

DESIGN COEFFICIENT TABLES

Hazen-Williams Friction Factor (C)

Pipe Material	Values for C		
	Range High/Low	Average Value	Typical Design Value
Plastic, PVC, Polyethylene pipe or tubing	160/150	150-155	150
Cement or mastic lined iron or steel pipe	160/130	148	140
Copper, brass, lead, tin or glass pipe or tubing	150/120	140	130
Wood Stave	145/110	120	110
Welded or Seamless Steel	150/80	130	100
Cast and ductile iron	150/80	130	100
Concrete	152/85	120	100
Corrugated steel	-	60	60

Manning's Equation roughness coefficient (n)

Material	Values for n	
	Range	Typical Design Value
Polyethylene pipe	0.008-0.011	0.009
Uncoated cast or ductile iron pipe	0.012-0.015	0.013
Corrugated steel pipe	0.021-0.030	0.024
Concrete pipe	0.012-0.016	0.015
Vitrified clay pipe	0.011-0.017	0.013
Brick and cement mortar sewers	0.012-0.017	0.015
Wood stave	0.010-0.013	0.011
Rubble masonry	0.017-0.030	0.021
Concrete Culvert Pipe (Smooth)	0.010-0.011	0.011
Concrete Boxes (Smooth)	0.012-0.015	0.013
Spiral Rib Metal Pipe (Smooth)	0.012-0.013	0.013
Corrugated Metal Pipe, Pipe-Arch and Box. (2 -2/3 in by ½ in Annular corrugation)	0.022-0.027	0.024
Corrugated Metal Pipe, Pipe-Arch and Box. (2 -2/3 in by ½ in Helical corrugation)	0.011-0.023	0.020
Corrugated Metal Pipe, Pipe-Arch and Box. (6 in by 1 in Helical corrugation)	0.022-0.025	0.024
Corrugated Metal Pipe, Pipe-Arch and Box. (5 in by 1 in)	0.025-0.026	0.026
Corrugated Metal Pipe, Pipe-Arch and Box. (3 in by 1 in)	0.027-0.028	0.028
Corrugated Metal Pipe, Pipe-Arch and Box. (6 in by 2 in Structural Plate)	0.033-0.035	0.034

Corrugated Metal Pipe, Pipe-Arch and Box. (9in by 2-1/2 in Structural Plate)	0.033-0.037	0.035
Corrugated Polyethylene Culvert Pipe (Smooth)	0.009-0.015	0.013
Corrugated Polyethylene Culvert Pipe (Corrugated)	0.018-0.025	0.023
Polyvinyl chloride (PVC) (Smooth)	0.009-0.011	0.010
Open Channel – regular section – some grass and weeds, little or no brush	0.030-0.035	0.035
Open Channel – regular section – dense grass and weeds, depth of flow materially greater than weed height	0.035-0.05	0.04
Open Channel – regular section – some weeds, light brush on banks	0.035-0.05	0.04
Open Channel – regular section – some weeds, heavy brush on banks	0.05-0.07	0.06
Open Channel – regular section – some weeds, dense willows on banks	0.06-0.08	0.07
Open Channel – regular section – for trees within channel, with branches submerged at high stage, increase all above open channel values by	0.01-0.02	0.02
Irregular sections, with pools, slight channel meander, increase open channel values given above by	0.01-0.02	0.02
Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage: bottom of gravel, cobbles, and few boulders	0.04-0.05	0.05
Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage: bottom of cobbles, with large boulders	0.05-0.07	0.06
Concrete gutter, trowel finish	0.012	0.012
Asphalt pavement (smooth texture)	0.013	0.013
Asphalt pavement (rough texture)	0.016	0.016
Combination asphalt pavement and concrete gutter	0.015	0.015
Concrete pavement	0.014-0.016	0.015

Culvert Design - Outlet Control, Full or Partly Full Entrance Head Loss Coefficient (Ke)

Type of Structure and Design of Entrance	Ke
<u>Pipe, Concrete</u>	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, sq. cut end	0.5
Headwall or headwall and wingwalls, Socket end	0.2
Headwall or headwall and wingwalls, Square-edge	0.5
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 deg. or 45 deg. bevels	0.2
Side- or slope-tapered inlet	0.2
<u>Pipe or Pipe-Arch Corrugated Metal</u>	
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 deg. or 45 deg. bevels	0.2
Side- or slope-tapered inlet	0.2
<u>Box, Reinforced Concrete</u>	
Headwall parallel to embankment (no wingwalls), Square-edge on 3 edges	0.5
Headwall parallel to embankment (no wingwalls), Rounded on 3 edges to radius of D/12 or B/12 or beveled edges on 3 sides	0.2
Wingwalls at 30 deg to 75 deg to barrel, Square-edged at crown	0.4
Wingwalls at 30 deg to 75 deg to barrel, Crown edge rounded to radius of D/12 or beveled top edge	0.2
Wingwalls at 10 deg to 25 deg to barrel, Square-edged at crown	0.5
Wingwalls parallel (extension of sides), Square-edged at crown	0.7
Wingwalls parallel (extension of sides), Side- or slope-tapered inlet	0.2

Culvert Design - Constants for Inlet Control Design Equation

Shape and Material	Inlet Edge Description	K	M	c	Y
Circular Concrete	Square edge w/headwall	.0098	2.0	.0398	.67
	Groove end w/headwall	.0018	2.0	.0292	.74
	Groove end projecting	.0045	2.0	.0317	.69
Circular CMP	Headwall	.0078	2.0	.0379	.69
	Mitered to slope	.0210	1.33	.0463	.75
Circular	Projecting	.0340	1.50	.0553	.54
	Beveled ring, 45 deg. bevels	.0018	2.50	.0300	.74
Rectangular Box	Beveled ring, 33.7 deg. bevels	.0018	2.50	.0243	.83
	30 to 75 deg wingwall flares	.026	1.0	.0347	.81
	90 and 15 deg wingwall flares	.061	.75	.0400	.80
	0 deg wingwall flares	.061	.75	.0423	.82
	45 deg wingwall flare d=.043D	.510	.667	.0309	.80
	18 to 33.7 deg wingwall flare d = .083D	.486	.667	.0249	.83
	90 deg headwall w/ 3/4" chamfers	.515	.667	.0375	.79
	90 deg headwall w/ 45 deg bevels	.495	.667	.0314	.82
	90 deg headwall w/ 33.7 deg bevels	.486	.667	.0252	.865
	3/4" chamfers, 45 deg skewed headwall	.545	.667	.04505	.73
	3/4" chamfers, 30 deg skewed headwall	.533	.667	.0425	.705
Rectangular Box 3/4" chamfers	3/4" chamfers, 15 deg skewed headwall	.522	.667	.0402	.68
	45 deg bevels; 10 to 45 deg skewed headwall	.498	.667	.0327	.75
	45 deg non-offset wingwall flares	.497	.667	.0339	.803
	18.4 deg non-offset wingwall flares	.493	.667	.0361	.806
	18.4 non-offset wingwall flares, 30 deg skewed barrel	.495	.667	.0386	.71

Rectangular Box Top Bevels	45 deg wingwall flares - offset	.497	.667	.0302	.835
	33.7 deg wingwall flares - offset	.495	.667	.0252	.881
	18.4 deg wingwall flares - offset	.493	.667	.0227	.887
C M Boxes	90 deg headwall	.0083	2.0	.0379	.69
	Thick wall projecting	.0145	1.75	.0419	.64
	Thin wall projecting	.0340	1.5	.0496	.57
Horizontal Ellipse – Concrete	Square edge w/headwall	.0100	2.0	.0398	.67
	Groove end w/headwall	.0018	2.5	.0292	.74
	Groove end projecting	.0045	2.0	.0317	.69
Vertical Ellipse – Concrete	Square edge w/headwall	.0100	2.0	.0398	.67
	Groove end w/headwall	.0018	2.5	.0292	.74
	Groove end projecting	.0095	2.0	.0317	.69
Pipe Arch, 18" Corner Radius - CM	90 deg headwall	.0083	2.0	.0379	.69
	Mitered to slope	.0300	1.0	.0463	.75
	Projecting	.0340	1.5	.0496	.57
	Projecting	.0300	1.5	.0496	.57
	No Bevels	.0088	2.0	.0368	.68
	33.7 deg Bevels	.0030	2.0	.0269	.77
Pipe Arch, 31" Corner Radius - CM	Projecting	.0300	1.5	.0496	.57
	No Bevels	.0088	2.0	.0368	.68
	33.7 deg Bevels	.0030	2.0	.0269	.77
Arch CM	90 deg headwall	.0083	2.0	.0379	.69
	Mitered to slope	.0300	1.0	.0463	.75
	Thin wall projecting	.0340	1.5	.0496	.57
Circular	Smooth tapered inlet throat	.534	.555	.0196	.90
	Rough tapered inlet throat	.519	.64	.0210	.90
Elliptical Inlet Face	Tapered inlet - beveled edges	.536	.622	.0368	.83
	Tapered inlet - square edges	.5035	.719	.0478	.80
	Tapered inlet - thin edge projecting	.547	.80	.0598	.75
Rectangular	Tapered inlet throat	.475	.667	.0179	.97
Rectangular - Concrete	Side tapered - less favorable edges	.56	.667	.0446	.85
	Side tapered - more favorable edges	.56	.667	.0378	.87
	Slope tapered - less favorable edges	.50	.667	.0446	.65
	Slope tapered - more favorable edges	.50	.667	.0378	.71

Rational Method/Modified Rational Method Runoff Coefficients (C)

<u>Categorized by surface</u>	C
forested	0.059-0.2
asphalt	0.7-0.95
brick	0.7-0.85
concrete	0.8-0.95
shingle roof	0.75-0.95
lawns, well drained (sandy soil), up to 2% slope	0.05-0.1
lawns, well drained (sandy soil), 2% to 78% slope	0.10-0.15
lawns, well drained (sandy soil), over 7% slope	0.15-0.2
lawns, poor drainage (clay soil), up to 2% slope	0.13-0.17
lawns, poor drainage (clay soil), 2% to 7% slope	0.18-0.22
lawns, poor drainage (clay soil), over 7% slope	0.25-0.35
driveways, walkways	0.75-0.85
<u>Categorized by use</u>	
farmland	0.05-0.3
pasture	0.05-0.3
unimproved	0.1-0.3
parks	0.1-0.25
cemeteries	0.1-0.25

railroad yard	0.2-0.40
playgrounds (except asphalt or concrete)	0.2-0.35
business districts, neighborhood	0.5-0.7
business districts, city (downtown)	0.7-0.95
residential, single family	0.3-0.5
residential, multi-plexes, detached	0.4-0.6
residential, multi-plexes, attached	0.6-0.75
residential, suburban	0.25-0.4
residential, apartments, condominiums	0.5-0.7
industrial, light	0.5-0.8
industrial, heavy	0.6-0.9

Modified Rational Method, Typical Values of Infiltration Rates, (F), inches/hour

Description	Soil group symbol	Infiltration, F, in/hr
Sand and gravel mixture	GW, GP, SW, SP	0.8-1.0
Silty gravels and silty sands to inorganic silt, and well-developed loams	GM, SM, ML, MH, OL	0.3-0.6
Silty clay sand to sandy clay	SC, CL	0.2-0.3
Clays, inorganic and organic	CH, OH	0.1-0.2
Bare rock, not highly fractured	-----	0.0-0.1

Soil Cohesion and Friction Factors (For use in Thrust Block Design)

Soil Material	Friction Angle (degrees)	Soil Cohesion and Friction Factors		
		Cs	fp	fs
Sand, dry well graded	44.5	0	0.76	0
Sand, saturated, well graded	39	0	0.80	0
Silt, dry, passing 200 sieve	40	0	0.95	0
Silt, saturated, passing 200 sieve	32	0	0.75	0
Cohesive granular soil wet to moist	13 - 22	385 - 920	0.65	0.35
Clay, wet to moist	11.5 – 16.5	460 – 1,175	0.50	0.50
Clay, wet to moist at maximum compaction	11.5 – 16.5	460 – 1,175	0.50	0.80

Kerby's Roughness Coefficient

<u>Categorized by surface</u>	Kerby n
Smooth, impervious surface	0.02
Smooth, packed bare soil	0.10
Poor grass, cultivated row crops of moderately rough bare soil	0.20
Pasture or average grass	0.40
Deciduous timberland	0.60
Timberland with deep forest litter or dense grass	0.80

Slope Intercept Coefficient k

<u>Categorized by surface</u>	k
Forest with heavy ground litter; hay meadow (overland flow)	0.076
Trash fallow or minimum tillage cultivation; contour or strip cropped; woodland (overland flow)	0.152
Short grass pasture (overland flow)	0.213
Cultivated straight row (overland flow)	0.274
Nearly bare and untilled (overland flow); alluvial fans in western mountain regions	0.305
Grassed waterway (shallow concentrated flow)	0.457
Unpaved (shallow concentrated flow)	0.491
Paved area (shallow concentrated flow); small upland gullies	0.619