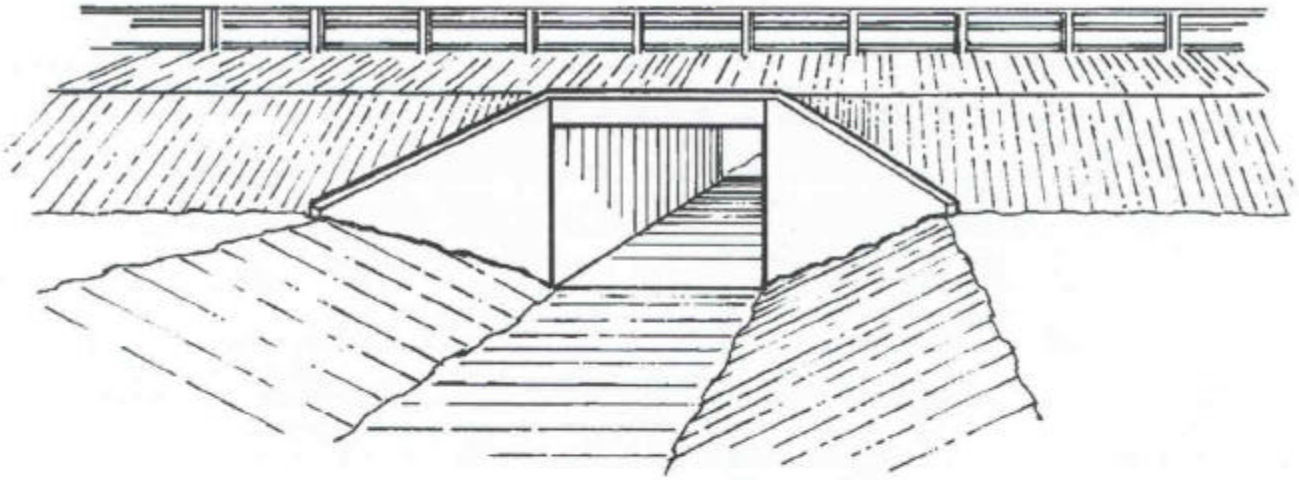


Culvert Manual

Illinois Department
of Transportation
Bureau of Bridges and Structures

June 2000

STATE OF ILLINOIS DEPARTMENT OF TRANSPORTATION BUREAU OF BRIDGES AND STRUCTURES	**FILE CLASSIFICATION:** *Culvert Manual*
	CULVERT MANUAL CHANGE LETTER NO. 00-1
To: *All holders of the Culvert Manual*	**DATE ISSUED:** June *1, 2000*

The Culvert Manual has been revised. All revised sheets are dated June 2000. A summary of the revisions is listed below. The updated base sheets are also available on the Internet.

Page	Remarks
Sect. 2 Table of Contents	editorial
Sect. 2 Table of Figures (1st page)	editorial
2-1 to 2-3	Updated AASHTO interims and references; revised text on design strength and live load.
2-8 to 2-9	Removed rigid frame reference in Sect. 2.1.9
2-10 to 2-21	Revised design example and figures based on updated culvert design tables.
2-23 to 2-28	Provided additional design criteria and limitations for the culvert design tables. Revised the design example based on the updated design tables.
2-30 to 2-80	Updated design tables utilizing the latest computer technologies and revised AASHTO interims.
2-84	Revised dimensioning on Details A and B.

2-86	Revised dimensioning on Details A and B.
2-91 to 2-93	editorial
2-95	editorial
3-2; 3-4 to 3-6; 3-8; 3-9	Revised slope references to read (vertical: horizontal)
Base Sheet Table of Contents	Added a column for Required Cells. These cells are those necessary to build each base sheet.
All Base Sheets SSB-H-O through SSB-T2-R	Added note requiring all joints to be bonded.

Ralph E. Anderson
Engineer of Bridges and Structures

KLR

Section 1 Introduction

As directed by the Engineer of Bridges and Structures, it is the responsibility of the Engineer of Bridge Design to develop, maintain and administer the policies that govern the design and preparation of plans and specifications for all bridges under the jurisdiction of the Department of Transportation. The vehicle by which this policy is controlled is the Bridge Manual.

This Manual is a supplement to the Bridge Manual. The purpose of this Manual is to aid in the design and detailing of single span reinforced concrete box culverts. Presented herein is a compilation of design procedures, design charts and tables, standard details and base sheets.

This Manual is an active Manual in the respect that as research, revised criteria and AASHTO specification revisions dictate, new or revised sheets will be issued. It is strongly urged that as these sheets are received, they immediately be incorporated in the book, so that the Manual's integrity is maintained.

Notations & Definitions

A_g = gross area of section
A_s = area of tension reinforcement
b = width of compression face of member
b = footing width of vertical cantilever T-Type wingwall
B = footing width of vertical cantilever L-Type wingwall
C = coefficient used to determine moment in horizontal cantilever wingwall
d = distance from extreme compression fiber to centroid of tension reinforcement
D = effect of dead load of concrete
D = drop of end of wingwall below top of headwall
E = effect of earth pressure
E = width of slab over which a wheel load is distributed for contact loading
E_c = modulus of elasticity of concrete
E_s = modulus of elasticity of reinforcement
f = height of headwall above top of top slab
f'_c = specified compressive strength of concrete
f_y = specified yield strength of reinforcement
F = fill height above top of culvert
h = distance from invert to top of top slab (used in design of horizontal cantilever wingwalls)
H = clear height of culvert
H = height used in determining horizontal pressure on wingwalls
H_D = distance from bottom of footing to point of intersection of embankment slope and back face of wing stem for T-Type wingwall (Design Height)
H_L = distance from top of headwall to invert
H_S = stem height of vertical cantilever L-Type wingwall
I = effect of live load impact

K_H	=	coefficient for determining horizontal pressure behind wingwall
K_V	=	coefficient for determining vertical pressure on plane behind vertical cantilever wingwall
L	=	effect of live load
L	=	length of wingwall
M_u	=	factored moment at section
n	=	modular ratio of elasticity = E_S/E_C
n	=	value used in determining active earth pressure coefficients. See Figure 3.1.2-1
N_u	=	factored axial load occuring simultaneously with V_u
P	=	design wheel load
P	=	horizontal pressure behind wingwall as shown in Section 3.1.2
P_H	=	total horizontal pressure behind wingwall
P_V	=	total vertical pressure on plane behind vertical cantilever wingwall
S	=	design span length as defined in AASHTO Article 3.24
T	=	top slab thickness for cast-in-place box
T	=	wingwall thickness for horizontal cantilever and vertical cantilever L-Type wingwalls
T	=	thickness of top of stem for vertical cantilever T-Type wingwall
T_1	=	thickness of bottom of stem for vertical cantilever T-Type wingwall
T_f	=	footing thickness of vertical cantilever L-Type and T-Type wingwall
V_c	=	nominal shear strength provided by concrete
V_u	=	factored shear force at section
W	=	sidewall thickness
X	=	toe width of vertical cantilever T-Type wingwall
z	=	quantity limiting distribution of flexural reinforcement
β_E	=	load combination coefficient for earth pressure
θ	=	skew angle of roadway, degrees
ρ	=	tension reinforcement ratio = A_S/bd
ρ_b	=	reinforcement ratio producing balanced strain conditions

Note: Other notations are defined in the text.

Section 2 Barrel Design

Table of Contents

Section 2 Barrel Design

Table of Figures

Section 2 Barrel Design

2.1 General

The following section covers a complete set of data for the design of simple span reinforced concrete box culverts using the Load Factor Design Method.

2.1.1 Specifications

AASHTO 1996 - Standard Specifications for Highway Bridges with 1997, 1998, and 1999 Interims and as further specified herein.

2.1.2 Design Strength

f'_c = 3,500 psi

f_y = 60,000 psi

$n = \frac{E_s}{E_c} = 9$ (used for computing service load requirements)

The nominal shear strength provided by the concrete (V_c) of the top slab is as follows:

1. For culverts with fill less than 2 feet, the current AASHTO shear provisions from Art. 3.24.4 are used.
2. For culverts with 2 feet or more fill, the following equation according to AASHTO Article 8.16.6.7 is used:

$$V_c = \left[2.14\sqrt{f'_c} + 4600\rho \frac{V_u d}{M_u} \right] bd \qquad \text{(Eq. 1)}$$

Where: $\frac{V_u d}{M_u} \le 1.0$ & $V_c \le 4\sqrt{f'_c}\,bd$

For single span culverts, V_c need not be taken less than $2.5\sqrt{f'_c}\,bd$.

V_u and M_u are the factored shear and moment occurring at the point where shear is being investigated.

For the design of sidewalls, V_c may be computed by:

$$V_c = 2\sqrt{f'_c}bd \qquad \text{or} \qquad V_c = 2\left(1+\frac{N_u}{2000\,A_g}\right)\sqrt{f'_c}bd$$

Where:

$$V_c \le 3.5\sqrt{f'_c}bd$$

N_u is the simultaneous factored axial load at the point where the shear is being investigated, and $\frac{N_u}{A_g}$ is in psi.

2.1.3 Loading

Group X of AASHTO Loading Combination, Article 3.22 is modified and applied as follows:

$$1.5(D+\beta_E E)+(1.3)\frac{5}{3}(L+I)$$

Where:

β_E = 1.0 for vertical earth load

β_E = 1.0 or 1.3 for lateral earth pressures

Live Load

The governing load of HS20-44 (excluding lane load), or the alternate military loading (Interstate only) of two axles 4 feet apart with each axle weighing 24,000 lbs.

For fills less than 2 feet, the live load is considered as a contact load with a distribution of E = 4 +0.06S per wheel load (in conformance with AASHTO 3.24.3.2), where S is the design span length in feet as described in section 2.2.1. For fills 2 feet and more, the live load or loads are considered as uniformly distributed over a square or rectangular area in conformance with AASHTO Article 6.4 and as shown in Figures 2.1.3-1 and 2.1.3-2. These figures illustrate the governing load cases for simple span box culverts. The box culvert length parallel to the stream is assumed to be longer than the limits of the live load in that same direction. The effect of live load is neglected when the fill exceeds 8 feet and is more than the design span.

Impact

The live load stresses are increased to allow for impact according to AASHTO Article 3.8.2.3 as follows:

Fills	0'-0" to 1'-0" inclusive	I = 30%
Fills	1'-1" to 2'-0" inclusive	I = 20%
Fills	2'-1" to 2'-11" inclusive	I = 10%
Fills	3'-0" and greater	No impact

Dead Loads

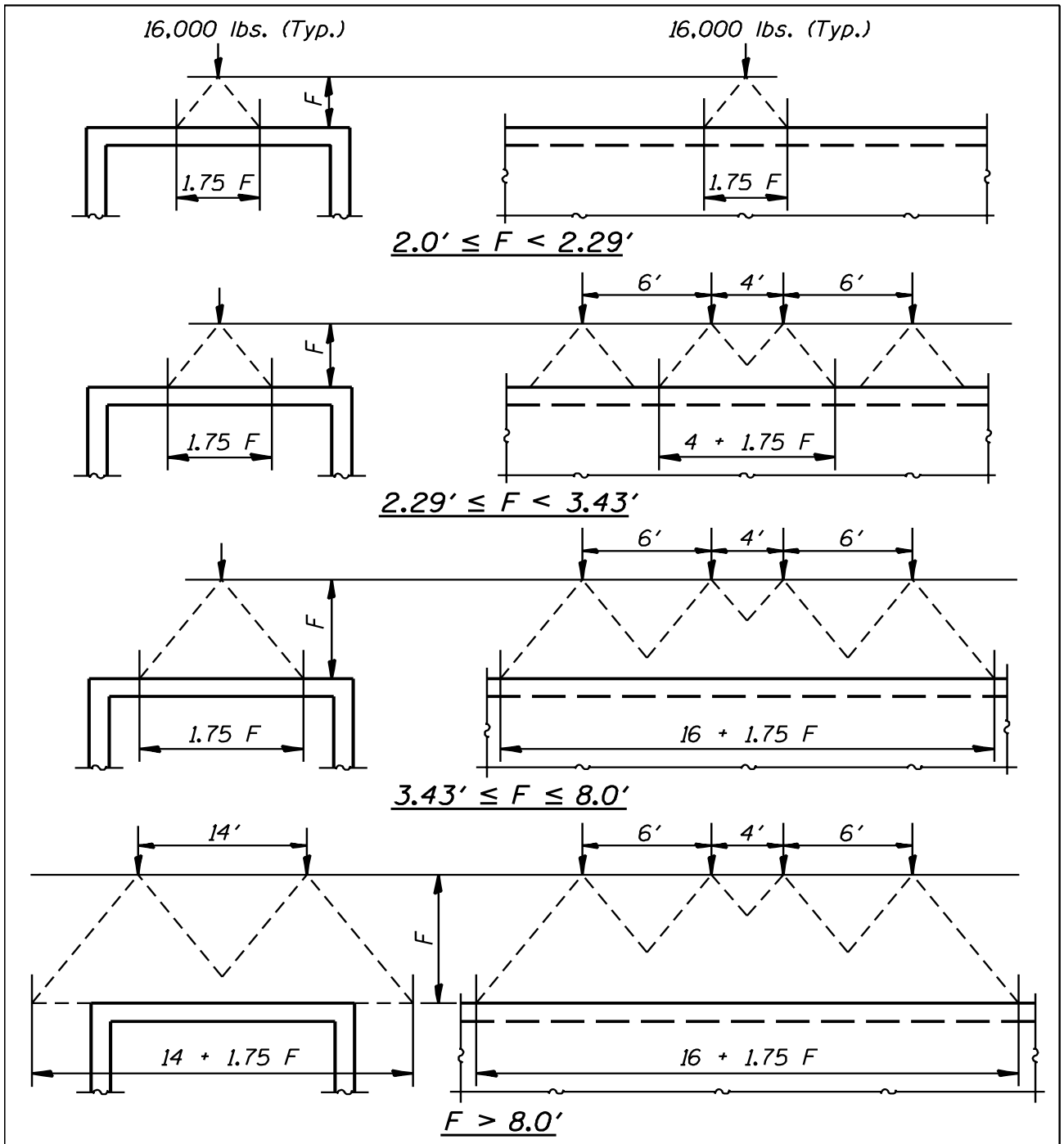
The dead loads are applied as follows:

Concrete - 150 lbs/ft^3

Earth (E) - 120 lbs/ft^3

Future wearing surface (FWS) - 50 lbs/ft^2

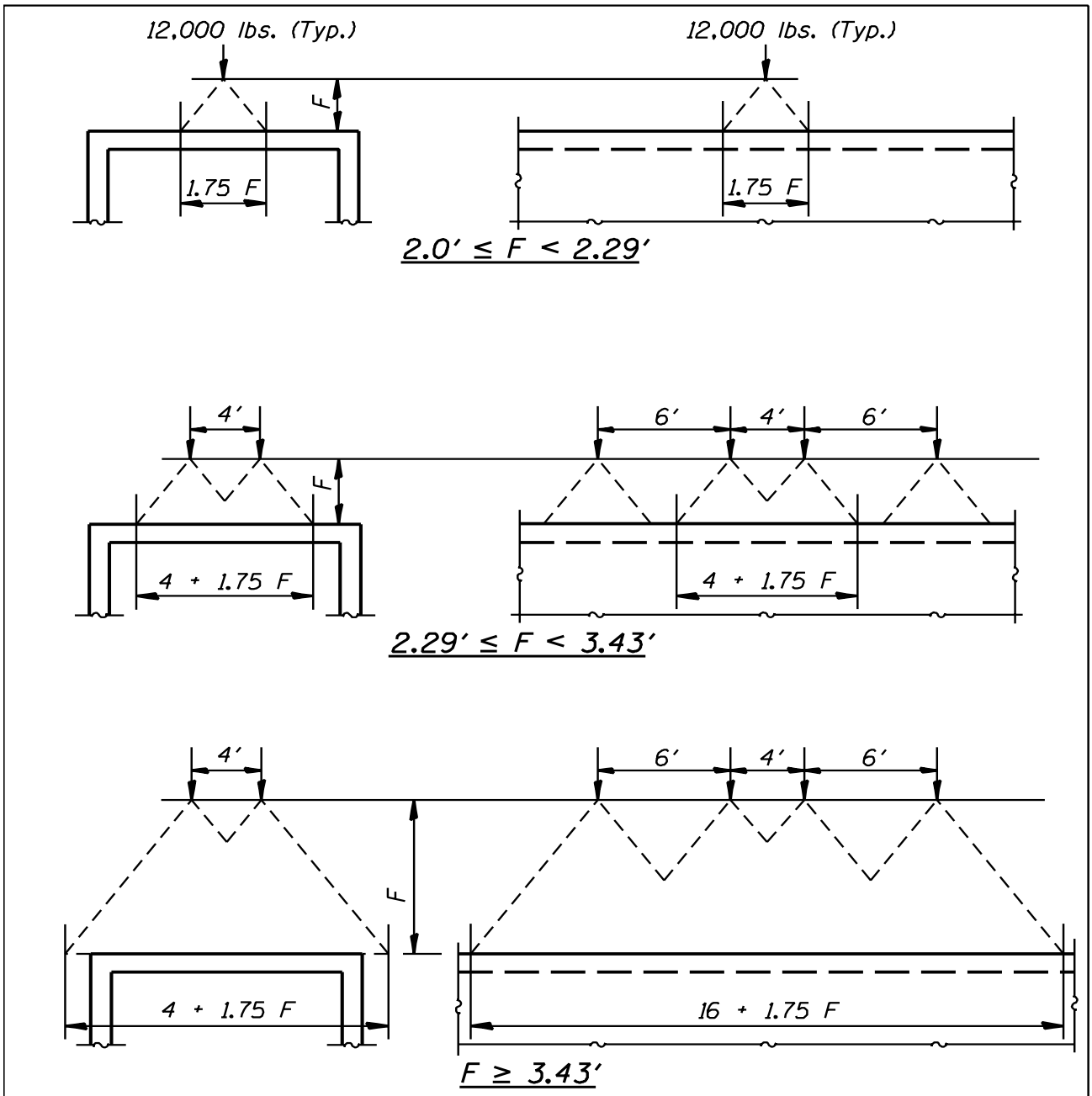
The lateral active earth pressure acting on the sidewalls is assumed as an equivalent fluid pressure of 40 lbs/ft^3 for the depth of the fill and 50 lbs/ft^3 for the height of the barrel. A surcharge of 2 feet is added to the fill when live load is considered in the design of the barrel. (See Figure 2.1.3-3).



Notes: The effect of live load may be neglected when the depth of fill is more than 8 feet and exceeds the design span. The effect of live load impact shall be included where applicable.

DISTRIBUTION OF HS20 WHEEL LOADS THROUGH FILL

Figure 2.1.3-1



Notes: The effect of live load may be neglected when the depth of fill is more than 8 feet and exceeds the design span. The effect of live load impact shall be included where applicable.

DISTRIBUTION OF ALTERNATE MILITARY WHEEL LOADS THROUGH FILL

Figure 2.1.3-2

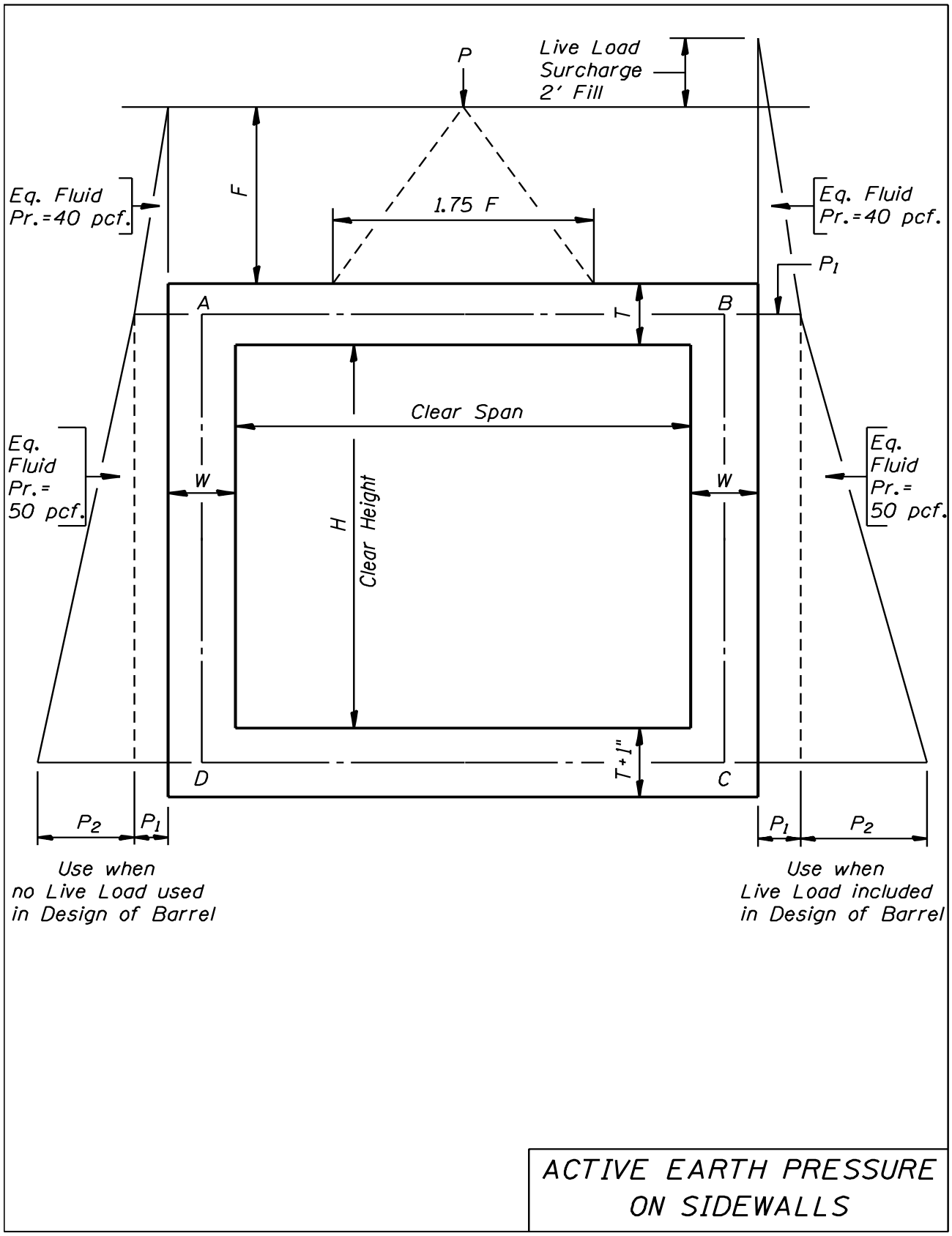

P
Live Load
Surcharge
2' Fill
F
1.75 F
Eq. Fluid
Pr.=40 pcf.
Eq. Fluid
Pr.=40 pcf.
P1
A
B
T
Clear Span
Eq.
Fluid
Pr.=
50 pcf.
W
W
H
Clear Height
Eq.
Fluid
Pr.=
50 pcf.
T+1"
D
C
P2
P1
P1
P2
Use when
no Live Load used
in Design of Barrel
Use when
Live Load included
in Design of Barrel
ACTIVE EARTH PRESSURE
ON SIDEWALLS

Figure 2.1.3-3

2.1.4 Dimensions

The minimum cross sectional dimensions of the box culvert are as follows and in increments of 1/2 inch:

Top Slab - Largest of the following:

a) governed by Load Factor Design

b) 6 inches

c) deflection control recommendations of AASHTO Article 8.9 are not required, but slabs and walls must meet the serviceability requirements of Article 8.16.8.3 and 8.16.8.4 (z = 130 k/in).

Sidewalls - Largest of the following:

a) governed by Load Factor Design

b) 6 inches

c) 1 inch per foot of clear height

Bottom Slab - Thickness is equal to the top slab thickness plus one inch.

2.1.5 Variable Box Culvert Cross-Sections

In cases of long box culverts under high fills, it is recommended to reduce the concrete thickness of the walls and slabs in areas of lower fill heights under the side slopes where economics indicate a substantial savings in material. This is generally accomplished by stepping down to the thinner sections at practicable intervals along the length of the culvert directly beneath the high end of the shallower fill heights in the side slopes. This practice shall be considered for single span and multiple span culverts.

2.1.6 Longitudinal Reinforcement

For fills less than two feet, the total area of the longitudinal reinforcement provided in each of the sidewalls and in the bottom slab is 0.4% of the cross-sectional area of the concrete in the respective component.

The reinforcement furnished in the bottom of the top slab is an amount equal to 50% of the area of main reinforcement provided for positive moments, but not less than 0.4% of the slab area. This reinforcement provides for the distribution of concentrated loads.

Additional reinforcement shall be placed in the top of the top slab if the thickness is equal to or more than 7.5 inches. (See Figure 2.2.2-1).

For fills of two feet or more, the total area of the longitudinal reinforcement provided in each of the top slab, bottom slab and sidewalls is 0.4% of the component's concrete cross sectional area for fills equal to or greater than two feet and less than ten feet. For fills ten feet and greater, this percentage is uniformly increased until 1% is provided for fills of 100 feet.

2.1.7 Settlement Collar

In soils susceptible to settlement, it may be necessary to camber the culvert by casting it in segments. The individual segments are connected with each other by means of a collar, the detail of which is shown in Figure 4-4.

2.1.8 Staged Construction

Skewed single box culverts which require construction parallel with the skew at the stage construction line shall utilize a headwall according to Section 3.1.8 along the stage construction line to act as an edge beam. An edge beam extending below the bottom of the bottom slab shall also be provided. The dimensions of this edge beam should be the same as for the headwall on the top slab. The reinforcement provided in the top of the bottom slab along the edge beam shall be the same as that provided in the bottom of the headwall for the top slab.

In the event that a headwall is required but the fill is too shallow to allow placement of the headwall below the roadway pavement, this portion of the design should be considered a special structural design problem and submitted to the Bureau of Bridges and Structures for analysis.

2.1.9 Culvert Extensions

The following is the criteria to be followed when extending existing culverts.

Culvert extensions shall be the same type of design as the existing culvert and shall be designed according to the tables and criteria in this manual. The culvert extension is to be connected to the existing barrel with 3/4-inch expansion bolts spaced at approximately 18-inch centers for extensions 15

feet or less and 24-inch centers for extensions greater than 15 feet. For the number of expansion bolts required per side, see Figure 4-5.

If possible, the headwall of the existing culvert shall remain in place. If the existing culvert headwall is far enough removed from the shoulder line so that it will not require removal, then the end of the culvert extension against the existing barrel shall be constructed with edge beams supporting the top and bottom slabs. The cross sectional dimensions and reinforcement of the top slab edge beam against the existing culvert shall be identical to that used for the headwall of the culvert extension. See Longitudinal Section in Figure 4-6.

If the existing culvert headwall requires removal and the culvert is skewed, an edge beam shall be used to support the bottom slab of the culvert extension adjacent to the end at the existing culvert. The cross sectional dimensions and the reinforcement in the bottom slab edge beam shall be identical to that used for the headwall of the culvert extension, as shown in Figure 4-7. The top slab of the existing culvert shall be removed to a line perpendicular to the centerline of the existing culvert and at least 3 inches behind the existing headwall as shown in Figure 4-7. Special care should be taken when removing the concrete to retain longitudinal reinforcement and dowel rods.

If the existing culvert headwall requires removal and the culvert is straight, the headwall and top slab shall be removed to a line approximately 9 inches behind the headwall. An edge beam shall be used to support the bottom slab. The cross sectional dimensions and reinforcement in the bottom slab edge beam shall be identical to that used for the headwall of the culvert extension.

2.1.10 Typical Design of Culvert

The following is a design example of a typical culvert installation, illustrating the use of the standard drawings, and the tables and charts contained in this manual.

Typical Design (Example 1)

Given: Size 10' Clear Span by 8' Clear Height

Skew:	Right Forward 30°
Grade:	0.00% With Crown Elevation at 619.00
Invert Elevation:	Upstream 600.50
	Downstream 600.00
Roadway:	Class (Major & Under 1900 DHV) with
	Shoulder - Shoulder 138'-0"
	Embankment Slopes 1:6 (V:H)
	Crown to Shoulder Drop 7 1/4"

Barrel Design

The following is the procedure to be used to determine the barrel cross sectional dimensions and reinforcement.

Estimate Fill:

Crown Elevation	619.00
Average Invert Elevation	- 600.25
Crown to Invert	18.75
Clear Height	- 8.00
Fill & Top Slab	10.75
Estimated Top Slab (8 1/2"±)	- 0.71
Estimated Fill	10.04 ft. use 10'

The high fill (crown to top of culvert) and low fill (edge of shoulder to top of culvert) should both be checked to determine the governing condition. By observation the high fill will control for this example.

From the barrel design tables, the top slab thickness is found to be 8 1/2 inches. Since the top slab thickness used in estimating the fill height was 8 1/2 inches, no revisions will be required.

Barrel Length Calculations

	Upstream	Downstream
Crown Elevation	619.00	619.00
Crown to Shoulder Elevation	- 0.60	- 0.60
Shoulder Elevation	618.40	618.40
Invert Elevation	- 600.50	- 600.00
Shoulder to Invert	17.90	18.40
Clear Height	- 8.00	- 8.00
	9.90	10.40
Top Slab & Headwall (8 1/2" + 9")	- 1.46	- 1.46
Shoulder to Headwall	8.44	8.94
Times Embankment Slope	x 6	x 6
Shoulder to Inside Face Headwall	50.64	53.64
1/2 Shoulder to Shoulder	+ 69.00	+ 69.00
Centerline to Inside Face Headwall	119.64	122.64
Headwall Width (12")	+ 1.00	+ 1.00
Centerline to Outside Face Headwall	120.64	123.64
Times Skew Angle Secant	x 1.15470	x 1.15470
Centerline to Outside Face Headwall	139.30	142.77
	139'-3"	142'-9"

Total out to out (Rounded off to nearest 3") = 282'-0"

Wingwall Lengths

With the known distance from the top of the headwall to the invert, the skew angle and a 1:2 (V:H) slope, the wingwall lengths are found to be 10'-6" and 18'-0". (See Figure 3.1.5-2). Wall length greater than 14'-0" indicates use of vertical cantilever wingwalls for both wall lengths.

Wingwall Design

The following is the procedure to be followed in the design of the wingwalls.

Determine type of vertical cantilever wingwall:

Distance from invert to top of headwall,

8'-0" + (0'-8 1/2") + (0'-9") = 9.46 ft.

Distance from invert to grade,

619.00 - (600.25 avg.) = 18.75 ft.

From Section 3.1.3;

Use T-Type wingwalls.

Design Height Calculations:

Top Slab Thickness	=	0'-8 1/2"
Clear Height of Barrel	=	+ 8'-0"
Invert to Bottom of Footing	=	+ 4'-0"
		12'-8 1/2"
Subtract (1" to 6 1/2")		- 0'-2 1/2"
Design Height (H_D)	=	12'-6"

Compute Fill:

Use estimated barrel fill height

Fill Height = 10.0 ft.

From the design tables for the T-Type vertical cantilever wingwalls, the stem thickness at top and bottom was found to be 10 inches and the footing width was found to be 6'-8". Using this footing width and the skew angle, the barrel cut-off wall length was found to be 4'-0" (marked up to nearest 3") (See Figure 3.4.3-1).

Incidental Calculations

The following will illustrate some of the incidental calculations required to complete the standard drawing:

a_1 bars - Total number required:

#8 @ 6 1/2" cts (Table for 10' x 8' culvert)

Top & bottom slabs -

Inside to inside of headwalls = $282.0 - \frac{2 \times 1.0}{\cos 30^\circ} = 279.69$ ft.

trial number $\frac{(279.69)12}{6.5"} = 516.35$

use 517 bars

Total a_1 bars = 517 + 517 = 1,034 - #8 @ 6 1/2" cts.

a_2 bars - #4 @ 2'-0" cts. (From Figure 2.2.2-2).

Inside to inside of headwalls - 279.69 ft.

trial number $\frac{279.69}{2'\text{–}0"} = 139.85$

Try 139 spaces @ 2'-0" cts = 278'-0"

use 140 bars in bottom of bottom slab, and one in each end of cutoff wall for a total of 142-#4 bars.

d bars - Number Required:

End Cutoff Wall

Clear Opening = 10'-0"

Use 11 bars spaced at 1'-0" cts.

Side Cutoff Wall (See Figure 3.4.3-1)

(4'-0") - (9 1/2") + (4'-0") = 7'-1 1/2"

Use 7 bars at 12" cts.

Total Number Required

End Cutoff Walls	= 2 x 11 =	22
Side Cutoff Walls	= 4 x 7 =	28
Total d bars		50

h bars - Total number and length required:

#6 @ 12" cts. (Table for 10' x 8' culvert)

Required Length (36'-0" maximum)

Trial Number = $\frac{282.0}{36.0} = 7.83$, try 9 lengths

Length = $\frac{282.0 + 8(2'\text{–}0")}{9} = 33.11$ ft.

Use length of 33'-2"

Total Number Required

Bottom of Top Slab 11 x 9	=	99
Top of Top Slab 2 x 9	=	18
Total Required	=	117

h_1 bars - Total number and length required:

#5 @ 15" cts. (Table for 10' x 8' culvert)

Required Length:

Trial Number = 9 Lengths

$$\text{Length} = \frac{282.0 + 8(1'-8")}{9} = 32.81 \text{ ft.}$$

Use Length of 32'-10"

Total Number Required

Bottom and Top of Bottom Slab 18 x 9 = 162

h_2 bars - Total number and length required:

16- #6 bars required (Table for 10' x 8' culvert)

Required Length:

Use same length as h bars (33'-2")

Total Number = 16 x 9 = 144

h_3 bars - Total number and length required (wingwall):

Length required = (10'-6") - 9"-3" = 9'-6"

Number required

Front face spacing 12" cts

Lower portion of wingwall : height = 7'-8 1/2"

Use 8 bars

Upper portion of wingwall : height = 4'-3"

Use 4 bars

Back face spacing ± 2'-0" cts

Lower portion of wingwall : height = 7'-8 1/2"

Use 4 bars

Upper portion of wingwall

Use 1 bar

Total number required 17 each wing or 34 for both short wings.

h_4 & h_5 bars - Length required (Headwall):

(See Figure 2.1.10-1)

h_6 bars:

Length required = (18'-0") - 9"-3" = 17'-0"

Total Number: Similar to h_3 above

n(E) and n_1(E) bar - From T-Type wingwall tables, for

H_D = 12'-6" and fill height 10', the required bars are #6 @ 11" cts. and #4 @ 11" cts. spaced alternately.

Long wing trial number $\frac{(17.25)12}{5.5} = 37.63$

Try 36 spaces at 5 1/2" = 16'-6" plus 4 1/2" clearance at each end. Use a total of 37 bars or 19 n(E) bars and 18 n_1(E) bars in long wing.

In a similar manner, it was found that 11 n(E) bars and 10 n_1(E) bars are required in the short wing for a total of 60 n(E) bars and 56 n_1(E) bars.

t, v, and v_1 bars - number required:

Use procedure similar to a_1 bars

v_4, v_5, v_6 and v_7 bars - total number and length required (See Figure 2.1.10-2)

Long wall length - (See Figure 2.1.10-2)

from wing wall length chart	(L) =	18'-0"
from head wall corner dimension tables	(X) =	- 0'-9"
Joint (1/2")	=	- 0'-1/2"
		17'-2 1/2"

Drop (D) -

(See Figure 3.1.5-1)

$$D = \frac{H_L}{2} - 6" = \frac{8'+8.5"+9"}{2} - 6"$$

$$= 4.23' \qquad \text{use } 4'\text{-}3"$$

Length of v_4 bars

Total Height of wall	13'-5 1/2"
Footing Thickness	- 1'-6"
	11'-11 1/2"
Cutoff length n(E) bar (C)	- 4'-6"
	7'-5 1/2"
Re-bar clear cover	- 1 1/2"
	7'-4"
Plus min. overlap (See Section 4)	+ 1'-8"
	9'-0"
use	9'-0"

Length of v_5 bar (See Figure 2.1.10-2)

Stem Height	11'-11 1/2"
Wall slope times distance to	
v_5 bar = (0.247)(5.85) =	- 1'-5"
	10'-6 1/2"
Cutoff length of n(E) bar (C)	- 4'-6"
	6'-1/2"
Re-bar clear cover	- 1 1/2"
	5'-11"
Plus min. overlap	+ 1'- 8"
	7'- 7"
use	7'-9"

Length of v_6 bars

Stem Height	11'-11 1/2"
0.247 times dist. to v_6 bar	- 2'-9 1/2"
	9'-2"
Cutoff length of n(E) bar	- 4'-6"
	4'-8"
Re-bar clear cover	- 1 1/2"
	4'-6 1/2"
Minimum overlap	+ 1'-8"
	6'-2 1/2"
use	6'-3"

Use sketch as in Figure 2.1.10-2 to determine number of v_4, v_5 and v_6 required in short wingwalls.

Total number of v_4, v_5 and v_6 bars: (space to match n(E) bars)

v_4	2 x (6+4) = 20
v_5	2 x (6+4) = 20
v_6	2 x (7+3) = 20

Length of v_7 bars

Length at tall end of wing = (11'-11 1/2") - 3" cl.

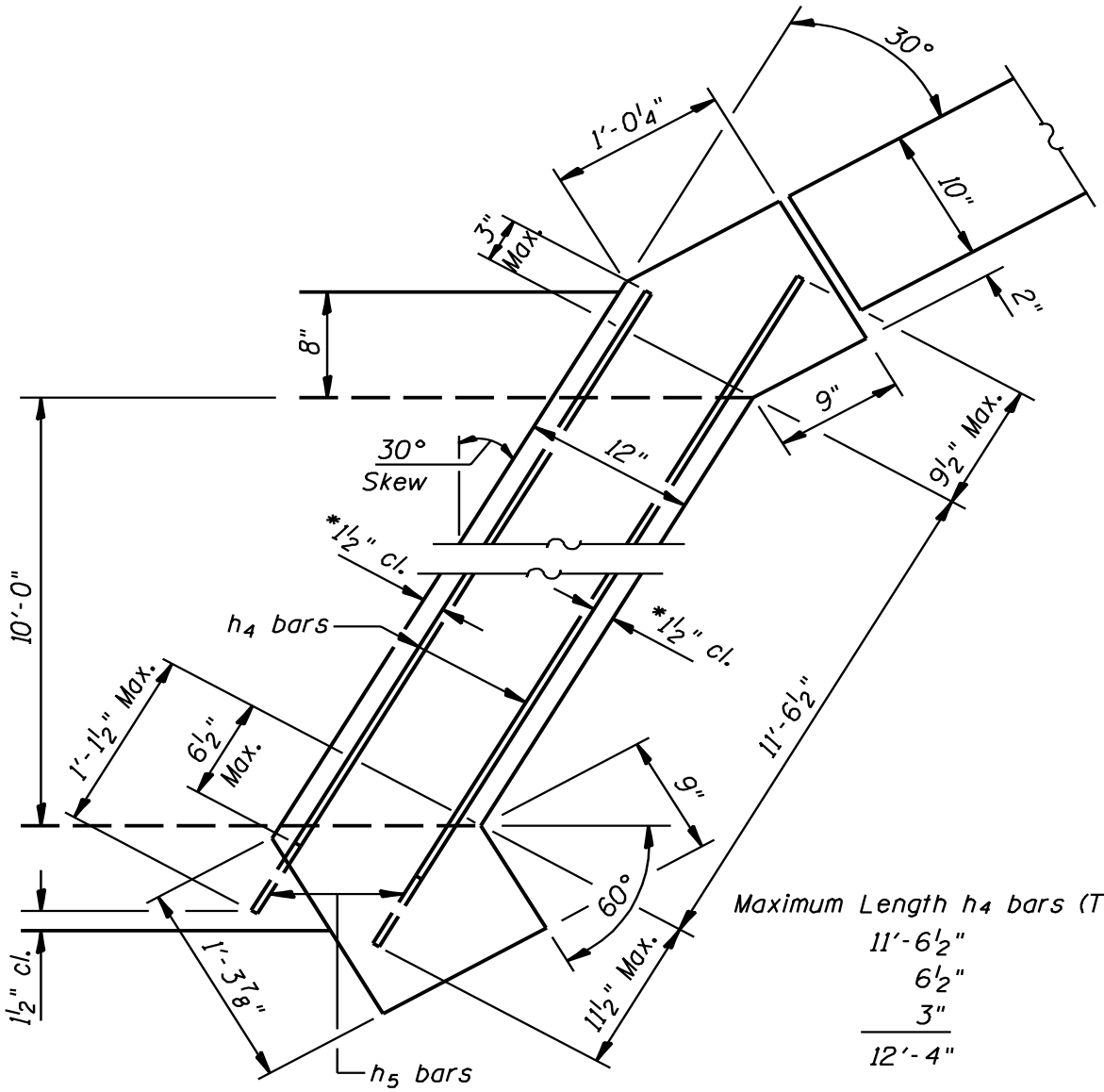
= 11'-8 1/2"

use 11'-8"

Cut v_7 bars to fit at other locations.

Use 5-v_7 at ± 4'-0" cts. in long wings and 3-v_7 at ± 4'-0" cts. in short wings.

Total number of v_7 bars = 2(5) + 2(3) = 16



Maximum Length h_4 bars (Top)

11'-6½"
6½"
3"
12'-4"

Maximum Length h_5 bars (Bott.)

11'-6½"
3"
1'-1½"
12'-11"

*Note : If stirrups are provided, 1½" clearance applies to stirrups instead of h bars.

HEADWALL REINFORCEMENT
EXAMPLE 1

Figure 2.1.10-1

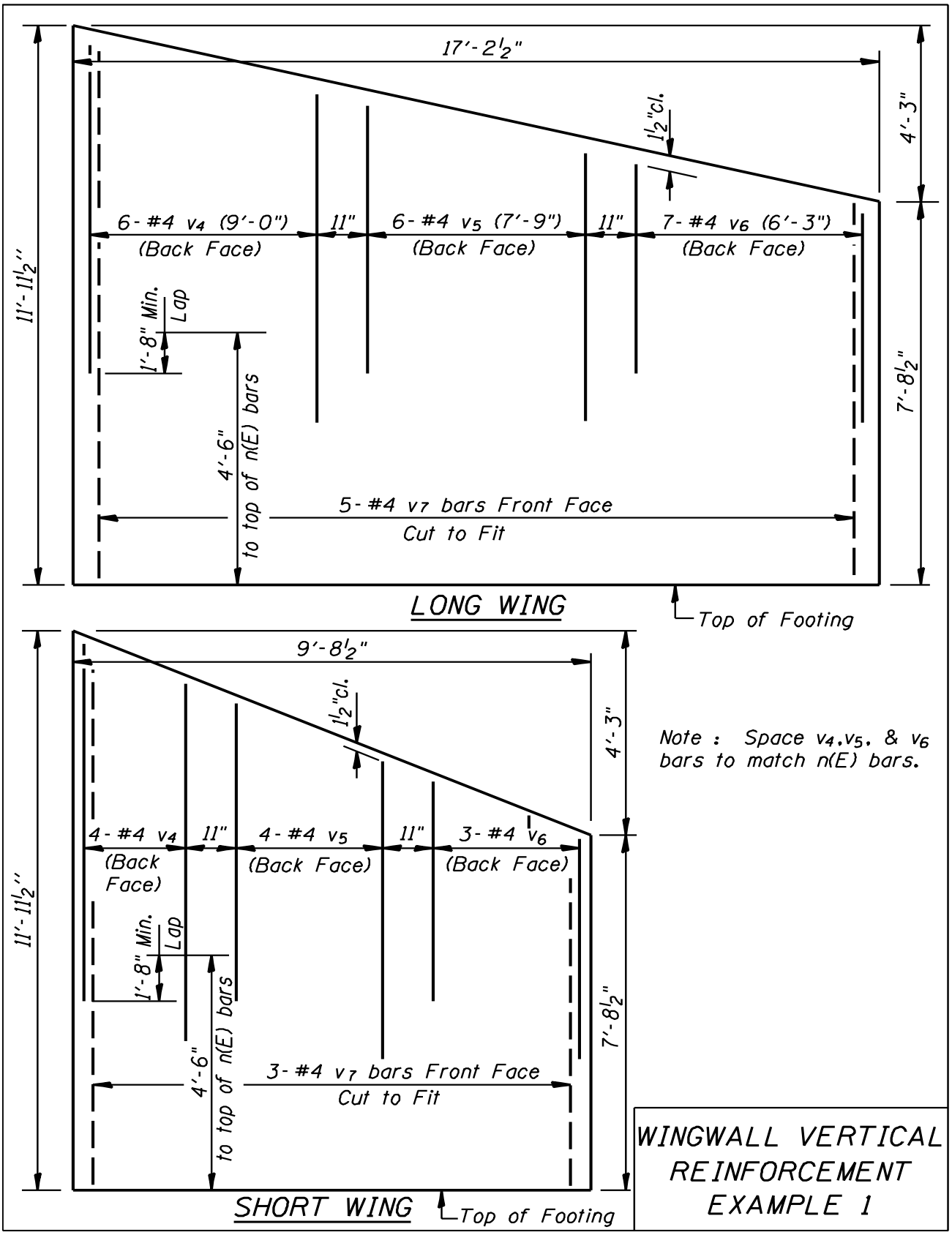


Figure 2.1.10-2

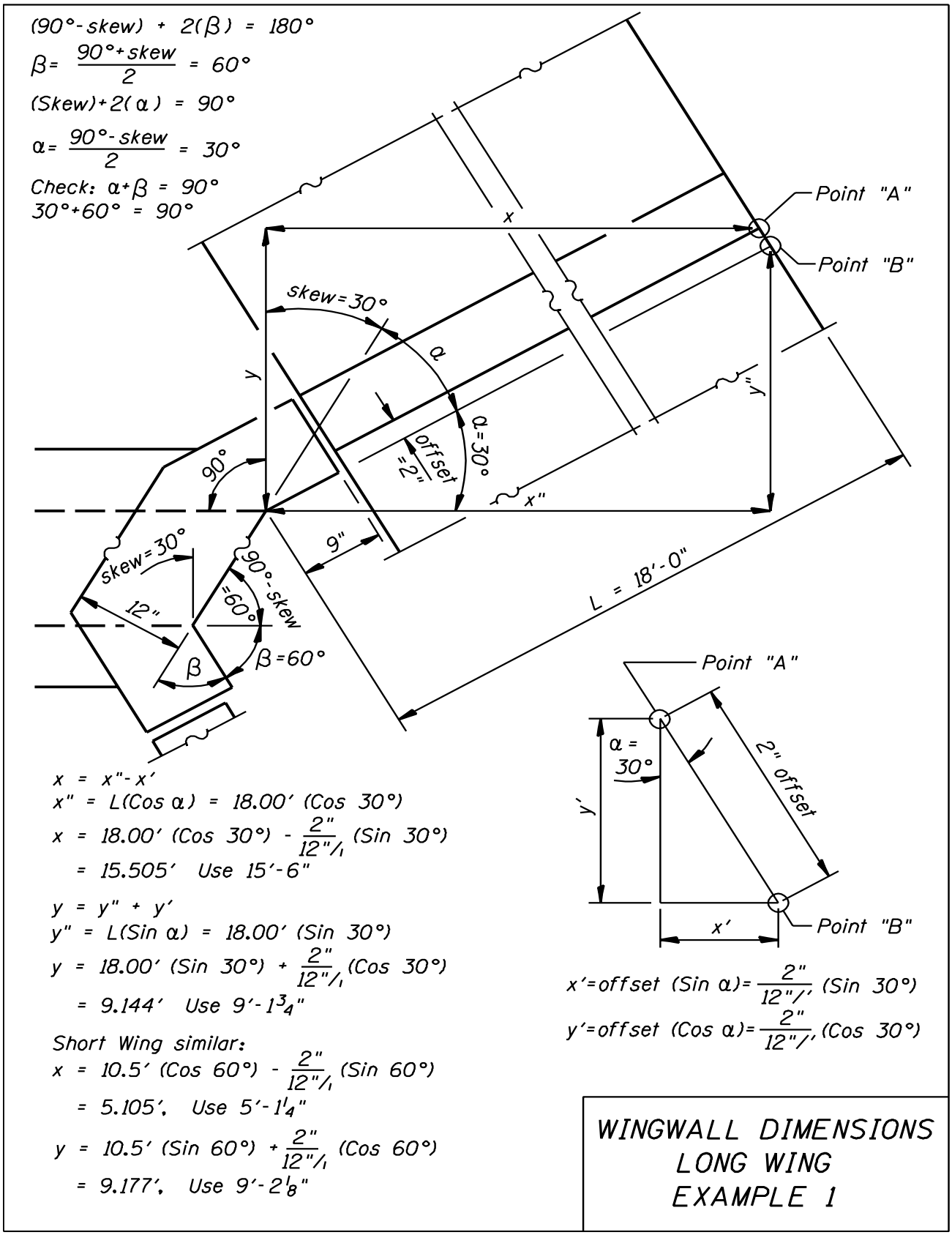
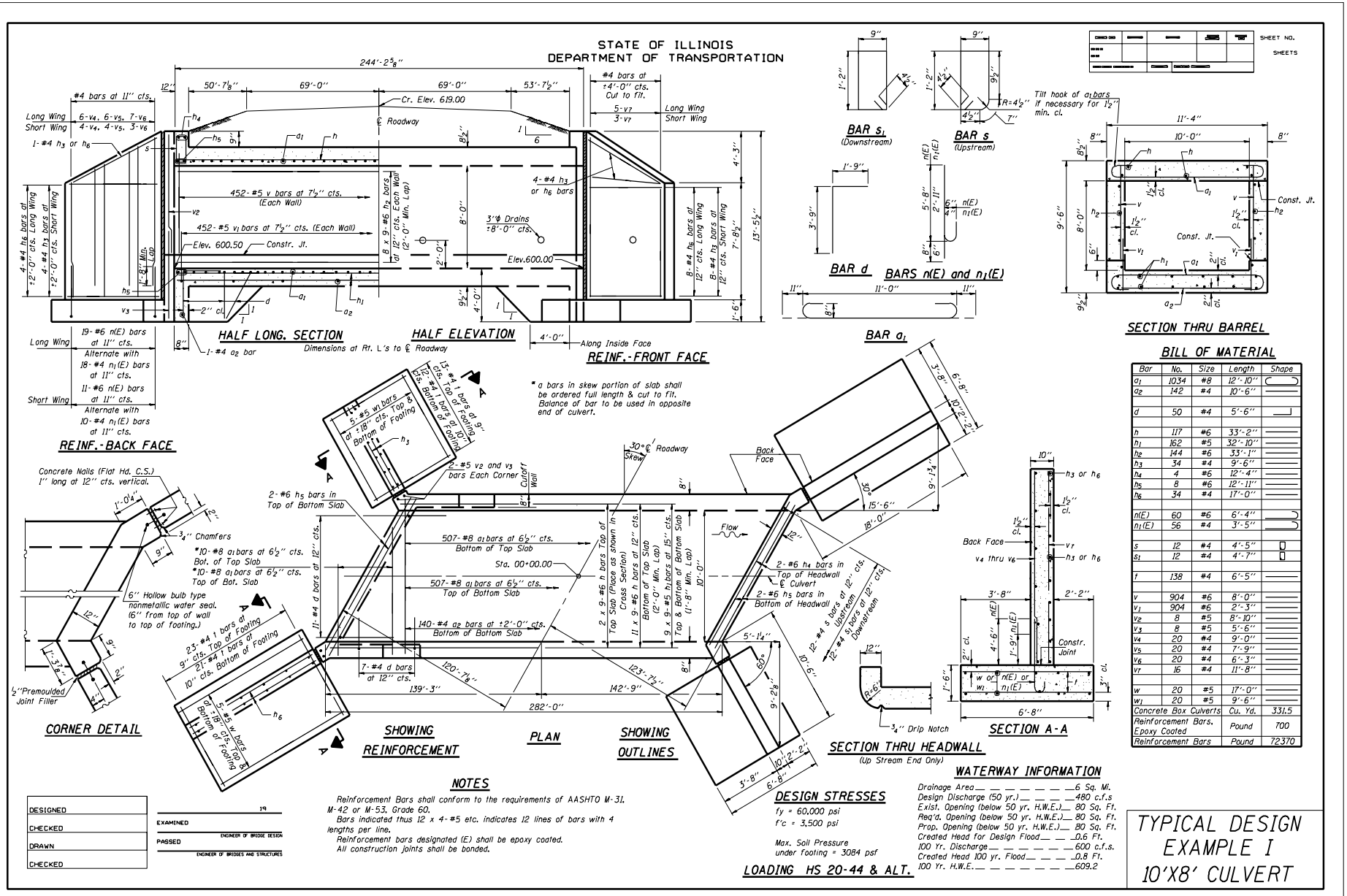


Figure 2.1.10-3



DESIGNED	
CHECKED	
DRAWN	
CHECKED	

19

EXAMINED

ENGINEER OF BRIDGE DESIGN

PASSED

ENGINEER OF BRIDGES AND STRUCTURES

SHEET NO.

SHEETS

BILL OF MATERIAL

Bar	No.	Size	Length	Shape
a_1	1034	#8	12'-10"	
a_2	142	#4	10'-6"	
d	50	#4	5'-6"	
h	117	#6	33'-2"	
h_1	162	#5	32'-10"	
h_2	144	#6	33'-1"	
h_3	34	#4	9'-6"	
h_4	4	#6	12'-4"	
h_5	8	#6	12'-11"	
h_6	34	#4	17'-0"	
n(E)	60	#6	6'-4"	
n_1(E)	56	#4	3'-5"	
s	12	#4	4'-5"	
s_1	12	#4	4'-7"	
t	138	#4	6'-5"	
v	904	#6	8'-0"	
v_1	904	#6	2'-3"	
v_2	8	#5	8'-10"	
v_3	8	#5	5'-6"	
v_4	20	#4	9'-0"	
v_5	20	#4	7'-9"	
v_6	20	#4	6'-3"	
v_7	16	#4	11'-8"	
w	20	#5	17'-0"	
w_1	20	#5	9'-6"	
Concrete Box Culverts			Cu. Yd.	331.5
Reinforcement Bars, Epoxy Coated			Pound	700
Reinforcement Bars			Pound	72370

NOTES

Reinforcement Bars shall conform to the requirements of AASHTO M-31, M-42 or M-53, Grade 60.

Bars indicated thus 12 x 4-#5 etc. indicates 12 lines of bars with 4 lengths per line.

Reinforcement bars designated (E) shall be epoxy coated.

All construction joints shall be bonded.

DESIGN STRESSES

fy = 60,000 psi

f'c = 3,500 psi

Max. Soil Pressure under footing = 3084 psf

LOADING HS 20-44 & ALT.

WATERWAY INFORMATION

Drainage Area ____ 6 Sq. Mi.
Design Discharge (50 yr.) ____ 480 c.f.s
Exist. Opening (below 50 yr. H.W.E.) ____ 80 Sq. Ft.
Req'd. Opening (below 50 yr. H.W.E.) ____ 80 Sq. Ft.
Prop. Opening (below 50 yr. H.W.E.) ____ 80 Sq. Ft.
Created Head for Design Flood ____ 0.6 Ft.
100 Yr. Discharge ____ 600 c.f.s.
Created Head 100 yr. Flood ____ 0.8 Ft.
100 Yr. H.W.E. ____ 609.2

TYPICAL DESIGN EXAMPLE I 10'X8' CULVERT

2.2 Simple Span Box Culverts

2.2.1 Design

The top slab of a simple span box culvert is simply supported and designed assuming beam action alone. The axial load in the top slab resulting from lateral pressures is neglected. The design span is the perpendicular distance center to center of sidewall, but not greater than the clear span plus the top slab thickness. The top slab is checked for shear, moment, and serviceability. It is designed to resist the dead load of the column of earth above it, the dead load of the top slab and the contributing live load intensity as illustrated in Figures 2.1.3-1 and 2.1.3-2. For fills less than two feet, the live load shall be treated as a contact load and the wheel load shall be distributed as in a concrete slab (See AASHTO Article 6.4.2) making shear analysis unnecessary according to Article 3.24.4. Lane load is not included in the analysis. When applicable, alternate military loading is considered for strength design (shear and moment) but is not considered for serviceability analyses (crack control, fatigue, etc....). Crack control is checked with a value of z equal to 130 kips/inch.

The bottom slab is not designed independently, but is assumed to be identical to the design of the top slab. The bottom slab thickness is equal to the top slab thickness (T) shown in the design tables plus one inch. An exception to this is when the culvert is founded on bedrock. In this case, individual footings may be designed for the sidewalls in lieu of the bottom slab. The Bureau of Bridges and Structures shall be contacted for this special design.

The sidewalls are designed for bending and shear due to trapezoidal active earth pressure loading with two feet of surcharge added to compensate for the live load if applicable. Also, a concentrated load of combined dead load and applicable live load is applied to the top of the sidewall with eccentricity conforming to AASHTO Article 8.16.4.1.1. Impact is not included for the sidewall live load reactions. The wall is then designed for beam column action. The wall design span is conservatively assumed to be the distance between the center of the top slab and the center of the bottom slab. Shear strength is determined according to AASHTO Article 8.16.6.2.2.

The Design Tables of Section 2.2.4 are applicable for culverts with skews ≤ 50°. The primary reinforcement (a_1 bars) from the Design Tables is intended to be placed perpendicular to the culvert walls. Sections 2.1.8 and 3.1.8 discuss additional requirements due to skews. Culverts requiring skews > 50° are considered a special design and shall be submitted to the Bureau of Bridges and Structures for analyses.

2.2.2 Table Use

The cross sectional dimensions, and size and spacing of reinforcement bars required for the simply supported barrel design are given in the design tables in Section 2.2.4, and the bar placement details are shown in Figures 2.2.2-1 and 2.2.2-2. The use of these tables is predicated on the determination of two main factors; the culvert size, and the amount of fill on top of the culvert.

Figure 2.2.2-1 shows the top slab details for different combinations of fill height and slab thickness. Top Slab Section A is used when the fill height is less than two feet and the slab thickness is equal to or greater than 7.5 inches. Section B is used if the fill height is equal to or greater than two feet and the slab thickness is equal to or greater than 12 inches. Section C is used if the fill height and slab thickness are other than those of Section A & B.

Figure 2.2.2-2 shows the typical cross sections of bottom slab and sidewalls for use with various clear heights. Typical Cross Section A is to be used when the clear height is less than 8 feet. Typical Cross Section B is to be used when the clear height is equal to or greater than 8 feet and the sidewall thickness is less than 12 inches. Typical Cross Section C is to be used when the clear height is equal to or greater than 8 feet and the sidewall thickness is equal to or greater than 12 inches.

The typical top slab and cross section details also show the nomenclature used in the presentation of the tables.

Required reinforcement size, spacing, length, and number of bars are given in the tables. Any information pertaining to number and length of bars not included in the tables or shown in the typical sections (Figures 2.2.2-1 and 2.2.2-2) shall be computed by the designer.

The number of longitudinal reinforcement bars (h) in the top slab as shown in the tables, and top slab Section C, includes the 2 bars required in the top of the top slab. The number shown in the tables for the top slab satisfying conditions of Top Slab Section B includes the total number required in the top and bottom of the top slab. The number of longitudinal reinforcement bars in the bottom slab (h_1) shown in the tables includes the total number required in the top and bottom of the bottom slab. The number of longitudinal reinforcement bars in the sidewalls (h_2) shown in the tables for sidewall thicknesses (W) less than 12 inches includes the total number required for both sidewalls; and for sidewall thickness equal to or greater than 12 inches includes the total number required in the inside and outside faces of both sidewalls.

2.2.3 Design Example

Given: 10' x 9' Simple Span Box Culvert,
Distance from Grade line to top of top slab 23'-6",
From the table for a 10' x 9' culvert with 25'-0" fill find:
Top Slab Thickness = T = 13 1/2"
Bottom Slab Thickness = 13 1/2" + 1" = 14 1/2"
Sidewall Thickness = W = 9 1/2"

a_1 bars (transverse bars - bottom of top slab and top of bottom slab)
#10 at 7" cts.; Total length = 14'-1"
Hook Dimension = A = 1'-5"
Out to Out Dimensions = 14'-1" - 2(1'-5") = 11'-3"

a_2 bars - #4 @ 2'-0" cts. - top of top slab
a_2 bars - #4 @ 2'-0" cts. - bottom of bottom slab.
Total length = 10'-3" for a_2 bars

h bars (longitudinal bars - top and bottom of top slab when $T \geq 12"$)
#6 at 12" cts.; 22 required

h_1 bars (longitudinal bars - top and bottom of bottom slab)
#7 at 1'-3" cts.; 18 required

h_2 bars (longitudinal bars - inside face of sidewalls only when W <12", both faces when W ≥ 12")

#7; 18 required (in 2 sidewalls)

v bars (vertical reinforcement in sidewalls)

#8 at 7" cts.; Total length = 9'-6"

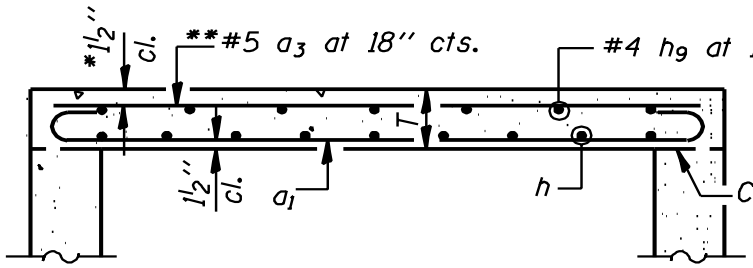
v_1 bars (dowel bar at lower construction joint of sidewalls; not required if H <8')

#7 at 7" cts.; Total length = 3'-1"

v_2 bars (vertical bars - outside face of sidewalls when W ≥ 12")

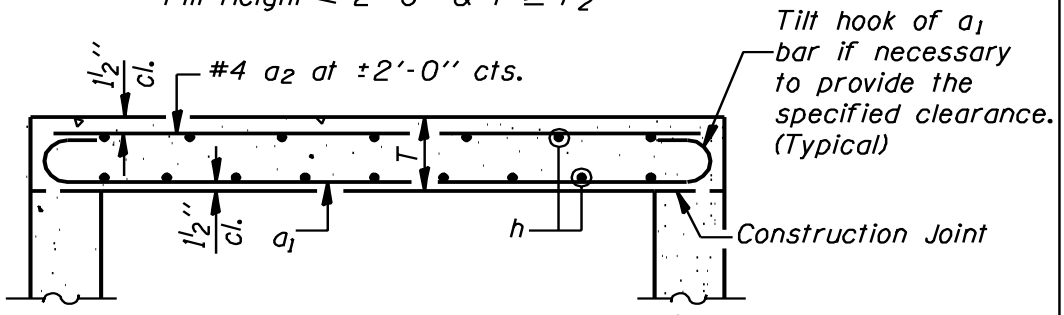
Not required since W = 9 1/2".

TYPICAL TOP SLAB DETAILS



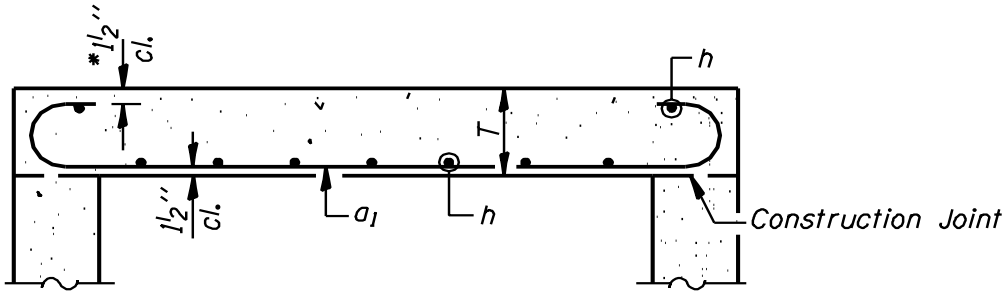
TOP SLAB SECTION - A

Fill Height < 2'-0" & T ≥ 7½"



TOP SLAB SECTION - B

Fill Height ≥ 2'-0" & T ≥ 12"



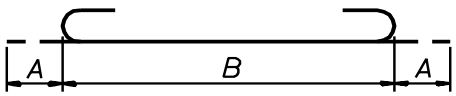
TOP SLAB SECTION - C

Fill Height < 2'-0" & T < 7½"
or Fill Height ≥ 2'-0" & T < 12"

NOTE:
Number of h bars in top slab includes 2-bars in top of the slab as shown.

* Provide 2¼" cl. ±¼" when fill on top slab is zero, and epoxy coat bars in top slab.

** a_3 bars shall be used in lieu of a_2 bars designated in Tables, Top Slab Only.

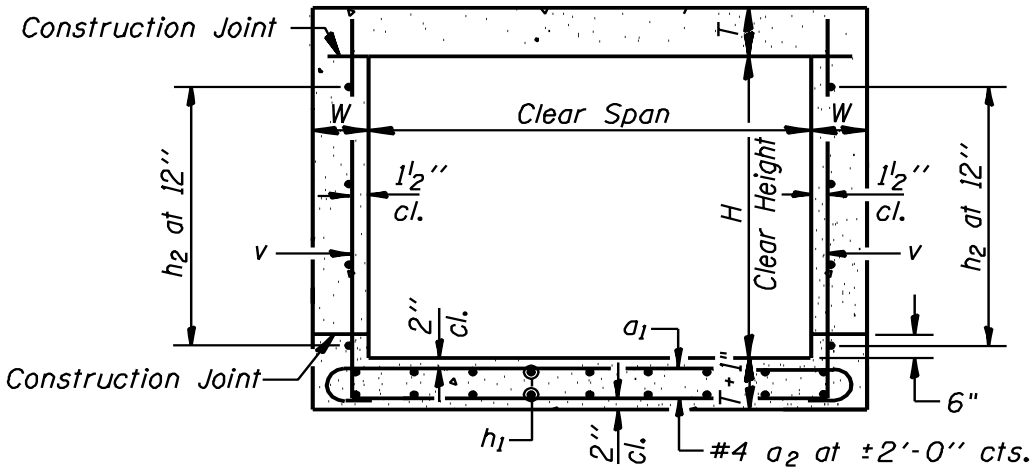


a_1 BARS

TOP SLAB DETAILS

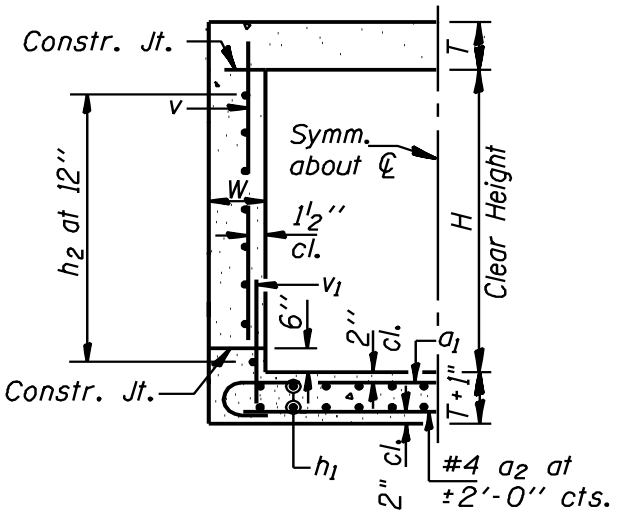
Figure 2.2.2-1

TYPICAL CROSS SECTION DETAILS



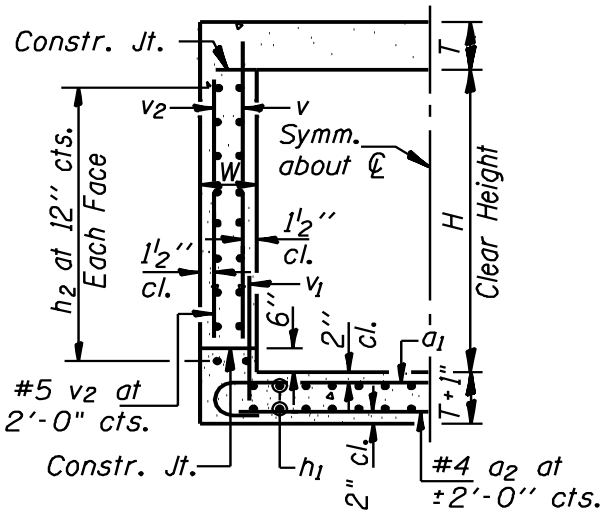
TYPICAL CROSS SECTION - A

$H < 8'\text{-}0''$



TYPICAL SECTION - B

$H \geq 8'\text{-}0''$ & $W < 12''$



TYPICAL SECTION - C

$H \geq 8'\text{-}0''$ & $W \geq 12''$

Note:

a_2 bars in bottom slab not included in design tables, but are req'd for all spans.

SIDEWALL AND BOTTOM SLAB DETAILS

Figure 2.2.2-2

2.2.4 Design Tables

2' CLEAR SPAN BY 2' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	6	5	8.5	3-10	0-7	2-8	0-0	5	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.194
2	6	4	9	3-8	0-6	2-8	0-0	5	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.194
3	6	4	9	3-8	0-6	2-8	0-0	5	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.194
4	6	4	9	3-8	0-6	2-8	0-0	5	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.194
5	6	4	9	3-8	0-6	2-8	0-0	5	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.194
6	6	4	9	3-8	0-6	2-8	0-0	5	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.194
7	6	4	9	3-8	0-6	2-8	0-0	5	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.194
8	6	4	9	3-8	0-6	2-8	0-0	5	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.194
9	6	4	9	3-8	0-6	2-8	0-0	5	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.194
10	6	4	9	3-8	0-6	2-8	0-0	5	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.194
11	6	4	9	3-8	0-6	2-8	0-0	5	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.194
12	6	4	9	3-8	0-6	2-8	0-0	5	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.194
13	6	4	9	3-8	0-6	2-8	0-0	5	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.194
14	6	4	9	3-8	0-6	2-8	0-0	6	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.194
15	6	4	9	3-8	0-6	2-8	0-0	6	12	5	4	12	6	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.194
20	6	4	9	3-8	0-6	2-8	0-0	6	12	5	5	18	4	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.194
25	6	4	9	3-8	0-6	2-8	0-0	6	12	5	5	12	6	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.194
30	6	4	8.5	3-8	0-6	2-8	0-0	6	12	5	5	12	6	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.194
35	6	4	7.5	3-8	0-6	2-8	0-0	6	12	5	5	12	6	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.194
40	6	4	7	3-8	0-6	2-8	0-0	6	12	5	5	12	6	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.194
45	6	4	6	3-8	0-6	2-8	0-0	7	12	5	5	12	6	6	4	9	2-9	0	0	0-0	0	0-0	7	4	.194
50	6	5	8	3-10	0-7	2-8	0-0	7	12	5	5	12	6	6	4	9	2-9	0	0	0-0	0	0-0	7	4	.194

2.5' CLEAR SPAN BY 2.5' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	6	5	7	4-4	0-7	3-2	0-0	6	15	5	5	18	4	6	4	9	3-3	0	0	0-0	0	0-0	5	5	.233
2	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	18	4	6	4	9	3-3	0	0	0-0	0	0-0	5	5	.233
3	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	18	4	6	4	9	3-3	0	0	0-0	0	0-0	5	5	.233
4	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	18	4	6	4	9	3-3	0	0	0-0	0	0-0	5	5	.233
5	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	18	4	6	4	9	3-3	0	0	0-0	0	0-0	5	5	.233
6	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	18	4	6	4	9	3-3	0	0	0-0	0	0-0	5	5	.233
7	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	18	4	6	4	9	3-3	0	0	0-0	0	0-0	5	5	.233
8	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	18	4	6	4	9	3-3	0	0	0-0	0	0-0	5	5	.233
9	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	18	4	6	4	9	3-3	0	0	0-0	0	0-0	5	5	.233
10	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	18	4	6	4	9	3-3	0	0	0-0	0	0-0	5	5	.233
11	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	18	4	6	4	9	3-3	0	0	0-0	0	0-0	5	5	.233
12	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	18	4	6	4	9	3-3	0	0	0-0	0	0-0	5	5	.233
13	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	15	6	6	4	9	3-3	0	0	0-0	0	0-0	5	5	.233
14	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	15	6	6	4	9	3-3	0	0	0-0	0	0-0	6	5	.233
15	6	4	9	4-2	0-6	3-2	0-0	6	15	5	5	15	6	6	4	9	3-3	0	0	0-0	0	0-0	6	5	.233
20	6	4	8.5	4-2	0-6	3-2	0-0	6	15	5	5	15	6	6	4	9	3-3	0	0	0-0	0	0-0	6	5	.233
25	6	4	7.5	4-2	0-6	3-2	0-0	6	15	5	5	15	6	6	4	9	3-3	0	0	0-0	0	0-0	6	5	.233
30	6	4	6	4-2	0-6	3-2	0-0	7	15	5	5	15	6	6	4	9	3-3	0	0	0-0	0	0-0	6	5	.233
35	6	5	8	4-4	0-7	3-2	0-0	7	15	5	5	15	6	6	4	9	3-3	0	0	0-0	0	0-0	6	5	.233
40	6	6	6.5	4-6	0-8	3-2	0-0	7	15	5	5	15	6	6	4	9	3-3	0	0	0-0	0	0-0	6	5	.233
45	6.5	5	7	4-4	0-7	3-2	0-0	7	15	5	6	15	6	6	4	9	3-4	0	0	0-0	0	0-0	7	5	.244
50	7	5	7	4-4	0-7	3-2	0-0	8	15	5	6	15	6	6	4	9	3-5	0	0	0-0	0	0-0	7	5	.255

3' CLEAR SPAN BY 2' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	6	6	8	5-0	0-8	3-8	0-0	6	18	5	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.235
2	6	4	6.5	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.235
3	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.235
4	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.235
5	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.235
6	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.235
7	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.235
8	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.235
9	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.235
10	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.235
11	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.235
12	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.235
13	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.235
14	6	4	9	4-8	0-6	3-8	0-0	6	18	5	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.235
15	6	4	8.5	4-8	0-6	3-8	0-0	6	18	5	4	12	8	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.235
20	6	4	7	4-8	0-6	3-8	0-0	6	12	6	5	18	6	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.235
25	6	5	8	4-10	0-7	3-8	0-0	6	12	6	5	18	6	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.235
30	6	5	7	4-10	0-7	3-8	0-0	6	12	6	5	18	6	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.235
35	6.5	5	6	4-10	0-7	3-8	0-0	7	18	5	5	12	8	6	4	9	2-10	0	0	0-0	0	0-0	6	4	.247
40	7	5	6	4-10	0-7	3-8	0-0	7	12	6	5	12	8	6	4	9	2-11	0	0	0-0	0	0-0	6	4	.259
45	7.5	5	6.5	4-10	0-7	3-8	0-0	7	12	6	6	18	6	6	4	9	3-0	0	0	0-0	0	0-0	7	4	.272
50	8	5	6.5	4-10	0-7	3-8	0-0	8	12	6	6	12	8	6	4	9	3-1	0	0	0-0	0	0-0	7	4	.284

3' CLEAR SPAN BY 3' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	6	6	8	5-0	0-8	3-8	0-0	6	18	5	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.272
2	6	4	6.5	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.272
3	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.272
4	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.272
5	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.272
6	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.272
7	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.272
8	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.272
9	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.272
10	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.272
11	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.272
12	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.272
13	6	4	9	4-8	0-6	3-8	0-0	5	12	6	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.272
14	6	4	9	4-8	0-6	3-8	0-0	6	18	5	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	6	6	.272
15	6	4	8.5	4-8	0-6	3-8	0-0	6	18	5	4	12	8	6	4	9	3-9	0	0	0-0	0	0-0	6	6	.272
20	6	4	7	4-8	0-6	3-8	0-0	6	12	6	5	18	6	6	4	9	3-9	0	0	0-0	0	0-0	6	6	.272
25	6	5	8	4-10	0-7	3-8	0-0	6	12	6	5	18	6	6	4	9	3-9	0	0	0-0	0	0-0	6	6	.272
30	6	5	7	4-10	0-7	3-8	0-0	6	12	6	5	18	6	6	4	9	3-9	0	0	0-0	0	0-0	6	6	.272
35	6.5	5	6	4-10	0-7	3-8	0-0	7	18	5	5	12	8	6	4	9	3-10	0	0	0-0	0	0-0	6	6	.284
40	7	5	6	4-10	0-7	3-8	0-0	7	12	6	5	12	8	6	4	9	3-11	0	0	0-0	0	0-0	6	6	.296
45	7.5	5	6.5	4-10	0-7	3-8	0-0	7	12	6	6	18	6	6	4	9	4-0	0	0	0-0	0	0-0	7	6	.309
50	8	5	6.5	4-10	0-7	3-8	0-0	8	12	6	6	12	8	6	4	8	4-1	0	0	0-0	0	0-0	7	6	.321

4' CLEAR SPAN BY 2' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	6	6	6	6-0	0-8	4-8	0-0	6	12	7	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.275
2	6	5	6.5	5-10	0-7	4-8	0-0	5	12	7	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.275
3	6	4	7.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.275
4	6	4	9	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.275
5	6	4	9	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.275
6	6	4	9	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.275
7	6	4	8.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.275
8	6	4	8	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.275
9	6	4	8.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.275
10	6	4	7.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.275
11	6	4	7	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.275
12	6	4	6.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.275
13	6	4	6	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	5	4	.275
14	6	5	8.5	5-10	0-7	4-8	0-0	6	16	6	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.275
15	6	5	8	5-10	0-7	4-8	0-0	6	16	6	4	12	10	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.275
20	6	5	6	5-10	0-7	4-8	0-0	6	16	6	5	16	8	6	4	9	2-9	0	0	0-0	0	0-0	6	4	.275
25	6.5	6	6	6-0	0-8	4-8	0-0	6	12	7	5	16	8	6	4	9	2-10	0	0	0-0	0	0-0	6	4	.29
30	7	7	6.5	6-4	0-10	4-8	0-0	7	16	6	5	12	10	6	4	9	2-11	0	0	0-0	0	0-0	6	4	.306
35	8	6	6	6-0	0-8	4-8	0-0	7	12	7	6	16	8	6	4	9	3-1	0	0	0-0	0	0-0	6	4	.336
40	8.5	7	6.5	6-4	0-10	4-8	0-0	8	16	6	6	16	8	6	4	9	3-2	0	0	0-0	0	0-0	6	4	.352
45	9	8	7	6-6	0-11	4-8	0-0	8	12	7	6	12	10	6	4	9	3-3	0	0	0-0	0	0-0	7	4	.367
50	9.5	8	6.5	6-6	0-11	4-8	0-0	8	12	7	6	12	10	6	4	9	3-4	0	0	0-0	0	0-0	7	4	.383

4' CLEAR SPAN BY 3' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	6	6	6	6-0	0-8	4-8	0-0	6	12	7	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.312
2	6	5	6.5	5-10	0-7	4-8	0-0	5	12	7	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.312
3	6	4	7.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.312
4	6	4	9	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.312
5	6	4	9	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.312
6	6	4	9	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.312
7	6	4	8.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.312
8	6	4	8	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.312
9	6	4	8.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.312
10	6	4	7.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.312
11	6	4	7	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.312
12	6	4	6.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.312
13	6	4	6	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.312
14	6	5	8.5	5-10	0-7	4-8	0-0	6	16	6	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	6	6	.312
15	6	5	8	5-10	0-7	4-8	0-0	6	16	6	4	12	10	6	4	9	3-9	0	0	0-0	0	0-0	6	6	.312
20	6	5	6	5-10	0-7	4-8	0-0	6	16	6	5	16	8	6	4	9	3-9	0	0	0-0	0	0-0	6	6	.312
25	6.5	6	6	6-0	0-8	4-8	0-0	6	12	7	5	16	8	6	4	9	3-10	0	0	0-0	0	0-0	6	6	.327
30	7	7	6.5	6-4	0-10	4-8	0-0	7	16	6	5	12	10	6	4	9	3-11	0	0	0-0	0	0-0	6	6	.343
35	8	6	6	6-0	0-8	4-8	0-0	7	12	7	6	16	8	6	4	9	4-1	0	0	0-0	0	0-0	6	6	.373
40	8.5	7	6.5	6-4	0-10	4-8	0-0	8	16	6	6	16	8	6	4	9	4-2	0	0	0-0	0	0-0	6	6	.389
45	9	8	7	6-6	0-11	4-8	0-0	8	12	7	6	12	10	6	4	9	4-3	0	0	0-0	0	0-0	7	6	.404
50	9.5	8	6.5	6-6	0-11	4-8	0-0	8	12	7	6	12	10	6	4	8.5	4-4	0	0	0-0	0	0-0	7	6	.42

4' CLEAR SPAN BY 4' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	6	6	6	6-0	0-8	4-8	0-0	6	12	7	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.349
2	6	5	6.5	5-10	0-7	4-8	0-0	5	12	7	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.349
3	6	4	7.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.349
4	6	4	9	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.349
5	6	4	9	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.349
6	6	4	9	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.349
7	6	4	8.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.349
8	6	4	8	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.349
9	6	4	8.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.349
10	6	4	7.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.349
11	6	4	7	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.349
12	6	4	6.5	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.349
13	6	4	6	5-8	0-6	4-8	0-0	5	12	7	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.349
14	6	5	8.5	5-10	0-7	4-8	0-0	6	16	6	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	6	8	.349
15	6	5	8	5-10	0-7	4-8	0-0	6	16	6	4	12	10	6	4	9	4-9	0	0	0-0	0	0-0	6	8	.349
20	6	5	6	5-10	0-7	4-8	0-0	6	16	6	5	16	8	6	4	9	4-9	0	0	0-0	0	0-0	6	8	.349
25	6.5	6	6	6-0	0-8	4-8	0-0	6	12	7	5	16	8	6	4	9	4-10	0	0	0-0	0	0-0	6	8	.364
30	7	7	6.5	6-4	0-10	4-8	0-0	7	16	6	5	12	10	6	4	8	4-11	0	0	0-0	0	0-0	6	8	.38
35	8	6	6	6-0	0-8	4-8	0-0	7	12	7	6	16	8	6	5	9	5-1	0	0	0-0	0	0-0	6	8	.41
40	8.5	7	6.5	6-4	0-10	4-8	0-0	8	16	6	6	16	8	6	5	7	5-2	0	0	0-0	0	0-0	6	8	.426
45	9	8	7	6-7	0-11	4-9	0-0	8	12	7	6	12	10	6.5	5	7	5-3	0	0	0-0	0	0-0	7	8	.459
50	9.5	8	6	6-8	0-11	4-10	0-0	9	16	6	6	12	10	7	5	7.5	5-4	0	0	0-0	0	0-0	7	8	.492

5' CLEAR SPAN BY 3' CLEAR HEIGHT

FILL	T	a_1 BAR			DIMENSION		a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	A	B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	6.5	7	7.5	7-4	0-10	5-8	0-0	7	15	7	4	12	12	6	4	9	3-10	0	0	0-0	0	0-0	5	6	.37
2	6.5	7	7.5	7-4	0-10	5-8	0-0	6	15	7	4	12	12	6	4	9	3-10	0	0	0-0	0	0-0	5	6	.37
3	6	5	7.5	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.352
4	6	4	6	6-8	0-6	5-8	0-0	5	12	8	4	12	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.352
5	6	4	6	6-8	0-6	5-8	0-0	5	12	8	4	12	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.352
6	6	5	9	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.352
7	6	5	8.5	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.352
8	6	5	8	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.352
9	6	5	8	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.352
10	6	5	7.5	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.352
11	6	5	7	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.352
12	6	5	6.5	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.352
13	6	5	6	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.352
14	6	6	7.5	7-0	0-8	5-8	0-0	6	15	7	4	12	12	6	4	9	3-9	0	0	0-0	0	0-0	6	6	.352
15	6	6	7	7-0	0-8	5-8	0-0	6	15	7	4	12	12	6	4	9	3-9	0	0	0-0	0	0-0	6	6	.352
20	6.5	7	7	7-4	0-10	5-8	0-0	6	15	7	5	15	10	6	4	9	3-10	0	0	0-0	0	0-0	6	6	.37
25	7.5	7	6.5	7-4	0-10	5-8	0-0	7	15	7	5	15	10	6	4	9	4-0	0	0	0-0	0	0-0	6	6	.407
30	8.5	7	6	7-4	0-10	5-8	0-0	7	12	8	5	12	12	6	4	9	4-2	0	0	0-0	0	0-0	6	6	.444
35	9.5	7	6.5	7-4	0-10	5-8	0-0	8	15	7	6	15	10	6	4	9	4-4	0	0	0-0	0	0-0	6	6	.481
40	10	8	6	7-6	0-11	5-8	0-0	8	12	8	6	12	12	6	4	9	4-5	0	0	0-0	0	0-0	6	6	.5
45	10.5	9	6.5	8-2	1-3	5-8	0-0	9	15	7	6	12	12	6	4	9	4-6	0	0	0-0	0	0-0	7	6	.519
50	11.5	9	7.5	8-2	1-3	5-8	0-0	9	12	8	7	12	12	6	4	8	4-8	0	0	0-0	0	0-0	7	6	.556

5' CLEAR SPAN BY 4' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	6.5	7	7.5	7-4	0-10	5-8	0-0	7	15	7	4	12	12	6	4	9	4-10	0	0	0-0	0	0-0	5	8	.407
2	6.5	7	7.5	7-4	0-10	5-8	0-0	6	15	7	4	12	12	6	4	9	4-10	0	0	0-0	0	0-0	5	8	.407
3	6	5	7.5	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.389
4	6	4	6	6-8	0-6	5-8	0-0	5	12	8	4	12	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.389
5	6	4	6	6-8	0-6	5-8	0-0	5	12	8	4	12	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.389
6	6	5	9	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.389
7	6	5	8.5	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.389
8	6	5	8	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.389
9	6	5	8	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.389
10	6	5	7.5	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.389
11	6	5	7	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.389
12	6	5	6.5	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.389
13	6	5	6	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.389
14	6	6	7.5	7-0	0-8	5-8	0-0	6	15	7	4	12	12	6	4	9	4-9	0	0	0-0	0	0-0	6	8	.389
15	6	6	7	7-0	0-8	5-8	0-0	6	15	7	4	12	12	6	4	9	4-9	0	0	0-0	0	0-0	6	8	.389
20	6.5	7	7	7-4	0-10	5-8	0-0	6	15	7	5	15	10	6	4	9	4-10	0	0	0-0	0	0-0	6	8	.407
25	7.5	7	6.5	7-4	0-10	5-8	0-0	7	15	7	5	15	10	6	4	9	5-0	0	0	0-0	0	0-0	6	8	.444
30	8.5	7	6	7-4	0-10	5-8	0-0	7	12	8	5	12	12	6	4	7.5	5-2	0	0	0-0	0	0-0	6	8	.481
35	9.5	7	6.5	7-4	0-10	5-8	0-0	8	15	7	6	15	10	6	5	8.5	5-4	0	0	0-0	0	0-0	6	8	.519
40	10	8	6	7-6	0-11	5-8	0-0	8	12	8	6	12	12	6	5	6.5	5-5	0	0	0-0	0	0-0	6	8	.537
45	10.5	9	6.5	8-3	1-3	5-9	0-0	9	15	7	6	12	12	6.5	5	7	5-6	0	0	0-0	0	0-0	7	8	.574
50	11.5	9	7	8-4	1-3	5-10	0-0	9	12	8	7	12	12	7	5	7	5-8	0	0	0-0	0	0-0	7	8	.63

5' CLEAR SPAN BY 5' CLEAR HEIGHT

FILL	T	a_1 BAR			DIMENSION		a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	A	B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	6.5	7	7.5	7-4	0-10	5-8	0-0	7	15	7	4	12	12	6	4	9	5-10	0	0	0-0	0	0-0	5	10	.444
2	6.5	7	7.5	7-4	0-10	5-8	0-0	6	15	7	4	12	12	6	4	9	5-10	0	0	0-0	0	0-0	5	10	.444
3	6	5	7.5	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.426
4	6	4	6	6-8	0-6	5-8	0-0	5	12	8	4	12	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.426
5	6	4	6	6-8	0-6	5-8	0-0	5	12	8	4	12	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.426
6	6	5	9	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.426
7	6	5	8.5	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.426
8	6	5	8	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.426
9	6	5	8	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.426
10	6	5	7.5	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.426
11	6	5	7	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.426
12	6	5	6.5	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.426
13	6	5	6	6-10	0-7	5-8	0-0	5	12	8	4	12	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.426
14	6	6	7.5	7-0	0-8	5-8	0-0	6	15	7	4	12	12	6	4	9	5-9	0	0	0-0	0	0-0	6	10	.426
15	6	6	7	7-0	0-8	5-8	0-0	6	15	7	4	12	12	6	4	9	5-9	0	0	0-0	0	0-0	6	10	.426
20	6.5	7	7	7-4	0-10	5-8	0-0	6	15	7	5	15	10	6	4	7	5-10	0	0	0-0	0	0-0	6	10	.444
25	7.5	7	6.5	7-4	0-10	5-8	0-0	7	15	7	5	15	10	6	5	7.5	6-0	0	0	0-0	0	0-0	6	10	.481
30	8.5	7	6	7-5	0-10	5-9	0-0	7	12	8	5	12	12	6.5	5	7	6-2	0	0	0-0	0	0-0	6	10	.539
35	9.5	7	6	7-6	0-10	5-10	0-0	8	12	8	6	12	12	7	5	6.5	6-4	0	0	0-0	0	0-0	7	10	.597
40	10	9	7.5	8-5	1-3	5-11	0-0	8	12	8	6	12	12	7.5	5	6	6-5	0	0	0-0	0	0-0	7	10	.637
45	11	8	6	7-10	0-11	6-0	0-0	9	12	8	7	15	10	8	5	6	6-7	0	0	0-0	0	0-0	8	10	.697
50	11.5	9	6.5	8-7	1-3	6-1	0-0	9	12	8	7	12	12	8.5	5	6	6-8	0	0	0-0	0	0-0	8	10	.738

6' CLEAR SPAN BY 3' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	7	7	7	8-4	0-10	6-8	0-0	7	12	9	4	12	14	6	4	9	3-11	0	0	0-0	0	0-0	5	6	.435
2	7	7	7	8-4	0-10	6-8	0-0	6	14	8	4	12	14	6	4	9	3-11	0	0	0-0	0	0-0	5	6	.435
3	6	6	7.5	8-0	0-8	6-8	0-0	5	12	9	4	14	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.392
4	6	5	6.5	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.392
5	6	5	6.5	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.392
6	6	5	6	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.392
7	6	5	6	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.392
8	6	6	8	8-0	0-8	6-8	0-0	5	12	9	4	14	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.392
9	6	5	6	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.392
10	6	6	7.5	8-0	0-8	6-8	0-0	5	12	9	4	14	12	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.392
11	6	6	7	8-0	0-8	6-8	0-0	5	12	9	4	12	14	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.392
12	6	6	6.5	8-0	0-8	6-8	0-0	5	12	9	4	12	14	6	4	9	3-9	0	0	0-0	0	0-0	5	6	.392
13	6.5	6	6.5	8-0	0-8	6-8	0-0	6	14	8	4	12	14	6	4	9	3-10	0	0	0-0	0	0-0	5	6	.414
14	6.5	6	6	8-0	0-8	6-8	0-0	6	14	8	4	12	14	6	4	9	3-10	0	0	0-0	0	0-0	6	6	.414
15	6.5	7	7.5	8-4	0-10	6-8	0-0	6	14	8	4	12	14	6	4	9	3-10	0	0	0-0	0	0-0	6	6	.414
20	7.5	7	6.5	8-4	0-10	6-8	0-0	6	12	9	5	14	12	6	4	9	4-0	0	0	0-0	0	0-0	6	6	.457
25	8.5	8	6.5	8-6	0-11	6-8	0-0	7	14	8	5	12	14	6	4	9	4-2	0	0	0-0	0	0-0	6	6	.5
30	10	7	6	8-4	0-10	6-8	0-0	8	14	8	6	14	12	6	4	9	4-5	0	0	0-0	0	0-0	6	6	.565
35	10.5	9	6.5	9-2	1-3	6-8	0-0	8	12	9	6	12	14	6	4	9	4-6	0	0	0-0	0	0-0	6	6	.586
40	11.5	9	6.5	9-2	1-3	6-8	0-0	9	14	8	7	14	12	6	4	9	4-8	0	0	0-0	0	0-0	6	6	.63
45	12.5	9	6.5	9-2	1-3	6-8	6-3	7	14	12	7	14	12	6	4	9	4-10	0	0	0-0	0	0-0	7	6	.673
50	13	10	6.5	9-6	1-5	6-8	6-3	7	12	14	7	12	14	6	4	8.5	4-11	0	0	0-0	0	0-0	7	6	.694

6' CLEAR SPAN BY 4' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	7	7	7	8-4	0-10	6-8	0-0	7	12	9	4	12	14	6	4	9	4-11	0	0	0-0	0	0-0	5	8	.472
2	7	7	7	8-4	0-10	6-8	0-0	6	14	8	4	12	14	6	4	9	4-11	0	0	0-0	0	0-0	5	8	.472
3	6	6	7.5	8-0	0-8	6-8	0-0	5	12	9	4	14	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.429
4	6	5	6.5	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.429
5	6	5	6.5	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.429
6	6	5	6	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.429
7	6	5	6	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.429
8	6	6	8	8-0	0-8	6-8	0-0	5	12	9	4	14	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.429
9	6	5	6	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.429
10	6	6	7.5	8-0	0-8	6-8	0-0	5	12	9	4	14	12	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.429
11	6	6	7	8-0	0-8	6-8	0-0	5	12	9	4	12	14	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.429
12	6	6	6.5	8-0	0-8	6-8	0-0	5	12	9	4	12	14	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.429
13	6.5	6	6.5	8-0	0-8	6-8	0-0	6	14	8	4	12	14	6	4	9	4-10	0	0	0-0	0	0-0	5	8	.451
14	6.5	6	6	8-0	0-8	6-8	0-0	6	14	8	4	12	14	6	4	9	4-10	0	0	0-0	0	0-0	6	8	.451
15	6.5	7	7.5	8-4	0-10	6-8	0-0	6	14	8	4	12	14	6	4	9	4-10	0	0	0-0	0	0-0	6	8	.451
20	7.5	7	6.5	8-4	0-10	6-8	0-0	6	12	9	5	14	12	6	4	9	5-0	0	0	0-0	0	0-0	6	8	.494
25	8.5	8	6.5	8-6	0-11	6-8	0-0	7	14	8	5	12	14	6	4	9	5-2	0	0	0-0	0	0-0	6	8	.537
30	10	7	6	8-4	0-10	6-8	0-0	8	14	8	6	14	12	6	4	7	5-5	0	0	0-0	0	0-0	6	8	.602
35	10.5	9	6.5	9-2	1-3	6-8	0-0	8	12	9	6	12	14	6	5	8.5	5-6	0	0	0-0	0	0-0	6	8	.623
40	11.5	9	6.5	9-2	1-3	6-8	0-0	9	14	8	7	14	12	6	5	6.5	5-8	0	0	0-0	0	0-0	6	8	.667
45	12.5	9	6.5	9-3	1-3	6-9	6-3	7	14	12	7	12	14	6.5	5	6.5	5-10	0	0	0-0	0	0-0	7	8	.729
50	13	10	6.5	9-7	1-5	6-9	6-3	7	12	14	7	12	14	6.5	6	6	5-11	0	0	0-0	0	0-0	7	8	.751

6' CLEAR SPAN BY 5' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	7	7	7	8-4	0-10	6-8	0-0	7	12	9	4	12	14	6	4	9	5-11	0	0	0-0	0	0-0	5	10	.509
2	7	7	7	8-4	0-10	6-8	0-0	6	14	8	4	12	14	6	4	9	5-11	0	0	0-0	0	0-0	5	10	.509
3	6	6	7.5	8-0	0-8	6-8	0-0	5	12	9	4	14	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.466
4	6	5	6.5	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.466
5	6	5	6.5	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.466
6	6	5	6	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.466
7	6	5	6	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.466
8	6	6	8	8-0	0-8	6-8	0-0	5	12	9	4	14	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.466
9	6	5	6	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.466
10	6	6	7.5	8-0	0-8	6-8	0-0	5	12	9	4	14	12	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.466
11	6	6	7	8-0	0-8	6-8	0-0	5	12	9	4	12	14	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.466
12	6	6	6.5	8-0	0-8	6-8	0-0	5	12	9	4	12	14	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.466
13	6.5	6	6.5	8-0	0-8	6-8	0-0	6	14	8	4	12	14	6	4	9	5-10	0	0	0-0	0	0-0	5	10	.488
14	6.5	6	6	8-0	0-8	6-8	0-0	6	14	8	4	12	14	6	4	9	5-10	0	0	0-0	0	0-0	6	10	.488
15	6.5	7	7.5	8-4	0-10	6-8	0-0	6	14	8	4	12	14	6	4	9	5-10	0	0	0-0	0	0-0	6	10	.488
20	7.5	7	6.5	8-4	0-10	6-8	0-0	6	12	9	5	14	12	6	4	7	6-0	0	0	0-0	0	0-0	6	10	.531
25	8.5	8	6.5	8-6	0-11	6-8	0-0	7	14	8	5	12	14	6	5	7.5	6-2	0	0	0-0	0	0-0	6	10	.574
30	10	7	6	8-5	0-10	6-9	0-0	8	14	8	6	14	12	6.5	5	6.5	6-5	0	0	0-0	0	0-0	6	10	.66
35	10.5	9	6.5	9-4	1-3	6-10	0-0	8	12	9	6	12	14	7	5	6	6-6	0	0	0-0	0	0-0	7	10	.703
40	11.5	9	6	9-4	1-3	6-10	0-0	9	14	8	7	14	12	7	6	7	6-8	0	0	0-0	0	0-0	7	10	.747
45	12.5	9	6	9-5	1-3	6-11	6-3	7	14	12	7	12	14	7.5	6	6.5	6-10	0	0	0-0	0	0-0	7	10	.813
50	13.5	9	6	9-6	1-3	7-0	6-3	7	12	14	8	14	12	8	6	6.5	7-0	0	0	0-0	0	0-0	8	10	.881

6' CLEAR SPAN BY 6' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	7	7	7	8-4	0-10	6-8	0-0	7	12	9	4	12	14	6	4	9	6-11	0	0	0-0	0	0-0	5	12	.546
2	7	7	7	8-4	0-10	6-8	0-0	6	14	8	4	12	14	6	4	9	6-11	0	0	0-0	0	0-0	5	12	.546
3	6	6	7.5	8-0	0-8	6-8	0-0	5	12	9	4	14	12	6	4	9	6-9	0	0	0-0	0	0-0	5	12	.503
4	6	5	6.5	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	6-9	0	0	0-0	0	0-0	5	12	.503
5	6	5	6.5	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	6-9	0	0	0-0	0	0-0	5	12	.503
6	6	5	6	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	9	6-9	0	0	0-0	0	0-0	5	12	.503
7	6	5	6	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	8	6-9	0	0	0-0	0	0-0	5	12	.503
8	6	6	8	8-0	0-8	6-8	0-0	5	12	9	4	14	12	6	4	8	6-9	0	0	0-0	0	0-0	5	12	.503
9	6	5	6	7-10	0-7	6-8	0-0	5	12	9	4	14	12	6	4	8.5	6-9	0	0	0-0	0	0-0	5	12	.503
10	6	6	7.5	8-0	0-8	6-8	0-0	5	12	9	4	14	12	6	4	8	6-9	0	0	0-0	0	0-0	5	12	.503
11	6	6	7	8-0	0-8	6-8	0-0	5	12	9	4	12	14	6	4	7	6-9	0	0	0-0	0	0-0	5	12	.503
12	6	6	6.5	8-0	0-8	6-8	0-0	5	12	9	4	12	14	6	4	6.5	6-9	0	0	0-0	0	0-0	5	12	.503
13	6.5	6	6.5	8-0	0-8	6-8	0-0	6	14	8	4	12	14	6	4	6	6-10	0	0	0-0	0	0-0	5	12	.525
14	6.5	6	6	8-0	0-8	6-8	0-0	6	14	8	4	12	14	6	5	8.5	6-10	0	0	0-0	0	0-0	6	12	.525
15	6.5	7	7.5	8-4	0-10	6-8	0-0	6	14	8	4	12	14	6	5	8	6-10	0	0	0-0	0	0-0	6	12	.525
20	7.5	7	6.5	8-4	0-10	6-8	0-0	6	12	9	5	14	12	6	6	7.5	7-0	0	0	0-0	0	0-0	6	12	.568
25	9	7	7	8-5	0-10	6-9	0-0	7	12	9	5	12	14	6.5	6	6.5	7-3	0	0	0-0	0	0-0	6	12	.656
30	10	8	7	8-9	0-11	6-11	0-0	8	14	8	6	14	12	7.5	6	8	7-5	0	0	0-0	0	0-0	7	12	.748
35	11	8	6	8-10	0-11	7-0	0-0	9	14	8	6	12	14	8	6	7	7-7	0	0	0-0	0	0-0	7	12	.817
40	12	8	6	8-11	0-11	7-1	6-3	7	14	12	7	14	12	8.5	6	6.5	7-9	0	0	0-0	0	0-0	8	12	.887
45	12.5	10	7	10-0	1-5	7-2	6-3	7	14	12	7	12	14	9	6	6.5	7-10	0	0	0-0	0	0-0	8	12	.935
50	13.5	10	7	10-1	1-5	7-3	6-3	7	12	14	8	14	12	9.5	6	6	8-0	0	0	0-0	0	0-0	8	12	1.007

7' CLEAR SPAN BY 4' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	7.5	7	7	9-4	0-10	7-8	7-3	7	14	7	5	16	12	6	4	9	5-0	0	0	0-0	0	0-0	5	8	.543
2	7.5	7	6.5	9-4	0-10	7-8	0-0	6	14	9	5	16	12	6	4	9	5-0	0	0	0-0	0	0-0	5	8	.543
3	6.5	6	6	9-0	0-8	7-8	0-0	6	16	8	4	12	16	6	4	9	4-10	0	0	0-0	0	0-0	5	8	.494
4	6	6	6.5	9-0	0-8	7-8	0-0	5	12	10	4	14	14	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.469
5	6	6	6.5	9-0	0-8	7-8	0-0	5	12	10	4	14	14	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.469
6	6	6	6	9-0	0-8	7-8	0-0	5	12	10	4	14	14	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.469
7	6.5	6	6.5	9-0	0-8	7-8	0-0	6	16	8	4	12	16	6	4	9	4-10	0	0	0-0	0	0-0	5	8	.494
8	6.5	6	6.5	9-0	0-8	7-8	0-0	6	16	8	4	12	16	6	4	9	4-10	0	0	0-0	0	0-0	5	8	.494
9	6	6	6	9-0	0-8	7-8	0-0	5	12	10	4	14	14	6	4	9	4-9	0	0	0-0	0	0-0	5	8	.469
10	6.5	6	6.5	9-0	0-8	7-8	0-0	6	16	8	4	12	16	6	4	9	4-10	0	0	0-0	0	0-0	5	8	.494
11	6.5	7	7.5	9-4	0-10	7-8	0-0	6	16	8	4	12	16	6	4	9	4-10	0	0	0-0	0	0-0	5	8	.494
12	6.5	7	7	9-4	0-10	7-8	0-0	6	16	8	4	12	16	6	4	9	4-10	0	0	0-0	0	0-0	5	8	.494
13	7	7	7	9-4	0-10	7-8	0-0	6	14	9	5	16	12	6	4	9	4-11	0	0	0-0	0	0-0	5	8	.519
14	7	7	7	9-4	0-10	7-8	0-0	6	14	9	5	16	12	6	4	9	4-11	0	0	0-0	0	0-0	6	8	.519
15	7	7	6.5	9-4	0-10	7-8	0-0	6	14	9	5	16	12	6	4	9	4-11	0	0	0-0	0	0-0	6	8	.519
20	8.5	7	6	9-4	0-10	7-8	0-0	7	14	9	5	14	14	6	4	9	5-2	0	0	0-0	0	0-0	6	8	.593
25	10	8	7	9-6	0-11	7-8	0-0	7	12	10	6	16	12	6	4	9	5-5	0	0	0-0	0	0-0	6	8	.667
30	11	9	7	10-2	1-3	7-8	0-0	8	12	10	6	14	14	6	4	7	5-7	0	0	0-0	0	0-0	6	8	.716
35	12	9	6	10-2	1-3	7-8	7-3	6	12	16	7	16	12	6	5	8	5-9	0	0	0-0	0	0-0	6	8	.765
40	13	10	6.5	10-6	1-5	7-8	7-3	7	14	14	7	14	14	6	5	6	5-11	0	0	0-0	0	0-0	6	8	.815
45	14	10	6	10-7	1-5	7-9	7-3	7	12	16	7	12	16	6.5	5	6.5	6-1	0	0	0-0	0	0-0	7	8	.884
50	15	10	6	10-8	1-5	7-10	7-3	8	14	14	8	14	14	7	5	6.5	6-3	0	0	0-0	0	0-0	7	8	.954

7' CLEAR SPAN BY 5' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	7.5	7	7	9-4	0-10	7-8	7-3	7	14	7	5	16	12	6	4	9	6-0	0	0	0-0	0	0-0	5	10	.58
2	7.5	7	6.5	9-4	0-10	7-8	0-0	6	14	9	5	16	12	6	4	9	6-0	0	0	0-0	0	0-0	5	10	.58
3	6.5	6	6	9-0	0-8	7-8	0-0	6	16	8	4	12	16	6	4	9	5-10	0	0	0-0	0	0-0	5	10	.531
4	6	6	6.5	9-0	0-8	7-8	0-0	5	12	10	4	14	14	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.506
5	6	6	6.5	9-0	0-8	7-8	0-0	5	12	10	4	14	14	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.506
6	6	6	6	9-0	0-8	7-8	0-0	5	12	10	4	14	14	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.506
7	6.5	6	6.5	9-0	0-8	7-8	0-0	6	16	8	4	12	16	6	4	9	5-10	0	0	0-0	0	0-0	5	10	.531
8	6.5	6	6.5	9-0	0-8	7-8	0-0	6	16	8	4	12	16	6	4	9	5-10	0	0	0-0	0	0-0	5	10	.531
9	6	6	6	9-0	0-8	7-8	0-0	5	12	10	4	14	14	6	4	9	5-9	0	0	0-0	0	0-0	5	10	.506
10	6.5	6	6.5	9-0	0-8	7-8	0-0	6	16	8	4	12	16	6	4	9	5-10	0	0	0-0	0	0-0	5	10	.531
11	6.5	7	7.5	9-4	0-10	7-8	0-0	6	16	8	4	12	16	6	4	9	5-10	0	0	0-0	0	0-0	5	10	.531
12	6.5	7	7	9-4	0-10	7-8	0-0	6	16	8	4	12	16	6	4	9	5-10	0	0	0-0	0	0-0	5	10	.531
13	7	7	7	9-4	0-10	7-8	0-0	6	14	9	5	16	12	6	4	9	5-11	0	0	0-0	0	0-0	5	10	.556
14	7	7	7	9-4	0-10	7-8	0-0	6	14	9	5	16	12	6	4	9	5-11	0	0	0-0	0	0-0	6	10	.556
15	7	7	6.5	9-4	0-10	7-8	0-0	6	14	9	5	16	12	6	4	9	5-11	0	0	0-0	0	0-0	6	10	.556
20	8.5	7	6	9-4	0-10	7-8	0-0	7	14	9	5	14	14	6	4	7	6-2	0	0	0-0	0	0-0	6	10	.63
25	10	8	7	9-6	0-11	7-8	0-0	7	12	10	6	16	12	6	5	6.5	6-5	0	0	0-0	0	0-0	6	10	.704
30	11	9	7	10-3	1-3	7-9	0-0	8	12	10	6	14	14	6.5	5	6.5	6-7	0	0	0-0	0	0-0	6	10	.774
35	12	9	6	10-3	1-3	7-9	7-3	6	12	16	7	16	12	6.5	6	6	6-9	0	0	0-0	0	0-0	7	10	.824
40	13	10	6.5	10-8	1-5	7-10	7-3	7	14	14	7	14	14	7	6	6.5	6-11	0	0	0-0	0	0-0	7	10	.897
45	14	10	6	10-9	1-5	7-11	7-3	7	12	16	7	12	16	7.5	6	6.5	7-1	0	0	0-0	0	0-0	7	10	.97
50	15	11	7	11-2	1-7	8-0	7-3	8	14	14	8	14	14	8	6	6.5	7-3	0	0	0-0	0	0-0	8	10	1.044

7' CLEAR SPAN BY 6' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	7.5	7	7	9-4	0-10	7-8	7-3	7	14	7	5	16	12	6	4	9	7-0	0	0	0-0	0	0-0	5	12	.617
2	7.5	7	6.5	9-4	0-10	7-8	0-0	6	14	9	5	16	12	6	4	9	7-0	0	0	0-0	0	0-0	5	12	.617
3	6.5	6	6	9-0	0-8	7-8	0-0	6	16	8	4	12	16	6	4	9	6-10	0	0	0-0	0	0-0	5	12	.568
4	6	6	6.5	9-0	0-8	7-8	0-0	5	12	10	4	14	14	6	4	9	6-9	0	0	0-0	0	0-0	5	12	.543
5	6	6	6.5	9-0	0-8	7-8	0-0	5	12	10	4	14	14	6	4	9	6-9	0	0	0-0	0	0-0	5	12	.543
6	6	6	6	9-0	0-8	7-8	0-0	5	12	10	4	14	14	6	4	9	6-9	0	0	0-0	0	0-0	5	12	.543
7	6.5	6	6.5	9-0	0-8	7-8	0-0	6	16	8	4	12	16	6	4	8.5	6-10	0	0	0-0	0	0-0	5	12	.568
8	6.5	6	6.5	9-0	0-8	7-8	0-0	6	16	8	4	12	16	6	4	7.5	6-10	0	0	0-0	0	0-0	5	12	.568
9	6	6	6	9-0	0-8	7-8	0-0	5	12	10	4	14	14	6	4	8.5	6-9	0	0	0-0	0	0-0	5	12	.543
10	6.5	6	6.5	9-0	0-8	7-8	0-0	6	16	8	4	12	16	6	4	8	6-10	0	0	0-0	0	0-0	5	12	.568
11	6.5	7	7.5	9-4	0-10	7-8	0-0	6	16	8	4	12	16	6	4	7	6-10	0	0	0-0	0	0-0	5	12	.568
12	6.5	7	7	9-4	0-10	7-8	0-0	6	16	8	4	12	16	6	4	6.5	6-10	0	0	0-0	0	0-0	5	12	.568
13	7	7	7	9-4	0-10	7-8	0-0	6	14	9	5	16	12	6	4	6	6-11	0	0	0-0	0	0-0	5	12	.593
14	7	7	7	9-4	0-10	7-8	0-0	6	14	9	5	16	12	6	5	8.5	6-11	0	0	0-0	0	0-0	6	12	.593
15	7	7	6.5	9-4	0-10	7-8	0-0	6	14	9	5	16	12	6	5	8	6-11	0	0	0-0	0	0-0	6	12	.593
20	8.5	7	6	9-4	0-10	7-8	0-0	7	14	9	5	14	14	6	6	6.5	7-2	0	0	0-0	0	0-0	6	12	.667
25	10	8	6.5	9-8	0-11	7-10	0-0	8	14	9	6	14	14	7	6	7.5	7-5	0	0	0-0	0	0-0	6	12	.789
30	11	9	6.5	10-4	1-3	7-10	0-0	8	12	10	6	12	16	7	7	6.5	7-7	0	0	0-0	0	0-0	7	12	.839
35	12.5	9	7	10-6	1-3	8-0	7-3	7	16	12	7	14	14	8	6	6.5	7-10	0	0	0-0	0	0-0	7	12	.965
40	13.5	9	6	10-7	1-3	8-1	7-3	7	14	14	7	12	16	8.5	6	6.5	8-0	0	0	0-0	0	0-0	8	12	1.042
45	14.5	10	6.5	11-0	1-5	8-2	7-3	7	12	16	8	14	14	9	6	6	8-2	0	0	0-0	0	0-0	8	12	1.12
50	15	11	6.5	11-5	1-7	8-3	7-3	8	14	14	8	12	16	9.5	6	6	8-3	0	0	0-0	0	0-0	8	12	1.173

7' CLEAR SPAN BY 7' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	7.5	4	11	8-10	0-6	7-10	7-3	6	14	7	5	16	12	7	4	10	8-0	0	0	0-0	0	0-0	6	14	.706
2	7.5	4	11	8-10	0-6	7-10	0-0	6	14	9	5	16	12	7	4	10	8-0	0	0	0-0	0	0-0	6	14	.706
3	6.5	6	6	9-2	0-8	7-10	0-0	6	16	8	4	12	16	7	4	10	7-10	0	0	0-0	0	0-0	6	14	.655
4	6	6	6.5	9-2	0-8	7-10	0-0	5	12	10	4	14	14	7	4	10	7-9	0	0	0-0	0	0-0	6	14	.63
5	6	6	6.5	9-2	0-8	7-10	0-0	5	12	10	4	14	14	7	4	8.5	7-9	0	0	0-0	0	0-0	6	14	.63
6	6	6	6	9-2	0-8	7-10	0-0	5	12	10	4	14	14	7	4	8.5	7-9	0	0	0-0	0	0-0	6	14	.63
7	6.5	6	6.5	9-2	0-8	7-10	0-0	6	16	8	4	12	16	7	4	7.5	7-10	0	0	0-0	0	0-0	6	14	.655
8	6.5	6	6.5	9-2	0-8	7-10	0-0	6	16	8	4	12	16	7	4	7	7-10	0	0	0-0	0	0-0	6	14	.655
9	6	6	6	9-2	0-8	7-10	0-0	5	12	10	4	14	14	7	4	7.5	7-9	0	0	0-0	0	0-0	6	14	.63
10	6.5	6	6.5	9-2	0-8	7-10	0-0	6	16	8	4	12	16	7	4	7	7-10	0	0	0-0	0	0-0	6	14	.655
11	6.5	7	7.5	9-6	0-10	7-10	0-0	6	16	8	4	12	16	7	4	6	7-10	0	0	0-0	0	0-0	6	14	.655
12	6.5	7	7	9-6	0-10	7-10	0-0	6	16	8	4	12	16	7	5	9	7-10	0	0	0-0	0	0-0	6	14	.655
13	7	7	7	9-6	0-10	7-10	0-0	6	14	9	5	16	12	7	5	8	7-11	0	0	0-0	0	0-0	6	14	.681
14	7	7	6.5	9-6	0-10	7-10	0-0	6	14	9	5	16	12	7	5	7.5	7-11	0	0	0-0	0	0-0	6	14	.681
15	7.5	7	7	9-6	0-10	7-10	0-0	6	12	10	5	16	12	7	5	7	8-0	0	0	0-0	0	0-0	6	14	.706
20	8.5	8	7	9-8	0-11	7-10	0-0	7	14	9	5	12	16	7	6	6.5	8-2	0	0	0-0	0	0-0	6	14	.756
25	10	8	6.5	9-9	0-11	7-11	0-0	8	14	9	6	14	14	7.5	7	7.5	8-5	0	0	0-0	0	0-0	7	14	.859
30	11	9	6.5	10-7	1-3	8-1	0-0	8	12	10	6	12	16	8.5	6	6.5	8-7	0	0	0-0	0	0-0	7	14	.965
35	12.5	9	6.5	10-8	1-3	8-2	7-3	7	14	14	7	14	14	9	7	7.5	8-10	0	0	0-0	0	0-0	8	14	1.071
40	13.5	9	6	10-9	1-3	8-3	7-3	7	14	14	7	12	16	9.5	7	7	9-0	0	0	0-0	0	0-0	8	14	1.152
45	14.5	10	6.5	11-2	1-5	8-4	7-3	7	12	16	8	14	14	10	7	6.5	9-2	0	0	0-0	0	0-0	8	14	1.235
50	15.5	10	6	11-4	1-5	8-6	7-3	8	12	16	8	12	16	11	7	7	9-4	0	0	0-0	0	0-0	9	14	1.348

8' CLEAR SPAN BY 3' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8	7	6.5	10-4	0-10	8-8	8-3	7	12	9	5	16	14	6	4	9	4-1	0	0	0-0	0	0-0	5	6	.583
2	8	7	6.5	10-4	0-10	8-8	0-0	6	13	10	5	16	14	6	4	9	4-1	0	0	0-0	0	0-0	5	6	.583
3	7	7	7.5	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	3-11	0	0	0-0	0	0-0	5	6	.528
4	6.5	7	7.5	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	3-10	0	0	0-0	0	0-0	5	6	.5
5	6.5	7	7.5	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	3-10	0	0	0-0	0	0-0	5	6	.5
6	6.5	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	3-10	0	0	0-0	0	0-0	5	6	.5
7	7	7	8	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	3-11	0	0	0-0	0	0-0	5	6	.528
8	7	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	3-11	0	0	0-0	0	0-0	5	6	.528
9	6.5	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	3-10	0	0	0-0	0	0-0	5	6	.5
10	7	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	3-11	0	0	0-0	0	0-0	5	6	.528
11	7	7	6.5	10-4	0-10	8-8	0-0	6	13	10	5	18	12	6	4	9	3-11	0	0	0-0	0	0-0	5	6	.528
12	7.5	7	6.5	10-4	0-10	8-8	0-0	6	13	10	5	16	14	6	4	9	4-0	0	0	0-0	0	0-0	5	6	.556
13	7.5	7	6	10-4	0-10	8-8	0-0	6	13	10	5	16	14	6	4	9	4-0	0	0	0-0	0	0-0	5	6	.556
14	8	7	6.5	10-4	0-10	8-8	0-0	6	12	11	5	16	14	6	4	9	4-1	0	0	0-0	0	0-0	6	6	.583
15	8	7	6	10-4	0-10	8-8	0-0	6	12	11	5	16	14	6	4	9	4-1	0	0	0-0	0	0-0	6	6	.583
20	9.5	8	6.5	10-6	0-11	8-8	0-0	7	12	11	5	12	18	6	4	9	4-4	0	0	0-0	0	0-0	6	6	.667
25	11	9	7.5	11-2	1-3	8-8	0-0	8	13	10	6	13	16	6	4	9	4-7	0	0	0-0	0	0-0	6	6	.75
30	12	10	7	11-6	1-5	8-8	8-3	6	13	16	6	12	18	6	4	9	4-9	0	0	0-0	0	0-0	6	6	.806
35	13.5	10	7	11-6	1-5	8-8	8-3	7	16	14	7	13	16	6	4	9	5-0	0	0	0-0	0	0-0	6	6	.889
40	14.5	10	6	11-6	1-5	8-8	8-3	7	13	16	7	12	18	6	4	9	5-2	0	0	0-0	0	0-0	6	6	.944
45	15.5	11	6.5	11-10	1-7	8-8	8-3	7	12	18	8	13	16	6	4	9	5-4	0	0	0-0	0	0-0	7	6	1
50	16.5	11	6	11-10	1-7	8-8	8-3	8	13	16	8	12	18	6	4	6	5-6	0	0	0-0	0	0-0	7	6	1.056

8' CLEAR SPAN BY 4' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8	7	6.5	10-4	0-10	8-8	8-3	7	12	9	5	16	14	6	4	9	5-1	0	0	0-0	0	0-0	5	8	.62
2	8	7	6.5	10-4	0-10	8-8	0-0	6	13	10	5	16	14	6	4	9	5-1	0	0	0-0	0	0-0	5	8	.62
3	7	7	7.5	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	4-11	0	0	0-0	0	0-0	5	8	.565
4	6.5	7	7.5	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	4-10	0	0	0-0	0	0-0	5	8	.537
5	6.5	7	7.5	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	4-10	0	0	0-0	0	0-0	5	8	.537
6	6.5	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	4-10	0	0	0-0	0	0-0	5	8	.537
7	7	7	8	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	4-11	0	0	0-0	0	0-0	5	8	.565
8	7	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	4-11	0	0	0-0	0	0-0	5	8	.565
9	6.5	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	4-10	0	0	0-0	0	0-0	5	8	.537
10	7	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	4-11	0	0	0-0	0	0-0	5	8	.565
11	7	7	6.5	10-4	0-10	8-8	0-0	6	13	10	5	18	12	6	4	9	4-11	0	0	0-0	0	0-0	5	8	.565
12	7.5	7	6.5	10-4	0-10	8-8	0-0	6	13	10	5	16	14	6	4	9	5-0	0	0	0-0	0	0-0	5	8	.593
13	7.5	7	6	10-4	0-10	8-8	0-0	6	13	10	5	16	14	6	4	9	5-0	0	0	0-0	0	0-0	5	8	.593
14	8	7	6.5	10-4	0-10	8-8	0-0	6	12	11	5	16	14	6	4	9	5-1	0	0	0-0	0	0-0	6	8	.62
15	8	7	6	10-4	0-10	8-8	0-0	6	12	11	5	16	14	6	4	9	5-1	0	0	0-0	0	0-0	6	8	.62
20	9.5	8	6.5	10-6	0-11	8-8	0-0	7	12	11	5	12	18	6	4	9	5-4	0	0	0-0	0	0-0	6	8	.704
25	11	9	7.5	11-2	1-3	8-8	0-0	8	13	10	6	13	16	6	4	9	5-7	0	0	0-0	0	0-0	6	8	.787
30	12	10	7	11-6	1-5	8-8	8-3	6	13	16	6	12	18	6	4	7.5	5-9	0	0	0-0	0	0-0	6	8	.843
35	13.5	10	7	11-6	1-5	8-8	8-3	7	16	14	7	13	16	6	5	8	6-0	0	0	0-0	0	0-0	6	8	.926
40	14.5	11	7	11-11	1-7	8-9	8-3	7	13	16	7	12	18	6.5	5	8	6-2	0	0	0-0	0	0-0	7	8	1.002
45	15.5	11	6.5	11-11	1-7	8-9	8-3	7	12	18	8	13	16	6.5	6	6	6-4	0	0	0-0	0	0-0	7	8	1.058
50	16.5	11	6	11-0	1-7	8-10	8-3	8	13	16	8	12	18	7	5	6	6-6	0	0	0-0	0	0-0	7	8	1.135

8' CLEAR SPAN BY 5' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8	7	6.5	10-4	0-10	8-8	8-3	7	12	9	5	16	14	6	4	9	6-1	0	0	0-0	0	0-0	5	10	.657
2	8	7	6.5	10-4	0-10	8-8	0-0	6	13	10	5	16	14	6	4	9	6-1	0	0	0-0	0	0-0	5	10	.657
3	7	7	7.5	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	5-11	0	0	0-0	0	0-0	5	10	.602
4	6.5	7	7.5	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	5-10	0	0	0-0	0	0-0	5	10	.574
5	6.5	7	7.5	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	5-10	0	0	0-0	0	0-0	5	10	.574
6	6.5	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	5-10	0	0	0-0	0	0-0	5	10	.574
7	7	7	8	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	5-11	0	0	0-0	0	0-0	5	10	.602
8	7	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	5-11	0	0	0-0	0	0-0	5	10	.602
9	6.5	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	5-10	0	0	0-0	0	0-0	5	10	.574
10	7	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	5-11	0	0	0-0	0	0-0	5	10	.602
11	7	7	6.5	10-4	0-10	8-8	0-0	6	13	10	5	18	12	6	4	9	5-11	0	0	0-0	0	0-0	5	10	.602
12	7.5	7	6.5	10-4	0-10	8-8	0-0	6	13	10	5	16	14	6	4	9	6-0	0	0	0-0	0	0-0	5	10	.63
13	7.5	7	6	10-4	0-10	8-8	0-0	6	13	10	5	16	14	6	4	9	6-0	0	0	0-0	0	0-0	5	10	.63
14	8	7	6.5	10-4	0-10	8-8	0-0	6	12	11	5	16	14	6	4	9	6-1	0	0	0-0	0	0-0	6	10	.657
15	8	7	6	10-4	0-10	8-8	0-0	6	12	11	5	16	14	6	4	9	6-1	0	0	0-0	0	0-0	6	10	.657
20	9.5	8	6.5	10-6	0-11	8-8	0-0	7	12	11	5	12	18	6	4	6.5	6-4	0	0	0-0	0	0-0	6	10	.741
25	11	9	7.5	11-2	1-3	8-8	0-0	8	13	10	6	13	16	6	5	6.5	6-7	0	0	0-0	0	0-0	6	10	.824
30	12	10	7	11-7	1-5	8-9	8-3	6	13	16	6	12	18	6.5	5	6.5	6-9	0	0	0-0	0	0-0	6	10	.901
35	13.5	10	6.5	11-8	1-5	8-10	8-3	7	13	16	7	13	16	7	5	6	7-0	0	0	0-0	0	0-0	7	10	1.008
40	14.5	11	7	11-0	1-7	8-10	8-3	7	13	16	7	12	18	7	7	7	7-2	0	0	0-0	0	0-0	7	10	1.065
45	16	11	7	12-1	1-7	8-11	8-3	8	13	16	8	13	16	7.5	7	7.5	7-5	0	0	0-0	0	0-0	7	10	1.174
50	17	11	6.5	12-2	1-7	9-0	8-3	8	12	18	8	12	18	8	7	7.5	7-7	0	0	0-0	0	0-0	8	10	1.255

8' CLEAR SPAN BY 6' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8	7	6.5	10-4	0-10	8-8	8-3	7	12	9	5	16	14	6	4	9	7-1	0	0	0-0	0	0-0	5	12	.694
2	8	7	6.5	10-4	0-10	8-8	0-0	6	13	10	5	16	14	6	4	9	7-1	0	0	0-0	0	0-0	5	12	.694
3	7	7	7.5	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	6-11	0	0	0-0	0	0-0	5	12	.639
4	6.5	7	7.5	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	6-10	0	0	0-0	0	0-0	5	12	.611
5	6.5	7	7.5	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	6-10	0	0	0-0	0	0-0	5	12	.611
6	6.5	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	6-10	0	0	0-0	0	0-0	5	12	.611
7	7	7	8	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	8.5	6-11	0	0	0-0	0	0-0	5	12	.639
8	7	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	7.5	6-11	0	0	0-0	0	0-0	5	12	.639
9	6.5	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	9	6-10	0	0	0-0	0	0-0	5	12	.611
10	7	7	7	10-4	0-10	8-8	0-0	6	16	9	4	12	18	6	4	7.5	6-11	0	0	0-0	0	0-0	5	12	.639
11	7	7	6.5	10-4	0-10	8-8	0-0	6	13	10	5	18	12	6	4	7	6-11	0	0	0-0	0	0-0	5	12	.639
12	7.5	7	6.5	10-4	0-10	8-8	0-0	6	13	10	5	16	14	6	4	6	7-0	0	0	0-0	0	0-0	5	12	.667
13	7.5	7	6	10-4	0-10	8-8	0-0	6	13	10	5	16	14	6	5	9	7-0	0	0	0-0	0	0-0	5	12	.667
14	8	7	6.5	10-4	0-10	8-8	0-0	6	12	11	5	16	14	6	5	8.5	7-1	0	0	0-0	0	0-0	6	12	.694
15	8	7	6	10-4	0-10	8-8	0-0	6	12	11	5	16	14	6	5	7.5	7-1	0	0	0-0	0	0-0	6	12	.694
20	9.5	8	6.5	10-7	0-11	8-9	0-0	7	12	11	5	12	18	6.5	5	6	7-4	0	0	0-0	0	0-0	6	12	.801
25	11	9	7	11-4	1-3	8-10	0-0	8	13	10	6	13	16	7	6	6.5	7-7	0	0	0-0	0	0-0	6	12	.91
30	12.5	9	6.5	11-5	1-3	8-11	8-3	6	12	18	6	12	18	7.5	6	7	7-10	0	0	0-0	0	0-0	7	12	1.02
35	13.5	10	6.5	11-9	1-5	8-11	8-3	7	13	16	7	13	16	7.5	7	7	8-0	0	0	0-0	0	0-0	7	12	1.077
40	15	10	6.5	11-11	1-5	9-1	8-3	7	12	18	8	16	14	8.5	6	6	8-3	0	0	0-0	0	0-0	8	12	1.216
45	16	11	6.5	12-4	1-7	9-2	8-3	8	13	16	8	13	16	9	6	6	8-5	0	0	0-0	0	0-0	8	12	1.301
50	17	11	6	12-5	1-7	9-3	8-3	8	12	18	8	12	18	9.5	7	7.5	8-7	0	0	0-0	0	0-0	8	12	1.387

8' CLEAR SPAN BY 7' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8	7	6.5	10-6	0-10	8-10	8-3	7	12	9	5	16	14	7	4	10	8-1	0	0	0-0	0	0-0	6	14	.783
2	8	7	6	10-6	0-10	8-10	0-0	6	13	10	5	16	14	7	4	10	8-1	0	0	0-0	0	0-0	6	14	.783
3	7	7	7.5	10-6	0-10	8-10	0-0	6	16	9	4	12	18	7	4	10	7-11	0	0	0-0	0	0-0	6	14	.727
4	6.5	7	7.5	10-6	0-10	8-10	0-0	6	16	9	4	12	18	7	4	10	7-10	0	0	0-0	0	0-0	6	14	.699
5	6.5	7	7.5	10-6	0-10	8-10	0-0	6	16	9	4	12	18	7	4	8.5	7-10	0	0	0-0	0	0-0	6	14	.699
6	6.5	7	7	10-6	0-10	8-10	0-0	6	16	9	4	12	18	7	4	8.5	7-10	0	0	0-0	0	0-0	6	14	.699
7	7	7	7.5	10-6	0-10	8-10	0-0	6	16	9	4	12	18	7	4	7	7-11	0	0	0-0	0	0-0	6	14	.727
8	7	7	7	10-6	0-10	8-10	0-0	6	16	9	4	12	18	7	4	7	7-11	0	0	0-0	0	0-0	6	14	.727
9	6.5	7	7	10-6	0-10	8-10	0-0	6	16	9	4	12	18	7	4	7.5	7-10	0	0	0-0	0	0-0	6	14	.699
10	7	7	7	10-6	0-10	8-10	0-0	6	16	9	4	12	18	7	4	7	7-11	0	0	0-0	0	0-0	6	14	.727
11	7	7	6.5	10-6	0-10	8-10	0-0	6	13	10	5	18	12	7	4	6.5	7-11	0	0	0-0	0	0-0	6	14	.727
12	7.5	7	6.5	10-6	0-10	8-10	0-0	6	13	10	5	16	14	7	5	9	8-0	0	0	0-0	0	0-0	6	14	.755
13	7.5	7	6	10-6	0-10	8-10	0-0	6	13	10	5	16	14	7	5	8.5	8-0	0	0	0-0	0	0-0	6	14	.755
14	8	7	6.5	10-6	0-10	8-10	0-0	6	12	11	5	16	14	7	5	7.5	8-1	0	0	0-0	0	0-0	6	14	.783
15	8	7	6	10-6	0-10	8-10	0-0	6	12	11	5	16	14	7	5	7	8-1	0	0	0-0	0	0-0	6	14	.783
20	9.5	8	6	10-8	0-11	8-10	0-0	7	12	11	5	12	18	7	6	6	8-4	0	0	0-0	0	0-0	6	14	.868
25	11	9	7	11-5	1-3	8-11	0-0	8	13	10	6	13	16	7.5	7	6.5	8-7	0	0	0-0	0	0-0	7	14	.981
30	12.5	9	6.5	11-6	1-3	9-0	8-3	6	12	18	7	16	14	8	7	6	8-10	0	0	0-0	0	0-0	7	14	1.095
35	13.5	10	6	12-0	1-5	9-2	8-3	7	13	16	7	13	16	9	7	7.5	9-0	0	0	0-0	0	0-0	8	14	1.21
40	15	10	6	12-1	1-5	9-3	8-3	7	12	18	8	13	16	9.5	7	7	9-3	0	0	0-0	0	0-0	8	14	1.327
45	16	11	6.5	12-6	1-7	9-4	8-3	8	13	16	8	13	16	10	7	6.5	9-5	0	0	0-0	0	0-0	8	14	1.417
50	17	11	6	12-7	1-7	9-5	8-3	8	12	18	8	12	18	10.5	7	6	9-7	0	0	0-0	0	0-0	9	14	1.507

8' CLEAR SPAN BY 8' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8	7	6.5	10-8	0-10	9-0	8-3	7	12	9	5	16	14	8	4	10.5	8-0	4	10.5	2-2	0	0-0	6	16	.885
2	8.5	7	6.5	10-8	0-10	9-0	0-0	6	12	11	5	16	14	8	4	10	8-0	4	10	2-3	0	0-0	6	16	.914
3	7	7	7.5	10-8	0-10	9-0	0-0	6	13	10	5	18	12	8	4	8.5	7-11	4	8.5	2-2	0	0-0	6	16	.827
4	6.5	7	7.5	10-8	0-10	9-0	0-0	6	16	9	4	12	18	8	4	8.5	7-10	4	8.5	2-2	0	0-0	6	16	.798
5	6.5	7	7.5	10-8	0-10	9-0	0-0	6	16	9	4	12	18	8	4	7.5	7-10	4	7.5	2-2	0	0-0	6	16	.798
6	6.5	7	7	10-8	0-10	9-0	0-0	6	16	9	4	12	18	8	4	7	7-10	4	7	2-2	0	0-0	6	16	.798
7	7	7	7.5	10-8	0-10	9-0	0-0	6	13	10	5	18	12	8	4	6.5	7-11	4	6.5	2-2	0	0-0	6	16	.827
8	7	7	7	10-8	0-10	9-0	0-0	6	13	10	5	18	12	8	4	6	7-11	4	6	2-2	0	0-0	6	16	.827
9	6.5	7	7	10-8	0-10	9-0	0-0	6	16	9	4	12	18	8	4	6.5	7-10	4	6.5	2-2	0	0-0	6	16	.798
10	7	7	7	10-8	0-10	9-0	0-0	6	13	10	5	18	12	8	4	6	7-11	4	6	2-2	0	0-0	6	16	.827
11	7	7	6.5	10-8	0-10	9-0	0-0	6	13	10	5	18	12	8	5	8.5	7-11	5	8.5	2-2	0	0-0	6	16	.827
12	7.5	7	6.5	10-8	0-10	9-0	0-0	6	13	10	5	16	14	8	5	8	7-11	5	8	2-2	0	0-0	6	16	.856
13	7.5	7	6	10-8	0-10	9-0	0-0	6	13	10	5	16	14	8	5	7.5	7-11	5	7.5	2-2	0	0-0	6	16	.856
14	8	7	6	10-8	0-10	9-0	0-0	6	12	11	5	13	16	8	5	7	8-0	5	7	2-2	0	0-0	6	16	.885
15	8.5	7	6.5	10-8	0-10	9-0	0-0	7	16	9	5	13	16	8	5	6.5	8-0	5	6.5	2-3	0	0-0	6	16	.914
20	9.5	8	6	10-10	0-11	9-0	0-0	7	12	11	6	16	14	8	6	6	8-2	6	6	2-5	0	0-0	7	16	.971
25	11	9	6.5	11-7	1-3	9-1	0-0	8	13	10	6	13	16	8.5	7	6.5	8-3	6	6.5	2-8	0	0-0	7	16	1.088
30	12.5	9	6	11-9	1-3	9-3	8-3	6	12	18	7	16	14	9.5	7	7.5	8-4	6	7.5	2-11	0	0-0	8	16	1.238
35	13.5	10	6	12-2	1-5	9-4	8-3	7	13	16	7	13	16	10	7	6.5	8-6	6	6.5	3-1	0	0-0	8	16	1.329
40	15	11	7	12-8	1-7	9-6	8-3	7	12	18	8	13	16	11	7	6.5	8-7	6	6.5	3-4	0	0-0	9	16	1.484
45	16.5	10	6	12-5	1-5	9-7	8-3	8	13	16	8	12	18	11.5	7	6	8-9	6	6	3-7	0	0-0	9	16	1.609
50	17.5	11	6.5	12-11	1-7	9-9	8-3	9	13	16	9	13	16	12.5	7	6.5	8-9	6	6.5	3-9	5	7-4	10	32	1.738

9' CLEAR SPAN BY 4' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8.5	7	6	11-4	0-10	9-8	9-3	7	12	10	5	15	16	6	4	9	5-2	0	0	0-0	0	0-0	5	8	.704
2	8.5	8	6.5	11-6	0-11	9-8	0-0	6	12	12	5	15	16	6	4	9	5-2	0	0	0-0	0	0-0	5	8	.704
3	7.5	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	9	5-0	0	0	0-0	0	0-0	5	8	.642
4	7	7	6.5	11-4	0-10	9-8	0-0	6	15	10	4	12	20	6	4	9	4-11	0	0	0-0	0	0-0	5	8	.611
5	7	7	6.5	11-4	0-10	9-8	0-0	6	15	10	4	12	20	6	4	9	4-11	0	0	0-0	0	0-0	5	8	.611
6	7.5	7	7	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	9	5-0	0	0	0-0	0	0-0	5	8	.642
7	7.5	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	9	5-0	0	0	0-0	0	0-0	5	8	.642
8	7.5	7	6	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	9	5-0	0	0	0-0	0	0-0	5	8	.642
9	8	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	15	16	6	4	9	5-1	0	0	0-0	0	0-0	5	8	.673
10	7.5	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	9	5-0	0	0	0-0	0	0-0	5	8	.642
11	8	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	15	16	6	4	9	5-1	0	0	0-0	0	0-0	5	8	.673
12	8	7	6	11-4	0-10	9-8	0-0	6	13	11	5	15	16	6	4	9	5-1	0	0	0-0	0	0-0	5	8	.673
13	8.5	7	6	11-4	0-10	9-8	0-0	6	12	12	5	15	16	6	4	9	5-2	0	0	0-0	0	0-0	5	8	.704
14	8.5	8	7	11-6	0-11	9-8	0-0	6	12	12	5	15	16	6	4	9	5-2	0	0	0-0	0	0-0	6	8	.704
15	8.5	8	6.5	11-6	0-11	9-8	0-0	6	12	12	5	15	16	6	4	9	5-2	0	0	0-0	0	0-0	6	8	.704
20	10.5	8	6	11-6	0-11	9-8	0-0	7	12	12	6	15	16	6	4	9	5-6	0	0	0-0	0	0-0	6	8	.827
25	12	9	6.5	12-2	1-3	9-8	9-3	6	13	18	6	13	18	6	4	9	5-9	0	0	0-0	0	0-0	6	8	.92
30	13.5	10	6.5	12-6	1-5	9-8	9-3	6	12	20	7	15	16	6	4	7	6-0	0	0	0-0	0	0-0	6	8	1.012
35	15	10	6	12-6	1-5	9-8	9-3	7	13	18	7	12	20	6	5	7.5	6-3	0	0	0-0	0	0-0	6	8	1.105
40	16	11	6.5	12-11	1-7	9-9	9-3	7	12	20	8	15	16	6.5	5	7.5	6-5	0	0	0-0	0	0-0	7	8	1.188
45	17.5	11	6	12-0	1-7	9-10	9-3	8	13	18	8	12	20	7	5	7.5	6-8	0	0	0-0	0	0-0	7	8	1.302
50	18.5	11	5.5	12-0	1-7	9-10	9-3	8	12	20	9	15	16	7	7	6.5	6-10	0	0	0-0	0	0-0	7	8	1.365

9' CLEAR SPAN BY 5' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8.5	7	6	11-4	0-10	9-8	9-3	7	12	10	5	15	16	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.741
2	8.5	8	6.5	11-6	0-11	9-8	0-0	6	12	12	5	15	16	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.741
3	7.5	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	9	6-0	0	0	0-0	0	0-0	5	10	.679
4	7	7	6.5	11-4	0-10	9-8	0-0	6	15	10	4	12	20	6	4	9	5-11	0	0	0-0	0	0-0	5	10	.648
5	7	7	6.5	11-4	0-10	9-8	0-0	6	15	10	4	12	20	6	4	9	5-11	0	0	0-0	0	0-0	5	10	.648
6	7.5	7	7	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	9	6-0	0	0	0-0	0	0-0	5	10	.679
7	7.5	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	9	6-0	0	0	0-0	0	0-0	5	10	.679
8	7.5	7	6	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	9	6-0	0	0	0-0	0	0-0	5	10	.679
9	8	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	15	16	6	4	9	6-1	0	0	0-0	0	0-0	5	10	.71
10	7.5	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	9	6-0	0	0	0-0	0	0-0	5	10	.679
11	8	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	15	16	6	4	9	6-1	0	0	0-0	0	0-0	5	10	.71
12	8	7	6	11-4	0-10	9-8	0-0	6	13	11	5	15	16	6	4	9	6-1	0	0	0-0	0	0-0	5	10	.71
13	8.5	7	6	11-4	0-10	9-8	0-0	6	12	12	5	15	16	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.741
14	8.5	8	7	11-6	0-11	9-8	0-0	6	12	12	5	15	16	6	4	9	6-2	0	0	0-0	0	0-0	6	10	.741
15	8.5	8	6.5	11-6	0-11	9-8	0-0	6	12	12	5	15	16	6	4	9	6-2	0	0	0-0	0	0-0	6	10	.741
20	10.5	8	6	11-6	0-11	9-8	0-0	7	12	12	6	15	16	6	4	6	6-6	0	0	0-0	0	0-0	6	10	.864
25	12	9	6.5	12-2	1-3	9-8	9-3	6	13	18	6	13	18	6	5	6.5	6-9	0	0	0-0	0	0-0	6	10	.957
30	13.5	10	6.5	12-7	1-5	9-9	9-3	6	12	20	7	15	16	6.5	5	6	7-0	0	0	0-0	0	0-0	6	10	1.072
35	15	10	6	12-8	1-5	9-10	9-3	7	13	18	7	12	20	7	6	7.5	7-3	0	0	0-0	0	0-0	7	10	1.189
40	16.5	11	7	13-1	1-7	9-11	9-3	8	15	16	8	13	18	7.5	6	7.5	7-6	0	0	0-0	0	0-0	7	10	1.307
45	17.5	11	6	13-2	1-7	10-0	9-3	8	13	18	8	12	20	8	6	7.5	7-8	0	0	0-0	0	0-0	8	10	1.395
50	19	11	6	13-3	1-7	10-1	9-3	9	15	16	9	13	18	8.5	6	7	7-11	0	0	0-0	0	0-0	8	10	1.516

9' CLEAR SPAN BY 6' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8.5	7	6	11-4	0-10	9-8	9-3	7	12	10	5	15	16	6	4	9	7-2	0	0	0-0	0	0-0	5	12	.778
2	8.5	8	6.5	11-6	0-11	9-8	0-0	6	12	12	5	15	16	6	4	9	7-2	0	0	0-0	0	0-0	5	12	.778
3	7.5	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	9	7-0	0	0	0-0	0	0-0	5	12	.716
4	7	7	6.5	11-4	0-10	9-8	0-0	6	15	10	4	12	20	6	4	9	6-11	0	0	0-0	0	0-0	5	12	.685
5	7	7	6.5	11-4	0-10	9-8	0-0	6	15	10	4	12	20	6	4	9	6-11	0	0	0-0	0	0-0	5	12	.685
6	7.5	7	7	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	9	7-0	0	0	0-0	0	0-0	5	12	.716
7	7.5	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	8.5	7-0	0	0	0-0	0	0-0	5	12	.716
8	7.5	7	6	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	7.5	7-0	0	0	0-0	0	0-0	5	12	.716
9	8	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	15	16	6	4	7	7-1	0	0	0-0	0	0-0	5	12	.747
10	7.5	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	18	14	6	4	7.5	7-0	0	0	0-0	0	0-0	5	12	.716
11	8	7	6.5	11-4	0-10	9-8	0-0	6	13	11	5	15	16	6	4	7	7-1	0	0	0-0	0	0-0	5	12	.747
12	8	7	6	11-4	0-10	9-8	0-0	6	13	11	5	15	16	6	4	6	7-1	0	0	0-0	0	0-0	5	12	.747
13	8.5	7	6	11-4	0-10	9-8	0-0	6	12	12	5	15	16	6	5	9	7-2	0	0	0-0	0	0-0	5	12	.778
14	8.5	8	7	11-6	0-11	9-8	0-0	6	12	12	5	15	16	6	5	8	7-2	0	0	0-0	0	0-0	6	12	.778
15	8.5	8	6.5	11-6	0-11	9-8	0-0	6	12	12	5	15	16	6	5	7	7-2	0	0	0-0	0	0-0	6	12	.778
20	10.5	8	6	11-7	0-11	9-9	0-0	7	12	12	6	15	16	6.5	6	7.5	7-6	0	0	0-0	0	0-0	6	12	.925
25	12	9	6	12-4	1-3	9-10	9-3	6	13	18	6	13	18	7	6	6.5	7-9	0	0	0-0	0	0-0	6	12	1.044
30	13.5	10	6.5	12-9	1-5	9-11	9-3	6	12	20	7	15	16	7.5	6	7	8-0	0	0	0-0	0	0-0	7	12	1.164
35	15	10	6	12-10	1-5	10-0	9-3	7	13	18	7	12	20	8	6	6.5	8-3	0	0	0-0	0	0-0	7	12	1.285
40	16.5	11	7	13-3	1-7	10-1	9-3	8	15	16	8	13	18	8.5	6	6	8-6	0	0	0-0	0	0-0	8	12	1.408
45	17.5	11	5.5	13-4	1-7	10-2	9-3	8	13	18	8	12	20	9	7	7.5	8-8	0	0	0-0	0	0-0	8	12	1.5
50	19	11	6	13-5	1-7	10-3	9-3	9	13	18	9	13	18	9.5	7	7	8-11	0	0	0-0	0	0-0	8	12	1.626

9' CLEAR SPAN BY 7' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8.5	7	6	11-6	0-10	9-10	9-3	8	15	8	5	15	16	7	4	10	8-2	0	0	0-0	0	0-0	6	14	.867
2	8.5	8	6.5	11-8	0-11	9-10	0-0	6	12	12	5	15	16	7	4	10	8-2	0	0	0-0	0	0-0	6	14	.867
3	7.5	7	6.5	11-6	0-10	9-10	0-0	6	13	11	5	18	14	7	4	10	8-0	0	0	0-0	0	0-0	6	14	.805
4	7	7	6.5	11-6	0-10	9-10	0-0	6	15	10	4	12	20	7	4	9.5	7-11	0	0	0-0	0	0-0	6	14	.773
5	7	7	6.5	11-6	0-10	9-10	0-0	6	15	10	4	12	20	7	4	8.5	7-11	0	0	0-0	0	0-0	6	14	.773
6	7.5	7	7	11-6	0-10	9-10	0-0	6	13	11	5	18	14	7	4	8	8-0	0	0	0-0	0	0-0	6	14	.805
7	7.5	7	6.5	11-6	0-10	9-10	0-0	6	13	11	5	18	14	7	4	7	8-0	0	0	0-0	0	0-0	6	14	.805
8	7.5	7	6	11-6	0-10	9-10	0-0	6	13	11	5	18	14	7	4	6.5	8-0	0	0	0-0	0	0-0	6	14	.805
9	8	7	6.5	11-6	0-10	9-10	0-0	6	13	11	5	15	16	7	4	6	8-1	0	0	0-0	0	0-0	6	14	.836
10	7.5	7	6	11-6	0-10	9-10	0-0	6	13	11	5	18	14	7	4	7	8-0	0	0	0-0	0	0-0	6	14	.805
11	8	7	6.5	11-6	0-10	9-10	0-0	6	12	12	5	15	16	7	4	6	8-1	0	0	0-0	0	0-0	6	14	.836
12	8.5	7	6.5	11-6	0-10	9-10	0-0	6	12	12	5	15	16	7	5	8.5	8-2	0	0	0-0	0	0-0	6	14	.867
13	8.5	7	6	11-6	0-10	9-10	0-0	6	12	12	5	15	16	7	5	8	8-2	0	0	0-0	0	0-0	6	14	.867
14	8.5	8	6.5	11-8	0-11	9-10	0-0	7	15	10	5	13	18	7	5	7	8-2	0	0	0-0	0	0-0	6	14	.867
15	9	8	7	11-8	0-11	9-10	0-0	7	15	10	5	13	18	7	5	7	8-3	0	0	0-0	0	0-0	6	14	.899
20	10.5	8	6	11-8	0-11	9-10	0-0	8	15	10	6	15	16	7	7	7.5	8-6	0	0	0-0	0	0-0	6	14	.993
25	12	9	6	12-5	1-3	9-11	9-3	6	13	18	6	12	20	7.5	7	6	8-9	0	0	0-0	0	0-0	7	14	1.115
30	13.5	10	6	12-11	1-5	10-1	9-3	7	15	16	7	15	16	8.5	6	6	9-0	0	0	0-0	0	0-0	7	14	1.267
35	15	11	7	13-4	1-7	10-2	9-3	7	13	18	7	12	20	9	7	7	9-3	0	0	0-0	0	0-0	8	14	1.394
40	16.5	11	6.5	13-5	1-7	10-3	9-3	8	13	18	8	13	18	9.5	7	6.5	9-6	0	0	0-0	0	0-0	8	14	1.521
45	17.5	11	5.5	13-6	1-7	10-4	9-3	8	13	18	8	12	20	10	7	6	9-8	0	0	0-0	0	0-0	8	14	1.617
50	19	11	5.5	13-7	1-7	10-5	9-3	9	13	18	9	13	18	10.5	7	6	9-11	0	0	0-0	0	0-0	9	14	1.748

9' CLEAR SPAN BY 8' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8.5	7	6	11-8	0-10	10-0	9-3	8	15	8	5	15	16	8	4	10	8-0	4	10	2-3	0	0-0	6	16	.969
2	9	7	6	11-8	0-10	10-0	0-0	7	15	10	5	13	18	8	4	10	8-1	4	10	2-4	0	0-0	6	16	1.001
3	7.5	7	6.5	11-8	0-10	10-0	0-0	6	13	11	5	18	14	8	4	8.5	7-11	4	8.5	2-2	0	0-0	6	16	.905
4	7	7	6.5	11-8	0-10	10-0	0-0	6	15	10	5	18	14	8	4	8.5	7-11	4	8.5	2-2	0	0-0	6	16	.873
5	7	7	6.5	11-8	0-10	10-0	0-0	6	15	10	5	18	14	8	4	7	7-11	4	7	2-2	0	0-0	6	16	.873
6	7.5	7	7	11-8	0-10	10-0	0-0	6	13	11	5	18	14	8	4	7	7-11	4	7	2-2	0	0-0	6	16	.905
7	7.5	7	6.5	11-8	0-10	10-0	0-0	6	13	11	5	18	14	8	4	6	7-11	4	6	2-2	0	0-0	6	16	.905
8	7.5	7	6	11-8	0-10	10-0	0-0	6	13	11	5	18	14	8	5	9	7-11	5	9	2-2	0	0-0	6	16	.905
9	8	7	6	11-8	0-10	10-0	0-0	6	13	11	5	15	16	8	5	8.5	8-0	5	8.5	2-2	0	0-0	6	16	.937
10	7.5	7	6	11-8	0-10	10-0	0-0	6	13	11	5	18	14	8	4	6	7-11	4	6	2-2	0	0-0	6	16	.905
11	8	7	6	11-8	0-10	10-0	0-0	6	12	12	5	15	16	8	5	8.5	8-0	5	8.5	2-2	0	0-0	6	16	.937
12	8.5	7	6	11-8	0-10	10-0	0-0	6	12	12	5	15	16	8	5	8	8-0	5	8	2-3	0	0-0	6	16	.969
13	8.5	8	7	11-10	0-11	10-0	0-0	7	15	10	5	13	18	8	5	7	8-0	5	7	2-3	0	0-0	6	16	.969
14	8.5	8	6.5	11-10	0-11	10-0	0-0	7	15	10	5	13	18	8	5	6.5	8-0	5	6.5	2-3	0	0-0	6	16	.969
15	9	8	6.5	11-10	0-11	10-0	0-0	7	15	10	5	13	18	8	5	6	8-1	5	6	2-4	0	0-0	6	16	1.001
20	10.5	9	7	12-6	1-3	10-0	0-0	8	15	10	6	15	16	8	7	7.5	8-3	6	7.5	2-7	0	0-0	7	16	1.097
25	12	10	7	12-11	1-5	10-1	9-3	6	13	18	6	12	20	8.5	7	6	8-4	6	6	2-10	0	0-0	7	16	1.224
30	13.5	10	6	13-1	1-5	10-3	9-3	7	15	16	7	13	18	9.5	7	7	8-6	6	7	3-1	0	0-0	8	16	1.384
35	15	11	6.5	13-6	1-7	10-4	9-3	7	12	20	7	12	20	10	7	6	8-7	6	6	3-4	0	0-0	8	16	1.514
40	16.5	11	6.5	13-8	1-7	10-6	9-3	8	13	18	8	13	18	11	7	6.5	8-9	6	6.5	3-7	0	0-0	9	16	1.68
45	17.5	11	5.5	13-9	1-7	10-7	9-3	8	12	20	8	12	20	11.5	7	6	8-9	6	6	3-9	0	0-0	9	16	1.781
50	19	11	5.5	13-10	1-7	10-8	9-3	9	13	18	9	13	18	12	8	7	8-11	7	7	4-0	5	7-4	9	32	1.917

9' CLEAR SPAN BY 9' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8.5	7	6	11-10	0-10	10-2	9-3	8	13	9	5	15	16	9	4	8.5	9-0	4	8.5	2-3	0	0-0	6	18	1.083
2	9	8	7.5	12-0	0-11	10-2	0-0	7	15	10	5	13	18	9	4	7.5	9-1	4	7.5	2-4	0	0-0	6	18	1.116
3	7.5	7	6.5	11-10	0-10	10-2	0-0	6	13	11	5	18	14	9	4	7.5	8-0	4	7.5	2-2	0	0-0	6	18	1.019
4	7	7	6.5	11-10	0-10	10-2	0-0	6	15	10	5	18	14	9	4	7	8-11	4	7	2-2	0	0-0	6	18	.986
5	7	7	6.5	11-10	0-10	10-2	0-0	6	15	10	5	18	14	9	4	7	8-11	4	7	2-2	0	0-0	6	18	.986
6	7.5	7	7	11-10	0-10	10-2	0-0	6	13	11	5	18	14	9	4	6	8-0	4	6	2-2	0	0-0	6	18	1.019
7	7.5	7	6.5	11-10	0-10	10-2	0-0	6	13	11	5	18	14	9	5	9	8-0	5	9	2-2	0	0-0	6	18	1.019
8	7.5	7	6	11-10	0-10	10-2	0-0	6	13	11	5	18	14	9	5	8	8-0	5	8	2-2	0	0-0	6	18	1.019
9	8	7	6	11-10	0-10	10-2	0-0	6	12	12	5	15	16	9	5	7.5	9-0	5	7.5	2-2	0	0-0	6	18	1.051
10	7.5	7	6	11-10	0-10	10-2	0-0	6	13	11	5	18	14	9	5	8.5	8-0	5	8.5	2-2	0	0-0	6	18	1.019
11	8	7	6	11-10	0-10	10-2	0-0	6	12	12	5	15	16	9	5	7.5	9-0	5	7.5	2-2	0	0-0	7	18	1.051
12	8.5	7	6	11-10	0-10	10-2	0-0	6	12	12	5	13	18	9	5	7	9-0	5	7	2-3	0	0-0	7	18	1.083
13	8.5	8	7	12-0	0-11	10-2	0-0	7	15	10	5	13	18	9	5	6.5	9-0	5	6.5	2-3	0	0-0	7	18	1.083
14	8.5	8	6.5	12-0	0-11	10-2	0-0	7	15	10	5	13	18	9	5	6	9-0	5	6	2-3	0	0-0	7	18	1.083
15	9	8	6.5	12-0	0-11	10-2	0-0	7	13	11	5	13	18	9	6	8	9-1	6	8	2-4	0	0-0	7	18	1.116
20	10.5	9	7	12-8	1-3	10-2	0-0	8	15	10	6	15	16	9	7	7.5	9-3	6	7.5	2-7	0	0-0	7	18	1.213
25	12.5	9	6.5	12-9	1-3	10-3	9-3	6	13	18	6	12	20	9.5	7	6	9-4	6	6	2-11	0	0-0	7	18	1.377
30	14	10	6.5	13-3	1-5	10-5	9-3	7	15	16	7	13	18	10.5	8	7	9-6	7	7	3-2	0	0-0	8	18	1.546
35	15	11	6.5	13-9	1-7	10-7	9-3	7	12	20	7	12	20	11.5	7	6	9-7	6	6	3-4	0	0-0	9	18	1.683
40	16.5	11	6	13-10	1-7	10-8	9-3	8	13	18	8	13	18	12	8	7	9-9	7	7	3-7	5	8-4	9	36	1.821
45	18	11	6	13-0	1-7	10-10	9-3	8	12	20	9	13	18	13	8	7	9-10	7	7	3-10	5	8-4	9	36	1.997
50	19	11	5	14-1	1-7	10-11	9-3	9	13	18	9	12	20	13.5	8	6.5	9-11	7	6.5	4-0	5	8-4	10	36	2.104

10' CLEAR SPAN BY 4' CLEAR HEIGHT

FILL	T	a_1 BAR			DIMENSION		a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	A	B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8.5	8	7	12-6	0-11	10-8	10-3	8	13	10	5	15	18	6	4	9	5-2	0	0	0-0	0	0-0	5	8	.759
2	9	8	6	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	9	5-3	0	0	0-0	0	0-0	5	8	.793
3	8	8	7.5	12-6	0-11	10-8	0-0	6	13	12	5	17	16	6	4	9	5-1	0	0	0-0	0	0-0	5	8	.725
4	7.5	7	6	12-4	0-10	10-8	0-0	6	15	11	5	17	16	6	4	9	5-0	0	0	0-0	0	0-0	5	8	.691
5	8	7	6.5	12-4	0-10	10-8	0-0	6	13	12	5	17	16	6	4	9	5-1	0	0	0-0	0	0-0	5	8	.725
6	8	7	6	12-4	0-10	10-8	0-0	6	13	12	5	17	16	6	4	9	5-1	0	0	0-0	0	0-0	5	8	.725
7	8	7	6	12-4	0-10	10-8	0-0	6	13	12	5	17	16	6	4	9	5-1	0	0	0-0	0	0-0	5	8	.725
8	8.5	7	6	12-4	0-10	10-8	0-0	6	12	13	5	15	18	6	4	9	5-2	0	0	0-0	0	0-0	5	8	.759
9	8.5	8	7.5	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	9	5-2	0	0	0-0	0	0-0	5	8	.759
10	8.5	8	7	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	9	5-2	0	0	0-0	0	0-0	5	8	.759
11	8.5	8	7	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	9	5-2	0	0	0-0	0	0-0	5	8	.759
12	8.5	8	6.5	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	9	5-2	0	0	0-0	0	0-0	5	8	.759
13	9	8	6.5	12-6	0-11	10-8	0-0	7	15	11	5	13	20	6	4	9	5-3	0	0	0-0	0	0-0	5	8	.793
14	9	8	6	12-6	0-11	10-8	0-0	7	15	11	5	13	20	6	4	9	5-3	0	0	0-0	0	0-0	6	8	.793
15	9.5	8	6	12-6	0-11	10-8	0-0	7	15	11	5	13	20	6	4	9	5-4	0	0	0-0	0	0-0	6	8	.827
20	11	9	6	13-2	1-3	10-8	0-0	8	15	11	6	15	18	6	4	9	5-7	0	0	0-0	0	0-0	6	8	.929
25	13	10	6.5	13-6	1-5	10-8	10-3	6	13	20	6	12	22	6	4	9	5-11	0	0	0-0	0	0-0	6	8	1.065
30	14.5	11	7	13-10	1-7	10-8	10-3	7	15	18	7	13	20	6	4	7	6-2	0	0	0-0	0	0-0	6	8	1.167
35	16.5	11	7	13-10	1-7	10-8	10-3	7	12	22	7	12	22	6	6	6.5	6-6	0	0	0-0	0	0-0	6	8	1.302
40	17.5	11	5.5	13-11	1-7	10-9	10-3	8	15	18	8	13	20	6.5	5	7	6-8	0	0	0-0	0	0-0	7	8	1.392
45	19	11	5.5	13-0	1-7	10-10	10-3	8	12	22	8	12	22	7	5	7	6-11	0	0	0-0	0	0-0	7	8	1.517
50	20.5	11	5	14-1	1-7	10-11	10-3	9	13	20	9	13	20	7.5	5	6.5	7-2	0	0	0-0	0	0-0	8	8	1.644

10' CLEAR SPAN BY 5' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8.5	8	7	12-6	0-11	10-8	10-3	8	13	10	5	15	18	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.796
2	9	8	6	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	9	6-3	0	0	0-0	0	0-0	5	10	.83
3	8	8	7.5	12-6	0-11	10-8	0-0	6	13	12	5	17	16	6	4	9	6-1	0	0	0-0	0	0-0	5	10	.762
4	7.5	7	6	12-4	0-10	10-8	0-0	6	15	11	5	17	16	6	4	9	6-0	0	0	0-0	0	0-0	5	10	.728
5	8	7	6.5	12-4	0-10	10-8	0-0	6	13	12	5	17	16	6	4	9	6-1	0	0	0-0	0	0-0	5	10	.762
6	8	7	6	12-4	0-10	10-8	0-0	6	13	12	5	17	16	6	4	9	6-1	0	0	0-0	0	0-0	5	10	.762
7	8	7	6	12-4	0-10	10-8	0-0	6	13	12	5	17	16	6	4	9	6-1	0	0	0-0	0	0-0	5	10	.762
8	8.5	7	6	12-4	0-10	10-8	0-0	6	12	13	5	15	18	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.796
9	8.5	8	7.5	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.796
10	8.5	8	7	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.796
11	8.5	8	7	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.796
12	8.5	8	6.5	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.796
13	9	8	6.5	12-6	0-11	10-8	0-0	7	15	11	5	13	20	6	4	9	6-3	0	0	0-0	0	0-0	5	10	.83
14	9	8	6	12-6	0-11	10-8	0-0	7	15	11	5	13	20	6	4	9	6-3	0	0	0-0	0	0-0	6	10	.83
15	9.5	8	6	12-6	0-11	10-8	0-0	7	15	11	5	13	20	6	4	9	6-4	0	0	0-0	0	0-0	6	10	.864
20	11	9	6	13-2	1-3	10-8	0-0	8	15	11	6	15	18	6	4	6.5	6-7	0	0	0-0	0	0-0	6	10	.966
25	13	10	6.5	13-6	1-5	10-8	10-3	6	13	20	6	12	22	6	5	6.5	6-11	0	0	0-0	0	0-0	6	10	1.102
30	14.5	11	7	13-11	1-7	10-9	10-3	7	15	18	7	13	20	6.5	5	6	7-2	0	0	0-0	0	0-0	6	10	1.227
35	16.5	11	7	13-0	1-7	10-10	10-3	7	12	22	8	15	18	7	6	7	7-6	0	0	0-0	0	0-0	7	10	1.388
40	17.5	11	5.5	14-1	1-7	10-11	10-3	8	13	20	8	13	20	7.5	6	7	7-8	0	0	0-0	0	0-0	7	10	1.481
45	19	11	5	14-2	1-7	11-0	10-3	8	12	22	8	12	22	8	6	7	7-11	0	0	0-0	0	0-0	8	10	1.611
50	20.5	11	5	14-3	1-7	11-1	10-3	9	13	20	9	13	20	8.5	6	6.5	8-2	0	0	0-0	0	0-0	8	10	1.742

10' CLEAR SPAN BY 6' CLEAR HEIGHT

FILL	T	a_1 BAR			DIMENSION		a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	A	B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8.5	8	7	12-6	0-11	10-8	10-3	8	13	10	5	15	18	6	4	9	7-2	0	0	0-0	0	0-0	5	12	.833
2	9	8	6	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	9	7-3	0	0	0-0	0	0-0	5	12	.867
3	8	8	7.5	12-6	0-11	10-8	0-0	6	13	12	5	17	16	6	4	9	7-1	0	0	0-0	0	0-0	5	12	.799
4	7.5	7	6	12-4	0-10	10-8	0-0	6	15	11	5	17	16	6	4	9	7-0	0	0	0-0	0	0-0	5	12	.765
5	8	7	6.5	12-4	0-10	10-8	0-0	6	13	12	5	17	16	6	4	9	7-1	0	0	0-0	0	0-0	5	12	.799
6	8	7	6	12-4	0-10	10-8	0-0	6	13	12	5	17	16	6	4	9	7-1	0	0	0-0	0	0-0	5	12	.799
7	8	7	6	12-4	0-10	10-8	0-0	6	13	12	5	17	16	6	4	8	7-1	0	0	0-0	0	0-0	5	12	.799
8	8.5	7	6	12-4	0-10	10-8	0-0	6	12	13	5	15	18	6	4	7	7-2	0	0	0-0	0	0-0	5	12	.833
9	8.5	8	7.5	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	6.5	7-2	0	0	0-0	0	0-0	5	12	.833
10	8.5	8	7	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	6	7-2	0	0	0-0	0	0-0	5	12	.833
11	8.5	8	7	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	7	7-2	0	0	0-0	0	0-0	5	12	.833
12	8.5	8	6.5	12-6	0-11	10-8	0-0	6	12	13	5	15	18	6	4	6	7-2	0	0	0-0	0	0-0	5	12	.833
13	9	8	6.5	12-6	0-11	10-8	0-0	7	15	11	5	13	20	6	5	8.5	7-3	0	0	0-0	0	0-0	5	12	.867
14	9	8	6	12-6	0-11	10-8	0-0	7	15	11	5	13	20	6	5	7.5	7-3	0	0	0-0	0	0-0	6	12	.867
15	9.5	8	6	12-6	0-11	10-8	0-0	7	15	11	5	13	20	6	5	6.5	7-4	0	0	0-0	0	0-0	6	12	.901
20	11	9	6	13-3	1-3	10-9	0-0	8	15	11	6	15	18	6.5	6	7.5	7-7	0	0	0-0	0	0-0	6	12	1.028
25	13	10	6.5	13-8	1-5	10-10	10-3	6	13	20	6	12	22	7	6	6	7-11	0	0	0-0	0	0-0	6	12	1.19
30	15	10	6	13-9	1-5	10-11	10-3	7	15	18	7	13	20	7.5	6	6.5	8-3	0	0	0-0	0	0-0	7	12	1.354
35	16.5	11	6.5	14-2	1-7	11-0	10-3	7	12	22	8	15	18	8	6	6	8-6	0	0	0-0	0	0-0	7	12	1.486
40	17.5	11	5.5	14-3	1-7	11-1	10-3	8	13	20	8	13	20	8.5	7	8	8-8	0	0	0-0	0	0-0	8	12	1.583
45	19	11	5	14-4	1-7	11-2	10-3	8	12	22	9	15	18	9	7	7.5	8-11	0	0	0-0	0	0-0	8	12	1.718
50	21	11	5.5	14-5	1-7	11-3	10-3	9	13	20	9	12	22	9.5	7	6.5	9-3	0	0	0-0	0	0-0	8	12	1.889

10' CLEAR SPAN BY 7' CLEAR HEIGHT

FILL	T	a_1 BAR			DIMENSION		a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	A	B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8.5	8	7	12-8	0-11	10-10	10-3	8	13	10	5	15	18	7	4	10	8-2	0	0	0-0	0	0-0	6	14	.923
2	9	8	6	12-8	0-11	10-10	0-0	6	12	13	5	15	18	7	4	10	8-3	0	0	0-0	0	0-0	6	14	.957
3	8.5	7	6.5	12-6	0-10	10-10	0-0	6	12	13	5	15	18	7	4	10	8-2	0	0	0-0	0	0-0	6	14	.923
4	8	7	6.5	12-6	0-10	10-10	0-0	6	13	12	5	17	16	7	4	9.5	8-1	0	0	0-0	0	0-0	6	14	.888
5	8	7	6.5	12-6	0-10	10-10	0-0	6	13	12	5	17	16	7	4	8.5	8-1	0	0	0-0	0	0-0	6	14	.888
6	8	7	6	12-6	0-10	10-10	0-0	6	13	12	5	17	16	7	4	8	8-1	0	0	0-0	0	0-0	6	14	.888
7	8	8	7.5	12-8	0-11	10-10	0-0	6	13	12	5	17	16	7	4	7	8-1	0	0	0-0	0	0-0	6	14	.888
8	8.5	7	6	12-6	0-10	10-10	0-0	6	12	13	5	15	18	7	4	6.5	8-2	0	0	0-0	0	0-0	6	14	.923
9	8.5	8	7	12-8	0-11	10-10	0-0	6	12	13	5	15	18	7	4	6	8-2	0	0	0-0	0	0-0	6	14	.923
10	8.5	8	6.5	12-8	0-11	10-10	0-0	6	12	13	5	15	18	7	5	8.5	8-2	0	0	0-0	0	0-0	6	14	.923
11	8.5	8	7	12-8	0-11	10-10	0-0	6	12	13	5	15	18	7	4	6	8-2	0	0	0-0	0	0-0	6	14	.923
12	8.5	8	6.5	12-8	0-11	10-10	0-0	6	12	13	5	15	18	7	5	9	8-2	0	0	0-0	0	0-0	6	14	.923
13	9	8	6.5	12-8	0-11	10-10	0-0	7	15	11	5	13	20	7	5	8	8-3	0	0	0-0	0	0-0	6	14	.957
14	9	8	6	12-8	0-11	10-10	0-0	7	15	11	5	13	20	7	5	7	8-3	0	0	0-0	0	0-0	6	14	.957
15	9.5	8	6	12-8	0-11	10-10	0-0	7	13	12	5	13	20	7	5	6.5	8-4	0	0	0-0	0	0-0	6	14	.992
20	11	9	6	13-4	1-3	10-10	0-0	8	15	11	6	15	18	7	7	7	8-7	0	0	0-0	0	0-0	6	14	1.095
25	13.5	9	6	13-6	1-3	11-0	10-3	6	12	22	7	15	18	8	7	7.5	9-0	0	0	0-0	0	0-0	7	14	1.325
30	15	10	6	13-11	1-5	11-1	10-3	7	13	20	7	13	20	8.5	7	7.5	9-3	0	0	0-0	0	0-0	7	14	1.46
35	16.5	11	6.5	14-4	1-7	11-2	10-3	7	12	22	8	15	18	9	7	7	9-6	0	0	0-0	0	0-0	8	14	1.596
40	18	11	6	14-5	1-7	11-3	10-3	8	13	20	8	12	22	9.5	7	6.5	9-9	0	0	0-0	0	0-0	8	14	1.733
45	19	11	5	14-6	1-7	11-4	10-3	8	12	22	9	15	18	10	7	6	9-11	0	0	0-0	0	0-0	8	14	1.836
50	21	11	5	14-7	1-7	11-5	10-3	9	13	20	9	12	22	10.5	8	7	10-3	0	0	0-0	0	0-0	9	14	2.013

10' CLEAR SPAN BY 8' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8.5	8	7	12-10	0-11	11-0	10-3	8	13	10	5	15	18	8	4	10.5	8-0	4	10.5	2-3	0	0-0	6	16	1.025
2	9.5	8	6.5	12-10	0-11	11-0	0-0	7	15	11	5	13	20	8	4	9	8-2	4	9	2-5	0	0-0	6	16	1.095
3	8.5	7	6	12-8	0-10	11-0	0-0	6	12	13	5	15	18	8	4	9	8-0	4	9	2-3	0	0-0	6	16	1.025
4	8	7	6.5	12-8	0-10	11-0	0-0	6	13	12	5	17	16	8	4	8	8-0	4	8	2-2	0	0-0	6	16	.99
5	8	7	6	12-8	0-10	11-0	0-0	6	13	12	5	17	16	8	4	7.5	8-0	4	7.5	2-2	0	0-0	6	16	.99
6	8	7	6	12-8	0-10	11-0	0-0	6	13	12	5	17	16	8	4	7	8-0	4	7	2-2	0	0-0	6	16	.99
7	8.5	7	6.5	12-8	0-10	11-0	0-0	6	12	13	5	15	18	8	4	6	8-0	4	6	2-3	0	0-0	6	16	1.025
8	8.5	7	6	12-8	0-10	11-0	0-0	6	12	13	5	15	18	8	5	9	8-0	5	9	2-3	0	0-0	6	16	1.025
9	8.5	8	7	12-10	0-11	11-0	0-0	6	12	13	5	15	18	8	5	8	8-0	5	8	2-3	0	0-0	6	16	1.025
10	8.5	8	6.5	12-10	0-11	11-0	0-0	6	12	13	5	15	18	8	5	7.5	8-0	5	7.5	2-3	0	0-0	6	16	1.025
11	8.5	8	6.5	12-10	0-11	11-0	0-0	6	12	13	5	15	18	8	5	8.5	8-0	5	8.5	2-3	0	0-0	6	16	1.025
12	9	8	6.5	12-10	0-11	11-0	0-0	7	15	11	5	13	20	8	5	7.5	8-1	5	7.5	2-4	0	0-0	6	16	1.06
13	9	8	6.5	12-10	0-11	11-0	0-0	7	15	11	5	13	20	8	5	7	8-1	5	7	2-4	0	0-0	6	16	1.06
14	9	8	6	12-10	0-11	11-0	0-0	7	15	11	5	13	20	8	5	6.5	8-1	5	6.5	2-4	0	0-0	6	16	1.06
15	9.5	8	6	12-10	0-11	11-0	0-0	7	13	12	5	12	22	8	5	6	8-2	5	6	2-5	0	0-0	6	16	1.095
20	11.5	9	6.5	13-6	1-3	11-0	0-0	8	13	12	6	13	20	8	7	7	8-3	6	7	2-9	0	0-0	7	16	1.235
25	13.5	9	6	13-7	1-3	11-1	10-3	6	12	22	7	15	18	8.5	8	7	8-6	7	7	3-1	0	0-0	7	16	1.406
30	15	11	7	14-5	1-7	11-3	10-3	7	13	20	7	13	20	9.5	7	6.5	8-7	6	6.5	3-4	0	0-0	8	16	1.577
35	16.5	11	6	14-6	1-7	11-4	10-3	7	12	22	8	15	18	10	7	6	8-9	6	6	3-7	0	0-0	8	16	1.718
40	18	11	5.5	14-8	1-7	11-6	10-3	8	13	20	8	12	22	11	7	6.5	8-10	6	6.5	3-10	0	0-0	9	16	1.895
45	19.5	11	5	14-9	1-7	11-7	10-3	9	15	18	9	13	20	11.5	8	7.5	8-0	7	7.5	4-1	0	0-0	9	16	2.039
50	21	11	5	14-10	1-7	11-8	10-3	9	12	22	9	12	22	12	8	7	9-1	7	7	4-4	5	7-4	9	32	2.185

10' CLEAR SPAN BY 9' CLEAR HEIGHT

FILL	T	a_1 BAR			DIMENSION		a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	A	B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8.5	8	7	13-0	0-11	11-2	10-3	8	13	10	5	15	18	9	4	9	9-0	4	9	2-3	0	0-0	6	18	1.139
2	9.5	8	6.5	13-0	0-11	11-2	0-0	7	15	11	5	13	20	9	4	7.5	9-2	4	7.5	2-5	0	0-0	6	18	1.21
3	8.5	7	6	12-10	0-10	11-2	0-0	6	12	13	5	15	18	9	4	7.5	9-0	4	7.5	2-3	0	0-0	6	18	1.139
4	8	7	6.5	12-10	0-10	11-2	0-0	6	12	13	5	15	18	9	4	7	9-0	4	7	2-2	0	0-0	6	18	1.103
5	8	7	6	12-10	0-10	11-2	0-0	6	12	13	5	15	18	9	4	6.5	9-0	4	6.5	2-2	0	0-0	6	18	1.103
6	8	7	6	12-10	0-10	11-2	0-0	6	12	13	5	15	18	9	4	6	9-0	4	6	2-2	0	0-0	6	18	1.103
7	8.5	7	6	12-10	0-10	11-2	0-0	6	12	13	5	15	18	9	5	8.5	9-0	5	8.5	2-3	0	0-0	6	18	1.139
8	8.5	7	6	12-10	0-10	11-2	0-0	6	12	13	5	15	18	9	5	8	9-0	5	8	2-3	0	0-0	6	18	1.139
9	8.5	8	7	13-0	0-11	11-2	0-0	6	12	13	5	15	18	9	5	7.5	9-0	5	7.5	2-3	0	0-0	6	18	1.139
10	8.5	8	6.5	13-0	0-11	11-2	0-0	6	12	13	5	15	18	9	5	7	9-0	5	7	2-3	0	0-0	6	18	1.139
11	8.5	8	6.5	13-0	0-11	11-2	0-0	6	12	13	5	15	18	9	5	7.5	9-0	5	7.5	2-3	0	0-0	7	18	1.139
12	9	8	6.5	13-0	0-11	11-2	0-0	7	15	11	5	13	20	9	5	7	9-1	5	7	2-4	0	0-0	7	18	1.174
13	9	8	6	13-0	0-11	11-2	0-0	7	15	11	5	13	20	9	5	6.5	9-1	5	6.5	2-4	0	0-0	7	18	1.174
14	9.5	8	6.5	13-0	0-11	11-2	0-0	7	13	12	5	12	22	9	5	6	9-2	5	6	2-5	0	0-0	7	18	1.21
15	9.5	8	6	13-0	0-11	11-2	0-0	7	13	12	5	12	22	9	6	7.5	9-2	6	7.5	2-5	0	0-0	7	18	1.21
20	11.5	9	6.5	13-8	1-3	11-2	0-0	8	13	12	6	13	20	9	7	7	9-3	6	7	2-9	0	0-0	7	18	1.352
25	13.5	10	7	14-1	1-5	11-3	10-3	6	12	22	7	15	18	9.5	8	7	9-6	7	7	3-1	0	0-0	7	18	1.529
30	15	11	7	14-7	1-7	11-5	10-3	7	13	20	7	13	20	10.5	8	6.5	9-7	7	6.5	3-4	0	0-0	8	18	1.708
35	16.5	11	6	14-9	1-7	11-7	10-3	8	15	18	8	13	20	11.5	7	6	9-9	6	6	3-7	0	0-0	9	18	1.889
40	18	11	5.5	14-10	1-7	11-8	10-3	8	13	20	8	12	22	12	8	7	9-10	7	7	3-10	5	8-4	9	36	2.037
45	19.5	11	5	14-0	1-7	11-10	10-3	9	15	18	9	13	20	13	8	7	9-0	7	7	4-1	5	8-4	9	36	2.224
50	21	11	5	15-1	1-7	11-11	10-3	9	12	22	9	12	22	13.5	8	6.5	10-1	7	6.5	4-4	5	8-4	10	36	2.376

10' CLEAR SPAN BY 10' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	8.5	8	7	13-2	0-11	11-4	10-3	8	12	11	5	15	18	10	4	7.5	10-0	4	7.5	2-3	0	0-0	7	20	1.265
2	9.5	8	6.5	13-2	0-11	11-4	0-0	7	15	11	5	13	20	10	4	7	10-2	4	7	2-5	0	0-0	7	20	1.337
3	8.5	7	6	12-0	0-10	11-4	0-0	6	12	13	5	15	18	10	4	6.5	10-0	4	6.5	2-3	0	0-0	7	20	1.265
4	8	7	6.5	12-0	0-10	11-4	0-0	6	12	13	5	15	18	10	4	6	10-0	4	6	2-2	0	0-0	7	20	1.229
5	8	7	6	12-0	0-10	11-4	0-0	6	12	13	5	15	18	10	5	9	10-0	5	9	2-2	0	0-0	7	20	1.229
6	8	7	6	12-0	0-10	11-4	0-0	6	12	13	5	15	18	10	5	8	10-0	5	8	2-2	0	0-0	7	20	1.229
7	8.5	7	6	12-0	0-10	11-4	0-0	6	12	13	5	15	18	10	5	7.5	10-0	5	7.5	2-3	0	0-0	7	20	1.265
8	8.5	7	6	12-0	0-10	11-4	0-0	6	12	13	5	15	18	10	5	7	10-0	5	7	2-3	0	0-0	7	20	1.265
9	8.5	8	7	13-2	0-11	11-4	0-0	6	12	13	5	15	18	10	5	6.5	10-0	5	6.5	2-3	0	0-0	7	20	1.265
10	8.5	8	6.5	13-2	0-11	11-4	0-0	6	12	13	5	15	18	10	5	6	10-0	5	6	2-3	0	0-0	7	20	1.265
11	8.5	8	6.5	13-2	0-11	11-4	0-0	7	15	11	5	15	18	10	5	7	10-0	5	7	2-3	0	0-0	7	20	1.265
12	9	8	6.5	13-2	0-11	11-4	0-0	7	15	11	5	13	20	10	5	6	10-1	5	6	2-4	0	0-0	7	20	1.301
13	9	8	6	13-2	0-11	11-4	0-0	7	15	11	5	13	20	10	6	8	10-1	6	8	2-4	0	0-0	7	20	1.301
14	9.5	8	6	13-2	0-11	11-4	0-0	7	13	12	5	12	22	10	6	7.5	10-2	6	7.5	2-5	0	0-0	7	20	1.337
15	10	8	6	13-2	0-11	11-4	0-0	7	12	13	5	12	22	10	6	7	10-2	6	7	2-6	0	0-0	7	20	1.373
20	11.5	9	6	13-10	1-3	11-4	0-0	8	13	12	6	13	20	10	7	6.5	10-3	6	6.5	2-9	0	0-0	7	20	1.481
25	13.5	10	7	14-3	1-5	11-5	10-3	6	12	22	7	15	18	10.5	8	6.5	10-6	7	6.5	3-1	0	0-0	8	20	1.664
30	15	11	6.5	14-9	1-7	11-7	10-3	7	13	20	7	12	22	11.5	8	6.5	10-7	7	6.5	3-4	0	0-0	8	20	1.85
35	16.5	11	6	14-11	1-7	11-9	10-3	8	15	18	8	13	20	12.5	8	6.5	10-9	7	6.5	3-7	5	9-4	9	40	2.04
40	18.5	11	6	15-1	1-7	11-11	10-3	8	12	22	8	12	22	13.5	8	6.5	10-10	7	6.5	3-11	5	9-4	9	40	2.27
45	19.5	11	5	15-3	1-7	12-1	10-3	9	13	20	9	13	20	14.5	8	6.5	10-0	7	6.5	4-1	5	9-4	10	40	2.428
50	21.5	11	5.5	15-4	1-7	12-2	10-3	9	12	22	10	15	18	15	8	6	11-2	7	6	4-5	5	9-4	10	40	2.623

11' CLEAR SPAN BY 5' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9	8	7	13-6	0-11	11-8	11-3	8	13	11	5	14	20	6	4	9	6-3	0	0	0-0	0	0-0	5	10	.889
2	9.5	9	7.5	14-2	1-3	11-8	0-0	7	14	12	5	14	20	6	4	9	6-4	0	0	0-0	0	0-0	5	10	.926
3	8.5	8	6.5	13-6	0-11	11-8	0-0	6	12	14	5	16	18	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.852
4	8.5	7	6	13-4	0-10	11-8	0-0	6	12	14	5	16	18	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.852
5	8.5	8	7.5	13-6	0-11	11-8	0-0	6	12	14	5	16	18	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.852
6	8.5	8	7	13-6	0-11	11-8	0-0	6	12	14	5	16	18	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.852
7	8.5	8	6.5	13-6	0-11	11-8	0-0	6	12	14	5	16	18	6	4	9	6-2	0	0	0-0	0	0-0	5	10	.852
8	9	8	7	13-6	0-11	11-8	0-0	6	12	14	5	14	20	6	4	9	6-3	0	0	0-0	0	0-0	5	10	.889
9	9	8	6.5	13-6	0-11	11-8	0-0	6	12	14	5	14	20	6	4	9	6-3	0	0	0-0	0	0-0	5	10	.889
10	9	8	6	13-6	0-11	11-8	0-0	6	12	14	5	14	20	6	4	9	6-3	0	0	0-0	0	0-0	5	10	.889
11	9.5	8	6	13-6	0-11	11-8	0-0	7	14	12	5	13	22	6	4	9	6-4	0	0	0-0	0	0-0	5	10	.926
12	9.5	8	6.5	13-6	0-11	11-8	0-0	7	14	12	5	13	22	6	4	9	6-4	0	0	0-0	0	0-0	5	10	.926
13	9.5	8	6	13-6	0-11	11-8	0-0	7	14	12	5	13	22	6	4	9	6-4	0	0	0-0	0	0-0	5	10	.926
14	10	8	6	13-6	0-11	11-8	0-0	7	13	13	5	12	24	6	4	9	6-5	0	0	0-0	0	0-0	6	10	.963
15	10.5	8	6	13-6	0-11	11-8	0-0	7	13	13	5	12	24	6	4	9	6-6	0	0	0-0	0	0-0	6	10	1
20	12	10	7	14-6	1-5	11-8	11-3	6	14	20	6	14	20	6	4	6.5	6-9	0	0	0-0	0	0-0	6	10	1.111
25	14	10	6	14-6	1-5	11-8	11-3	6	12	24	7	16	18	6	5	6	7-1	0	0	0-0	0	0-0	6	10	1.259
30	16	11	6.5	14-11	1-7	11-9	11-3	7	13	22	7	13	22	6.5	6	6	7-5	0	0	0-0	0	0-0	6	10	1.431
35	17.5	11	5.5	14-0	1-7	11-10	11-3	8	14	20	8	14	20	7	6	6	7-8	0	0	0-0	0	0-0	7	10	1.568
40	19	11	5	15-1	1-7	11-11	11-3	8	13	22	8	12	24	7.5	7	7	7-11	0	0	0-0	0	0-0	7	10	1.706
45	21	11	5	15-2	1-7	12-0	11-3	9	14	20	9	13	22	8	7	6.5	8-3	0	0	0-0	0	0-0	8	10	1.884
50	23	11	5	15-3	1-7	12-1	11-3	9	12	24	9	12	24	8.5	8	6.5	8-7	0	0	0-0	0	0-0	8	10	2.064

11' CLEAR SPAN BY 6' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9	8	7	13-6	0-11	11-8	11-3	8	13	11	5	14	20	6	4	9	7-3	0	0	0-0	0	0-0	5	12	.926
2	9.5	9	7.5	14-2	1-3	11-8	0-0	7	14	12	5	14	20	6	4	9	7-4	0	0	0-0	0	0-0	5	12	.963
3	8.5	8	6.5	13-6	0-11	11-8	0-0	6	12	14	5	16	18	6	4	9	7-2	0	0	0-0	0	0-0	5	12	.889
4	8.5	7	6	13-4	0-10	11-8	0-0	6	12	14	5	16	18	6	4	9	7-2	0	0	0-0	0	0-0	5	12	.889
5	8.5	8	7.5	13-6	0-11	11-8	0-0	6	12	14	5	16	18	6	4	9	7-2	0	0	0-0	0	0-0	5	12	.889
6	8.5	8	7	13-6	0-11	11-8	0-0	6	12	14	5	16	18	6	4	9	7-2	0	0	0-0	0	0-0	5	12	.889
7	8.5	8	6.5	13-6	0-11	11-8	0-0	6	12	14	5	16	18	6	4	8.5	7-2	0	0	0-0	0	0-0	5	12	.889
8	9	8	7	13-6	0-11	11-8	0-0	6	12	14	5	14	20	6	4	7	7-3	0	0	0-0	0	0-0	5	12	.926
9	9	8	6.5	13-6	0-11	11-8	0-0	6	12	14	5	14	20	6	4	7	7-3	0	0	0-0	0	0-0	5	12	.926
10	9	8	6	13-6	0-11	11-8	0-0	6	12	14	5	14	20	6	4	6	7-3	0	0	0-0	0	0-0	5	12	.926
11	9.5	8	6	13-6	0-11	11-8	0-0	7	14	12	5	13	22	6	5	8.5	7-4	0	0	0-0	0	0-0	5	12	.963
12	9.5	8	6.5	13-6	0-11	11-8	0-0	7	14	12	5	13	22	6	4	6	7-4	0	0	0-0	0	0-0	5	12	.963
13	9.5	8	6	13-6	0-11	11-8	0-0	7	14	12	5	13	22	6	5	8	7-4	0	0	0-0	0	0-0	5	12	.963
14	10	8	6	13-6	0-11	11-8	0-0	7	13	13	5	12	24	6	5	7	7-5	0	0	0-0	0	0-0	6	12	1
15	10.5	8	6	13-6	0-11	11-8	0-0	7	13	13	5	12	24	6	5	6.5	7-6	0	0	0-0	0	0-0	6	12	1.037
20	12	10	7	14-7	1-5	11-9	11-3	6	14	20	6	13	22	6.5	6	7	7-9	0	0	0-0	0	0-0	6	12	1.173
25	14	10	6	14-8	1-5	11-10	11-3	6	12	24	7	14	20	7	6	6	8-1	0	0	0-0	0	0-0	6	12	1.348
30	16	11	6.5	15-1	1-7	11-11	11-3	7	13	22	7	12	24	7.5	6	6.5	8-5	0	0	0-0	0	0-0	7	12	1.525
35	17.5	11	5.5	15-2	1-7	12-0	11-3	8	14	20	8	14	20	8	6	6	8-8	0	0	0-0	0	0-0	7	12	1.667
40	19	11	5	15-3	1-7	12-1	11-3	8	13	22	8	12	24	8.5	7	7	8-11	0	0	0-0	0	0-0	8	12	1.809
45	21	11	5	15-4	1-7	12-2	11-3	9	14	20	9	13	22	9	7	6	9-3	0	0	0-0	0	0-0	8	12	1.992
50	23	11	5	15-5	1-7	12-3	11-3	9	12	24	10	14	20	9.5	9	7.5	9-7	0	0	0-0	0	0-0	8	12	2.177

11' CLEAR SPAN BY 7' CLEAR HEIGHT

FILL	T	a_1 BAR			DIMENSION		a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	A	B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9	8	6.5	13-8	0-11	11-10	11-3	8	12	12	5	14	20	7	4	10	8-3	0	0	0-0	0	0-0	6	14	1.016
2	10	8	6	13-8	0-11	11-10	0-0	7	14	12	5	13	22	7	4	10	8-5	0	0	0-0	0	0-0	6	14	1.091
3	8.5	8	6.5	13-8	0-11	11-10	0-0	6	12	14	5	14	20	7	4	10	8-2	0	0	0-0	0	0-0	6	14	.978
4	8.5	8	7.5	13-8	0-11	11-10	0-0	6	12	14	5	14	20	7	4	9.5	8-2	0	0	0-0	0	0-0	6	14	.978
5	8.5	8	7.5	13-8	0-11	11-10	0-0	6	12	14	5	14	20	7	4	8.5	8-2	0	0	0-0	0	0-0	6	14	.978
6	8.5	8	7	13-8	0-11	11-10	0-0	6	12	14	5	14	20	7	4	7.5	8-2	0	0	0-0	0	0-0	6	14	.978
7	8.5	8	6.5	13-8	0-11	11-10	0-0	6	12	14	5	14	20	7	4	7	8-2	0	0	0-0	0	0-0	6	14	.978
8	9	8	7	13-8	0-11	11-10	0-0	6	12	14	5	14	20	7	4	6.5	8-3	0	0	0-0	0	0-0	6	14	1.016
9	9	8	6.5	13-8	0-11	11-10	0-0	6	12	14	5	14	20	7	4	6	8-3	0	0	0-0	0	0-0	6	14	1.016
10	9	8	6	13-8	0-11	11-10	0-0	6	12	14	5	14	20	7	5	8.5	8-3	0	0	0-0	0	0-0	6	14	1.016
11	9.5	8	6	13-8	0-11	11-10	0-0	7	14	12	5	13	22	7	5	7.5	8-4	0	0	0-0	0	0-0	6	14	1.053
12	9.5	8	6	13-8	0-11	11-10	0-0	7	14	12	5	13	22	7	5	8.5	8-4	0	0	0-0	0	0-0	6	14	1.053
13	10	8	6	13-8	0-11	11-10	0-0	7	13	13	5	12	24	7	5	7.5	8-5	0	0	0-0	0	0-0	6	14	1.091
14	10	9	7	14-4	1-3	11-10	0-0	7	13	13	5	12	24	7	5	7	8-5	0	0	0-0	0	0-0	6	14	1.091
15	10.5	8	6	13-8	0-11	11-10	0-0	7	13	13	5	12	24	7	5	6	8-6	0	0	0-0	0	0-0	6	14	1.129
20	12.5	9	6.5	14-5	1-3	11-11	11-3	6	14	20	6	13	22	7.5	6	6.5	8-10	0	0	0-0	0	0-0	6	14	1.307
25	14.5	10	6.5	14-10	1-5	12-0	11-3	7	16	18	7	14	20	8	7	7	9-2	0	0	0-0	0	0-0	7	14	1.488
30	16	11	6.5	15-3	1-7	12-1	11-3	7	13	22	7	12	24	8.5	7	7.5	9-5	0	0	0-0	0	0-0	7	14	1.632
35	17.5	11	5.5	15-4	1-7	12-2	11-3	8	14	20	8	13	22	9	7	7	9-8	0	0	0-0	0	0-0	8	14	1.778
40	19.5	11	5	15-5	1-7	12-3	11-3	8	12	24	8	12	24	9.5	7	6	10-0	0	0	0-0	0	0-0	8	14	1.964
45	21.5	11	5.5	15-6	1-7	12-4	11-3	9	13	22	9	13	22	10	8	6	10-4	0	0	0-0	0	0-0	8	14	2.152
50	23	11	5	15-7	1-7	12-5	11-3	9	12	24	10	14	20	10.5	9	6.5	10-7	0	0	0-0	0	0-0	9	14	2.303

11' CLEAR SPAN BY 8' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9	8	6.5	13-10	0-11	12-0	11-3	8	12	12	5	14	20	8	4	10	8-1	4	10	2-4	0	0-0	6	16	1.118
2	10	8	6	13-10	0-11	12-0	0-0	7	14	12	5	13	22	8	4	8.5	8-2	4	8.5	2-6	0	0-0	6	16	1.194
3	8.5	8	6.5	13-10	0-11	12-0	0-0	6	12	14	5	14	20	8	4	8.5	8-0	4	8.5	2-3	0	0-0	6	16	1.08
4	8.5	8	7.5	13-10	0-11	12-0	0-0	6	12	14	5	14	20	8	4	8	8-0	4	8	2-3	0	0-0	6	16	1.08
5	8.5	8	7	13-10	0-11	12-0	0-0	6	12	14	5	14	20	8	4	7.5	8-0	4	7.5	2-3	0	0-0	6	16	1.08
6	8.5	8	7	13-10	0-11	12-0	0-0	6	12	14	5	14	20	8	4	6.5	8-0	4	6.5	2-3	0	0-0	6	16	1.08
7	8.5	8	6.5	13-10	0-11	12-0	0-0	6	12	14	5	14	20	8	4	6	8-0	4	6	2-3	0	0-0	6	16	1.08
8	9	8	6.5	13-10	0-11	12-0	0-0	7	16	11	5	14	20	8	5	9	8-1	5	9	2-4	0	0-0	6	16	1.118
9	9	8	6	13-10	0-11	12-0	0-0	7	16	11	5	14	20	8	5	8	8-1	5	8	2-4	0	0-0	6	16	1.118
10	9.5	8	6.5	13-10	0-11	12-0	0-0	7	14	12	5	13	22	8	5	7.5	8-2	5	7.5	2-5	0	0-0	6	16	1.156
11	9.5	8	6	13-10	0-11	12-0	0-0	7	14	12	5	13	22	8	5	7	8-2	5	7	2-5	0	0-0	6	16	1.156
12	9.5	8	6	13-10	0-11	12-0	0-0	7	14	12	5	13	22	8	5	7.5	8-2	5	7.5	2-5	0	0-0	6	16	1.156
13	10	8	6	13-10	0-11	12-0	0-0	7	13	13	5	12	24	8	5	7	8-2	5	7	2-6	0	0-0	6	16	1.194
14	10	9	7	14-6	1-3	12-0	0-0	7	13	13	5	12	24	8	5	6	8-2	5	6	2-6	0	0-0	6	16	1.194
15	10.5	9	7	14-6	1-3	12-0	0-0	7	12	14	5	12	24	8	6	8	8-3	6	8	2-7	0	0-0	6	16	1.233
20	12.5	9	6	14-6	1-3	12-0	11-3	6	14	20	6	13	22	8	7	6.5	8-4	6	6.5	2-11	0	0-0	7	16	1.385
25	14.5	10	6	15-0	1-5	12-2	11-3	7	14	20	7	14	20	9	7	6.5	8-6	6	6.5	3-3	0	0-0	7	16	1.602
30	16.5	11	7	15-5	1-7	12-3	11-3	7	13	22	7	12	24	9.5	7	6.5	8-9	6	6.5	3-7	0	0-0	8	16	1.79
35	18	11	6	15-6	1-7	12-4	11-3	8	14	20	8	13	22	10	7	6	8-10	6	6	3-10	0	0-0	8	16	1.94
40	19.5	11	5	15-7	1-7	12-5	11-3	8	12	24	8	12	24	10.5	8	6.5	8-0	7	6.5	4-1	0	0-0	8	16	2.093
45	21.5	11	5	15-9	1-7	12-7	11-3	9	13	22	9	13	22	11.5	8	7	9-2	7	7	4-5	0	0-0	9	16	2.322
50	23.5	11	5.5	15-10	1-7	12-8	11-3	10	14	20	10	13	22	12	8	6.5	9-3	7	6.5	4-9	5	7-4	9	32	2.519

11' CLEAR SPAN BY 9' CLEAR HEIGHT

FILL	T	a_1 BAR			DIMENSION		a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	A	B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9	8	6.5	14-0	0-11	12-2	11-3	8	12	12	5	14	20	9	4	9	9-1	4	9	2-4	0	0-0	6	18	1.233
2	10	8	6	14-0	0-11	12-2	0-0	7	14	12	5	13	22	9	4	8	9-2	4	8	2-6	0	0-0	6	18	1.31
3	8.5	8	6.5	14-0	0-11	12-2	0-0	6	12	14	5	14	20	9	4	7.5	9-0	4	7.5	2-3	0	0-0	6	18	1.194
4	8.5	8	7	14-0	0-11	12-2	0-0	6	12	14	5	14	20	9	4	7	9-0	4	7	2-3	0	0-0	6	18	1.194
5	8.5	8	7	14-0	0-11	12-2	0-0	6	12	14	5	14	20	9	4	6.5	9-0	4	6.5	2-3	0	0-0	6	18	1.194
6	8.5	8	7	14-0	0-11	12-2	0-0	6	12	14	5	14	20	9	4	6	9-0	4	6	2-3	0	0-0	6	18	1.194
7	8.5	8	6.5	14-0	0-11	12-2	0-0	6	12	14	5	14	20	9	5	8.5	9-0	5	8.5	2-3	0	0-0	6	18	1.194
8	9	8	6.5	14-0	0-11	12-2	0-0	7	16	11	5	14	20	9	5	8	9-1	5	8	2-4	0	0-0	6	18	1.233
9	9	8	6	14-0	0-11	12-2	0-0	7	16	11	5	14	20	9	5	7.5	9-1	5	7.5	2-4	0	0-0	6	18	1.233
10	9.5	8	6	14-0	0-11	12-2	0-0	7	14	12	5	13	22	9	5	6.5	9-2	5	6.5	2-5	0	0-0	6	18	1.272
11	9.5	8	6	14-0	0-11	12-2	0-0	7	14	12	5	13	22	9	5	6.5	9-2	5	6.5	2-5	0	0-0	7	18	1.272
12	9.5	8	6	14-0	0-11	12-2	0-0	7	14	12	5	13	22	9	5	7	9-2	5	7	2-5	0	0-0	7	18	1.272
13	10	8	6	14-0	0-11	12-2	0-0	7	13	13	5	12	24	9	5	6.5	9-2	5	6.5	2-6	0	0-0	7	18	1.31
14	10	9	7	14-8	1-3	12-2	0-0	7	13	13	5	12	24	9	6	8	9-2	6	8	2-6	0	0-0	7	18	1.31
15	10.5	9	7	14-8	1-3	12-2	0-0	7	12	14	6	16	18	9	6	7.5	9-3	6	7.5	2-7	0	0-0	7	18	1.349
20	12.5	9	6	14-8	1-3	12-2	11-3	6	14	20	6	13	22	9	7	6.5	9-4	6	6.5	2-11	0	0-0	7	18	1.503
25	14.5	10	6	15-1	1-5	12-3	11-3	7	14	20	7	14	20	9.5	8	6.5	9-6	7	6.5	3-3	0	0-0	7	18	1.693
30	16.5	11	6.5	15-7	1-7	12-5	11-3	7	12	24	7	12	24	10.5	8	6.5	9-9	7	6.5	3-7	0	0-0	8	18	1.921
35	18	11	5.5	15-8	1-7	12-6	11-3	8	13	22	8	13	22	11	8	6.5	9-10	7	6.5	3-10	0	0-0	8	18	2.077
40	19.5	11	5	15-10	1-7	12-8	11-3	8	12	24	9	14	20	12	8	6.5	9-0	7	6.5	4-1	5	8-4	9	36	2.272
45	21.5	11	5	15-0	1-7	12-10	11-3	9	13	22	9	12	24	13	8	7	10-2	7	7	4-5	5	8-4	9	36	2.51
50	23.5	11	5	16-1	1-7	12-11	11-3	10	14	20	10	13	22	13.5	8	6	10-3	7	6	4-9	5	8-4	10	36	2.713

11' CLEAR SPAN BY 10' CLEAR HEIGHT

FILL	T	a_1 BAR			DIMENSION		a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	A	B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9	8	6.5	14-2	0-11	12-4	11-3	8	12	12	5	14	20	10	4	7.5	10-1	4	7.5	2-4	0	0-0	7	20	1.36
2	10	8	6	14-2	0-11	12-4	0-0	7	13	13	5	13	22	10	4	7	10-2	4	7	2-6	0	0-0	7	20	1.438
3	8.5	8	6.5	14-2	0-11	12-4	0-0	6	12	14	5	14	20	10	4	6.5	10-0	4	6.5	2-3	0	0-0	7	20	1.321
4	8.5	8	7	14-2	0-11	12-4	0-0	6	12	14	5	14	20	10	4	6	10-0	4	6	2-3	0	0-0	7	20	1.321
5	8.5	8	7	14-2	0-11	12-4	0-0	6	12	14	5	14	20	10	5	9	10-0	5	9	2-3	0	0-0	7	20	1.321
6	8.5	8	7	14-2	0-11	12-4	0-0	6	12	14	5	14	20	10	5	8	10-0	5	8	2-3	0	0-0	7	20	1.321
7	8.5	8	6.5	14-2	0-11	12-4	0-0	6	12	14	5	14	20	10	5	7.5	10-0	5	7.5	2-3	0	0-0	7	20	1.321
8	9	8	6.5	14-2	0-11	12-4	0-0	7	14	12	5	14	20	10	5	7	10-1	5	7	2-4	0	0-0	7	20	1.36
9	9	8	6	14-2	0-11	12-4	0-0	7	14	12	5	14	20	10	5	6.5	10-1	5	6.5	2-4	0	0-0	7	20	1.36
10	9.5	8	6	14-2	0-11	12-4	0-0	7	14	12	5	13	22	10	5	6	10-2	5	6	2-5	0	0-0	7	20	1.399
11	10	8	6	14-2	0-11	12-4	0-0	7	13	13	5	12	24	10	6	8	10-2	6	8	2-6	0	0-0	7	20	1.438
12	9.5	8	6	14-2	0-11	12-4	0-0	7	14	12	5	13	22	10	5	6	10-2	5	6	2-5	0	0-0	7	20	1.399
13	10	8	6	14-2	0-11	12-4	0-0	7	13	13	5	12	24	10	6	8	10-2	6	8	2-6	0	0-0	7	20	1.438
14	10.5	8	6	14-2	0-11	12-4	0-0	7	12	14	6	16	18	10	6	7.5	10-3	6	7.5	2-7	0	0-0	7	20	1.477
15	10.5	9	6.5	14-10	1-3	12-4	0-0	7	12	14	6	16	18	10	6	7	10-3	6	7	2-7	0	0-0	7	20	1.477
20	12.5	9	6	14-10	1-3	12-4	11-3	6	13	22	6	13	22	10	7	6	10-4	6	6	2-11	0	0-0	7	20	1.634
25	14.5	10	6	15-3	1-5	12-5	11-3	7	14	20	7	14	20	10.5	8	6	10-6	7	6	3-3	0	0-0	8	20	1.829
30	16.5	11	6.5	15-9	1-7	12-7	11-3	7	12	24	7	12	24	11.5	8	6	10-9	7	6	3-7	0	0-0	8	20	2.065
35	18	11	5.5	15-11	1-7	12-9	11-3	8	13	22	8	13	22	12.5	8	6.5	10-10	7	6.5	3-10	5	9-4	9	40	2.266
40	20	11	5.5	16-1	1-7	12-11	11-3	9	14	20	9	13	22	13.5	8	6.5	11-0	7	6.5	4-2	5	9-4	9	40	2.51
45	22	11	5.5	16-3	1-7	13-1	11-3	9	12	24	9	12	24	14.5	8	6.5	11-2	7	6.5	4-6	5	9-4	10	40	2.758
50	23.5	11	5	16-4	1-7	13-2	11-3	10	13	22	10	13	22	15	8	6	11-3	7	6	4-9	5	9-4	10	40	2.926

11' CLEAR SPAN BY 11' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9	8	6.5	14-4	0-11	12-6	11-3	8	12	12	5	13	22	11	4	6.5	11-1	4	6.5	2-4	0	0-0	7	22	1.499
2	10	8	6	14-4	0-11	12-6	0-0	7	13	13	5	12	24	11	4	6	11-2	4	6	2-6	0	0-0	7	22	1.579
3	8.5	8	6.5	14-4	0-11	12-6	0-0	6	12	14	5	14	20	11	4	6	11-0	4	6	2-3	0	0-0	7	22	1.46
4	8.5	8	7	14-4	0-11	12-6	0-0	6	12	14	5	14	20	11	5	8	11-0	5	8	2-3	0	0-0	7	22	1.46
5	8.5	8	7	14-4	0-11	12-6	0-0	6	12	14	5	14	20	11	5	8	11-0	5	8	2-3	0	0-0	7	22	1.46
6	8.5	8	7	14-4	0-11	12-6	0-0	6	12	14	5	14	20	11	5	7	11-0	5	7	2-3	0	0-0	7	22	1.46
7	8.5	8	6.5	14-4	0-11	12-6	0-0	6	12	14	5	14	20	11	5	7	11-0	5	7	2-3	0	0-0	7	22	1.46
8	9	8	6.5	14-4	0-11	12-6	0-0	7	14	12	5	13	22	11	5	6	11-1	5	6	2-4	0	0-0	7	22	1.499
9	9	8	6	14-4	0-11	12-6	0-0	7	14	12	5	13	22	11	5	6	11-1	5	6	2-4	0	0-0	7	22	1.499
10	9.5	8	6	14-4	0-11	12-6	0-0	7	14	12	5	13	22	11	6	7.5	11-2	6	7.5	2-5	0	0-0	7	22	1.539
11	10	8	6	14-4	0-11	12-6	0-0	7	13	13	5	12	24	11	6	7	11-2	6	7	2-6	0	0-0	7	22	1.579
12	9.5	8	6	14-4	0-11	12-6	0-0	7	14	12	5	13	22	11	6	8	11-2	6	8	2-5	0	0-0	7	22	1.539
13	10	8	6	14-4	0-11	12-6	0-0	7	13	13	5	12	24	11	6	7	11-2	6	7	2-6	0	0-0	7	22	1.579
14	10.5	8	6	14-4	0-11	12-6	0-0	7	12	14	6	16	18	11	6	6.5	11-3	6	6.5	2-7	0	0-0	7	22	1.618
15	10.5	9	6.5	15-0	1-3	12-6	0-0	7	12	14	6	16	18	11	6	6.5	11-3	6	6.5	2-7	0	0-0	7	22	1.618
20	13	9	6.5	15-0	1-3	12-6	11-3	6	13	22	6	12	24	11	7	6	11-5	6	6	3-0	0	0-0	8	22	1.816
25	14.5	11	7	15-9	1-7	12-7	11-3	7	14	20	7	14	20	11.5	8	6	11-6	7	6	3-3	0	0-0	8	22	1.977
30	16.5	11	6.5	15-11	1-7	12-9	11-3	7	12	24	8	14	20	12.5	9	7	11-9	8	7	3-7	5	10-4	9	44	2.222
35	18.5	11	6	16-2	1-7	13-0	11-3	8	13	22	8	12	24	14	8	6.5	11-10	7	6.5	3-11	5	10-4	9	44	2.514
40	20	11	5	16-4	1-7	13-2	11-3	9	14	20	9	13	22	15	8	6	12-0	7	6	4-2	5	10-4	10	44	2.727
45	22	11	5.5	16-5	1-7	13-3	11-3	9	12	24	9	12	24	15.5	9	7	12-2	8	7	4-6	5	10-4	10	44	2.939
50	23.5	11	5	16-7	1-7	13-5	11-3	10	13	22	10	13	22	16.5	9	7	12-3	8	7	4-9	5	10-4	11	44	3.157

12' CLEAR SPAN BY 6' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9	8	6	14-6	0-11	12-8	12-3	8	12	13	5	14	22	6	4	9	7-3	0	0	0-0	0	0-0	5	12	.985
2	10.5	9	7.5	15-2	1-3	12-8	0-0	7	14	13	5	13	24	6	4	9	7-6	0	0	0-0	0	0-0	5	12	1.105
3	9	8	6	14-6	0-11	12-8	0-0	6	12	15	5	14	22	6	4	9	7-3	0	0	0-0	0	0-0	5	12	.985
4	9	8	7	14-6	0-11	12-8	0-0	6	12	15	5	14	22	6	4	9	7-3	0	0	0-0	0	0-0	5	12	.985
5	9	8	6.5	14-6	0-11	12-8	0-0	6	12	15	5	14	22	6	4	9	7-3	0	0	0-0	0	0-0	5	12	.985
6	9	8	6.5	14-6	0-11	12-8	0-0	6	12	15	5	14	22	6	4	9	7-3	0	0	0-0	0	0-0	5	12	.985
7	9	8	6	14-6	0-11	12-8	0-0	6	12	15	5	14	22	6	4	8	7-3	0	0	0-0	0	0-0	5	12	.985
8	9.5	8	6	14-6	0-11	12-8	0-0	7	16	12	5	14	22	6	4	7	7-4	0	0	0-0	0	0-0	5	12	1.025
9	9.5	9	7.5	15-2	1-3	12-8	0-0	7	16	12	5	14	22	6	4	6.5	7-4	0	0	0-0	0	0-0	5	12	1.025
10	10	8	6	14-6	0-11	12-8	0-0	7	14	13	5	13	24	6	5	9	7-5	0	0	0-0	0	0-0	5	12	1.065
11	10	9	7	15-2	1-3	12-8	0-0	7	14	13	5	13	24	6	5	8	7-5	0	0	0-0	0	0-0	5	12	1.065
12	10.5	9	7	15-2	1-3	12-8	0-0	7	13	14	5	13	24	6	5	7	7-6	0	0	0-0	0	0-0	5	12	1.105
13	10.5	9	7	15-2	1-3	12-8	0-0	7	13	14	5	12	26	6	5	7.5	7-6	0	0	0-0	0	0-0	5	12	1.105
14	10.5	9	6.5	15-2	1-3	12-8	0-0	7	13	14	5	12	26	6	5	6.5	7-6	0	0	0-0	0	0-0	6	12	1.105
15	11	9	6.5	15-2	1-3	12-8	0-0	7	12	15	6	16	20	6	5	6	7-7	0	0	0-0	0	0-0	6	12	1.145
20	13	10	6.5	15-7	1-5	12-9	12-3	6	14	22	6	13	24	6.5	6	6.5	7-11	0	0	0-0	0	0-0	6	12	1.331
25	15	11	6.5	16-1	1-7	12-11	12-3	7	16	20	7	14	22	7.5	5	6.5	8-3	0	0	0-0	0	0-0	7	12	1.546
30	17.5	11	6.5	16-1	1-7	12-11	12-3	7	12	26	7	12	26	7.5	7	7.5	8-8	0	0	0-0	0	0-0	7	12	1.75
35	19	11	5	16-2	1-7	13-0	12-3	8	13	24	8	13	24	8	7	6.5	8-11	0	0	0-0	0	0-0	7	12	1.901
40	21	11	5	16-4	1-7	13-2	12-3	8	12	26	9	14	22	9	6	6.5	9-3	0	0	0-0	0	0-0	8	12	2.125
45	23.5	11	5	16-5	1-7	13-3	12-3	9	12	26	9	12	26	9.5	7	7.5	9-8	0	0	0-0	0	0-0	8	12	2.364
50	25.5	11	5	16-6	1-7	13-4	12-3	10	13	24	10	13	24	10	7	6.5	10-0	0	0	0-0	0	0-0	9	12	2.564

12' CLEAR SPAN BY 7' CLEAR HEIGHT

FILL	T	a_1 BAR			DIMENSION		a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	A	B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9	8	6	14-8	0-11	12-10	12-3	9	14	11	5	14	22	7	4	10	8-3	0	0	0-0	0	0-0	6	14	1.075
2	10.5	9	7	15-4	1-3	12-10	0-0	7	13	14	5	13	24	7	4	10	8-6	0	0	0-0	0	0-0	6	14	1.197
3	9	8	6	14-8	0-11	12-10	0-0	6	12	15	5	14	22	7	4	10	8-3	0	0	0-0	0	0-0	6	14	1.075
4	9	8	6.5	14-8	0-11	12-10	0-0	6	12	15	5	14	22	7	4	9.5	8-3	0	0	0-0	0	0-0	6	14	1.075
5	9	8	6.5	14-8	0-11	12-10	0-0	6	12	15	5	14	22	7	4	8.5	8-3	0	0	0-0	0	0-0	6	14	1.075
6	9	8	6	14-8	0-11	12-10	0-0	6	12	15	5	14	22	7	4	7.5	8-3	0	0	0-0	0	0-0	6	14	1.075
7	9	8	6	14-8	0-11	12-10	0-0	6	12	15	5	14	22	7	4	7	8-3	0	0	0-0	0	0-0	6	14	1.075
8	9.5	8	6	14-8	0-11	12-10	0-0	7	16	12	5	14	22	7	4	6.5	8-4	0	0	0-0	0	0-0	6	14	1.115
9	10	8	6	14-8	0-11	12-10	0-0	7	14	13	5	13	24	7	5	9	8-5	0	0	0-0	0	0-0	6	14	1.156
10	10	9	7	15-4	1-3	12-10	0-0	7	14	13	5	13	24	7	5	8	8-5	0	0	0-0	0	0-0	6	14	1.156
11	10	9	7	15-4	1-3	12-10	0-0	7	14	13	5	13	24	7	5	7.5	8-5	0	0	0-0	0	0-0	6	14	1.156
12	10.5	9	7	15-4	1-3	12-10	0-0	7	13	14	5	12	26	7	5	6.5	8-6	0	0	0-0	0	0-0	6	14	1.197
13	10.5	9	6.5	15-4	1-3	12-10	0-0	7	13	14	5	12	26	7	5	7.5	8-6	0	0	0-0	0	0-0	6	14	1.197
14	10.5	9	6.5	15-4	1-3	12-10	0-0	7	13	14	5	12	26	7	5	6.5	8-6	0	0	0-0	0	0-0	6	14	1.197
15	11	9	6.5	15-4	1-3	12-10	0-0	7	12	15	6	16	20	7	6	8	8-7	0	0	0-0	0	0-0	6	14	1.237
20	13.5	9	6	15-5	1-3	12-11	12-3	6	13	24	6	12	26	7.5	6	6	9-0	0	0	0-0	0	0-0	6	14	1.469
25	15	11	6.5	16-2	1-7	13-0	12-3	7	16	20	7	14	22	8	7	7	9-3	0	0	0-0	0	0-0	7	14	1.621
30	17.5	11	6	16-3	1-7	13-1	12-3	7	12	26	8	14	22	8.5	7	7.5	9-8	0	0	0-0	0	0-0	7	14	1.858
35	19	11	5	16-4	1-7	13-2	12-3	8	13	24	8	13	24	9	7	6.5	9-11	0	0	0-0	0	0-0	8	14	2.014
40	21.5	11	5	16-6	1-7	13-4	12-3	9	14	22	9	13	24	10	7	7	10-4	0	0	0-0	0	0-0	8	14	2.288
45	23.5	11	5	16-7	1-7	13-5	12-3	9	12	26	9	12	26	10.5	7	6	10-8	0	0	0-0	0	0-0	9	14	2.491
50	25.5	11	5	16-8	1-7	13-6	12-3	10	13	24	10	13	24	11	8	6.5	11-0	0	0	0-0	0	0-0	9	14	2.695

12' CLEAR SPAN BY 8' CLEAR HEIGHT

FILL	T	a_1 BAR			DIMENSION		a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	A	B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9.5	8	6.5	14-10	0-11	13-0	12-3	8	12	13	5	14	22	8	4	10	8-2	4	10	2-5	0	0-0	6	16	1.218
2	10.5	9	7	15-6	1-3	13-0	0-0	7	13	14	5	13	24	8	4	9	8-3	4	9	2-7	0	0-0	6	16	1.3
3	9	8	6	14-10	0-11	13-0	0-0	7	16	12	5	14	22	8	4	8.5	8-1	4	8.5	2-4	0	0-0	6	16	1.177
4	9	8	6.5	14-10	0-11	13-0	0-0	7	16	12	5	14	22	8	4	8	8-1	4	8	2-4	0	0-0	6	16	1.177
5	9	8	6.5	14-10	0-11	13-0	0-0	7	16	12	5	14	22	8	4	7	8-1	4	7	2-4	0	0-0	6	16	1.177
6	9	8	6	14-10	0-11	13-0	0-0	7	16	12	5	14	22	8	4	6.5	8-1	4	6.5	2-4	0	0-0	6	16	1.177
7	9	8	6	14-10	0-11	13-0	0-0	7	16	12	5	14	22	8	4	6.5	8-1	4	6.5	2-4	0	0-0	6	16	1.177
8	9.5	8	6	14-10	0-11	13-0	0-0	7	14	13	5	14	22	8	5	9	8-2	5	9	2-5	0	0-0	6	16	1.218
9	10	8	6	14-10	0-11	13-0	0-0	7	14	13	5	13	24	8	5	8	8-2	5	8	2-6	0	0-0	6	16	1.259
10	10	9	7	15-6	1-3	13-0	0-0	7	14	13	5	13	24	8	5	7.5	8-2	5	7.5	2-6	0	0-0	6	16	1.259
11	10.5	9	7	15-6	1-3	13-0	0-0	7	13	14	5	12	26	8	5	6.5	8-3	5	6.5	2-7	0	0-0	6	16	1.3
12	10.5	9	6.5	15-6	1-3	13-0	0-0	7	13	14	5	12	26	8	5	6	8-3	5	6	2-7	0	0-0	6	16	1.3
13	10.5	9	6.5	15-6	1-3	13-0	0-0	7	13	14	5	12	26	8	5	6.5	8-3	5	6.5	2-7	0	0-0	6	16	1.3
14	10.5	9	6.5	15-6	1-3	13-0	0-0	7	12	15	5	12	26	8	5	6	8-3	5	6	2-7	0	0-0	6	16	1.3
15	11	9	6.5	15-6	1-3	13-0	0-0	7	12	15	6	16	20	8	6	8	8-3	6	8	2-8	0	0-0	6	16	1.342
20	13.5	10	7	15-10	1-5	13-0	12-3	6	13	24	6	12	26	8	7	6	8-6	6	6	3-1	0	0-0	7	16	1.547
25	15.5	11	7	16-4	1-7	13-2	12-3	7	14	22	7	13	24	9	7	6.5	8-8	6	6.5	3-5	0	0-0	7	16	1.778
30	17.5	11	6	16-5	1-7	13-3	12-3	7	12	26	8	14	22	9.5	7	6.5	8-9	6	6.5	3-9	0	0-0	8	16	1.978
35	19	11	5	16-6	1-7	13-4	12-3	8	13	24	8	13	24	10	8	7.5	8-11	7	7.5	4-0	0	0-0	8	16	2.139
40	21.5	11	5	16-7	1-7	13-5	12-3	9	14	22	9	13	24	10.5	8	6	9-2	7	6	4-5	0	0-0	8	16	2.386
45	23.5	11	5	16-9	1-7	13-7	12-3	9	12	26	9	12	26	11.5	8	6.5	9-3	7	6.5	4-9	0	0-0	9	16	2.63
50	25.5	11	5	16-10	1-7	13-8	12-3	10	13	24	10	13	24	12	8	6	9-6	7	6	5-1	5	7-4	9	32	2.84

12' CLEAR SPAN BY 9' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9.5	8	6.5	15-0	0-11	13-2	12-3	8	12	13	5	13	24	9	4	8.5	9-2	4	8.5	2-5	0	0-0	6	18	1.333
2	10.5	9	7	15-8	1-3	13-2	0-0	7	13	14	5	12	26	9	4	7.5	9-3	4	7.5	2-7	0	0-0	6	18	1.417
3	9	8	6	15-0	0-11	13-2	0-0	7	16	12	5	14	22	9	4	7.5	9-1	4	7.5	2-4	0	0-0	6	18	1.292
4	9	8	6.5	15-0	0-11	13-2	0-0	7	16	12	5	14	22	9	4	7	9-1	4	7	2-4	0	0-0	6	18	1.292
5	9	8	6.5	15-0	0-11	13-2	0-0	7	16	12	5	14	22	9	4	6.5	9-1	4	6.5	2-4	0	0-0	6	18	1.292
6	9	8	6	15-0	0-11	13-2	0-0	7	16	12	5	14	22	9	4	6	9-1	4	6	2-4	0	0-0	6	18	1.292
7	9.5	8	6.5	15-0	0-11	13-2	0-0	7	14	13	5	13	24	9	5	8.5	9-2	5	8.5	2-5	0	0-0	6	18	1.333
8	9.5	8	6	15-0	0-11	13-2	0-0	7	14	13	5	13	24	9	5	8	9-2	5	8	2-5	0	0-0	6	18	1.333
9	10	8	6	15-0	0-11	13-2	0-0	7	14	13	5	13	24	9	5	7	9-2	5	7	2-6	0	0-0	6	18	1.375
10	10	9	7	15-8	1-3	13-2	0-0	7	14	13	5	13	24	9	5	6.5	9-2	5	6.5	2-6	0	0-0	6	18	1.375
11	10.5	9	7	15-8	1-3	13-2	0-0	7	13	14	5	12	26	9	5	6	9-3	5	6	2-7	0	0-0	7	18	1.417
12	10.5	9	6.5	15-8	1-3	13-2	0-0	7	13	14	5	12	26	9	6	8	9-3	6	8	2-7	0	0-0	7	18	1.417
13	10.5	9	6.5	15-8	1-3	13-2	0-0	7	13	14	5	12	26	9	5	6	9-3	5	6	2-7	0	0-0	7	18	1.417
14	11	9	6.5	15-8	1-3	13-2	0-0	7	12	15	6	16	20	9	6	8	9-3	6	8	2-8	0	0-0	7	18	1.458
15	11	9	6	15-8	1-3	13-2	0-0	7	12	15	6	16	20	9	6	7.5	9-3	6	7.5	2-8	0	0-0	7	18	1.458
20	13.5	10	7	16-0	1-5	13-2	12-3	6	13	24	6	12	26	9	7	6	9-6	6	6	3-1	0	0-0	7	18	1.667
25	15.5	11	7	16-5	1-7	13-3	12-3	7	14	22	7	13	24	9.5	8	6	9-8	7	6	3-5	0	0-0	7	18	1.869
30	17.5	11	6	16-7	1-7	13-5	12-3	7	12	26	8	14	22	10.5	8	6	9-9	7	6	3-9	0	0-0	8	18	2.111
35	19.5	11	5.5	16-8	1-7	13-6	12-3	8	13	24	8	12	26	11	8	6.5	9-0	7	6.5	4-1	0	0-0	8	18	2.319
40	21.5	11	5	16-10	1-7	13-8	12-3	9	14	22	9	13	24	12	8	6.5	10-2	7	6.5	4-5	5	8-4	9	36	2.568
45	23.5	11	5	16-11	1-7	13-9	12-3	9	12	26	10	14	22	12.5	9	7.5	10-3	8	7.5	4-9	5	8-4	9	36	2.781
50	25.5	11	5	17-1	1-7	13-11	12-3	10	13	24	10	13	24	13.5	8	6	10-6	7	6	5-1	5	8-4	10	36	3.037

12' CLEAR SPAN BY 10' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9.5	8	6.5	15-2	0-11	13-4	12-3	8	12	13	5	13	24	10	4	7.5	10-2	4	7.5	2-5	0	0-0	7	20	1.461
2	10.5	9	7	15-10	1-3	13-4	0-0	7	13	14	5	12	26	10	4	6.5	10-3	4	6.5	2-7	0	0-0	7	20	1.545
3	9	8	6	15-2	0-11	13-4	0-0	7	16	12	5	14	22	10	4	6.5	10-1	4	6.5	2-4	0	0-0	7	20	1.419
4	9	8	6.5	15-2	0-11	13-4	0-0	7	16	12	5	14	22	10	4	6	10-1	4	6	2-4	0	0-0	7	20	1.419
5	9	8	6.5	15-2	0-11	13-4	0-0	7	16	12	5	14	22	10	5	9	10-1	5	9	2-4	0	0-0	7	20	1.419
6	9	8	6	15-2	0-11	13-4	0-0	7	16	12	5	14	22	10	5	8	10-1	5	8	2-4	0	0-0	7	20	1.419
7	9.5	8	6	15-2	0-11	13-4	0-0	7	14	13	5	13	24	10	5	7.5	10-2	5	7.5	2-5	0	0-0	7	20	1.461
8	9.5	8	6	15-2	0-11	13-4	0-0	7	14	13	5	13	24	10	5	7	10-2	5	7	2-5	0	0-0	7	20	1.461
9	10	8	6	15-2	0-11	13-4	0-0	7	14	13	5	13	24	10	5	6.5	10-2	5	6.5	2-6	0	0-0	7	20	1.503
10	10	9	7	15-10	1-3	13-4	0-0	7	14	13	5	13	24	10	5	6	10-2	5	6	2-6	0	0-0	7	20	1.503
11	10.5	9	7	15-10	1-3	13-4	0-0	7	13	14	5	12	26	10	6	8	10-3	6	8	2-7	0	0-0	7	20	1.545
12	10.5	9	6.5	15-10	1-3	13-4	0-0	7	13	14	5	12	26	10	6	7.5	10-3	6	7.5	2-7	0	0-0	7	20	1.545
13	10.5	9	6.5	15-10	1-3	13-4	0-0	7	12	15	5	12	26	10	6	8	10-3	6	8	2-7	0	0-0	7	20	1.545
14	11	9	6.5	15-10	1-3	13-4	0-0	7	12	15	6	16	20	10	6	7	10-3	6	7	2-8	0	0-0	7	20	1.587
15	11	9	6	15-10	1-3	13-4	0-0	7	12	15	6	16	20	10	6	6.5	10-3	6	6.5	2-8	0	0-0	7	20	1.587
20	13.5	10	6.5	16-2	1-5	13-4	12-3	6	13	24	6	12	26	10	8	7.5	10-6	7	7.5	3-1	0	0-0	7	20	1.798
25	15.5	11	6.5	16-7	1-7	13-5	12-3	7	14	22	7	13	24	10.5	8	6	10-8	7	6	3-5	0	0-0	8	20	2.006
30	17.5	11	5.5	16-9	1-7	13-7	12-3	7	12	26	8	14	22	11.5	9	7.5	10-9	8	7.5	3-9	0	0-0	8	20	2.256
35	19.5	11	5	16-11	1-7	13-9	12-3	8	13	24	8	12	26	12.5	8	6.5	10-0	7	6.5	4-1	5	9-4	9	40	2.51
40	22	11	5.5	17-1	1-7	13-11	12-3	9	13	24	9	13	24	13.5	8	6	11-2	7	6	4-6	5	9-4	9	40	2.813
45	24	11	5.5	17-2	1-7	14-0	12-3	10	14	22	10	14	22	14	9	7	11-4	8	7	4-10	5	9-4	10	40	3.032
50	26	11	5.5	17-4	1-7	14-2	12-3	10	13	24	10	12	26	15	9	7	11-6	8	7	5-2	5	9-4	10	40	3.298

12' CLEAR SPAN BY 11' CLEAR HEIGHT

FILL	T	a_1 BAR			DIMENSION		a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	A	B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9.5	8	6.5	15-4	0-11	13-6	12-3	8	12	13	5	13	24	11	4	7	11-2	4	7	2-5	0	0-0	7	22	1.601
2	10.5	9	7	16-0	1-3	13-6	0-0	7	13	14	5	12	26	11	4	6	11-3	4	6	2-7	0	0-0	7	22	1.686
3	9	8	6	15-4	0-11	13-6	0-0	7	16	12	5	14	22	11	5	9	11-1	5	9	2-4	0	0-0	7	22	1.558
4	9	8	6.5	15-4	0-11	13-6	0-0	7	16	12	5	14	22	11	5	8.5	11-1	5	8.5	2-4	0	0-0	7	22	1.558
5	9	8	6.5	15-4	0-11	13-6	0-0	7	16	12	5	14	22	11	5	8	11-1	5	8	2-4	0	0-0	7	22	1.558
6	9	8	6	15-4	0-11	13-6	0-0	7	16	12	5	14	22	11	5	7	11-1	5	7	2-4	0	0-0	7	22	1.558
7	9.5	8	6	15-4	0-11	13-6	0-0	7	14	13	5	13	24	11	5	6.5	11-2	5	6.5	2-5	0	0-0	7	22	1.601
8	9.5	8	6	15-4	0-11	13-6	0-0	7	14	13	5	13	24	11	5	6	11-2	5	6	2-5	0	0-0	7	22	1.601
9	10	8	6	15-4	0-11	13-6	0-0	7	13	14	5	13	24	11	6	8	11-2	6	8	2-6	0	0-0	7	22	1.644
10	10	9	7	16-0	1-3	13-6	0-0	7	13	14	5	13	24	11	6	7.5	11-2	6	7.5	2-6	0	0-0	7	22	1.644
11	10.5	9	7	16-0	1-3	13-6	0-0	7	13	14	5	12	26	11	6	7	11-3	6	7	2-7	0	0-0	7	22	1.686
12	10.5	9	6.5	16-0	1-3	13-6	0-0	7	13	14	5	12	26	11	6	6.5	11-3	6	6.5	2-7	0	0-0	7	22	1.686
13	10.5	9	6.5	16-0	1-3	13-6	0-0	7	12	15	6	16	20	11	6	7	11-3	6	7	2-7	0	0-0	7	22	1.686
14	11	9	6.5	16-0	1-3	13-6	0-0	8	16	12	6	16	20	11	6	6.5	11-3	6	6.5	2-8	0	0-0	7	22	1.729
15	11	9	6	16-0	1-3	13-6	0-0	8	16	12	6	16	20	11	6	6	11-3	6	6	2-8	0	0-0	7	22	1.729
20	13.5	10	6.5	16-4	1-5	13-6	12-3	6	13	24	6	12	26	11	8	7	11-6	7	7	3-1	0	0-0	8	22	1.942
25	15.5	11	6.5	16-9	1-7	13-7	12-3	7	14	22	7	13	24	11.5	9	7	11-8	8	7	3-5	0	0-0	8	22	2.155
30	17.5	11	5.5	16-11	1-7	13-9	12-3	8	16	20	8	14	22	12.5	9	6.5	11-9	8	6.5	3-9	5	10-4	9	44	2.414
35	19.5	11	5	17-1	1-7	13-11	12-3	8	12	26	8	12	26	13.5	9	7.5	11-0	8	7.5	4-1	5	10-4	9	44	2.676
40	22	11	5	17-3	1-7	14-1	12-3	9	13	24	9	13	24	14.5	9	7	12-2	8	7	4-6	5	10-4	10	44	2.987
45	24	11	5	17-5	1-7	14-3	12-3	10	14	22	10	14	22	15.5	9	7	12-4	8	7	4-10	5	10-4	10	44	3.258
50	26	11	5	17-7	1-7	14-5	12-3	10	12	26	10	12	26	16.5	9	6.5	12-6	8	6.5	5-2	5	10-4	11	44	3.533

12' CLEAR SPAN BY 12' CLEAR HEIGHT

FILL	T	a_1 BAR					a_2 BAR	h BAR			h_1 BAR			W	v BAR			v_1 BAR			v_2 BAR		h_2 BAR		CONCRETE BOX CULVERTS Cu. Yds. per Ft.
		SIZE	SPACING	LENGTH	DIMENSION A	DIMENSION B	LENGTH	SIZE	SPACING	NUMBER	SIZE	SPACING	NUMBER		SIZE	SPACING	LENGTH	SIZE	SPACING	LENGTH	SIZE	LENGTH	SIZE	NUMBER	
Ft.	In.		In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.		In.			In.		In.		In.	Ft.-In.		In.	Ft.-In.		Ft.-In.			
1	9.5	8	6.5	15-6	0-11	13-8	12-3	8	12	13	5	13	24	12	5	9	12-2	5	9	2-5	5	11-4	7	48	1.753
2	10.5	9	7	16-2	1-3	13-8	0-0	7	13	14	5	12	26	12	5	8	12-3	5	8	2-7	5	11-4	7	48	1.84
3	9	8	6	15-6	0-11	13-8	0-0	7	14	13	5	14	22	12	5	8	12-1	5	8	2-4	5	11-4	7	48	1.71
4	9	8	6.5	15-6	0-11	13-8	0-0	7	14	13	5	14	22	12	5	7.5	12-1	5	7.5	2-4	5	11-4	7	48	1.71
5	9	8	6.5	15-6	0-11	13-8	0-0	7	14	13	5	14	22	12	5	7	12-1	5	7	2-4	5	11-4	7	48	1.71
6	9	8	6	15-6	0-11	13-8	0-0	7	14	13	5	14	22	12	5	6.5	12-1	5	6.5	2-4	5	11-4	7	48	1.71
7	9.5	8	6	15-6	0-11	13-8	0-0	7	14	13	5	13	24	12	5	6	12-2	5	6	2-5	5	11-4	7	48	1.753
8	9.5	8	6	15-6	0-11	13-8	0-0	7	14	13	5	13	24	12	6	8	12-2	6	8	2-5	5	11-4	7	48	1.753
9	10	8	6	15-6	0-11	13-8	0-0	7	13	14	5	12	26	12	6	7.5	12-2	6	7.5	2-6	5	11-4	7	48	1.796
10	10	9	7	16-2	1-3	13-8	0-0	7	13	14	5	12	26	12	6	7	12-2	6	7	2-6	5	11-4	7	48	1.796
11	10.5	9	7	16-2	1-3	13-8	0-0	7	12	15	5	12	26	12	6	6.5	12-3	6	6.5	2-7	5	11-4	7	48	1.84
12	10.5	9	6.5	16-2	1-3	13-8	0-0	7	12	15	5	12	26	12	6	6	12-3	6	6	2-7	5	11-4	7	48	1.84
13	10.5	9	6.5	16-2	1-3	13-8	0-0	7	12	15	6	16	20	12	6	6.5	12-3	6	6.5	2-7	5	11-4	8	48	1.84
14	11	9	6.5	16-2	1-3	13-8	0-0	8	14	13	6	16	20	12	6	6	12-3	6	6	2-8	5	11-4	8	48	1.883
15	11	9	6	16-2	1-3	13-8	0-0	8	14	13	6	16	20	12	7	7.5	12-3	6	7.5	2-8	5	11-4	8	48	1.883
20	13.5	10	6	16-6	1-5	13-8	12-3	6	12	26	6	12	26	12	8	7	12-6	7	7	3-1	5	11-4	8	48	2.099
25	16	11	7	17-0	1-7	13-10	12-3	7	13	24	7	12	26	13	8	6	12-8	7	6	3-6	5	11-4	8	48	2.406
30	18	11	6	17-2	1-7	14-0	12-3	8	14	22	8	13	24	14	9	7	12-10	8	7	3-10	5	11-4	9	48	2.674
35	19.5	11	5	17-4	1-7	14-2	12-3	8	12	26	8	12	26	15	9	7	12-0	8	7	4-1	5	11-4	10	48	2.901
40	22	11	5	17-6	1-7	14-4	12-3	9	13	24	9	12	26	16	9	6.5	13-2	8	6.5	4-6	5	11-4	10	48	3.222
45	24	11	5	17-8	1-7	14-6	12-3	10	14	22	10	13	24	17	9	6.5	13-4	8	6.5	4-10	5	11-4	11	48	3.503
50	26	11	5	17-10	1-7	14-8	12-3	10	12	26	10	12	26	18	9	6.5	13-6	8	6.5	5-2	5	11-4	11	48	3.787

2.3 Precast Concrete Box Culverts

2.3.1 General

One advantage of precast culverts is the economy that results from the duplication of forms, elimination of most falsework and the need for only a small construction crew. Precast construction is particularly convenient in places where labor and material are not readily available. Use of precast units allows rapid repair or replacement of existing structures without long, inconvenient detours and with minimum interference to traffic. Precasting in a central plant provides more uniform control and better quality concrete.

Precast boxes may be manufactured using conventional structural concrete and forms (formed) or with dry concrete and vibrating form pipe making methods (machine-made). Standard sizes and dimensions are shown in AASHTO Materials Specifications M 259 (ASTM C 789) and M 273 (ASTM C 850).

2.3.2 Design

Precast boxes are designed using the Load Factor method according to the AASHTO Specifications. The design stresses are as follows:

f'_c = 5,000 psi
f_y = 65,000 psi (welded wire fabric)

The designs given in the tables of AASHTO M 259 (ASTM C 789) and M 273 (ASTM C 850) are determined by the shear strength of the box sections without the use of special shear reinforcement. Special designs for sizes and loads other than those shown in AASHTO M 259 and M 273 may be allowed subject to the approval of the Bureau of Bridges and Structures. Availability of these special sections should also be verified with the Illinois Concrete Pipe Association.

The contract plans for precast concrete box culverts should indicate the appropriate specification according to the guidelines below. These guidelines should also be followed when determining the appropriate specification if a contractor elects to use precast box sections for a culvert detailed in the plans as cast-in-place:

1. If the depth of fill at the edge of shoulder is less than 2 feet, the entire precast box shall conform to the requirements of AASHTO M 273.
2. If the depth of fill at the edge of shoulder is greater than or equal to 2 feet, the entire precast box shall conform to the requirements of AASHTO M 259.
3. Culvert extensions shall also conform to the provisions stated in 1 and 2 above.
4. Precast end sections shall conform to the same specifications as the adjacent box section.

Precast box culvert designs must provide hydraulic equivalence to conventional cast-in-place designs. This may occasionally require a larger precast culvert size to compensate for the additional inlet losses and the adjustment to standard sizes.

2.3.3 Applications

Depending upon the requirements of the project, the precast culvert can be a single cell or multi-cell construction. When multi-cell boxes are used, a 3 inch space shall be provided between adjacent precast sections. The decision to substitute a precast culvert for cast-in-place type construction should be arrived at only after making a careful avaluation of the site to determine its suitability for this type of construction.

It should be noted that precast concrete culverts are not suitable in areas which are subject to flooding or in areas with highly scourable flow line soils such as silt and fine sand. Also, since precast concrete segments do not lend themselves to cambering (providing a collar around every joint is not practical), this type of construction cannot be considered in soils which are susceptible to excessive settlements. The use of precast concrete box culverts under the following conditions is not recommended and the Bureau of Bridges and Structures shall be consulted before use:

1. Special designs such as "imperfect trench" and when set directly on rock.

2. Conditions where pile foundations would be required.
3. Locations with an Acceleration Coefficient A>0.19 as defined in the AASHTO Standard Specifications for Highway Bridges.

Geometric limitations on the use of precast culverts include a maximum skew of 60 degrees and a maximum cell span and rise of 12 feet. A minimum cover of 6 inches, measured at the edge of the shoulder, is also required. Plans prepared for cast-in-place culverts to be constructed under any of the conditions above which preclude the use of precast culverts should contain the note "Precast culvert alternate is not allowed".

Shop plans for precast concrete box culvert sections, precast or cast-in-place end sections and cast-in-place collars shall be submitted by the Contractor to the District Office according to the applicable requirements of Article 504.04(a) of the Standard Specifications. Typical shop plan details and notes for precast concrete box culverts manufactured by a precaster are shown in Figures 2.3.3-1 through 2.3.3-4.

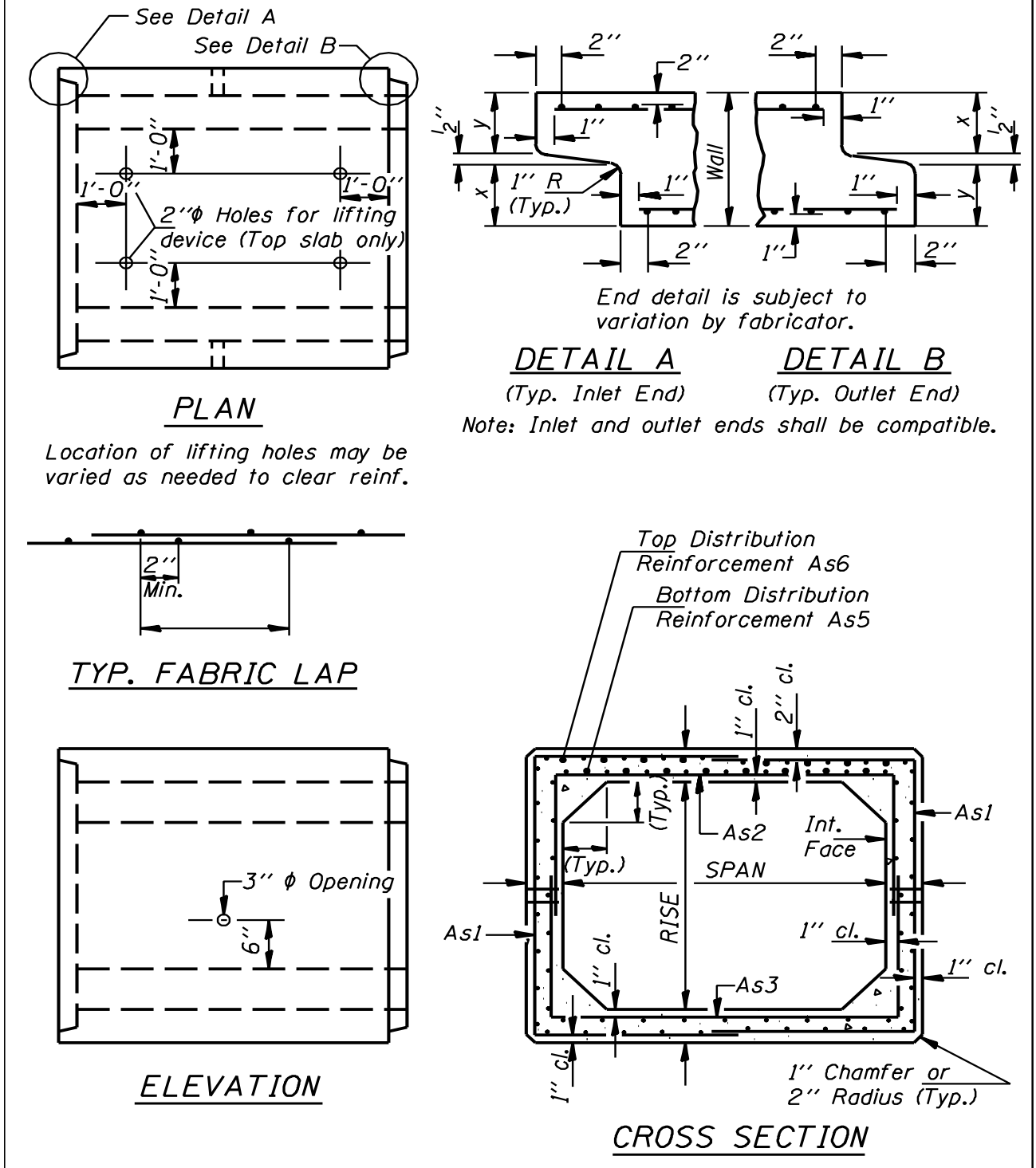

See Detail A
See Detail B
1'-0"
1'-0"
1'-0"
1'-0"
2"ϕ Holes for lifting device (Top slab only)
PLAN
Location of lifting holes may be varied as needed to clear reinf.
2"
2"
2"
2"
1"
1"
1"
1"
1" R (Typ.)
Wall
1"
1"
2"
2"
End detail is subject to variation by fabricator.
DETAIL A
(Typ. Inlet End)
DETAIL B
(Typ. Outlet End)
Note: Inlet and outlet ends shall be compatible.
2" Min.
TYP. FABRIC LAP
3" ϕ Opening
6"
ELEVATION
Top Distribution Reinforcement As6
Bottom Distribution Reinforcement As5
1" cl.
2" cl.
(Typ.)
(Typ.)
As2
Int. Face
As1
SPAN
RISE
As1
1" cl.
1" cl.
1" cl.
As3
1" cl.
1" Chamfer or 2" Radius (Typ.)
CROSS SECTION
PRECAST BOX CULVERT
SHOP DRAWING DETAILS FOR
FILL < 2.0 ft. ; AASHTO M 273

Figure 2.3.3-1

GENERAL NOTES

Precast Concrete Box Culvert sections shall conform to the requirements of Article 540.06 of the Standard Specifications and the applicable requirements of AASHTO M 273.

The minimum concrete strength shall be 5,000 psi.

Reinforcement bars shall conform to the requirements of AASHTO M 31, M 42, or M 53 Grade 60.

Lifting holes shall be filled with concrete plugs and mastic after box sections are in place.

FILL < 2.0 ft. ; TABLE _____

REQUIRED AASHTO STEEL AREAS ($in^2/ft.$)

A_{s1} _____ A_{s5} _____
A_{s2} _____ A_{s6} _____
A_{s3} _____ A_{s7} _____
A_{s4} _____ A_{s8} _____

REINFORCEMENT PROVIDED **AREA** ($in^2/ft.$)

A_{s1} ____ x ____ W _____ x W _____ = _____
A_{s2} ____ x ____ W _____ x W _____ = _____
A_{s3} ____ x ____ W _____ x W _____ = _____
A_{s4} provided by A_{s2} and A_{s3}
A_{s5} _____ = _____
A_{s6} _____ = _____
A_{s7} provided by A_{s1}
A_{s8} provided by A_{s1}

BILL OF MATERIAL

ITEM	UNIT	TOTAL
Precast Concrete Box Culvert x	Ft.	

CONTRACT _____ COUNTY _____
ROUTE _____ SECTION _____
SPAN _____ X RISE _____ ; STATION _____

PRECAST BOX CULVERT
SHOP DRAWING NOTES FOR
FILL < 2.0 ft. ; AASHTO M 273

Figure 2.3.3-2

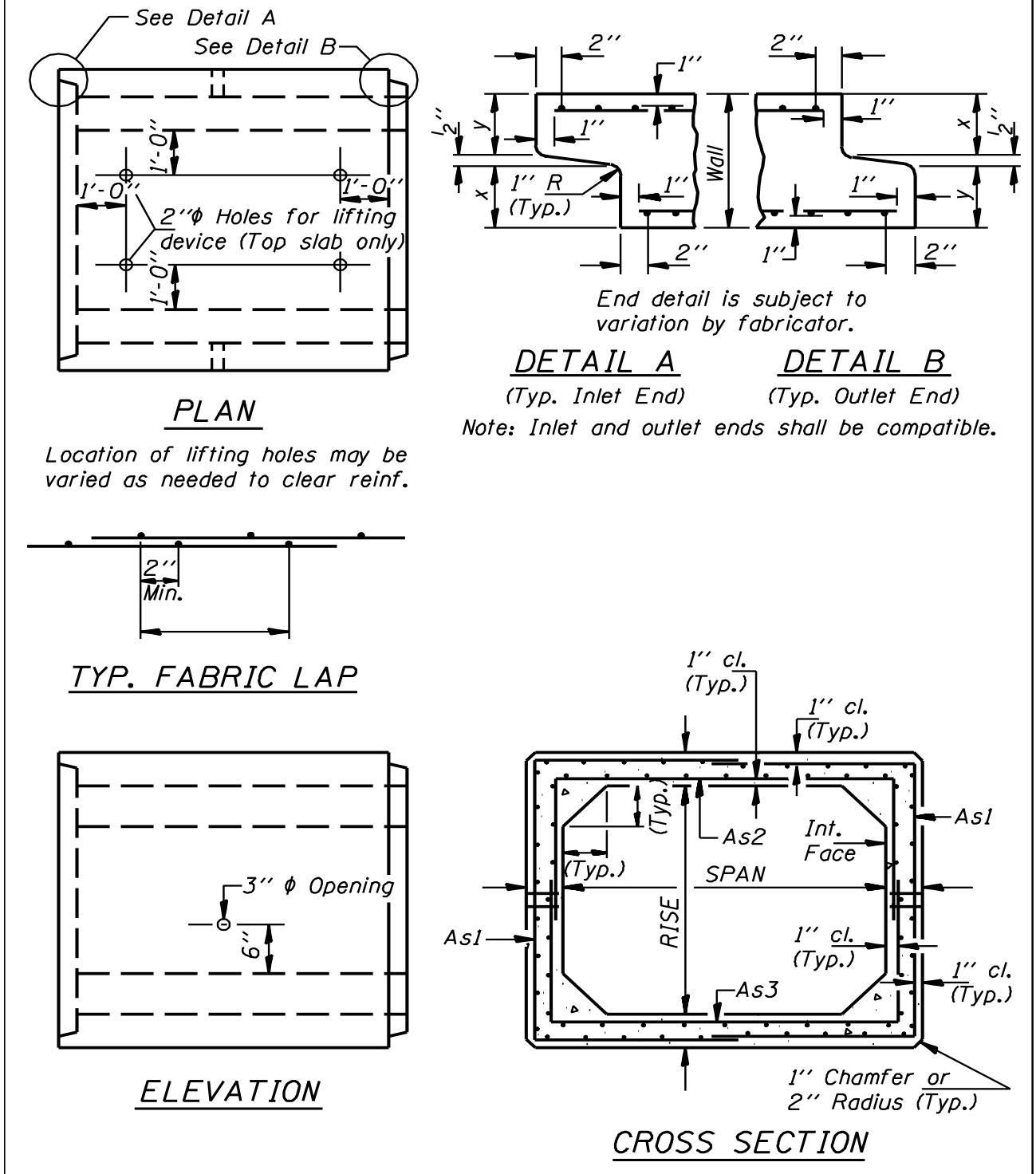

See Detail A
See Detail B
1'-0"
1'-0"
1'-0"
1'-0"
2"ϕ Holes for lifting device (Top slab only)
PLAN
Location of lifting holes may be varied as needed to clear reinf.
2"
1"
1/2"
y
x
1" R (Typ.)
Wall
2"
1"
End detail is subject to variation by fabricator.
DETAIL A
(Typ. Inlet End)
DETAIL B
(Typ. Outlet End)
Note: Inlet and outlet ends shall be compatible.
2" Min.
TYP. FABRIC LAP
3" ϕ Opening
6"
ELEVATION
1" cl. (Typ.)
As1
As2
As3
Int. Face
SPAN
RISE
(Typ.)
1" Chamfer or 2" Radius (Typ.)
CROSS SECTION
PRECAST BOX CULVERT
SHOP DRAWING DETAILS FOR
FILL ≥ 2.0 ft. ; AASHTO M 259

Figure 2.3.3-3

GENERAL NOTES

Precast Concrete Box Culvert sections shall conform to the requirements of Article 540.06 of the Standard Specifications and the applicable requirements of AASHTO M 259.

The minimum concrete strength shall be 5,000 psi.

Lifting holes shall be filled with concrete plugs and mastic after box sections are in place.

FILL = _____ ft. ; TABLE _____

REQUIRED AASHTO STEEL AREAS ($in^2/ft.$)

A_{s1} _____
A_{s2} _____
A_{s3} _____
A_{s4} _____

REINFORCEMENT PROVIDED	**AREA** ($in^2/ft.$)
A_{s1} ____ x ____ W _____ x W _____	= _____
A_{s2} ____ x ____ W _____ x W _____	= _____
A_{s3} ____ x ____ W _____ x W _____	= _____
A_{s4} provided by A_{s2} and A_{s3}	

BILL OF MATERIAL

ITEM	UNIT	TOTAL
Precast Concrete Box Culvert x	Ft.	

CONTRACT _____ COUNTY _____
ROUTE _____ SECTION _____
SPAN _____ X RISE _____ ; STATION _____

PRECAST BOX CULVERT
SHOP DRAWING NOTES FOR
FILL ≥ 2.0 ft. ; AASHTO M 259

Figure 2.3.3-4

2.3.4 End Sections

Figures 2.3.4-1 and 2.3.4-2 show the acceptable types of end sections that can be used for a precast box culvert. End sections may either be precast, if hydraulically acceptable, or cast-in-place.

When a precast box culvert is built as an alternate to a culvert detailed as cast-in-place in the plans, cast-in-place apron end sections or precast end sections may be used in lieu of the wingwalls detailed for the cast-in-place box culvert. The pay limits for the precast box sections and end sections are shown in Figures 2.3.4-1 and 2.3.4-2 for culverts which are designed and detailed as precast in the plans. However, the detail showing horizontal cantilever wingwalls on a precast culvert with no skew would typically only apply to a culvert detailed as cast-in-place in the plans but constructed using the precast alternate. Horizontal cantilever wingwalls are typically not used on culverts with no skew and detailed as precast in the plans due to the 6 feet of cast-in-place box that would not be required with another type of end section.

Figures 2.3.4-3 and 2.3.4-4 show typical details of a cast-in-place apron end section. Figures 2.3.4-5 through 2.3.4-8 show typical shop plan details and notes for precast end sections manufactured by a precaster.

If the end section for a precast box culvert includes a cast-in-place section of box, the cast-in-place portion of the box must be attached to the precast portion. There are two commonly used methods of attaching a cast-in-place section of box to a precast section of box. The reinforcement may be extended out of the last precast section and incorporated into the cast-in-place section. Attachment may also be accomplished by the use of a reinforced cast-in-place collar as shown in Figure 4-8.

Single cell reinforcement details may be used for cast-in-place ends on multi-cell precast box culverts provided a 1/4" wide by 1" deep saw cut is made over the center of the interior walls the full length of the cast-in-place portion. One-half inch PJF shall also be placed in the headwalls at these locations.

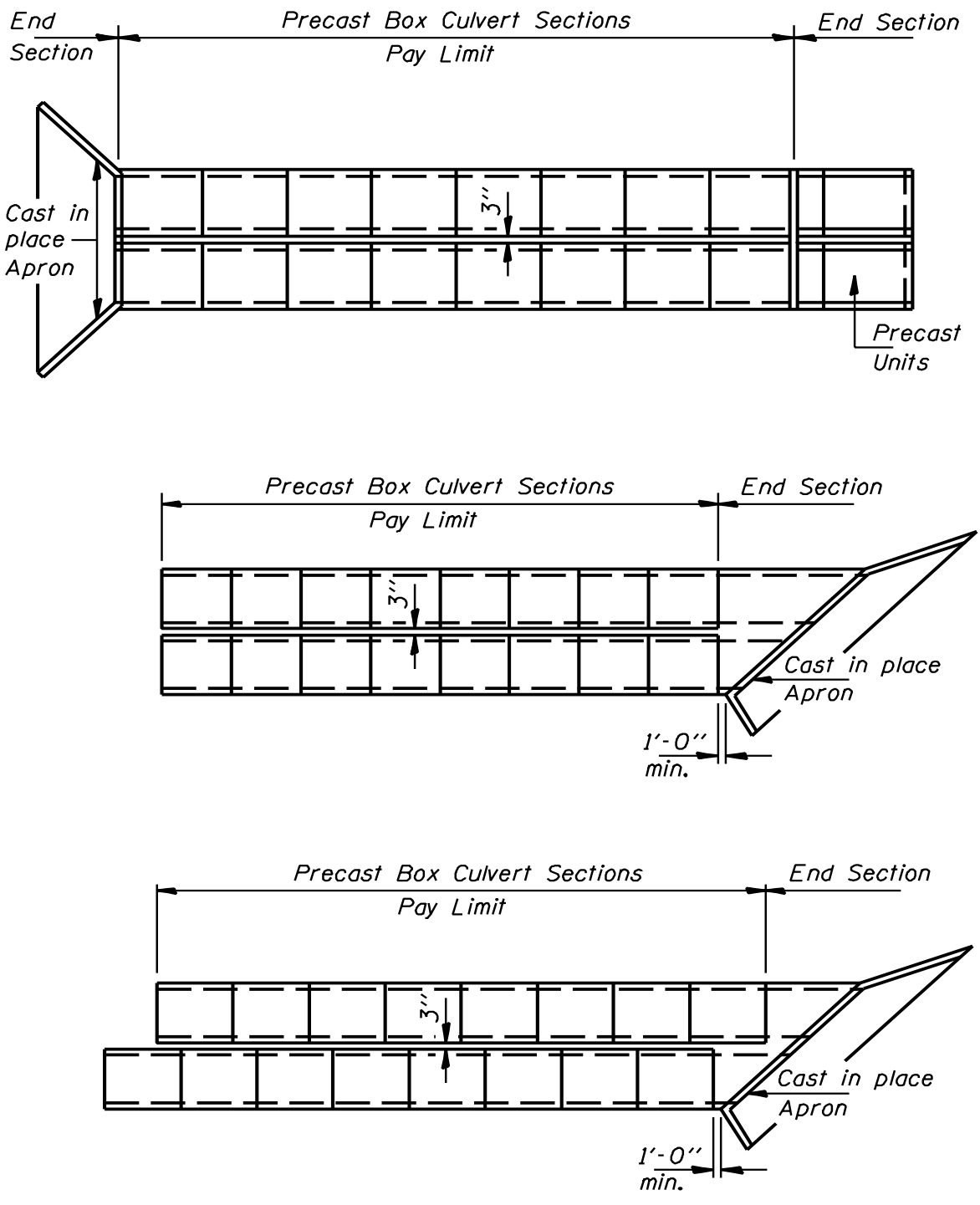

End Section
Precast Box Culvert Sections
Pay Limit
End Section
Cast in place Apron
3"
Precast Units
Precast Box Culvert Sections
Pay Limit
End Section
3"
Cast in place Apron
1'-0" min.
Precast Box Culvert Sections
Pay Limit
End Section
3"
Cast in place Apron
1'-0" min.
PRECAST CULVERT END SECTIONS

Figure 2.3.4-1

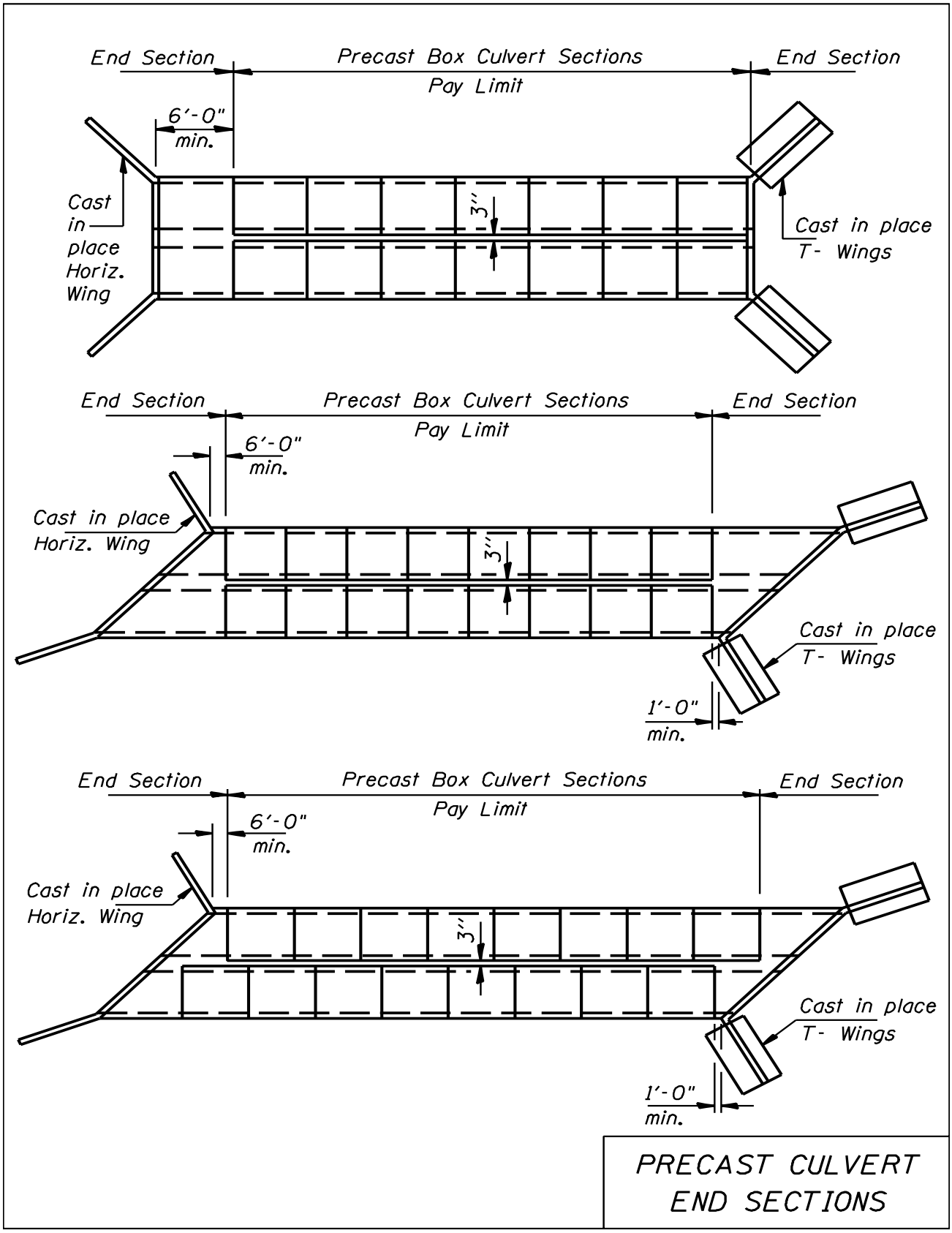

End Section
Precast Box Culvert Sections
Pay Limit
End Section
6'-0" min.
Cast in place Horiz. Wing
3"
Cast in place T- Wings
End Section
Precast Box Culvert Sections
Pay Limit
End Section
6'-0" min.
Cast in place Horiz. Wing
3"
Cast in place T- Wings
1'-0" min.
End Section
Precast Box Culvert Sections
Pay Limit
End Section
6'-0" min.
Cast in place Horiz. Wing
3"
Cast in place T- Wings
1'-0" min.
PRECAST CULVERT END SECTIONS

Figure 2.3.4-2

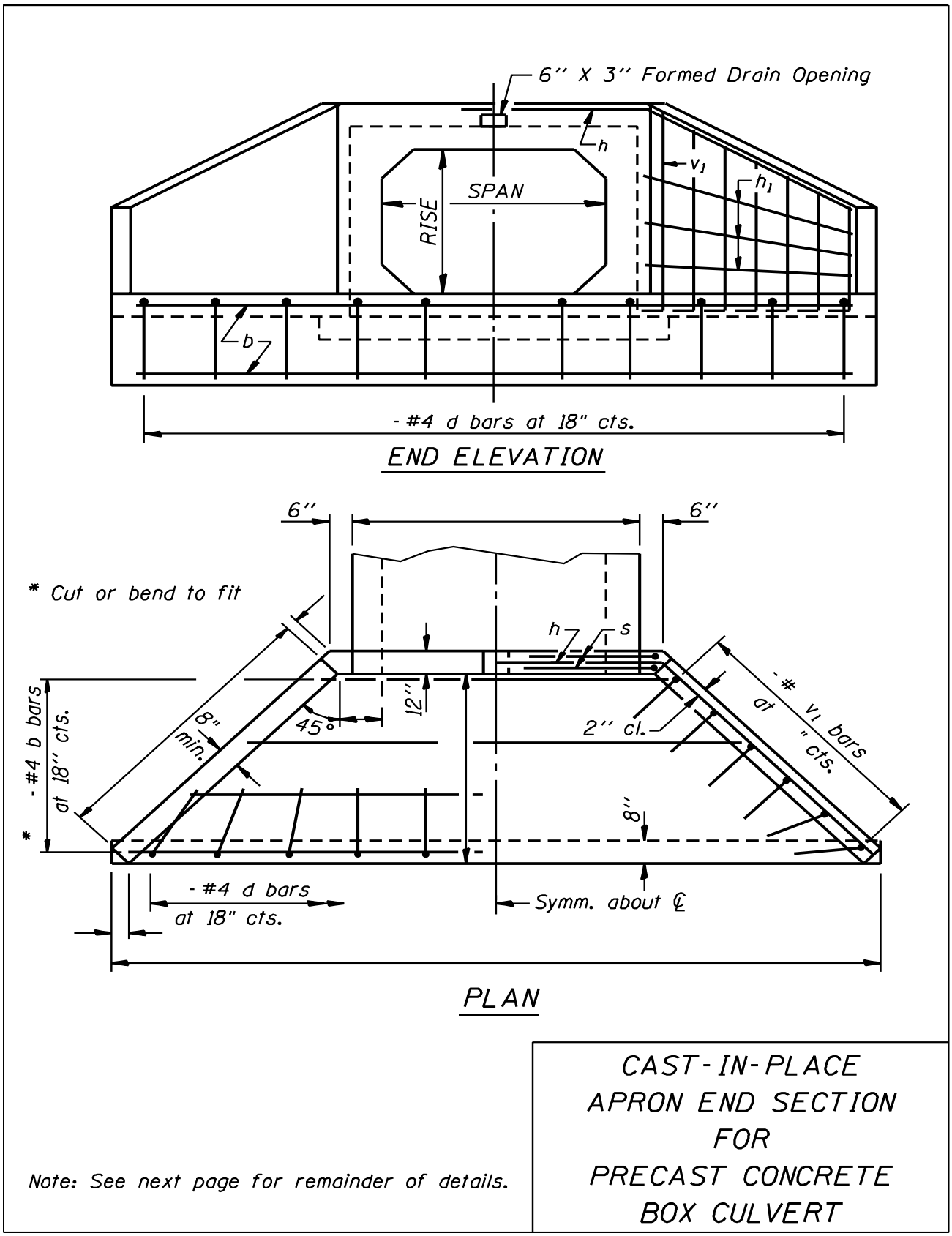

6'' X 3'' Formed Drain Opening
h
v_1
h_1
SPAN
RISE
b
- #4 d bars at 18" cts.
END ELEVATION
6''
6''
* Cut or bend to fit
h
s
- #4 b bars at 18'' cts.
8" min.
45°
12''
2'' cl.
- # v_1 bars at " cts.
8''
*
- #4 d bars at 18" cts.
Symm. about ℄
PLAN
CAST-IN-PLACE APRON END SECTION FOR PRECAST CONCRETE BOX CULVERT
Note: See next page for remainder of details.

Figure 2.3.4-3

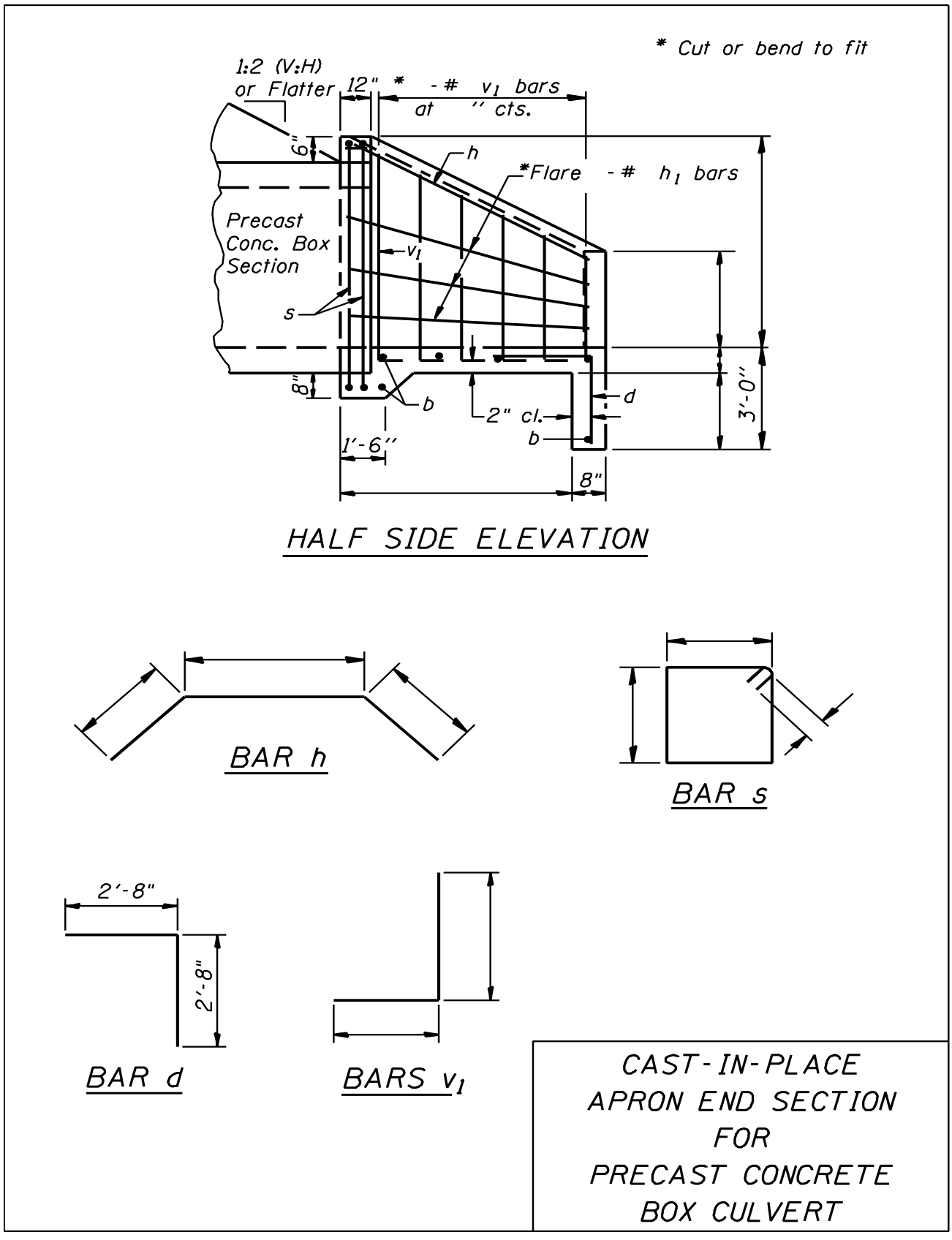

* Cut or bend to fit
1:2 (V:H)
or Flatter
12" * - # v_1 bars
at '' cts.
9"
h
*Flare - # h_1 bars
Precast
Conc. Box
Section
v_1
s
8"
b
2" cl.
b
d
3'-0''
1'-6''
8"
HALF SIDE ELEVATION
BAR h
BAR s
2'-8"
2'-8"
BAR d
BARS v_1
CAST-IN-PLACE
APRON END SECTION
FOR
PRECAST CONCRETE
BOX CULVERT

Figure 2.3.4-4

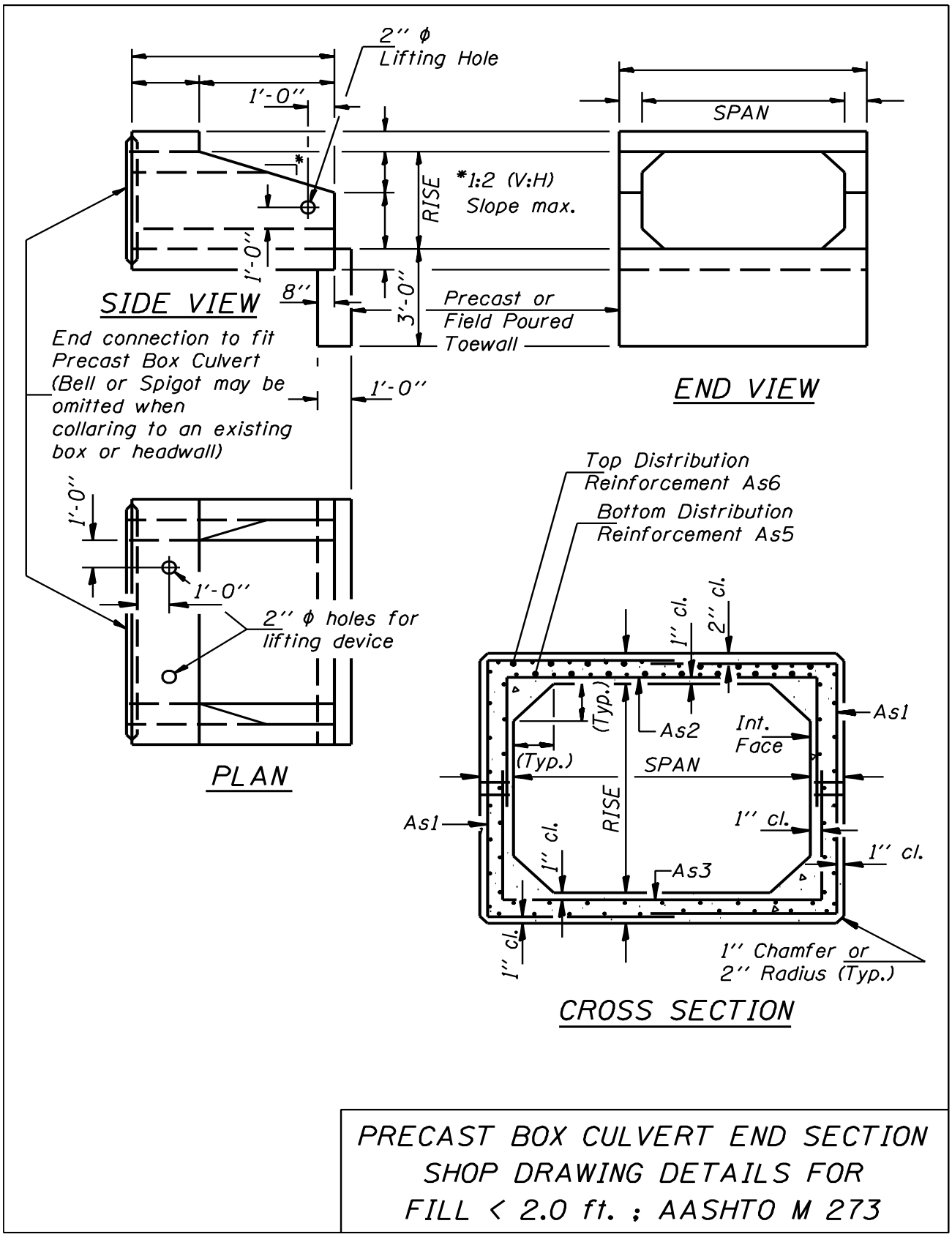

2'' ϕ
Lifting Hole
1'-0''
SPAN
*1:2 (V:H)
Slope max.
RISE
1'-0''
8''
3'-0''
Precast or
Field Poured
Toewall
SIDE VIEW
END VIEW
End connection to fit
Precast Box Culvert
(Bell or Spigot may be
omitted when
collaring to an existing
box or headwall)
1'-0''
1'-0''
1'-0''
2'' ϕ holes for
lifting device
PLAN
Top Distribution
Reinforcement As6
Bottom Distribution
Reinforcement As5
1'' cl.
2'' cl.
(Typ.)
(Typ.)
As2
Int.
Face
As1
SPAN
RISE
As1
1'' cl.
1'' cl.
1'' cl.
As3
1'' cl.
1'' Chamfer or
2'' Radius (Typ.)
CROSS SECTION
PRECAST BOX CULVERT END SECTION
SHOP DRAWING DETAILS FOR
FILL < 2.0 ft. ; AASHTO M 273

Figure 2.3.4-5

GENERAL NOTES

Box Culvert End Sections shall conform to the requirements of Article 540.06 of the Standard Specifications and the applicable requirements of AASHTO M 273.

The minimum concrete strength shall be 5,000 psi.

Reinforcement bars shall conform to the requirements of AASHTO M 31, M 42, or M 53 Grade 60.

Lifting holes shall be filled with concrete plugs and mastic after box sections are in place.

FILL < 2.0 ft. ; TABLE _____

REQUIRED AASHTO STEEL AREAS ($in^2/ft.$)

A_{s1} _____	A_{s5} _____
A_{s2} _____	A_{s6} _____
A_{s3} _____	A_{s7} _____
A_{s4} _____	A_{s8} _____

REINFORCEMENT PROVIDED **AREA** ($in^2/ft.$)

A_{s1} ____ x ____ W _____ x W _____ = _____
A_{s2} ____ x ____ W _____ x W _____ = _____
A_{s3} ____ x ____ W _____ x W _____ = _____
A_{s4} provided by A_{s2} and A_{s3}
A_{s5} _____ = _____
A_{s6} _____ = _____
A_{s7} provided by A_{s1}
A_{s8} provided by A_{s1}

BILL OF MATERIAL

ITEM	UNIT	TOTAL
Box Culvert End Sections	Each	

CONTRACT _____ COUNTY _____
ROUTE _____ SECTION _____
SPAN _____ X RISE _____ ; STATION _____

PRECAST BOX CULVERT END SECTION
SHOP DRAWING NOTES FOR
FILL < 2.0 ft. ; AASHTO M 273

Figure 2.3.4-6

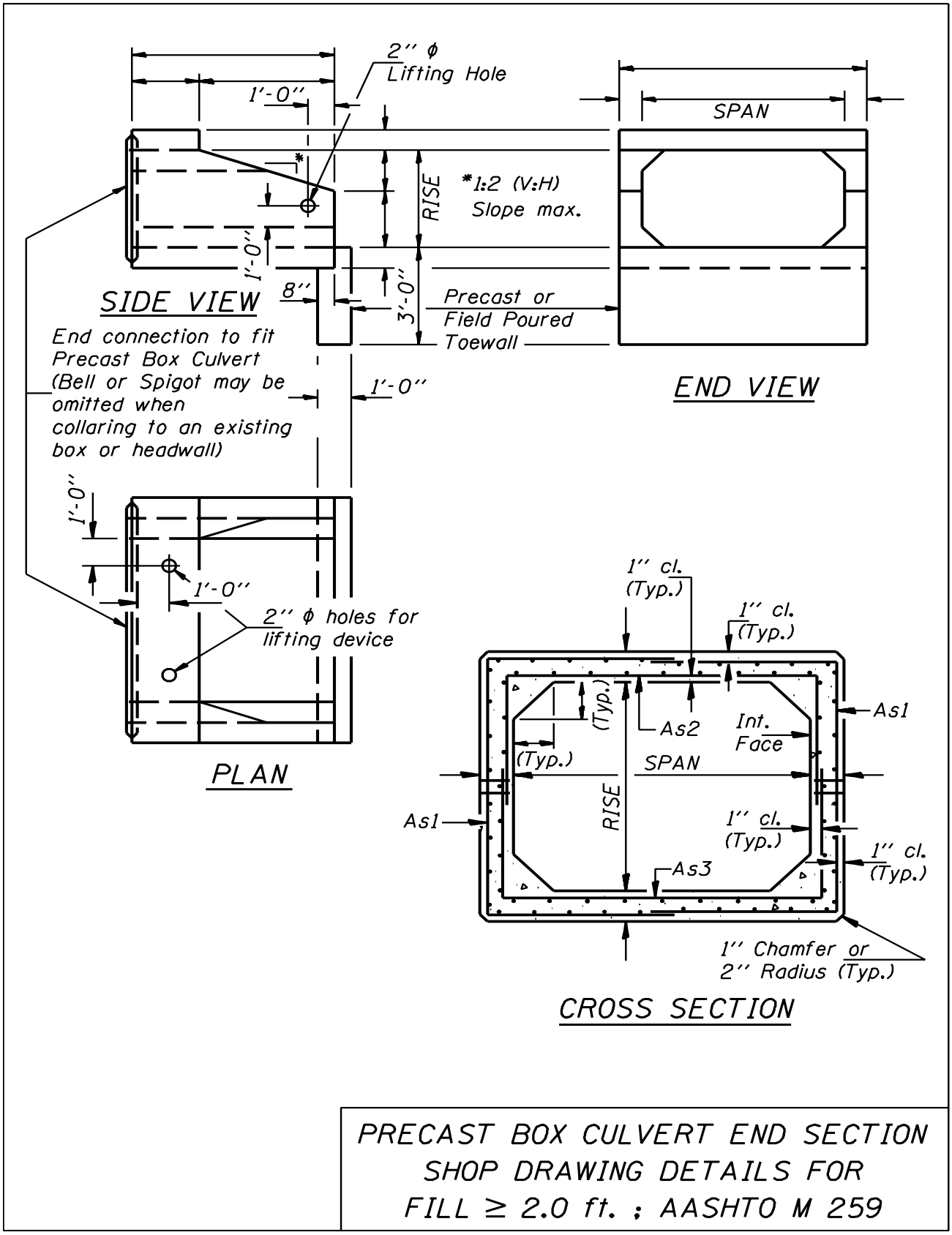

2'' ϕ
Lifting Hole
1'-0''
SPAN
*1:2 (V:H)
Slope max.
RISE
1'-0''
8''
3'-0''
Precast or
Field Poured
Toewall
SIDE VIEW
END VIEW
End connection to fit
Precast Box Culvert
(Bell or Spigot may be
omitted when
collaring to an existing
box or headwall)
1'-0''
1'-0''
1'-0''
2'' ϕ holes for
lifting device
PLAN
1'' cl.
(Typ.)
1'' cl.
(Typ.)
(Typ.)
(Typ.)
As2
Int.
Face
As1
SPAN
RISE
As1
1'' cl.
(Typ.)
1'' cl.
(Typ.)
As3
1'' Chamfer or
2'' Radius (Typ.)
CROSS SECTION
PRECAST BOX CULVERT END SECTION
SHOP DRAWING DETAILS FOR
FILL ≥ 2.0 ft. ; AASHTO M 259

Figure 2.3.4-7

GENERAL NOTES

Box Culvert End Sections shall conform to the requirements of Article 540.06 of the Standard Specifications and the applicable requirements of AASHTO M 259.

The minimum concrete strength shall be 5,000 psi.

Lifting holes shall be filled with concrete plugs and mastic after box sections are in place.

FILL = _____ ft. ; TABLE _____

REQUIRED AASHTO STEEL AREAS ($in^2/ft.$)

A_{s1} _____
A_{s2} _____
A_{s3} _____
A_{s4} _____

REINFORCEMENT PROVIDED	**AREA** ($in^2/ft.$)
A_{s1} ___ x ___ W _____ x W _____	= _____
A_{s2} ___ x ___ W _____ x W _____	= _____
A_{s3} ___ x ___ W _____ x W _____	= _____
A_{s4} provided by A_{s2} and A_{s3}	

BILL OF MATERIAL

ITEM	UNIT	TOTAL
Box Culvert End Sections	Each	

CONTRACT _____ COUNTY _____
ROUTE _____ SECTION _____
SPAN _____ X RISE _____ ; STATION _____

PRECAST BOX CULVERT END SECTION
SHOP DRAWING NOTES FOR
FILL ≥ 2.0 ft. ; AASHTO M 259

Figure 2.3.4-8

Section 3 Wingwall Design

Table of Contents

Section 3 Wingwall Design

Table of Figures

Section 3 Wingwall Design

3.1 General

This section covers criteria, tables and charts for the design of horizontal and vertical cantilever wingwalls, including the headwalls for box culverts.

3.1.1 Design Strength

f'_c = 3,500 psi

f_y = 60,000 psi

$n = \frac{E_s}{E_c}$ = 9 (used for computing service load requirements)

$V_c = 2\sqrt{f'_c}bd$

3.1.2 Loading

Group I of AASHTO Loading Combination Article 3.22 is applied as follows:

$$13[D + \beta_E E]$$

where β_E = 1.0 for vertical earth loads

and β_E = 1.3 for lateral earth pressures.

Live Loads

No live loads are included in the development of the design tables in this section. Wingwalls built parallel to the centerline of roadway shall be designed for live load surcharge pressure equal to not less than 2 feet of earth pressure according to AASHTO Article 3.20.3.

Dead Loads

Concrete = 150 pcf

Earth (E) = 120 pcf

The active earth pressure is assumed as an equivalent fluid pressure of 40 pcf for level fills and increases with the increase in fill height. This is illustrated in Figures 3.1.2-1 and 3.1.2-2. The height (H) (shown in Figure 3.1.2-1) upon

which the active earth pressure acts, is computed assuming 1:2 (V:H) embankment slope perpendicular to the wingwall. This is the basis for the horizontal wingwall design chart and the vertical (L-Type and T-Type) wingwall design tables. If a 1:1.5 (V:H) embankment slope is used as permitted hereinafter, the wingwall design charts and tables are not applicable.

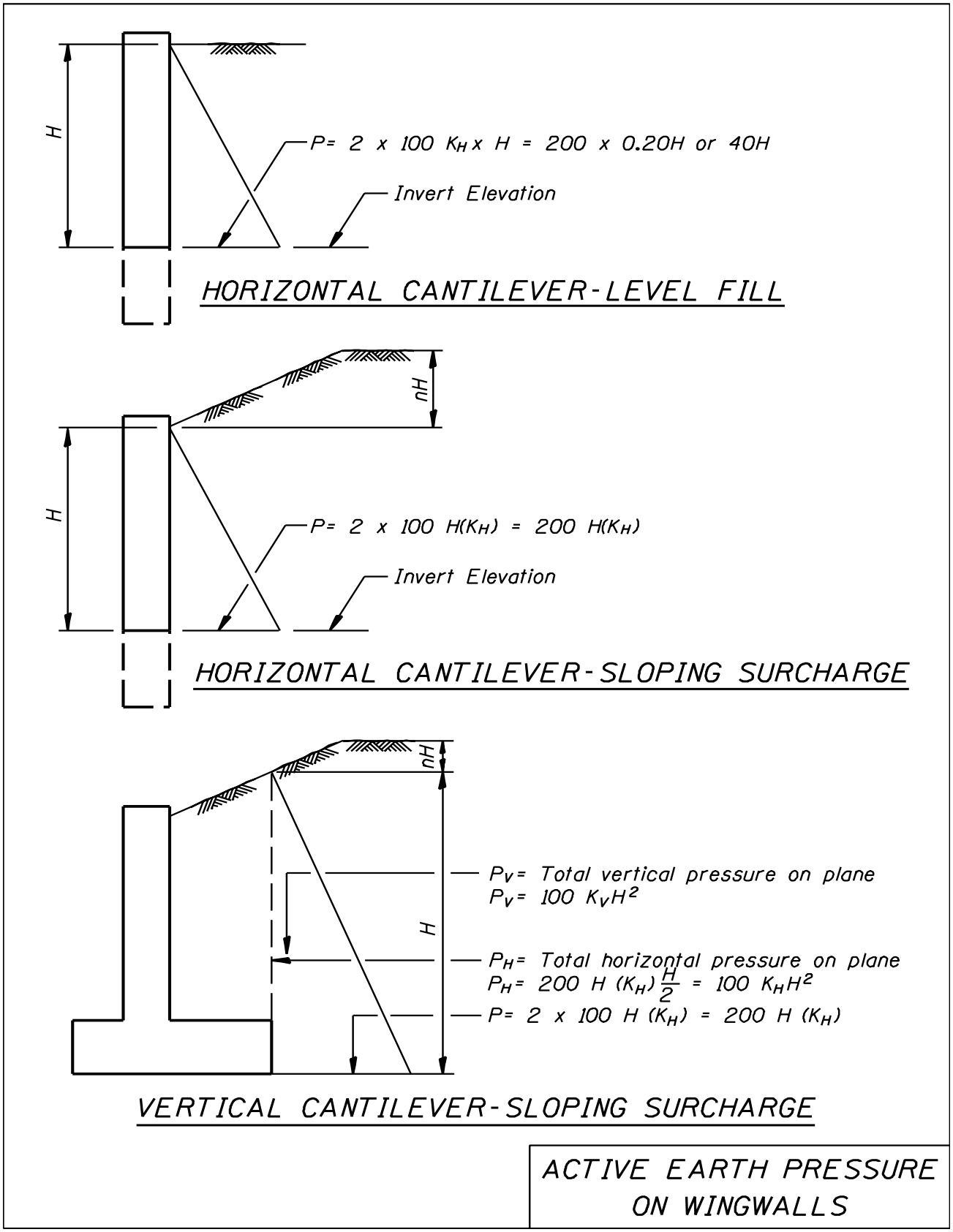

H
P= 2 x 100 KH x H = 200 x 0.20H or 40H
Invert Elevation
HORIZONTAL CANTILEVER-LEVEL FILL
nH
H
P= 2 x 100 H(KH) = 200 H(KH)
Invert Elevation
HORIZONTAL CANTILEVER-SLOPING SURCHARGE
nH
H
PV= Total vertical pressure on plane
PV= 100 KVH2
PH= Total horizontal pressure on plane
PH= 200 H (KH) H/2 = 100 KHH2
P= 2 x 100 H (KH) = 200 H (KH)
VERTICAL CANTILEVER-SLOPING SURCHARGE
ACTIVE EARTH PRESSURE
ON WINGWALLS

Figure 3.1.2-1

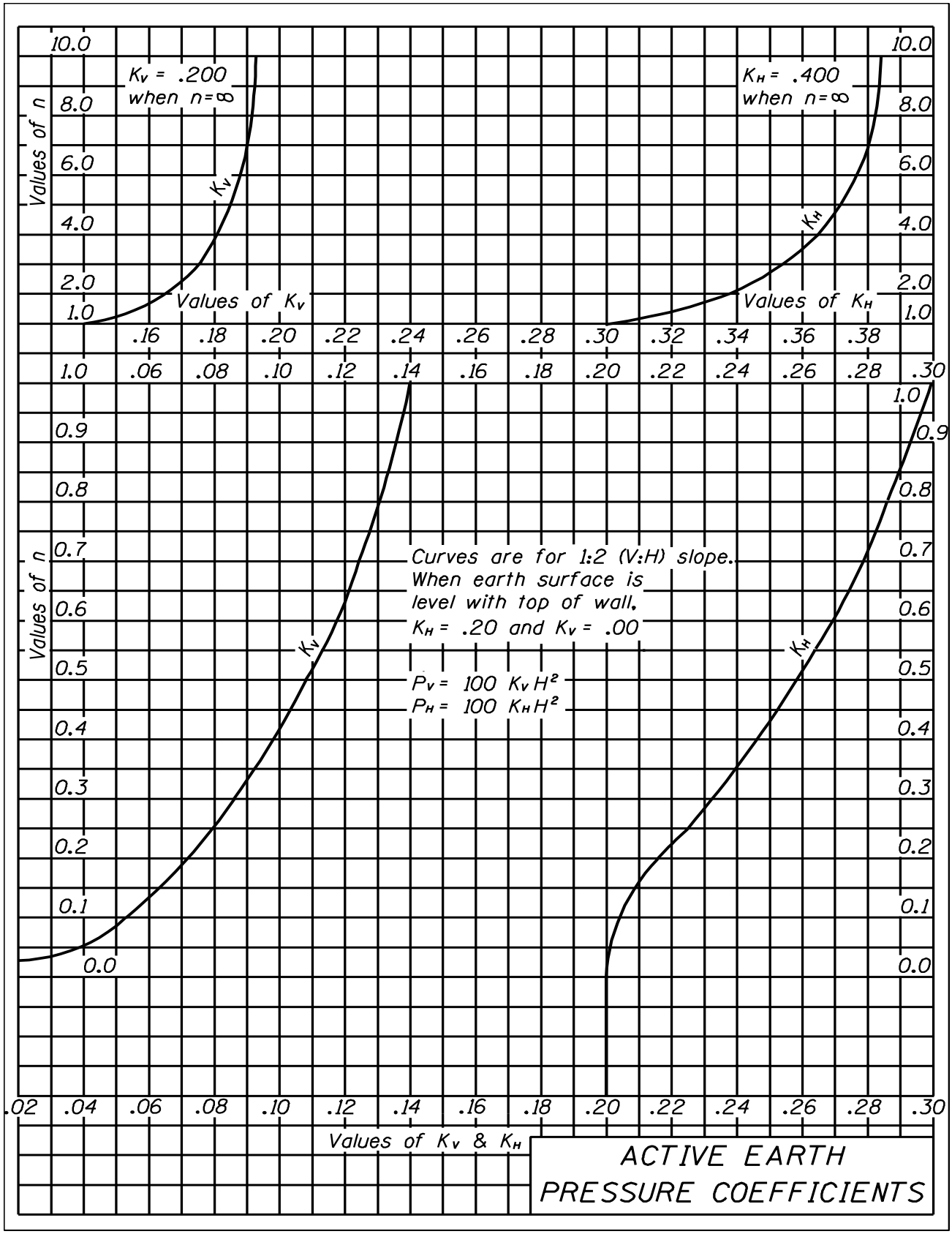

Kv = .200
when n=∞
KH = .400
when n=∞
Values of n
Kv
KH
Values of Kv
Values of KH
Curves are for 1:2 (V:H) slope.
When earth surface is
level with top of wall.
KH = .20 and Kv = .00
Pv = 100 Kv H²
PH = 100 KH H²
Values of Kv & KH
ACTIVE EARTH
PRESSURE COEFFICIENTS

Figure 3.1.2-2

3.1.3 Types and Applications

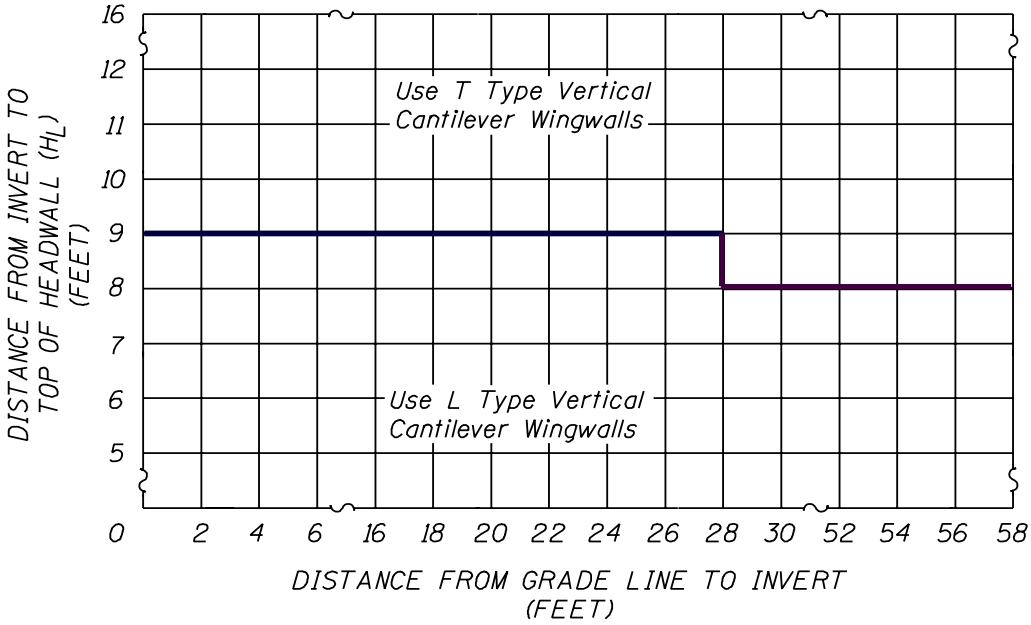
Horizontal Cantilever Wingwalls

Shall be used if length of wingwall is equal to or less than 14 feet.*

Vertical Cantilever Wingwalls

Generally to be used when the length of wingwall is greater than 14 feet. However, if any individual wing on a culvert is greater than 14 feet, vertical cantilever wingwalls shall be used for all wingwalls.*

Both L-Type and T-Type vertical cantilever wingwalls are covered in the tables. The type selected for use is dependent on the distance from the invert to the top of headwall, and the distance from the grade line to the invert as indicated in the following figure:



*Note: For special situations where soil conditions preclude the use of L-Type and T-Type wings on spread foundations, special horizontal cantilever wings may be designed to avoid the use of very long piles and/or seal coats with cofferdams for T-Type wings. A slope of 1:1.5 (V:H) can be used to reduce the length of the horizontal cantilever wingwall required; however, this should only be done in special situations and avoided on high visibility projects. Approval by the Bureau of Bridges and Structures and the District Office is required for the use of the steeper slope.

3.1.4 Limits of Charts and Tables

Chart for Horizontal Cantilever Wingwalls	
Length of Wingwalls (L)	- 5'-0" to 14'-0"
Design Height of Wingwalls (h)	- 3'-0" to 10'-0"
Fill	- zero to 50'-0"
Tables for Vertical Cantilever Wingwalls	
L-Type (Soil conditions permitting)	
Stem height (H_S)	- 3'-0" to 8'-0"
Fill	- Zero to 50'-0"
Stem height (H_S)	- 8'-6" to 9'-0"
Fill	- Zero to 20'-0"
T-Type (Tables apply to spread footings only)	
Design height (H_D)	- 8'-6" to 19'-6"
Fill	- zero to 50'-0"

3.1.5 Length of Wingwalls

The length of the wingwall shall be determined from the chart shown in Figure 3.1.5-2 to the nearest three inches. The chart shown in Figure 3.1.5-3 is for slopes of 1:1.5 (V:H) and should only be used under the conditions described in Section 3.1.3.

$H_L = H+T+f$ (Top of Headwall to Invert)

- H = Clear Height
- T = Thickness of Top Slab
- f = Height of Headwall

$D = \frac{H_L}{2} - 6"$ (Drop of the End of Wingwall below top of Headwall)

Dimension "L" to nearest 3" and "D" to nearest 1"

Example - Beyond the Chart: Given H_L = 14'-0" α=20°-00'. From the chart H_L = 9'-0" L=24'-10" increasing 3.036 ⅟₁ increase in H_L (14.0-9.0) x 3.036 = 15.18 added to 24.83' = 40.01 or 40'-0".

EXAMPLE -

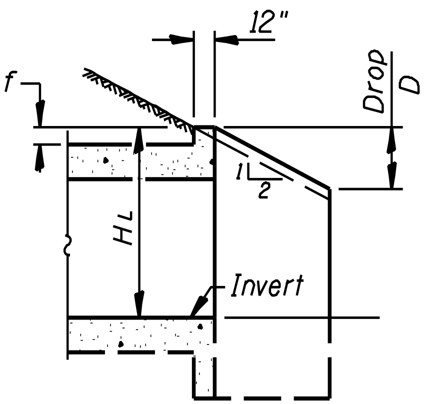
Given H= 8'-0", T= 10", f= 6"
Skew Angle θ = 20°-00'

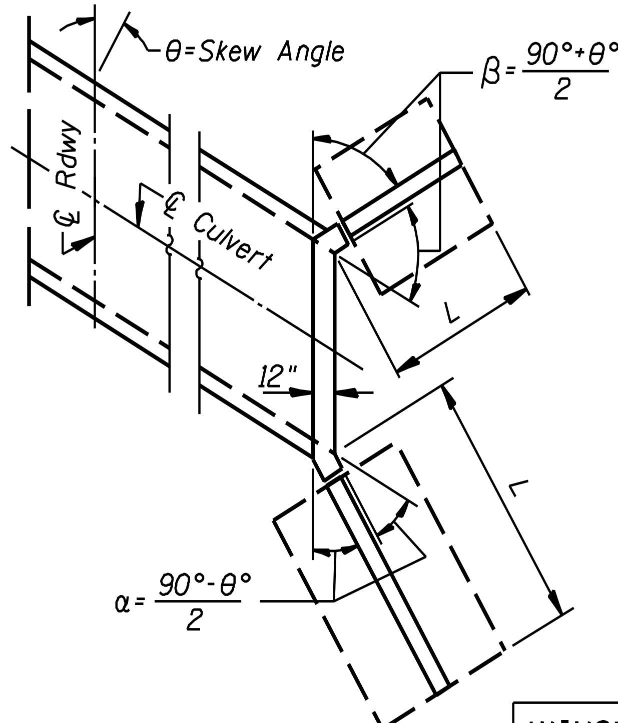
H_L = 8'-0" + 10" + 6" = 9'-4"

$\alpha = \frac{90° - 20°}{2} = 35°$, $\beta = \frac{90° + 20°}{2} = 55°$

Enter Chart with H_L = 9'-4". Horizontally to β=55°; read "L" vertically below = 10"-9". Continue horizontally to α=35°; read "L" vertically below = 15'-5". Use 15'-6".

Drop $D = \frac{9'\text{-}4"}{2} - 6" = 4'\text{-}2"$





Note: Use with Chart in Figure 3.1.5-2.

WINGWALL LENGTH AND DROP

Figure 3.1.5-1

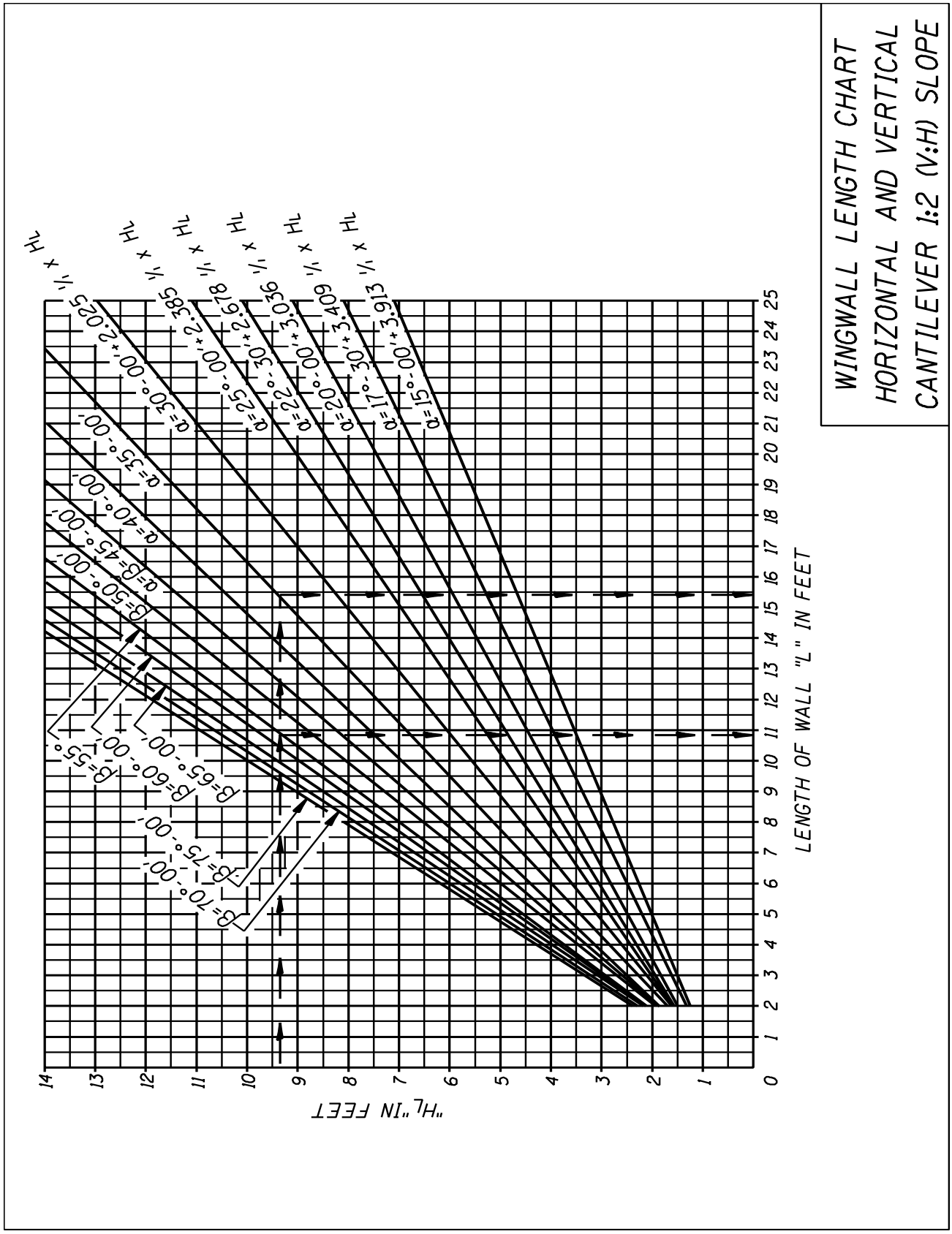

WINGWALL LENGTH CHART
HORIZONTAL AND VERTICAL
CANTILEVER 1:2 (V:H) SLOPE
LENGTH OF WALL "L" IN FEET
"HL" IN FEET
α=15°-00'+3.913 x 1/1 HL
α=17°-30'+3.609 x 1/1 HL
α=20°-00'+3.364 x 1/1 HL
α=22°-30'+3.136 x 1/1 HL
α=25°-00'+2.918 x 1/1 HL
α=30°-00'+2.585 x 1/1 HL
α=35°-00'
α=40°-00'
α=45°-00'
β=50°-00'
β=55°-00'
β=60°-00'
β=65°-00'
β=70°-00'
β=75°-00'

Figure 3.1.5-2

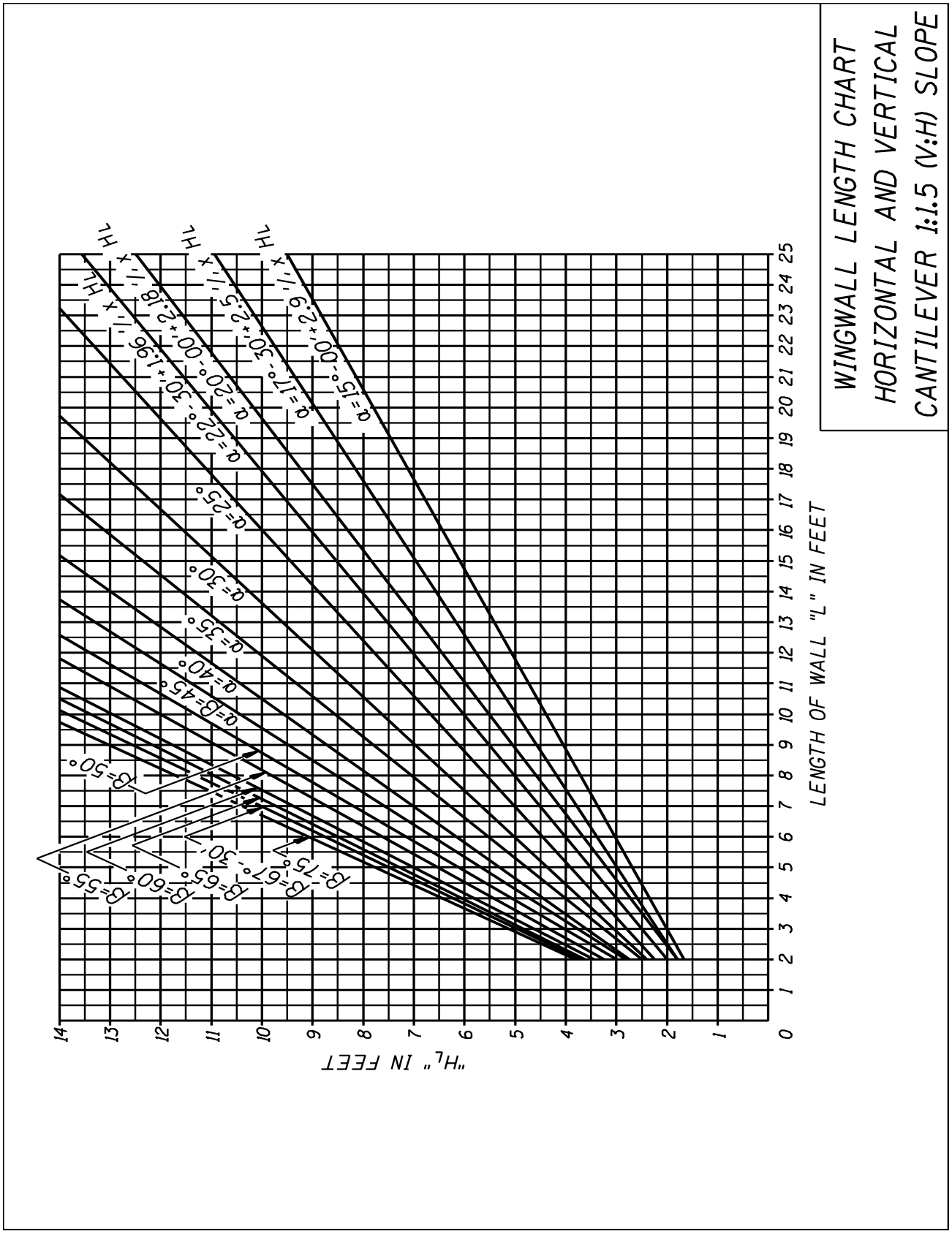

WINGWALL LENGTH CHART
HORIZONTAL AND VERTICAL
CANTILEVER 1:1.5 (V:H) SLOPE
LENGTH OF WALL "L" IN FEET
"HL" IN FEET
HL x 1/1.9
HL x 1/2.3
HL x 1/2.18
HL x 1/1.96
α=15°-00'
α=17°-30'
α=20°-00'
α=22°-30'
α=25°
α=30°
α=35°
α=40°
α=B=45°
β=50°
β=55°
β=60°
β=63°-30'
β=67°-30'
β=75°

Figure 3.1.5-3

3.1.6 Dimensions

The minimum wall thickness of both the L-Type vertical cantilever and the horizontal cantilever wingwalls is 8 inches, and increases in increments of one inch. The minimum footing thickness of the L-Type vertical cantilever wingwall is 10 inches and increases in increments of one inch.

The minimum stem thickness of the T-Type vertical cantilever wingwall is 10 inches and increases in increments of 1/2 inch up to 12 inches. No batter is provided when the stem thickness is equal to or less than 12 inches. The maximum thickness at the top of the stem is 12 inches. For stems requiring thicknesses greater than 12 inches at the base, the stem base thickness is increased in increments of one inch and batter is provided on the back face (the face in contact with the earth), while maintaining constant vertical slope.

The minimum spread footing thickness of the T-Type vertical cantilever wingwall is 18 inches and is increased in increments of 3 inches. In no case is the spread footing thickness less than the stem thickness at the base plus 3 inches.

For pile supported footings on T-Type wingwalls, the minimum thickness shall be 1'-9" and the pile shall be embedded 12 inches. The front row(s) shall be battered if the piles' lateral resistance to sliding is not adequate. The maximum pile spacing shall be as specified in the Bridge Manual Section 3.8, which also establishes required details and design criteria.

3.1.7 Reinforcement Design and Details

The size and spacing of all main reinforcement is given in the tables, with the exception of the horizontal cantilever wingwall reinforcement, which is given in a chart. Unless otherwise shown in the table, all reinforcement lengths shall be given on the drawings to the nearest three inches. The minimum bar lap length shall be as specified in Section 4 and based on the smaller bar size.

In the case of the vertical cantilever wingwalls, it is advisable that the designer draw a large scale sketch of the wingwall to obtain the length of the top vertical reinforcement.

The maximum reinforcement ratio (ρ) used in the design of the wingwalls is limited to approximately one half of $0.75\rho_b$, where ρ_b is the balanced reinforcement ratio.

3.1.8 Headwalls

Figure 3.1.8-1 gives the criteria for determining the depth of headwalls. When the headwalls are far enough removed from the shoulder line so that the slight variation in the fill slope will not be observed, the headwalls may be built at a constant depth. If this is not the case, the headwalls should be constructed parallel to the grade line and a note should be added to the plans stating "Build top of headwalls parallel to grade line".

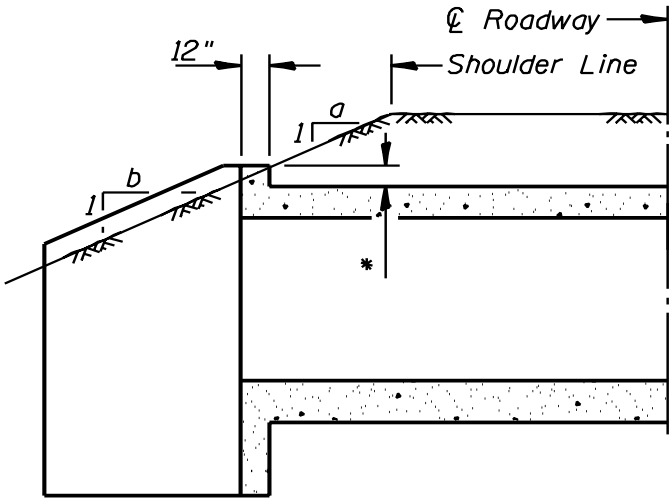
The width of the headwall shall be 12 inches for all wingwall thicknesses, and shall be reinforced as shown in Figure 3.1.8-2. Stirrup reinforcement #4 bars at 12 inches on centers, are to be provided in headwalls when the fill height is less than 2 feet or when the skew angle of the culvert is 30° or greater.

The headwall is reinforced as an edge beam. For fills less than two feet, the headwall is reinforced to support additional moment due to live load given as 0.10 PS (where P is the concentrated wheel load plus impact and S is the design span). For skewed culverts, the edge beam is reinforced to support that half of the slab, including one foot of fill, resulting from the skew.

For fills two feet or more, the headwall is reinforced to support live load moment resulting from one third of the concentrated wheel load, including impact, distributed uniformly over the middle third of the design span. The fill loads are assumed at two feet.

The headwall corner dimensions shown as X, X_1 and X_2 in Figure 3.1.8-3 are listed in the tables in Figures 3.1.8-4 and 3.1.8-5.

Figure 3.1.8-6 shows an example of typical calculations for determining headwall corner dimensions.



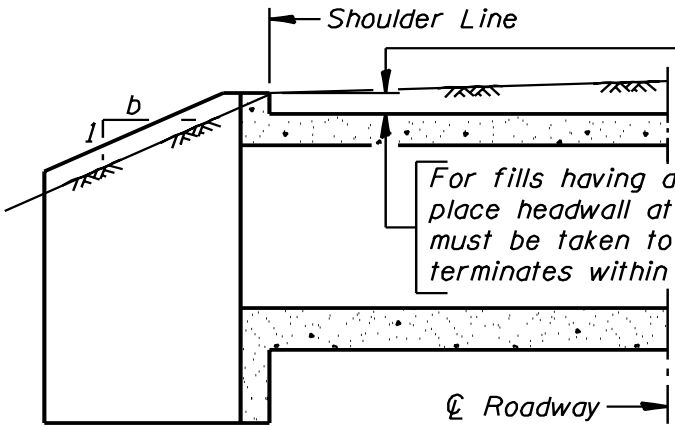
a:1= roadway embankment slope.
b:1= embankment slope for Wingwalls. continuous from top of headwall to flow line.

b=2 when a=2 or more.

When the earth fill at shoulder line is 3" greater than height at headwall, extend the barrel not less than 6".

* Height of headwall to be equal to 1'' per foot of clear span.
Max. height 9''
Min. height 6''
Use increments of $\frac{1}{2}$''

HALF LONGITUDINAL SECTION
THRU CULVERT WITH EXTENDED BARREL
Note: Dimensions at Rt. angles to ℄ Roadway.



Height of headwall to be equal to depth of fill at shoulder line but not less than 1'' per foot of clear span.
Max. height 9"
Min. height 6"
Use increments of $\frac{1}{2}$''

For fills having a depth at shoulder line of 9" or less, place headwall at shoulder line. Appropriate measures must be taken to shield the headwalls when the culvert terminates within the clear zone.

HALF LONGITUDINAL SECTION
THRU CULVERT WITH HEADWALL AT SHOULDER LINE

HEIGHT OF HEADWALLS WHEN LOCATED AT OR OUTSIDE OF SHOULDER LINES

Figure 3.1.8-1

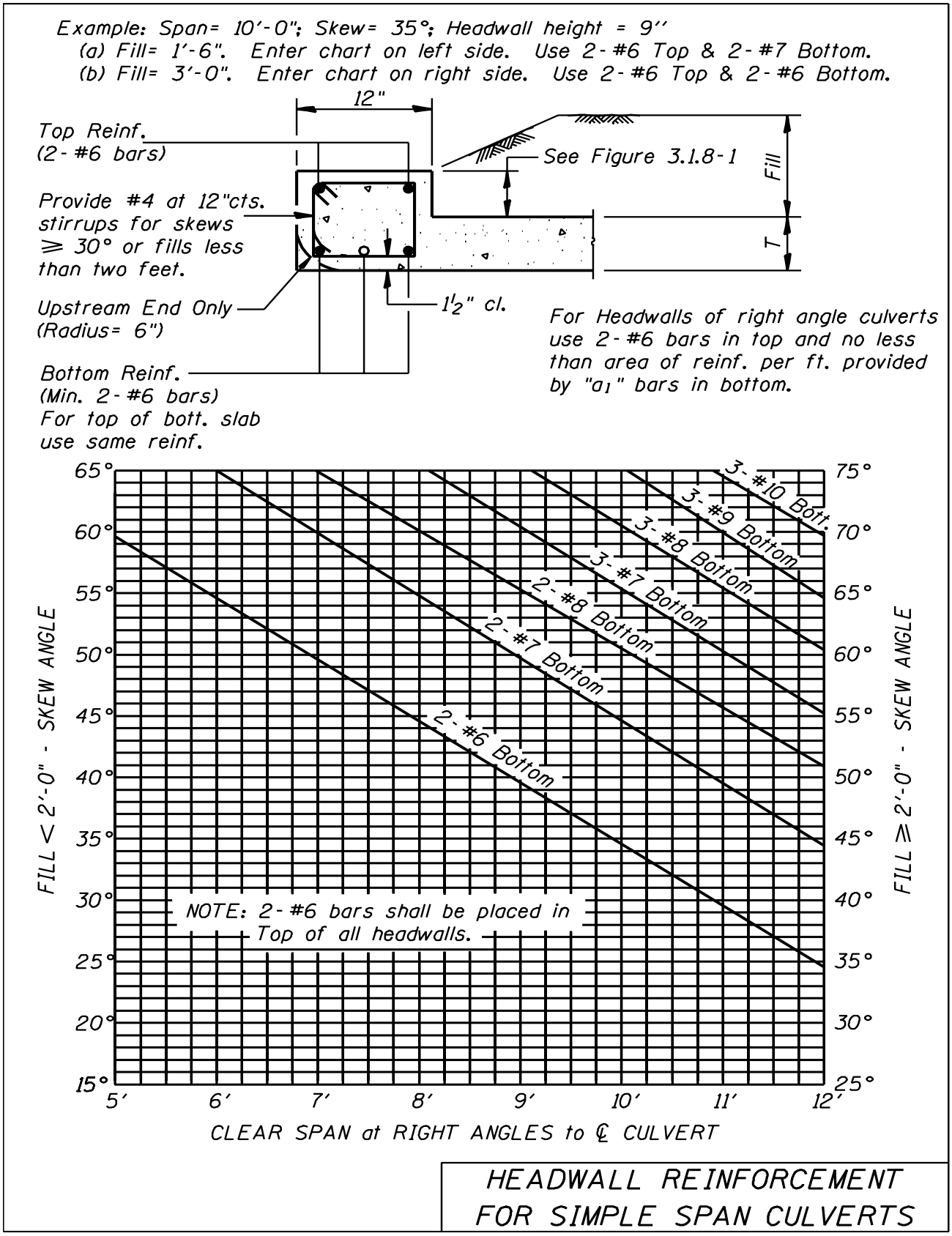

Example: Span= 10'-0"; Skew= 35°; Headwall height = 9''
(a) Fill= 1'-6". Enter chart on left side. Use 2-#6 Top & 2-#7 Bottom.
(b) Fill= 3'-0". Enter chart on right side. Use 2-#6 Top & 2-#6 Bottom.
12"
Top Reinf.
(2-#6 bars)
Provide #4 at 12"cts. stirrups for skews ≥ 30° or fills less than two feet.
Upstream End Only
(Radius= 6")
Bottom Reinf.
(Min. 2-#6 bars)
For top of bott. slab use same reinf.
See Figure 3.1.8-1
Fill
T
1½" cl.
For Headwalls of right angle culverts use 2-#6 bars in top and no less than area of reinf. per ft. provided by "a1" bars in bottom.
3-#10 Bott.
3-#9 Bottom
3-#8 Bottom
3-#7 Bottom
2-#8 Bottom
2-#7 Bottom
2-#6 Bottom
NOTE: 2-#6 bars shall be placed in Top of all headwalls.
FILL < 2'-0" - SKEW ANGLE
FILL ≥ 2'-0" - SKEW ANGLE
65° 60° 55° 50° 45° 40° 35° 30° 25° 20° 15°
75° 70° 65° 60° 55° 50° 45° 40° 35° 30° 25°
5' 6' 7' 8' 9' 10' 11' 12'
CLEAR SPAN at RIGHT ANGLES to ℄ CULVERT
HEADWALL REINFORCEMENT FOR SIMPLE SPAN CULVERTS

Figure 3.1.8-2

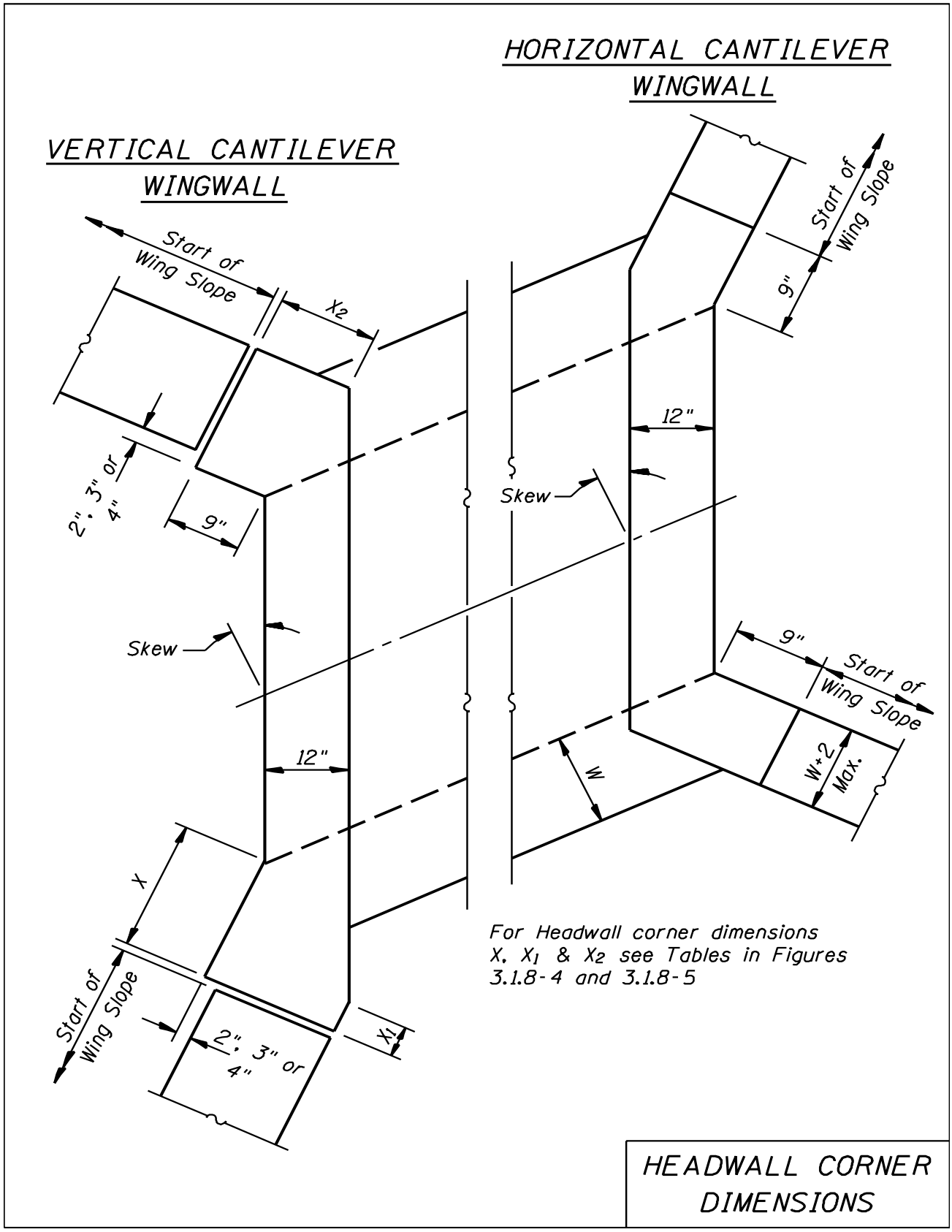

HORIZONTAL CANTILEVER WINGWALL
VERTICAL CANTILEVER WINGWALL
Start of Wing Slope
X2
2", 3" or 4"
9"
12"
Skew
Start of Wing Slope
9"
12"
Skew
9"
Start of Wing Slope
W
W+2 Max.
X
Start of Wing Slope
2", 3" or 4"
X1
For Headwall corner dimensions X, X1 & X2 see Tables in Figures 3.1.8-4 and 3.1.8-5
HEADWALL CORNER DIMENSIONS

Figure 3.1.8-3

HEADWALL CORNER DIMENSIONS

Skew	8" Wing - 12" Hdwl. - 4" Offset			9" Wing - 12" Hdwl. - 3" Offset			10" Wing - 12" Hdwl. - 2" Offset			10 1/2" Wing - 12" Hdwl. - 2" Offset			Skew
	X	X_1	X_2	X	X_1	X_2	X	X_1	X_2	X	X_1	X_2	
0°	9"	1'-2"	1'-2"	9"	1'-2"	1'-2"	9"	1'-2"	1'-2"	9"	1'-1 1/2"	1'-1 1/2"	0°
5°	9"	1'-1 5/8"	1'-2 1/4"	9"	1'-1 5/8"	1'-2 1/4"	9"	1'-1 5/8"	1'-2 1/4"	9"	1'-1 1/8"	1'-1 7/8"	5°
10°	9"	1'-1 3/8"	1'-2 5/8"	9"	1'-1 3/8"	1'-2 5/8"	9"	1'-1 3/8"	1'-2 5/8"	9"	1'-0 3/4"	1'-2 1/8"	10°
15°	9"	1'-1 1/8"	1'-2 7/8"	9"	1'-1 1/8"	1'-2 7/8"	9"	1'-1 1/8"	1'-2 7/8"	9"	1'-0 3/8"	1'-2 1/2"	15°
20°	9"	1'-0 3/4"	1'-3 1/4"	9"	1'-0 3/4"	1'-3 1/4"	9"	1'-0 3/4"	1'-3 1/4"	9"	1'-0 1/8"	1'-2 7/8"	20°
25°	9"	1'-0 1/2"	1'-3 5/8"	9"	1'-0 1/2"	1'-3 5/8"	9"	1'-0 1/2"	1'-3 5/8"	9"	11 3/4"	1'-3 1/4"	25°
30°	9"	1'-0 1/4"	1'-3 7/8"	9"	1'-0 1/4"	1'-3 7/8"	9"	1'-0 1/4"	1'-3 7/8"	9"	11 3/8"	1'-3 5/8"	30°
35°	9"	11 7/8"	1'-4 1/4"	9"	11 7/8"	1'-4 1/4"	9"	11 7/8"	1'-4 1/4"	9"	11"	1'-4"	35°
40°	9"	11 5/8"	1'-4 5/8"	9"	11 5/8"	1'-4 5/8"	9"	11 5/8"	1'-4 5/8"	9"	10 5/8"	1'-4 3/8"	40°
45°	9"	11 3/8"	1'-5"	9"	11 3/8"	1'-5"	9"	11 3/8"	1'-5"	9"	10 1/8"	1'-4 3/4"	45°
50°	9"	11 1/8"	1'-5 3/8"	9"	11 1/8"	1'-5 3/8"	9"	11 1/8"	1'-5 3/8"	9"	9 3/4"	1'-5 1/4"	50°
55°	9"	10 7/8"	1'-5 3/4"	9"	10 7/8"	1'-5 3/4"	9"	10 7/8"	1'-5 3/4"	9"	9 1/4"	1'-5 5/8"	55°
60°	9"	10 5/8"	1'-6 1/4"	9"	10 5/8"	1'-6 1/4"	9"	10 5/8"	1'-6 1/4"	9"	8 3/4"	1'-6 1/8"	60°
65°	9"	10 3/8"	1'-6 5/8"	9"	10 3/8"	1'-6 5/8"	9"	10 3/8"	1'-6 5/8"	9"	8"	1'-6 1/2"	65°

X = 9" min.
X_1 = 4" min.

Figure 3.1.8-4

HEADWALL CORNER DIMENSIONS

Skew	11" Wing - 12" Hdwl - 2" Offset			11 1/2" Wing - 12" Hdwl - 2" Offset			12" Wing - 12" Hdwl - 2" Offset			Skew
	X	X_1	X_2	X	X_1	X_2	X	X_1	X_2	
0°	9"	1'-1"	1'-1"	9"	1'-0 1/2"	1'-0 1/2"	9"	1'-0"	1'-0"	0°
5°	9"	1'-0 5/8"	1'-1 3/8"	9"	1'-0"	1'-0 7/8"	9"	11 1/2"	1'-0 1/2"	5°
10°	9"	1'-0 1/8"	1'-1 3/4"	9"	11 5/8"	1'-1 3/8"	9"	11"	1'-0 7/8"	10°
15°	9"	11 3/4"	1'-2 1/8"	9"	11 1/8"	1'-1 3/4"	9"	10 1/2"	1'-1 3/8"	15°
20°	9"	11 3/8"	1'-2 1/2"	9"	10 5/8"	1'-2 1/4"	9"	9 7/8"	1'-1 7/8"	20°
25°	9"	10 7/8"	1'-3"	9"	10 1/8"	1'-2 5/8"	9"	9 3/8"	1'-2 1/4"	25°
30°	9"	10 1/2"	1'-3 3/8"	9"	9 5/8"	1'-3"	9"	8 3/4"	1'-2 3/4"	30°
35°	9"	10"	1'-3 3/4"	9"	9"	1'-3 1/2"	9"	8 1/8"	1'-3 1/4"	35°
40°	9"	9 1/2"	1'-4 1/8"	9"	8 1/2"	1'-4"	9"	7 3/8"	1'-3 3/4"	40°
45°	9"	9"	1'-4 5/8"	9"	7 3/4"	1'-4 3/8"	9"	6 1/2"	1'- 4 1/4"	45°
50°	9"	8 3/8"	1'-5"	9"	7"	1'-4 7/8"	9"	5 5/8"	1'-4 5/8"	50°
55°	9"	7 5/8"	1'-5 1/2"	9"	6 1/8"	1'-5 3/8"	9"	4 1/2"	1'-5 1/4"	55°
60°	9"	6 7/8"	1'-6"	9"	5"	1'-5 3/4"	9 7/8"	4"	1'-5 5/8"	60°
65°	9"	5 3/4"	1'-6 3/8"	9 1/2"	4"	1'-6 1/4"	11 3/4"	4"	1'-6 1/4"	65°

X = 9" min.
X_1 = 4" min.

Figure 3.1.8-5

DESIGN EXAMPLE

(Typical calculation of headwall corner dimensions)

For condition of 4" offset.

$X = 9"$

$$X_1 = 9" + \frac{12"}{\sin\left(\frac{90°-\theta}{2}\right)} - \frac{T+4"}{\tan\left(\frac{90°-\theta}{2}\right)} \geq 4"$$

$$X_2 = 9" + \frac{12"}{\sin\left(\frac{90°+\theta}{2}\right)} - \frac{T+4"}{\tan\left(\frac{90°+\theta}{2}\right)}$$

For condition where X_1 is computed to be less than or equal to 4", use the following equations:

Set $X_1 = 4"$, and find X as follows:

$$X = 4" + \frac{T+4"}{\tan\left(\frac{90°-\theta}{2}\right)} - \frac{12"}{\sin\left(\frac{90°-\theta}{2}\right)}$$

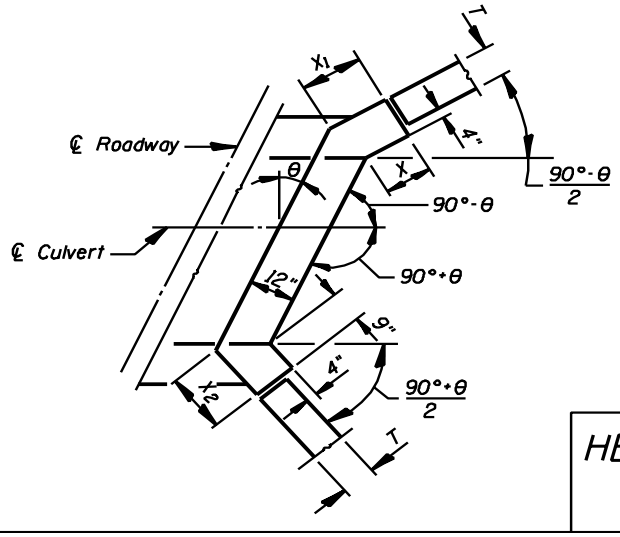
$$X_2 = 9" + \frac{12"}{\sin\left(\frac{90°+\theta}{2}\right)} - \frac{T+4"}{\tan\left(\frac{90°+\theta}{2}\right)}$$

Given: (Skew Angle) $\theta = 30°$, (Wingwall Thickness) $T = 8"$

$X = 9"$

$$X_1 = 9" + \frac{12"}{\sin\left(\frac{90°-30°}{2}\right)} - \frac{8"+4"}{\tan\left(\frac{90°-30°}{2}\right)} = 12.215" \quad \text{Use } 12\tfrac{1}{4}"$$

$$X_2 = 9" + \frac{12"}{\sin\left(\frac{90°+30°}{2}\right)} - \frac{8"+4"}{\tan\left(\frac{90°+30°}{2}\right)} = 15.927" \quad \text{Use } 15\tfrac{7}{8}"$$



HEADWALL DIMENSIONS EXAMPLE

Figure 3.1.8-6

3.2 Horizontal Cantilever

3.2.1 Applications

The horizontal cantilever type wingwall shall be used for culverts requiring wing lengths 14 feet or less, and the design height (h) is 10 feet or less. If the length of any individual wing on a culvert exceeds 14 feet, the horizontal cantilever type wingwalls shall not be used for any wing, except as noted in Section 3.1.3.

3.2.2 Design Chart

The nomenclature used in the presentation of the design chart can be found in Figures 3.2.2-1 and 3.2.2-2. The thickness of the wingwall and required reinforcement shall be obtained from the horizontal wingwall design chart in Figure 3.2.2-3. In no case should the wingwall thickness exceed the barrel sidewall thickness by more than two inches; and if such a condition exists, the portion of barrel wall which must be cast monolithically with the wingwall shall be modified. This portion of the barrel shall be equal to half of the wingwall length, but not less than 6 feet. The termination of the wall thickness curves at the upper end of the chart reflect the use of a maximum reinforcement ratio of one half of $0.75\,\rho_b$.

The area of steel required per foot of wall height, will determine the h_6 or h_8 bar spacing and size. The values for area of steel on the chart are based on assumed bar sizes, and therefore the maximum bars which can be used in design are given below. The minimum primary flexural reinforcement, h_6 or h_8 bars, shall be #4 at 12 inch centers. The h_3 and h_7 bars should be the same size as the h_6 and h_8 bars respectively, and spaced as shown in Figure 3.2.2-1.

AREA OF REINFORCEMENT in^2/ft.	Bar Size
0.2 - 0.29	#4
0.3 - 0.43	#5
0.44 - 0.59	#6
0.6 - 0.79	#7
0.8 - 0.99	#8
1.0 - 1.5	#9

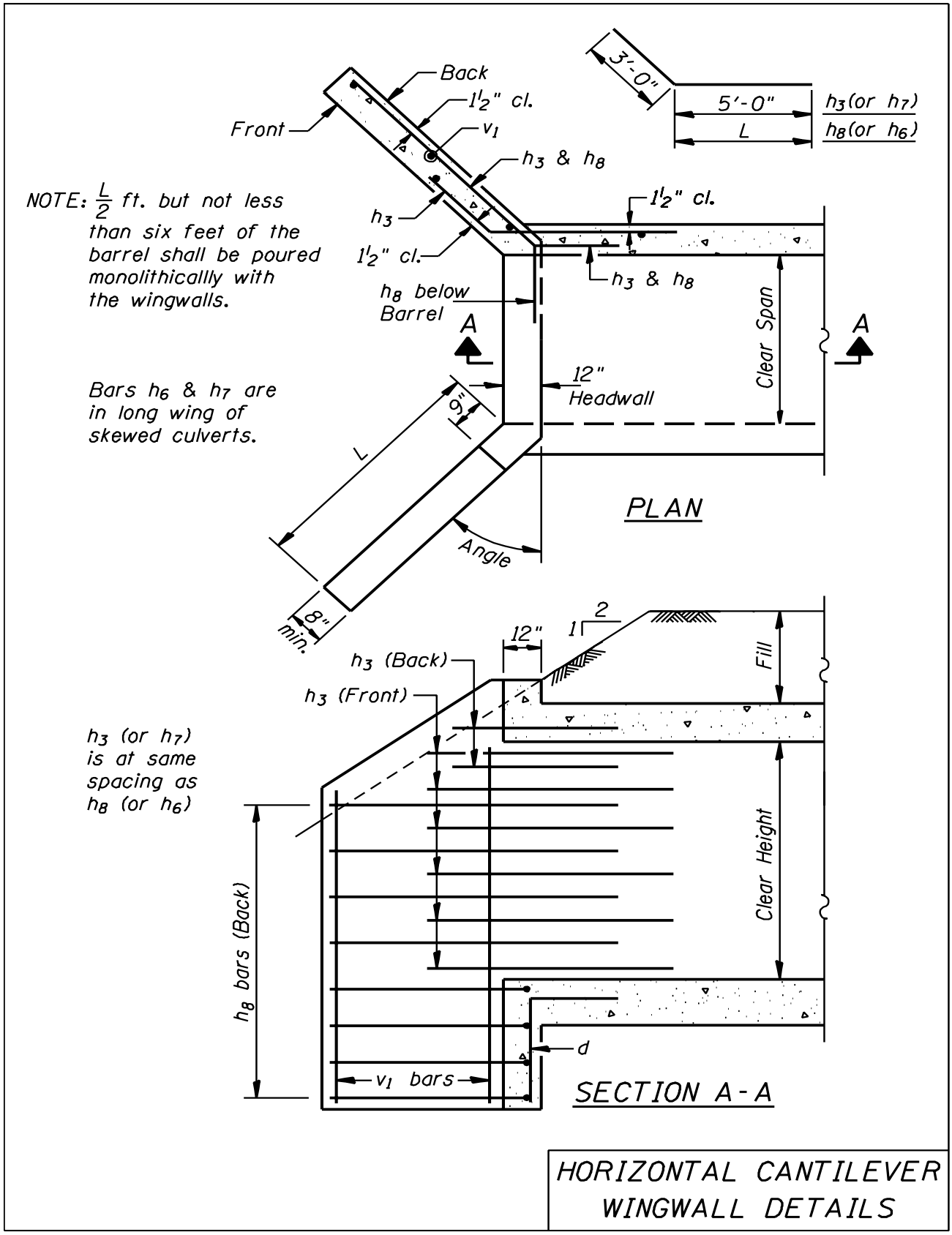
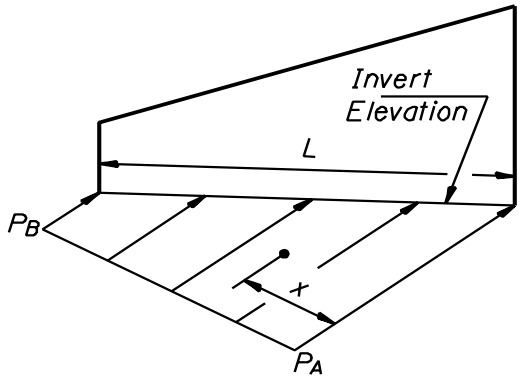

3'-0"
5'-0"
L
h3(or h7)
h8(or h6)
Back
1½" cl.
Front
v1
h3 & h8
NOTE: L/2 ft. but not less than six feet of the barrel shall be poured monolithicallly with the wingwalls.
h3
1½" cl.
1½" cl.
h3 & h8
h8 below Barrel
A
A
Clear Span
12" Headwall
Bars h6 & h7 are in long wing of skewed culverts.
9"
L
PLAN
Angle
8" min.
12"
2
1
h3 (Back)
h3 (Front)
Fill
h3 (or h7) is at same spacing as h8 (or h6)
Clear Height
h8 bars (Back)
d
v1 bars
SECTION A-A
HORIZONTAL CANTILEVER WINGWALL DETAILS

Figure 3.2.2-1



BACK OF WING ELEVATION

F = Force on design strip = $L\left(\frac{P_A + P_B}{2}\right)$

x = distance to resultant of force

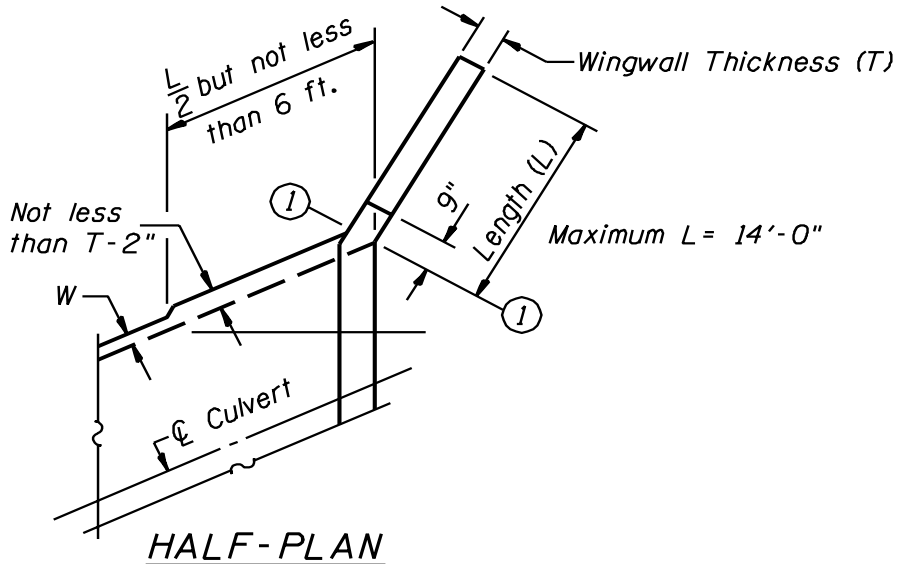
$x = \frac{L}{3}\left(\frac{P_A + 2P_B}{P_A + P_B}\right)$

Factored moment $(M_{1\text{-}1})$ = $(1.3)^2(F)(x)$

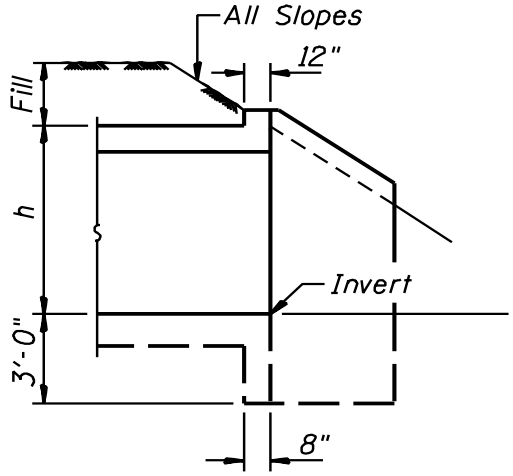
$= \frac{(1.3)^2 L^2}{6}(P_A + 2P_B)$

Letting $C = \frac{(1.3)^2}{6}(P_A + 2P_B)$

Then $M_{1\text{-}1} = CL^2$



HALF-PLAN



SECTION

Area of Reinforcement (sq. in.) is given per foot of wall height. Use same size and spacing of reinforcement bars thru-out full height of wall.

HORIZONTAL CANTILEVER WINGWALL DESIGN

Figure 3.2.2-2

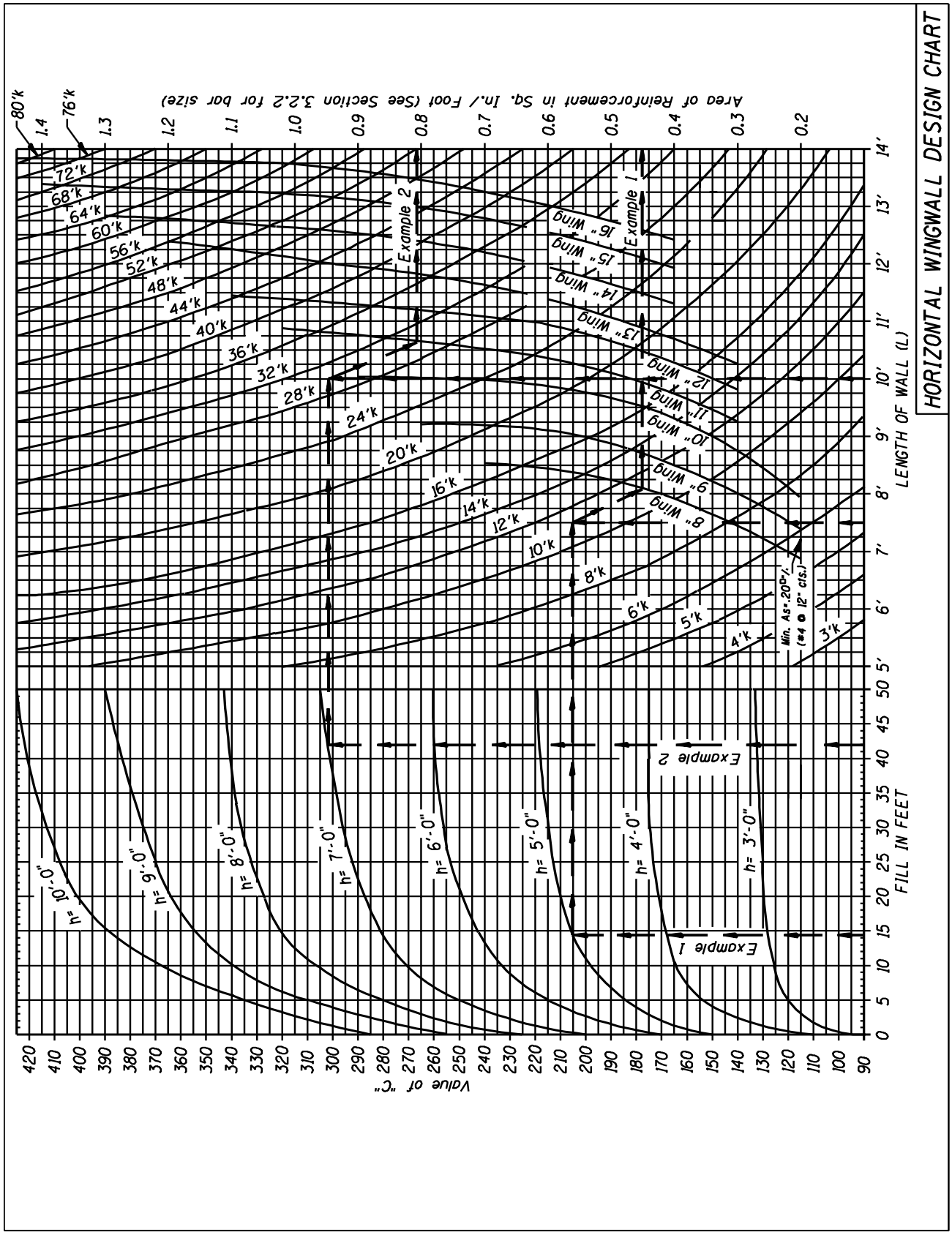

HORIZONTAL WINGWALL DESIGN CHART
LENGTH OF WALL (L)
FILL IN FEET
Value of "C"
Area of Reinforcement in Sq. In./ Foot (See Section 3.2.2 for bar size)
Example 1
Example 2
Min. As=.20b/fy
(#4 @ 12" c/s.)
80'k
76'k
72'k
68'k
64'k
60'k
56'k
52'k
48'k
44'k
40'k
36'k
32'k
28'k
24'k
20'k
16'k
14'k
12'k
10'k
8'k
6'k
5'k
4'k
3'k
16" Wing
15" Wing
14" Wing
13" Wing
12" Wing
11" Wing
10" Wing
9" Wing
8" Wing
h= 10'-0"
h= 9'-0"
h= 8'-0"
h= 7'-0"
h= 6'-0"
h= 5'-0"
h= 4'-0"
h= 3'-0"

Figure 3.2.2-3

3.2.3 Design Examples

Horizontal wingwall design chart.

EXAMPLE 1

GIVEN: Fill = 14.5', h = 5'-0", L = 7'-6"

Enter chart at fill equal to 14.5', project line vertically to line h = 5'-0", extend line horizontally from the intersection of these two lines, to the intersection of vertical length of wall (L = 7'-6") line, and project a line parallel to moment curve. At the intersection of wall thickness curve (8" wing), project a line horizontally to area of reinforcement, and read $A_S = 0.45$ in^2 per foot. Referring to the table above, a #6 bar should be used, making the spacing of h_6 or h_8 bars #6 @ 11" cts.

EXAMPLE 2

GIVEN: Fill = 42.0', h = 7'-0", L = 10'-0"

Enter charts at fill = 42.0', vertically to h = 7'-0", and horizontally to L = 10'-0". At the intersection of these two lines draw a line parallel to moment curve; at intersection of first wall thickness curve (11" wing), and project a line horizontally to A_S = 0.805 in^2 per foot. Referring to the table above, a #8 bar should be used, making the spacing of h_6 or h_8 bars, #8 @ 11" cts.

EXAMPLE 3 (Not shown on Design Chart)

GIVEN: Fill = 2'-0", h = 3'-0", L = 9'-0"

Enter at fill = 2'-0", vertically to h = 3'-0", then horizontally to L = 9'-0". At the intersection of these two lines, draw a line parallel to the moment curve. At the intersection of 8" wall thickness curve (most economical wing), project a line horizontally to A_S = 0.34 in^2 per foot.

EXAMPLE 4 (Not shown on Design Chart)

GIVEN: Fill = 10'-0", h = 3'-0", L = 12'-0"

Enter at fill = 10'-0", vertically to h = 3'-0", then horizontally to L = 12'-0". At the intersection of these two lines, draw a line parallel to the moment curve. At the intersection of 9" wall thickness curve (most economical wing), project a line horizontally to $A_S = 0.6$ in^2 per foot. (Note that 8" wall thickness curve cannot be used since it terminates at $A_S = 0.7$ in^2, and therefore will not be intersected).

3.3 Vertical Cantilever L-Type

3.3.1 Applications

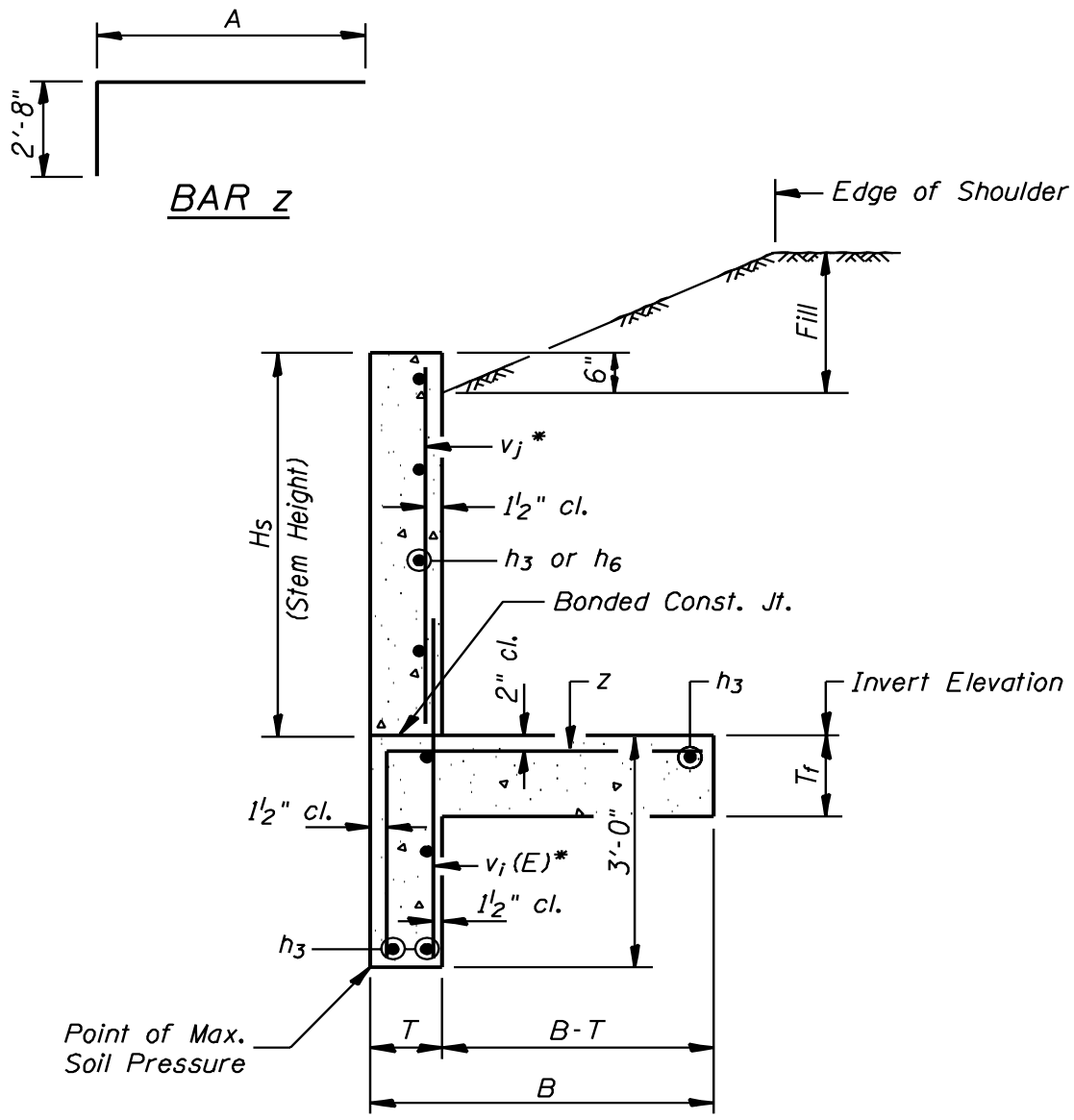
The L-Type vertical cantilever wingwall shall be used when the required length of any of the culvert wingwalls is greater than 14 feet, and the soil will support the footing pressure indicated. See Sections 3.1.3 and 3.1.4 for limitations.

3.3.2 Table Use

The cross sectional dimensions, and size and spacing of main reinforcement bars required for the L-Type wingwalls are tabulated in the design tables in Section 3.3.4. The use of these tables are predicated on the determination of two factors; the stem height (H_S) and the fill height (see Figure 3.3.2-1).

The stem height (H_S) as shown in Figure 3.3.2-1, is the vertical distance from the top of the stem to the invert, or top of footing. In the case of the ordinary wingwall which has a variable stem height, it is not necessary to design for the absolute maximum of the stem height. In this case, it is safe to assume the stem height (H_S) at a horizontal distance of 1'-6" from the joint. A simpler method to approximate this stem height is obtained by adding the clear height of the barrel to the top slab thickness and the headwall height and then subtracting an amount (1" to 6 1/2") to obtain an even six-inch increment. The fill height is obtained by subtracting the design stem height from the shoulder to invert dimension, and then adding the distance from the top of the stem to the ground line at the back face of the stem (approximately 6 inches).

Figure 3.3.2-1 shows the nomenclature used in the presentation of the tables. It should be noted that in the case of the v-bars, subscripts “i” and “j” have been used so that those subscripts can assume individual values on the plans for various groups of bars, e.g., v_5, v_6, v_2, etc. The v_j bars should be furnished in groups of equal length bars, each group to be of a length that will fit within the slope of the top of the wingwall, and at the same time, not cause a bar lap of less than the minimum reinforcement bar laps as shown in Section 4.



* Note:
The subscripts "i" and "j" are variables. These can assume individual values as shown on the plans such as v_1, v_2, v_3, ...etc.

L-TYPE VERTICAL CANTILEVER WINGWALLS

Figure 3.3.2-1

3.3.3 Design Example

Given: 6' x 4' Simple Span Box

Top Slab = 6", Shoulder to Invert = 15.5'

Compute Design Stem Height

Clear Height of barrel	= 4'-0"
Thickness of top slab	= + 6"
Headwall	= + 6"
	5'-0"
Subtract (1" to 6 1/2")	- 6"
Design Stem Height (H_S)	= 4'-6"

Compute Fill

Shoulder to Invert	= 15.5'
Design Stem Height (H_S)	= - 4.5
	= 11.0'
Top of Stem to ground line (6")	+ .5
Fill Height	= 11.5'

The fill of 11'-6" is between the limits of 10'-0" and 20'-0".
From the tables for stem height (H_s) = 4'-6" and a fill of 20'-0", find the following:

Stem thickness = T = 8"

Footing width - Stem thickness = B - T = 2'-10"

Footing thickness = T_f =10"

Stem Reinforcement:

v_i(E) bars: #4 @ 12"

v_j bars: Not required

Footing reinforcement:

z bars: #4 @ 12"

A dimension (Horizontal leg) = 3'-3"

Total length = 5'-11"

Maximum soil pressure = 1,930 psf

Check this maximum soil pressure with that allowed for the encountered soil conditions. If the allowable bearing capacity of the soil is less than the maximum soil pressure given in the tables, the wingwall should be considered a special structural design problem and, therefore, submitted to the Bureau of Bridges and Structures for analysis.

The location of maximum soil pressure given in the tables, is located at the lowest corner of the front face of the L-Type wall.

3.3.4 Design Tables

VERTICAL CANTILEVER L-TYPE WINGWALLS

STEM HEIGHT	FILL	STEM	FOOTING			v_i(E) BARS			v_j BARS		z BARS				MAX. SOIL PRESSURE AT TOE
		T	B	B-T	T_f	SIZE	SPACING	LENGTH	SIZE	SPACING	SIZE	SPACING	A	LENGTH	
	Ft.	In.	Ft.-In.	Ft.-In.	In.		In.	Ft.-In.		In.		In.	Ft.-In.	Ft.-In.	Lbs. per Sq. Ft.
H_S = 3'-0"	0.0	8.0	2- 5	1- 9	10.0	4	12	-	-	-	4	12	2- 2	4-10	1094
	5.0	8.0	2- 5	1- 9	10.0	4	12	-	-	-	4	12	2- 2	4-10	1371
	10.0	8.0	2- 6	1-10	10.0	4	12	-	-	-	4	12	2- 3	4-11	1396
	20.0	8.0	2- 6	1-10	10.0	4	12	-	-	-	4	12	2- 3	4-11	1445
	30.0	8.0	2- 7	1-11	10.0	4	12	-	-	-	4	12	2- 4	5- 0	1425
	40.0	8.0	2- 7	1-11	10.0	4	12	-	-	-	4	12	2- 4	5- 0	1436
	50.0	8.0	2- 7	1-11	10.0	4	12	-	-	-	4	12	2- 4	5- 0	1442
H_S = 3'-6"	0.0	8.0	2- 8	2- 0	10.0	4	12	-	-	-	4	12	2- 5	5- 1	1199
	5.0	8.0	2- 9	2- 1	10.0	4	12	-	-	-	4	12	2- 6	5- 2	1501
	10.0	8.0	2- 9	2- 1	10.0	4	12	-	-	-	4	12	2- 6	5- 2	1581
	20.0	8.0	2-10	2- 2	10.0	4	12	-	-	-	4	12	2- 7	5- 3	1604
	30.0	8.0	2-11	2- 3	10.0	4	12	-	-	-	4	12	2- 8	5- 4	1591
	40.0	8.0	2-11	2- 3	10.0	4	12	-	-	-	4	12	2- 8	5- 4	1605
	50.0	8.0	2-11	2- 3	10.0	4	12	-	-	-	4	12	2- 8	5- 4	1614
H_S = 4'-0"	0.0	8.0	2-11	2- 3	10.0	4	12	-	-	-	4	12	2- 8	5- 4	1310
	5.0	8.0	3- 0	2- 4	10.0	4	12	-	-	-	4	12	2- 9	5- 5	1669
	10.0	8.0	3- 1	2- 5	10.0	4	12	-	-	-	4	12	2-10	5- 6	1728
	20.0	8.0	3- 2	2- 6	10.0	4	12	-	-	-	4	12	2-11	5- 7	1766
	30.0	8.0	3- 3	2- 7	10.0	4	12	-	-	-	4	12	3- 0	5- 8	1760
	40.0	8.0	3- 3	2- 7	10.0	4	12	-	-	-	4	12	3- 0	5- 8	1779
	50.0	8.0	3- 3	2- 7	10.0	4	12	-	-	-	4	12	3- 0	5- 8	1791

VERTICAL CANTILEVER L-TYPE WINGWALLS

STEM HEIGHT	FILL	STEM	FOOTING			$v_i(E)$ BARS			v_j BARS		Z BARS				MAX. SOIL PRESSURE AT TOE
		T	B	B-T	T_f	SIZE	SPACING	LENGTH	SIZE	SPACING	SIZE	SPACING	A	LENGTH	
	Ft.	In.	Ft.-In.	Ft.-In.	In.		In.	Ft.-In.		In.		In.	Ft.-In.	Ft.-In.	Lbs. per Sq. Ft.
H_S = 4'-6"	0.0	8.0	3- 2	2- 6	10.0	4	12	-	-	-	4	12	2-11	5- 7	1424
	5.0	8.0	3- 4	2- 8	10.0	4	12	-	-	-	4	12	3- 1	5- 9	1796
	10.0	8.0	3- 5	2- 9	10.0	4	12	-	-	-	4	12	3- 2	5-10	1876
	20.0	8.0	3- 6	2-10	10.0	4	12	-	-	-	4	12	3- 3	5-11	1930
	30.0	8.0	3- 7	2-11	10.0	4	12	-	-	-	4	12	3- 4	6- 0	1931
	40.0	8.0	3- 7	2-11	10.0	4	12	-	-	-	4	12	3- 4	6- 0	1956
	50.0	8.0	3- 8	3- 0	10.0	4	12	-	-	-	4	12	3- 5	6- 1	1930
H_S = 5'-0"	0.0	8.0	3- 6	2-10	10.0	4	12	-	-	-	4	12	3- 3	5-11	1509
	5.0	8.0	3- 8	3- 0	10.0	4	12	-	-	-	4	12	3- 5	6- 1	1923
	10.0	8.0	3- 9	3- 1	10.0	4	12	-	-	-	4	12	3- 6	6- 2	2025
	20.0	8.0	3-10	3- 2	10.0	4	12	-	-	-	4	12	3- 7	6- 3	2094
	30.0	8.0	3-11	3- 3	10.0	4	12	-	-	-	4	12	3- 8	6- 4	2104
	40.0	8.0	3-11	3- 3	10.0	4	12	-	-	-	4	12	3- 8	6- 4	2134
	50.0	8.0	4- 0	3- 4	10.0	4	12	-	-	-	4	12	3- 9	6- 5	2111
H_S = 5'-6"	0.0	8.0	3- 9	3- 1	10.0	4	12	-	-	-	4	12	3- 6	6- 2	1628
	5.0	8.0	3-11	3- 3	10.0	4	12	-	-	-	4	12	3- 8	6- 4	2091
	10.0	8.0	4- 1	3- 5	10.0	4	12	-	-	-	4	10	3-10	6- 6	2176
	20.0	8.0	4- 2	3- 6	10.0	4	12	-	-	-	4	10	3-11	6- 7	2259
	30.0	8.0	4- 3	3- 7	10.0	4	12	-	-	-	4	9	4- 0	6- 8	2278
	40.0	8.0	4- 4	3- 8	10.0	4	12	-	-	-	4	9	4- 1	6- 9	2271
	50.0	8.0	4- 4	3- 8	10.0	4	12	-	-	-	4	9	4- 1	6- 9	2294

VERTICAL CANTILEVER L-TYPE WINGWALLS

STEM HEIGHT	FILL	STEM	FOOTING			v_i(E) BARS			v_j BARS		z BARS				MAX. SOIL PRESSURE AT TOE
		T	B	B-T	T_f	SIZE	SPACING	LENGTH	SIZE	SPACING	SIZE	SPACING	A	LENGTH	
	Ft.	In.	Ft.-In.	Ft.-In.	In.		In.	Ft.-In.		In.		In.	Ft.-In.	Ft.-In.	Lbs. per Sq. Ft.
H_S = 6'-0"	0.0	8.0	4- 0	3- 4	10.0	4	12	-	-	-	4	12	3- 9	6- 5	1749
	5.0	8.0	4- 3	3- 7	10.0	4	12	-	-	-	4	9	4- 0	6- 8	2225
	10.0	8.0	4- 5	3- 9	10.0	4	12	-	-	-	4	8	4- 2	6-10	2315
	20.0	8.0	4- 6	3-10	10.0	4	12	-	-	-	5	12	4- 3	6-11	2424
	30.0	8.0	4- 7	3-11	10.0	4	12	-	-	-	5	11	4- 4	7- 0	2452
	40.0	8.0	4- 8	4- 0	10.0	4	12	-	-	-	5	10	4- 5	7- 1	2451
	50.0	8.0	4- 8	4- 0	10.0	4	12	-	-	-	5	10	4- 5	7- 1	2478
H_S = 6'-6"	0.0	8.0	4- 5	3- 9	10.0	4	12	-	-	-	4	9	4- 2	6-10	1809
	5.0	8.0	4- 7	3-11	10.0	4	12	-	-	-	5	10	4- 4	7- 0	2351
	10.0	8.0	4- 8	4- 0	10.0	4	12	-	-	-	5	10	4- 5	7- 1	2508
	20.0	8.0	4-10	4- 2	10.0	4	12	-	-	-	5	9	4- 7	7- 3	2589
	30.0	8.0	4-11	4- 3	10.0	4	12	-	-	-	5	9	4- 8	7- 4	2626
	40.0	8.0	5- 0	4- 4	10.0	4	12	-	-	-	6	12	4- 9	7- 5	2631
	50.0	8.0	5- 0	4- 4	10.0	4	12	-	-	-	6	12	4- 9	7- 5	2662
H_S = 7'-0"	0.0	8.0	4- 9	4- 1	10.0	4	12	-	-	-	5	10	4- 6	7- 2	1903
	5.0	8.0	4-11	4- 3	10.0	4	12	-	-	-	6	12	4- 8	7- 4	2479
	10.0	8.0	5- 0	4- 4	10.0	4	12	-	-	-	6	11	4- 9	7- 5	2655
	20.0	8.0	5- 2	4- 6	10.0	4	10	-	-	-	6	10	4-11	7- 7	2753
	30.0	8.0	5- 3	4- 7	10.0	4	10	-	-	-	6	10	5- 0	7- 8	2800
	40.0	8.0	5- 4	4- 8	10.0	4	10	-	-	-	6	9	5- 1	7- 9	2811
	50.0	8.0	5- 4	4- 8	10.0	4	10	-	-	-	6	9	5- 1	7- 9	2847

VERTICAL CANTILEVER L-TYPE WINGWALLS

STEM HEIGHT	FILL	STEM	FOOTING			v_i(E) BARS			v_j BARS		z BARS				MAX. SOIL PRESSURE AT TOE
		T	B	B-T	T_f	SIZE	SPACING	LENGTH	SIZE	SPACING	SIZE	SPACING	A	LENGTH	
	Ft.	In.	Ft.-In.	Ft.-In.	In.		In.	Ft.-In.		In.		In.	Ft.-In.	Ft.-In.	Lbs. per Sq. Ft.
H_S = 7'-9"	0.0	8.0	5- 2	4- 6	10.0	4	12	4- 9	4	12	6	12	4-11	7- 7	1969
	5.0	8.0	5- 3	4- 7	10.0	4	12	4- 9	4	12	6	9	5- 0	7- 8	2609
	10.0	8.0	5- 4	4- 8	10.0	4	10	4- 9	4	10	6	9	5- 1	7- 9	2799
	20.0	8.0	5- 6	4-10	10.0	4	9	4- 9	4	9	7	11	5- 3	7-11	2917
	30.0	8.0	5- 7	4-11	10.0	4	8	4- 9	4	8	7	11	5- 4	8- 0	2974
	40.0	8.0	5- 8	5- 0	10.0	4	8	4- 9	4	8	7	10	5- 5	8- 1	2991
	50.0	8.0	5- 8	5- 0	10.0	4	8	4- 9	4	8	7	10	5- 5	8- 1	3032
H_S = 8'-0"	0.0	8.0	5- 6	4-10	10.0	4	12	4- 9	4	12	6	9	5- 3	7-11	2065
	5.0	8.0	5- 6	4-10	10.0	4	9	4- 9	4	9	7	11	5- 3	7-11	2778
	10.0	8.0	5- 8	5- 0	10.0	4	8	4- 9	4	8	7	10	5- 5	8- 1	2941
	20.0	8.0	5-10	5- 2	10.0	5	11	5- 3	4	11	7	9	5- 7	8- 3	3081
	30.0	8.0	5-11	5- 3	10.0	5	11	5- 3	4	11	7	9	5- 8	8- 4	3147
	40.0	8.0	6- 0	5- 4	10.0	5	10	5- 3	4	10	7	8	5- 9	8- 5	3171
	50.0	8.0	6- 1	5- 5	10.0	5	10	5- 3	4	10	7	8	5-10	8- 6	3173
H_S = 8'-9"	0.0	8.0	5-11	5- 3	10.0	4	10	4- 9	4	10	7	10	5- 8	8- 4	2136
	5.0	8.0	5-11	5- 3	10.0	4	8	4- 9	4	8	7	8	5- 8	8- 4	2873
	10.0	8.0	5-11	5- 3	10.0	5	10	5- 3	4	10	7	8	5- 8	8- 4	3124
	20.0	9.0	6- 2	5- 5	11.0	5	11	5- 3	4	11	7	9	5-11	8- 7	3300

VERTICAL CANTILEVER L-TYPE WINGWALLS

STEM HEIGHT	FILL	STEM	FOOTING			v_i(E) BARS			v_j BARS		z BARS				MAX. SOIL PRESSURE AT TOE
		T	B	B-T	T_f	SIZE	SPACING	LENGTH	SIZE	SPACING	SIZE	SPACING	A	LENGTH	
	Ft.	In.	Ft.-In.	Ft.-In.	In.		In.	Ft.-In.		In.		In.	Ft.-In.	Ft.-In.	Lbs. per Sq. Ft.
H_S = 9'-0"	0.0	8.0	6- 3	5- 7	10.0	4	9	4- 9	4	9	7	8	6- 0	8- 8	2234
	5.0	9.0	6- 3	5- 6	11.0	5	12	5- 3	4	12	7	8	6- 0	8- 8	3060
	10.0	9.0	6- 4	5- 7	11.0	5	10	5- 3	4	10	7	8	6- 1	8- 9	3276
	20.0	9.0	6- 6	5- 9	11.0	5	9	5- 3	5	9	7	7	6- 3	8-11	3462

3.4 Vertical Cantilever T-Type

3.4.1 Applications

The T-type vertical cantilever wingwall shall be used when the required length of any of the culvert wingwalls is greater than 14 feet. See Sections 3.1.3 and 3.1.4 for limitations.

3.4.2 Table Use

The cross sectional dimensions, and size and spacing of reinforcement bars required for the T-type vertical cantilever wingwall, are tabulated in the design tables in Section 3.4.5. The use of these tables is predicated on the determination of design height (H_D) and fill height, shown in Figure 3.4.2-2.

The design height (H_D) is the vertical distance from the bottom of the footing to the point of intersection of the embankment slope and backface of the wing stem. In the case of the ordinary wingwall which has a variable stem height, it is safe to assume the design height at a horizontal distance of 1'-6" from the joint. A simpler method to approximate this design height is obtained by adding the clear height of the barrel, top slab thickness and the distance below invert to the bottom of footing (4'-0"), and then subtracting an amount (1" to 6 1/2") to obtain an even six-inch increment.

Figure 3.4.2-2 shows the nomenclature used in the presentation of the tables. The v_j bars should be furnished in groups of equal length bars, each group to be of a length that will fit within the slope on the top of the wingwall, and at the same time, provide an adequate bar lap as shown in Section 4.

It should also be noted that in some instances, especially with higher walls and fills, 2 dowel bars (n(E) & n_1(E)) are used. When this condition exists, both bars shall be used, labeled separately and placed alternately at one half the indicated spacing. One of the reinforcement arrangements shown in Figure 3.4.2-1 will be obtained from the tables for any particular T-type wingwall.

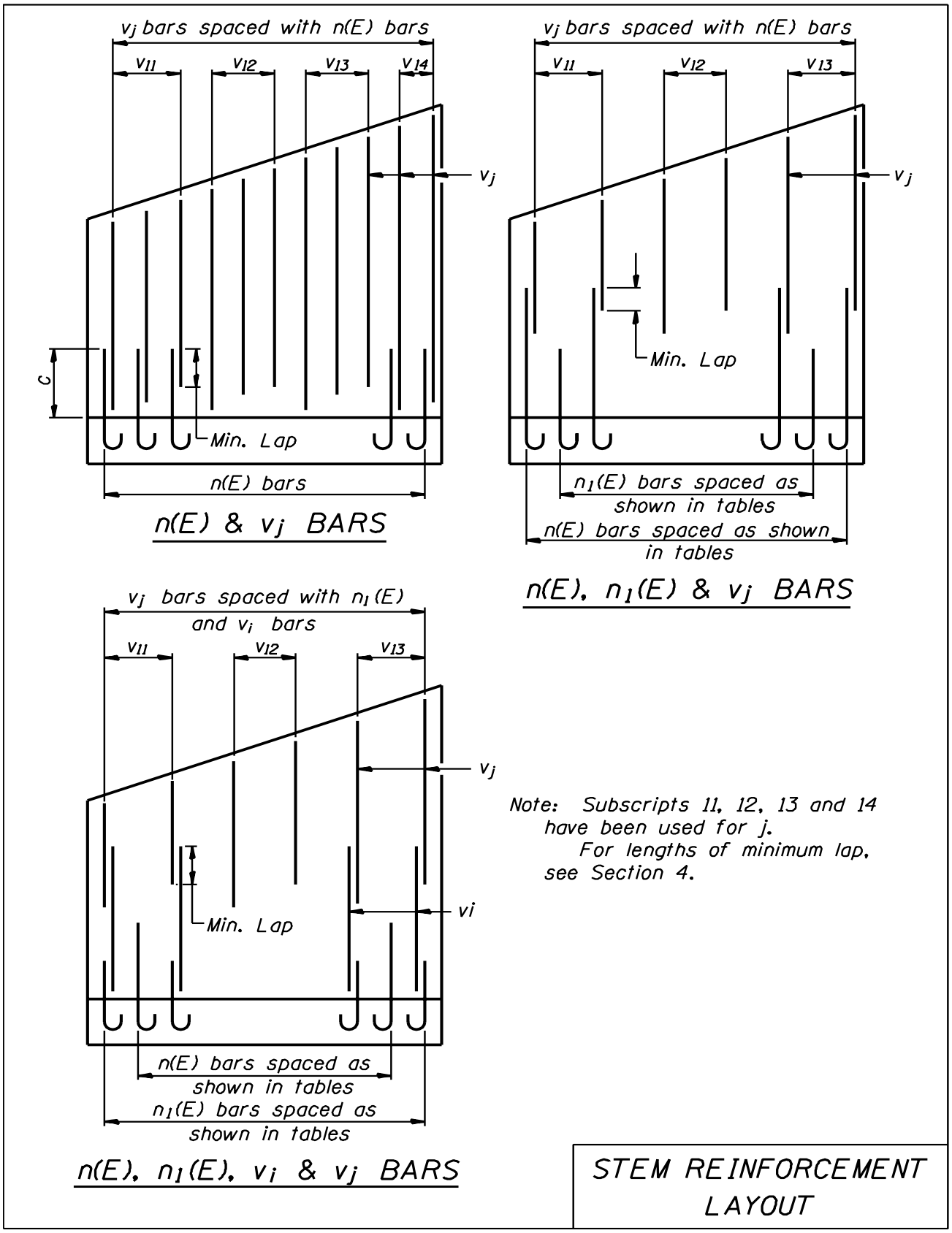

vj bars spaced with n(E) bars
v11
v12
v13
v14
vj
c
Min. Lap
n(E) bars
n(E) & vj BARS
vj bars spaced with n(E) bars
v11
v12
v13
vj
Min. Lap
n1(E) bars spaced as shown in tables
n(E) bars spaced as shown in tables
n(E), n1(E) & vj BARS
vj bars spaced with n1(E) and vi bars
v11
v12
v13
vj
vi
Min. Lap
n(E) bars spaced as shown in tables
n1(E) bars spaced as shown in tables
n(E), n1(E), vi & vj BARS
Note: Subscripts 11, 12, 13 and 14 have been used for j.
For lengths of minimum lap, see Section 4.
STEM REINFORCEMENT LAYOUT

Figure 3.4.2-1

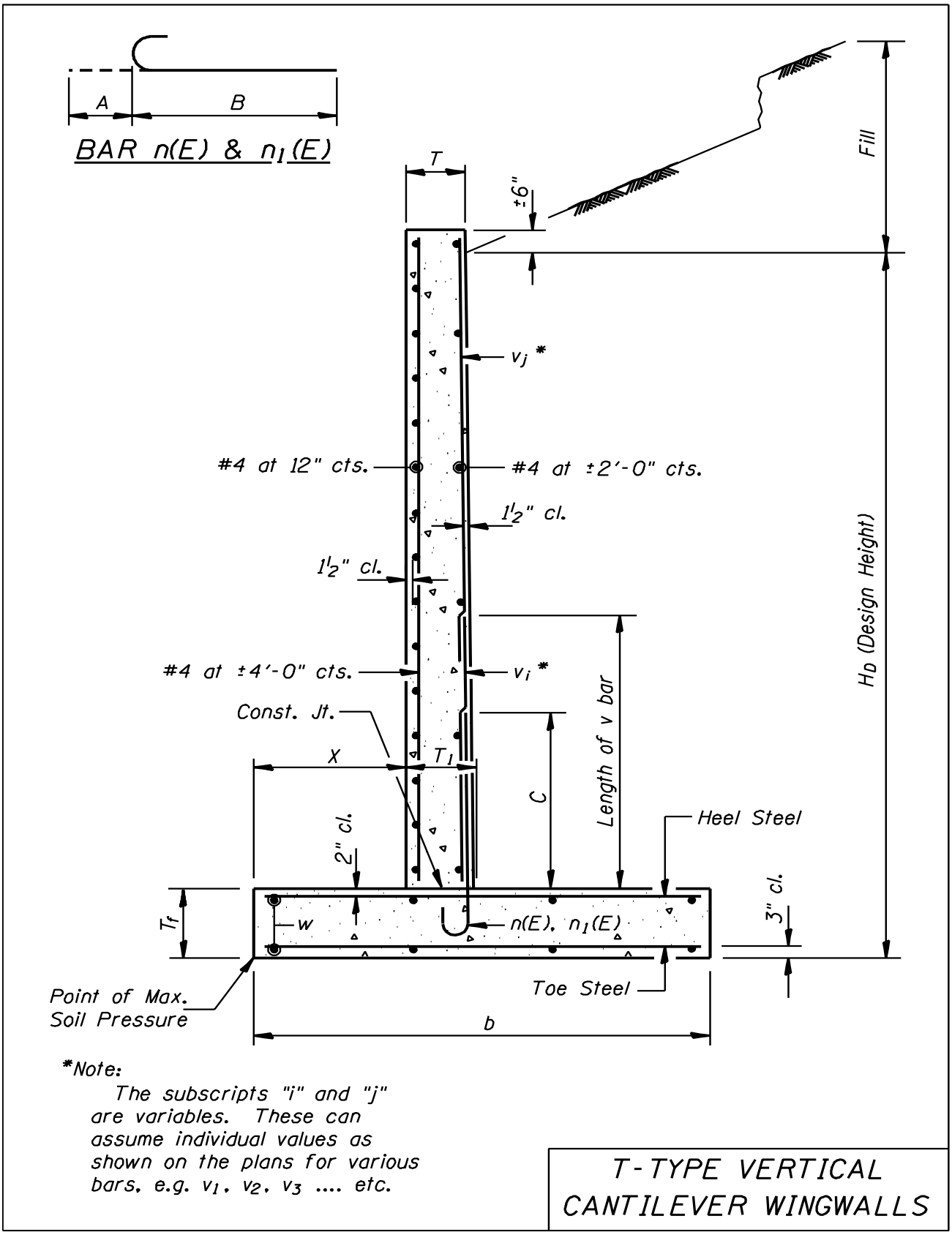

A
B
BAR n(E) & n1(E)
T
±6"
Fill
vj *
#4 at 12" cts.
#4 at ±2'-0" cts.
1½" cl.
1½" cl.
HD (Design Height)
#4 at ±4'-0" cts.
vi *
Const. Jt.
X
T1
C
Length of v bar
Heel Steel
2" cl.
Tf
w
n(E), n1(E)
3" cl.
Toe Steel
Point of Max.
Soil Pressure
b
*Note:
The subscripts "i" and "j" are variables. These can assume individual values as shown on the plans for various bars. e.g. v1, v2, v3 .... etc.
T-TYPE VERTICAL
CANTILEVER WINGWALLS

Figure 3.4.2-2

3.4.3 Barrel Cutoff Wall

While excavating for the footing of the T-type wingwalls, it is possible that the corner of the bottom slab, which has previously been poured, would be undermined. To avoid this possibility, the barrel cutoff wall has been returned along the edges of the barrel as shown in Figure 3.4.3-1. The length of this return cutoff wall is a function of two variables; (1) the skew angle, and (2) the width of footing. This length shall be determined from the chart in Figure 3.4.3-1 to the nearest 3 inches.

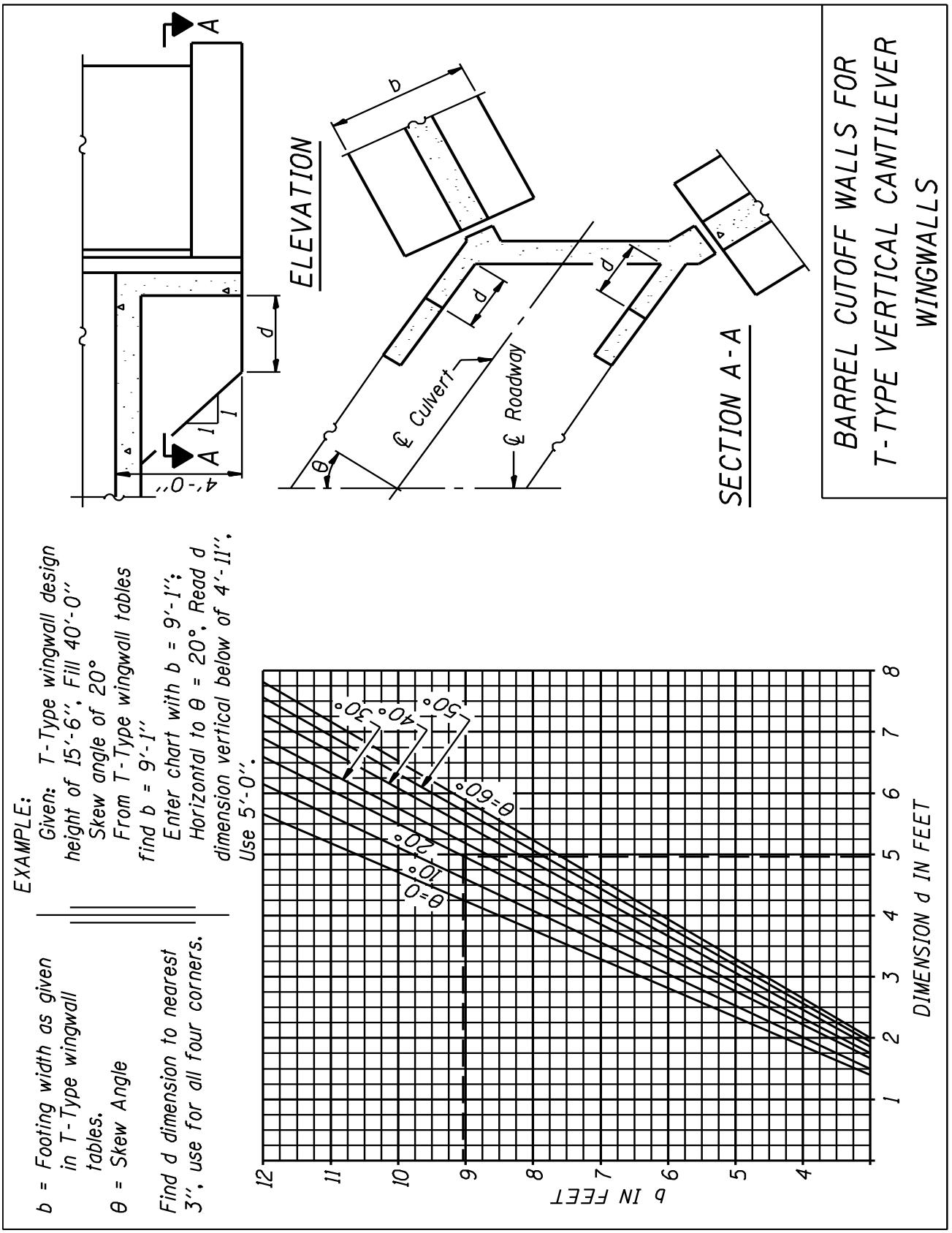

BARREL CUTOFF WALLS FOR
T-TYPE VERTICAL CANTILEVER
WINGWALLS
ELEVATION
SECTION A-A
A
A
1
1
4'-0"
d
b
d
d
d
θ
℄ Culvert
℄ Roadway
EXAMPLE:
Given: T-Type wingwall design
height of 15'-6", Fill 40'-0"
Skew angle of 20°
From T-Type wingwall tables
find b = 9'-1"
Enter chart with b = 9'-1";
Horizontal to θ = 20°, Read d
dimension vertical below of 4'-11",
Use 5'-0".
b = Footing width as given
in T-Type wingwall
tables.
θ = Skew Angle
Find d dimension to nearest
3", use for all four corners.
θ=0°
10°
20°
θ=60°
40°
50°
b IN FEET
DIMENSION d IN FEET
12
11
10
9
8
7
6
5
4
1
2
3
4
5
6
7
8

Figure 3.4.3-1

3.4.4 Design Example

Given: 12' x 10' Simple Span Box,

(Top Slab Thickness = 22"), Shoulder to Invert = 48.32'

Compute Design Height:

Clear Height	= 10'-0"
Top Slab (22")	= + 1'-10"
From Invert to bottom of footing	= + 4'-0"
	15'-10"
Subtract (1" to 6 1/2")	- 4"
Design Height (H_D)	= 15'-6"

Compute Fill:

Shoulder to Invert	= 48.32'
From Invert to bottom of footing	= + 4.00
	52.32
Design Height	= - 15.50'
Fill	36.82'

The fill of 36.82' is between the limits of 35'-0" and 40'-0".

From the tables for the design height of 15'-6" and fill of 40'-0" find the following:

Stem thickness at top	=	T =	12"
Stem thickness at bottom	=	T_1 =	13"
Footing thickness	=	T_f =	1'-6"
Footing width	=	b =	9'-1"
Toe dimension	=	X =	3'-0"

Dowel bars

n(E) and n_1(E) bars #7 @ 10" cts and #6 @ 10" cts

Stem Reinforcement

v_i bars #5 @ 10" cts

v_j bars #4 @ 10" cts (same spacing as v_i bars and n_1(E) bars)

Footing Reinforcement

t bars	#6 at 11" cts Heel (top)
	#6 at 12" cts toe (bottom)
	length 8'-10"

Maximum Soil Pressure (toe) 3,849 psf.

Check this maximum soil pressure with that allowed for the encountered soil conditions. If the allowable bearing capacity of the soil is less than the maximum soil pressure given in the table, the wingwall should then be considered a special structural design problem, and, therefore, submitted to the Bureau of Bridges and Structures for analysis.

Depending on the available soil boring data, it may be necessary to investigate the use of piles. This condition is not to be handled through the use of these tables and also should be considered a special structural design problem and submitted to the Bureau of Bridges and Structures for analysis.

3.4.5 Design Tables

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 8' - 6"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	10.0	10.0	1-6	4- 6	1- 6	4 -	12 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 3	1514
2.5	10.0	10.0	1-6	4- 6	1- 6	4 -	12 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 3	1832
5.0	10.0	10.0	1-6	4- 6	1- 6	4 -	12 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 3	2008
7.5	10.0	10.0	1-6	4- 6	1- 6	4 -	12 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 3	2159
10.0	10.0	10.0	1-6	4- 6	1- 6	4 -	12 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 3	2264
15.0	10.0	10.0	1-6	4- 7	1- 6	4 -	12 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 4	2356
20.0	10.0	10.0	1-6	4- 8	1- 6	4 -	12 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 5	2394
25.0	10.0	10.0	1-6	4- 9	1- 7	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 6	2346
30.0	10.0	10.0	1-6	4- 9	1- 7	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 6	2393
35.0	10.0	10.0	1-6	4-10	1- 7	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 7	2382
40.0	10.0	10.0	1-6	4-10	1- 7	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 7	2412
45.0	10.0	10.0	1-6	4-11	1- 7	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 8	2389
50.0	10.0	10.0	1-6	5- 0	1- 8	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 9	2303

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 9' - 0"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	10.0	10.0	1-6	4-10	1- 7	4 -	12 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 7	1562
2.5	10.0	10.0	1-6	4-10	1- 7	4 -	12 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 7	1899
5.0	10.0	10.0	1-6	4-10	1- 7	4 -	12 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 7	2075
7.5	10.0	10.0	1-6	4-10	1- 7	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 7	2224
10.0	10.0	10.0	1-6	4-10	1- 7	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 7	2340
15.0	10.0	10.0	1-6	4-10	1- 7	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 7	2489
20.0	10.0	10.0	1-6	4-11	1- 7	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 8	2534
25.0	10.0	10.0	1-6	5- 0	1- 8	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 9	2491
30.0	10.0	10.0	1-6	5- 0	1- 8	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4- 9	2543
35.0	10.0	10.0	1-6	5- 1	1- 8	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4-10	2535
40.0	10.0	10.0	1-6	5- 2	1- 8	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4-11	2520
45.0	10.0	10.0	1-6	5- 4	1- 9	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	5- 1	2397
50.0	10.0	10.0	1-6	5- 4	1- 9	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	5- 1	2418

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 9' - 6"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	10.0	10.0	1-6	5- 1	1- 8	4 -	12 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4-10	1642
2.5	10.0	10.0	1-6	5- 1	1- 8	4 -	12 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4-10	1999
5.0	10.0	10.0	1-6	5- 1	1- 8	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4-10	2176
7.5	10.0	10.0	1-6	5- 1	1- 8	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4-10	2333
10.0	10.0	10.0	1-6	5- 1	1- 8	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	4-10	2460
15.0	10.0	10.0	1-6	5- 2	1- 8	5 -	12 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	4-11	2573
20.0	10.0	10.0	1-6	5- 3	1- 9	5 -	12 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 0	2562
25.0	10.0	10.0	1-6	5- 3	1- 9	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 0	2635
30.0	10.0	10.0	1-6	5- 4	1- 9	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 1	2643
35.0	10.0	10.0	1-6	5- 5	1- 9	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 2	2639
40.0	10.0	10.0	1-6	5- 7	1-10	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 4	2524
45.0	10.0	10.0	1-6	5- 8	1-10	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 5	2509
50.0	10.0	10.0	1-6	5- 8	1-10	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 5	2532

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 10' - 0"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft. - In.	Ft. - In.	Ft. - In.		In.	Ft. - In.	Ft. - In.	Ft. - In.		In.	Ft. - In.			In.	In.	Ft. - In.	
0.0	10.0	10.0	1-6	5- 4	1- 9	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	5- 1	1722
2.5	10.0	10.0	1-6	5- 4	1- 9	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	5- 1	2093
5.0	10.0	10.0	1-6	5- 4	1- 9	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	5- 1	2276
7.5	10.0	10.0	1-6	5- 4	1- 9	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 1	2440
10.0	10.0	10.0	1-6	5- 4	1- 9	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 1	2576
15.0	10.0	10.0	1-6	5- 5	1- 9	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 2	2704
20.0	10.0	10.0	1-6	5- 6	1-10	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 3	2699
25.0	10.0	10.0	1-6	5- 6	1-10	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 3	2778
30.0	10.0	10.0	1-6	5- 7	1-10	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 4	2790
35.0	10.0	10.0	1-6	5- 9	1-11	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 6	2681
40.0	10.0	10.0	1-6	5-10	1-11	6 -	12 -	0- 8 -	3- 8 -	2-6 -	-	-	-	4	4	12	12	5- 7	2674
45.0	10.0	10.0	1-6	5-11	1-11	6 -	12 -	0- 8 -	3- 8 -	2-6 -	-	-	-	4	4	12	12	5- 8	2661
50.0	10.0	10.0	1-6	6- 1	2- 0	6 -	12 -	0- 8 -	3- 8 -	2-6 -	-	-	-	4	4	12	12	5-10	2546

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 10' - 6"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	10.0	10.0	1-6	5- 7	1-10	4 -	9 -	0- 6 -	2-11 -	1-9 -	-	-	-	4	4	12	12	5- 4	1802
2.5	10.0	10.0	1-6	5- 7	1-10	5 -	12 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 4	2215
5.0	10.0	10.0	1-6	5- 7	1-10	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 4	2377
7.5	10.0	10.0	1-6	5- 7	1-10	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 4	2547
10.0	10.0	10.0	1-6	5- 7	1-10	5 -	10 -	0- 7 -	3- 8 -	2-6 -	-	-	-	4	4	12	12	5- 4	2691
15.0	10.0	10.0	1-6	5- 8	1-10	6 -	12 -	0- 8 -	3-11 -	2-9 -	-	-	-	4	4	12	12	5- 5	2834
20.0	10.0	10.0	1-6	5- 9	1-11	6 -	10 -	0- 8 -	3-11 -	2-9 -	-	-	-	4	4	12	12	5- 6	2835
25.0	10.0	10.0	1-6	5-10	1-11	6 -	10 -	0- 8 -	4- 2 -	3-0 -	-	-	-	4	4	12	12	5- 7	2870
30.0	10.0	10.0	1-6	5-11	1-11	6 -	10 -	0- 8 -	4- 2 -	3-0 -	-	-	-	4	4	12	12	5- 8	2887
35.0	10.0	10.0	1-6	6- 1	2- 0	6 -	10 -	0- 8 -	4- 2 -	3-0 -	-	-	-	4	4	12	12	5-10	2784
40.0	10.0	10.0	1-6	6- 2	2- 0	6 -	10 -	0- 8 -	4- 2 -	3-0 -	-	-	-	4	4	12	12	5-11	2781
45.0	10.0	10.0	1-6	6- 4	2- 1	6 -	10 -	0- 8 -	4- 2 -	3-0 -	-	-	-	4	4	12	12	6- 1	2671
50.0	10.0	10.0	1-6	6- 5	2- 1	6 -	10 -	0- 8 -	4- 2 -	3-0 -	-	-	-	4	4	12	12	6- 2	2659

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 11' - 0"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft. - In.	Ft. - In.	Ft. - In.		In.	Ft. - In.	Ft. - In.	Ft. - In.		In.	Ft. - In.			In.	In.	Ft. - In.	
0.0	10.0	10.0	1-6	5-11	1-11	5 -	12 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 8	1850
2.5	10.0	10.0	1-6	5-11	1-11	5 -	10 -	0- 7 -	3- 5 -	2-3 -	-	-	-	4	4	12	12	5- 8	2311
5.0	10.0	10.0	1-6	5-11	1-11	5 -	10 -	0- 7 -	3- 8 -	2-6 -	-	-	-	4	4	12	12	5- 8	2438
7.5	10.0	10.0	1-6	5-11	1-11	6 -	10 -	0- 8 -	4- 2 -	3-0 -	-	-	-	4	4	12	12	5- 8	2609
10.0	10.0	10.0	1-6	5-11	1-11	6 -	10 -	0- 8 -	4- 2 -	3-0 -	-	-	-	4	4	12	12	5- 8	2756
15.0	10.0	10.0	1-6	5-11	1-11	6 -	10 -	0- 8 -	4- 5 -	3-3 -	-	-	-	4	4	12	12	5- 8	2963
20.0	10.0	10.0	1-6	6- 0	2- 0	6 -	10 -	0- 8 -	4- 5 -	3-3 -	-	-	-	4	4	12	10	5- 9	2969
25.0	10.0	10.0	1-6	6- 1	2- 0	6 -	10 -	0- 8 -	4- 8 -	3-6 -	-	-	-	4	4	12	10	5-10	3010
30.0	10.0	10.0	1-6	6- 2	2- 0	6 -	10 -	0- 8 -	4- 8 -	3-6 -	-	-	-	4	4	12	10	5-11	3031
35.0	10.0	10.0	1-6	6- 4	2- 1	6 -	9 -	0- 8 -	4- 8 -	3-6 -	-	-	-	4	4	12	10	6- 1	2930
40.0	10.0	10.0	1-6	6- 7	2- 2	6 -	9 -	0- 8 -	4- 8 -	3-6 -	-	-	-	4	4	10	10	6- 4	2786
45.0	10.0	10.0	1-6	6- 8	2- 2	6 -	9 -	0- 8 -	4- 8 -	3-6 -	-	-	-	4	4	10	10	6- 5	2780
50.0	10.0	10.0	1-6	6- 9	2- 3	6 -	9 -	0- 8 -	4- 8 -	3-6 -	-	-	-	4	4	10	10	6- 6	2713

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 11' - 6"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	10.0	10.0	1-6	6- 2	2- 0	5	10	0- 7	3- 5	2-3	-	-	-	4	4	12	12	5-11	1930
						-	-	-	-	-									
2.5	10.0	10.0	1-6	6- 2	2- 0	5	10	0- 7	3- 8	2-6	-	-	-	4	4	12	12	5-11	2434
						-	-	-	-	-									
5.0	10.0	10.0	1-6	6- 2	2- 0	6	10	0- 8	4- 5	3-3	-	-	-	4	4	12	12	5-11	2539
						-	-	-	-	-									
7.5	10.0	10.0	1-6	6- 2	2- 0	6	10	0- 8	4- 8	3-6	-	-	-	4	4	12	12	5-11	2713
						-	-	-	-	-									
10.0	10.0	10.0	1-6	6- 2	2- 0	6	10	0- 8	4- 8	3-6	-	-	-	4	4	12	12	5-11	2867
						-	-	-	-	-									
15.0	10.0	10.0	1-6	6- 3	2- 1	6	9	0- 8	4-11	3-9	-	-	-	4	4	12	10	6- 0	2981
						-	-	-	-	-									
20.0	10.0	10.0	1-6	6- 3	2- 1	6	9	0- 8	4-11	3-9	-	-	-	4	4	12	10	6- 0	3103
						-	-	-	-	-									
25.0	10.0	10.0	1-6	6- 4	2- 1	6	9	0- 8	5- 2	4-0	-	-	-	4	4	12	10	6- 1	3149
						-	-	-	-	-									
30.0	10.0	10.0	1-6	6- 6	2- 2	6	9	0- 8	5- 2	4-0	-	-	-	4	4	10	10	6- 3	3064
						-	-	-	-	-									
35.0	10.0	10.0	1-6	6- 8	2- 2	6	12	0- 8	5- 2	4-0	-	-	-	4	4	10	10	6- 5	3031
						4	12	0- 6	2- 5	1-3									
40.0	10.0	10.0	1-6	6-10	2- 3	6	12	0- 8	5- 2	4-0	-	-	-	4	4	10	10	6- 7	2932
						4	12	0- 6	2-11	1-9									
45.0	10.0	10.0	1-6	6-11	2- 3	6	12	0- 8	5- 2	4-0	-	-	-	4	4	9	10	6- 8	2928
						4	12	0- 6	2-11	1-9									
50.0	10.0	10.0	1-6	7- 1	2- 4	6	11	0- 8	5- 2	4-0	-	-	-	4	4	9	9	6-10	2824
						4	11	0- 6	2- 8	1-6									

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 12' - 0"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	10.0	10.0	1-6	6- 5	2- 1	6 -	12 -	0- 8 -	4- 2 -	3-0 -	-	-	-	4	4	12	12	6- 2	2010
2.5	10.0	10.0	1-6	6- 5	2- 1	6 -	10 -	0- 8 -	4- 5 -	3-3 -	-	-	-	4	4	10	12	6- 2	2556
5.0	10.0	10.0	1-6	6- 5	2- 1	6 -	10 -	0- 8 -	4-11 -	3-9 -	-	-	-	4	4	10	12	6- 2	2639
7.5	10.0	10.0	1-6	6- 5	2- 1	6 -	9 -	0- 8 -	4-11 -	3-9 -	-	-	-	4	4	10	10	6- 2	2818
10.0	10.0	10.0	1-6	6- 5	2- 1	6 -	9 -	0- 8 -	5- 2 -	4-0 -	-	-	-	4	4	10	10	6- 2	2976
15.0	10.0	10.0	1-6	6- 6	2- 2	6 4	12 12	0- 8 0- 6	5- 5 2-11	4-3 1-9	-	-	-	4	4	10	10	6- 3	3085
20.0	10.0	10.0	1-6	6- 7	2- 2	6 4	11 11	0- 8 0- 6	5- 5 2-11	4-3 1-9	-	-	-	4	4	10	9	6- 4	3187
25.0	10.0	10.0	1-6	6- 8	2- 2	6 4	11 11	0- 8 0- 6	5- 8 2-11	4-6 1-9	-	-	-	4	4	10	9	6- 5	3238
30.0	10.0	10.0	1-6	6-10	2- 3	6 4	11 11	0- 8 0- 6	5- 8 2-11	4-6 1-9	-	-	-	4	4	9	9	6- 7	3159
35.0	10.0	10.0	1-6	6-11	2- 3	6 5	12 12	0- 8 0- 7	5- 8 3- 5	4-6 2-3	-	-	-	4	4	9	9	6- 8	3175
40.0	10.0	10.0	1-6	7- 2	2- 4	6 5	11 11	0- 8 0- 7	5- 8 3- 2	4-6 2-0	-	-	-	4	4	8	9	6-11	3036
45.0	10.0	10.0	1-6	7- 4	2- 5	6 5	11 11	0- 8 0- 7	5- 8 3- 2	4-6 2-0	-	-	-	4	4	8	8	7- 1	2939
50.0	10.0	10.0	1-6	7- 5	2- 5	6 5	11 11	0- 8 0- 7	5- 8 3- 2	4-6 2-0	-	-	-	4	4	8	8	7- 2	2933

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 12' - 6"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	10.0	10.0	1-6	6- 8	2- 2	6 -	10 -	0- 8 -	4- 8 -	3-6 -	-	-	-	4	4	10	12	6- 5	2089
2.5	10.0	10.0	1-6	6- 8	2- 2	6 -	10 -	0- 8 -	4-11 -	3-9 -	-	-	-	4	4	9	10	6- 5	2680
5.0	10.0	10.0	1-6	6- 8	2- 2	6 -	9 -	0- 8 -	5- 2 -	4-0 -	-	-	-	4	4	9	10	6- 5	2739
7.5	10.0	10.0	1-6	6- 8	2- 2	6 4	12 12	0- 8 0- 6	5- 5 2-11	4-3 1-9	-	-	-	4	4	9	10	6- 5	2931
10.0	10.0	10.0	1-6	6- 8	2- 2	6 4	11 11	0- 8 0- 6	5- 8 2-11	4-6 1-9	-	-	-	4	4	9	10	6- 5	3084
15.0	10.0	10.0	1-6	6- 9	2- 3	6 5	11 11	0- 8 0- 7	4- 8 3- 2	3-6 2-0	-	-	-	5	4	9	9	6- 6	3211
20.0	10.0	10.0	1-6	6-10	2- 3	6 5	11 11	0- 8 0- 7	4-11 3- 5	3-9 2-3	-	-	-	5	4	9	8	6- 7	3319
25.0	10.0	10.0	1-6	6-11	2- 3	6 5	11 11	0- 8 0- 7	4-11 3- 5	3-9 2-3	-	-	-	5	4	8	8	6- 8	3374
30.0	10.0	10.0	1-6	7- 1	2- 4	6 5	10 10	0- 8 0- 7	4-11 3- 5	3-9 2-3	-	-	-	5	4	8	8	6-10	3299
35.0	10.0	10.0	1-6	7- 4	2- 5	6 5	10 10	0- 8 0- 7	5- 2 3- 5	4-0 2-3	-	-	-	5	4	8	8	7- 1	3170
40.0	10.0	10.0	1-6	7- 5	2- 5	6 5	10 10	0- 8 0- 7	5- 2 3- 5	4-0 2-3	-	-	-	5	4	8	8	7- 2	3179
45.0	10.0	10.0	1-6	7- 7	2- 6	6 5	10 10	0- 8 0- 7	5- 2 3- 5	4-0 2-3	-	-	-	5	4	8	8	7- 4	3083
50.0	10.0	10.0	1-6	7- 9	2- 7	6 5	10 10	0- 8 0- 7	5- 2 3- 5	4-0 2-3	-	-	-	5	4	8	8	7- 6	2986

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 13' - 0"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.- In.	Ft.- In.	Ft.- In.		In.	Ft.- In.	Ft.- In.	Ft.- In.		In.	Ft.- In.			In.	In.	Ft.- In.	
0.0	10.0	10.0	1-6	6-11	2- 3	6 -	10 -	0- 8 -	5- 2 -	4-0 -	-	-	-	4	4	9	12	6- 8	2169
2.5	10.0	10.0	1-6	7- 0	2- 4	6 -	9 -	0- 8 -	5- 5 -	4-3 -	-	-	-	4	4	8	10	6- 9	2715
5.0	10.0	10.0	1-6	7- 0	2- 4	6 4	11 11	0- 8 0- 6	5- 8 2-11	4-6 1-9	-	-	-	4	4	8	10	6- 9	2748
7.5	10.0	10.0	1-6	7- 0	2- 4	6 5	12 12	0- 8 0- 7	4-11 3- 8	3-9 2-6	-	-	-	5	4	8	9	6- 9	2933
10.0	10.0	10.0	1-6	7- 0	2- 4	6 5	11 11	0- 8 0- 7	4-11 3- 5	3-9 2-3	-	-	-	5	4	8	8	6- 9	3087
15.0	10.0	10.0	1-6	7- 0	2- 4	6 5	10 10	0- 8 0- 7	5- 2 3- 5	4-0 2-3	-	-	-	5	4	8	8	6- 9	3334
20.0	10.0	10.0	1-6	7- 1	2- 4	6 5	10 10	0- 8 0- 7	5- 5 3- 8	4-3 2-6	-	-	-	5	4	8	8	6-10	3450
25.0	10.0	10.0	1-6	7- 2	2- 4	6 5	10 10	0- 8 0- 7	5- 5 3- 8	4-3 2-6	-	-	-	5	4	8	8	6-11	3510
30.0	10.5	10.5	1-6	7- 5	2- 5	6 5	10 10	0- 8 0- 7	5- 5 3- 8	4-3 2-6	-	-	-	5	4	8	8	7- 2	3382
35.0	10.5	10.5	1-6	7- 7	2- 6	6 5	10 10	0- 8 0- 7	5- 5 3- 8	4-3 2-6	-	-	-	5	4	8	8	7- 4	3301
40.0	10.5	10.5	1-6	7- 8	2- 6	6 5	10 10	0- 8 0- 7	5- 5 3- 8	4-3 2-6	-	-	-	5	4	8	8	7- 5	3313
45.0	10.5	10.5	1-6	7-11	2- 7	6 5	10 10	0- 8 0- 7	5- 5 3- 8	4-3 2-6	-	-	-	5	4	8	8	7- 8	3179
50.0	10.5	10.5	1-6	8- 1	2- 8	6 5	10 10	0- 8 0- 7	5- 5 3- 8	4-3 2-6	-	-	-	5	5	12	12	7-10	3085

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 13' - 6"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	10.0	10.0	1-6	7- 3	2- 5	6	9	0- 8	5- 8	4-6	-	-	-	4	4	8	10	7- 0	2180
						-	-	-	-	-									
2.5	10.0	10.0	1-6	7- 3	2- 5	6	11	0- 8	4- 8	3-6	-	-	-	5	4	8	9	7- 0	2837
						4	11	0- 6	2-11	1-9									
5.0	10.0	10.0	1-6	7- 3	2- 5	6	11	0- 8	4-11	3-9	-	-	-	5	4	8	9	7- 0	2848
						5	11	0- 7	3- 5	2-3									
7.5	10.0	10.0	1-6	7- 3	2- 5	6	10	0- 8	5- 2	4-0	-	-	-	5	4	8	8	7- 0	3033
						5	10	0- 7	3- 5	2-3									
10.0	10.0	10.0	1-6	7- 3	2- 5	6	10	0- 8	5- 5	4-3	-	-	-	5	4	8	8	7- 0	3194
						5	10	0- 7	3- 8	2-6									
15.0	10.0	10.0	1-6	7- 3	2- 5	6	9	0- 8	5- 8	4-6	-	-	-	5	4	8	8	7- 0	3455
						5	9	0- 7	3- 8	2-6									
20.0	10.0	10.0	1-6	7- 4	2- 5	6	9	0- 8	4-11	3-9	5	9	5-6	4	4	8	8	7- 1	3580
						5	9	0- 7	2-11	1-9									
25.0	10.5	10.5	1-6	7- 5	2- 5	6	9	0- 8	5- 8	4-6	-	-	-	5	4	8	8	7- 2	3635
						5	9	0- 7	3- 8	2-6									
30.0	10.5	10.5	1-6	7- 8	2- 6	6	9	0- 8	4-11	3-9	5	9	5-6	4	4	8	8	7- 5	3520
						5	9	0- 7	2-11	1-9									
35.0	10.5	10.5	1-6	7-10	2- 7	6	9	0- 8	5- 2	4-0	5	9	5-6	4	4	8	8	7- 7	3441
						5	9	0- 7	2-11	1-9									
40.0	10.5	10.5	1-6	8- 1	2- 8	6	9	0- 8	5- 2	4-0	5	9	5-9	4	5	11	12	7-10	3315
						5	9	0- 7	2-11	1-9									
45.0	10.5	10.5	1-6	8- 2	2- 8	7	11	0-10	6- 2	5-0	-	-	-	5	5	11	12	7-11	3322
						6	11	0- 8	3- 8	2-6									
50.0	11.0	11.0	1-6	8- 4	2- 9	6	9	0- 8	5- 8	4-6	-	-	-	5	5	10	12	8- 1	3220
						5	9	0- 7	3- 8	2-6									

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 14' - 0"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	10.0	10.0	1-6	7- 6	2- 6	6	11	0- 8	4-11	3-9	-	-	-	5	4	8	10	7- 3	2259
						4	11	0- 6	3- 2	2-0									
2.5	10.0	10.0	1-6	7- 7	2- 6	6	11	0- 8	5- 2	4-0	-	-	-	5	4	8	8	7- 4	2935
						5	11	0- 7	3- 5	2-3									
5.0	10.0	10.0	1-6	7- 7	2- 6	6	10	0- 8	5- 5	4-3	-	-	-	5	4	8	8	7- 4	2912
						5	10	0- 7	3- 8	2-6									
7.5	10.0	10.0	1-6	7- 7	2- 6	6	10	0- 8	5- 8	4-6	-	-	-	5	4	8	8	7- 4	3093
						5	10	0- 7	3-11	2-9									
10.0	10.0	10.0	1-6	7- 7	2- 6	6	9	0- 8	5- 2	4-0	5	9	5-9	4	4	8	8	7- 4	3256
						5	9	0- 7	2-11	1-9									
15.0	10.5	10.5	1-6	7- 7	2- 6	6	9	0- 8	5- 2	4-0	5	9	5-9	4	4	8	8	7- 4	3517
						5	9	0- 7	2-11	1-9									
20.0	11.0	11.0	1-6	7- 7	2- 6	6	9	0- 8	5- 2	4-0	5	9	5-9	4	4	8	8	7- 4	3690
						5	9	0- 7	2-11	1-9									
25.0	11.0	11.0	1-6	7- 8	2- 6	6	9	0- 8	5- 2	4-0	5	9	5-9	4	4	8	8	7- 5	3759
						5	9	0- 7	2-11	1-9									
30.0	11.0	11.0	1-6	7-11	2- 7	7	11	0-10	6- 2	5-0	-	-	-	5	5	12	12	7- 8	3647
						6	11	0- 8	3-11	2-9									
35.0	11.0	11.0	1-6	8- 1	2- 8	7	11	0-10	6- 5	5-3	-	-	-	5	5	11	12	7-10	3571
						6	11	0- 8	3-11	2-9									
40.0	11.0	11.0	1-6	8- 4	2- 9	7	11	0-10	6- 5	5-3	-	-	-	5	5	10	12	8- 1	3446
						6	11	0- 8	3-11	2-9									
45.0	11.5	11.5	1-6	8- 5	2- 9	7	11	0-10	6- 2	5-0	-	-	-	5	5	10	12	8- 2	3446
						6	11	0- 8	3- 8	2-6									
50.0	11.5	11.5	1-6	8- 7	2-10	7	11	0-10	6- 5	5-3	-	-	-	5	5	10	12	8- 4	3354
						6	11	0- 8	3-11	2-9									

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 14' - 6"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	10.0	10.0	1-6	7- 9	2- 7	6	11	0- 8	5- 5	4-3	-	-	-	5	4	8	9	7- 6	2339
						5	11	0- 7	3- 8	2-6									
2.5	10.0	10.0	1-6	7-11	2- 7	6	10	0- 8	5- 8	4-6	-	-	-	5	5	11	12	7- 8	3033
						5	10	0- 7	3- 8	2-6									
5.0	10.0	10.0	1-6	7-11	2- 7	6	9	0- 8	5- 2	4-0	5	9	5-9	4	5	11	12	7- 8	2978
						5	9	0- 7	2-11	1-9									
7.5	10.5	10.5	1-6	7-11	2- 7	6	9	0- 8	5- 2	4-0	5	9	6-0	4	5	11	12	7- 8	3148
						5	9	0- 7	2-11	1-9									
10.0	10.5	10.5	1-6	7-11	2- 7	7	11	0-10	6- 5	5-3	-	-	-	5	5	11	12	7- 8	3312
						6	11	0- 8	3-11	2-9									
15.0	11.0	11.0	1-6	7-11	2- 7	7	11	0-10	6- 5	5-3	-	-	-	5	5	11	12	7- 8	3579
						6	11	0- 8	3-11	2-9									
20.0	11.5	11.5	1-6	7-11	2- 7	7	11	0-10	6- 5	5-3	-	-	-	5	5	12	12	7- 8	3761
						6	11	0- 8	3-11	2-9									
25.0	11.5	11.5	1-6	7-11	2- 7	7	11	0-10	6- 8	5-6	-	-	-	5	5	12	12	7- 8	3882
						6	11	0- 8	3-11	2-9									
30.0	12.0	12.0	1-6	8- 2	2- 8	7	11	0-10	6- 5	5-3	-	-	-	5	5	11	12	7-11	3764
						6	11	0- 8	3-11	2-9									
35.0	12.0	12.0	1-6	8- 4	2- 9	7	11	0-10	6- 5	5-3	-	-	-	5	5	10	12	8- 1	3690
						6	11	0- 8	3-11	2-9									
40.0	12.0	12.0	1-6	8- 7	2-10	7	11	0-10	6- 8	5-6	-	-	-	5	5	10	12	8- 4	3568
						6	11	0- 8	3-11	2-9									
45.0	12.0	13.0	1-6	8- 8	2-10	6	9	0- 8	5- 5	4-3	5	9	6-3	4	5	9	12	8- 5	3582
						5	9	0- 7	2-11	1-9									
50.0	12.0	13.0	1-6	8-10	2-11	6	9	0- 8	5- 5	4-3	5	9	6-3	4	5	9	12	8- 7	3490
						5	9	0- 7	2-11	1-9									

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 15' - 0"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	10.0	10.0	1-6	8- 0	2- 8	6	10	0- 8	5- 2	4-0	5	10	5-9	4	5	12	12	7- 9	2418
						5	10	0- 7	2-11	1-9									
2.5	10.5	10.5	1-6	8- 3	2- 9	6	10	0- 8	5- 2	4-0	5	10	5-9	4	5	10	12	8- 0	3061
						5	10	0- 7	2-11	1-9									
5.0	10.5	10.5	1-6	8- 3	2- 9	6	9	0- 8	5- 5	4-3	5	9	6-3	4	5	10	12	8- 0	2987
						5	9	0- 7	2-11	1-9									
7.5	11.0	11.0	1-6	8- 3	2- 9	6	9	0- 8	5- 5	4-3	5	9	6-3	4	5	10	12	8- 0	3151
						5	9	0- 7	2-11	1-9									
10.0	11.0	11.0	1-6	8- 3	2- 9	7	11	0-10	6- 8	5-6	-	-	-	5	5	10	12	8- 0	3314
						6	11	0- 8	4- 2	3-0									
15.0	12.0	12.0	1-6	8- 3	2- 9	7	11	0-10	6- 8	5-6	-	-	-	5	5	10	12	8- 0	3575
						6	11	0- 8	3-11	2-9									
20.0	12.0	13.0	1-6	8- 3	2- 9	6	9	0- 8	5- 5	4-3	5	9	6-6	4	5	11	12	8- 0	3774
						5	9	0- 7	2-11	1-9									
25.0	12.0	13.0	1-6	8- 3	2- 9	6	9	0- 8	5- 8	4-6	5	9	6-6	4	5	11	12	8- 0	3896
						5	9	0- 7	2-11	1-9									
30.0	12.0	13.0	1-6	8- 4	2- 9	7	11	0-10	6- 8	5-6	-	-	-	5	5	10	12	8- 1	3950
						6	11	0- 8	3-11	2-9									
35.0	12.0	13.0	1-6	8- 7	2-10	7	11	0-10	6- 8	5-6	5	11	6-9	4	5	10	12	8- 4	3832
						6	11	0- 8	3- 2	2-0									
40.0	12.0	13.0	1-6	8-10	2-11	7	10	0-10	6- 5	5-3	5	10	6-9	4	5	9	12	8- 7	3710
						6	10	0- 8	3- 2	2-0									
45.0	12.0	13.0	1-6	9- 1	3- 0	7	10	0-10	6- 5	5-3	5	10	6-9	4	6	12	12	8-10	3588
						6	10	0- 8	3- 2	2-0									
50.0	12.0	13.0	1-6	9- 2	3- 0	7	10	0-10	6- 5	5-3	5	10	6-9	4	6	11	12	8-11	3595
						6	10	0- 8	3- 2	2-0									

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 15' - 6"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	10.0	10.0	1-6	8- 4	2- 9	6	9	0- 8	5- 5	4-3	5	9	6-3	4	5	10	12	8- 1	2466
						5	9	0- 7	2-11	1-9									
2.5	10.5	10.5	1-6	8- 7	2-10	6	9	0- 8	5- 5	4-3	5	9	6-3	4	6	12	12	8- 4	3160
						5	9	0- 7	2-11	1-9									
5.0	11.0	11.0	1-6	8- 7	2-10	6	9	0- 8	5- 8	4-6	5	9	6-6	4	6	12	12	8- 4	3049
						5	9	0- 7	2-11	1-9									
7.5	11.5	11.5	1-6	8- 7	2-10	7	11	0-10	6- 8	5-6	5	11	6-6	4	5	9	12	8- 4	3210
						6	11	0- 8	3- 2	2-0									
10.0	12.0	12.0	1-6	8- 7	2-10	7	11	0-10	6- 8	5-6	5	11	6-9	4	5	9	12	8- 4	3367
						6	11	0- 8	3- 2	2-0									
15.0	12.0	12.0	1-6	8- 7	2-10	7	10	0-10	6- 8	5-6	5	10	7-0	4	5	9	12	8- 4	3645
						6	10	0- 8	3- 2	2-0									
20.0	12.0	13.0	1-6	8- 7	2-10	7	10	0-10	6- 5	5-3	5	10	7-0	4	5	9	12	8- 4	3826
						6	10	0- 8	3- 2	2-0									
25.0	12.0	13.0	1-6	8- 7	2-10	7	10	0-10	6- 8	5-6	5	10	7-0	4	5	9	12	8- 4	3981
						6	10	0- 8	3- 2	2-0									
30.0	12.0	13.0	1-6	8- 8	2-10	7	10	0-10	6- 8	5-6	5	10	7-0	4	5	9	12	8- 5	4038
						6	10	0- 8	3- 2	2-0									
35.0	12.0	13.0	1-6	8-11	2-11	7	10	0-10	6- 8	5-6	5	10	7-3	4	6	12	12	8- 8	3926
						6	10	0- 8	3- 2	2-0									
40.0	12.0	13.0	1-6	9- 1	3- 0	7	10	0-10	6- 8	5-6	5	10	7-3	4	6	11	12	8-10	3849
						6	10	0- 8	3- 2	2-0									
45.0	12.0	14.0	1-6	9- 4	3- 1	7	10	0-10	6- 8	5-6	5	10	7-0	4	6	11	12	9- 1	3731
						6	10	0- 8	3- 2	2-0									
50.0	12.0	14.0	1-6	9- 5	3- 1	7	10	0-10	6- 8	5-6	5	10	7-3	4	6	11	12	9- 2	3740
						6	10	0- 8	3- 2	2-0									

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 16' - 0"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	10.5	10.5	1-6	8- 7	2-10	6	9	0- 8	5- 8	4-6	5	9	6-6	4	5	9	12	8- 4	2549
						5	9	0- 7	2-11	1-9									
2.5	11.0	11.0	1-6	8-10	2-11	6	9	0- 8	5- 8	4-6	5	9	6-9	4	6	11	12	8- 7	3273
						5	9	0- 7	2-11	1-9									
5.0	11.5	11.5	1-6	8-10	2-11	7	11	0-10	6- 8	5-6	5	11	6-9	4	6	11	12	8- 7	3144
						6	11	0- 8	3- 2	2-0									
7.5	12.0	13.0	1-6	8-10	2-11	6	9	0- 8	5- 8	4-6	5	9	6-9	4	6	12	12	8- 7	3308
						5	9	0- 7	2-11	1-9									
10.0	12.0	13.0	1-6	8-10	2-11	7	11	0-10	6- 8	5-6	5	11	7-0	4	6	12	12	8- 7	3474
						6	11	0- 8	3- 2	2-0									
15.0	12.0	13.0	1-6	8-10	2-11	7	10	0-10	6- 8	5-6	5	10	7-3	4	6	12	12	8- 7	3760
						6	10	0- 8	3- 2	2-0									
20.0	12.0	13.0	1-6	8-10	2-11	7	10	0-10	6- 8	5-6	5	10	7-6	4	6	12	12	8- 7	3954
						6	10	0- 8	3- 2	2-0									
25.0	12.0	14.0	1-6	8-10	2-11	7	10	0-10	6- 8	5-6	5	10	7-6	4	6	12	12	8- 7	4115
						6	10	0- 8	3- 2	2-0									
30.0	12.0	14.0	1-6	8-11	2-11	7	10	0-10	6- 8	5-6	5	10	7-6	4	6	12	12	8- 8	4176
						6	10	0- 8	3- 2	2-0									
35.0	12.0	14.0	1-6	9- 2	3- 0	7	10	0-10	6- 8	5-6	5	10	7-6	4	6	11	12	8-11	4066
						6	10	0- 8	3- 2	2-0									
40.0	12.0	14.0	1-6	9- 5	3- 1	8	12	0-11	7- 2	6-0	5	12	7-6	4	6	10	12	9- 2	3950
						7	12	0-10	3-11	2-9									
45.0	12.0	15.0	1-6	9- 7	3- 2	7	10	0-10	6- 8	5-6	5	10	7-6	4	6	10	12	9- 4	3873
						6	10	0- 8	3- 2	2-0									
50.0	12.0	15.0	1-6	9-10	3- 3	7	10	0-10	6- 8	5-6	5	10	7-6	4	6	9	12	9- 7	3753
						6	10	0- 8	3- 2	2-0									

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 16' - 6"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	11.0	11.0	1-6	8-10	2-11	7	11	0-10	6- 8	5-6	5	11	7-0	4	6	12	12	8- 7	2632
						6	11	0- 8	3- 2	2-0									
2.5	11.5	11.5	1-6	9- 1	3- 0	7	11	0-10	6- 8	5-6	5	11	7-0	4	6	10	12	8-10	3356
						6	11	0- 8	3- 2	2-0									
5.0	12.0	13.0	1-6	9- 1	3- 0	6	9	0- 8	5- 8	4-6	5	9	7-0	4	6	11	12	8-10	3242
						5	9	0- 7	2-11	1-9									
7.5	12.0	13.0	1-6	9- 1	3- 0	7	10	0-10	6- 8	5-6	5	10	7-3	4	6	11	12	8-10	3408
						6	10	0- 8	3- 2	2-0									
10.0	12.0	13.0	1-6	9- 1	3- 0	7	10	0-10	6- 8	5-6	5	10	7-6	4	6	11	12	8-10	3589
						6	10	0- 8	3- 2	2-0									
15.0	12.0	14.0	1-6	9- 1	3- 0	7	10	0-10	6- 8	5-6	5	10	7-9	4	6	11	12	8-10	3874
						6	10	0- 8	3- 2	2-0									
20.0	12.0	14.0	1-6	9- 1	3- 0	7	10	0-10	6- 8	5-6	5	10	7-9	4	6	11	12	8-10	4082
						6	10	0- 8	3- 2	2-0									
25.0	12.0	15.0	1-6	9- 1	3- 0	7	10	0-10	6- 8	5-6	5	10	7-9	4	6	11	12	8-10	4248
						6	10	0- 8	3- 2	2-0									
30.0	12.0	15.0	1-6	9- 2	3- 0	7	10	0-10	6- 8	5-6	5	10	7-9	4	6	11	12	8-11	4313
						6	10	0- 8	3- 2	2-0									
35.0	12.0	15.0	1-6	9- 5	3- 1	7	10	0-10	6- 8	5-6	5	10	8-0	4	6	10	12	9- 2	4205
						6	10	0- 8	3- 2	2-0									
40.0	12.0	15.0	1-6	9- 8	3- 2	8	11	0-11	7- 2	6-0	5	11	8-0	4	6	10	12	9- 5	4091
						7	11	0-10	3-11	2-9									
45.0	12.0	15.0	1-6	9-11	3- 3	8	11	0-11	7- 2	6-0	5	11	8-0	4	6	9	12	9- 8	3974
						7	11	0-10	3-11	2-9									
50.0	12.0	15.0	1-6	10- 1	3- 4	8	11	0-11	7- 2	6-0	5	11	8-0	4	6	9	12	9-10	3892
						7	11	0-10	3-11	2-9									

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 17' - 0"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	12.0	12.0	1-6	9- 1	3- 0	7	11	0-10	6- 8	5-6	5	11	7-3	4	6	11	12	8-10	2718
						6	11	0- 8	3- 2	2-0									
2.5	12.0	13.0	1-6	9- 4	3- 1	6	9	0- 8	5- 8	4-6	5	9	7-3	4	6	10	12	9- 1	3441
						5	9	0- 7	2-11	1-9									
5.0	12.0	13.0	1-6	9- 4	3- 1	7	10	0-10	6- 8	5-6	5	10	7-6	4	6	10	12	9- 1	3341
						6	10	0- 8	3- 2	2-0									
7.5	12.0	13.0	1-6	9- 4	3- 1	7	10	0-10	6- 8	5-6	5	10	7-9	4	6	10	12	9- 1	3508
						6	10	0- 8	3- 2	2-0									
10.0	12.0	14.0	1-6	9- 4	3- 1	7	10	0-10	6- 8	5-6	5	10	8-0	4	6	10	12	9- 1	3692
						6	10	0- 8	3- 2	2-0									
15.0	12.0	15.0	1-6	9- 4	3- 1	7	10	0-10	6- 8	5-6	5	10	8-0	4	6	10	12	9- 1	3987
						6	10	0- 8	3- 2	2-0									
20.0	12.0	15.0	1-6	9- 4	3- 1	8	12	0-11	7- 2	6-0	5	12	8-3	4	6	10	12	9- 1	4208
						7	12	0-10	3-11	2-9									
25.0	12.0	15.0	1-6	9- 4	3- 1	8	11	0-11	7- 2	6-0	5	11	8-3	4	6	10	12	9- 1	4378
						7	11	0-10	3-11	2-9									
30.0	12.0	15.0	1-6	9- 5	3- 1	8	11	0-11	7- 2	6-0	5	11	8-3	4	6	10	12	9- 2	4446
						7	11	0-10	3-11	2-9									
35.0	12.0	15.0	1-6	9- 8	3- 2	8	11	0-11	7- 2	6-0	5	11	8-6	4	6	9	12	9- 5	4341
						7	11	0-10	3-11	2-9									
40.0	12.0	15.0	1-6	9-11	3- 3	8	11	0-11	7- 2	6-0	5	11	8-6	4	6	9	12	9- 8	4228
						7	11	0-10	3-11	2-9									
45.0	12.0	15.0	1-6	10- 2	3- 4	8	11	0-11	7- 2	6-0	5	11	8-6	4	6	8	12	9-11	4112
						7	11	0-10	3-11	2-9									
50.0	12.0	16.0	1-9	10- 5	3- 5	8	12	0-11	7- 5	6-0	5	12	8-3	4	6	10	12	10- 2	4034
						7	12	0-10	4- 2	2-9									

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 17' - 6"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	12.0	13.0	1-6	9- 4	3- 1	6	9	0- 8	5- 8	4-6	5	9	7-6	4	6	10	12	9- 1	2801
						5	9	0- 7	2-11	1-9									
2.5	12.0	13.0	1-6	9- 7	3- 2	7	11	0-10	6- 8	5-6	5	11	7-9	4	6	9	12	9- 4	3522
						6	11	0- 8	3- 2	2-0									
5.0	12.0	13.0	1-6	9- 7	3- 2	7	10	0-10	6- 8	5-6	5	10	8-0	4	6	9	12	9- 4	3441
						6	10	0- 8	3- 2	2-0									
7.5	12.0	14.0	1-6	9- 7	3- 2	7	10	0-10	6- 8	5-6	5	10	8-3	4	6	9	12	9- 4	3611
						6	10	0- 8	3- 2	2-0									
10.0	12.0	15.0	1-6	9- 7	3- 2	7	10	0-10	6- 8	5-6	5	10	8-3	4	6	9	12	9- 4	3795
						6	10	0- 8	3- 2	2-0									
15.0	12.0	15.0	1-6	9- 7	3- 2	8	11	0-11	7- 2	6-0	5	11	8-6	4	6	9	12	9- 4	4096
						7	11	0-10	3-11	2-9									
20.0	12.0	15.0	1-6	9- 7	3- 2	8	11	0-11	7- 2	6-0	6	11	8-9	4	6	9	12	9- 4	4329
						7	11	0-10	3-11	2-9									
25.0	12.0	16.0	1-9	9- 7	3- 2	8	12	0-11	7- 5	6-0	5	12	8-6	4	6	12	12	9- 4	4546
						7	12	0-10	4- 2	2-9									
30.0	12.0	16.0	1-9	9- 7	3- 2	8	11	0-11	7- 5	6-0	5	11	8-6	4	6	12	12	9- 4	4666
						7	11	0-10	4- 2	2-9									
35.0	12.0	16.0	1-9	9-10	3- 3	8	11	0-11	7- 5	6-0	5	11	8-6	4	6	11	12	9- 7	4560
						7	11	0-10	4- 2	2-9									
40.0	12.0	16.0	1-9	10- 1	3- 4	8	11	0-11	7- 5	6-0	5	11	8-9	4	6	10	12	9-10	4447
						7	11	0-10	4- 2	2-9									
45.0	12.0	16.0	1-9	10- 4	3- 5	8	11	0-11	7- 5	6-0	6	11	8-9	4	6	10	12	10- 1	4329
						7	11	0-10	4- 2	2-9									
50.0	12.0	16.0	1-9	10- 7	3- 6	8	11	0-11	7- 5	6-0	6	11	8-9	4	6	9	12	10- 4	4210
						7	11	0-10	4- 2	2-9									

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 18' - 0"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	12.0	13.0	1-6	9- 8	3- 2	7	10	0-10	6- 8	5-6	5	10	8-0	4	6	9	12	9- 5	2849
						6	10	0- 8	3- 2	2-0									
2.5	12.0	13.0	1-6	9-10	3- 3	7	10	0-10	6- 8	5-6	5	10	8-3	4	6	8	12	9- 7	3602
						6	10	0- 8	3- 2	2-0									
5.0	12.0	14.0	1-6	9-10	3- 3	7	10	0-10	6- 8	5-6	5	10	8-6	4	6	8	12	9- 7	3543
						6	10	0- 8	3- 2	2-0									
7.5	12.0	15.0	1-6	9-10	3- 3	7	10	0-10	6- 8	5-6	5	10	8-6	4	6	8	12	9- 7	3714
						6	10	0- 8	3- 2	2-0									
10.0	12.0	15.0	1-6	9-10	3- 3	8	11	0-11	7- 2	6-0	6	11	8-9	4	6	8	12	9- 7	3895
						7	11	0-10	3-11	2-9									
15.0	12.0	16.0	1-9	9-10	3- 3	8	12	0-11	7- 5	6-0	6	12	8-9	4	6	11	12	9- 7	4243
						7	12	0-10	4- 2	2-9									
20.0	12.0	16.0	1-9	9-10	3- 3	8	11	0-11	7- 5	6-0	6	11	8-9	4	6	11	12	9- 7	4487
						7	11	0-10	4- 2	2-9									
25.0	12.0	16.0	1-9	9-10	3- 3	8	11	0-11	7- 5	6-0	6	11	9-0	4	6	11	12	9- 7	4674
						7	11	0-10	4- 2	2-9									
30.0	12.0	16.0	1-9	9-11	3- 3	8	10	0-11	7- 5	6-0	5	10	9-0	4	6	10	12	9- 8	4750
						7	10	0-10	4- 2	2-9									
35.0	12.0	16.0	1-9	10- 1	3- 4	8	10	0-11	7- 5	6-0	6	10	9-0	4	6	10	12	9-10	4696
						7	10	0-10	4- 2	2-9									
40.0	12.0	16.0	1-9	10- 5	3- 5	8	10	0-11	7- 5	6-0	6	10	9-3	4	6	9	12	10- 2	4540
						7	10	0-10	4- 2	2-9									
45.0	12.0	16.0	1-9	10- 7	3- 6	8	10	0-11	7- 5	6-0	6	10	9-3	4	6	9	12	10- 4	4467
						7	10	0-10	4- 2	2-9									
50.0	12.0	16.0	1-9	10-10	3- 7	8	10	0-11	7- 5	6-0	6	10	9-3	4	6	8	12	10- 7	4349
						7	10	0-10	4- 2	2-9									

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 18' - 6"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	12.0	13.0	1-9	9-11	3- 3	7	10	0-10	6-11	5-6	5	10	8-3	4	6	10	12	9- 8	2964
						6	10	0- 8	3- 5	2-0									
2.5	12.0	14.0	1-9	10- 1	3- 4	7	10	0-10	6-11	5-6	5	10	8-3	4	6	9	12	9-10	3722
						6	10	0- 8	3- 5	2-0									
5.0	12.0	15.0	1-9	10- 1	3- 4	7	10	0-10	6-11	5-6	5	10	8-6	4	6	9	12	9-10	3669
						6	10	0- 8	3- 5	2-0									
7.5	12.0	15.0	1-9	10- 1	3- 4	8	11	0-11	7- 5	6-0	6	11	8-9	4	6	9	12	9-10	3850
						7	11	0-10	4- 2	2-9									
10.0	12.0	15.0	1-9	10- 1	3- 4	8	11	0-11	7- 5	6-0	6	11	9-0	4	6	9	12	9-10	4031
						7	11	0-10	4- 2	2-9									
15.0	12.0	16.0	1-9	10- 1	3- 4	8	11	0-11	7- 5	6-0	6	11	9-3	4	6	10	12	9-10	4351
						7	11	0-10	4- 2	2-9									
20.0	12.0	16.0	1-9	10- 1	3- 4	8	10	0-11	7- 5	6-0	6	10	9-3	4	6	10	12	9-10	4606
						7	10	0-10	4- 2	2-9									
25.0	12.0	16.0	1-9	10- 1	3- 4	8	10	0-11	7- 5	6-0	6	10	9-6	4	6	10	12	9-10	4803
						7	10	0-10	4- 2	2-9									
30.0	12.0	16.0	1-9	10- 2	3- 4	8	10	0-11	7- 5	6-0	6	10	9-6	4	6	9	12	9-11	4882
						7	10	0-10	4- 2	2-9									
35.0	12.0	16.0	1-9	10- 5	3- 5	8	10	0-11	7- 5	6-0	6	10	9-6	4	6	9	12	10- 2	4784
						7	10	0-10	4- 2	2-9									
40.0	12.0	17.0	1-9	10- 8	3- 6	8	10	0-11	7- 5	6-0	6	10	9-6	4	6	8	12	10- 5	4680
						7	10	0-10	4- 2	2-9									
45.0	12.0	17.0	1-9	10-11	3- 7	8	10	0-11	7- 5	6-0	6	10	9-6	4	6	8	8	10- 8	4567
						7	10	0-10	4- 2	2-9									
50.0	12.0	17.0	1-9	11- 1	3- 8	8	10	0-11	7- 5	6-0	6	10	9-9	4	6	8	8	10-10	4491
						7	10	0-10	4- 2	2-9									

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 19' - 0"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	12.0	14.0	1-9	10- 2	3- 4	7	10	0-10	6-11	5-6	5	10	8-9	4	6	10	12	9-11	3047
						6	10	0- 8	3- 5	2-0									
2.5	12.0	14.0	1-9	10- 4	3- 5	8	12	0-11	7- 5	6-0	6	12	8-9	4	6	8	12	10- 1	3803
						7	12	0-10	4- 2	2-9									
5.0	12.0	15.0	1-9	10- 4	3- 5	8	11	0-11	7- 5	6-0	6	11	9-0	4	6	9	12	10- 1	3790
						7	11	0-10	4- 2	2-9									
7.5	12.0	15.0	1-9	10- 4	3- 5	8	11	0-11	7- 5	6-0	6	11	9-3	4	6	9	12	10- 1	3950
						7	11	0-10	4- 2	2-9									
10.0	12.0	16.0	1-9	10- 4	3- 5	8	11	0-11	7- 5	6-0	6	11	9-6	4	6	9	12	10- 1	4134
						7	11	0-10	4- 2	2-9									
15.0	12.0	16.0	1-9	10- 4	3- 5	8	10	0-11	7- 5	6-0	6	10	9-9	4	6	9	12	10- 1	4458
						7	10	0-10	4- 2	2-9									
20.0	12.0	16.0	1-9	10- 4	3- 5	8	10	0-11	7- 5	6-0	6	10	9-9	4	6	9	12	10- 1	4722
						7	10	0-10	4- 2	2-9									
25.0	12.0	17.0	1-9	10- 4	3- 5	8	10	0-11	7- 5	6-0	6	10	9-9	4	6	9	12	10- 1	4934
						7	10	0-10	4- 2	2-9									
30.0	12.0	17.0	1-9	10- 5	3- 5	8	10	0-11	7- 5	6-0	6	10	10-0	4	6	9	12	10- 2	5016
						7	10	0-10	4- 2	2-9									
35.0	12.0	18.0	1-9	10- 8	3- 6	8	10	0-11	7- 5	6-0	6	10	10-0	4	6	8	8	10- 5	4923
						7	10	0-10	4- 2	2-9									
40.0	12.0	18.0	1-9	10-11	3- 7	8	10	0-11	7- 5	6-0	6	10	10-0	4	6	8	8	10- 8	4818
						7	10	0-10	4- 2	2-9									
45.0	12.0	18.0	1-9	11- 2	3- 8	8	10	0-11	7- 5	6-0	6	10	10-0	4	7	10	10	10-11	4707
						7	10	0-10	4- 2	2-9									
50.0	12.0	18.0	1-9	11- 4	3- 9	8	10	0-11	7- 5	6-0	6	10	10-0	4	7	10	10	11- 1	4632
						7	10	0-10	4- 2	2-9									

VERTICAL CANTILEVER T-TYPE WINGWALLS

DESIGN HEIGHT H_D = 19' - 6"

FILL	STEM		FOOTING			n(E) and n_1(E) BARS					v_i BAR			v_j BAR	t BAR				MAX. SOIL PRESSURE AT TOE
	T	T_1	T_f	b	X	SIZE	SPA.	A	B	C	SIZE	SPA.	LENGTH	SIZE	SIZE	SPACING HEEL	SPACING TOE	LENGTH	Lbs. per Sq. Ft.
Ft.	In.	In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.	Ft.-In.	Ft.-In.		In.	Ft.-In.			In.	In.	Ft.-In.	
0.0	12.0	15.0	1-9	10- 5	3- 5	7	10	0-10	6- 8	5-3	6	10	9-0	4	6	9	12	10- 2	3130
						6	10	0- 8	3- 5	2-0									
2.5	12.0	15.0	1-9	10- 7	3- 6	8	12	0-11	7- 5	6-0	6	12	9-3	4	6	8	12	10- 4	3887
						7	12	0-10	4- 2	2-9									
5.0	12.0	15.0	1-9	10- 7	3- 6	8	11	0-11	7- 5	6-0	6	11	9-6	4	6	8	12	10- 4	3911
						7	11	0-10	4- 2	2-9									
7.5	12.0	16.0	1-9	10- 7	3- 6	8	11	0-11	7- 5	6-0	6	11	9-9	4	6	8	12	10- 4	4054
						7	11	0-10	4- 2	2-9									
10.0	12.0	16.0	1-9	10- 7	3- 6	8	10	0-11	7- 5	6-0	6	10	10-0	4	6	8	12	10- 4	4235
						7	10	0-10	4- 2	2-9									
15.0	12.0	17.0	1-9	10- 7	3- 6	8	10	0-11	7- 5	6-0	6	10	10-0	4	6	8	12	10- 4	4568
						7	10	0-10	4- 2	2-9									
20.0	12.0	17.0	1-9	10- 7	3- 6	8	10	0-11	7- 5	6-0	6	10	10-3	4	6	8	8	10- 4	4841
						7	10	0-10	4- 2	2-9									
25.0	12.0	18.0	1-9	10- 7	3- 6	8	10	0-11	7- 5	6-0	6	10	10-3	4	6	8	8	10- 4	5026
						7	10	0-10	4- 2	2-9									
30.0	12.0	18.0	1-9	10- 8	3- 6	8	10	0-11	7- 5	6-0	6	10	10-3	4	6	8	8	10- 5	5150
						7	10	0-10	4- 2	2-9									
35.0	12.0	19.0	2-0	10-11	3- 7	8	10	0-11	7- 8	6-0	6	10	10-0	4	6	9	12	10- 8	5096
						7	10	0-10	4- 5	2-9									
40.0	12.0	19.0	2-0	11- 1	3- 8	8	10	0-11	7- 8	6-0	6	10	10-3	4	6	9	12	10-10	5037
						7	10	0-10	4- 5	2-9									
45.0	12.0	19.0	2-0	11- 4	3- 9	8	10	0-11	7- 8	6-0	6	10	10-3	4	6	9	8	11- 1	4925
						7	10	0-10	4- 5	2-9									
50.0	12.0	19.0	2-0	11- 7	3-10	8	10	0-11	7- 8	6-0	6	10	10-3	4	6	8	8	11- 4	4809
						7	10	0-10	4- 5	2-9									

Section 4 Design Aids and Details

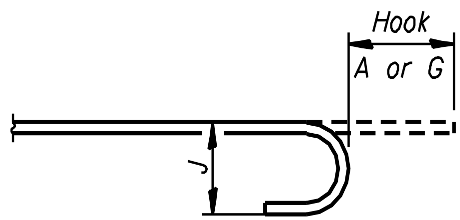
Table of Figures

Location:	Barrels
Size	Lap
#4	1'-4"
#5	1'-8"
#6	2'-0"
#7	2'-9"
#8	3'-8"
#9	4'-7"

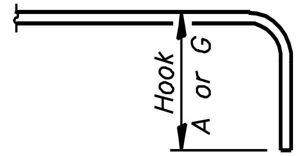
Location:	Wingwalls
Size	Lap
#4	1'-8"
#5	2'-2"
#6	2'-7"
#7	3'-5"
#8	4'-6"
#9	5'-9"

MINIMUM BAR LAP LENGTH OF REINFORCEMENT

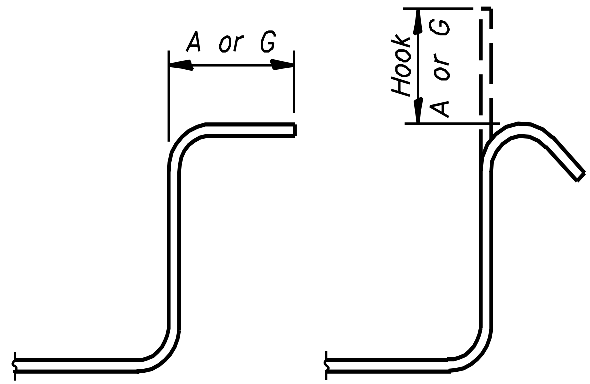
Figure 4-1



180° END HOOK



90° END HOOK



90° 135°
STIRRUP & TIE HOOKS

180° END HOOK

All Grades

Bar Size	Hook A or G	J
#4	6"	4"
#5	7"	5"
#6	8"	6"
#7	10"	7"
#8	11"	8"
#9	1'-3"	11 3/4"
#10	1'-5"	1'-1 1/4"
#11	1'-7"	1'-2 3/4"
#14	2'-3"	1'-9 3/4"
#18	3'-0"	2'-4 1/2"

90° END HOOK

All Grades

Bar Size	Hook A or G
#4	8"
#5	10"
#6	1'-0"
#7	1'-2"
#8	1'-4"
#9	1'-7"
#10	1'-10"
#11	2'-0"
#14	2'-7"
#18	3'-5"

STIRRUP & TIE HOOKS

Grades 40-50-60 ksi

Bar Size	90° Hook	135° Hook
	Hook A or G	Hook A or G
#4	4 1/2"	4 1/2"
#5	6"	5 1/2"
#6	1'-0"	8"

REINFORCEMENT BAR HOOK DIMENSIONS

Figure 4-2

REINFORCEMENT BARS
AREAS, WEIGHTS, PERIMETERS & SPACING PER ONE FT. SECTION

Size	Area Sq. in.	Wght. per ft. Lbs.	AREAS - As, given in **bold** type (top) in sq. inches. PERIMETERS - Σo, given in light type (bottom) in inches.													
			4"	4½"	5"	5½"	6"	6½"	7"	7½"	8"	8½"	9"	10"	11"	12"
2	.0490	.167	**.147**	**.131**	**.118**	**.107**	**.098**	**.090**	**.084**	**.078**	**.074**	**.069**	**.065**	**.059**	**.053**	**.049**
			2.36	2.10	1.89	1.71	1.57	1.45	1.35	1.26	1.18	1.11	1.05	.943	.858	.786
3	.1104	.376	**.33**	**.29**	**.27**	**.24**	**.22**	**.20**	**.19**	**.18**	**.17**	**.16**	**.15**	**.13**	**.12**	**.11**
			3.54	3.14	2.83	2.57	2.36	2.18	2.02	1.89	1.77	1.66	1.57	1.41	1.29	1.18
4	.1963	.668	**.59**	**.52**	**.47**	**.43**	**.39**	**.36**	**.34**	**.31**	**.29**	**.28**	**.26**	**.24**	**.21**	**.20**
			4.71	4.19	3.77	3.43	3.14	2.90	2.69	2.51	2.36	2.22	2.09	1.88	1.71	1.57
5	.3068	1.043	**.92**	**.82**	**.74**	**.67**	**.61**	**.57**	**.53**	**.49**	**.46**	**.43**	**.41**	**.37**	**.33**	**.31**
			5.89	5.24	4.71	4.28	3.93	3.62	3.36	3.14	2.94	2.77	2.62	2.36	2.14	1.96
6	.4418	1.502	**1.32**	**1.18**	**1.06**	**.96**	**.88**	**.82**	**.76**	**.71**	**.66**	**.62**	**.59**	**.53**	**.48**	**.44**
			7.07	6.28	5.66	5.14	4.71	4.35	4.04	3.77	3.53	3.33	3.14	2.83	2.57	2.36
7	.6013	2.044	**1.80**	**1.60**	**1.44**	**1.31**	**1.20**	**1.11**	**1.03**	**.96**	**.90**	**.85**	**.80**	**.72**	**.66**	**.60**
			8.25	7.33	6.60	6.00	5.50	5.07	4.71	4.40	4.12	3.88	3.67	3.30	3.00	2.75
8	.7854	2.670	**2.36**	**2.09**	**1.88**	**1.71**	**1.57**	**1.45**	**1.35**	**1.26**	**1.18**	**1.11**	**1.05**	**.94**	**.86**	**.79**
			9.42	8.38	7.54	6.86	6.28	5.80	5.39	5.03	4.71	4.44	4.19	3.77	3.43	3.14
9	1.000	3.400	**3.00**	**2.67**	**2.40**	**2.18**	**2.00**	**1.85**	**1.71**	**1.60**	**1.50**	**1.41**	**1.33**	**1.20**	**1.09**	**1.00**
			10.63	9.45	8.51	7.73	7.09	6.54	6.08	5.67	5.32	5.00	4.73	4.25	3.87	3.54
10	1.2667	4.303	**3.80**	**3.38**	**3.04**	**2.76**	**2.53**	**2.34**	**2.17**	**2.03**	**1.90**	**1.79**	**1.69**	**1.52**	**1.38**	**1.27**
			11.96	10.63	9.58	8.71	7.98	7.37	6.84	6.39	5.99	5.64	5.32	4.79	4.35	3.99
11	1.5615	5.313	**4.69**	**4.17**	**3.75**	**3.41**	**3.13**	**2.89**	**2.68**	**2.50**	**2.34**	**2.21**	**2.08**	**1.87**	**1.70**	**1.56**
			13.28	11.80	10.63	9.67	8.86	8.18	7.60	7.09	6.65	6.26	5.91	5.32	4.83	4.43

Figure 4-3

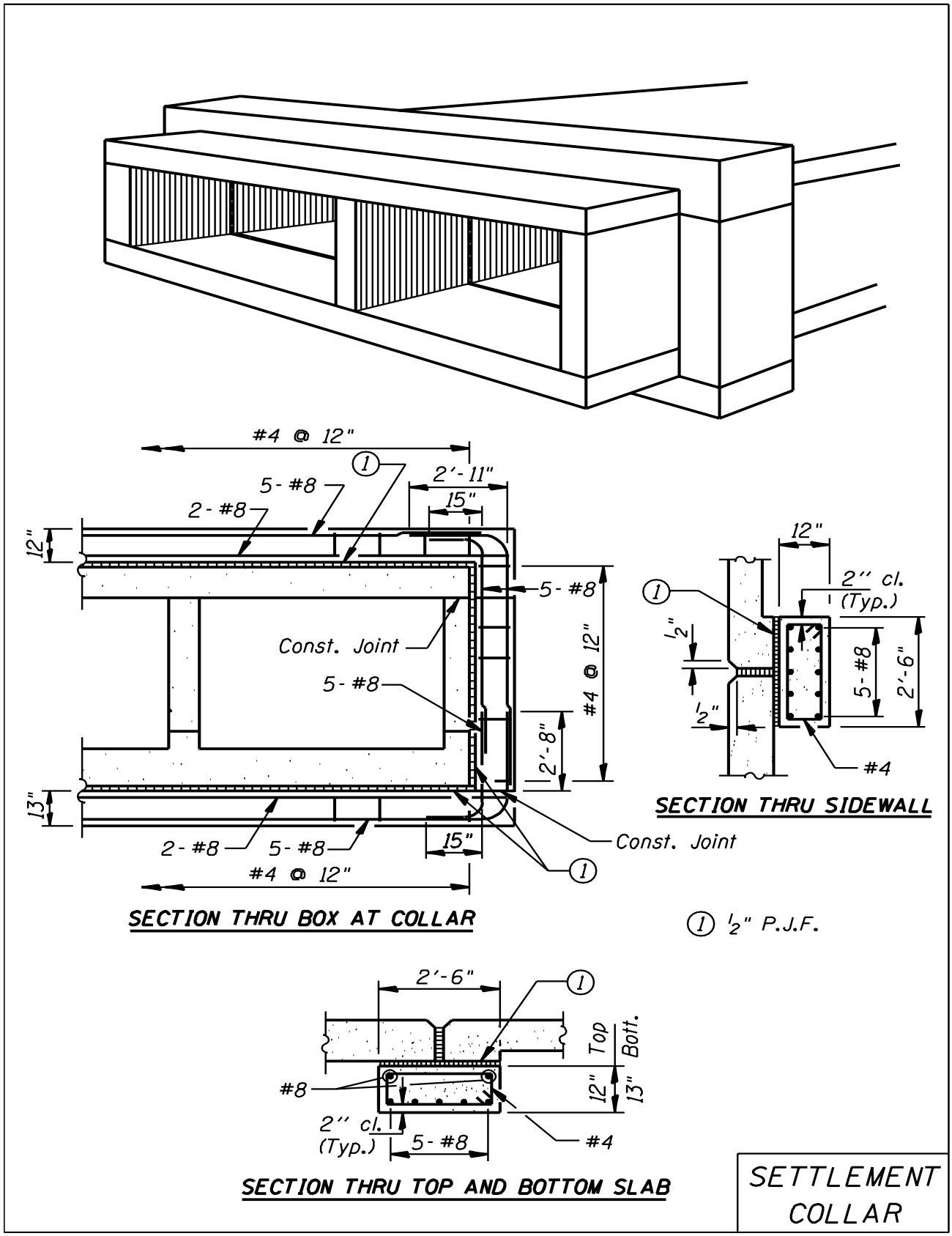
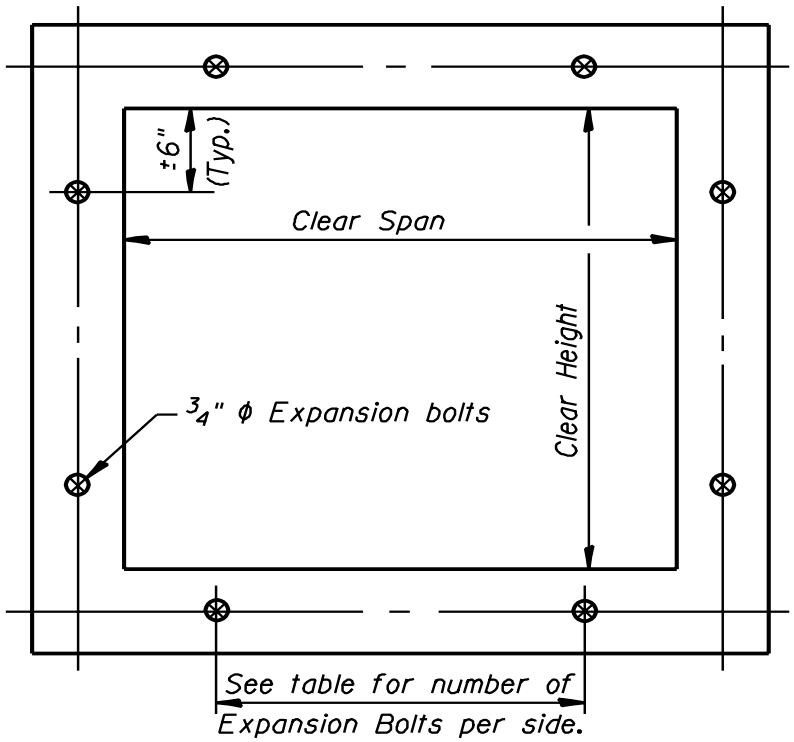

#4 @ 12"
1
2'-11"
15"
5 - #8
2 - #8
12"
5 - #8
Const. Joint
5 - #8
#4 @ 12"
2'-8"
13"
2 - #8
5 - #8
15"
Const. Joint
1
#4 @ 12"
SECTION THRU BOX AT COLLAR
12"
2" cl.
(Typ.)
1
1/2"
5 - #8
2'-6"
1/2"
#4
SECTION THRU SIDEWALL
1 1/2" P.J.F.
2'-6"
1
Top
Bott.
#8
12"
13"
2" cl.
(Typ.)
5 - #8
#4
SECTION THRU TOP AND BOTTOM SLAB
SETTLEMENT COLLAR

Figure 4-4



CROSS SECTION THRU BARREL

Note: (to be placed on the plans) Expansion bolts shall be $\frac{3}{4}$" ϕ hooked bolts. Hooked bolts shall extend a minimum of 9" into new concrete.

Clear Span or Clear Height	No. of $\frac{3}{4}$"ϕ Exp. Bolts Req'd per side			
	Extension ≤ 15'		Extension > 15'	
	No. *	Spacing	No. *	Spacing
2.0	**	**	**	**
2.5	2	18"	2	18"
3.0	2	24"	2	24"
4.0	3	18"	3	18"
5.0	4	16"	3	24"
6.0	5	15"	4	20"
7.0	5	18"	4	24"
8.0	6	17"	5	21"
9.0	6	19"	5	24"
10.0	7	18"	6	21"
11.0	8	17"	6	24"
12.0	8	19"	7	22"

Example:
6'x4' box culvert to be extended 18' at one end only.
From table find
6' side requires 4-$\frac{3}{4}$" ϕ Expansion bolts at 20" cts.
4' side requires 3-$\frac{3}{4}$" ϕ Expansion bolts at 18" cts.

Total Number required
(4+3)2 = 14-$\frac{3}{4}$" ϕ Expansion Bolts.

* Note: Expansion bolts based on non-skewed culverts.

** Note: Use minimum of one (1) Expansion bolt at each corner.

EXPANSION BOLTS REQUIRED FOR CULVERT EXTENSIONS

Figure 4-5

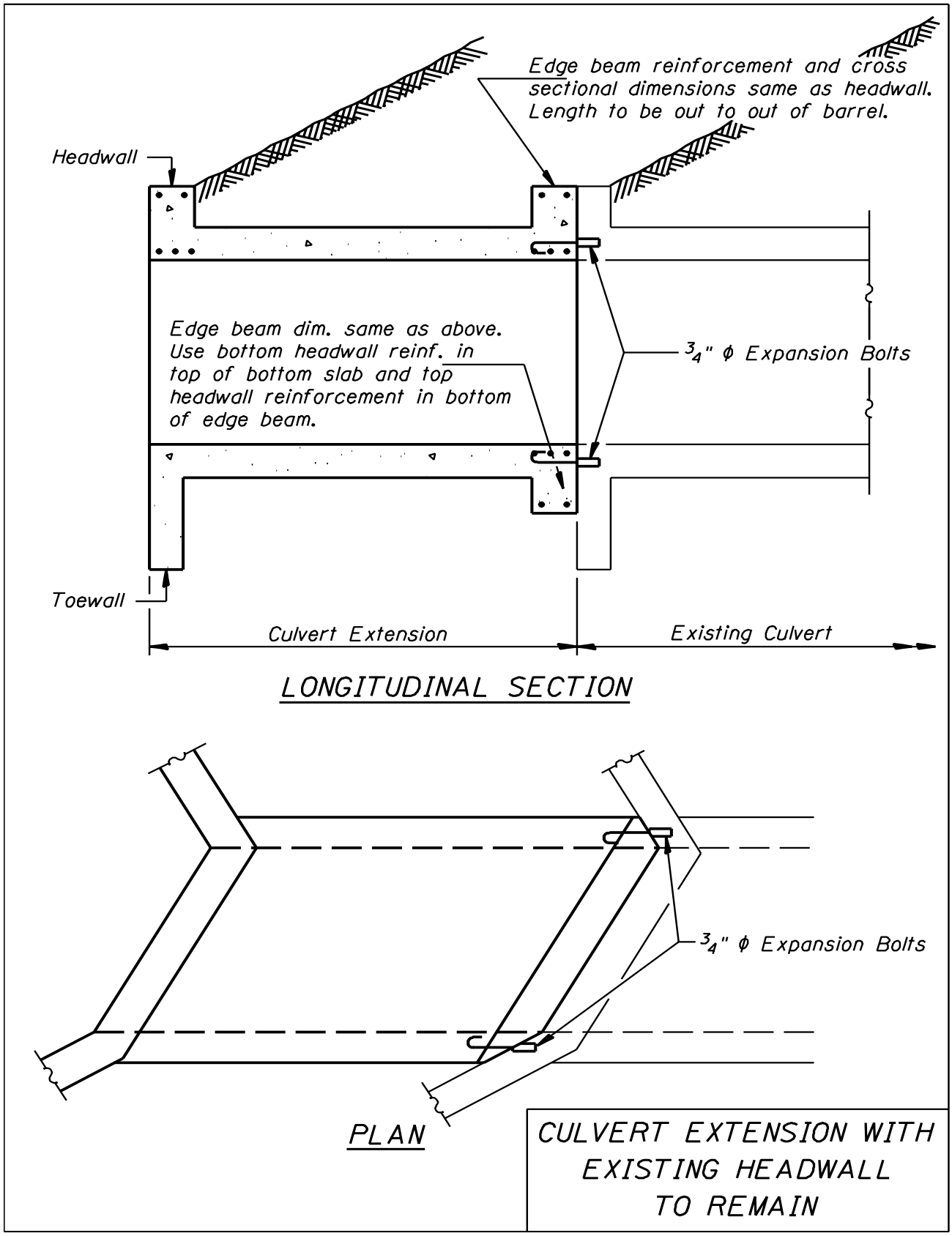

Edge beam reinforcement and cross sectional dimensions same as headwall. Length to be out to out of barrel.
Headwall
Edge beam dim. same as above. Use bottom headwall reinf. in top of bottom slab and top headwall reinforcement in bottom of edge beam.
3/4" ϕ Expansion Bolts
Toewall
Culvert Extension
Existing Culvert
LONGITUDINAL SECTION
3/4" ϕ Expansion Bolts
PLAN
CULVERT EXTENSION WITH EXISTING HEADWALL TO REMAIN

Figure 4-6

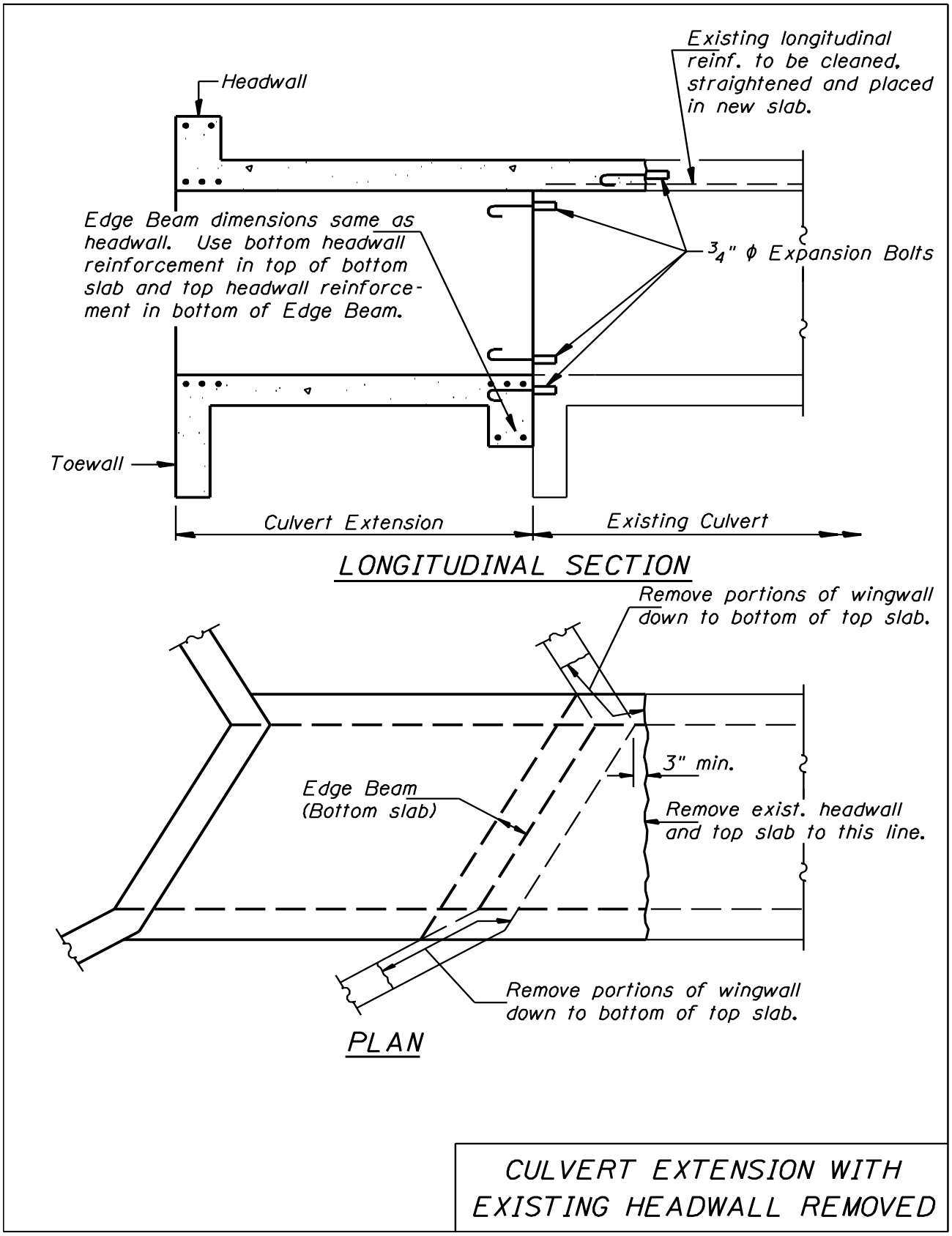

Existing longitudinal reinf. to be cleaned, straightened and placed in new slab.
Headwall
Edge Beam dimensions same as headwall. Use bottom headwall reinforcement in top of bottom slab and top headwall reinforcement in bottom of Edge Beam.
3/4" ϕ Expansion Bolts
Toewall
Culvert Extension
Existing Culvert
LONGITUDINAL SECTION
Remove portions of wingwall down to bottom of top slab.
3" min.
Edge Beam (Bottom slab)
Remove exist. headwall and top slab to this line.
Remove portions of wingwall down to bottom of top slab.
PLAN
CULVERT EXTENSION WITH EXISTING HEADWALL REMOVED

Figure 4-7

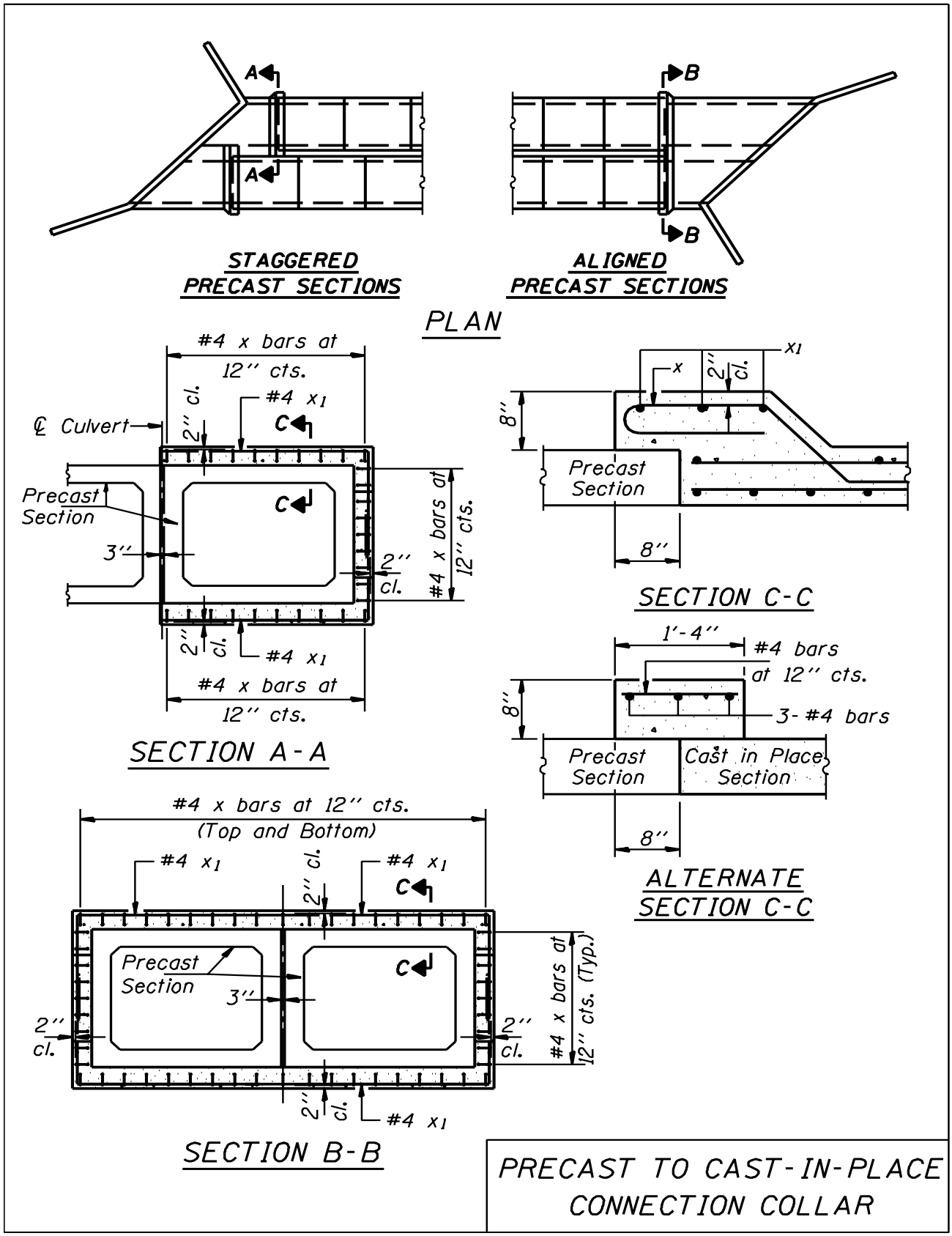

A
A
B
B
STAGGERED PRECAST SECTIONS
ALIGNED PRECAST SECTIONS
PLAN
#4 x bars at 12'' cts.
2'' cl.
#4 x1
℄ Culvert
C
Precast Section
3''
2'' cl.
#4 x bars at 12'' cts.
SECTION A-A
x1
x
2'' cl.
8''
Precast Section
8''
SECTION C-C
1'-4''
#4 bars at 12'' cts.
3-#4 bars
Precast Section
Cast in Place Section
8''
ALTERNATE SECTION C-C
#4 x bars at 12'' cts. (Top and Bottom)
#4 x1
2'' cl.
#4 x1
Precast Section
3''
2'' cl.
2'' cl.
#4 x bars at 12'' cts. (Typ.)
2'' cl.
#4 x1
SECTION B-B
PRECAST TO CAST-IN-PLACE CONNECTION COLLAR

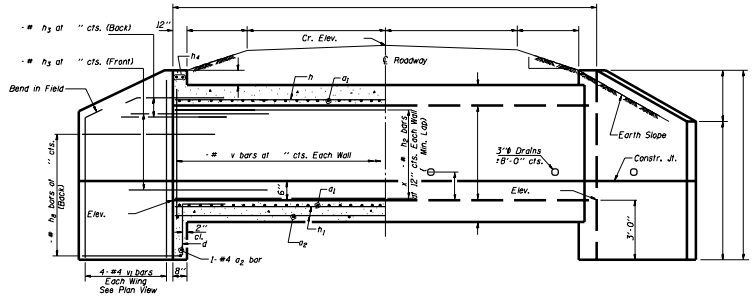
Figure 4-8

Section 5 Base Sheets

Table of Contents

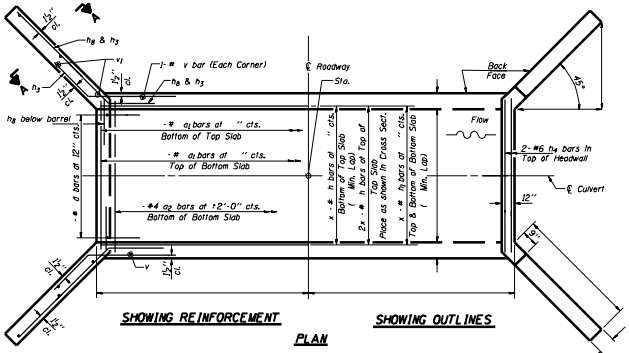
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO.
SHEETS



HALF LONG. SECTION

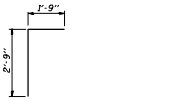
HALF ELEVATION



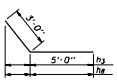
SHOWING REINFORCEMENT

SHOWING OUTLINES

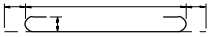
PLAN



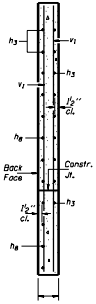
BAR d



BARS h3 & h8

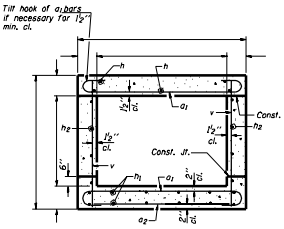


BAR a1



SECTION A-A

SECTION THRU HEADWALL
(Up Stream End Only)



SECTION THRU BARREL

BILL OF MATERIAL

Bar	No.	Size	Length	Shape
a1				
a2		#4		
d		#4	4'-6"	
h				
h1				
h2				
h3			8'-0"	
h4		#6		
h8				
v				
v1		#4		
Concrete Box Culverts Reinforcement Bars			Cu. Yd. Pound	

NOTES

A distance of half the length of the wingwall but not less than six feet of the barrel shall be poured monolithically with the wingwalls.
Reinforcement Bars shall conform to the requirements of AASHTO M-31, M-42 or M-53, Grade 60.
Bars indicated thus 12 x 4-#5 etc. indicates 12 lines of bars with 4 lengths per line.
All construction joints shall be banded.

DESIGN STRESSES
fy = 60,000 psi
f'c = 3,500 psi

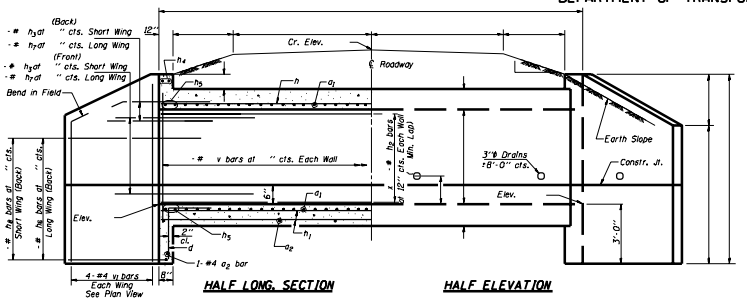
LOADING HS 20-44 & ALT.

DESIGNED	
CHECKED	
DRAWN	
CHECKED	
EXAMINED	
PASSED	

SSB-H-0 6-1-2000

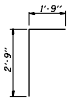
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO.
SHEETS

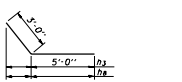


HALF LONG. SECTION

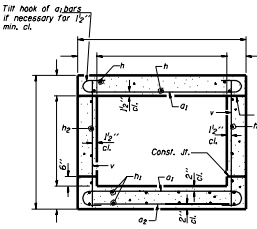
HALF ELEVATION



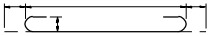
BAR d



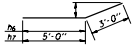
BARS h3 & h8



SECTION THRU BARREL



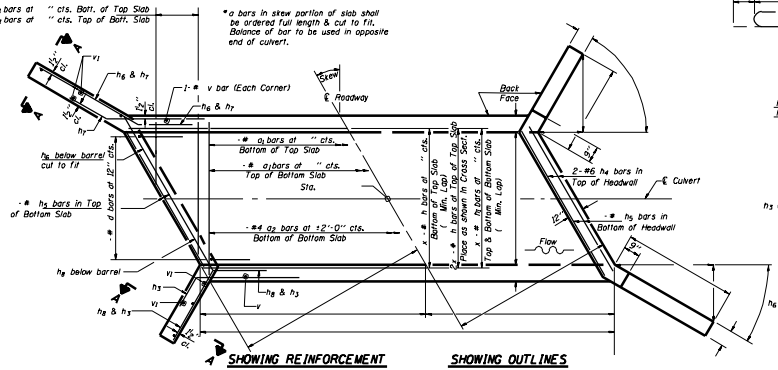
BAR a1



BARS h6 & h7

BILL OF MATERIAL

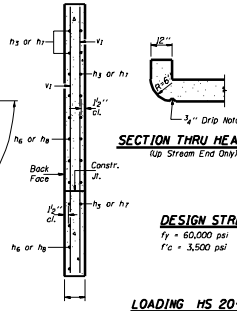
Bar	No.	Size	Length	Shape
a1				
a2		#4		
d		#4	4'-6"	
h				
h1				
h2				
h3			8'-0"	
h4		#6		
h5				
h6				
h7			8'-0"	
h8				
v				
v1		#4		
Concrete Box Culverts			Cu. Yd.	
Reinforcement Bars			Pound	



SHOWING REINFORCEMENT

SHOWING OUTLINES

PLAN



SECTION A-A

SECTION THRU HEADWALL
(Up Stream End Only)

DESIGN STRESSES
fy = 60,000 psi
f'c = 3,500 psi

LOADING HS 20-44 & ALT.

NOTES

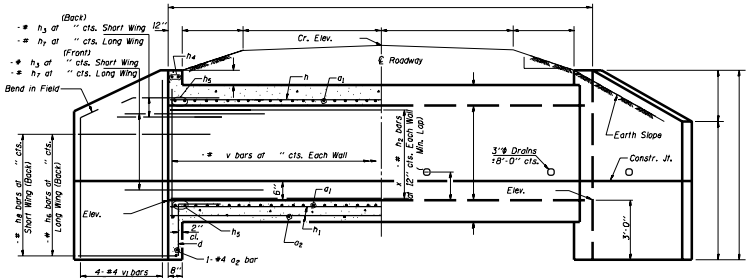
A distance of half the length of the wingwall but not less than six feet of the barrel shall be poured monolithically with the wingwalls.
Reinforcement Bars shall conform to the requirements of AASHTO M-31, M-42 or M-53, Grade 60.
Bars indicated thus 12 x 4-#5 etc. indicates 12 lines of bars with 4 lengths per line.
All construction joints shall be banded.

DESIGNED	
CHECKED	
DRAWN	
CHECKED	
EXAMINED	
PASSED	

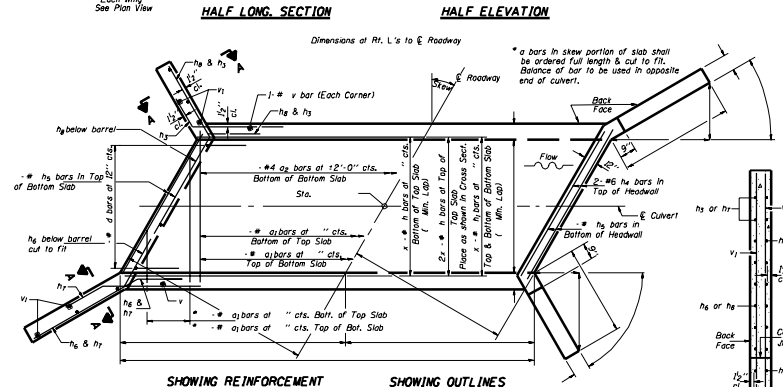
SSB-H-L 6-1-2000

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO.
SHEETS



HALF LONG. SECTION

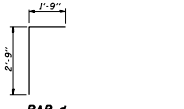


SHOWING REINFORCEMENT

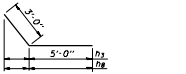
SHOWING OUTLINES

PLAN

SECTION A-A

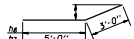


BAR d

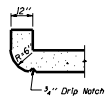


BARS h_3 & h_8

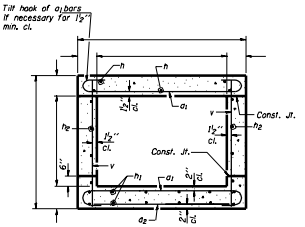
BAR a_1



BARS h_6 & h_7



SECTION THRU HEADWALL
(Up Stream End Only)



SECTION THRU BARREL

BILL OF MATERIAL

Bar	No.	Size	Length	Shape
a_1		#4		
a_2				
d		#4	4'-6"	
h				
h_1				
h_2				
h_3			8'-0"	
h_4		#6		
h_5				
h_6				
h_7			8'-0"	
h_8				
v				
v_1		#4		
Concrete Box Culverts Reinforcement Bars			Cu. Yd. Pound	

DESIGN STRESSES
fy = 60,000 psi
f'c = 3,500 psi

LOADING HS 20-44 & ALT.

NOTES

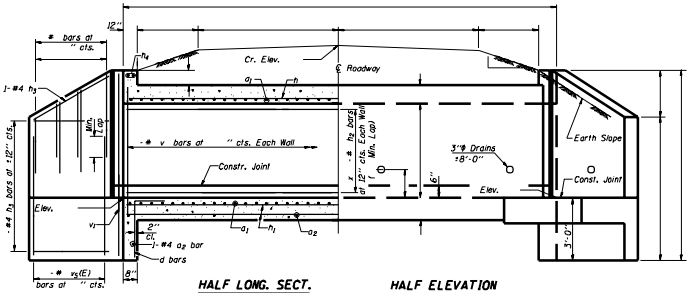
A distance of half the length of the wingwall but not less than six feet of the barrel shall be poured monolithically with the wingwalls.
Reinforcement Bars shall conform to the requirements of AASHTO M-31, M-42 or M-53, Grade 60.
Bars indicated thus 12 x 4-#5 etc. indicates 12 lines of bars with 4 lengths per line.
All construction joints shall be banded.

DESIGNED	
CHECKED	
DRAWN	
CHECKED	
EXAMINED	
PASSED	

SSB-H-R 6-1-2000

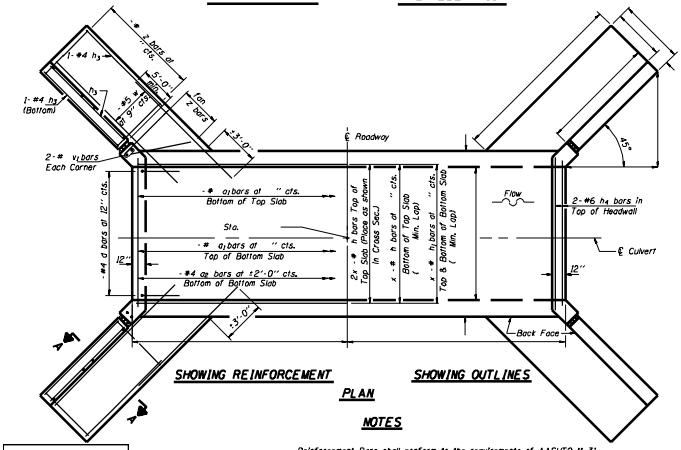
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO.
SHEETS



HALF LONG. SECT.

HALF ELEVATION



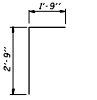
SHOWING REINFORCEMENT

SHOWING OUTLINES

PLAN

NOTES

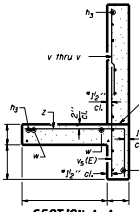
Reinforcement Bars shall conform to the requirements of AASHTO M-31, M-42 or M-53, Grade 60.
Bars indicated thus 12 x 4-#5 etc. indicates 12 lines of bars with 4 lengths per line.
Reinforcement bars designated (E) shall be epoxy coated.
All construction joints shall be bonded.



BAR d

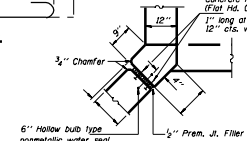
BAR z

BAR a1

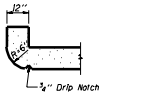


SECTION A-A

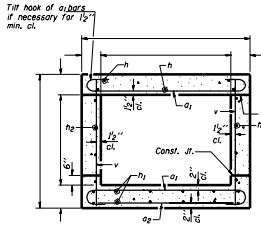
*v bars shall not be placed more than 1½" cl. from back face of wingwall.



CORNER DETAIL



SECTION THRU HEADWALL
(Up Stream End Only)



SECTION THRU BARREL

BILL OF MATERIAL

Bar	No.	Size	Length	Shape
a1				
a2		#4		
d		#4	4'-6"	
h				
h1				
h2				
h3		#4		
h4		#6		
v				
v1				
v2				
v3				
v4				
v5(E)				
w		#5		
z				
Concrete Box Culverts			Cu. Yd.	
Reinforcement Bars, Epoxy Coated			Pound	
Reinforcement Bars			Pound	

DESIGNED
CHECKED
DRAWN
CHECKED

EXAMINED
PASSED

DESIGN STRESSES

fy = 60,000 psi
f'c = 3,500 psi

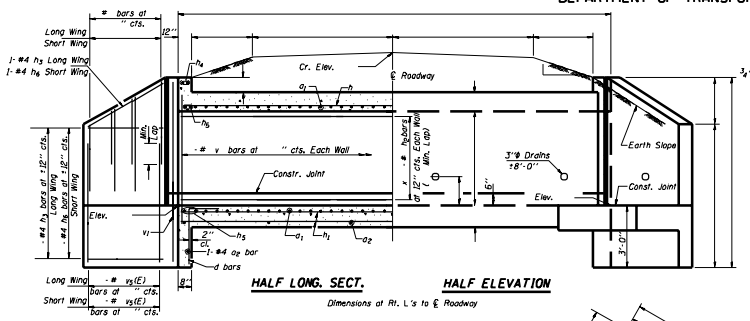
Max. Soil Pressure under footing = psf

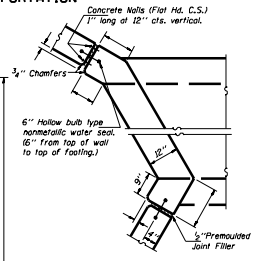
LOADING HS 20-44 & ALT.

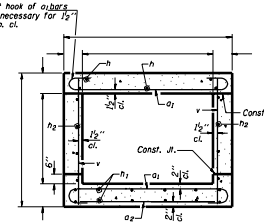
SSB-L-0 6-1-2000

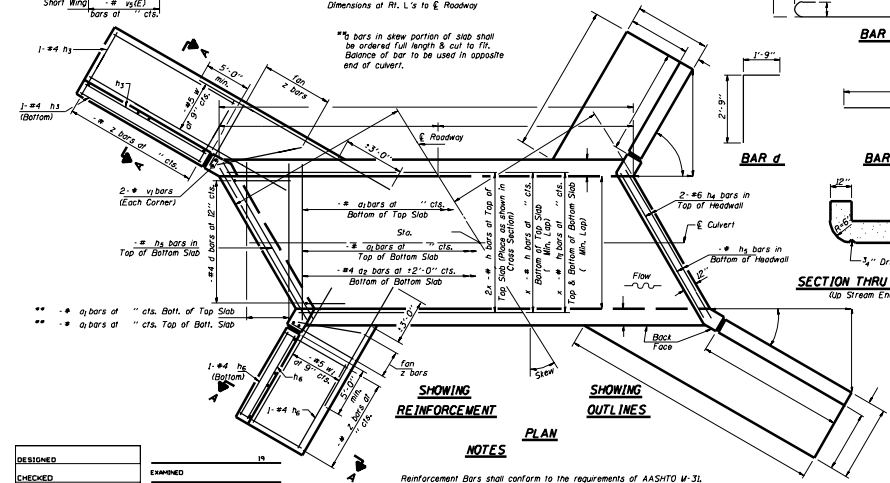
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO.
SHEETS

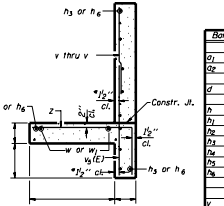








**ϕ bars in skew portion of slab shall be ordered full length & cut to fit. Balance of bar to be used in opposite end of culvert.



*v bars shall not be placed more than 1½'' cl. from back face of wingwall.

DESIGN STRESSES

fy = 60,000 psi
f'c = 3,500 psi

Max. Soil Pressure under Footing - psf

LOADING HS 20-44 & ALT.

BILL OF MATERIAL

Bar	No.	Size	Length	Shape
a1				
a2		#4		
d		#4	4'-6''	
h				
h1				
h2				
h3		#4		
h4		#6		
h5				
h6		#4		
v				
v1				
v2				
v3				
v4				
v5(E)				
w		#5		
w1		#5		
z				
Concrete Box Culverts			Cu. Yd.	
Reinforcement Bars, Epoxy Coated			Pound	
Reinforcement Bars			Pound	

NOTES

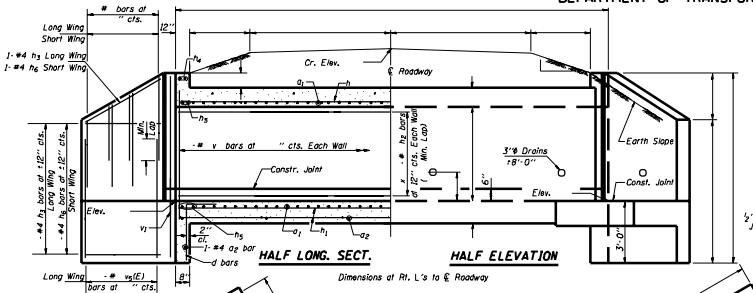
Reinforcement Bars shall conform to the requirements of AASHTO M-31, M-42 or M-53, Grade 60.
Bars indicated thus 12 x 4-#5 etc. indicates 12 lines of bars with 4 lengths per line.
Reinforcement bars designated (E) shall be epoxy coated.
All construction joints shall be bonded.

DESIGNED	
CHECKED	
DRAWN	
CHECKED	
EXAMINED	
PASSED	

SSB-L·L 6-1-2000

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

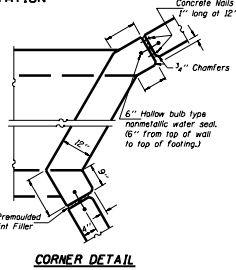
SHEET NO.
SHEETS



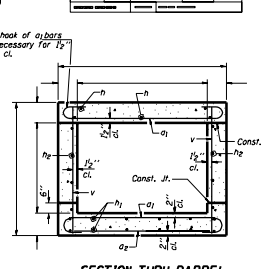
HALF LONG. SECT.

HALF ELEVATION

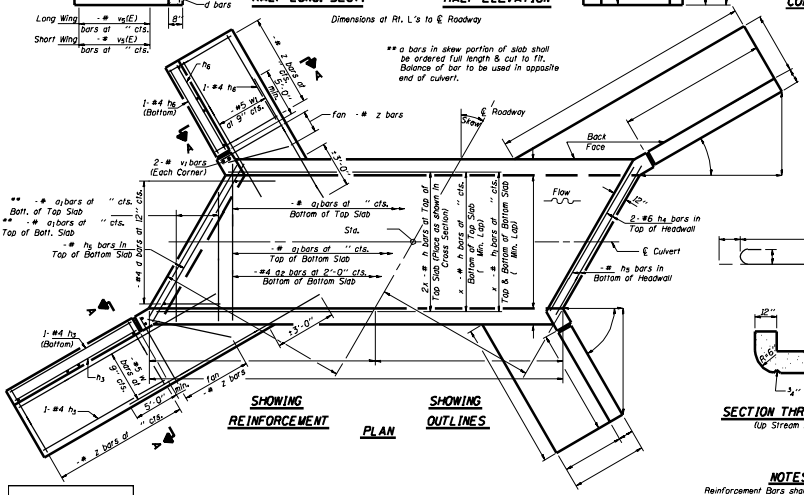
Dimensions at Rt. L's to ℄ Roadway



CORNER DETAIL



SECTION THRU BARREL

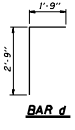


** -# q1 bars at " cts. Batt. of Top Slab
** -# q1 bars at " cts. Top of Bott. Slab

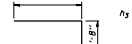
SHOWING REINFORCEMENT

PLAN

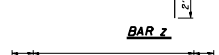
SHOWING OUTLINES



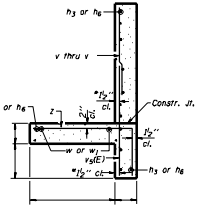
BAR d



BAR z

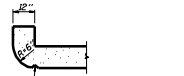


BAR q1



SECTION A-A

*v bars shall not be placed more than ½" cl. from back face of wingwall.



SECTION THRU HEADWALL
(Up Stream End Only)

DESIGN STRESSES

fy = 60,000 psi
f'c = 3,500 psi

Max. Soil Pressure under footing = psf

LOADING HS 20-44 & ALT.

BILL OF MATERIAL

Bar	No.	Size	Length	Shape
q1				
q2		#4		
d		#4	4'-6"	
h				
h1				
h2				
h3		#4		
h4		#6		
h5				
h6		#4		
v				
v1				
v2				
v3				
v4				
v3(E)				
w		#5		
w1		#5		
z				
Concrete Box Culverts			Cu. Yd.	
Reinforcement Bars, Epoxy Coated			Pound	
Reinforcement Bars			Pound	

NOTES

Reinforcement Bars shall conform to the requirements of AASHTO M-31, M-42 or M-53, Grade 60.
Bars indicated thus 12 x 4-#5 etc. indicates 12 lines of bars with 4 lengths per line.
Reinforcement bars designated (E) shall be epoxy coated.
All construction joints shall be bonded.

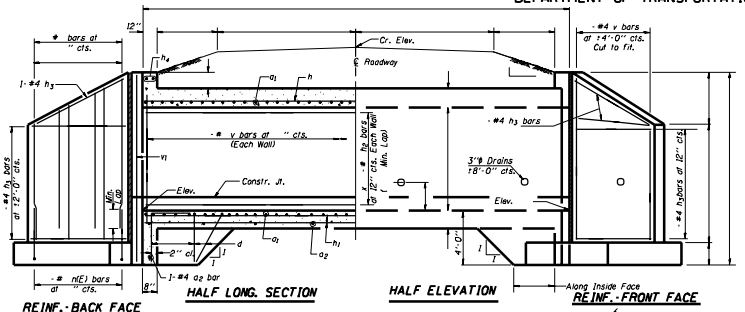
DESIGNED	
CHECKED	
DRAWN	
CHECKED	

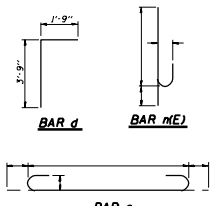
EXAMINED
PASSED

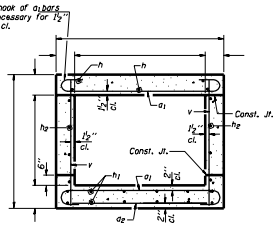
SSB-L·R 6-1-2000

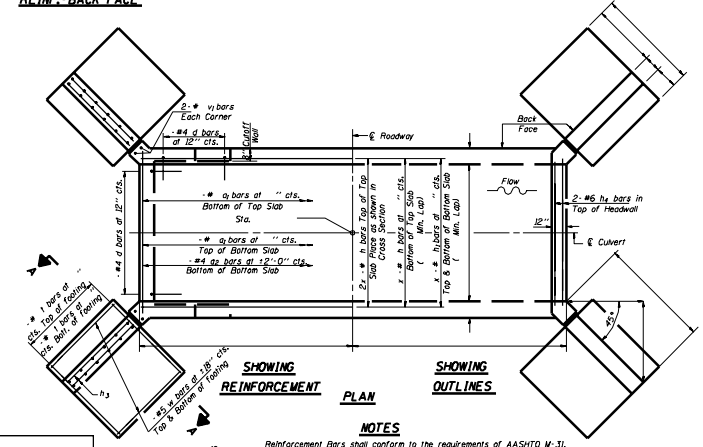
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

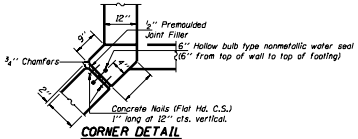
SHEET NO.
SHEETS

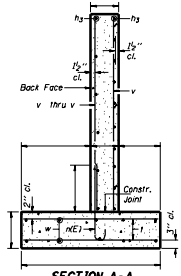












BILL OF MATERIAL

Bar	No.	Size	Length	Shape
a_1				
a_2		#4		
d		#4	5'-6"	
h				
h_1				
h_2				
h_3		#4		
h_4		#6		
n(E)				
t				
v				
v_1				
v_2				
v_3				
v_4				
w		#5		
Concrete Box Culverts			Cu. Yd.	
Reinforcement Bars, Epoxy Coated			Pound	
Reinforcement Bars			Pound	

NOTES

Reinforcement Bars shall conform to the requirements of AASHTO M-31, M-42 or M-53, Grade 60.
Bars indicated thus 12 x 4-#5 etc. indicates 12 lines of bars with 4 lengths per line.
Reinforcement bars designated (E) shall be epoxy coated.
All construction joints shall be bonded.

DESIGN STRESSES

f_y = 60,000 psi
$f'c$ = 3,500 psi

Max. Soil Pressure under footing = psf

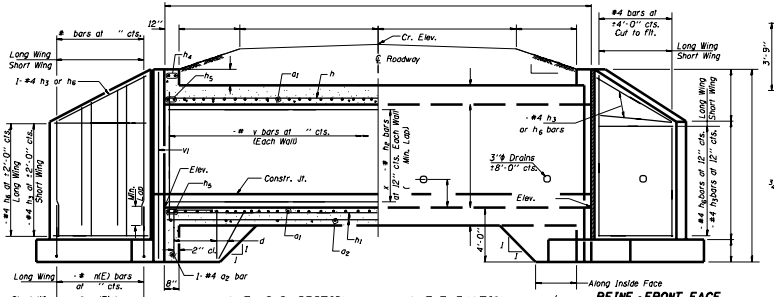
LOADING HS 20-44 & ALT.

DESIGNED	
CHECKED	
DRAWN	
CHECKED	
EXAMINED	
PASSED	

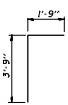
SSB-T1-0 6-1-2000

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO.
SHEETS

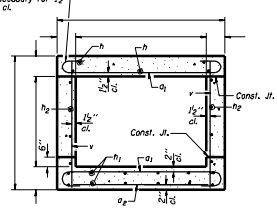


HALF LONG. SECTION

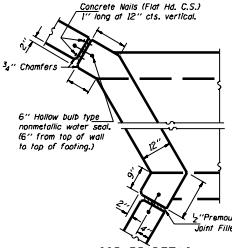


BAR d

BAR n(E)



SECTION THRU BARREL

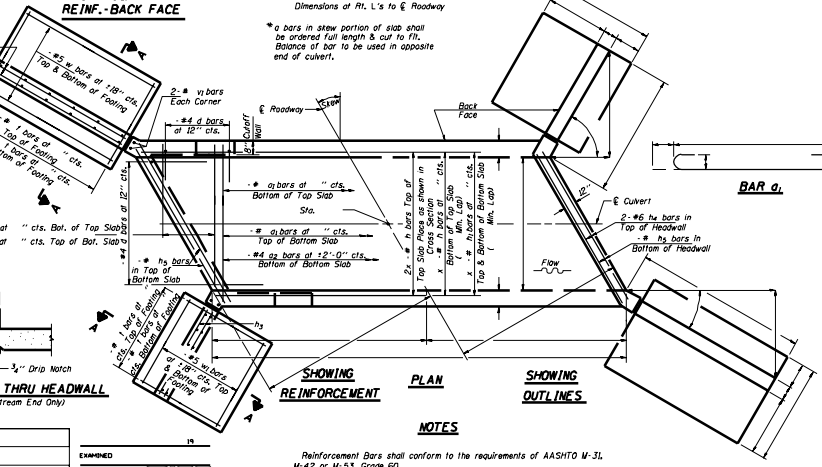


CORNER DETAIL

BILL OF MATERIAL

Bar	No.	Size	Length	Shape
a_1				
a_2		#4		
d		#4	5'-6"	
h				
h_1				
h_2				
h_3		#4		
h_4		#6		
h_5				
h_6		#4		
n(E)				
t				
v				
v_1				
v_2				
v_3				
v_4				
w		#5		
w_1		#5		

Concrete Box Culverts	Cu. Yd.
Reinforcement Bars, Epoxy Coated	Pound
Reinforcement Bars	Pound



REINF.-BACK FACE

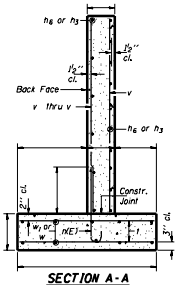
HALF ELEVATION

Dimensions at Rt. L's to ℄ Roadway

*ϕ bars in stem portion of slab shall be ordered full length & cut to fit. Balance of bar to be used in opposite end of culvert.

REINF.-FRONT FACE

BAR a_1



SECTION A-A

SECTION THRU HEADWALL
(Up Stream End Only)

SHOWING REINFORCEMENT PLAN SHOWING OUTLINES

NOTES

Reinforcement Bars shall conform to the requirements of AASHTO M-31, M-42 or M-53, Grade 60.
Bars indicated thus 12 x 4-#5 etc. indicates 12 lines of bars with 4 lengths per line.
Reinforcement bars designated (E) shall be epoxy coated.
All construction joints shall be bonded.

DESIGN STRESSES

fy = 60,000 psi
f'c = 3,500 psi

Max. Soil Pressure under footing = psf

LOADING HS 20-44 & ALT.

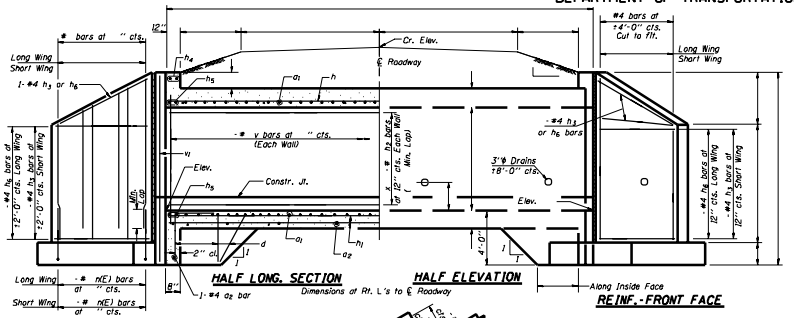
DESIGNED	
CHECKED	
DRAWN	
CHECKED	

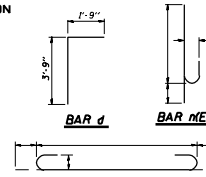
EXAMINED
PASSED

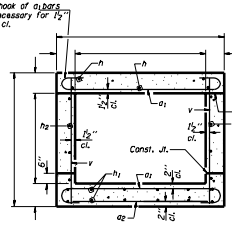
SSB-TI-L 6-1-2000

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO.
SHEETS



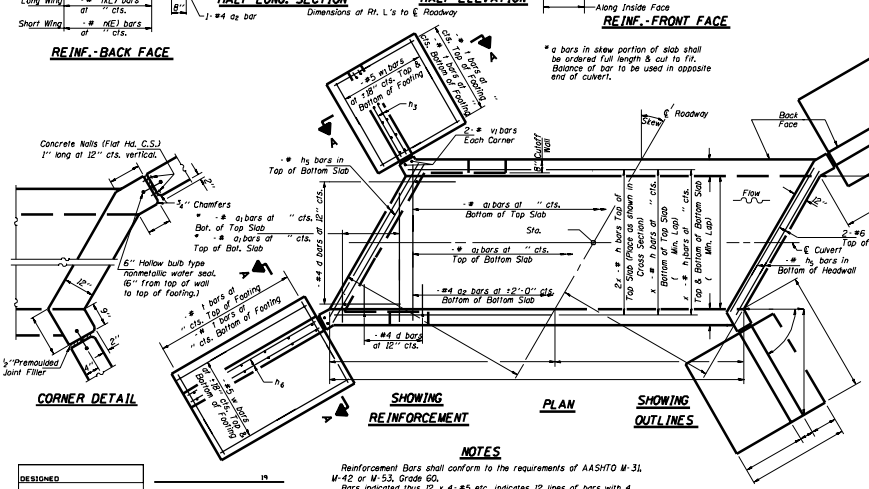


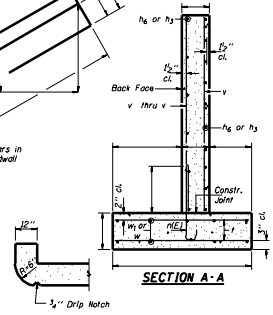


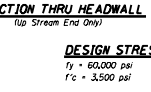
SECTION THRU BARREL

REINF.-BACK FACE

REINF.-FRONT FACE







SECTION THRU HEADWALL
(Up Stream End Only)

BILL OF MATERIAL

Bar	No.	Size	Length	Shape
a_1				
a_2		#4		
d		#4	5'-6"	
h				
h_1				
h_2				
h_3		#4		
h_4		#6		
h_5				
h_6		#4		
n(E)				
t				
v				
v_1				
v_2				
v_3				
v_4				
w		#5		
w_1		#5		
Concrete Box Culverts				Cu. Yd.
Reinforcement Bars, Epoxy Coated				Pound
Reinforcement Bars				Pound

NOTES

Reinforcement Bars shall conform to the requirements of AASHTO M-31, M-42 or M-53, Grade 60.
Bars indicated thus 12 x 4 - #5 etc. indicates 12 lines of bars with 4 lengths per line.
Reinforcement bars designated (E) shall be epoxy coated.
All construction joints shall be bonded.

DESIGN STRESSES

fy = 60,000 psi
f'c = 3,500 psi

Max. Soil Pressure under footing = psi

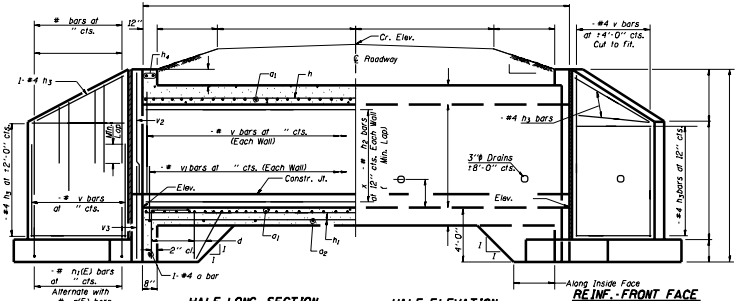
LOADING HS 20-44 & ALT.

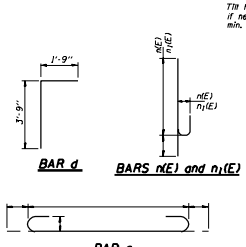
DESIGNED	
CHECKED	
DRAWN	
CHECKED	
EXAMINED	
PASSED	

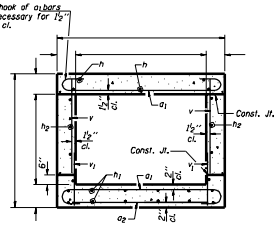
SSB-T1-R 6-1-2000

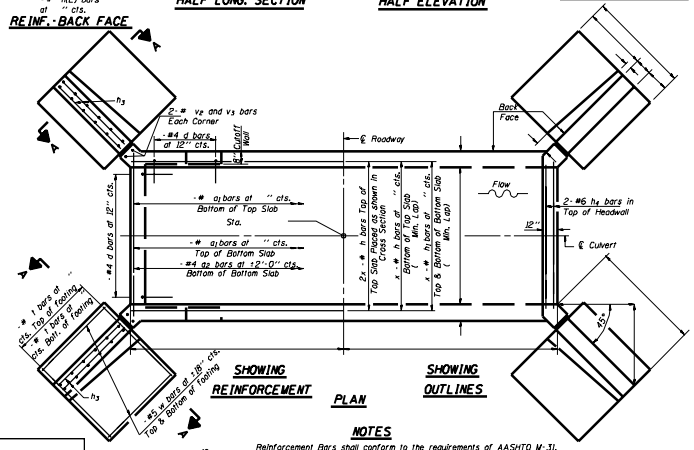
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

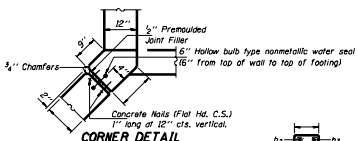
SHEET NO.
SHEETS

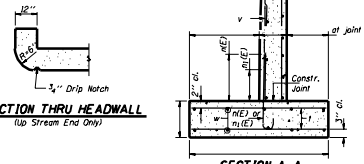












BILL OF MATERIAL

Bar	No.	Size	Length	Shape
a_1				
a_2		#4		
d		#4	5'-6"	
h				
h_1				
h_2				
h_3		#4		
h_4		#6		
n(E)				
$n_1(E)$				
f				
v				
v_1				
v_2				
v_3				
v_4				
v_5				
v_6				
v_7				
w		#5		
Concrete Box Culverts			Cu. Yd.	
Reinforcement Bars, Epoxy Coated			Pound	
Reinforcement Bars			Pound	

NOTES

Reinforcement Bars shall conform to the requirements of AASHTO M-31, M-42 or M-53, Grade 60.
Bars indicated thus 12 x 4-#5 etc. indicates 12 lines of bars with 4 lengths per line.
Reinforcement bars designated (E) shall be epoxy coated.
All construction joints shall be bonded.

DESIGN STRESSES

fy = 60,000 psi
f'c = 3,500 psi

Max. Soil Pressure under footing = psf

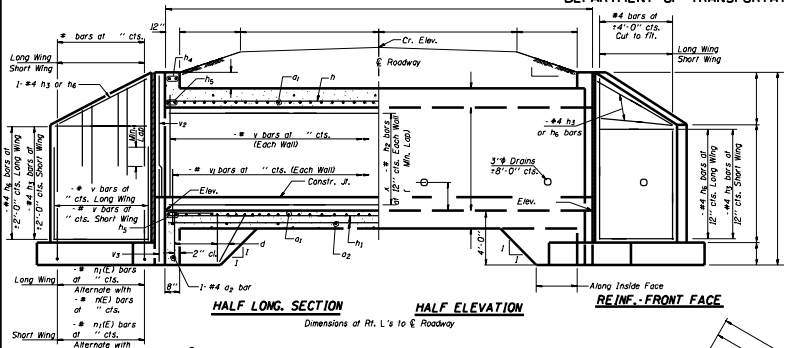
LOADING HS 20-44 & ALT.

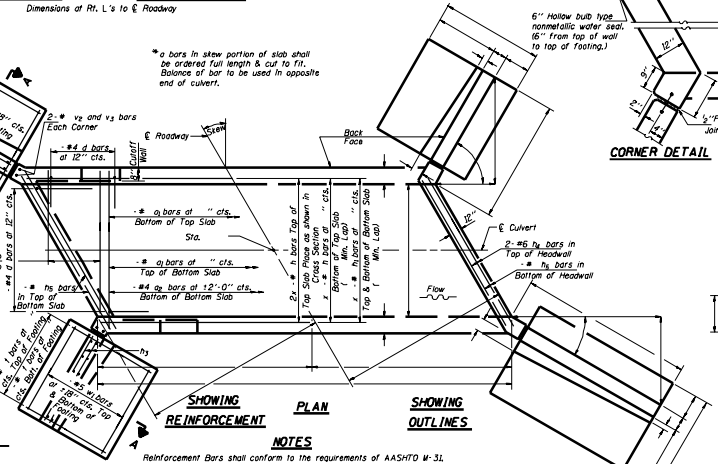
DESIGNED	
CHECKED	
DRAWN	
CHECKED	
EXAMINED	
PASSED	

SSB-T2-0 6-1-2000

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO.
SHEETS



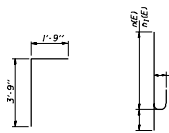


SECTION THRU HEADWALL
(Up Stream End Only)

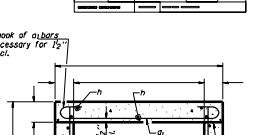
SHOWING REINFORCEMENT PLAN SHOWING OUTLINES

NOTES

Reinforcement Bars shall conform to the requirements of AASHTO M-31, M-42 or M-53, Grade 60.
Bars indicated thus 12 x - 4-#5 etc. indicates 12 lines of bars with 4 lengths per line.
Reinforcement bars designated (E) shall be epoxy coated.
All construction joints shall be bonded.



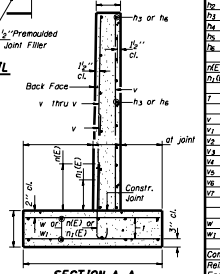
BAR d BARS n(E) and n1(E)



SECTION THRU BARREL

BAR a1

CORNER DETAIL



SECTION A-A

BILL OF MATERIAL

Bar	No.	Size	Length	Shape
a1				
a2		#4		
d		#4	5'-6"	
h				
h1				
h2				
h3		#4		
h4		#6		
h5				
h6		#4		
n(E)				
n1(E)				
t				
v				
v1				
v2				
v3				
v4				
v5				
v6				
v7				
w		#5		
w1		#5		
Concrete Box Culverts			Cu. Yd.	
Reinforcement Bars, Epoxy Coated			Pound	
Reinforcement Bars			Pound	

DESIGN STRESSES
fy = 60,000 psi
f'c = 3,500 psi
Max. Soil Pressure under footing = psf

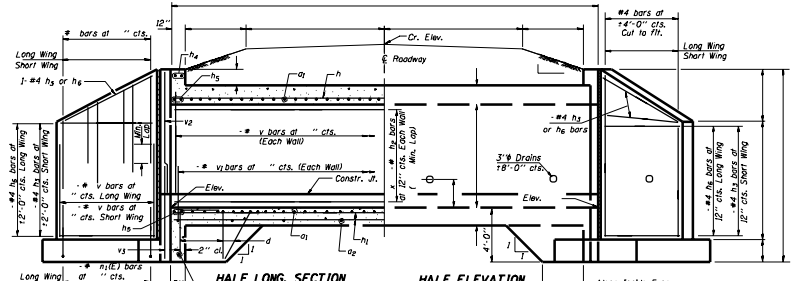
LOADING HS 20-44 & ALT.

DESIGNED	
CHECKED	
DRAWN	
CHECKED	
EXAMINED	
PASSED	

SSB-T2-L 6-1-2000

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

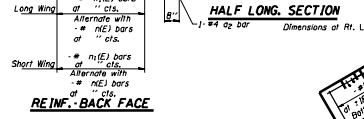
SHEET NO.
SHEETS



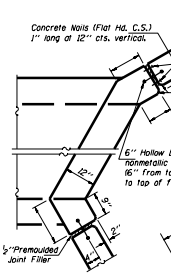
HALF LONG. SECTION

HALF ELEVATION

REINF.-FRONT FACE



REINF.-BACK FACE



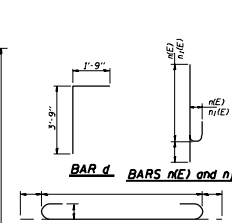
CORNER DETAIL

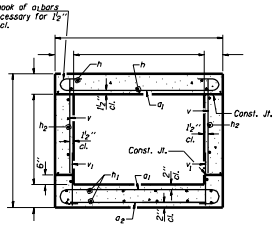
SHOWING REINFORCEMENT

PLAN

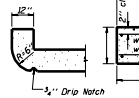
SHOWING OUTLINES

* q bars in skew portion of slab shall be ordered full length & cut to fit. Balance of bar to be used in opposite end of culvert.

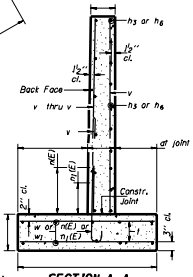




SECTION THRU BARREL



SECTION THRU HEADWALL
(Up Stream End Only)



SECTION A-A

BILL OF MATERIAL

Bar	No.	Size	Length	Shape
a_1				
a_2		#4		
d		#4	5'-6"	
h				
h_1				
h_2				
h_3		#4		
h_4		#6		
h_5				
h_6		#4		
n(E)				
n_1(E)				
t				
v				
v_1				
v_2				
v_3				
v_4				
v_5				
v_6				
v_7				
w		#5		
w_1		#5		
Concrete Box Culverts				Cu. Yd.
Reinforcement Bars, Epoxy Coated				Pound
Reinforcement Bars				Pound

NOTES

Reinforcement Bars shall conform to the requirements of AASHTO M-31, M-42 or M-53, Grade 60.

Bars indicated thus 12 x 4 - #5 etc. indicates 12 lines of bars with 4 lengths per line.

Reinforcement bars designated (E) shall be epoxy coated.

All construction joints shall be bonded.

DESIGN STRESSES

fy = 60,000 psi

f'c = 3,500 psi

Max. Soil Pressure
under footing = psf

LOADING HS 20-44 & ALT.

DESIGNED	
CHECKED	
DRAWN	
CHECKED	
EXAMINED	
PASSED	

SSB-T2-R 6-1-2000