6.21 In Tinyland, houses are less than a foot high! The rainfall is laminar! The drainpipe in Fig. P6.21 is only 2 mm in diameter. (a) When the gutter is full, what is the rate of draining? (b) The gutter is designed for a sudden rainstorm of up to 5 mm per hour. For this condition, what is the maximum roof area that can be drained successfully? (c) What is Red?

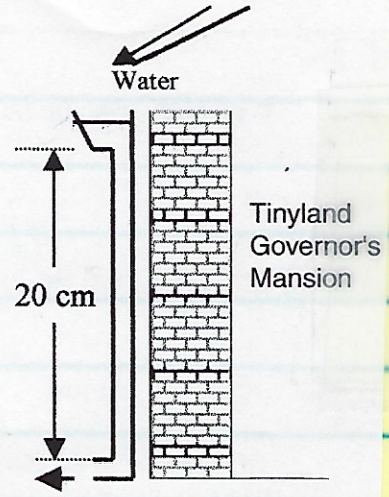

Fig. P6.21

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_f$$

$$\Delta z = \frac{V^2}{2g} + h_f \qquad h_f = \frac{32\mu L V}{\rho g d^2} \qquad \text{Laminar flow}$$

$\rho = 998\ kg/m^3$

$\mu = .001\ kg/ms$

$$.2 = \frac{V^2}{2 \times 9.81} + \frac{32(.001)(.2)V}{998 \times 9.81 \times (.002)^2}$$

$$.051V^2 + .1634V - .2 = 0$$

$V = .945\ m/s \qquad Q = AV = \frac{\pi}{4}(.002)^2 \times .945$

$= 2.97E{-6}\ m^3/s$

ie $A_{roof} = \dfrac{.0107\ m^3/h}{.005\ m/h} = Q/v \quad = .0107\ m^3/h$

$= 2.14\ m^2$

$Re_d = \rho V D/\mu = 1890 < 2000$ OK

$Re_{d\ w/o\ hf} = 1000$ ∴ turbulent