SECTION 109 - STORM SEWERS

SECTION 109 - STORM SEWERS

This section covers the design of closed piping for conveyance of storm drainage. Design of bridges, culverts, open channels and other conveyances is covered in other sections.

109.1 GENERAL REQUIREMENTS

109.1.1 Horizontal Alignment

Except for crossings, storm sewers shall not be located under streets. Storm sewers paralleling curbed streets shall be located such that the outside edge of the pipe is six inches (6") minimum behind the back edge of the curb. Pipes shall be aligned in straight lines. Curved alignments are not allowed.

Storm sewers located on private property shall be located within drainage easements and shall be aligned parallel with property lines unless otherwise approved. Where storm drains exit the street right-of-way between residential lots, the pipe shall be extended a minimum of forty feet (40')

past the front yard setback line, or to the estimated location of the rear of the dwellings, whichever is more. The outside edge of the pipe shall be located a minimum of five feet (5') from the easement
line. Minimum easement widths are given in Table 109.1.

TABLE 109.1 MINIMUM EASEMENT WIDTHS

INSIDE HORIZONTAL DIMENSION	MINIMUM EASEMENT WIDTH
15"- 48"	15 FEET
54"- 72"	17.5 FEET
84" & 96"	20 FEET
OVER 96"	APPROVAL REQUIRED

109.1.2 Bends and Junctions

A manhole or junction structure must be provided at each change in direction or grade of the piping, EXCEPT that bends may be located at junction structures in order to provide a perpendicular connection. Bends must be provided at junction structures if the angle of entry is less than sixty (60) degrees (see Figure 109.1). Pipes shall be aligned such that the direction of flow of any incoming pipe is not less than perpendicular to the direction of flow of the outflow pipe (i.e. flow "against the grain" shall be avoided).

Access manholes for junction structures shall not be located within the pavement area for public streets. Junction structures shall be located such that the outside edge of the access manhole is twelve inches (12") minimum behind the curb or from the edge of a retaining wall or other obstruction.

Access manholes shall be provided at a maximum of three hundred feet (300') spacing along the pipe.

Precast circular manholes, square cast-in-place or precast junction boxes, or inlets may be used for junction structures.

109.1.3 Vertical Alignment

The recommended minimum slope for storm drain piping is 0.5% (five-tenths percent). Pipe grades may not be less than the minimum friction slope required to convey the design flow, unless specifically approved. Maximum recommended grade is 10% (ten percent). Properly designed anchorage may be required for grades above 10% (ten percent) and will be required for grades above 20% (twenty percent).

When changing pipe diameters, the inside tops of the pipes shall be set at the same elevation. Pipe size shall never be reduced downstream even though pipe slope and theoretical capacity may increase. A minimum vertical drop of 0.2' (two-tenths feet) shall always be provided across a junction structure, unless otherwise approved.

Under or within two feet (2') of streets or paved areas, the top of the pipe shall be located a minimum of twelve inches (12") below the pavement or curb subgrade, or greater if required to meet minimum cover and strength requirements for the type of pipe specified to withstand an AASHTO HS-20 loading. Outside of paved areas, the top of the pipe shall be located a minimum of twelve inches (12") below finished earth grade. Box culverts or other relatively wide and flat conveyance structures may be required to have additional cover if deemed necessary to support grass or other vegetative cover.

109.1.4 Clearance from Other Utilities

Horizontal Clearance:

Utility	Minimum distance from outside edge of pipe to centerline
Storm sewer	Inside diameter of largest pipe*
Sanitary sewer	Five feet (5')
Water, gas, electric line, or other utility	Five feet (5')

* or greater, if needed to allow proper placement and alignment of flared end sections

Vertical Clearance:

A minimum clear distance of twelve inches (12") from any other utility line shall be maintained above or below the storm drain pipe, unless otherwise approved.

109.1.5 Allowable Sizes

The minimum allowable inside diameter for any storm drain pipe on or connecting to storm drain piping in public right-of-way is fifteen inches (15"). The maximum allowable diameter is six feet (6'), unless otherwise approved.

109.1.6 Plan Requirements

Each storm drain line shown on the plan shall be numbered or lettered (Line 1, Storm1, Line A, etc.). Structures in each line shall be numbered or lettered in sequence beginning at the downstream end of the line. Stationing shall begin at the downstream end of the line and proceed upstream. Branch lines shall be numbered consecutively moving in an upstream direction. A continuous profile shall be drawn for each storm drain line.

109.2 CONSTRUCTION MATERIALS

109.2.1 Types of Pipe Allowed

Storm sewers may be constructed of any of the following materials:

Material	Symbol	Standard
Reinforced concrete round pipe	RCP	ASTM C-76, Class III
Reinforced concrete elliptical pipe	RCEP	ASTM C-507
Reinforced concrete pipe-arch	RCPA	ASTM C-478
Precast concrete flared end sections	FES	ASTM C-76
Corrugated, galvanized steel round pipe	CMP	ASTM A-760 AASHTO M-36
Corrugated, galvanized steel pipe-arch	CMPA	AASHTO M-167
Galvanized steel flared end sections	FES	ASTM A-760
Corrugated polyethylene pipe	CPP	ASTM D-1248
Cast-in-place reinforced concrete box culverts	RCB	MODOT Specification
Precast concrete box culvert	RCB	ASTM-789

Cast-in-place concrete pipe, masonry, vitrified clay, or other pipe not shown above is not allowed unless specifically approved.

Detailed information on structural and hydraulic properties of the type of pipe referred to above can be found in the Concrete Pipe Design Manual (Reference 109.1), the Handbook of Streel Drainage & Highway Construction Products (Reference 109.2) and manufacturer's information for corrugated polyethylene pipe.

Corrugated polyethylene pipe (CPP) is not allowed within the public right-of-way or public drainage easements, unless approved in writing by the Stormwater Engineer.

109.2.2 Junction Structures

Precast Manholes

Precast concrete manholes shall conform to the requirements of ASTM-C478. Cast-in-place circular manholes are not permitted.

The following minimum manhole diameters shall be used:

Pipe Diameter	Minimum Inside Diameter of Manhole
15"-24"	Four feet (4')
27"-42"	Five feet (5')
48"	Six feet (6')
54"-66"	Eight feet (8')
>66"	Special junction structure

A minimum clearance of two feet (2') measured at the inside face of the manhole must be maintained between the outside edge of storm sewer pipes.

Junction Boxes

Square or rectangular junction boxes may be constructed of cast-in-place or precast concrete. Cast-in-place junction boxes shall be constructed as shown in Figure 109.2.

Minimum horizontal dimensions for junction boxes are as follows:

Pipe Diameter	Minimum Inside Width of Junction Box
15"- 30"	Four feet (4')
36"- 42"	Five feet (5')
48"	Five feet six inches (5' 6")
54"	Six feet (6')
60"	Six feet six inches (6' 6")
66"	Seven feet (7')
72"	Seven feet six inches (7 '6")
>72"	Special approval required

Junction boxes shall not exceed eight feet (8') in depth measured from the interior invert of the junction box to the top of the junction box rim, unless structural calculations are submitted and approved.

Precast junction structures shall have a maximum inside horizontal dimension of eight feet (8') and a maximum depth of eight feet (8'), unless structural calculations are submitted and approved. Precast junction boxes shall be as manufactured by Rose-Con Pipe, Springfield, Missouri, or approval equal.

109.3 HYDRAULIC DESIGN

109.3.1 Design Storm

Storm sewers shall be designed to convey the peak flow rate resulting from the required design storm having a rainfall intensity corresponding to the time of concentration at the point of interest, or a duration which produces the maximum runoff rate at the point of interest, depending upon the method used for computing runoff. It is preferred that storm sewers draining less than two hundred (200) acres be designed for runoff rates computed by the Rational Method.

Major (Emergency) System

Total drainage area less than one (1) square mile: 25-year (4% AEP) storm

Total drainage area one (1) square mile or more: 100-year (1% AEP) storm

In cases where no overland relief area is provided for the difference between the 25- and 100-year storm, storm sewers shall be designed to convey the 100-year storm.

Minor (Convenience) System

Storm sewers shall be designed to convey only intercepted flow necessary to maintain allowable street flooding depths, set forth in Figure 108.1.

Reductions in peak flow rates to account for the effects of stormwater detention facilities located upstream will be allowed only in instances where the detention basin has been incorporated into an approved hydrologic model of the tributary watershed.

109.3.2 Storm Sewer Capacity

Storm sewers shall be designed to convey the peak flow rate from the design storm set forth in Section 109.3.1 while maintaining allowable maximum and minimum velocities, and without surcharging which would adversely effect the performance of inlets or other components or the drainage system, or cause flooding of structures or streets.

Allowable Hydraulic Grades

Maximum hydraulic grade elevation for the design discharge shall be six inches (6") below the lowest level of any inlet opening or twelve inches (12") below the rim of a junction box or manhole.

Pipe Capacity

Pipe capacity and velocity shall be computed using Manning's Equation:

$$Q = \frac{1.49}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Q = rate of flow, cubic feet per second

n = Manning's roughness coefficient, see below

A = cross sectional area of flow, square feet

P = wetted perimeter, feet

R = hydraulic radius = A/P, feet

S = slope

Type of Pipe	Manning's Roughness Coefficient
Reinforced concrete (all shapes, cast in place & precast)	0.013
Corrugated metal (annular corrugations)	0.024
Corrugated metal (helical corrugations)	0.011-0.024 (Use values recommended in Table 3.9 of the Handbook of Street Drainage and Highway Construction Products (Reference 109.2))
Corrugated polyethylene (smooth wall)	0.013

The expression (1.49/n) A R^(2/3) is termed the conveyance of the pipe section. Full flow values for area, hydraulic radius and conveyance for circular pipe is shown in Figure 109.3 (Reference 109.1). Properties for reinforced concrete elliptical pipe and reinforced concrete pipe-arch are shown in Figure 109.4 (Reference 109.1). Properties for corrugated metal pipe-arch are shown in Figure 109.5 (Reference 109.2).

Energy Grade Line (EGL)

The energy grade line is computed using the principle of conservation of energy and the energy equation for open channel or pressure flow, and is written as follows:

Open Channel Flow

$$z_1 + d_1 + \frac{V_1^2}{2g} = z_2 + d_2 + \frac{V_2^2}{2g} + H_L$$

Pressure Flow

$$z_1 + \frac{p_1}{\gamma} + \frac{V_1^2}{2g} = z_2 + \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + H_L$$

z = elevation (gravity) head, feet

d = depth of flow, feet

V = velocity of flow = Q/A, feet/second

P/γ = pressure head, feet

γ = unit fluid weight, pounds per cubic foot

H_L = total head loss, feet = $h_f + \sum h_m$

h_f = head loss due to friction, feet = L x S_f

L = pipe length, feet

S_f = pipe friction slope from Manning's Equation, feet/foot, $Sf = \left(\frac{Q}{C_1}\right)^2$

C_1 = conveyance = $\frac{1.49}{n} A\ R^{2/3} S^{1/2}$ (See Figure 109.3)

h_m = minor head loss, at entrance, exit, bends, and junctions, feet (see below)

D = pipe diameter, or vertical dimension, feet

Q_f = pipe capacity at full flow, cubic feet per second

V_f = velocity at full flow, feet/second

V = velocity, feet/second

Hydraulic Grade Line (HGL)

Hydraulic grades are computed by subtracting the velocity head , $\left(V^2/2g \right)$, from the energy head. When the velocity is zero, the hydraulic grade line is coincident with the energy grade line.

Minor Head Losses

Minor head losses are computed as follows:

Pipe Entrance

$$h_c = K_c \frac{V^2}{2g}$$

Contraction coefficient, K_c = 0.5 (Reference 109.3) (for square edge conditions)

$$h_e = K_e \frac{V^2}{2g}$$, Expansion coefficient, K_e = 1.0

Junction and Manhole Losses

$$h_j = \frac{V_2^2}{2g} - K_j \frac{V_1^2}{2g}$$

Junction loss coefficient, K_j , for use in the foregoing equation is as defined in Figure 109.6 (Reference 109.4). Other methods of computing junction and manhole losses are acceptable, provided they are documented in generally accepted literature.

Bends

$h_b = K_b \frac{V^2}{2g}$, Bend coefficient, K_b as follows (Reference 109.2):

Deflection at Bend	Head Loss Coefficient, K_b
90 degrees	0.50
60 degrees	0.43
45 degrees	0.35
22.5 degrees	0.20

109.4 OUTLET REQUIREMENTS

Storm sewer outlets shall be designed to allow expansion of flow and reduction of velocity, without undue risk of erosion downstream, and allowing for proper construction and maintenance of cut or embankment slopes at the outlet.

A headwall or flared end section shall be provided at all pipe outlets. Flared end sections and headwalls shall have a toewall extending a minimum of eighteen inches (18") below grade at their downstream end to prevent undercutting.

An erosion resistant lining of concrete or grouted riprap shall be provided for a distance equal to five (5) times the diameter of the outlet pipe or the box culvert width, downstream of the headwall apron or flared end section. The width of the grouted riprap shall be a minimum of two (2) times the pipe diameter or box culvert width or five feet (5'), whichever is less. Where velocity exceeds fifteen feet (15') per second at the pipe outlet an energy dissipator may be required. Energy dissipators shall be designed as set forth in the ASCE design manual (Reference 109.4).

109.5 REFERENCES

1. American Concrete Pipe Association, Concrete Pipe Design Manual.

2. American Iron and Steel Institute, Handbook of Steel Drainage & Highway Products, 5th Edition (1994).

3. Hydraulic Design of Highway Culverts (1985) Federal Highway Administration, Hydraulic Design Series No. 5, Report No. FHWA-IP-85-15, Washington, D.C.

4. American Society of Civil Engineers Manuals and Reports of Engineering Practice No. 77

(WEF Manual of Practice FD-20), Design and Construction of Urban Stormwater Management Systems, Chapters 6 and 8. American Society of Civil Engineers, New York, NY, 1992.

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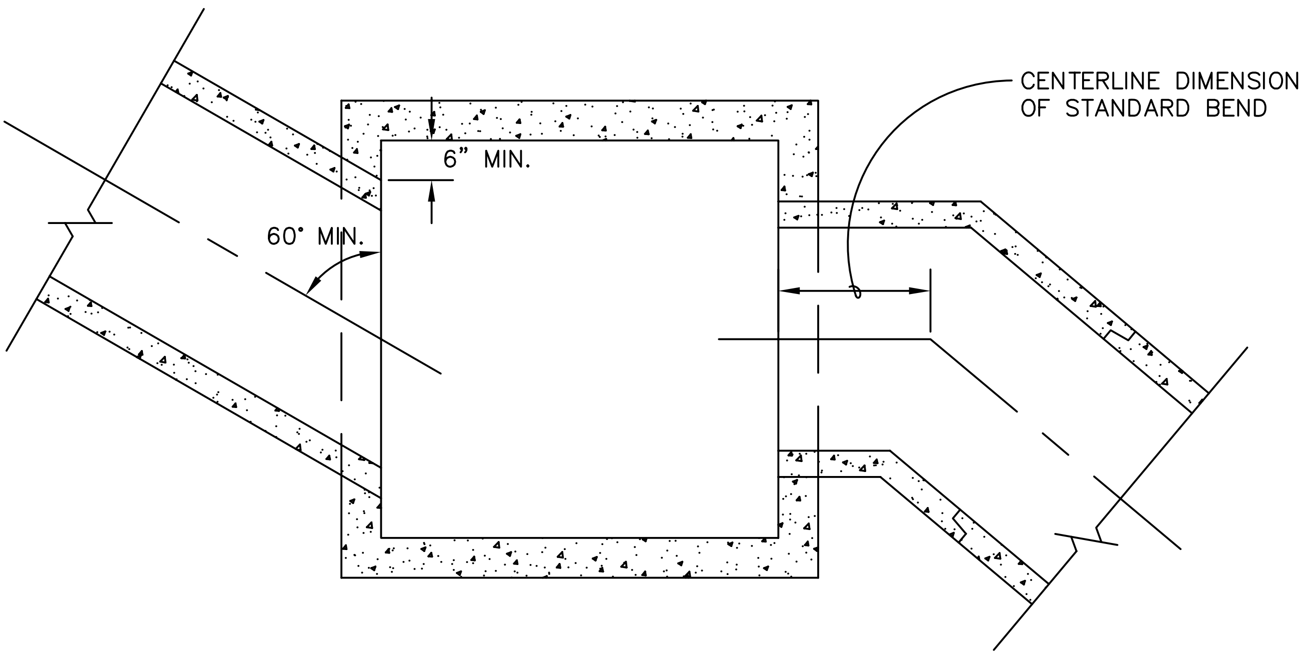

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

TYPICAL PIPE CONNECTIONS AT JUNCTION STRUCTURE

FIGURE 109.1

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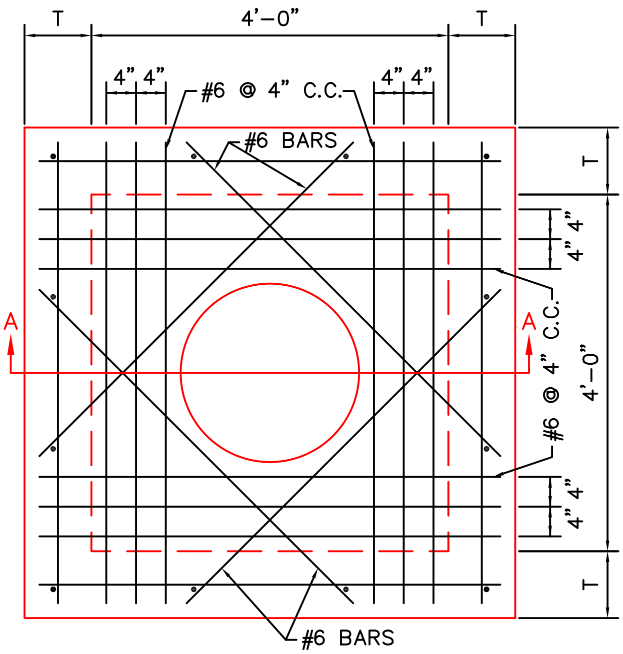
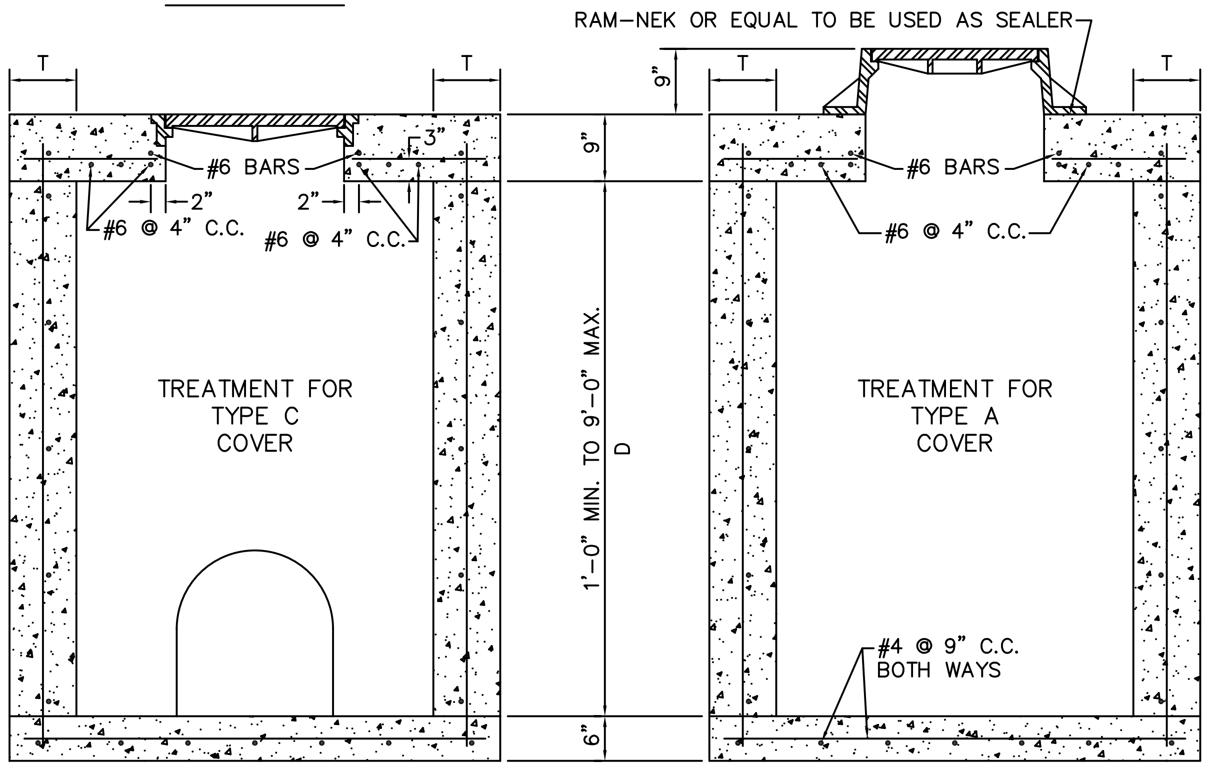


PLAN

STANDARD JUNCTION BOX				
TABLE OF REINFORCEMENT			WALL THICK.	CONC.
"D"	VERT. BARS	HOR. BARS	"T"	CU. YDS.
1'–0"	NONE	NONE	9"	1.93
2'–0"	"	"	9"	2.45
3'–0"	"	"	9"	2.98
4'–0"	"	"	9"	3.50
5'–0"	12 #5 @ 18" C.C. 5'–11" EACH	20 #4 @ 14" C.C. 5'–2" EACH	9"	4.03
6'–0"	12 #5 @ 18" C.C. 6'–11" EACH	20 #4 @ 17" C.C. 5'–2" EACH	9"	4.55
7'–0"	20 #5 @ 12" C.C. 7'–11" EACH	24 #4 @ 16" C.C. 5'–2" EACH	9"	5.08
8'–0"	20 #5 @ 12" C.C. 8'–11" EACH	28 #4 @ 15" C.C. 5'–2" EACH	9"	5.61
9'–0"	20 #5 @ 12" C.C. 9'–11" EACH	28 #4 @ 17" C.C. 5'–2" EACH	9"	6.14

STEEL IN TOP SLAB 16 #6 5'–2" EACH
4 #6 5'–0" EACH
STEEL IN BOTTOM 14 #4 5'–2" EACH
SEE DRAWINGS FOR STEEL PLACEMENT



SECTION AA

1. DIAGONAL BARS IN TOP SLAB PLACED NEAR BOTTOM OF SLAB.
2. REINFORCING BARS SHALL BE CUT OR BENT AT PIPE OPENINGS.
3. ALL PIPES SHALL FIT FLUSH WITH INSIDE FACE OF BOX.
4. MAXIMUM PIPE SIZE FOR BOX IS 42". FOR LARGER PIPES INCREASE INSIDE BOX DIMENSIONS TO THE INSIDE PIPE DIAMETER PLUS 6". USE GIVEN BAR SPACING FOR LARGER BOXES. MAXIMUM ALLOWABLE BOX SIZE IS 72".
5. BOTTOM OF BOX TO BE FILLED WITH CONCRETE TO MID–DEPTH OF PIPE FORMING CHANNELS TOWARD OUTLET PIPE FROM ALL INLET PIPES.
6. ALL CONCRETE SHALL HAVE 28 DAY COMPRESSIVE STRENGTH OF 3000 PSI
7. ALL REINFORCING BARS TO BE DEFORMED BARS AND MEET REQUIREMENTS OF ASTM A–615 MIN. GRADE 40.
8. 4" BEDDING MATERIAL TO BE USED UNDER BOX.
9. IF BOX IS GREATER THAN 9', MUST BE SPECIAL DESIGN.

FROM CITY OF SPRINGFIELD STANDARDS

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

STANDARD JUNCTION BOX

FIGURE 109.2

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DATE: 04/05/99

FULL FLOW DATA FOR CIRCULAR PIPE

D Pipe Diameter (inches)	A Area (Square feet)	R Hydraulic Radius (feet)	Value of $C_1 = \frac{1.486}{n} \times A \times R^{2/3}$	
			n=0.013	n=0.024
4	0.0873	0.083	1.9	---
6	0.196	0.125	5.6	---
8	0.349	0.167	12.1	---
10	0.545	0.208	21.8	---
12	0.785	0.250	35.7	26.3
15	1.227	0.312	64.7	35.0
18	1.767	0.375	105	56.9
21	2.405	0.437	158	85.6
24	3.142	0.500	226	122
27	3.976	0.562	310	167
30	4.909	0.625	410	222
36	7.069	0.750	666	360
42	9.621	0.875	1006	545
48	12.566	1.000	1436	778
54	15.904	1.125	1967	1065
60	19.635	1.250	2604	1414
66	23.758	1.375	3357	1818
72	28.274	1.500	4234	2293
84	38.485	1.750	6388	3460
96	50.266	2.000	9119	4439

FROM: American Concrete Pipe Association, 1985
"Concrete Pipe Design Manual"

TABLE 4

FULL FLOW COEFFICIENT VALUES
ELLIPTICAL CONCRETE PIPE

Pipe Size R x S (HE) S x R (VE) (Inches)	Approximate Equivalent Circular Diameter (Inches)	A Area (Square Feet)	R Hydraulic Radius (Feet)	Value of $C_1 = \frac{1.486}{n} \times A \times R^{2/3}$			
				n = 0.010	n = 0.011	n = 0.012	n = 0.013
14 x 23	18	1.8	0.367	138	125	116	108
19 x 30	24	3.3	0.490	301	274	252	232
22 x 34	27	4.1	0.546	405	368	339	313
24 x 38	30	5.1	0.613	547	497	456	421
27 x 42	33	6.3	0.686	728	662	607	560
29 x 45	36	7.4	0.736	891	810	746	686
32 x 49	39	8.8	0.812	1140	1036	948	875
34 x 53	42	10.2	0.875	1386	1260	1156	1067
38 x 60	48	12.9	0.969	1878	1707	1565	1445
43 x 68	54	16.6	1.106	2635	2395	2196	2027
48 x 76	60	20.5	1.229	3491	3174	2910	2686
53 x 83	66	24.8	1.352	4503	4094	3753	3464
58 x 91	72	29.5	1.475	5680	5164	4734	4370
63 x 98	78	34.6	1.598	7027	6388	5856	5406
68 x 106	84	40.1	1.721	8560	7790	7140	6590
72 x 113	90	46.1	1.845	10300	9365	8584	7925
77 x 121	96	52.4	1.967	12220	11110	10190	9403
82 x 128	102	59.2	2.091	14380	13070	11980	11060
87 x 136	108	66.4	2.215	16770	15240	13970	12900
92 x 143	114	74.0	2.340	19380	17620	16150	14910
97 x 151	120	82.0	2.461	22190	20180	18490	17070
106 x 166	132	99.2	2.707	28630	26020	23860	22020
116 x 180	144	118.6	2.968	36400	33100	30340	28000

TABLE 5

FULL FLOW COEFFICIENT VALUES
CONCRETE ARCH PIPE

Pipe Size R x S (Inches)	Approximate Equivalent Circular Diameter (Inches)	A Area (Square Feet)	R Hydraulic Radius (Feet)	Value of $C_1 = \frac{1.486}{n} \times A \times R^{2/3}$			
				n = 0.010	n = 0.011	n = 0.012	n = 0.013
11 x 18	15	1.1	0.25	65	59	54	50
13½ x 22	18	1.6	0.30	110	100	91	84
15½ x 26	21	2.2	0.36	165	150	137	127
18 x 28½	24	2.8	0.45	243	221	203	187
22½ x 36¼	30	4.4	0.56	441	401	368	339
26⅝ x 43¾	36	6.4	0.68	736	669	613	566
31$\frac{5}{16}$ x 51⅛	42	8.8	0.80	1125	1023	938	866
36 x 58½	48	11.4	0.90	1579	1435	1315	1214
40 x 65	54	14.3	1.01	2140	1945	1783	1646
45 x 73	60	17.7	1.13	2851	2592	2376	2193
54 x 88	72	25.6	1.35	4641	4219	3867	3569
62 x 102	84	34.6	1.57	6941	6310	5784	5339
72 x 115	90	44.5	1.77	9668	8789	8056	7436
77¼ x 122	96	51.7	1.92	11850	10770	9872	9112
87⅛ x 138	108	66.0	2.17	16430	14940	13690	12640
96⅞ x 154	120	81.8	2.42	21975	19977	18312	16904
106½ x 168¾	132	99.1	2.65	28292	25720	23577	21763

FROM: American Iron and Steel Institute, 1994
"Handbook of Steel Drainage & Highway Construction Products"

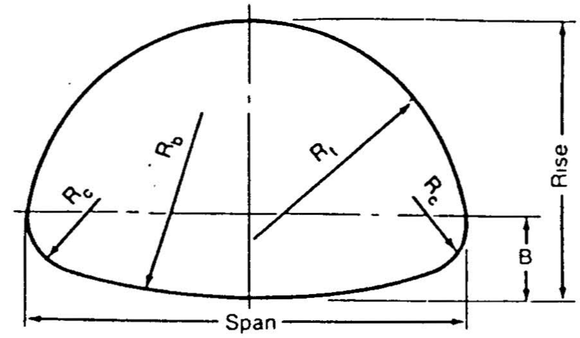

***Table 2.18 Sizes and Layout Details—CSP Pipe Arch.**
2 ⅔ x ½ in. Corrugation

Equiv. Diameter, in.	Span, in.	Rise, in.	Waterway Area, ft²	Layout Dimensions B in.	R_c in.	R_t in.	R_b in.
15	17	13	1.1	4⅛	3½	8⅝	25⅝
18	21	15	1.6	4⅞	4⅛	10¾	33⅛
21	24	18	2.2	5⅝	4⅞	11⅞	34⅝
24	28	20	2.9	6½	5½	14	42¼
30	35	24	4.5	8⅛	6⅞	17⅞	55⅛
36	42	29	6.5	9¾	8¼	21½	66⅛
42	49	33	8.9	11⅜	9⅝	25⅛	77¼
48	57	38	11.6	13	11	28⅝	88¼
54	64	43	14.7	14⅝	12⅜	32¼	99¼
60	71	47	18.1	16¼	13¾	35¾	110¼
66	77	52	21.9	17⅞	15⅛	39⅜	121¼
72	83	57	26.0	19½	16½	43	132¼

***Table 2.19 Sizes and Layout Details—CSP Pipe-Arch**
3 x 1 or 5 x 1 in. Corrugation

Equiv. Diameter, in.	Nominal Size, in.	Design Span, in.	Design Rise, in.	Waterway Area, ft²	Layout Dimensions B in.	R_c in.	R_t in.	R_b in.
48	53 x 41	53	41	11.7	15¼	10³⁄₁₆	28¹⁄₁₆	73⁷⁄₁₆
54	60 x 46	58½	48½	15.6	20½	18¾	29⅜	51⅛
60	66 x 51	65	54	19.3	22¾	20¾	32⅝	56¼
66	73 x 55	72½	58¼	23.2	25⅛	22⅞	36¾	63¾
72	81 x 59	79	62½	27.4	23¾	20⅞	39½	82⅝
78	87 x 63	86½	67¼	32.1	25¾	22⅝	43⅜	92¼
84	95 x 67	93½	71¾	37.0	27¾	24⅜	47	100¼
90	103 x 71	101½	76	42.4	29¾	26⅛	51¼	111⅝
96	112 x 75	108½	80½	48.0	31⅝	27¾	54⅞	120¼
102	117 x 79	116½	84¾	54.2	33⅝	29½	59⅜	131¾
108	128 x 83	123½	89¼	60.5	35⅝	31¼	63¼	139¾
114	137 x 87	131	93¾	67.4	37⅝	33	67⅜	149½
120	142 x 91	138½	98	74.5	39½	34¾	71⅝	162⅜
126	150 x 96	146	102	81	41	36	76	172
132	157 x 101	153	107	89	43	38	80	180
138	164 x 105	159	113	98	45	40	82	184
144	171 x 110	165	118½	107	47	41	85	190

*Dimensions shown not for specification purposes, subject to manufacturing tolerances.

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

DATA FOR CORRUGATED METAL PIPE–ARCH

FIGURE 109.5

FILE: f10905.dwg
DATE: 04/05/99

FROM: **American Society of Civil Engineers**
ASCE Manuals and Reports of Engineering Practice No. 77
"Design and Construction of Urban Stormwater Management Systems"

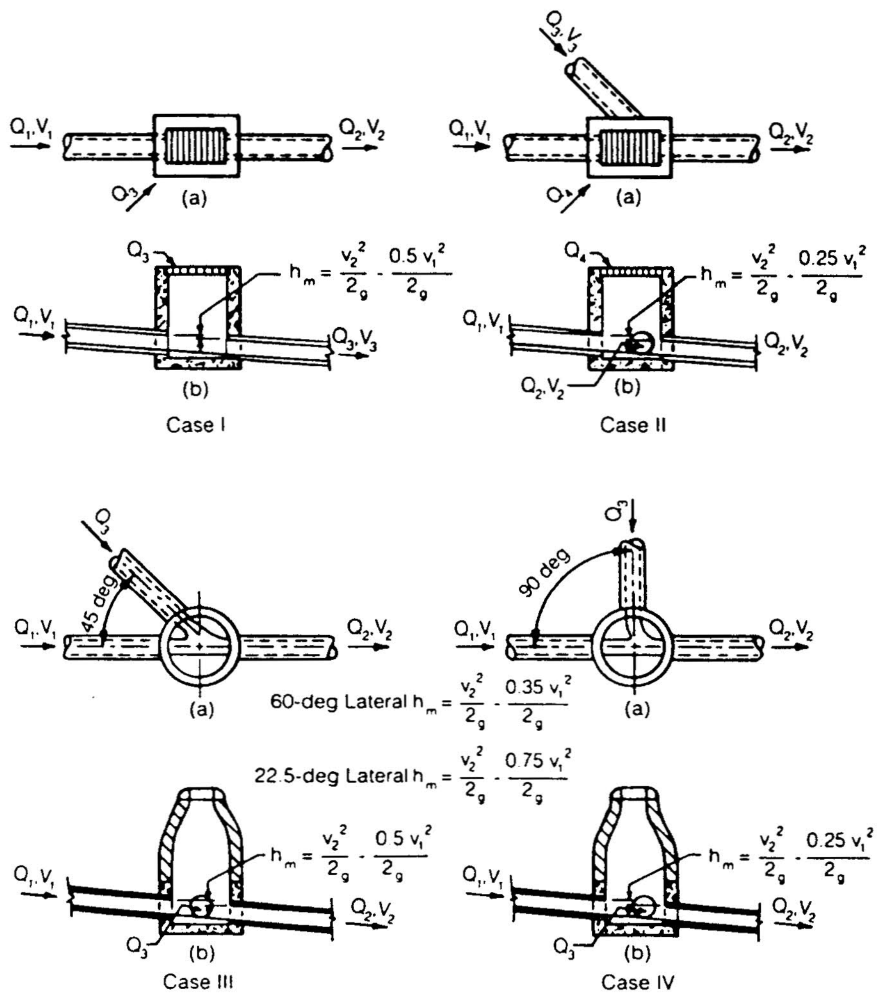

Figure 6.14—Minor head losses due to turbulence at structures: case I—inlet on main line (a) plan and (b) section, case II—inlet on main line with branch lateral (a) plan and (b) section, case III—manhole on main line with 45-deg branch lateral (a) plan and (b) section, and case IV—manhole on main line with 90-deg branch lateral (a) plan and (b) section (City of Austin, 1987).

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

MINOR LOSSES AT STRUCTURES	**FIGURE 109.6** FILE: f10906.dwg DATE: 04/05/99