Culvert Coefficients Tables

Module D

Orifice discharge coefficients C_d table

	$r/b,\ r/d;$ $w/b,\ w/d$						
HW/d	0.00	0.02	0.04	0.06	0.08	0.10	0.14
1.4	0.44	0.46	0.49	0.50	0.50	0.51	0.51
1.5	0.46	0.49	0.52	0.53	0.53	0.54	0.54
1.6	0.47	0.51	0.54	0.55	0.55	0.56	0.56
1.7	0.48	0.52	0.55	0.57	0.57	0.57	0.57
1.8	0.49	0.54	0.57	0.58	0.58	0.58	0.58
1.9	0.50	0.55	0.58	0.59	0.60	0.60	0.60
2.0	0.51	0.56	0.59	0.60	0.61	0.61	0.62
2.5	0.54	0.59	0.62	0.64	0.64	0.65	0.66
3.0	0.55	0.61	0.64	0.66	0.67	0.69	0.70
3.5	0.57	0.62	0.65	0.67	0.69	0.70	0.71
4.0	0.58	0.63	0.66	0.68	0.70	0.71	0.72
5.0	0.59	0.64	0.67	0.69	0.71	0.72	0.73

Source: Data from Bodhaine (1976), as shown in the provided table image.
Notes: r = edge rounding radius; w = bevel/flare parameter; d = culvert rise; b = culvert span.

Transition (weir-to-orifice) constants table

(From David Chin "Water Resources Engineering", 3rd edition)

TABLE 7.1: Constants for Empirical Culvert-Design Equations

Shape and material	Inlet shape	c	Y	Form (Type 5)	K or K'	M or M'
Circular concrete	Square edge with headwall	0.0398	0.67	1	0.0098	2.0
	Groove end with headwall	0.0292	0.74		0.0018	2.0
	Groove end projecting	0.0317	0.69		0.0045	2.0
Circular CMP*	Headwall	0.0379	0.69	1	0.0078	2.0
	Mitered to slope	0.0463	0.75		0.0210	1.33
	Projecting	0.0553	0.54		0.0340	1.5
Circular	Beveled ring, 45°	0.0300	0.74	1	0.0018	2.5
	Beveled ring, 33.7°	0.0243	0.83		0.0018	2.5
Rectangular box, concrete	30°–75° wingwall flares	0.0347	0.81	1	0.026	1.0
	30° and 75° wingwall flares	0.0400	0.80		0.061	0.75
	0° wingwall flares	0.0423	0.82		0.061	0.75
Rectangular box, concrete	45° wingwall flare, $w/D = 0.043$	0.0309	0.80	2	0.510	0.667
	18° to 33.7° wingwall flare, $w/D = 0.083$	0.0249	0.83		0.486	0.667
	90° headwall, 19-mm chamfers	0.0375	0.79		0.515	0.667
	90° headwall, 45° bevels	0.0314	0.82		0.495	0.667
	90° headwall, 33.7° bevels	0.0252	0.865		0.486	0.667
	19-mm chamfers, 45° skewed headwall	0.04505	0.73		0.545	0.667
	19-mm chamfers, 30° skewed headwall	0.0425	0.705		0.533	0.667
	19-mm chamfers, 15° skewed headwall	0.0402	0.68		0.522	0.667
	45° bevels, 10°–45° skewed headwall	0.0327	0.75		0.498	0.667
	19-mm chamfers, 45° wingwall flare, nonoffset	0.0339	0.803		0.497	0.667
	19-mm chamfers, 18.4° wingwall flare, nonoffset	0.0361	0.806		0.493	0.667
	19-mm chamfers, 18.4° wingwall flare, nonoffset, 30° skew	0.0386	0.71		0.495	0.667
	Top bevels, 45° wingwall flare, offset	0.0302	0.835		0.497	0.667
	Top bevels, 33.7° wingwall flare, offset	0.0252	0.881		0.495	0.667
	Top bevels, 18.4° wingwall flare, offset	0.0227	0.887		0.493	0.667
Box CM	90° headwall	0.0379	0.69	1	0.0083	2.0
	Thick wall projecting	0.0419	0.64		0.0145	1.75
	Thin wall projecting	0.0496	0.57		0.0340	1.5

TABLE 7.1: (*Continued*)

Shape and material	Inlet shape	c	Y	Form (Type 5)	K or K'	M or M'
Ellipse concrete	Horizontal ellipse, square edge with headwall	0.0398	0.67	1	0.0100	2.0
	Horizontal ellipse, groove end with headwall	0.0292	0.74		0.0018	2.5
	Horizontal ellipse, groove end projecting	0.0317	0.69		0.0045	2.0
	Vertical ellipse, square edge with headwall	0.0398	0.67		0.010	2.0
	Vertical ellipse, groove end with headwall	0.0292	0.74		0.0018	2.5
	Vertical ellipse, groove end projecting	0.0317	0.69		0.0095	2.0
Arch CM[†]	46-cm corner radius, 90° headwall	0.0379	0.69	1	0.0083	2.0
	46-cm corner radius, mitered to slope	0.0463	0.75		0.0300	1.0
	46-cm corner radius, projecting	0.0496	0.57		0.0340	1.5
	46-cm corner radius, projecting	0.0496	0.57		0.0300	1.5
	46-cm corner radius, no bevels	0.0368	0.68		0.0088	2.0
	46-cm corner radius, 33.7° bevels	0.0269	0.77		0.0030	2.0
	79-cm corner radius, projecting	0.0496	0.57		0.0300	1.5
	79-cm corner radius, no bevels	0.0368	0.68		0.0088	2.0
	79-cm corner radius, 33.7° bevels	0.0269	0.77		0.0030	2.0
	90° headwall	0.0379	0.69		0.0083	2.0
	Mitered to slope	0.0473	0.75		0.0300	1.0
	Thin-wall projecting	0.0496	0.57		0.0340	1.5
Circular	Smooth-tapered inlet throat	0.0196	0.90	2	0.534	0.555
	Rough-tapered inlet throat	0.0210	0.90		0.519	0.64
Elliptical inlet face	Tapered inlet, beveled edges	0.0368	0.83	2	0.536	0.622
	Tapered inlet, square edges	0.0478	0.80		0.5035	0.719
	Tapered inlet, thin edge projecting	0.0598	0.75		0.547	0.80
Rectangular concrete	Tapered inlet throat	0.0179	0.97	2	0.475	0.667
Rectangular concrete	Side tapered, less favorable edge	0.0446	0.85	2	0.56	0.667
	Side tapered, more favorable edge	0.0378	0.87		0.56	0.667
Rectangular concrete	Side tapered, less favorable edge	0.0446	0.65	2	0.50	0.667
	Side tapered, more favorable edge	0.0378	0.71		0.50	0.667

Source: U.S. Federal Highway Administration (2012).

Notes: *CMP = corrugated metal pipe; [†]CM = corrugated metal.

Manning's n in culverts

Type of conduit	**Wall and joint description**	n
Concrete pipe	Good joints, smooth walls	0.011–0.013
	Good joints, rough walls	0.014–0.016
	Poor joints, rough walls	0.016–0.017
	Badly spalled	0.015–0.020
Concrete box	Good joints, smooth, finished walls	0.012–0.015
	Poor joints, rough, unfinished walls	0.014–0.018
Spiral rib metal pipe	19-mm × 19-mm recesses at 30-cm spacing, good joints	0.012–0.013
Corrugated metal pipe,	68-mm × 13-mm annular corrugations	0.022–0.027
pipe arch, and box	68-mm × 13-mm helical corrugations	0.011–0.023
	150-mm × 25-mm helical corrugations	0.022–0.025
	125-mm × 25-mm corrugations	0.025–0.026
	75-mm × 25-mm corrugations	0.027–0.028
	150-mm × 50-mm structural plate	0.033–0.035
	230-mm × 64-mm structural plate	0.033–0.037
Polyethylene	Corrugated	0.018–0.025
	Smooth	0.009–0.015
PVC	Smooth	0.009–0.011

Source: U.S. Federal Highway Administration (2005a; 2012), as reproduced in the uploaded text.

Entrance loss coefficients k_e

Culvert type and entrance conditions	k_e
Pipe, concrete:	
Projecting from fill, socket end (groove end)	0.2
Projecting from fill, square-cut end	0.5
Headwall or headwall and wingwalls, socket end (groove end)	0.2
Headwall or headwall and wingwalls, square edge	0.5
Headwall or headwall and wingwalls, rounded (radius = $D/12$)	0.2
Mitered to conform to fill slope	0.7
End section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe, or pipe arch, corrugated metal:	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls, square edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
End section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Box, reinforced concrete:	
Headwall parallel to embankment (no wingwalls), square edged on 3 edges	0.5
Headwall parallel to embankment (no wingwalls), rounded on 3 edges	0.2
Wingwalls at 30° to 75° to barrel, square edged at crown	0.4
Wingwalls at 30° to 75° to barrel, crown edge rounded	0.2
Wingwalls at 10° to 25° to barrel, square edged at crown	0.5
Wingwalls parallel (extension of sides), square edged at crown	0.7
Side or slope-tapered inlet	0.2

Source: U.S. Federal Highway Administration (2012), as reproduced in the uploaded text.