British Precast Drainage Association

Publications from the British Precast Drainage Association (BPDA):

BPDA was formed in 2017 from the integration of the Concrete Pipeline Systems Association (CPSA) and the Box Culvert Association (BCA).

Information published by both CPSA and BCA will be rebranded and replaced as BPDA in due course. New material will be branded BPDA.

All CPSA and BCA web traffic will be redirected to the new BPDA web site at www.precastdrainage.co.uk

Concrete and Plastic Pipes: the Durability Question

The durability of a sewer pipeline system should is a major priority for the industry. While concrete pipes have a proven track record and a specified service life, plastic pipes are relatively new and may need further research on the area of design service life.

Introduction

In 2002 OFWAT estimated that replacing/ renovating the UK's 309,000 km sewerage and drainage network would require £200 billion. The average cost can be considerably high for the larger sewer pipe ranges exceeding 300mm in diameter. With such high stakes, the serviceabiliy and design life of sewerage/drainage pipeline systems is a major priority for the water and sewerage industry. Sewer asset design life is still an under-researched area. Due to the considerable number of factors affecting the performance and serviceability of sewers, there is still a level of uncertainty about the design life of different types of pipeline systems. Rigid sewer systems (including clay and concrete) have been in service for well over 100 years. The earliest technical reference to thermoplastic based sewers in the UK is found in BS3505: "*Class B pressure pipe approved as sewer pipe*" in 1965. It is thought that thermoplastic pipes were introduced to mainland Europe around the same period. The design and technology of concrete and plastic pipes has progressed in the last few decades and today these two types comprise the majority of large (>DN300) drainage and sewerage pipes installed throughout the UK.

Factors affecting the Service Life of Concrete and Plastic Pipes

A service life comparative analysis between the two types of sewerage and drainage pipes is not as straightforward and simple as many would expect. Concrete and thermoplastics have different material characteristics and pipeline systems made of these two materials employ different mechanisms to respond to loading. Failure modes and propabilities for the two types of pipelines are therefore different.

A study carried out in the late 1990's to investigate serviceability of concrete pipes found no specific age-associated factors causing failure (Davies *et al*, 2001). The fact that concrete grows stronger over time makes it even more dificult to single out an age associated faliure cause. This does not mean that concrete pipes are completely immune to failure during, or at the end of, its servie life as there are a number of situation specific factors that may lead, at least theorotically, to failure (poor workmanship, design defects, Sulphide attack, external acid attack, etc). However most of these factors are associated with the older generations of pipeline solutions and the actual impact of these factors on 21st Century, SD-1 compliant, Class 120 (in accordance with BS 5911:2004) concrete drainage products is unknown.

Unlike concrete pipes, there are a number of age-related factors that can be linked directly to thermoplastics. At the microscopic level, change in strength and stiffness are two aspects that can be associated with long-term behaviour (Farshad, 2006). Ageing of plastics can be triggered by aspects like weathering (mainly temperature and moisture), stress (static and dynamic loading, residual loading, etc), biological, incompatibility, and application factors. The impact of these factors could differ from one type of thermoplastic to the other (i.e. high density polyethylene, polypropylene, and polyvinyl Chloride) Plastic pipe systems are affected by the "Bathtub theory" as the possibility of failure reduces immediately after installation but increases continuously throughout the service life (see Figure 1).

While the concrete pipe industry has worked on a number of its vulnerability areas and ironed out a number of older generation problems such as joints sealability, external sulfate affects, and excessive loading, the plastic pipe industry still has a number of unanswered questions: Sensitivity to deformation, bedding problems, and third party damage are all major concerns. There are also references to poor material selection increasing the possibility of thermoplastic pipes' ageing. The University of East London did some research on structured wall plastic sewer pipes in the 1990s investigating thin structured wall plastic pipes' resistance to damage (Lawrence et al, 1998). The study referred to irregularities in performance found in PVCu pipes made of the same material using the same method, these even varied from segment to segment.

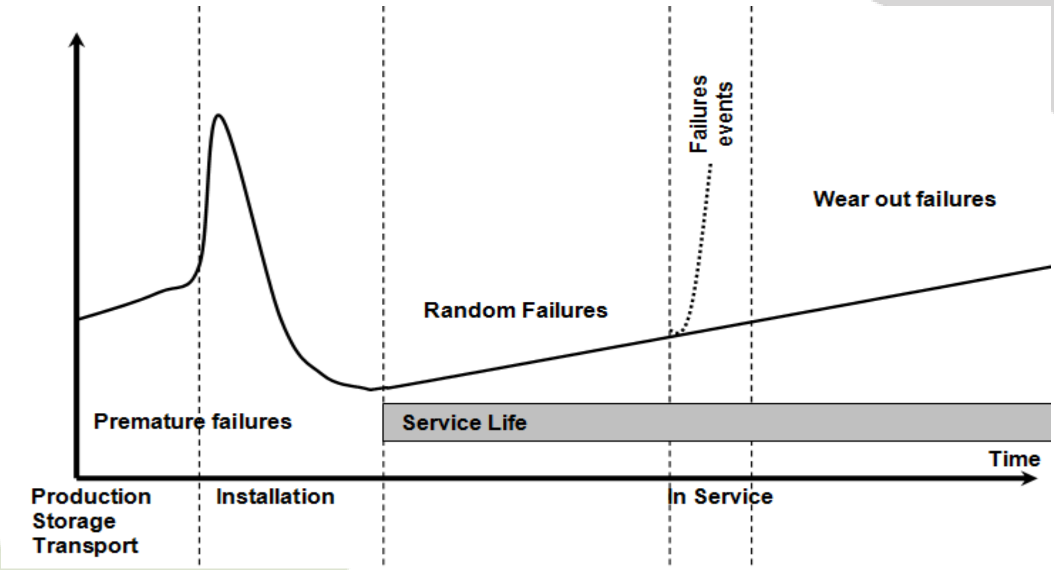

Figure 1. Plastic Pipeline Systems are affected by the Bath tub Theory (Farshad, 2006).

This leaves a few main questions unanswered, such as: What is the actual service life of a concrete pipe if none of the factors mentioned above was involved? Are there any age-associated factors that can lead to failure of concrete pipes? And, how many years a plastic sewer pipe can survive if no deformation problems occurred in the first period of its service life? How much time a plastic pipe needs to deteriorate?

Concrete vs. Plastic Pipes: Suggested Service Life

The performance of concrete pipeline systems is supported by a long track record dating back to the late Nineteenth, early Twentieth Century:

- **Over 100 years:** There are several case studies on concrete pipes exceeding 100 years. In Norwich, sections of a 100 year old concrete pipeline were recovered and subjected to a number of tests; most pipe sections passed these tests successfully. In New York, five DN150 sections of a concrete sewer installed in 1842 were removed and found to be in excellent condition. There are even reports of sections of concrete sewers found in the German city of Cologne dating back to the times of Romans.
- **100 years:** More recent estimations also offer long service life, the BRE's *Special Digest – 1* (SD-1) offers an estimate for concrete pipes' service life reaching a maximum exceeding 100 years if necessary. The same applies to the Highway Agency Design Manual for Roads and Bridges (subject to extension).
- **100 years:** A similar life span is also being acknowledged in the United States, with a number of states' specifications approving a 100 year life for concrete pipe systems. The same applies to the US Army Corps of Engineers' engineering and design manual for conduits, culverts and pipes.
- **400 to 1000 years:** Research at Manchester University estimates a service life of 500 years. the Robens Centre for Public and Environmental Health (University of Surrey) offers 400 years. These should not be taken as one-off estimations, according to the Campaign for the Renewal of Older Sewerage Systems (CROSS) the industry presumes sewers last on average 355 years, and by this measure two companies optimistically presumed their sewers will last over 1000 years (Downey, 2004).

This has led to more specifications offering clear figures worldwide. The latest of which is the Australia/New Zealand Precast Concrete Pipes standard AS/NZS 4058 which states that when reinforced concrete pipes are manufactured in accordance with the standard and installed in accordance with AS/NZS3725 the product can be expected to be in service, without undue maintenance, for in excess of 100 years.

Information on plastic sewer pipes is much vaguer. The main way to estimate a service life for plastic drainage products is via extrapolation (ISO 9080:2003). Different literature offer service life estimations ranging from 30 to 100 years;

- **30 years (PVC):** In a PVC pipe impacts report by American organisation "Healthy Buildings Network" it was noted that PVC may have a "*long life span, not proven beyond 30*". This is exactly the number of years estimated by the Building Rearch Establishment (BRE) in the UK for PVC-based construction components (e.g. windows). However, this is mainly due to U.V exposure.
- **50 to 100 years (general):** This is an extrapolation for pressurised plastic pipes that can be found in a number of references (Lang, 2005; Farshad, 2006) and based on ISO 9080. However the gap is apparently wide and there is no proof that different ageing factors were accounted for sufficiently due to the complete lack of a track record. Most plastic pipe companies in the UK usually offer service life estimations somewhere between those two benchmarks (i.e. 60 yrs, 70 yrs).
- **100 years (HDPE):** This estimation was made by the Institute of Plastic Pipes (IPP) in Washington DC. However, there is no comprehensive methodology behind this estimation and the whole concept was built around a limited number of elements and did not account for a number of aspects such as ageing and degradation over time. The methodology used was severely criticised as the SCR tests performed on the tested pipes were carried out for both liner and junction locations, yet the paper published on the tests only used the extrapolated values for the junction.

Lack of a track record and real-life information means that all these estimations are questionable. The only study to ever use real-life information was carried out for PVC sewer pipes by Ipswich Water and Iplex Pipelines in Australia in 2005 where a number of pipes, with different service lives reaching up to 25 years, were salvaged and tested. The methodology had numerous flaws where a number of pipe failure types were omitted. The final results only accounted for seven samples and astonishingly one of these samples failed the infiltration/ exfiltration test. The socket of another pipe sample (within the same seven samples group) was also damaged.

It is therefore clear that **concrete pipes should currently be considered as more durable than plastic counterpart**. This situation is not expected to change unless the plastic pipe industry starts to take its deformation and durability problems heads on and try to address all these different concerns.

Conclusion

There is no doubt that durability is one of the most desirable characteristics in any sewer system. There are a number of elements and factors that can play a role in determining the durability of sewers: aspects such as workmanship, bedding conditions, joints quality and design can all affect the state of a rigid or flexible pipe. However the type and nature of the material used can also play a vital role in the short and long-term.

Concrete pipes have a proven track record of a +100 years service life, the same cannot be said or generalised on different types of thermoplastic pipeline systems. One major question which is not being addressed properly by the industry is associated with the current assessment and classification systems used in the UK to rate sewer assets' life span: the current asset life categories widely used by the water industries only consider +50 yrs as the maximum service life for a sewer. Considering the huge costs of replacing sewers this service life range may not be as long as one would expect. **CPSA believes that this will have to be addressed by the industry and regulators**. Moreover there are still gaps in knowledge in regard to deterioration rates for plastic pipeline systems. Unless these questions are addressed it will be difficult to answer the main question of durability within the drainage and sewerage sector.

References

- **Davies**, J. P; **Clarke**, B. A ; **Whiter**, J.T.; **Cunningham**, R.J (2001) Factors influencing the Structural Deterioration and Collapse of rigid sewer pipes. Urban Water 3, 71 – 89.
- **Davis**, J. L; **Nica**, D; **Shields**, K; **Roberts**, D. J. (1998) Analysis of concrete from corroded sewer pipe. International Biodeterioration and Biodegregation, 42, P 75-84.
- **Downey**, D (2004) Sewer and Water Mains Rehabilitation - A Challenge for the UK Water Industry (White Paper). IDS Water Website. www.idswater.com
- **Farshad**, M. (2006) *Plastic Pipe Systems: Failure Investigation and Diagnosis*. First Edition 2006. Elsevier Ltd. ISBN-13: 978-1-85-617496-1.
- **Hau**, Y; **Clarke**, B; **Howes**, C; **Cunningham**, R.; **Mathews**, M (2005) Defects in sewer pipe joints and water tests. Proceedings of the Institute of Civil Engineers, Water Management 158. Issue WM 3, Paper 14044, Pages 119- 125. September 2005.
- **Jones**, M. (1998) Sewer Leakage – Detection and Cure. The 'Sewer Leakage, Detection and Cure' Project. Wessex Water.
- **Lang**, R. (2005) the phenomenon of slow crack growth in PE pipe materials – applicability and limitations of various test methods. *PIPES 2005: "Highlighting the latest developments in markets, standards and technology in the plastic pipes industry" Conference*, 1 – 2 February 2005, Brussels, Belgium.
- **Lawrence**, C; Rasbash, J; Potter, R; Teo, A (1998) A new Approach to the instrumented falling weight method of testing pipe which compensates for the pipe's geometry and minimises the dynamic effects. Proceedings of the 10th International Conference on Plastic Pipes. Gothenburg, Sweden, pp 301-310.
- **OFWAT** (2002) Maintaining Water and Sewerage Systems in England and Wales, Our Proposed Approach for the 2004 Periodic Review. OFWAT, London, 2002, pp. 1–22.
- **Parande**, A. K.; **Ramsamy**, P. L; **Ethirajan**, S; **Rao**, C. R. O; **Palanisamy**, N (2006) Deterioration of reinforced concrete in sewer environments. Proceedings of the Institute of Civil Engineers, Water Management 159. Issue WM 3, Paper 14044, Pages 11- 20. March 2006.
- **Ridgers**, D (2006) Development of a test of the infiltration resistance of sewer linings. No Dig – Live Conference and Exhibition, Coventry, 2006.

For further information please contact your usual supplier

Buchan Concrete Solutions
Tel: 01606 843 500

CPM Group
Tel: 0117 981 2791

F P McCann
Tel: 01530 240 000

Milton Precast
Tel: 01795 425 191

Stanton Bonna
Tel: 0115 944 1448

Concrete Pipeline Systems Association – 60 Charles Street, Leicester, LE1 1FB
Tel: 0116 253 6161 Email: mail@concretepipes.co.uk www.concretepipes.co.uk