22.314/1.56/2.084/13.14 Fall 2006

Problem Set VIII

Due 11/09/06

Consider the pre-stressed concrete containment example of Problem Set L.54.
Evaluate the impact of changing the longitudinal tendon pitch from 165 mm to 200 mm on the required prestress level to prevent tensile stresses in the concrete upon pressurization.

Structural Mechanics in Nuclear Power Technology

(1.565J, 2.084J, 3.82J, 13.14J, 16.261J, 22.314J)

Problem Set L.54

This problem illustrates some of the concepts in reinforced/prestressed concrete containment stress calculations.

1. Geometry

Consider the concrete and steel geometry of Fig. 1 for a section of a cylindrical containment shell.

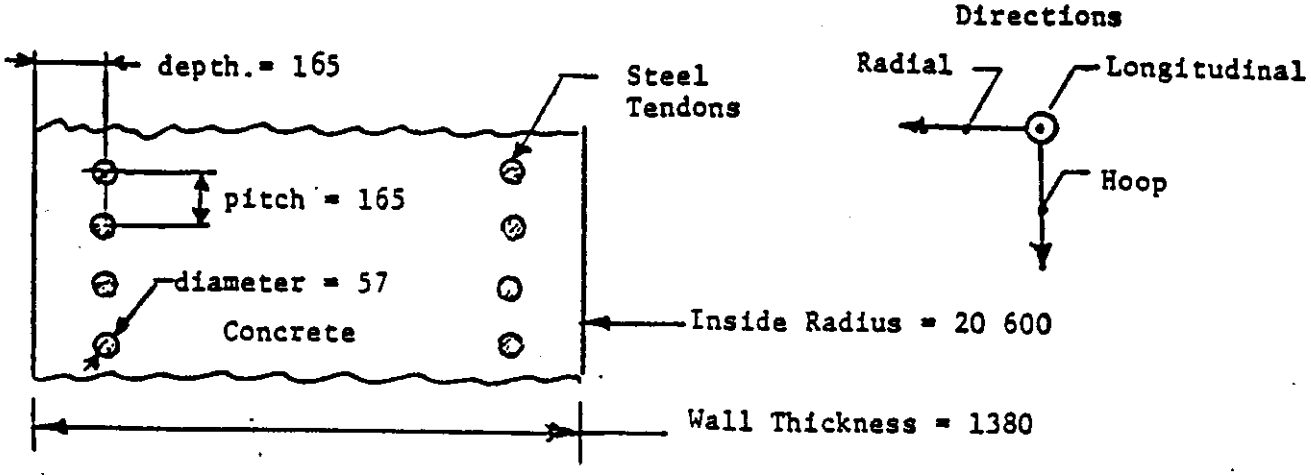

Figure 1 Section Normal to the Longitudinal Axis of the Containment Shell (dimensions in mm).

That is, the longitudinal tendons are in the form of two rows of 57 mm diameter steel bars (one row near each surface) with a pitch of approximately 165 mm. The hoop tendons are in the form of four rows of 57 mm diameter steel bars (two rows near each surface). However the pitch of the hoop tendons in each row is 200 mm.

2. Material Properties and Operating Conditions

For the steel, Young's Modulus = 210 GPa. For the concrete, Young's Modulus = 21 GPa and Poisson's Ratio = 0.15. In the pressurized condition the internal pressure is 350 kPa above the external pressure.

3. Questions

(a) What prestress levels (one level for all longitudinal tendons, another for all hoop tendons) are required to prevent tensile stresses in the concrete upon pressurization?

(b) What is the maximum tensile stress in the rebars upon pressurization?

4. Calculational Basis

- Assume elastic behavior.
- Consider that the cylinder is "long" but consider the region near the base mat.
- Consider the cylinder to be built-in at the position it joins the base mat (zero radial deflection, zero slope of radial deflection).
- Define the flexural rigidity on the basis of the section shown in Fig. 1. Consider that the tendons move in the longitudinal direction the same as the concrete. Calculate rigidity on the basis that "plane sections remain plane" and that transverse Poisson's ratio can be treated the same as the concrete.
- Consider that there is no bending of the shell in the unpressurized condition.
- Consider the prestressing to be achieved by "post-tensioning".