BOX ELEVATION

$m = h, B_a$ OR RISE + (1'-4")
UNLESS OTHERWISE SHOWN ON PLANS

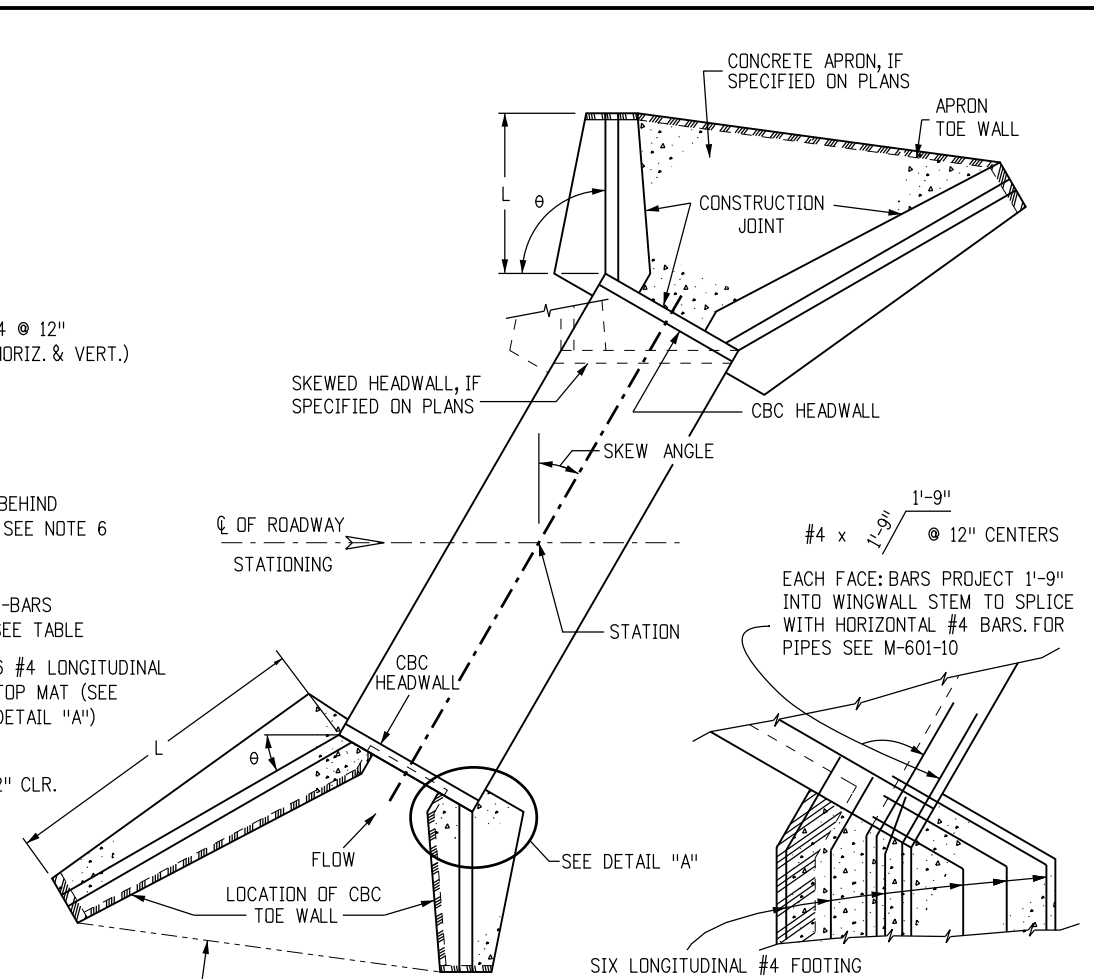FINISHED SLOPE
6"
h, B_a OR RISE
k
m
CHANNEL INVERT
TOE WALL
CULVERT INVERT

#4 @ 12" HORIZONTAL BARS NOT SHOWN FOR CLARITY
#5 PLACE ALONG TOP OF WALL (TOT. 2)
d-BARS (TYP.)

h =	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'	■ 12'	■ 13'	■ 14'
a =	1'-0"	1'-2"	1'-4"	1'-6"	1'-8"	1'-10"	2'-0"	2'-2"	2'-4"	2'-6"	2'-8"	2'-10"	3'-0"
b =	1'-8"	2'-0"	2'-4"	2'-8"	3'-0"	3'-4"	3'-8"	4'-0"	4'-4"	4'-8"	5'-0"	5'-4"	5'-8"
w =	2'-8"	3'-2"	3'-8"	4'-2"	4'-8"	5'-2"	5'-8"	6'-2"	6'-8"	7'-2"	7'-8"	8'-2"	8'-8"
d-BARS	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"	#5 @ 11"	#5 @ 10"	#5 @ 10"	#5 @ 8"	#6 @ 8"	#7 @ 9"	#7 @ 7"
✱ CONC. CY/LF	0.161	0.210	0.259	0.309	0.358	0.407	0.457	0.506	0.556	0.605	0.654	0.704	0.753

✱ DOES NOT INCLUDE TOE WALL QUANTITIES
SEE SHEET 2 OF 2 FOR REINFORCING STEEL QUANTITY

■ REQUIRED DRAINAGE BEHIND WINGWALLS
SEE NOTE 6

PLAN

DESIGN FOOTING LINE
CONSTRUCTION FOOTING LINE.
2'-4" 3'-2" 2'-10"
3'-8"   1'-4" 1'-2"
10"
b = 4'-0"
w = 6'-2"
a = 2'-2"

ELEVATION DESIGN EXAMPLE

USE DESIGN FOR
h=4' | h=5' | h=6' | h=7' | h=8' | h=9'
L
4'-6" MAX. | 5'-6" MAX. | 6'-6" MAX. | 7'-6" MAX. | 8'-6" MAX.
m = 9'-6" MAX.
k = 4'-0"
TOP OF FOOTING ELEVATION

TYPICAL SECTION

#5 PLACE ALONG TOP OF WALL (TOT. 2)
10" STEM
FILL SLOPE 2 (MIN.):1
6"
CONCRETE SEALER AT FRONT,(SEE SHEET 2 OF 2 FOR LIMITS)
2" CLR.
2" CLR.
#4 @ 12" (HORIZ. & VERT.)
c-BARS (VERT.) EQUAL SIZE & SPA. (SEE SHEET 2 OF 2)
■ DRAINAGE BEHIND WINGWALL, SEE NOTE 6
#4 x 2'-8" @ 12" PROJECT 1'-10" INTO STEM
h
3½" X 1½" CONSTR. KEY
d-BARS SEE TABLE
6 #4 LONGITUDINAL TOP MAT (SEE DETAIL "A")
1'-0"
5" R.
3" CLR.
2" CLR.
2 #4 LONGITUDINAL BOTTOM MAT
a
b
w

WITH TOE WALL

#4 BARS
3'-0"
3"CLR.
#4 AT 1'-0"
8"

WITH CONCRETE APRON

#4 @ 1'-0"
1'-0" MIN.
3" CLR
#4 x 2'-0" @ 1'-0"
REINFORCEMENT 1.34 LB./SQ. FT.

APRON TOE WALL

6"
3'-0"
3" CLR
#4 BARS
8"
QUANTITIES FOR TOE WALL ONLY
CONCRETE 0.049 CU. YD./LIN. FT.
REINFORCEMENT 5.1 LB./LIN. FT.

TYPICAL CULVERT LAYOUT

CONCRETE APRON, IF SPECIFIED ON PLANS
APRON TOE WALL
L
θ
CONSTRUCTION JOINT
SKEWED HEADWALL, IF SPECIFIED ON PLANS
CBC HEADWALL
℄ OF ROADWAY STATIONING
SKEW ANGLE
STATION
CBC HEADWALL
θ
L
FLOW
LOCATION OF CBC TOE WALL
SEE DETAIL "A"
INLET APRON IS REQUIRED IF CBC IS USED AS AN ANIMAL PASS

DETAIL "A"

1'-9"
#4 x 1'-9" @ 12" CENTERS
EACH FACE: BARS PROJECT 1'-9" INTO WINGWALL STEM TO SPLICE WITH HORIZONTAL #4 BARS. FOR PIPES SEE M-601-10
SIX LONGITUDINAL #4 FOOTING BARS (TOP MAT), PROJECT 1'-9" MIN. INTO CULVERT FLOOR. FOR PIPES (SEE M-601-10)
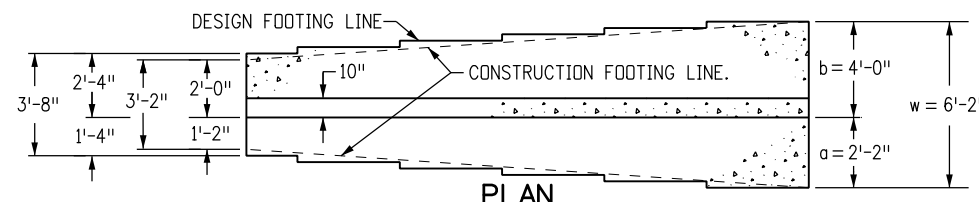
DESIGN DATA:

AASHTO LRFD EIGHTH EDITION, 2017
DESIGN METHOD: LOAD AND RESISTANCE FACTOR DESIGN, YIELD LINE METHOD

REINFORCED CONCRETE:
  CONCRETE CLASS D (BOX CULVERT): f'_c = 4,500 PSI
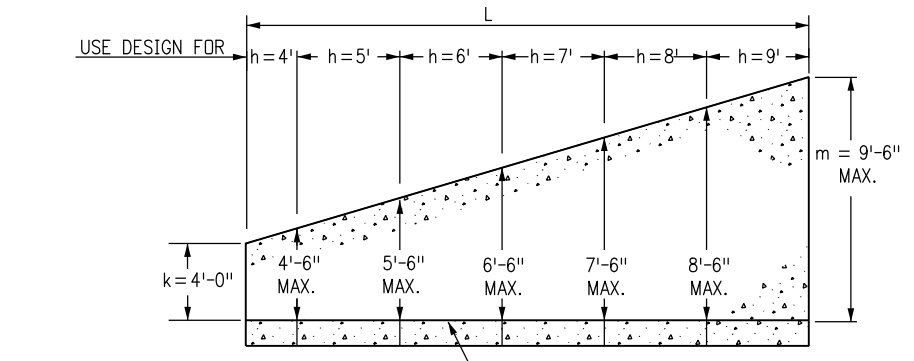 REINFORCING STEEL: f_y = 60,000 PSI

LOADING:
  AT-REST EARTH (FLUID) PRESSURE FOR CONCRETE STEM DESIGN = 55 PCF FOR 2 (MIN.):1 SLOPED BACKFILL
  ACTIVE EARTH (FLUID) PRESSURE FOR CONCRETE FOOTING DESIGN = 40 PCF FOR 2 (MIN.):1 SLOPED BACKFILL
  LIVE LOAD SURCHARGE = 2'
  MINIMUM RESISTANCE FOR SOIL BEARING = 5.5 KSF
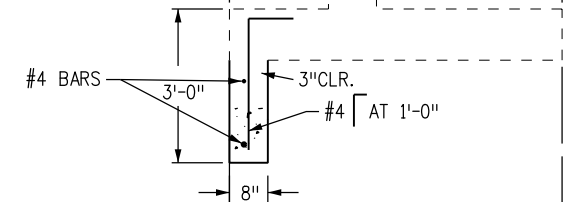 SOIL BEARING RESISTANCE FACTOR = 0.45

GENERAL NOTES:

1. ALL EXPOSED CONCRETE CORNERS SHALL BE CHAMFERED ¾ IN.
2. WINGWALL FOOTING AND FLOOR OF BOX CULVERT SHALL BE PLACED MONOLITHICALLY.
3. DIMENSIONS "h","k","L","m" AND ANGLE "θ" FOR WINGWALL SHALL BE AS SHOWN ON THE PLANS.
4. MINIMUM CLASS B LAP SPLICE LENGTH FOR BLACK REINFORCING BARS:
   BAR SIZE: #4   #5   #6   #7
   SPLICE LENGTH: 1'- 6"   1'-11"   2'-3"   2'-7"
5. DESIGN DOES NOT CONSIDER ANY SCOUR EFFECTS.
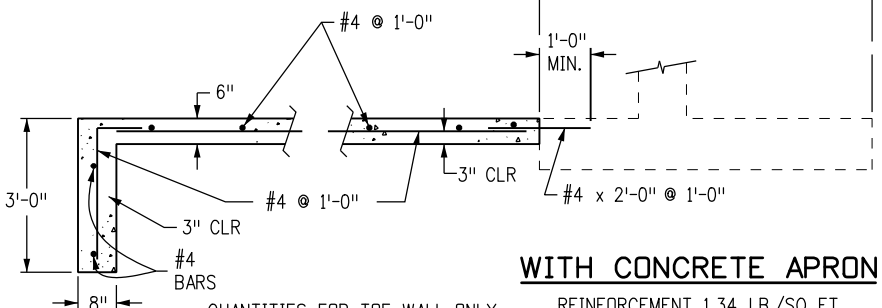6. WINGWALL DRAIN SHALL BE REQUIRED IF "h" ≥ 12.0 FT., SEE SHEET 2 OF 2 FOR DETAILS.

c-BARS AND REINFORCING STEEL QUANTITY (EXCLUDE TOE WALL)

✳ REINFORCING STEEL QUANTITY INCLUDES STEM AND FOOTING QUANTITIES, BUT DOES NOT INCLUDE TOE WALL QUANTITIES.

m (FT)	k (FT)	≤(1.0×m) c-BARS	REINF LB./L.F.	≤(1.25×m) c-BARS	REINF	≤(1.5×m) c-BARS	REINF	≤(1.75×m) c-BARS	REINF	≤(2.0×m) c-BARS	REINF	≤(2.25×m) c-BARS	REINF	≤(2.5×m) c-BARS	REINF	≤(2.75×m) c-BARS	REINF	≤(3.0×m) c-BARS	REINF	≤(3.25×m) c-BARS	REINF	≤(3.5×m) c-BARS	REINF
14	4	#4@10"	53.60	#5@10"	57.95	#5@10"	57.10	#5@8"	60.22	#5@7"	62.43	#5@7"	62.09	#5@6"	65.38	#5@6"	65.15	#6@8"	67.10	#6@8"	66.94	#6@7"	70.66
14	5	#4@10"	55.86	#5@10"	60.46	#5@10"	59.60	#5@8"	62.89	#5@7"	65.23	#5@7"	64.88	#5@6"	68.34	#5@6"	68.11	#6@8"	70.17	#6@8"	70.00	#6@7"	73.90
14	6	#5@10"	64.43	#6@10"	70.60	#6@10"	69.69	#6@8"	74.93	#6@8"	74.45	#6@7"	78.30	#6@6"	83.64	#6@6"	83.40	#6@6"	83.22	#6@6"	83.05	#7@7"	89.64
14	7	#5@10"	67.29	#6@10"	73.76	#6@10"	72.83	#6@8"	78.32	#6@8"	77.84	#7@7"	81.87	#6@6"	87.45	#6@6"	87.21	#6@6"	87.02	#6@6"	86.86	#7@7"	93.73
14	8	#5@8"	74.71	#6@8"	83.46	#6@7"	87.09	#6@6"	92.54	#7@7"	99.47	#7@7"	99.08	#7@6"	107.11	#7@6"	106.86	#7@6"	106.66	#7@6"	106.49	#7@6"	106.35
14	9	#5@8"	78.10	#6@8"	87.23	#6@7"	91.03	#6@6"	96.72	#7@7"	103.93	#7@7"	103.54	#7@6"	111.90	#7@6"	111.65	#7@6"	111.45	#7@6"	111.28	#7@6"	111.13
13	4	#4@10"	50.51	#4@10"	49.25	#5@10"	53.71	#5@10"	53.09	#5@10"	52.36	#5@9"	53.85	#5@8"	55.54	#5@7"	57.85	#5@7"	57.67	#5@7"	57.51	#6@9"	59.93
13	5	#4@10"	52.66	#4@10"	51.37	#5@10"	56.09	#5@10"	55.46	#5@10"	54.99	#5@9"	56.29	#5@8"	58.08	#5@7"	60.51	#5@7"	60.33	#5@7"	60.17	#6@9"	62.72
13	6	#4@10"	54.92	#5@10"	59.48	#5@9"	60.31	#6@9"	67.56	#6@9"	67.08	#6@8"	69.53	#6@8"	69.28	#6@7"	73.12	#6@7"	72.95	#6@7"	72.81	#6@7"	72.66
13	7	#4@10"	57.36	#5@10"	62.16	#5@9"	63.05	#6@9"	70.66	#6@9"	70.16	#6@9"	69.78	#6@8"	72.75	#6@8"	72.50	#6@7"	76.52	#6@7"	76.35	#6@7"	76.20
13	8	#5@10"	66.39	#6@10"	72.82	#6@8"	77.97	#6@7"	81.68	#6@7"	81.19	#6@6"	86.67	#6@6"	86.37	#7@7"	93.18	#7@7"	92.97	#7@7"	92.80	#7@7"	92.64
13	9	#5@10"	69.37	#6@10"	76.10	#6@8"	81.49	#6@7"	85.37	#6@7"	84.87	#6@6"	90.59	#6@6"	90.29	#7@7"	97.39	#7@7"	97.18	#7@7"	97.00	#7@6"	96.85
12	2	#4@10"	43.91	#4@10"	42.65	#4@10"	41.82	#4@10"	41.22	#4@10"	40.78	#4@9"	41.29	#5@10"	44.61	#5@10"	44.37	#5@10"	44.18	#5@10"	44.01	#5@10"	43.87
12	3	#4@10"	45.82	#4@10"	44.55	#4@10"	43.71	#4@10"	43.11	#4@10"	42.66	#4@9"	43.22	#5@10"	46.75	#5@10"	46.51	#5@10"	46.32	#5@10"	46.15	#5@10"	46.01
12	4	#4@10"	47.80	#4@10"	46.51	#4@10"	45.65	#5@10"	50.06	#5@10"	49.59	#5@10"	49.23	#5@10"	48.94	#5@10"	48.69	#5@9"	50.00	#5@8"	51.72	#5@8"	51.57
12	5	#4@10"	49.84	#4@10"	48.53	#4@10"	47.66	#5@10"	52.33	#5@10"	51.85	#5@10"	51.48	#5@10"	51.19	#5@10"	50.94	#5@9"	52.33	#5@8"	54.14	#5@8"	54.00
12	6	#4@10"	51.99	#4@10"	50.65	#5@10"	55.34	#5@8"	58.41	#5@8"	57.93	#6@10"	60.60	#6@10"	60.34	#6@9"	62.42	#6@9"	62.22	#6@9"	62.04	#6@8"	64.89
12	7	#4@10"	54.30	#5@10"	58.80	#5@10"	57.87	#5@8"	61.10	#5@8"	60.61	#6@10"	63.43	#6@10"	63.11	#6@9"	65.35	#6@9"	65.15	#6@9"	64.97	#6@8"	67.96
12	8	#5@10"	62.91	#5@10"	61.45	#5@7"	67.46	#5@6"	70.68	#5@6"	70.20	#6@7"	76.44	#6@7"	76.13	#6@7"	75.87	#6@6"	81.30	#6@6"	81.12	#6@6"	80.98
12	9	#5@10"	65.64	#5@10"	64.15	#5@7"	70.44	#5@6"	73.82	#5@6"	73.33	#6@7"	79.86	#6@7"	79.54	#6@7"	79.28	#6@6"	84.95	#6@6"	84.77	#6@6"	84.62
11	2	#4@10"	41.70	#4@10"	40.42	#4@10"	39.57	#4@10"	38.96	#4@10"	38.50	#4@10"	38.15	#4@10"	37.87	#4@10"	37.63	#4@9"	38.25	#5@10"	41.46	#5@10"	41.31
11	3	#4@10"	43.57	#4@10"	42.27	#4@10"	41.40	#4@10"	40.79	#4@10"	40.33	#4@10"	39.97	#4@10"	39.69	#4@10"	39.45	#4@9"	40.12	#5@10"	43.39	#5@10"	43.24
11	4	#4@10"	45.48	#4@10"	44.16	#4@10"	43.28	#4@10"	42.66	#4@9"	43.09	#5@10"	46.57	#5@10"	46.27	#5@10"	46.02	#5@10"	45.82	#5@10"	45.65	#5@10"	45.50
11	5	#4@10"	47.46	#4@10"	46.10	#4@10"	45.21	#4@10"	44.58	#4@9"	45.06	#5@10"	48.74	#5@10"	48.44	#5@10"	48.19	#5@10"	47.99	#5@10"	47.81	#5@10"	47.67
11	6	#4@10"	49.52	#4@10"	48.14	#4@9"	48.23	#5@10"	51.88	#5@10"	51.38	#5@9"	52.57	#5@9"	52.27	#5@8"	53.99	#5@8"	53.79	#5@7"	56.16	#5@7"	56.01
11	7	#4@10"	51.73	#4@10"	50.31	#4@9"	50.43	#5@10"	54.29	#5@10"	53.78	#5@9"	54.73	#5@9"	56.55	#5@8"	56.35	#5@8"	56.35	#5@7"	58.84	#5@7"	58.70
11	8	#4@10"	54.00	#5@10"	58.44	#5@10"	57.45	#5@8"	60.64	#5@7"	62.92	#6@6"	66.25	#6@6"	65.94	#6@6"	65.69	#6@8"	67.76	#6@8"	67.57	#6@7"	71.45
11	9	#4@10"	56.20	#5@10"	60.87	#5@10"	59.85	#5@8"	63.21	#5@6"	65.60	#5@6"	69.09	#6@8"	68.78	#6@8"	68.52	#6@8"	70.69	#6@8"	70.51	#6@7"	74.57
10	2	#4@10"	39.84	#4@10"	38.53	#4@10"	37.65	#4@10"	37.03	#4@10"	36.57	#4@10"	36.20	#4@10"	35.91	#4@10"	35.67	#4@10"	35.48	#4@10"	36.07	#4@9"	35.93
10	3	#4@10"	41.68	#4@10"	40.35	#4@10"	39.47	#4@10"	38.84	#4@10"	38.36	#4@10"	38.00	#4@10"	37.71	#4@10"	37.46	#4@10"	37.27	#4@10"	37.91	#4@9"	37.76
10	4	#4@10"	43.58	#4@10"	42.22	#4@10"	41.31	#4@10"	40.67	#4@10"	40.19	#4@10"	39.82	#4@10"	39.53	#4@10"	39.28	#4@10"	39.08	#4@9"	39.77	#4@9"	39.63
10	5	#4@10"	45.53	#4@10"	44.14	#4@10"	43.21	#4@10"	42.56	#4@10"	42.07	#5@10"	46.44	#5@10"	46.13	#5@10"	45.87	#5@10"	45.67	#5@10"	45.49	#5@10"	45.34
10	6	#4@10"	47.58	#4@10"	46.14	#4@10"	45.20	#4@10"	44.53	#4@10"	44.03	#5@10"	48.67	#5@10"	48.35	#5@10"	48.08	#5@10"	47.88	#5@10"	47.69	#5@10"	47.54
10	7	#4@10"	49.79	#4@10"	48.31	#4@10"	47.34	#5@10"	51.97	#5@10"	51.45	#5@10"	51.04	#5@9"	52.29	#5@9"	52.03	#5@8"	53.79	#5@8"	53.56	#5@7"	58.00
10	8	#4@10"	52.06	#4@10"	50.54	#4@10"	49.54	#5@10"	54.43	#5@10"	53.89	#5@10"	53.47	#5@9"	54.80	#5@9"	54.53	#5@8"	56.39	#5@8"	56.20	#5@7"	58.72
9	2	#4@10"	38.01	#4@10"	36.75	#4@10"	35.85	#4@10"	35.21	#4@10"	34.73	#4@10"	34.36	#4@10"	34.06	#4@10"	33.81	#4@10"	33.61	#4@10"	33.44	#4@10"	33.30
9	3	#4@10"	39.93	#4@10"	38.56	#4@10"	37.64	#4@10"	36.99	#4@10"	36.51	#4@10"	36.13	#4@10"	35.83	#4@10"	35.58	#4@10"	35.38	#4@10"	35.21	#4@10"	35.06
9	4	#4@10"	41.81	#4@10"	40.40	#4@10"	39.47	#4@10"	38.81	#4@10"	38.31	#4@10"	37.93	#4@10"	37.63	#4@10"	37.37	#4@10"	37.17	#4@10"	36.99	#4@10"	36.84
9	5	#4@10"	43.75	#4@10"	42.30	#4@10"	41.35	#4@10"	40.67	#4@10"	40.17	#4@10"	39.78	#4@10"	39.47	#4@10"	39.20	#4@9"	39.86	#5@10"	43.28	#5@10"	43.12
9	6	#4@10"	45.79	#4@10"	44.30	#4@10"	43.31	#4@10"	42.62	#4@10"	42.10	#4@10"	41.71	#4@10"	41.39	#4@10"	41.12	#4@9"	41.82	#5@10"	45.46	#5@10"	45.30
9	7	#4@10"	48.04	#4@10"	46.50	#4@10"	45.49	#4@10"	44.77	#5@10"	49.29	#5@10"	48.86	#5@10"	48.53	#5@10"	48.24	#5@10"	48.03	#5@10"	47.84	#5@10"	47.67
9	8	#4@10"	50.43	#4@10"	48.87	#4@10"	47.80	#4@10"	47.06	#5@10"	51.83	#5@10"	51.40	#5@10"	51.05	#5@10"	50.77	#5@10"	50.54	#5@10"	50.35	#5@10"	50.18
8	2	#4@10"	36.41	#4@10"	35.01	#4@10"	34.08	#4@10"	33.42	#4@10"	32.92	#4@10"	32.54	#4@10"	32.23	#4@10"	31.97	#4@10"	31.77	#4@10"	31.59	#4@10"	31.44
8	3	#4@10"	38.23	#4@10"	36.80	#4@10"	35.85	#4@10"	35.18	#4@10"	34.67	#4@10"	34.28	#4@10"	33.97	#4@10"	33.70	#4@10"	33.50	#4@10"	33.32	#4@10"	33.17
8	4	#4@10"	40.09	#4@10"	38.61	#4@10"	37.64	#4@10"	36.95	#4@10"	36.44	#4@10"	36.04	#4@10"	35.72	#4@10"	35.45	#4@10"	35.25	#4@10"	35.07	#4@10"	34.91
8	5	#4@10"	41.99	#4@10"	40.47	#4@10"	39.47	#4@10"	38.76	#4@10"	38.24	#4@10"	37.83	#4@10"	37.50	#4@10"	37.23	#4@10"	37.02	#4@10"	36.84	#4@10"	36.68
8	6	#4@10"	43.97	#4@10"	42.40	#4@10"	41.36	#4@10"	40.64	#4@10"	40.10	#4@10"	39.68	#4@10"	39.35	#4@9"	39.07	#4@9"	43.33	#5@10"	43.13	#5@10"	42.96
8	7	#4@10"	46.19	#4@10"	44.56	#4@10"	43.49	#4@10"	42.74	#4@10"	42.18	#4@10"	41.75	#4@10"	41.41	#4@10"	41.13	#4@9"	45.65	#5@10"	45.45	#5@10"	45.28
7	2	#4@10"	34.90	#4@10"	33.44	#4@10"	32.47	#4@10"	31.78	#4@10"	31.27	#4@10"	30.86	#4@10"	30.54	#4@10"	30.27	#4@10"	30.06	#4@10"	29.88	#4@10"	29.72
7	3	#4@10"	36.73	#4@10"	35.23	#4@10"	34.23	#4@10"	33.53	#4@10"	33.00	#4@10"	32.59	#4@10"	32.26	#4@10"	31.99	#4@10"	31.78	#4@10"	31.59	#4@10"	31.43
7	4	#4@10"	38.59	#4@10"	37.04	#4@10"	36.01	#4@10"	35.29	#4@10"	34.75	#4@10"	34.33	#4@10"	33.99	#4@10"	33.71	#4@10"	33.50	#4@10"	33.31	#4@10"	33.14
7	5	#4@10"	40.48	#4@10"	38.86	#4@10"	37.80	#4@10"	37.06	#4@10"	36.50	#4@10"	36.07	#4@10"	35.73	#4@10"	35.44	#4@10"	35.22	#4@10"	35.03	#4@10"	34.86
7	6	#4@10"	42.39	#4@10"	40.71	#4@10"	39.61	#4@10"	38.84	#4@10"	38.26	#4@10"	37.82	#4@10"	37.47	#4@10"	37.17	#4@10"	36.95	#4@10"	36.75	#4@10"	36.58

EXAMPLE:

SELECT THE c-BARS SIZE, SPACING AND STEEL QUANTITY FOR A 25.0 FEET LONG WINGWALL WITH m = 11.8 FT. AND k = 6.3 FT.

SOLUTION:

1. DETERMINE WINGWALL LENGTH IN MULTIPLE OF m:
   L / m = 25.0 / 11.8 = 2.12
   L = (2.12 x m), USE L ≤ (2.25 x m)
2. ROUND TO NEAREST WHOLE NUMBER FOR m AND k:
   m = 11.8 FT., USE m = 12.0 FT.
   k = 6.3 FT., USE k = 6.0 FT.
3. DETERMINE c-BARS BY USING THE TABLE:
   L ≤ (2.25 x m)
   m = 12
   k = 6
   c-BARS: #6 @ 10"
   REINF. STEEL = 60.60 LB / LF
4. DETERMINE REINFORCING STEEL QUANTITY OF WHOLE WINGWALL:
   REINFORCING STEEL QUANTITY = 25.0 x 60.60 = 1,515 LB.

APPLY CONCRETE SEALER

1'-0"

3'-0" MAX.

PLASTIC DRAINAGE CORE

GEOTEXTILE (DRAINAGE) (CLASS 2) SHALL BE ON EMBANKMENT SIDE OR ON BOTH SIDE OF CORE

2%

3" Ø DRAIN HOLE, 20'-0" MAX. CENTER TO CENTER, LOCATE 0'-6" ABOVE FINISHED GRADE OR APRON.

LIMITS OF CONCRETE SEALER AND WINGWALL DRAIN DETAILS

NOTES: 1. THE GEOCOMPOSITE SHALL BE SECURED TO THE WALL TO PREVENT MOVEMENT DURING BACKFILLING.

2. COST OF GEOCOMPOSITE DRAIN AND CONCRETE SEALER SHALL BE INCLUDED IN THE WORK.