Maximum Fill Depth
Over Thermoplastic Culverts

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The following are just a few useful pieces of information from known and trusted sources that help us to place the fill depth question for Enviro-Span into context for anyone trying to do calculations. To begin, **a Finite Element Analysis of Enviro Span demonstrates that it may be safely installed under at least 115 feet of fill. This is orders of magnitude deeper than for corrugated steel arches of comparable size and specifications.**

Some general facts about the properties of thermoplastics in deep fills

The factored critical buckling stress for Enviro-Span from the L150 (150 ton, 5 axle configuration) Finite Element analysis was in the range of 20-25 Mpa. The yield stress of Metton is 70 Mpa. So, to begin with, the yield stress of Enviro-Span under an extreme loading is reaching only 1/3 of its potential.

Further to that, the maximum yield stress of HDPE is only 26-33 MPa and in AASHTO specs, a five foot diameter HDPE pipe can be buried (in highway installations) in the vicinity of 55 feet deep. Research conducted by Sargand and Masada (Soil Arching over Deeply Buried Thermoplastic Pipe, 2002) indicates that the AASHTO figures are 50 to 80% conservative. The reality is that a five foot HDPE pipe can be safely buried to something more like 82.5 to 99 feet deep with good compaction during installation.

Enviro-Span is made of material that is more than double the yield strength of HDPE and the product itself has a higher static and dynamic load capacity than HDPE pipe. Further, Enviro-Span is made from a thermoplastic (Metton) and therefore readily forms a soil arch composite under deep fills. It likely follows that the potential burial depth of Enviro-Span in a well compacted installation is fairly extreme.

The following is an abstract from Sargand and Masada:

This paper discusses soil arching associated with buried thermoplastic pipe. First, the soil arching phenomenon is described. Then, two different approaches are mentioned from literature to represent the degree of soil arching (or vertical arching factor). The elastic solutions of Burns and Richard are revisited to derive expressions for the vertical soil arching factor for buried pipe. Upon comparing the elastic solutions to field soil pressure cell readings, the importance of incorporating bending stiffness ratio is clearly observed. With this finding, the AASHTO method for calculating the load on buried pipe is evaluated against the elastic solutions. The analysis reveals that the AASHTO method is conservative, overestimating the load on thermoplastic pipe by 50 to 80%. Further evidences to support the finding are found in the strain gage readings taken on the pipe walls in the field. Therefore, alternative equations derived directly from the elastic solutions are recommended to predict the load on buried thermoplastic pipe, instead of the AASHTO method.

General Statements about the use of engineering thermoplastics (e.g. Metton) versus stiffer culvert materials (e.g. steel or concrete).

Interaction of a Soil Envelope with a Flexible Pipe (Development of a soil arch)

Flexible pipe provides many advantages compared with pipe manufactured from rigid materials, most significantly its ability to draw upon the strength of the adjacent soil to readily withstand deep burial without experiencing wall collapse. Because of the composite soil-pipe interaction, flexible pipe design procedures are vastly different than for more rigid pipes such as steel or even more so, concrete. Understanding how the flexible pipe relates to its neighboring soil — thereby establishing a functional pipe-soil composite structure (**a soil arch**) — is key to a successful design (paraphrased from Gabriel, 1998).

Flexibility in buried pipes is a desired attribute. Understanding how the flexible pipe relates to its neighboring soil – thereby establishing a functional pipe/soil composite structure – is key to successful design. A buried pipe and its adjacent soil elements will attract earth embankment loads and live loads in accordance with a fundamental principle of structural analysis: *stiffer elements will attract greater proportions of shared load than those that are more flexible.*

Influence of Profile Wall Geometry An important property of a flexible pipe is that it has the ability to adjust its geometry in a manner that reduces internal resisting moments in favor of increased ring compression. Greater ring compression and lesser bending result in lower net tension or none at all, **a favorable outcome**. Within constraints of handling, shipping and storage, the greater the flexibility, the more efficient the in-service performance of buried pipes. Studies have shown that the flexural stiffness may be disregarded in favor of studying only the hoop response with little lost accuracy in analytical predictions. A properly bedded flexible pipe gives rise to reasonably predictable passive soil forces in the vicinity of springline.

A very straightforward quote given by Blair Gohl, P.Eng, Phd. In his 2002 Enviro Span FEA was “For greater depths of cover, soil arching is promoted by more flexible culverts, stiffer/stronger granular soils, and compliant (i.e. flexible) foundations.”

Corrosion and Galvanic Corrosion. Unlike metals, thermoplastic pipes are non-conductors and are not vulnerable to galvanic corrosion associated with electrochemical attack. Thermoplastic pipes are not degraded by pH extremes, aggressive salts or chemically induced corrosion (e.g. acid mine runoff).

Abrasion. Chemicals and abrasion are the most common durability concerns for drainage pipes, especially when the effluent flows at high velocities. In test after test, results show that it takes longer to abrade through polyethylene than concrete and metallic pipes. In fact, in testing in both the United States and Europe, polyethylene has demonstrated wear rates up to 10 times less than steel. We have no figures for Metton for abrasion. However, it is a thermoplastic as is polyethylene.

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