Example 8.2: Layout of a storm sewer system is shown in Figure 8.15. The sewer BE will be designed for a storm having a return period of T_r=10 years. Inlet times for all areas are accepted to be 10 minutes. The maximum and minimum allowable velocities in sewers are 4 m/s and 0.5 m/s, respectively. The flow time between two successive manholes can be taken as 2 minutes. Take variable Manning's roughness coefficient with N=0.016. Street slope of BE is 4%. Commercial pipes are available at every 25 mm increments of diameters. Rainfall intensity for the project area can be determined from the following relation, $i=90(T_r/t_c)^{0.5}$, where T_r is the return period in years, t_c is the total time of concentration in minutes and i is the rainfall intensity in mm/hr.

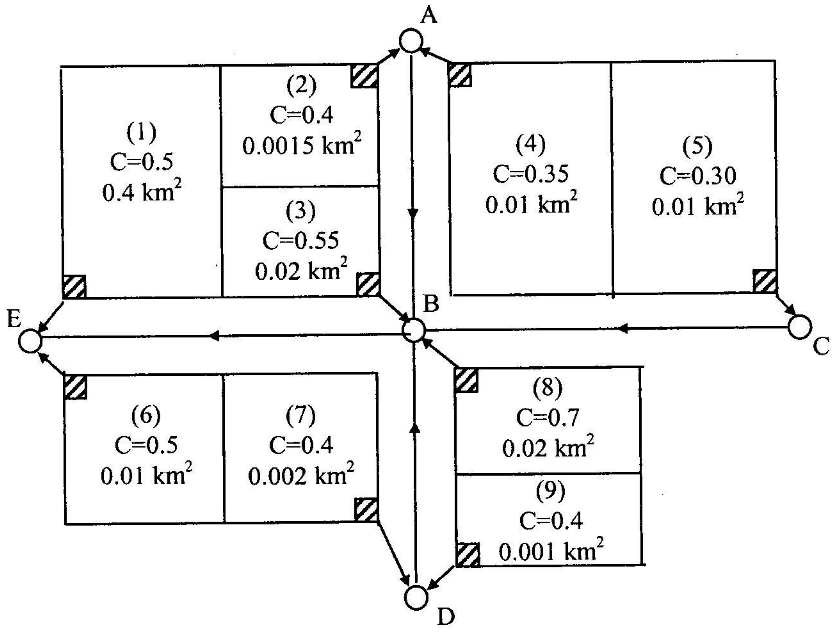

Figure 8.15 Layout for Example 8.2.

Solution:

Different paths contributing to the manhole B should be considered.

a) The direct path from areas 3 and 8:

The inlet times are 10 minutes. Therefore, the rainfall intensity becomes:

$i = 90\sqrt{\frac{10}{10}} = 90$ mm/hr and the storm runoff is

$$Q = \frac{90}{3.6}(0.55 * 0.02 + 0.7 * 0.02) = 0.625 \text{ m}^3/\text{s}.$$

b) Other paths (Areas 2, 3, 4, 5, 7, 8, 9): Total t_c=10+2=12 minutes. So, the rainfall intensity becomes $i = 82.16$ mm/hr.

$$Q = \frac{82.16}{3.6}(0.55 * 0.02 + 0.7 * 0.02 + 0.4 * 0.0015 + 0.35 * 0.01 + 0.4 * 0.002 +$$

$$0.4 * 0.001 + 0.3 * 0.01) = 0.760 \text{ m}^3/\text{s}.$$

Hence, the design discharge is $Q = 0.760$ m^3/s.

Let us determine the required pipe size to carry this discharge using Manning's equation:

$$Q = \frac{A}{N}R^{2/3}\sqrt{S} = \frac{\pi D^2}{4N}\left(\frac{D}{4}\right)^{2/3}\sqrt{S} = \frac{0.312}{N}D^{8/3}\sqrt{S}$$

$0.760 = \frac{0.312}{0.016}(D)^{8/3}\sqrt{0.04}$ or $D = 0.542$ m. Let us choose ϕ550.

Full flow discharge and velocity:

$$Q_{full} = \frac{0.312}{0.016}(0.550)^{8/3}\sqrt{0.04} = 0.792 \text{ m}^3/\text{s}$$

$$u_{full} = \frac{4Q_{full}}{\pi D^2} = \frac{4 * 0.792}{\pi(0.55)^2} = 3.33 \text{ m/s} < 4 \text{ m/s O.K.}$$