

Table 6-2

**Values of Coefficient of Manning's Roughness (n)
for Corrugated Metal and Aluminum Alloy Pipe
(Unpaved Inverts and Unlined Pipe)**

Annular 2 2/3" x 1/2" Corrugations	Helical Corrugations*							
All Diameters	1 1/2" x 1/4"			2 2/3" x 1/2"				
	8 inch	10 inch	12 inch	18 inch	24 inch	36 inch	48 inch	60 inch & Larger
0.024	0.012	0.014	0.011	0.013	0.015	0.018	0.020	0.021
Annular 3" x 1"	Helical - 3" x 1"							
	48 inch	54 inch	60 inch	66 inch	72 inch	78 inch & Larger		
0.027	0.023	0.023	0.024	0.025	0.026	0.027		
Annular 5" x 1"	Helical - 5" x 1"							
	54 inch	60 inch	66 inch	72 inch	78 inch & Larger			
0.025	0.022	0.023	0.024	0.025	0.027			

*The "n" values shown above for helical corrugations apply only when spiral flow can be developed. The design engineer must assure himself/herself that spiral flow will occur in his/her design situation. Spiral flow will not occur when the following conditions exist, in which case the "n" value for annular corrugations is to be used:

1. Partly full flow
2. Non-circular pipes, such as pipe arches
3. When helical C.M.P. is lined or partly lined
4. Short runs less than 20 diameters long

Pipe arches have the same roughness characteristics as their equivalent round pipes

F. Structural design (class or gauge) of storm drains shall be in accordance with current AASHTO Standard Specifications for Highway Bridges. Structural evaluation of storm drains may be made using the following texts/references where appropriate if they are consistent with AASHTO:

1. Concrete: Concrete Pipe Design Manual American Concrete Pipe Association
2. Corrugated Metal Pipe: Handbook of Steel Drainage and Highway Construction Products
3. Aluminum Alloy Pipes (as recommended by manufacturer)
4. Smooth interior HDPE (as recommended by manufacturer)

G. Maximum grade on which concrete pipe should be placed is 10%.

H. HDPE pipe shall be used as an alternate pipe for low-traffic volume roadways having less than 20,000 ADT. (For other highways, Interstates or freeways with ADTs exceeding 20,000 vehicles, the use of HDPE is not allowed within the roadway or as

outlet pipes to water courses and water bodies, however, the use of HDPE is permitted outside of the roadbed only.) Installation of HDPE pipe shall be according to the manufacturer's specifications. End sections for HDPE pipe shall be concrete. Construction equipment loading and constructability should be taken into account when considering the use of HDPE for storm drains. A minimum cover of three (3) feet is required. HDPE pipe is not to be used in wet conditions.

- I. Flared end-sections should be used whenever and wherever possible, for concrete and metal pipe.
- J. Pipe sizes should not decrease in the downstream direction even though an increase in slope would allow a smaller size.
- K. Pipe slopes should conform to the original ground slope so far as possible to minimize excavation.
- L. For durability, the minimum thickness for steel pipe is 14 gauge and for aluminum alloy pipe is 16 gauge. In extremely corrosive areas and where high abrasion can be expected the design engineer shall determine whether heavier gauges should be used.
- M. Material types: See Figure 6-1.
 - a. Concrete, HDPE, and Aluminum Alloy pipe may be used in the shaded area.
 - b. Concrete, HDPE, Steel and Aluminum Alloy pipe may be used in the unshaded area.
- N. Alternate Items:
 - a. When the length of the pipe exceeds 500 LF, alternate bid items are required.
 - b. Alternate pipe materials include aluminum alloy and HDPE.
 - c. Some materials may be eliminated as alternate items due to unstable support, high impact, concentrated loading, limited clearance, steep gradients, etc.
- O. The drainage layout should attempt to avoid conflicts with existing underground utilities and such items as utility poles, signal pole foundations, guide rail posts, etc. Implementation of the following design approaches may be necessary.
 - a. Use of pipe material with the lowest friction factor to minimize pipe size
 - b. Use of elliptical or arch pipe to minimize vertical dimension of pipe.
 - c. Test pits should be obtained early in the design process to obtain horizontal and vertical information for existing utilities. If the suggested design approaches do not avoid conflict, use of special drainage structures may be used to avoid the utility.