Manning’s Roughness Coefficient

Should Designers Accept Laboratory Test Results from Suppliers?

Since it's conception in 1890, Manning's equation is still the most widely used and accepted formula for calculating the hydraulic capacity of gravity flow sewer systems; most major North American municipalities reference their accepted Manning's 'n' coefficient to avoid any subjectivity. Manning's 'n' is an empirical roughness coefficient used in the Manning Formula for evaluating the hydraulic capacity of gravity-flow conduits. Manning's 'n' is used to calculate a required pipe diameter and slope needed to obtain a desired flow capacity:

$$Q = Velocity * Area = \frac{1}{n} AR^{2/3}\sqrt{S}$$

Where:

- Q = flow rate ($\frac{m^3}{s}$)
- n = Manning's roughness coefficient
- A = area of conduit (m^2)
- R = Hydraulic Radius, expressed as the area/wetted perimeter (m)
- S = slope of conduit

Because the coefficient is in the denominator of the equation, a higher roughness coefficient means a rougher pipe surface and hence a lower flow rate.

From a designers perspective, it can be tempting to accept a lower roughness coefficient to achieve a desired hydraulic capacity:

- The designer could be limited by a fixed slope or a spacial constraint where the maximum diameter of the conduit is restricted by existing buried infrastructure.
- It adds a significant cost to up-size a pipe diameter. Pipe smaller than 750mm ID typically differ by 75mm and pipe larger differ by 150mm; this includes added costs associated with excavating a larger trench to accommodate the pipe and more imported aggregates needed for backfilling as well.

Even ribbed PVC, which claims to have a smooth ID, will experience corrugation growth. Will it have the same hydraulic capacity as other smooth-walled pipe?

Determining the correct roughness coefficient to use is subjective by nature because it is based on empirical testing. Countless laboratory tests have been done over many decades on various pipe materials and configurations which provide a range of acceptable values; some of which are outlined in the table below:

Pipe Material	Laboratory Values
Concrete	0.009-0.010[1]
Solid Wall Plastic	0.009-0.011[2]
Ribbed Wall Plastic	0.009-0.015[3]
Corrugated Metal	0.012-0.030[4]

[1]American Concrete Pipe Association's "Concrete Pipe Design Manual" - 2000
[2]Uni-Bell's "Handbook of PVC Pipe" – 2001
[3]Tullis and Barfuss Study – 1989
[4]University of Minnesota Test on Culvert Pipes - 1950

However, the reality is that any pipe producer can fund a study to prove their roughness coefficient can be lowered; it would be irresponsible for a producer to promote the use of a roughness coefficient based on laboratory testing alone:

- These tests typically involve the use of clean water, not storm or sanitary water.
- They usually involve small diameter pipe sizes with short run lengths and don't take into account any obstructions in the pipe, corrugation growth, manhole connections, or pipe defection.
- Unless a credible, independent testing body is conducting the research, there will likely be biases included. Ensure you ask: Who conducted the study and who funded it?
- Over time, sewer lines will typically develop sediment deposits or a slime layer which normalizes the roughness coefficient, regardless of the pipe material chosen.

Municipalities across Canada have recognized the limitations of these laboratory results and chosen to adopt a consistent roughness coefficient of 0.012 or 0.013 for all smooth wall pipe. Using either of these values allows for versatility in the tendering stage of a project because only one hydraulic design is needed, regardless of the pipe material (Concrete, PVC, or HDPE). The following table shows what roughness coefficient is used in different regions:

Jurisdiction	Roughness Coefficient Value	Specification Reference
Ontario	0.013	Ontario Ministry of Transportation - Gravity Pipe Design Guidelines
Ottawa	0.013	City of Ottawa - Sewer Design Guidelines
Winnipeg	0.013	City of Winnipeg - Wastewater Design Guidelines
Sask. Highways	0.012	Ministry of Highways & Infrastructure - Hydraulic Manual
Regina	0.013	City of Regina - Development Standards Manual
Edmonton	0.013	City of Edmonton Design and Construction Standards - Drainage Vol. 3
Red Deer	0.013	City of Red Deer Engineering Services - Design Guidelines
Kamloops	0.013	City of Kamloops - Design Criteria Manual
British Columbia	0.013	Master Municipal Construction Document (MMCD) - Municipal Infrastructure Design Guidelines
US Federal Highway Administration	0.012	Hydraulic Design of Highway Culverts - Third Edition

Additional Hydraulic Advantages of Concrete Pipe:

- Concrete pipe internal diameters are commonly larger than plastic pipe. Most concrete pipe manufacturers in Canada use “soft metric” forms, meaning they are designed in inches and then converted to metric; for example, a 900mm pipe is actually 36 inches (914mm).
- Plastic pipe will defect under load, like it’s designed to, up to 7.5% (most widely accepted upper deflection limit). This will decrease the effective area of the conduit and increase the wetted perimeter. Are designers using oval cross-sections in their hydraulic calculations?

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