TECHNICAL NOTE

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RESPONSE OF PLASTICS PIPES TO AXIAL STRAINS

Introduction

Pipelines may be subjected to axial strain originating from a number of sources:-

(a) Thermal expansion or contraction of the pipe and/or soil.

(b) Expansion and contraction of soil due to changes in moisture content.

(c) Ground subsidence due to mining activities.

It is necessary that the system retain integrity under these conditions, and most pipe systems incorporate rubber ring joints which allow axial movement and thus relieve material strain. An inherent assumption here is that the pipe is able to slide through the soil, and the frictional forces developed in this process do not induce stresses in the pipe material of significant magnitude.

Axial Stress

Axial stress induced is a function of the length between moveable joints. Materials with a low stress/strain capability require frequent joints to provide stress/strain relief, for example, rigid materials such as clay pipes. Cast (ductile) iron and reinforced concrete pipes may support longer lengths[1].

If the strain capacity of the material exceeds the soil or other induced strains occurring in service, then the length permissible without strain relief is unlimited. This is the case with the commonly used thermoplastic pipe materials, PVC and polyethylene, ABS, polyamide, etc.[2] It is this factor that permits the use of continuous rigidly welded or solvent cemented joint pipe systems, which operate successfully with no provision for stress/strain relief at all.

To illustrate this point, strains developed under practical conditions are compared with the material limits in the examples below:

(a) The coefficient of thermal expansion of PVC is $7 \times 10^{-5}/^{o}C$. The strain developed in a fully restrained member over a $50^{o}C$ temperature change is 3.5×10^{-3} or 0.35%. This does not approach long term strain limits for PVC, considered to be at least 3.5%.[1,2] For a short term modulus of 3 GPa, the stress level induced is 10.5 MPa, which is only 20% of the ultimate short term stress.[3]

(b) The maximum soil strain generally considered likely in mine subsidence areas is around 0.7%. Again this is only 20% of the ultimate long term strain capability of PVC, giving us a factor of safety of 5 against rupture.

Structural profiled wall pipes

These pipes have a formed external structure which effectively keys the pipe to the soil, so that there is no possibility of sliding through the

[1] It should be borne in mind that whilst these pipes have adequate axial tensile strength, concrete and cement linings have limited strain capability, and cracking may expose the composite to corrosion. Depending on the application, this may be considered the limiting criterion for loss of integrity.

[2] This does not apply to thermosets, GRP or FRP materials, and may not apply to some of the special purpose thermoplastics.

[3] In pressure pipe systems, such stresses should not be accepted without analysis for multiaxial stress conditions. Consult our Technical Department. In above ground systems, it is preferable to provide for expansion to occur to avoid overstressing supports, and in pipes with large l/k ratio, the possibility of column buckling due to axial compression.

soil when strains develop. The pipe acts like a fully restrained member in respect of thermal expansion and contraction, and any other strains developed in the soil will be transferred directly to the pipe also.

A further aspect to be considered is that the part of the wall profile carrying the axial stresses may vary in cross-sectional area along the pipe. Now the stresses and strains will be concentrated at the points of smallest cross-section. It is therefore necessary to demonstrate that stress/strain limits will not be exceeded under service conditions, which may be done from a theoretical standpoint for simple profiles, or experimentally for more complex structures.

Ultra-Rib pipes have a complex wall section, and determination of the axial stress/strain capability was carried out experimentally through tensile testing of whole pipe sections at the Roads and Traffic Authority - Materials Service Laboratory, NSW. Vinidex Report AW910430.014 refers. The findings were that the macro axial strain capacity of the pipe exceeds mine subsidence maximum soil strain requirements (0.7%) with a factor of safety of 2.49 in tension (failure by tensile fracture), and 1.97 in compression (failure by buckling).

References:

[1] L E Janson, V B B Consulting Group, Stockholm, "Advances in Underground Pipeline Engineering", ASCE Conference, Madison, Wisconsin, 1985.

[2] Moser A P, Shupe O K, and Bishop R R, "Is PVC Pipe Strain Limited After All These Years?", Buried Plastic Pipe Technology, ASTM Conference STP 1093, Dallas, Texas, 1990.

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