



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

Structural design of buried pipelines: The importance of correct classification of pipes and validating theory with practice

There is no common method for the structural design of buried pipelines. Varying practices exist across Europe and further afield. BS EN 1295-1:1997 - *Structural design of buried pipelines under various conditions of loading. General requirements* - specifies general requirements and guidance on the application of National Standards.

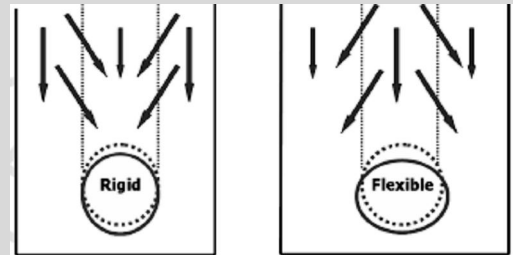
BS 9295:2010 - Guide to the structural design of buried pipelines - provides guidance for the use of BS EN 1295-1:1997 National Annex A describing the established UK method for the structural design of buried pipelines. It also consolidates and updates the various documents that collectively describe the UK method. Much of this paper has been drawn from BS 9295:2010.

Structural Classification of Pipes depends on their inherent response to external loading and interaction with the surrounding soil. There are three types:

Rigid: deflection on loading too small to develop lateral earth pressures. Load taken by pipe and bending moments developed in the pipe walls. Amplified backfill load generated upon burial and a reaction from the bedding in response.

Semi-rigid: range of behaviour from rigid to flexible.

Flexible: pipe deflects downwards to oval in response to loading and can develop significant lateral earth pressure (also known as $\% \sigma$ soil load+or $\% \sigma$ backfill load+) from the surrounding embedment



Rigid and flexible pipe behaviour. Displacement and deflection exaggerated.

Pipes are classified in the UK according to the strength criteria required to be proven in testing or otherwise established in the design.

Embedment design

Rigid Pipes: rely on the embedment to distribute loads imposed by the backfill and traffic to reduce circumferential bending moments in the pipe walls. The pipes response to loading is to settle marginally into the supporting material until sufficient reaction is achieved.

Semi-rigid pipes: display elements of rigid and flexible pipe behaviour, i.e. they will deflect and settle in response to loading.

Flexible pipes: derive much of their structural strength from the embedment that is to the sides of the installed pipeline. Due to the response of flexible pipes to loading, appropriate embedment selection and compaction are essential to control ovalisation. It is also very important to understand the relationship between pipe stiffness and the increased risk of damage to pipes with relatively low stiffness (or thin walls) during the compaction process. In these situations, a rounded, single-size, self-compacting gravel may help reduce the risk of damage.

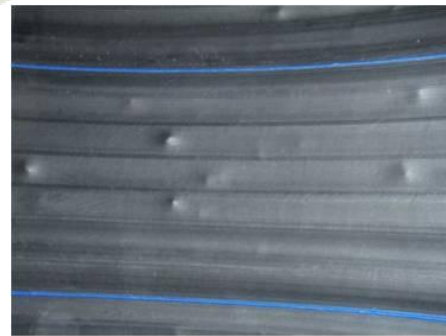
Pipe Material Selection

BS 9295 Table 1 provides examples of common, established pipe materials and their structural classification:

| Type of Pipe | Classification |
|--|----------------|
| Clay, concrete, reinforced concrete | Rigid |
| Ductile iron, thick walled steel | Semi-rigid |
| Thermoplastic, glass reinforced plastic, thin walled steel | Flexible |

When selecting a pipe material for a specific application, the designer must be confident that the pipe will behave in a manner that accords with the classification and that the design theory applied to the pipeline system has been validated, with acceptable certainty, against empirical results determined in practice. This is of particular importance when new pipe materials and material combinations are developed where products have not benefited from knowledge gained following many years of experience in the field. Combining certain materials into products can lead to excellent results. For example, steel has been successfully combined with concrete to provide tensile capacity to give enhanced performance. In terms of pipe design, the introduction of reinforcing steel has made it possible to produce precast concrete elements of lower mass. However, the structural behaviour of un-reinforced concrete pipes and reinforced concrete pipes is the same and the classification of the pipe is still regarded as rigid.

Other material combinations are also possible and at first glance can appear to offer benefits over established pipe materials and product designs. However, not all material combinations result in the best properties of each material being utilised in the hybrid product and it is essential that the way in which the combined materials interact in the short and long term, at material and product level, is properly understood. Without such knowledge, correct structural classification can become difficult and in the case of semi-rigid pipes, the degree by which the pipe behaves as a rigid pipe and as a flexible pipe needs to be determined



Indentations from bedding on wall of hybrid pipe (as seen from inside pipe) suggesting insufficient wall thickness

In addition to overall structural performance, the pipe wall must also be of sufficient strength, stiffness and robustness to prevent damage and indentation during transport, storage, installation, settlement and full operational lifetime.

Whilst acceptable structural performance is of fundamental importance, other factors such as responsible sourcing of the pipe itself and the choice of embedment material used to install a pipeline must not be overlooked. Flexible and semi-rigid pipes usually require imported granular material for embedment to a defined specification and laid to a minimum level of compaction. This can add time, cost and embodied carbon to the installation which needs to be considered against installations using rigid pipes requiring reduced amounts of (or no) granular embedment material.

If considering innovative new systems, it is strongly advisable to obtain evidence from the manufacturer to demonstrate that the product's structural behaviour has been proven by a credible, independent third party and clearly states that the structural design model proposed for buried pipeline installations is based on flexible, semi-rigid or rigid pipe behaviour and that this reliably reflects actual performance observed in practice, in the short and long term.

For further information please contact your usual supplier

CPM Group

Tel: 0117 981 2791
www.cpm-group.com

Stanton Bonna

Tel: 0115 944 1448
www.stanton-bonna.co.uk

F P McCann

Tel: 0153 024 0000
www.fpmccann.co.uk

Milton Pipes

Tel: 0179 542 5191
www.miltonprecast.com

Concrete Pipeline Systems Association – 60 Charles Street, Leicester. LE1 1FB
Tel: 0116 253 6161, Fax: 0116 251 4568, Email: mail@concretepipes.co.uk, Web: www.concretepipes.co.uk