Facts - Fiction and Fantasy

Concrete Pipe Association of Australasia

ACN 007 067 656

DISCHARGE CAPACITY OF PIPELINES OF DIFFERENT MATERIALS

INTRODUCTION

Competitive marketing of pipes made of different materials has resulted in a proliferation of claims of relative performances, many of which have no technical justification. One notable area is that of relative hydraulic characteristics of various types of pipes where misleading information concerning discharge capacities is being widely circulated.

In culvert conditions, under roads or railways, surface roughness of nominally smooth bore pipes has no influence in most practical installations - "smooth" in this sense meaning free from deliberate circumferential or helical corrugation.

In all culvert conditions whether the discharge is under inlet or outlet control, the maximum discharge capacity is virtually unaffected by variations in pipe surface roughness ranging from Mannings "n" = 0.008mm to Mannings "n" = 0.012mm. This means that all nominally smooth bore pipes - concrete or plastic - perform equally hydraulically.

Rough bore pipe - corrugated steel or aluminium - with Mannings "n" values up to 0.028mm have significantly reduced discharge capacity in these applications.

FACT

The computation of peak flow rate, the maximum volume of water to be conveyed by a sewer, stormwater drain or culvert, is not an exact science. Discharges computed by pipe formulae are based on assumptions regarding line loss coefficients and in effect there is little practical difference between calculated discharges that vary by a few per cent.

FACT

It has become generally accepted practice in Australia and New Zealand that pipeline discharge capacities are computed using the Colebrook-White formula, except for short culvert installations where the Manning formula is used. In both these formulae the maximum discharge for a pipeline on a given grade is dependent only on internal diameter and the roughness coefficient.

However, the roughness coefficient is not a constant for a given pipe material as it varies as a function of type of flow in the service condition. For example, a given pipe in a specific installation flowing full will discharge more clean water (e.g. in water supply or irrigation) than it will stormwater (which contains debris) or sewage (where discharge is affected both by solids and growth of slimes on the pipe wall).

FACT

In culvert conditions, such as relatively short lengths of pipe under roads or railways, surface roughness of nominally smooth bore pipes has no influence in most applications.

Maximum discharge capacity depends on whether the installation is under inlet or outlet control. In the situation of inlet control, the discharge is totally independent of pipe surface roughness. In general, under outlet control conditions, the maximum discharge capacity is virtually unaffected by variations in surface roughness from Mannings "n" = 0.008mm to "n" = 0.012mm.

This means that all nominally smooth bore pipes - concrete or plastic - perform equally hydraulically, but corrugated pipe, steel or aluminium, with "n" values up to 0.028mm have significantly reduced discharge capacity under outlet control conditions

FICTION

Where the Colebrook-White equation is adopted, and roughness coefficient "k" values are used to compute discharges, laboratory test values of "k" can be used to predict the capacity.

Use of laboratory test values of "k" can be totally misleading because roughness coefficients vary widely and increase as a result of field conditions such as slime deposits, incrustations, detritus and other debris, irregularities at joints, amount and size of solids being transported, fittings (valves, bends, etc.) and disturbance from branches especially in sewers.

FANTASY

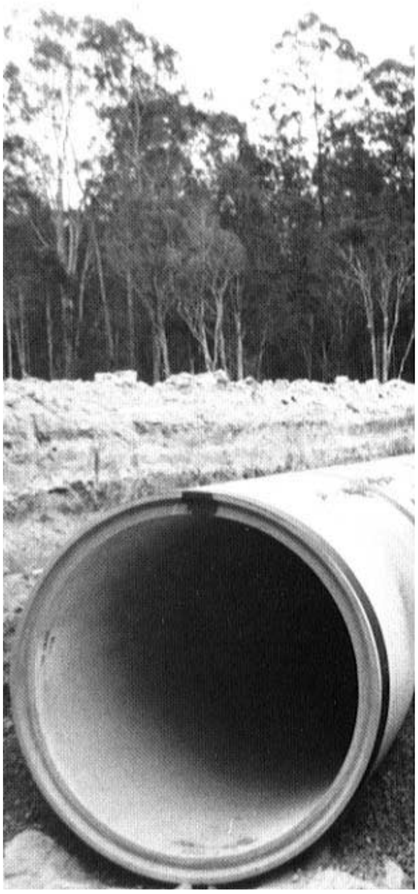
A flow chart based on a Colebrook-White "k" value of 0.010mm (the only one published in some flexible pipe brochures) can be used to determine discharge from a flexible plastic sewer pipeline. A fantasy for all the reasons previously stated.

It is common practice to use a "k" value of between 0.6mm and 1.5mm to allow for the build up of biological slimes.

FICTION

The published statement that the smooth bore of plastic pipe "allows design engineers to use a smaller diameter pipe and/or reduced grades to accomplish given flow rates" and the example quoted where "the equivalent reinforced concrete pipe has an approximate 10 per cent reduction in flow capacity", are fiction.

These statements are "supported" by a carefully selected example (selected grade, diameter and Colebrook-White "k" values) which ignores the effect of actual pipe diameters and does not use comparable roughness coefficients.



Typical smooth bore of concrete pipe.

If realistic values are used, the theoretical discharge difference virtually disappears. Further, by similar careful selection of grade, diameter and "k" values, examples can be quoted which show higher discharges from reinforced concrete pipe than commercially available plastic pipes.

FACT

For practical purposes, for stormwater drainage systems, the pipeline designer should use educated engineering judgment in the selection of friction coefficients.

For steel reinforced concrete pipelines, laboratory tests establish a "k" value of less than 0.06mm. For straight lines, with typical fittings, carrying clean water a design value minimum of 0.015mm is recommended by the Concrete Pipe Association of Australasia.

Conservatively this value could be increased to 0.06mm for typical suburban or semi-rural systems, where debris must be anticipated. The "penalty" for this conservatism is very small, perhaps a single step up in pipe diameter.

For smooth bore plastic pipe, similar judgment must be exercised both for the effect of debris and the head losses due to fittings. Manufacturers give no guidance in this area.
For corrugated metal pipe, an increase in diameter of one or two steps is normally required to compensate for the deep corrugations.

FACT

The published technical data on roughness coefficients for concrete pipes, covers both laboratory conditions and field installations and the test data is available for public scrutiny.

The data on plastic pipe is not so transparent and data on roughness coefficients for actual pipelines has not been located. Further, overseas published data raises questions as to the applicability of data on uniform wall HDPE to the profile wall and spirally wound pipe currently available in Australia and New Zealand.

FACT

Excessive deflection of flexible pipe will reduce its discharge capacity, and, if combined with joint irregularities, can be of significance.

FACT OR FICTION?

Is roughness coefficient "k" = 0.01mm correct for solid wall UPVC, HDPE, GRP, profile wall and spirally wound plastic pipes, and if so under what service conditions?

Do the manufacturers know?

FANTASY

The published tables by plastic pipe manufacturers which show large increases in pipe diameter required for concrete to equal the discharge capacity of plastic pipes, is fantasy because it ignores actual diameter, flow service conditions (velocity, detritus, fittings) and the limitations of Mannings "n" in these situations.

THE FINAL FACTS ARE

- Plastic pipe manufacturers' literature significantly over estimates pipe discharge capacity in every situation (except for pure water in straight pipelines without fittings - if this ever occurs).
- For practical purposes the discharge capacities of reinforced concrete pipe and plastic pipe of the same nominal diameter are equal.
- For the latest technical information supporting the facts contact the Concrete Pipe Association of Australasia at the address shown overleaf.

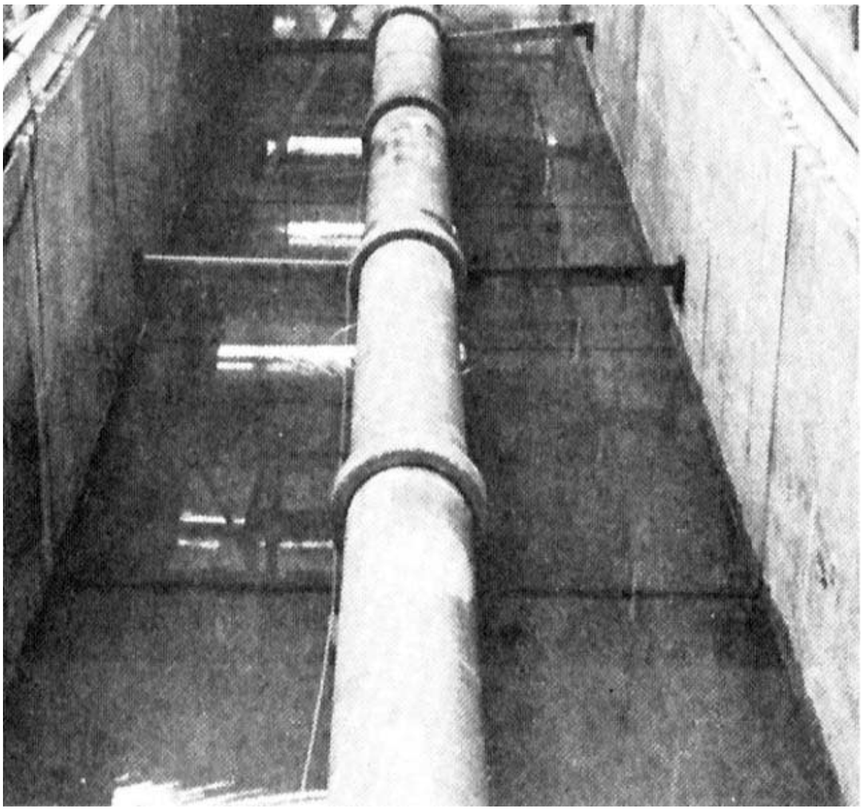


Photo shows concrete pipe under test at the Water Research Laboratory of Utah State University. The 84 separate tests with different diameters, with partial flow and full flow, and different velocities showed the concrete pipe to be just as hydraulically efficient as any other smooth wall pipe. These tests duplicate the tests performed previously at the University of Alberta and the University of Minnesota.

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Revised: January 1995
Publication: B05/95