Chapter 6: Plastic Pipe for Other Applications

Pipe Stiffness

D = 0.250 m (10 in.) - Pipe diameter

$R = \frac{D}{2}$ R = 0.125 m (5 in.) - Pipe radius

t = 8 mm (0.134 5 in.) - Wall thickness

$E_p = 3.03 \cdot 10^9$ N/m^2 (440,000 psi) - Initial modulus of elasticity (plastic)

$I = \frac{t^3}{12} \cdot 10^{-9}$ m^4/m (in.^{4}/in.) Moment of inertia

$I = 4.27 \cdot 10^{-8}$ m^4/m (0.0026 in.^{4}in.)

$$FF = \frac{D^2}{E \cdot I} * 1000 < = 0.542 \text{ m/N (95 in./lb)} \quad (6\text{-}1)$$

FF = 0.4834 m/N (85 in.lb)

$$PS = \frac{E \cdot I}{0.149 \cdot R^3} > = 98{,}946/D \text{ N/m/m } (565/D \text{ lb/in./in.}) \quad (6\text{-}2)$$

$PS = 444{,}237 \geq \frac{98{,}946}{D} = 395{,}784$ *OK*

Deflection

D_L = 2.5 Deflection lag factor for long-term prediction

K = 0.11 Bedding constant

E' = 6.89 · 10^6 N/m^2 (1,000 psi) - Soil modulus

P = 69,000 N/m^2 (10 psi) - Service pressure at the crown of the pipe

$$\frac{\Delta Y}{D} = \frac{D_L \cdot K \cdot P}{0.149 \cdot (PS) + 0.061 \cdot (E')} \cdot 100 \text{ percent} \quad (6\text{-}3)$$

$\frac{\Delta Y}{D}$ = 3.90% - Pipe deflection

Wall Stress (Crushing)

P_{ST} = 68,950 N/m^2 (1,440 psf) - Short-term pressure at the crown of the conduit

P_{LT} = 68,950 N/m^2 (1,440 psf) - Long-term pressure at the crown of the conduit

f_i = 3.03 · 10^9 N/m^2 (440,000 psi) Initial tensile strength of the pipe material

f_{50} = 1.09 · 10^9 N/m^2 (158,400 psi) - 50-year tensile strength of the pipe material

D = 0.3 m (1 ft) - Diameter of pipe

$$T_{ST} = D \cdot \frac{P_{ST}}{2} T_{ST} = 10{,}343 \text{ N/m (720 lbf/ft)} - \text{Short-term wall thrust} \quad (6\text{-}4)$$

$$T_{LT} = D \cdot \frac{P_{LT}}{2} T_{LT} = 10{,}343 \text{ N/m (720 lbf/ft)} - \text{Long-term wall thrust} \quad (6\text{-}5)$$

$$A \geq 2 \cdot \left(\frac{T_{ST}}{f_i} + \frac{T_{LT}}{f_{50}} \right) \cdot 10^6 \; A = 25.8 \text{ mm}^2\text{/m (0.0124 in.}^2\text{/ft)} - \text{Wall area} \quad (6\text{-}6)$$

Ring Buckling

H = 3 m (10 ft) - Height of soil above the crown of the pipe

H_w = 6 m (20 ft) - Height of water above the crown of the pipe

R = 0.3 m (12 in.) - Mean radius

$B = 1 - 0.33 \cdot \frac{h_w}{h}$ Buoyancy factor B = 0.34

E = 9.65 · 10^8 N/m^2 (140,000 psi) - 50-year Modulus of elasticity

M_s = 11.72 · 10^6 N/m^2 (1,700 psi) - Soil modulus

A = 3,050 mm^2/m (1.44 in.^{2}/ft) - Wall area

I = 42,610 mm^4/m (0.0026 in.^{4}/in.) - Moment of inertia of the wall section

$$f_{cr} = \frac{0.77 \cdot R}{A} \cdot \sqrt{\frac{B \cdot M_s \cdot E \cdot I}{0.149 \cdot R^3}} \text{ N/m}^2 \; (fa* 12 \text{ (psi)}) - \text{Wall buckling stress} \quad (6\text{-}7)$$

$f_{cr} = \frac{f_a}{2} FS = 2\, f_{cr} = 7.6424 \cdot 10^6$ N/m^2 (1,096 psi)

Hydrostatic Buckling

$v = 0.39$ Poisson's ration

$K = 1.5\ (10)^{-12}$ SI, 216 non-SI

$$P_{cr} = C\left(\frac{KEI}{(1 - v^2)R^3}\right) \cdot 0.7 \text{ N/m}^2 \text{ (psf) - Buckling stress} \qquad (6\text{-}8)$$

C = Ovality = 0.7 for 4 percent deflection

P_{cr} = 1,886 N/m^2 (37.3 psf) - Field stress or radial pressure from the water

Wall Strain Cracking

t_{max} = 6 mm (0.25 in.) - Thickness of pipe wall

D = 250 mm (10 in.) - Pipe diameter

$\frac{\Delta Y}{D}$ = 3.9% Ratio of pipe deflection to pipe diameter

$$\varepsilon_b = \frac{t_{max}}{D} \cdot \left[\frac{0.03 \cdot \frac{\Delta Y}{D}}{1 - \left(0.02 \cdot \frac{\Delta Y}{D}\right)}\right] \text{ mm/mm (in./in.) - Wall strain < strain limit/2} \qquad (6\text{-}9)$$

$\varepsilon_b = 0.003 < 0.05/2 = 0.025$ OK