***6.118** For the piping system of Fig. P6.118, all pipes are concrete with a roughness of 0.04 inch. Neglecting minor losses, compute the overall pressure drop $p_1 - p_2$ in lbf/in^2. The flow rate is 20 ft^3/s of water at 20°C.

Solution: For water at 20°C, take ρ = 1.94 slug/ft^3 and μ = 2.09E−5 slug/ft·s. Since the pipes are all different make a little table of their respective *L/d* and *ε/d*:

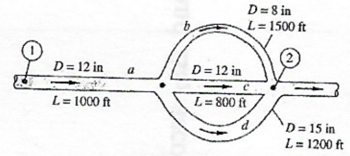

Fig. P6.118

(a)	L = 1000 ft,	d = 12 in,	L/d = *1000*,	ε/d = 0.00333
(b)	1500 ft	8 in	*2250*	0.00500
(c)	800 ft	12 in	*800*	0.00333
(d)	1200 ft	15 in	*960*	0.00267

$$Q_a = 20\ ft^3/s = Q_b + Q_c + Q_d$$

$$h_f = f\frac{L}{D}\frac{V^2}{2g} = h_b = h_c = h_d$$

L, D, g known

$$= \frac{8 f_b L_b Q_b^2}{\pi^2 g D_b^5} = \frac{8 f_c L_c Q_c^2}{\pi^2 g D_c^2} = \frac{8 f_d L_d Q_d^2}{\pi^2 g D_d^2}$$

$$Q_c = 3.77\, Q_b (f_b/f_c)^{1/2} \qquad Q_d = 5.38\, Q_b (f_b/f_d)^{1/2}$$

Continuity: $20 = Q_b\left[1 + 3.77(f_b/f_c)^{1/2} + 5.38(f_b/f_d)^{1/2}\right]$

$V_a = Q_a/A_a = 25.5$ ft/s $\quad Re_a = \frac{V_a D_a \rho}{\mu} = 2.36E6$

$f_a = .027$

			Re
1st guess	$f_b = f_c = f_d$	$Q_b = 1.97$ ft^3/s	349,000
		$Q_c = 7.43$ ft^3/s	878,000
		$Q_d = 10.6$ ft^3/s	1,002,000

2nd	$f_b = .0306$	$Q_b = 1.835$ ft^3/s
	$f_c = .0271$	$Q_c = 7.351$ ft^3/s
	$f_d = 0255$	$Q_d = 10.814$ ft^3/s

3rd

$Q_b = 1.833 \ ft^3/s \qquad V_b = 5.25 \ ft/s$

$Q_c = 7.349 \ ft^3/s \qquad V_c = 9.36 \ ft/s$

$Q_d = 10.819 \ ft^3/s \qquad V_d = 8.82 \ ft/s$

$$P_1 - P_2 = \Delta p_a + \Delta p_b = f_a \frac{L_a}{D_a} \frac{\rho V_a^2}{2} + f_b \frac{L_b}{D_b} \frac{\rho V_b^2}{2}$$

$$= 17{,}000 + 1800 = 18{,}800 \ psf = 131 \ \frac{lbf}{in^2}$$