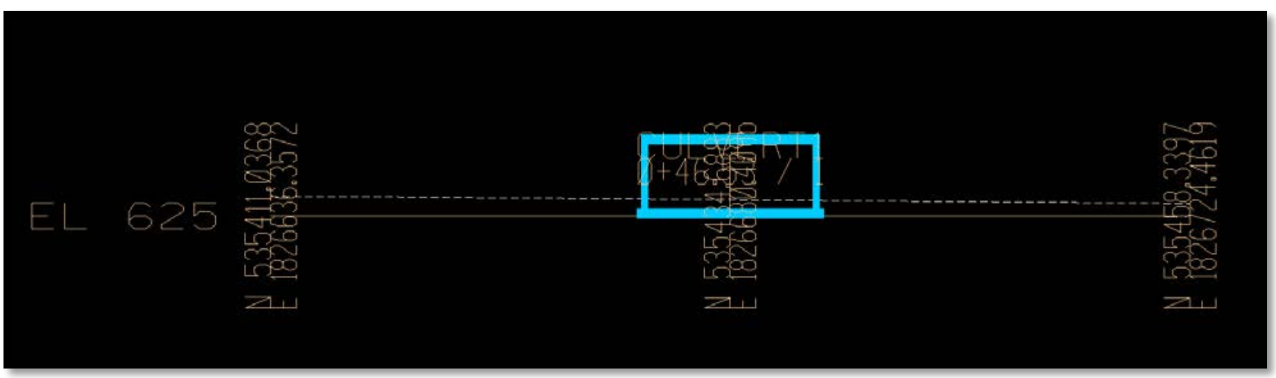
Fill in the data as applicable (numbers shown are for this example culvert):

Refer to Standard Drawings found at this link for dimensions of Box culverts and Bridges:

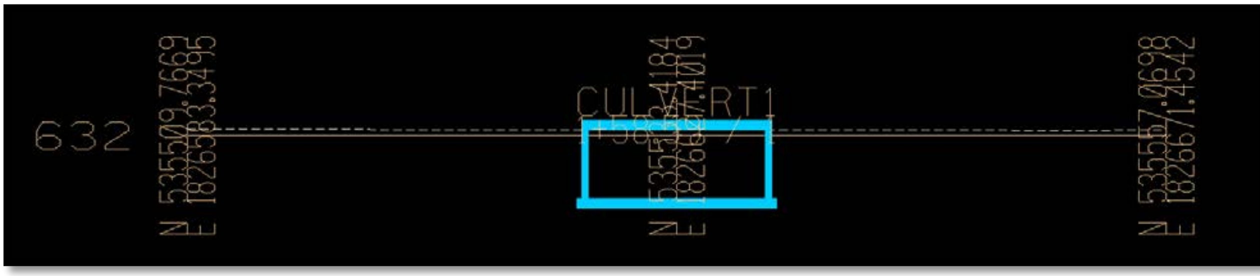
LRFD Box Culverts



Place the cell at the flow elevation corresponding to the section. The section shown below is the right (inlet) end where the flow elevation is 625.80.

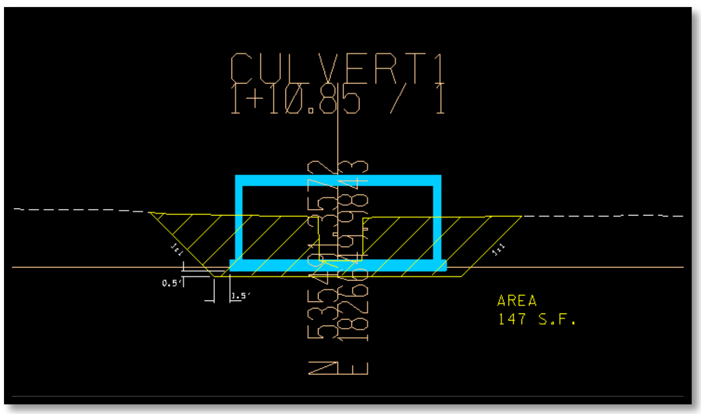


This section is the left (outlet) end of the culvert. The flow elevation is 625.60:



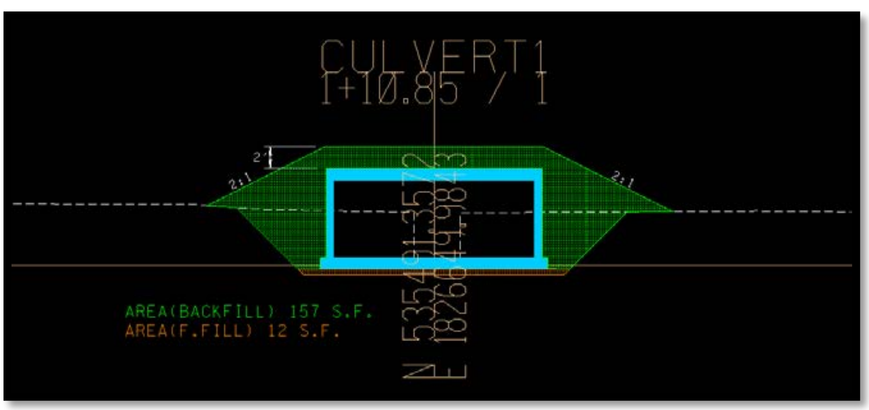
Do the same for all sections in between.

Referencing Figure 4-14 of the Roadway Design Guidelines from Section 4-204.05, the culvert excavation area can be drawn:



Section showing Culvert Excavation

When the culvert excavation area is known then the backfill area can be drawn as shown:



Section showing Backfill

With the culvert excavation and backfill areas determined; the volumes can be calculated. An Excel file is a good way to do this:

			Culvert Exc.		Backfill		Found.Fill	
Station	Dist.	Flow Elev.	Area	*Volume	Area	*Volume	Area	*Volume
			Sq. ft.	Cu. Yd.	Sq. ft.	Cu. Yd.	Sq. ft.	Cu. Yd.
0+46.53		625.80	63		217		12	
	13.47			30.18		108.01		5.99
0+60.00		625.78	58		216		12	
	20.00			41.48		160.37		8.89
0+80.00		625.75	54		217		12	
	20.00			47.78		148.89		8.89
1+00.00		625.73	75		185		12	
	10.85			44.61		68.72		4.82
1+10.85		625.70	147		157		12	
	3.00			18.67		17.11		1.33
1+13.85		625.68	189		151		12	
	6.15			50.91		34.96		2.73
1+20.00		625.66	258		156		12	
	20.00			200.37		117.41		8.89
1+40.00		625.63	283		161		12	
	18.59			190.03		109.82		8.26
1+58.59		625.60	269		158		12	
Total	112.06			624.02		765.29		49.80

*Volume =((Area1+Area2)/2 * Dist) /27

In this example the backfill volume is 765 C.Y., therefore the quantity for Item No. 303-01.01 Granular Backfill (Roadway) is:

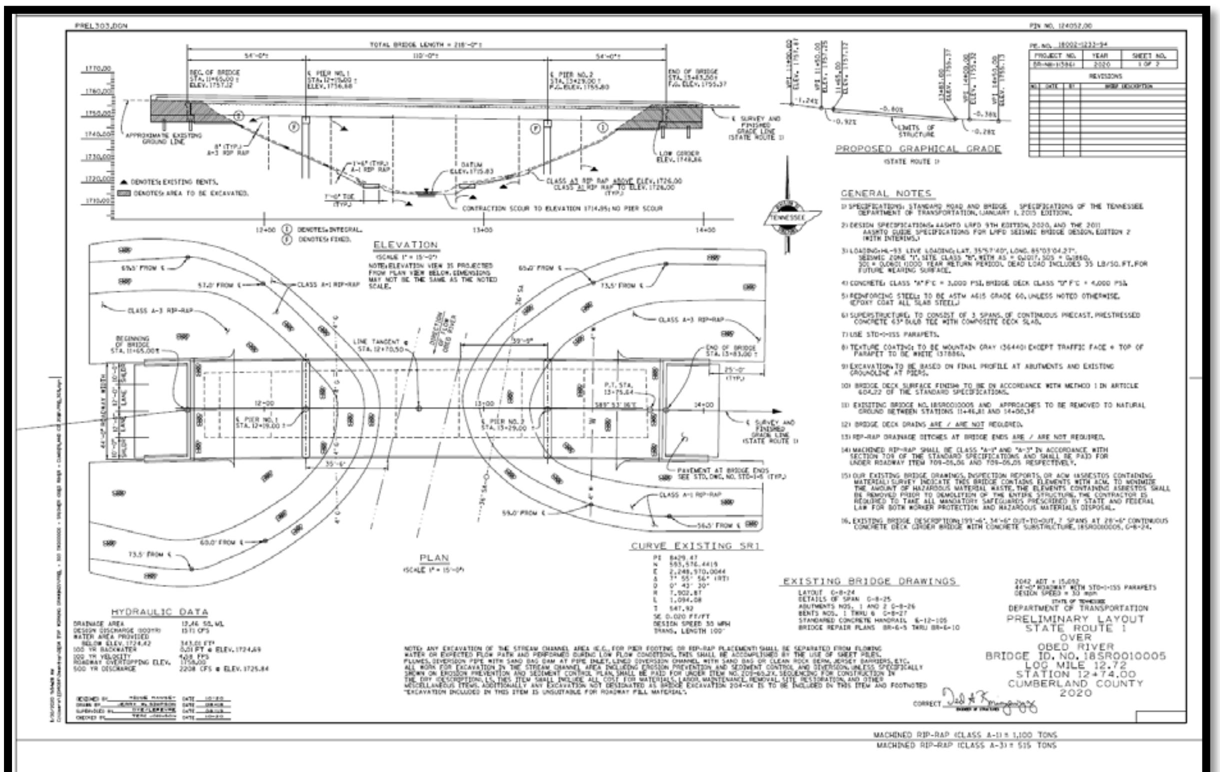
765 c.y. x 1.75 tons/c.y. = 1339 tons

In this example the quantity for Item No. 204-08 Foundation Fill Material is 50 C.Y.

Part 6 – Bridge Apron Calculation

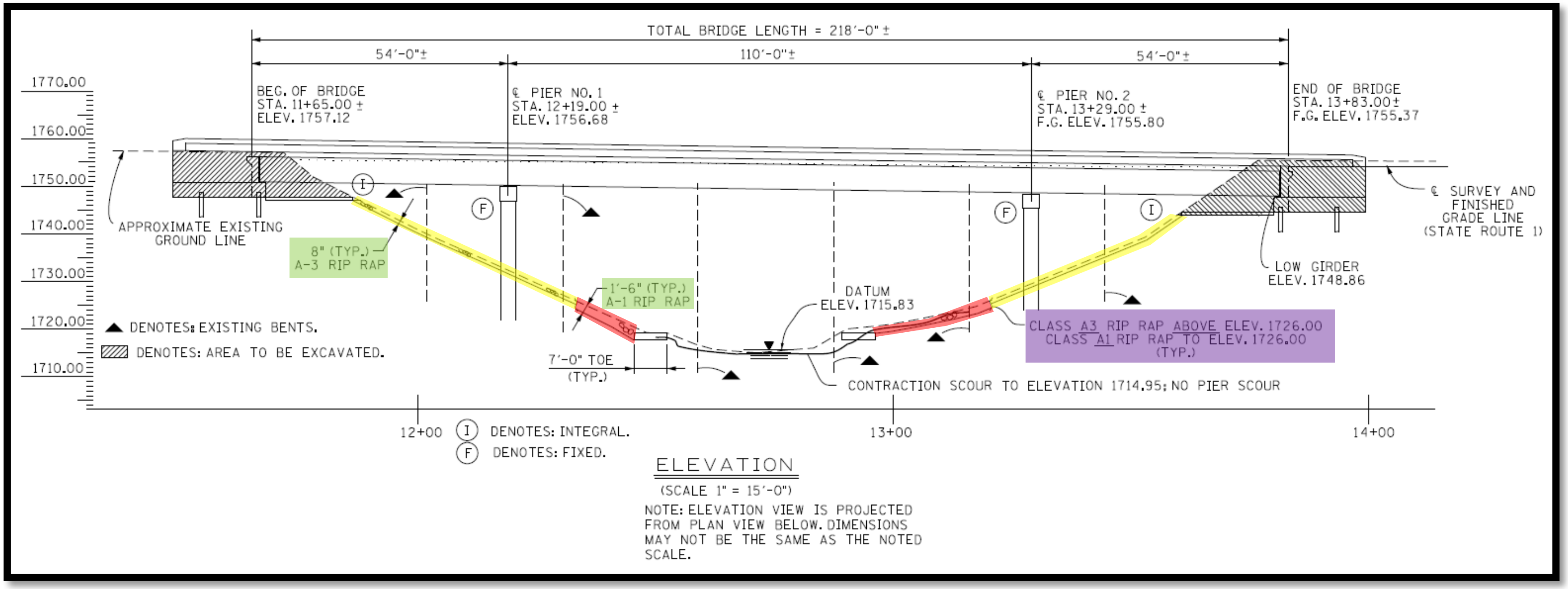
A bridge apron will most likely be required on projects that include a proposed bridge. A bridge apron is a form of scour protection consisting of timber, concrete, riprap, paving, or other construction materials placed adjacent to abutments and piers to prevent undermining. For most TDOT projects, the bridge apron will be constructed with rip-rap. This part of the guide will go into detail of the calculation of how much rip-rap will be needed for the bridge apron around the bridge abutments.

An approximate location of the bridge apron will be shown on the bridge drawing. Once the bridge drawing or the hydraulic layout has been received from Structures Division, the bridge apron can then be analyzed. An example bridge drawing a designer will receive is shown below.

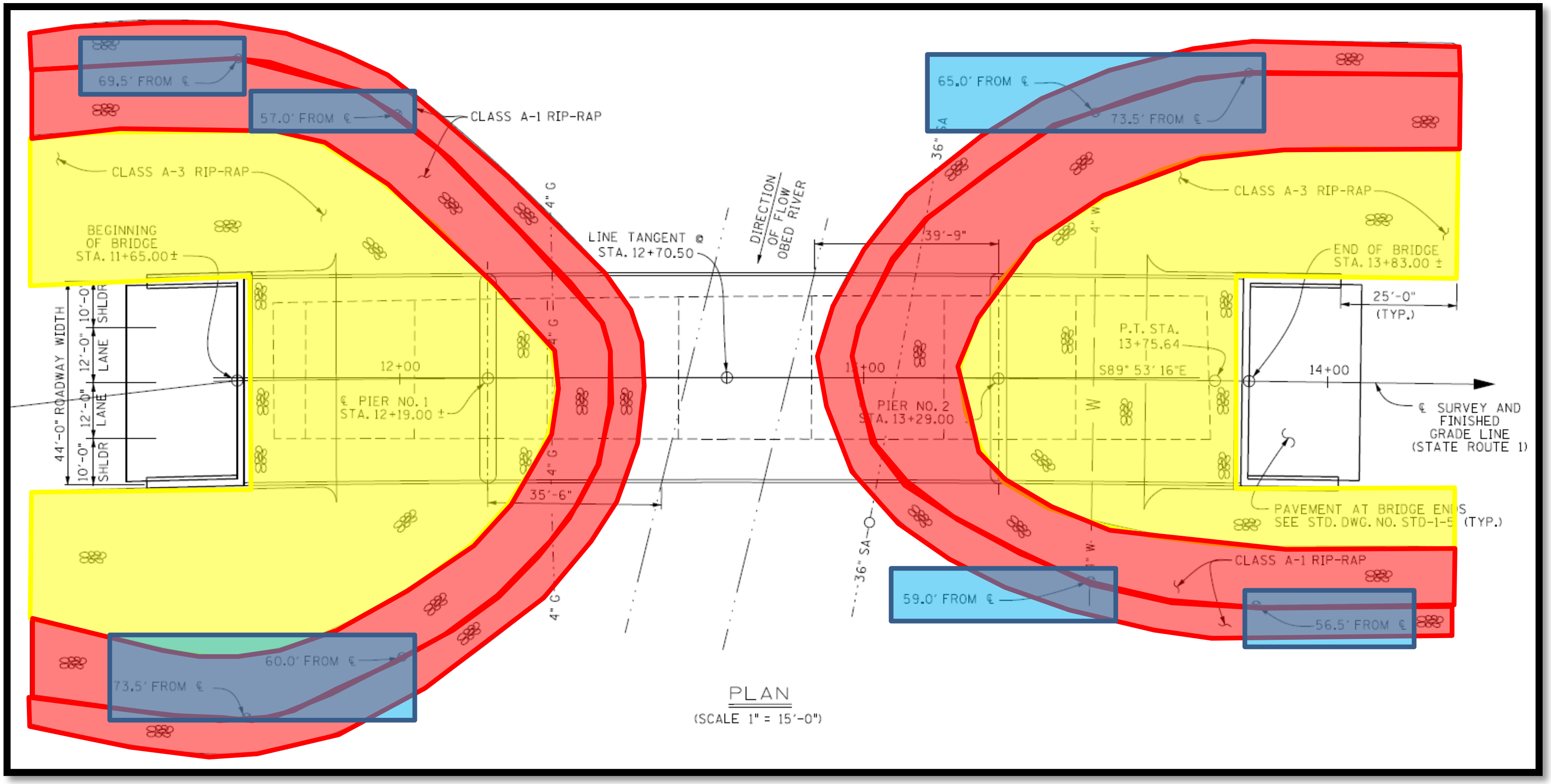


Preliminary Bridge Drawing

The first step is to locate the position of the rip-rap for the bridge apron. The dimensions and elevations constraints of the rip-rap are highlighted in the figures below. The red highlighted area is Class A-1 rip-rap and the yellow highlighted area is Class A-3 rip-rap. More information on the specific details of each rip-rap class can be found in the 2021 TDOT Standard Specifications Book, Section 709.03.

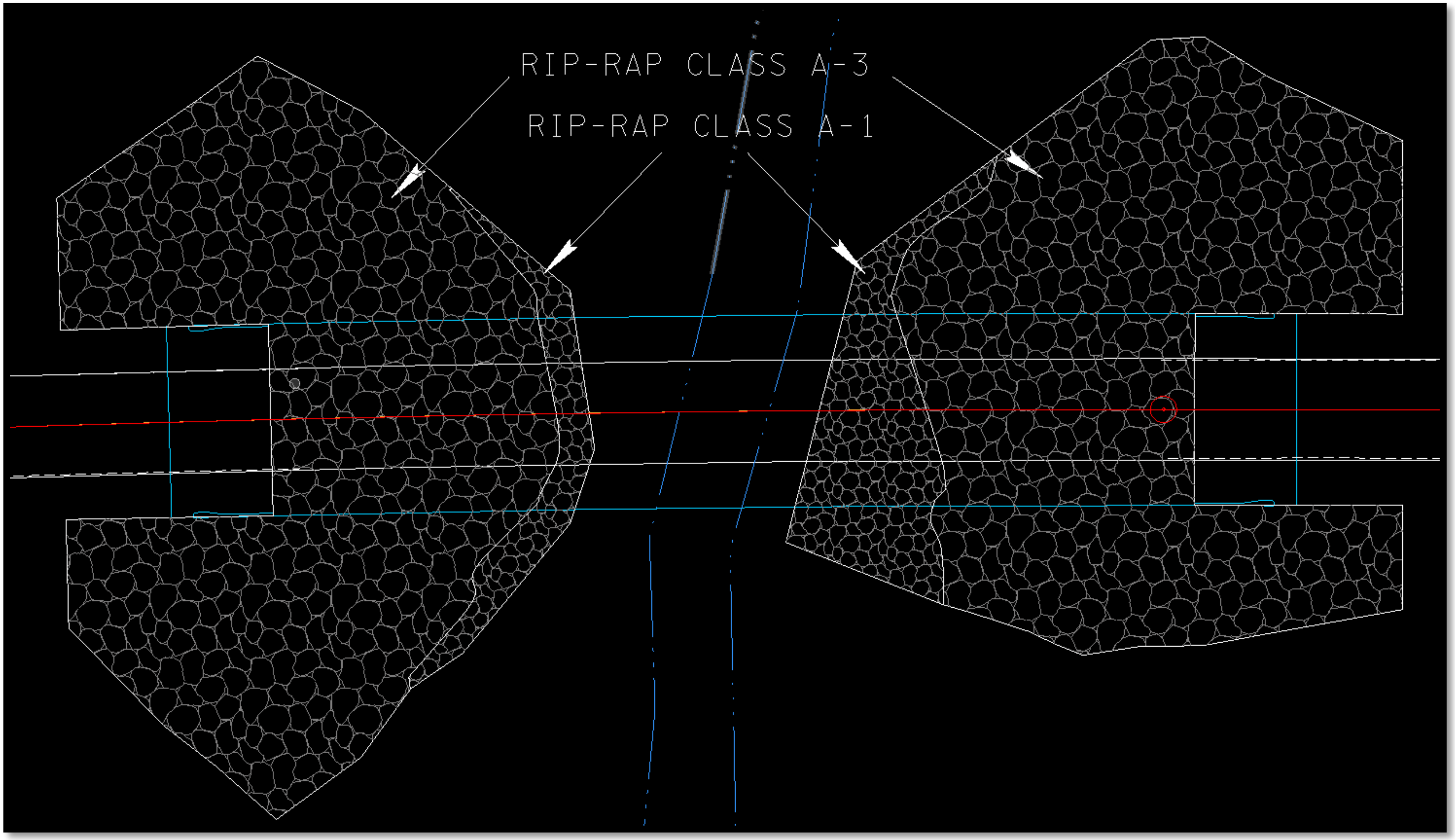


Elevation View


69.5' FROM ℄
57.0' FROM ℄
CLASS A-1 RIP-RAP
CLASS A-3 RIP-RAP
BEGINNING OF BRIDGE STA. 11+65.00±
44'-0" ROADWAY WIDTH
10'-0" SHLDR
12'-0" LANE
12'-0" LANE
10'-0" SHLDR
12+00
℄ PIER NO. 1 STA. 12+19.00 ±
35'-6"
LINE TANGENT @ STA. 12+70.50
DIRECTION OF FLOW OBED RIVER
39'-9"
PIER NO. 2 STA. 13+29.00
65.0' FROM ℄
73.5' FROM ℄
CLASS A-3 RIP-RAP
END OF BRIDGE STA. 13+83.00 ±
25'-0" (TYP.)
P.T. STA. 13+75.64
S89° 53' 16"E
14+00
℄ SURVEY AND FINISHED GRADE LINE (STATE ROUTE 1)
PAVEMENT AT BRIDGE ENDS SEE STD. DWG. NO. STD-1-5 (TYP.)
CLASS A-1 RIP-RAP
59.0' FROM ℄
56.5' FROM ℄
60.0' FROM ℄
73.5' FROM ℄
PLAN
(SCALE 1" = 15'-0")

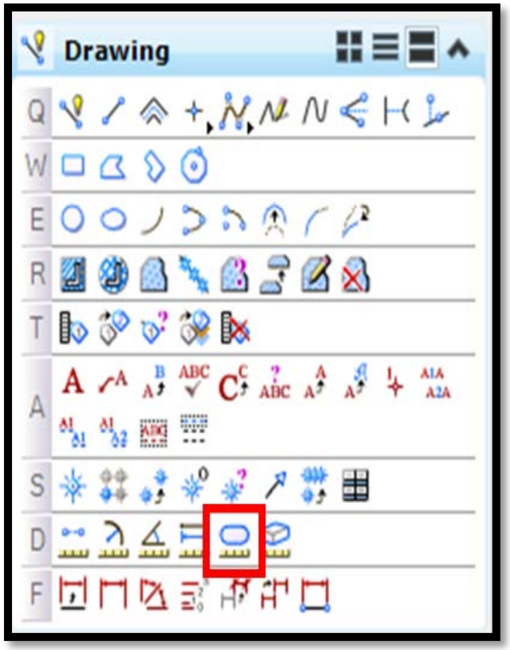
Plan View

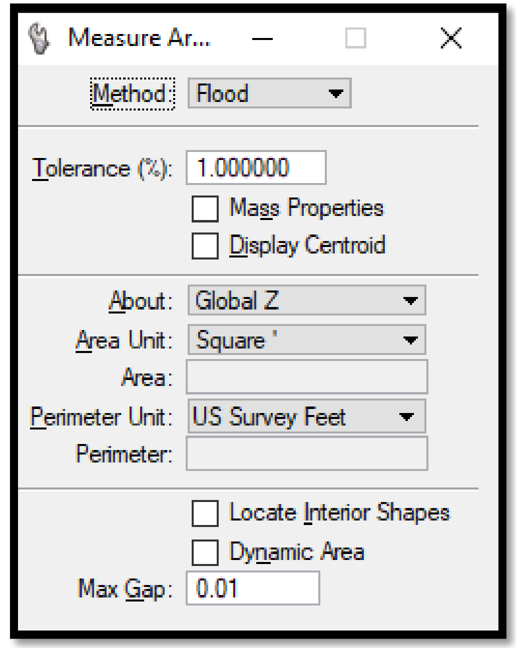
Once the location of rip-rap is determined, the designer can begin to draw the rip-rap shapes into the project's Proposed DGN. Using the offsets and elevations, the approximate locations of each riprap class can be plotted, see the blue highlight in the **Plan View** and the purple view in the **Elevation View**. The final plotted shape can be seen in the figure below. Labels can be added to easily identify the two different types of rip-rap.



Plan View in Proposed DGN

After the rip-rap is plotted in the Proposed DGN, the area of each class of rip-rap can be calculated. Use the Measure Area tool below to calculate the surface area of each class of rip-rap.





The table below summarizes the total surface area of riprap for both class A-1 and A-3.

Rip-rap Surface Area

	Class A-1 Rip-rap (Square Feet)	Class A-3 Rip-rap (Square Feet)
Beginning Bridge	933	12631
End Bridge	1981	11822
Totals	2914	24453

After the surface area is calculated, the depth of the rip-rap needs to be determined. As highlighted in green in the **Elevation View** figure above, the depth of the Class A-1 rip-rap is 1.5 ft and the depth of the Class A-3 rip-rap is 0.67 ft. Once the depth is determined, the volume of rip-rap can be calculated in cubic yards and then converted to tons. A summary of this process is shown in the table below. The conversion from cubic yards to tons can be found in the Roadway Design Guidelines Section 4-709.05 or in the equation below.

Computed Quantity (C.Y.) x 1.75 Tons/C.Y. = Total (Tons)

Rip-rap Volumes & Tons

	Total Surface Area (SF)	Depth (FT)	Volume (CY)	Total (TONS)
Class A-1 Rip-rap	2914	1.50	162	283
Class A-3 Rip-rap	24453	0.67	604	1057

The total quantity for each type of riprap can be shown in the plans as follows:

709-05.05 MACHINED RIP-RAP (CLASS A-3) 1057 TONS

709-05.06 MACHINED RIP-RAP (CLASS A-1) 283 TONS