mpa British Precast Drainage Association

Understanding hydraulic performance and roughness coefficients of sewers and drains

There is a wide range of factors that affect the hydraulic performance and roughness coefficients of sewers and drains. Contrary to popular belief, the nature of a sewerage or drainage pipe material has very minimal impact on the roughness value of the pipe. Most industry standards in the UK and Europe use single coefficients for all drain and sewers regardless of pipe material. This factsheet explains why.

Hydraulic design of sewers and drains.

The basis for hydraulic design of storm and sewerage pipeline systems is that flows are usually turbulent. These turbulent flows can be calculated using the Manning or the Cole-brook-White formulas. Several factors can lead to pipe headlosses. Hydraulic pipeline roughness factors (Ks) in accordance to Colebrook-White, or Manning flow coefficient (K), allow for headlosses due to pipe material. However, the issue of hydraulic efficiency and roughness is not as straightforward and can be affected by a wide range of factors. These factors often dominate roughness coefficients as demonstrated below.

What do the standards say?

A range of roughness coefficients have been reported for different types of rigid and flexible pipeline material systems over the years. In the UK, roughness coefficient for different pipe materials can be found in the "*Tables for Hydraulic Design of Pipes, Sewers and Channels*", the latest edition (No. 98) was published in 2006. However, all standards and guidance manuals in the UK suggest that these could be largely, and for the vast majority of applications, irrelevant.

The main European standard on hydraulic design of drains and sewers, EN 16933-2, notes that local factors leading to headlosses need to be accounted for. In addition to headlosses due to pipe material, a roughness factor or flow coefficient take account of "*other factors including, the internal profile of the pipe, losses due to discontinuities at the joints and biofilm that grow on the pipe surface below the water level*". As flexible pipes usually experience some form of deformation, even if slight, after settlement, headlosses due to such change to the profile of the pipe needs to be taken into account.

Clause 7.2.1 of EN 16933-2 then notes "*The effect of the biofilm can be more significant than any difference in the roughness of the material without the biofilm. A single value, regardless of pipe material is therefore often used*". This is why Sewers for Adoption 8 and adoption code Design & Construction Guide (DCG), B4.1 and C6.4, give roughness values (Ks) for foul gravity sewer design and surface water sewer/ lateral drain design of 1.5mm and 0.6mm respectively to all pipes regardless of material type.

The new National Annex of EN 16933-2 offers a very simlar advice (clause NA 2.3.2):
"*In pipes carrying foul sewage, the roughness will be influenced to some extent by the pipe material but will be primarily dependent on the slime that grows on the inside surface of the pipe below the water level corresponding to the maximum daily discharge*". The National Annex then recommends exactly similar values of Ks for sewers and drains (at Table NA.4).

What if no slime biofilm exists?

The National Annex to EN 16933-2 notes that headlosses due to pipe material roughness can be used in cases where biofilm does not exist. But the standard indicates that such cases would be exceptional and cannot be taken as the general rule. As noted above, the European standard calls for elements affecting the pipe profile (such as deformations or pipe sagging) to be accounted for as well. The National Annex of EN 16933-2 explicitly advises against the use of standard roughness factors based on pipe materials in cases where elements such as corrugations affect the internal surface of pipes.

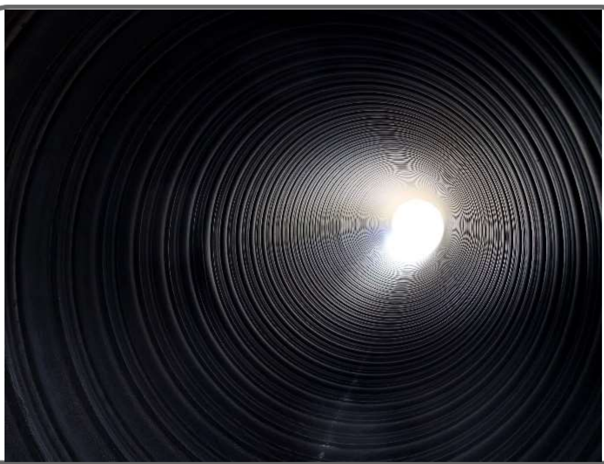

Figure 1: Based on EN 16933-2 NA, standard pipe material roughness coefficients cannot be used with corrugated pipes.

The impact of imperfect joints on roughness

The condition of joints can also play a part. A faulty joint could clearly lead to leaks and headlosses to the flow. This will depend mainly on the nature of defect within joints. A University of Minnesota research in 1957 looked at “good” concrete pipe joints and “average” joints affected by specific types of joint irregularities such as offsets due to misalignment, grooves formed by annular openings in joints, and beads/ fillets formed by mortar in the joints. The results showed very little difference in Manning’s ‘n values’ between “good” and “average” which did not exceed 2% (ACPA, 2012). Therefore, as long as the joint is not damaged or failing, the condition of a pipeline joint has minimal impact on sewer pipes’ roughness coefficients.

Conclusions

The subject of sewers and drains’ hydraulic roughness coefficient and performance has been covered extensively with research since the 1950’s. There is consensus in the UK, and Europe, that sewers’ hydraulic roughness coefficients are not generally the subject of pipe materials. All sewers (regardless of pipe material) are designed with a single roughness coefficient in mind: Ks = 1.5. Similarly, all surface water drains are designed to a single roughness coefficient: Ks = 0.6.

References

- ACPA (2012) Manning's n Values History of Research – *Design Data 10*. ©American Concrete Pipe Association, 2014.
- CEN (2017) *BD EN 16933-2: Drain and sewer systems outside buildings – Design – Hydraulic Design*. CEN, 2017.
- Water UK (2019) *Design and Construction Guidance for foul and surface water sewers offered for adoption under the Code for adoption agreements for water and sewerage companies operating wholly or mainly in England ("the Code")*. Approved Version 1.0. Water UK, October, 2019.
- Water UK (2018) *Sewers for Adoption – A Design and Construction Guide for Developers, 8th Ed*. Water UK. August, 2018.

For product information please contact BPDA members:

Marshalls CPM - 01179 814 500

F P McCann - 028 7964 2558

Stanton Bonna Concrete - 01159 441 448

British Precast Drainage Association (BPDA), The Old Rectory, Main Street, Leicester, LE3 8DG
Tel: 0116 232 5170
email@precastdrainage.co.uk
www.precastdrainage.co.uk