Water Supply and Sewerage Network

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Sewer Appurtenances

Following are Some of the important sewer appurtenances:-

- Manholes

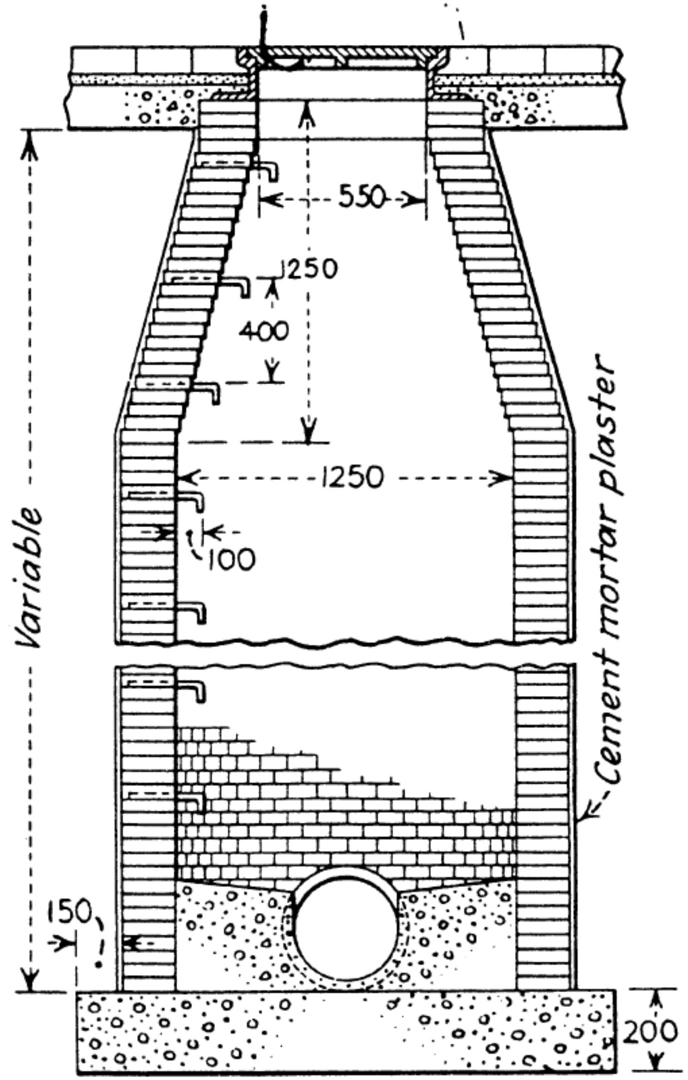
They are used for inspection & cleaning. They placed when:

1. Intervals between manholes: 90-150m (300-500ft.)
2. Change in direction.
3. Change in pipe slope.
4. Change in pipe size.

- For total depth < 4m (12ft) → 250mm (10″) thick brick wall. For any additional 2m depth → additional 125mm thick.

- Concrete walls are often used in Iraq.

- Manholes bottom: Upper surface sloped toward the open channel. Channel depth should be equal to pipe diameter to prevent sewage from spreading over manhole bottom, & odors result. Changes of direction are made in channels.



Precast Concrete Manhole

- Drop manhole, It is a join between submain & a deeper sewer.
It is used when the drop between two sewers ≥ 0.6m (2ft).

- Manhole opening … Cast iron frame & cover 500-600mm (20″-24″).

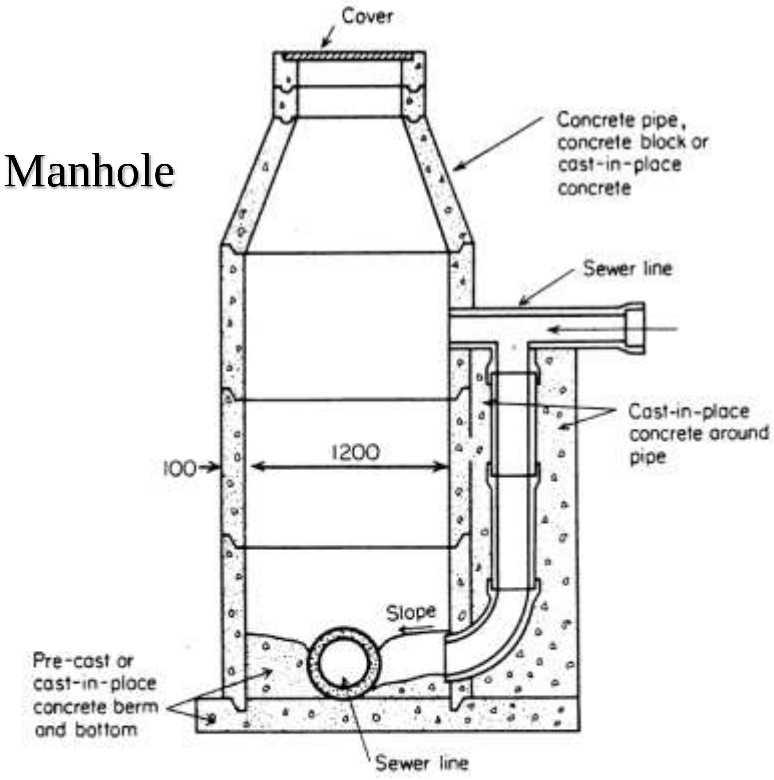
- Manholes in large sewers ≥ 1520mm (60″), These sewers can be entered for inspection & need fewer manholes.

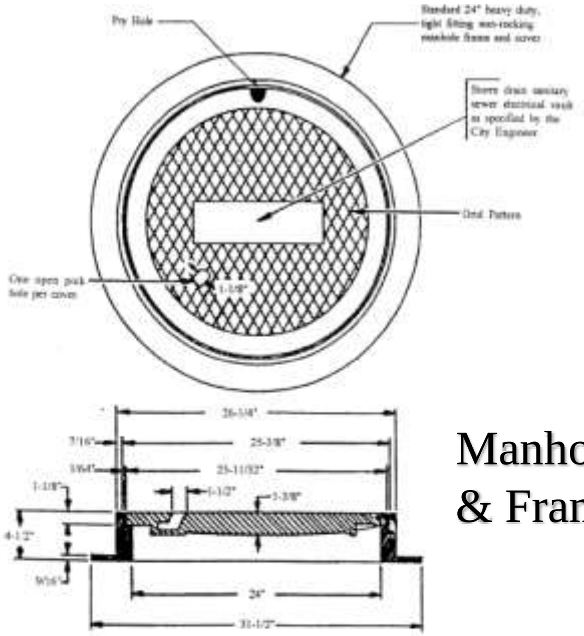
- Manhole cover & frame
For heavy city traffic → 340kg (750Lb)
Light city traffic → 245kg (540Lb)
Suburban traffic → 150-180kg (325-400Lb)
Foot traffic → 70kg (150Lb)
Covers shall be roughened to prevent slipperiness. Perforated covers should not be used for sanitary sewers. Ventilation should be done by stacks, not by openings.

Opening disadvantages: permitting rainwater, sand & grit to enter sewers.

Ladder: steps made of epoxy coated cast iron.

Drop Manhole





Manhole Cover & Frame

➢ Cleanouts

They may be used instead of manholes as an economy measure. They permit flushing the sewer with a fire hose & rods mat also be inserted to clear heavy obstructions. Some cities not permit cleanouts. They may be used at head end of small sewers.

➢ Inlets

They are openings into a storm or combined sewer for entrance of storm runoff. They placed at:

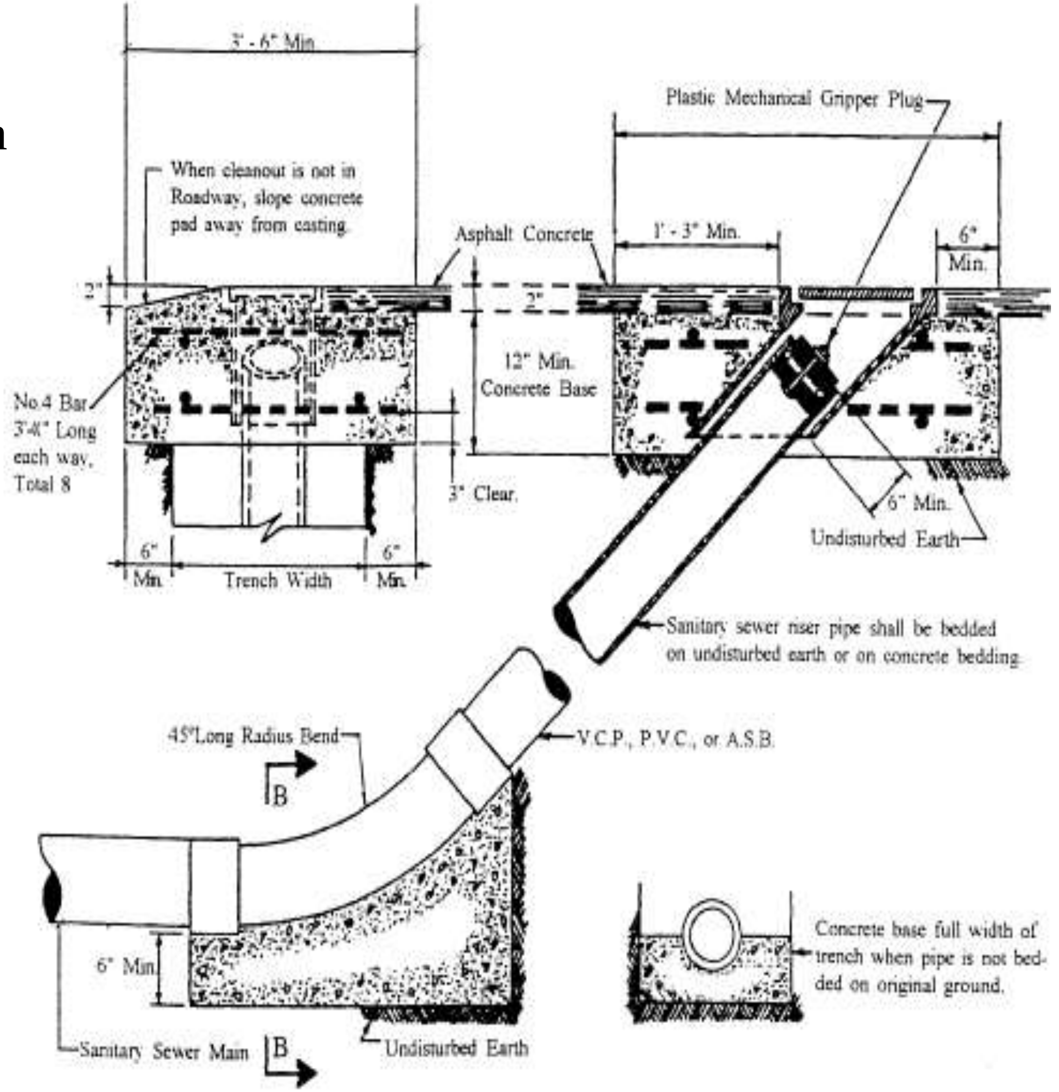
1. Street intersections, they located near the intersection but not in it, why?

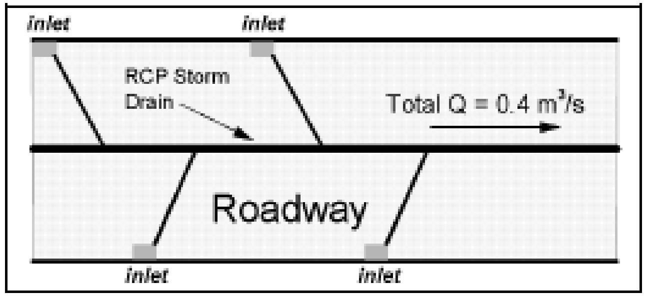
a. Crosswalks will not be flooded.

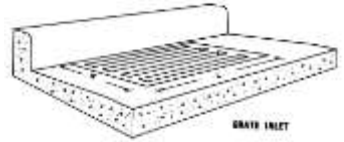
b. Inlets will not be subjected to traffic wear & damage.

2. Midpoints of the blocks for > 150m (500ft) long. Locally ≈ 40m

Inlets connected to a manhole, or through Ys at nearest points.







➢ Catch Basins

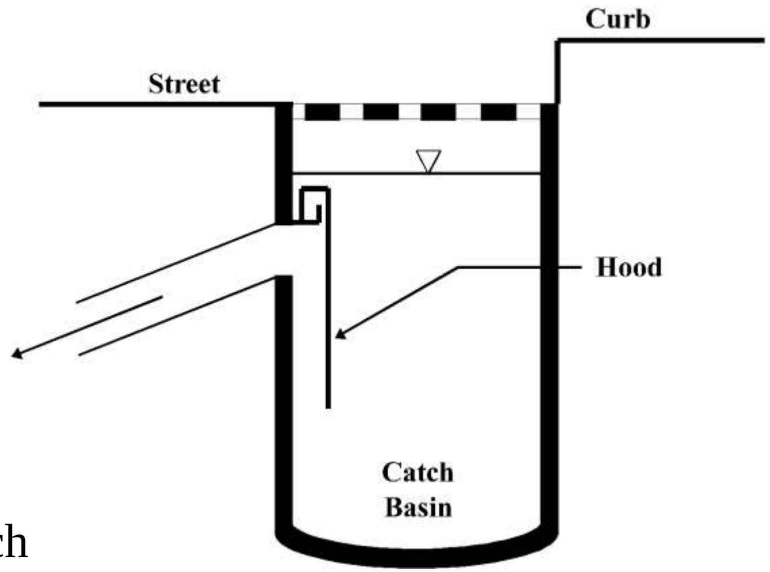
Catch basin is an inlet with a basin which allows debris to settle out. Outlet pipe is trapped in order to prevent escape of odors from sewer & causes retention of floating matter. It is limited in use, why.

Advantages:

Collect sand, grits, & floating objects.

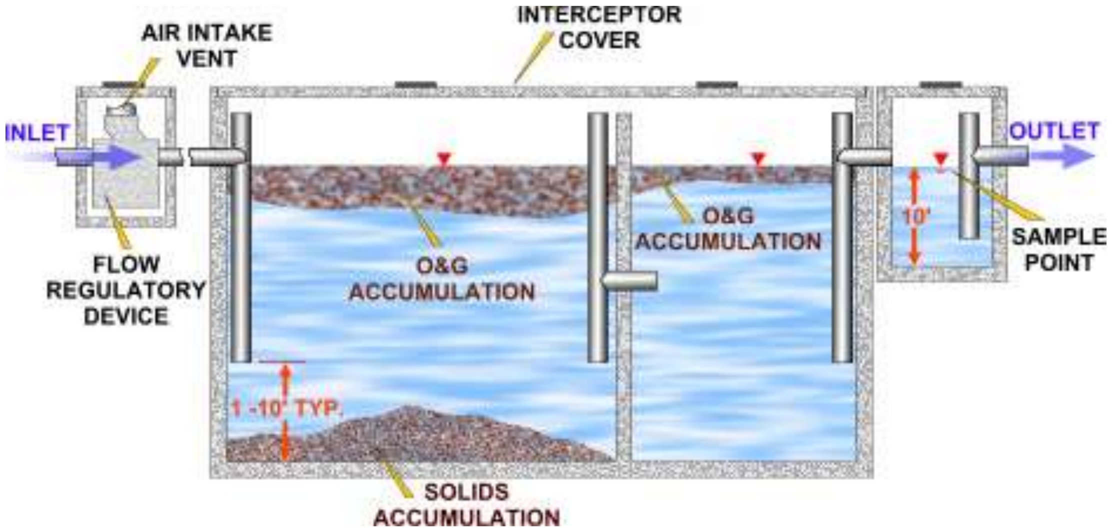
Disadvantages:

1. Produce mosquitoes.
2. Source of odors.
3. Must be cleaned frequently, this is costly.



➢ Grease & Oil Traps

They used after sewers from kitchens, hotels, garages & restaurants to trap grease which tends to accumulate on sewer walls & cause clogging.



Sewer System Networks

Wastewater is a complex mixture of natural inorganic and organic material mixed with man-made substances. It contains everything discharged to the sewer, including material washed from roads and roofs, and of course where the sewer is damaged groundwater will also gain entry. This complex mixture ends up at the wastewater treatment plant for purification. The composition of sewage changes on an hourly, daily and seasonal basis, with the average dependents on per capita water usage, infiltration, surface runoff as well as local habits.

Sewage (foul) is 99.9% water with the material that requires to be removed amounting to just 0.1% by volume. This solid material is a mixture of food particles, grease, oils, soap, salts, metals, detergents, plastic, sand and grit

There are two basic types of sewerage systems, combined and separate. Sewerage being the network of pipes that collects and transfers the sewage to the wastewater treatment plant. Sewer pipes are laid 1-3 m below ground. Normally laid beneath one side of the road, the precise depth of the sewer pipe depends on the gradient, geology and road surface loading. Pipe diameters vary in the same way as water mains with individual houses served by 150 mm diameter plastic pipes that feed into pipes that get progressively larger as the number of connections and area served increases. Sewer pipes up to 3 m in diameter are common within towns.

Sewer system networks can be classified as:

1. Separate system

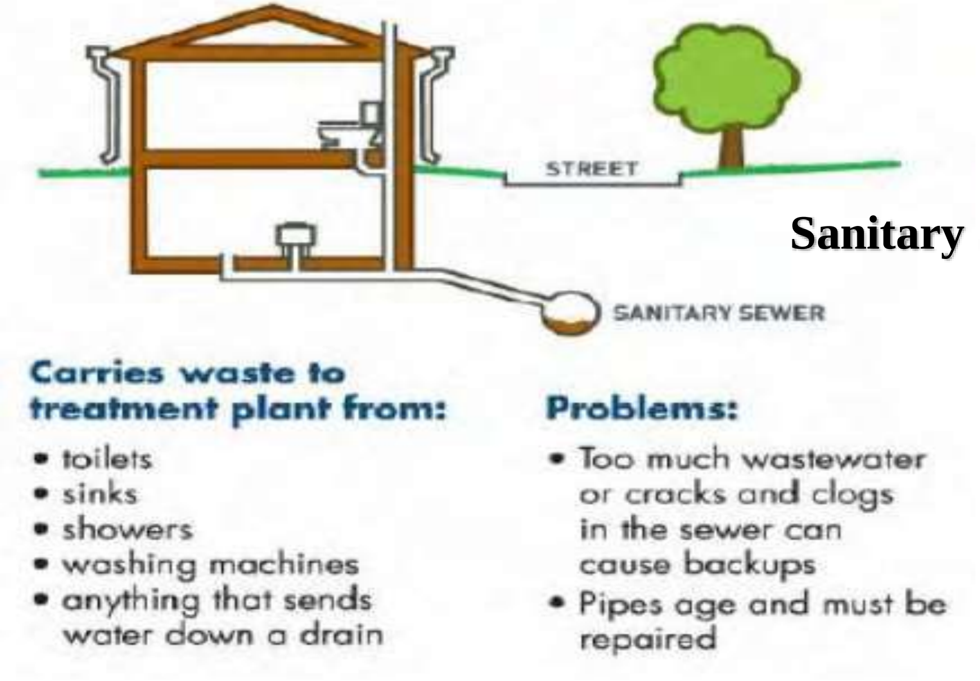
- <u>Sanitary sewer</u>: It carries sanitary flow only, from toilet, kitchen & bathroom areas.
- <u>Storm sewer</u>: It carries storm runoff only. Rainfall washes any material deposited on paved areas, such as roads, into the nearest drain.

2. Combined system

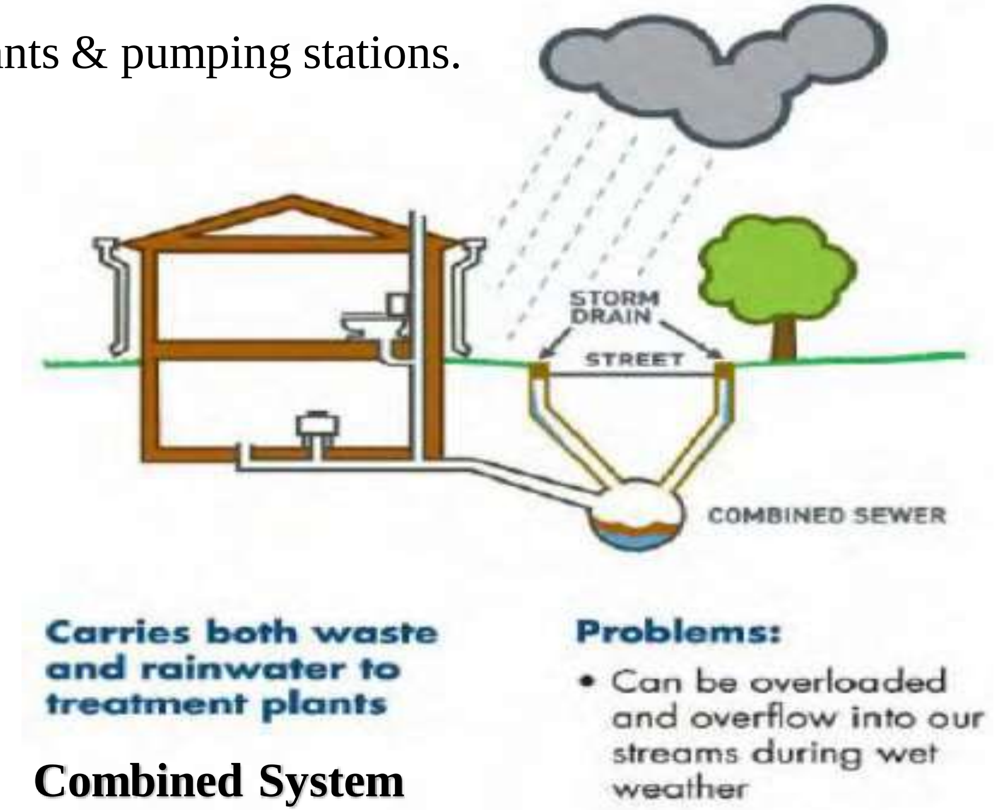
It carries sanitary & storm flows. Except where rainfall is very light, storm flows will tend to be very much greater than foul flows. This leads to two problems.

First for most of the time, sewers will carry only relatively small foul flows & there may be problem with deposition of solids.

Secondly, there will be a need to cope with large storm flows at treatment plants & pumping stations.



Sanitary Sewer



Combined System

Pipe Materials

A circular sewer is the most efficient shape when the flow is between full & half full.

1. Plastic pipes (PVC, uPVC, & GRP)

They are resisted chemical attack, light weight & cheap. Their expected designed period is > 50years.

They produced in diameters between 110 – 1200mm.

In sizes above 1m in diameter there may be no economic alternative to Glass Reinforced Plastic pipes (GRP) where the ground is laden with sulfates & chlorides.

2. Cast Iron pipes

They used in the following conditions:

a) High crushing strength is required.

b) Inverted siphons & pumping mains due to pressure.

c) When the pipe is above the ground on supports.

3. Concrete pipes

They were cast in situ for large sizes & precast for small sizes.

4. Asbestos cement pipes

Amount of Storm Sewage

The first step in the design of sewers is the estimation of the flow they will receive. The primary source of storm flow is rainfall—the sources of rainfall data and descriptions of rain gauges. *The Rational Method* is a used technique for estimating storm flow, and it is based upon the use of rainfall data—either implicitly or explicitly. The rational method relates the flow to the rainfall intensity, the tributary area, and a coefficient representing the combined effects of ponding, percolation, and evaporation. The total volume which falls upon an area, A, per unit time under a rainfall of intensity, i, is:

$$Q_{Prec} = i * A$$

The actual amount which appears as runoff may then be calculated from :

$$\boxed{Q = C * i * A}$$

in which C is the runoff coefficient, i.e., the fraction of the incident precipitation which appears as surface flow.

Runoff Coefficient of Different Types of Area and Surface

Description of area	C
Business	
Downtown area	0.70–0.95
Neighborhood area	0.50–0.70
Residential (urban)	
Single family area	0.30–0.50
Multi-units, detached	0.40–0.60
Multi-units, attached	0.60–0.75
Residential (suburban)	0.25–0.40
Apartment areas	0.50–0.70
Industrial	
Light	0.50–0.80
Heavy	0.60–0.90
Parks, cemeteries	0.10–0.25
Playgrounds	0.20–0.35
Railroad yards	0.20–0.40
Unimproved areas	0.10–0.30

Type of surface	C
Watertight roofs	0.70–0.95
Asphaltic cement streets	0.85–0.90
Portland cement streets	0.80–0.95
Paved driveways and walks	0.75–0.85
Gravel driveways and walks	0.15–0.30
Lawns, sandy soil	
2% slope	0.05–0.10
2–7% slope	0.10–0.15
> 7% slope	0.15–0.20
Lawns, heavy soil	
2% slope	0.13–0.17
2–7% slope	0.18–0.22
> 7% slope	0.25–0.35

Runoff Coefficient

Average values of runoff coefficient C are commonly used for various surfaces and areas. For example, an effective runoff coefficient for a composite drainage area can be obtained by estimating the percentage of the total covered by roofs, paving, lawns, etc., multiplying each fraction by the appropriate coefficient, and then summing the products.

Example:- Determine the runoff coefficient for an area of 0.20 km^2. A 3000 m^2 is covered by buildings, 5000 m^2 by paved driveways and walks, and 2000 m^2 by Portland cement streets. The remaining area is flat, with heavy soil, covered by a grass lawn at 2% slope.

SOLUTION From Table obtain values for C for each area. Calculate the percentage of land area in each category.

$$\text{Roofs} - C \times A/A_{\text{total}} = 0.70 \text{ to } 0.95 \times \frac{3000}{200{,}000}$$

$$= 0.01050 \text{ to } 0.01425$$

$$\text{Driveways and walks} = 0.75 \text{ to } 0.85 \times \frac{5000}{200{,}000}$$

$$= 0.01875 \text{ to } 0.02125$$

$$\text{Street} = 0.80 \text{ to } 0.95 \times \frac{2000}{200{,}000}$$

$$= 0.0080 \text{ to } 0.0095$$

$$\text{Lawn} = 0.13 \text{ to } 0.17 \times \frac{190{,}000}{200{,}000}$$

$$= 0.1235 \text{ to } 0.1615$$

$$C_{\text{avg}} = 0.16 \text{ to } 0.21$$

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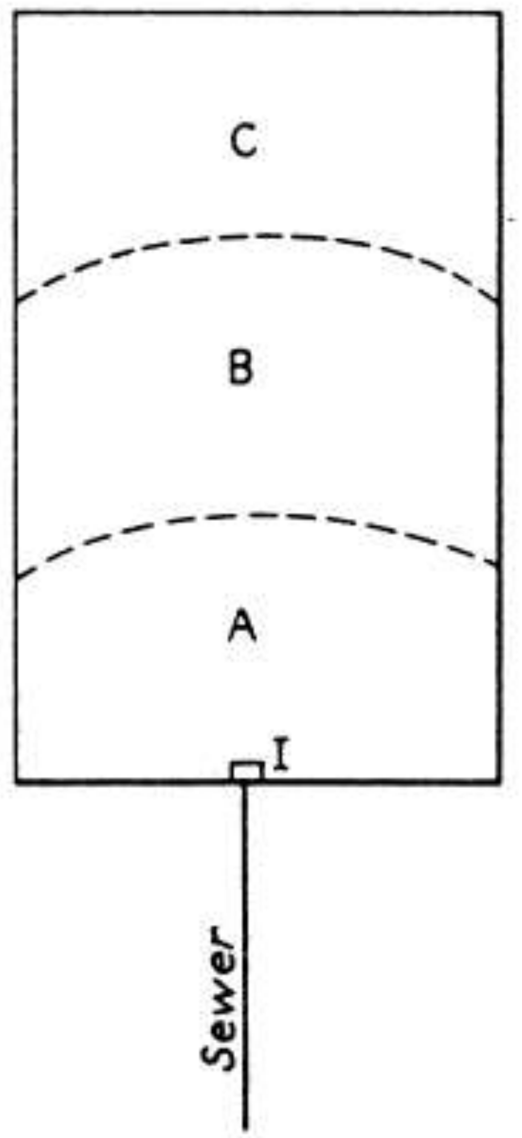
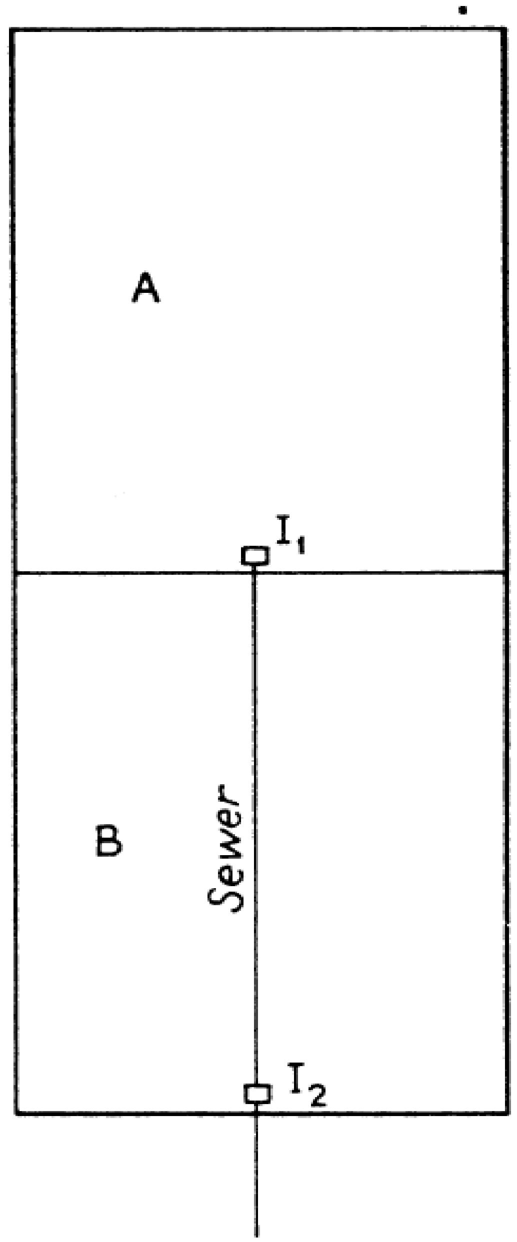
Time of Concentration

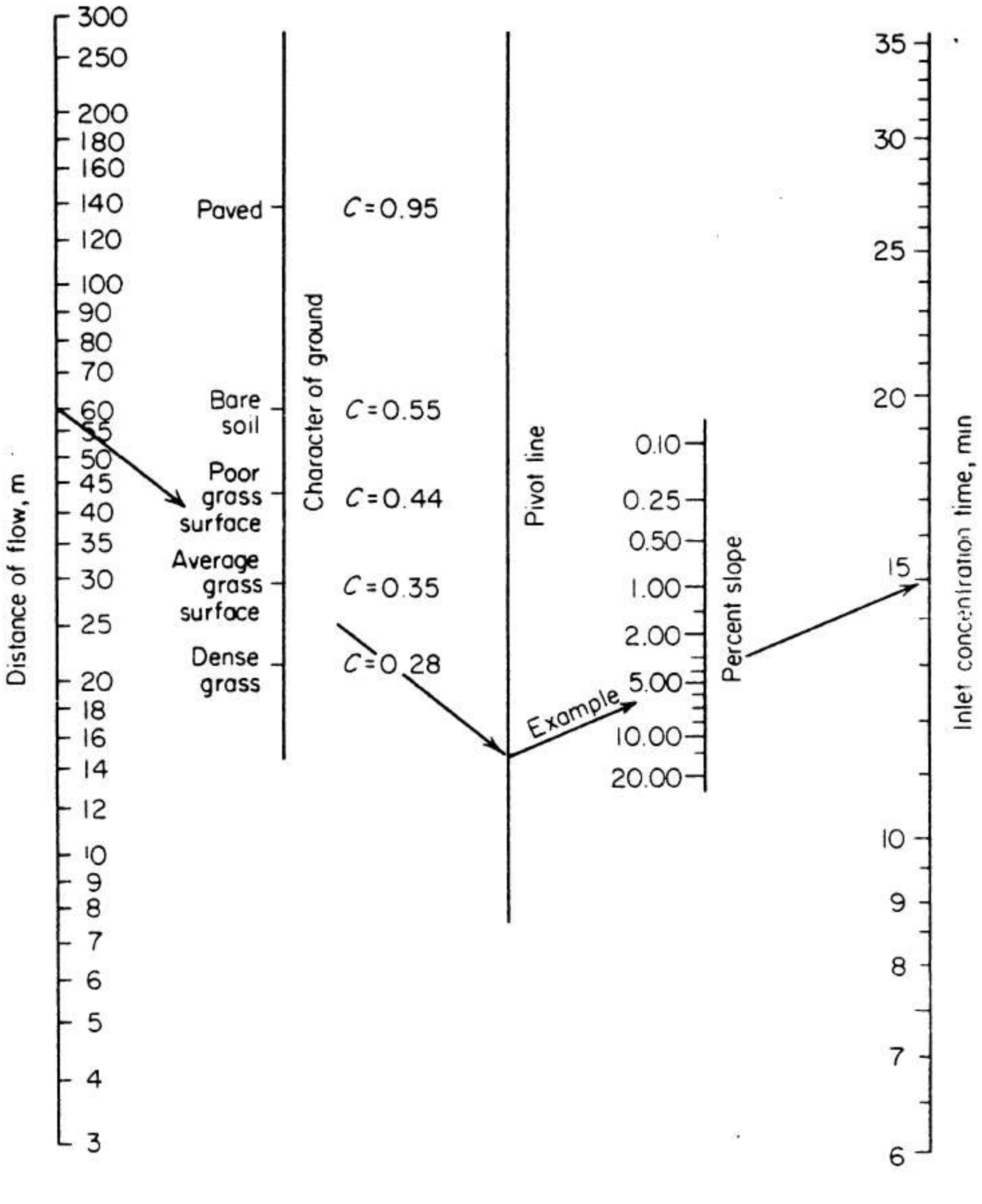
When a rainfall event occurs upon an area served by a storm sewer, the runoff will flow over roofs, yards, and pavement to the gutter and eventually to the sewer inlet. This travel will require measurable time and, while the areas immediately adjacent to the inlet will contribute flow quickly, areas which are distant will not. The maximum rate of runoff for a given rainfall intensity will occur when the rainfall has continued for a period sufficient to permit flow to reach the inlet from the most remote point of the drainage area. The time required for the maximum runoff rate to develop is called the time of concentration. The figure illustrates a rectangular watershed discharging into an inlet I. It is assumed that it takes 5 min for water to run from the boundary of one zone to the next, or to the inlet in zone A. Only zone A will contribute flow after 5 min, only A and B after 10 min, and all three after 15 min or more. If the rain lasted only 10 min, the water arriving at I from zone C during the period 10 to 15 min after beginning would be offset by the decreasing runoff from zone A.



The same logic may be applied to the watershed of the Figure below. The water from A enters the sewer at I_1, and that from B at I_2 . The time of concentration at I_2 is either the time of concentration for area B or the inlet time plus the time of flow from I_1 to I_2 , whichever is greater. The inlet time is the time of concentration at I_1, while the time of flow is a function of the velocity in line I_1 - I_2 and its length.

The time of concentration for each sewer line is determined in a similar fashion. At each point the inlet time to the sewer most remote in time is added to the time of flow in the sewer. When branches join, the longest time of concentration for any branch is used as the basis for subsequent design. The time of concentration will depend largely upon the slope of the ground surface and the resulting slope of the sewer, which generally parallels the ground surface.




Distance of flow, m
300
250
200
180
160
140
120
100
90
80
70
60
55
50
45
40
35
30
25
20
18
16
14
12
10
9
8
7
6
5
4
3
Paved
Bare soil
Poor grass surface
Average grass surface
Dense grass
Character of ground
C = 0.95
C = 0.55
C = 0.44
C = 0.35
C = 0.28
Pivot line
Example
0.10
0.25
0.50
1.00
2.00
5.00
10.00
20.00
Percent slope
35
30
25
20
15
10
9
8
7
6
Inlet concentration time, min

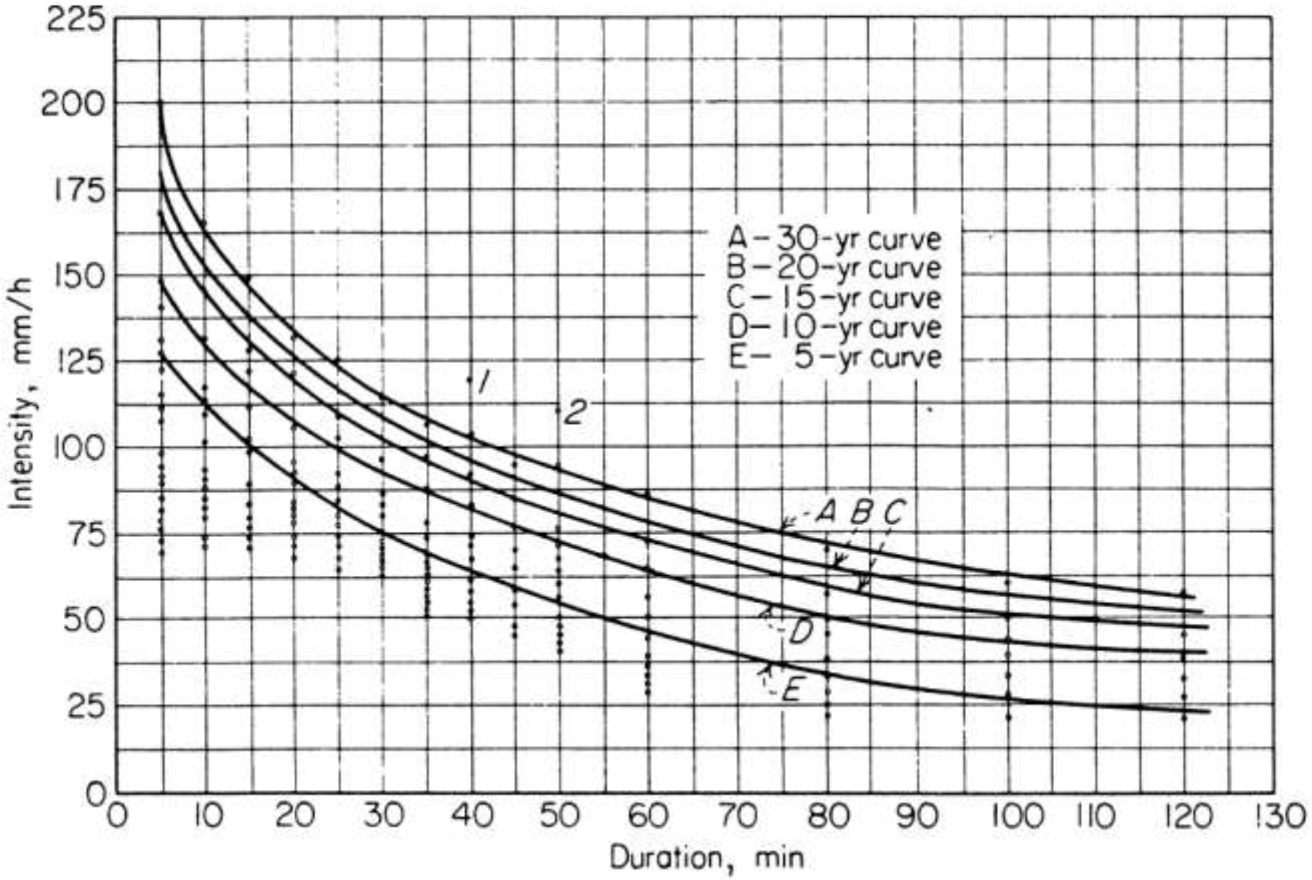
Intensity Curves and Formulas

The data obtained at rainfall gauging stations can be used to develop intensity-duration-frequency curves such as those shown in Figure below. Curve A represents the rainfall intensity-duration which will be equaled or exceeded once in 30 years on average. The other curves present the intensities to be expected, on average, once in 20, 15, 10, or 5 years. Wide variations in point rainfall occur in relatively short distances, hence data from two stations which are separated by a reasonable distance may be combined to obtain what is, effectively, a longer period of record.

The equations of intensity-duration curves are often more convenient. The equations are typically of the form:

$$i = \frac{A}{t + B}$$

in which i is the precipitation rate (usually per hour), t is the duration (usually in minutes), and A and B are constants.



Precipitation formulas for various parts of the United States (i, mm/h; t, min)

Frequency, years	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
2	$i = \frac{5230}{t + 30}$	$i = \frac{3550}{t + 21}$	$i = \frac{2590}{t + 17}$	$i = \frac{1780}{t + 13}$	$i = \frac{1780}{t + 16}$	$i = \frac{1730}{t + 14}$	$i = \frac{810}{t + 11}$
5	$i = \frac{6270}{t + 29}$	$i = \frac{4830}{t + 25}$	$i = \frac{3330}{t + 19}$	$i = \frac{2460}{t + 16}$	$i = \frac{2060}{t + 13}$	$i = \frac{1900}{t + 12}$	$i = \frac{1220}{t + 12}$
10	$i = \frac{7620}{t + 36}$	$i = \frac{5840}{t + 29}$	$i = \frac{4320}{t + 23}$	$i = \frac{2820}{t + 16}$	$i = \frac{2820}{t + 17}$	$i = \frac{3100}{t + 23}$	$i = \frac{1520}{t + 13}$
25	$i = \frac{8300}{t + 33}$	$i = \frac{6600}{t + 32}$	$i = \frac{5840}{t + 30}$	$i = \frac{4320}{t + 27}$	$i = \frac{3300}{t + 17}$	$i = \frac{3940}{t + 26}$	$i = \frac{1700}{t + 10}$
50	$i = \frac{8000}{t + 28}$	$i = \frac{8890}{t + 38}$	$i = \frac{6350}{t + 27}$	$i = \frac{4750}{t + 24}$	$i = \frac{4750}{t + 25}$	$i = \frac{4060}{t + 21}$	$i = \frac{1650}{t + 8}$
100	$i = \frac{9320}{t + 33}$	$i = \frac{9520}{t + 36}$	$i = \frac{7370}{t + 31}$	$i = \frac{5590}{t + 28}$	$i = \frac{6100}{t + 29}$	$i = \frac{5330}{t + 26}$	$i = \frac{1960}{t + 10}$

Example A sewer line drains a single-family residential area with $C = 0.35$. The distance of flow from the most remote point is 60 m over ordinary grass with a slope of 4 percent. The area drained is 100,000 m^2 and the intensity-duration formula is:

$$i = \frac{5230}{t + 30} \text{ mm/h}$$

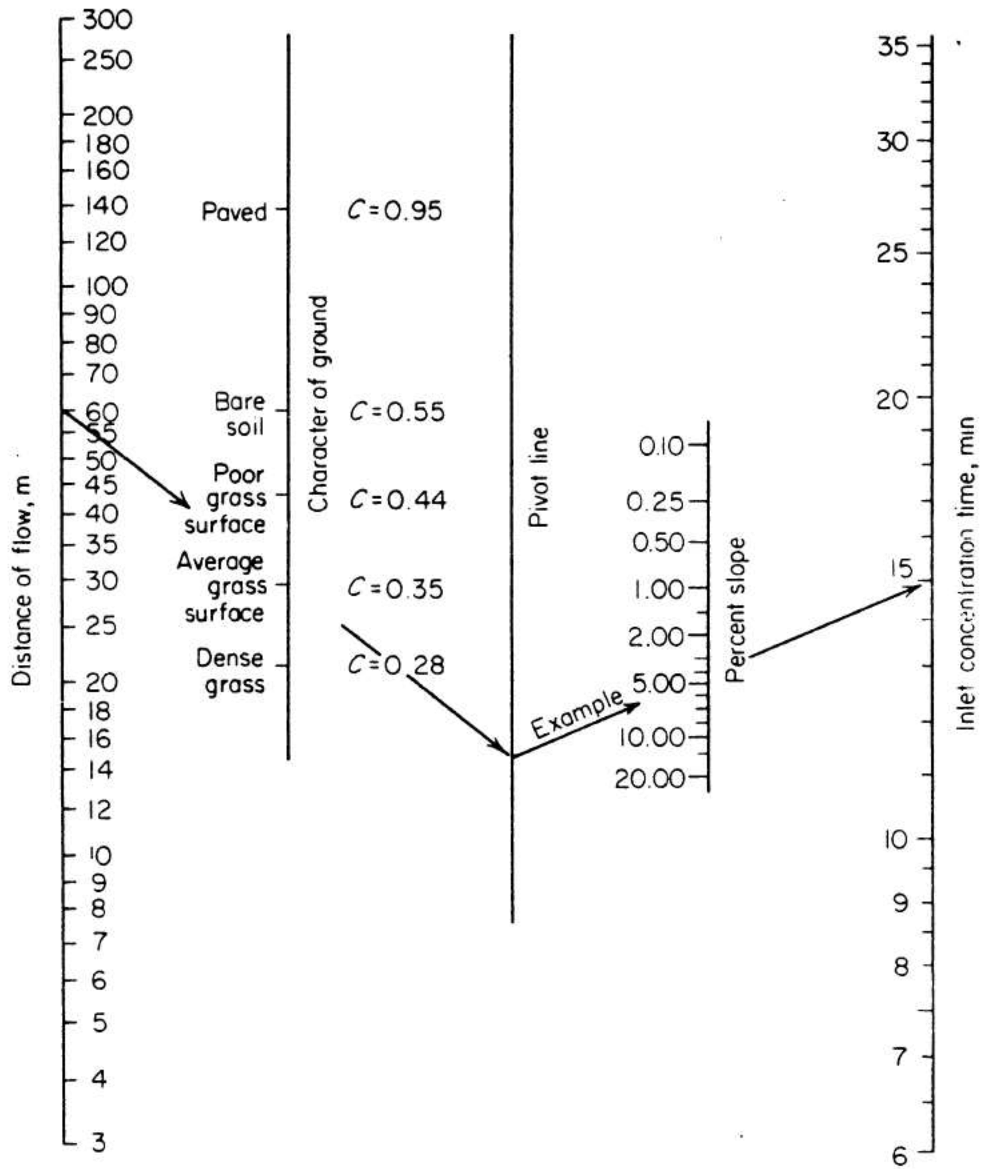
From Figure the time of concentration is found to be 15 min, and,

$$i = \frac{5230}{45} = 116 \text{ mm/h}$$

Substituting in the rational formula,

$$\begin{aligned} Q &= CiA \\ &= 0.35 \times 0.116 \text{ m/h} \times 100{,}000 \text{ m}^2 \\ &= 4060 \text{ m}^3\text{/h} \\ &= 1.13 \text{ m}^3\text{/s} \end{aligned}$$

The engineer must select the appropriate return period for the design storm. This establishes the frequency with which the collection system will be overloaded, on average. It is too expensive to design a sewer to carry the largest flow which could ever occur, but, on the other hand, flood damage to property should be avoided when possible. A formal calculation of minimum expected cost is seldom made in storm drainage design for urban areas, but consideration of these costs is implicit in selection of 2- to 5-year frequencies for residential areas and 10- to 15-year frequencies for business and commercial districts.



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