Analysis of PVC-PC-PVC Sandwich Pipes

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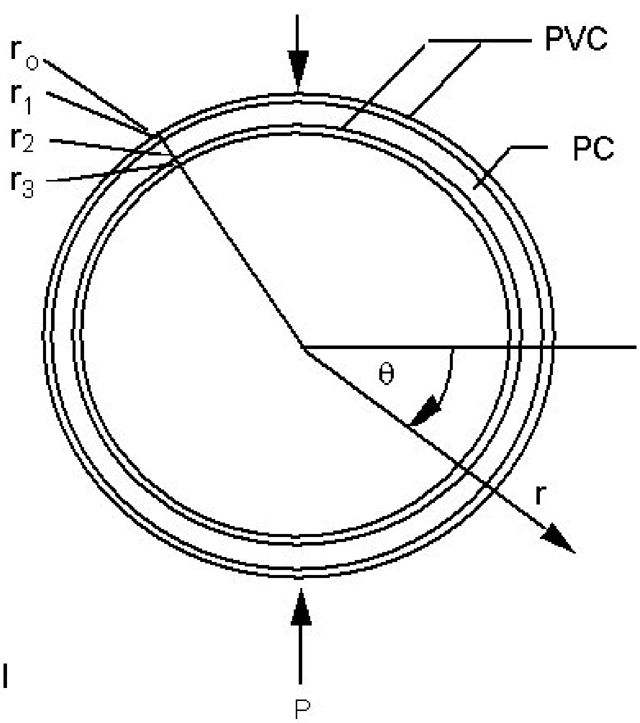
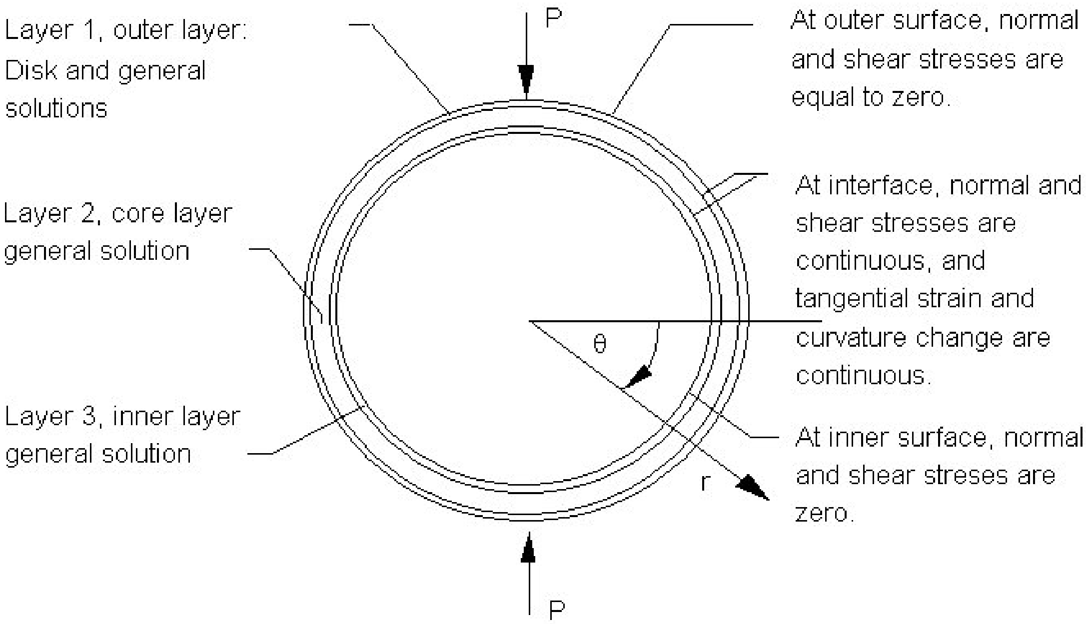
In wastewater pipeline applications it is desirable to have a pipe that is stiff enough to satisfy placement requirements and also corrosion resistant for long term durability. One possible design for such pipes is a sandwich construction, with PVC pipes as the outer and inner components and a core pipe of polymer concrete (PC). The outer and inner PVC pipes are corrosion resistant. Their smooth surfaces also make them attractive in microtunneling applications because they offer smaller resistance when pushed through the surrounding soil longitudinally.

In characterizing the mechanical behavior of such pipes, a standard test is that of a concentrated line loading applied at the crown of the pipe with a supporting plate at the bottom. This effectively creates a pair of concentrated loading to the pipe. Under such a loading condition, we want to find the stiffness of the pipe, the maximum tensile stress and the maximum shearing stress at the interface of the sandwich pipe. The stiffness of the pipe is represented by the deflection under the load. The maximum tensile stress is most likely located in the PC and is important in designing against pre-mature cracking in the core pipe and the maximum shearing stress at the interface is important in designing against bonding failure between the PVC and the PC components.

While such an analysis can be carried out with finite element methods, the concentrated loading creates a local stress variation that is difficult to model in finite element analysis and convergent solutions may take many elements. Because of the simplicity in the geometry of the problem, however, we are able to produce an analytical solution using available solutions for rings and disks through a recently proposed method of enforcing interface compatibility.

The problem to be solved is depicted in the following figure. The load, P, is a line load acting along the longitudinal axis of the pipe. The problem is essentially a two dimensional one in linear elasticity. The solution to this problem is obtained by the combination of two fundamental solutions: a Disk Solution and a general solution for a ring. For each of the three layers in the sandwich pipe, the applicable solutions are indicated in the following figure; the boundary conditions that must be satisfied are also indicated.





The stress and displacement conditions are used to determine the parameters in the general solutions. Accurate results are then obtained for a given sandwich pipe tested in the UH lab. Contour plots of tangential stress and shear stress are obtained to show the general distribution of stresses in a sandwich pipe.

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