6.4 Design and construction of sewers

- Estimation of quantity of waste water
- Sewerage system and types
- Design criteria of sewers
- Shapes of sewers
- Design of sewers for separate and combined systems
- Construction of sewers and sewer appurtenances

Estimation of quantity of waste water

I. Sanitary sewage / dry weather flow (DWF) :

Flow available at non rainfall period, normal flow

II. Storm water or wet weather flow (WWF) :

Additional Flow that occur during rainfall.

Therefore ,

Total Sewage = DWF + WWF

DWF Calculation

DWF = Return factor x population x rate of W/S x Peak factor

- For Nepal, Return factor is taken as 80%

S.No.	Contributory Population of Sewer Stretch	Peak Factor
1	Up to 20,000	3.00
2	20,000 – 50,000	2.50
3	50.000 – 750,000	2.25
4	More than 750,000	2.00

Peak factors to be considered for design of sewer pipes

Types of sewer	Peak factors
Domestic Sewer	6
Lateral Sewer	2-6
Branch Sewer	3
Submain Sewer	3
Main Sewer	2.5
Outfall sewer	2

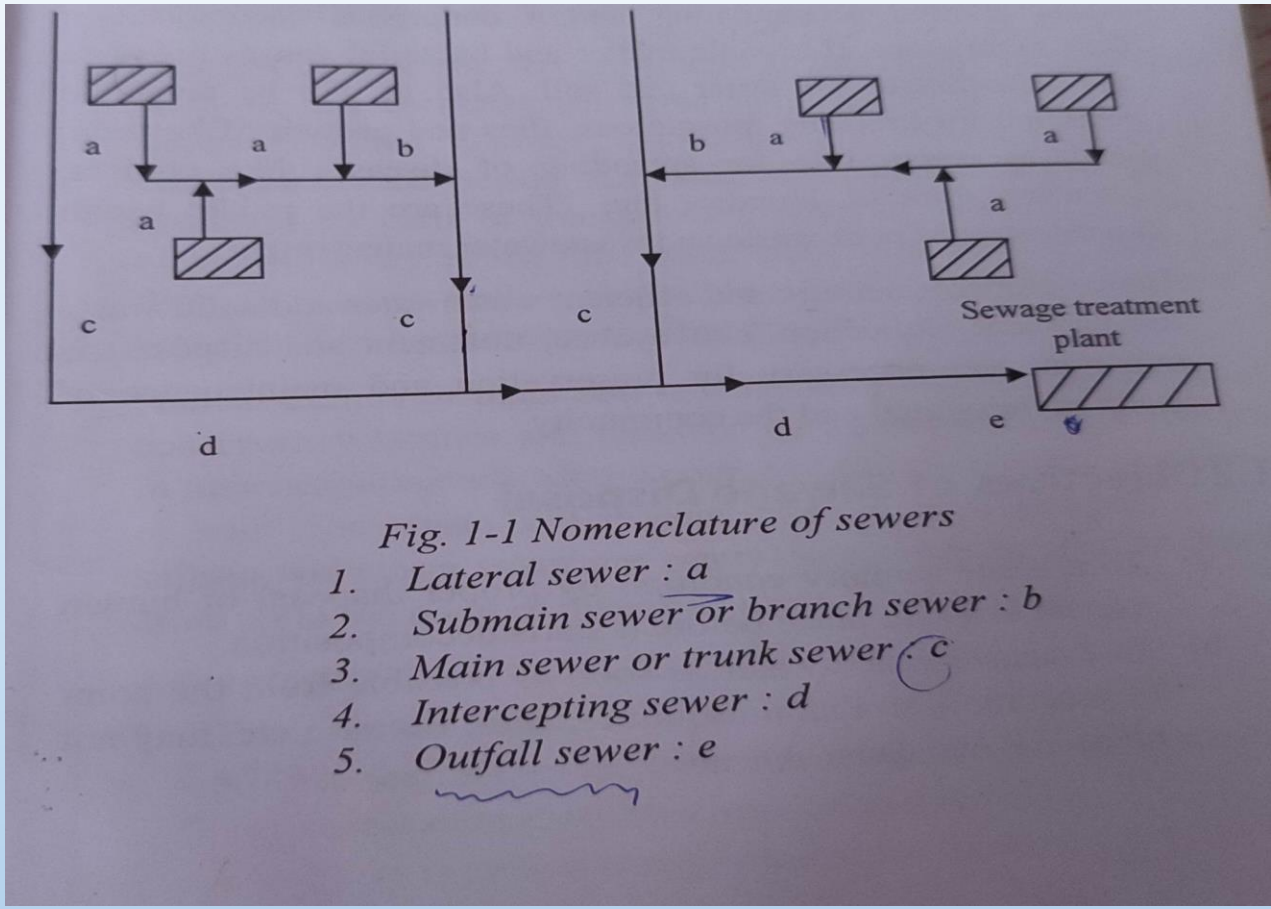


Fig. 1-1 Nomenclature of sewers

1. *Lateral sewer : a*
2. *Submain sewer or branch sewer : b*
3. *Main sewer or trunk sewer : c*
4. *Intercepting sewer : d*
5. *Outfall sewer : e*

Note: Peak flow is considered for design of sewer.

Storm Sewage Calculations

Two methods: Rational and empirical

- **Rational Method**

$Q = CIA/360$

Where, Q = WW

C = run off coe

I = intensity o

A = Area of ca

$$C = \frac{C1\ A1+C2\ A2+\cdots}{A1+A2+\cdots}$$

Intensity of rainfall:

- Intensity is calculated using the

uency curve

al formula

formula for

for 5 to 20

for 20 to 100

minutes

A catchment of area 200 ha has a runoff coefficient 0.5. A storm of duration larger than the time of concentration of the catchment and of intensity 3.6 cm/h causes a peak discharge of

A $5\ m^3/s$

B $10\ m^3/s$

C $100\ m^3/s$

D $360\ m^3/s$

Storm Sewage Calculations……..

Note: Rational formula is limited to catchment area up to 400 hectares.

Empirical methods

- Burkli – Zeiglar formula

$$Q = (CIA/141.58) * \sqrt[4]{\frac{S}{A}}$$

- Fuller's formula

$$Q = \frac{C \,.\, M\text{^}0.8}{13.23}$$

(Where, S- Slope of the area in meter per thousand meter,

M- drainage area in sq. km.,

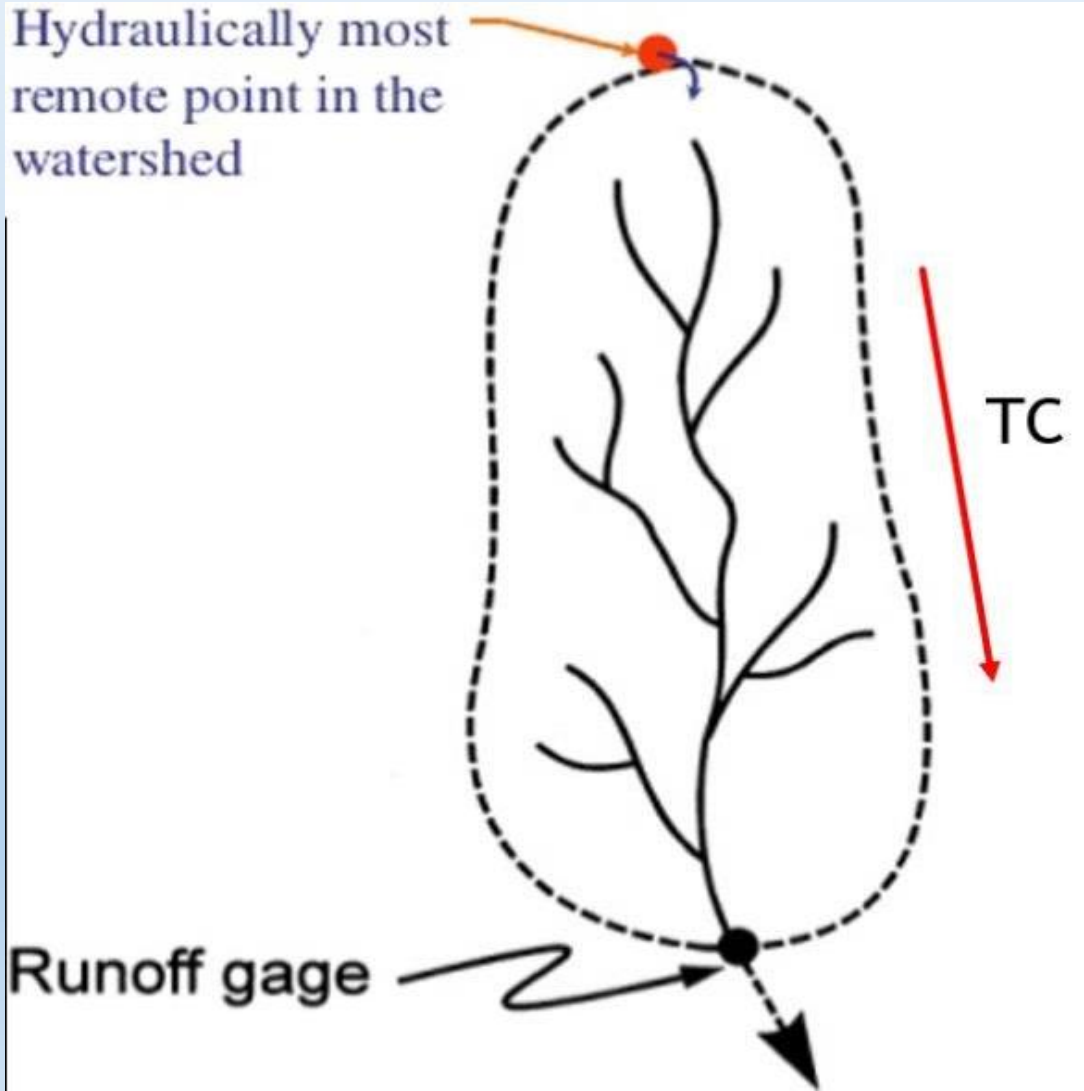
A – drainage area in hectare)

Time of concentration

- Tc = Te + Tf

Where Te is time **of entry**

- Tf = Time of travel or flow



Q. Time of concentration is the

1. time of maximum possible precipitation that may concentrate and fall over a given basin
2. time taken by the rain water to flow to an existing defined drain in a basin.
3. time for which the rain water remains concentrated on the basin
4. maximum time taken by the rain water to reach the outlet of the basin.

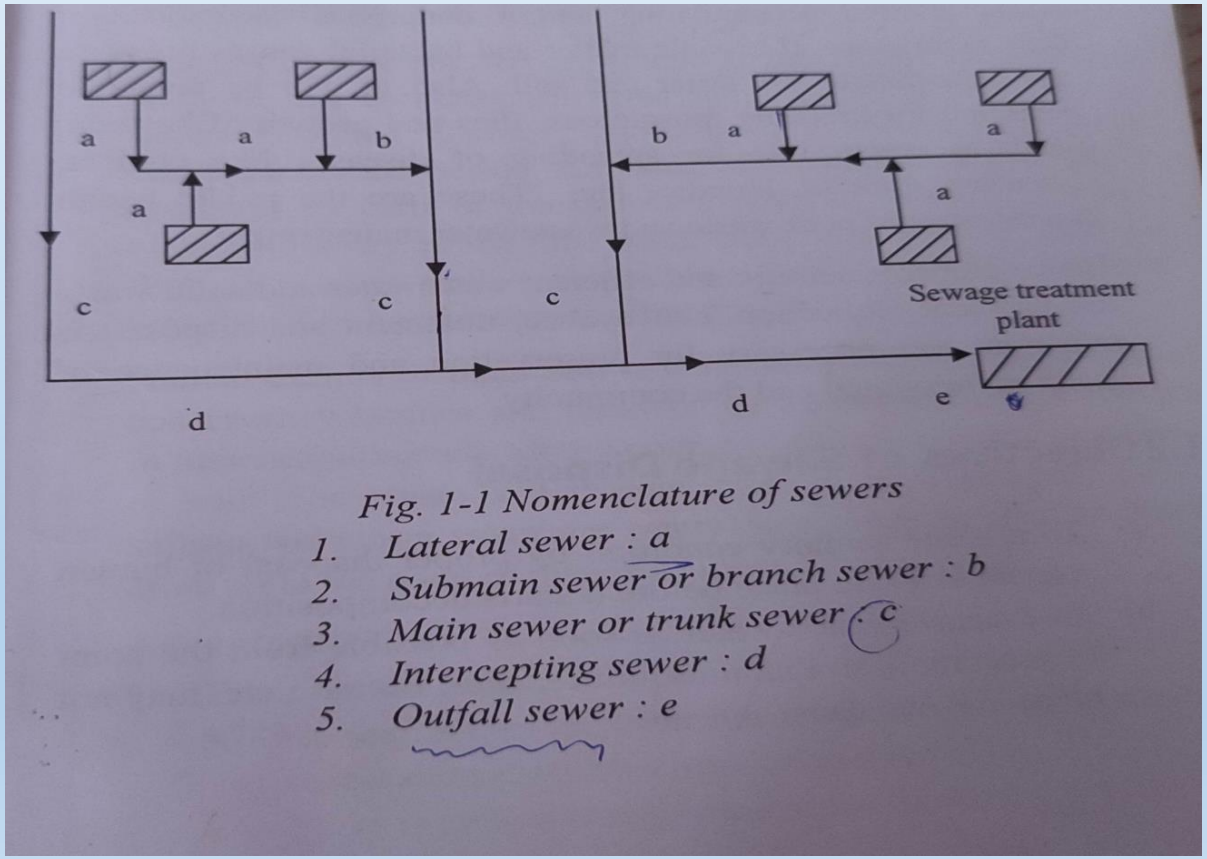
Sewerage System

- The entire system or network of sewers for collecting and delivering sewage to a disposal point is called sewerage system.
- Types:

I. Separate system

II. Partially separate

III. Combined system



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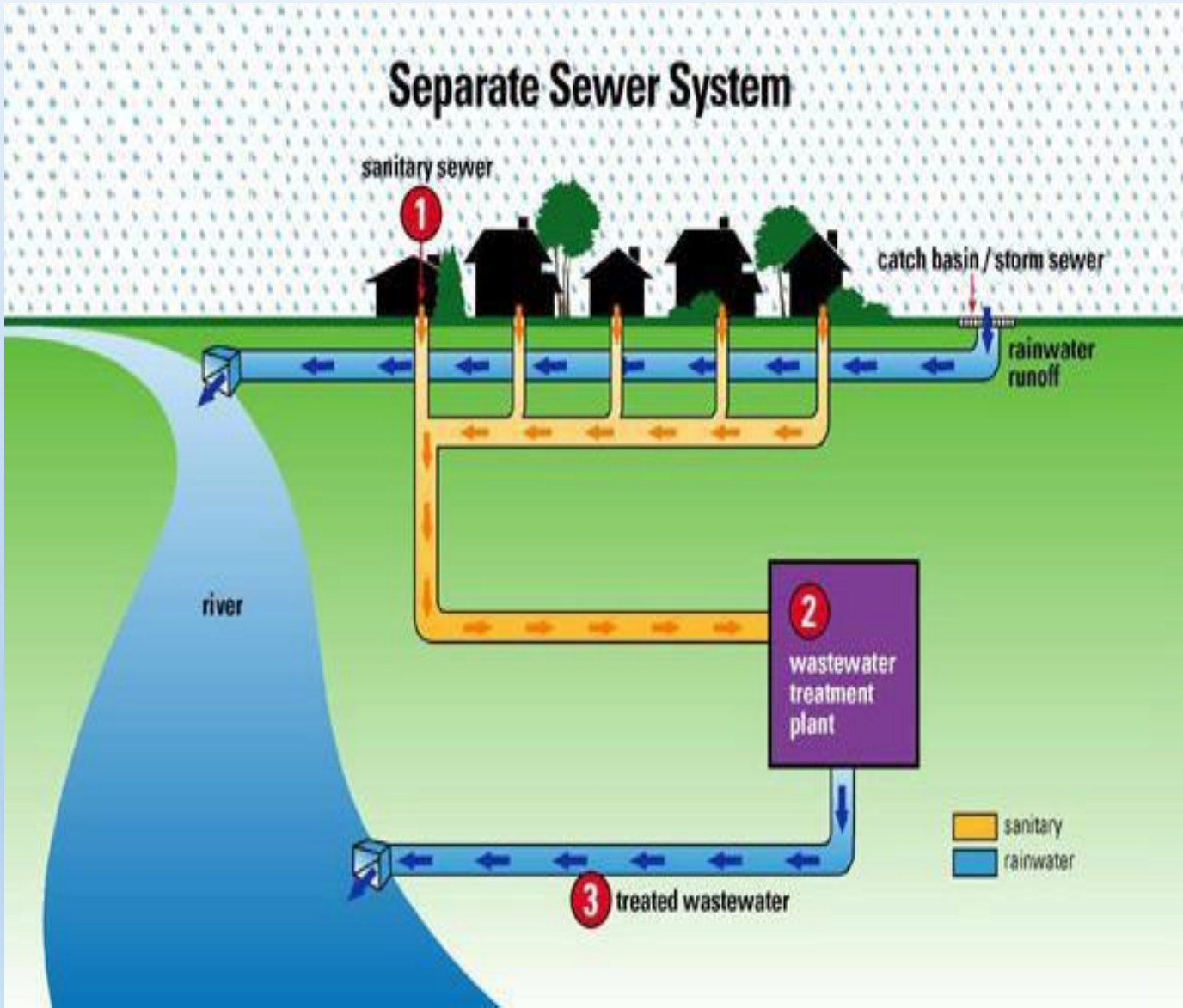
Sewerage System

1. Separate System

- Two different pipes for sewage and storm water.



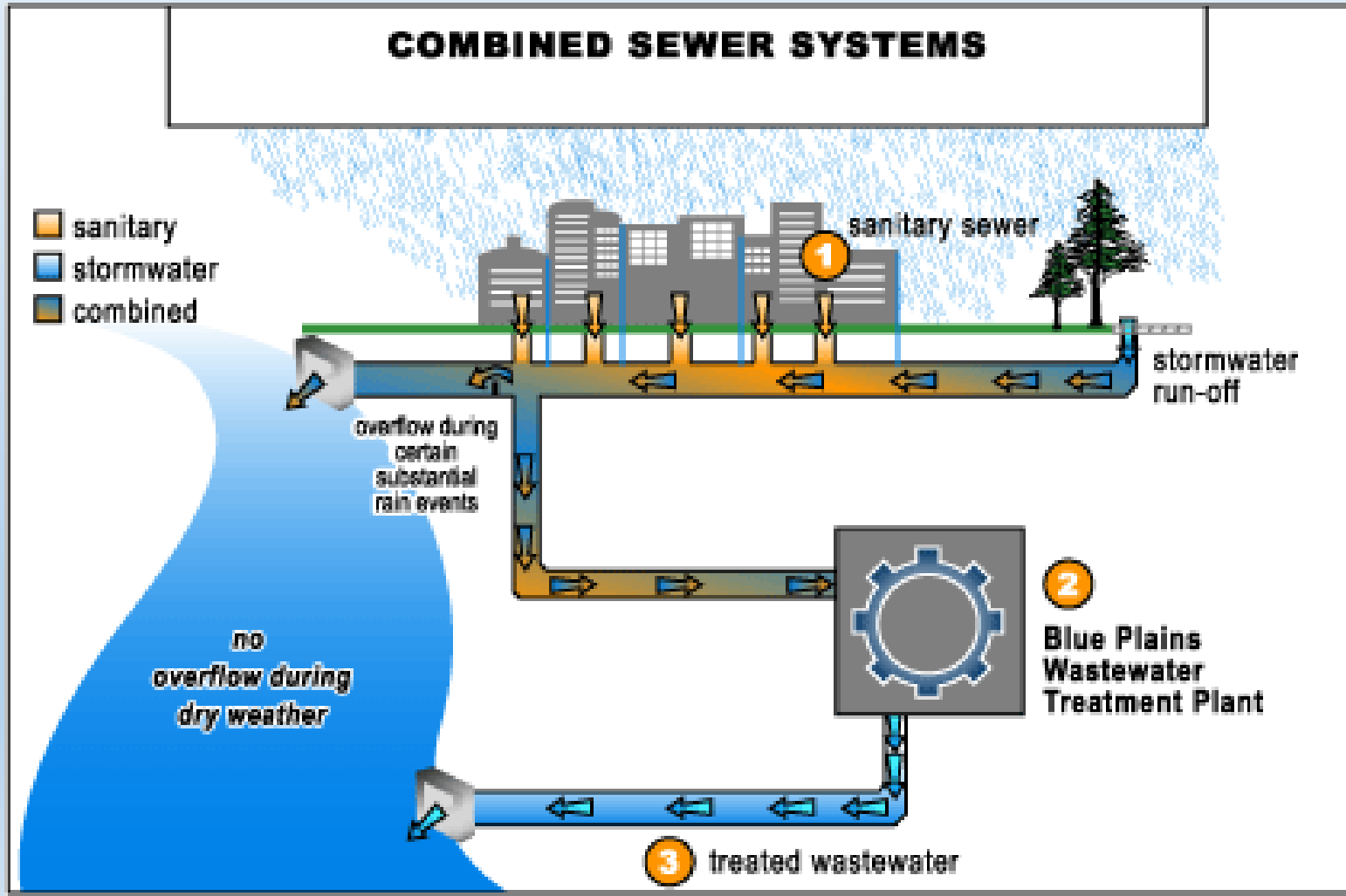
Separate system

Advantages	Disadvantages
I. Storm water is not polluted II. Uniform characteristics of sewage III. Economical in treatment due to less quantity of sewage IV. No risk of overflow of sanitary sewage etc..	I. Maintenance cost is high due to two set of pipes and difficulty in laying of pipe in in narrow streets II. Chances of blockade and difficult to clean III. Uneasy in house plumbing due to two sets of pipes

Sewerage System

2. Combined System

- Single pipe or system is used.

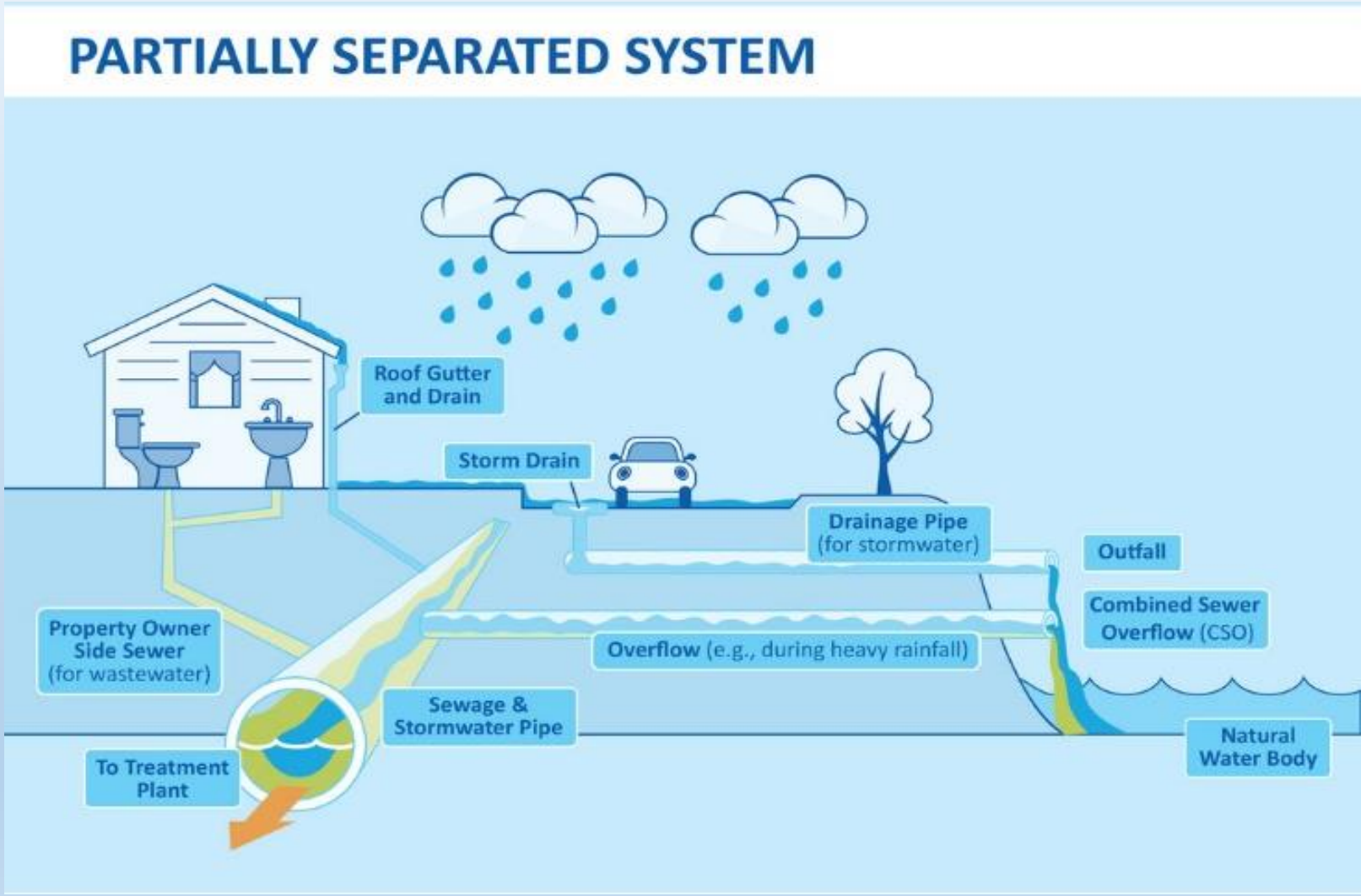


Combined system

Advantages	Disadvantages
I. Easy house plumbing II. No chances of choking due to large size of sewer and availability of storm sewage III. Laying of pipe is easy in congested area IV. Strength of sewage is reduced making it economical to treatment	I. Rain water gets polluted risk of overflow during heavy rainfall. II. Uneconomical if plumbing required due to ,large quantity of sewage III. Risk of entry of stream sewage to sanitary sewage during heavy rain IV. High initial cost due to more depth of laying

Sewerage System

- Partially Separate System



Partially Separate system

Advantages	Disadvantages
• It combines the advantages of both the combined system and separate system. • The entry of stormwater prevents the silting of the sewer. • The sewers are of reasonable size. • The problem of disposing stormwater from houses is simplified.	• The velocity of flow is low in dry weather. • There is a possibility of overflow. • The entry of stormwater in the sewer may increase the load on the pumping and treatment unit. • If the diversion of stormwater is not done at a proper time, then it may create unnecessary troubles.

Design criteria of Sewers……

- Amount of liquid in sewage= 99.9 %
- S.P gravity =nearly one(1.001)
- 25 to 30 yrs. design period (30 yrs preferred)
- Min $velocity\ of\ flow = self\ cleansing\ velocity$ given by Camp Shield formula

- $Vmin = \sqrt{8k(s-1)gd/f}$
- Where,
- d= size of particle,
- S= 2.65 for inorganic & 1.2 for organic sediments.
- f = coefficient of friction = 0.03
- K constant depends upon characteristics of particle = 0.04 for grit and 0.8 for sticky materials

Design criteria of Sewers……

Self cleansing velocity:

Self cleansing velocity could not be maintained due to inability in determining k and friction factor f, so certain criteria like sewer size etc. are considered for finding limiting velocity.

Diameter	Velocity (m/s)
15cm-25 30cm -60 cm >60cm	1.0 m/s 0.7 m/s 0.6 m/s

Note: Minimum self cleansing velocity = 0.6 m/s

Maximum self cleansing velocity = 3 m/s

Design criteria of Sewers …..

- Sewer size should not less than 15cm and available sizes in market are 15, 20, 30,35, 40 ….cm up to 1.6 m (according to DWSSM standards)
- Gradient is selected as per site condition
- Sewer are designed to flow 2/3 full at peak or maximum discharge.
- Sewer are designed to ensure self-cleansing velocity , limiting velocity , non-silting and non-scouring velocity

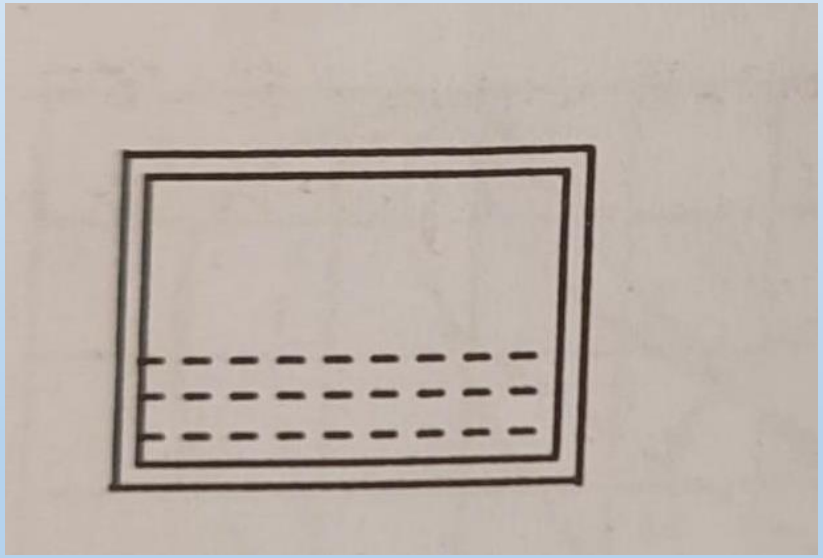
Shapes of Sewers

- Rectangular section

I. Used in early days, but rarely used nowadays

II. May be pre cast or in-situ

III. Easy for construction but hydraulically not efficient



Shapes of Sewers

- Circular Section

I. Most common section

II. Maximum hydraulic depth and less chances of deposition of silt

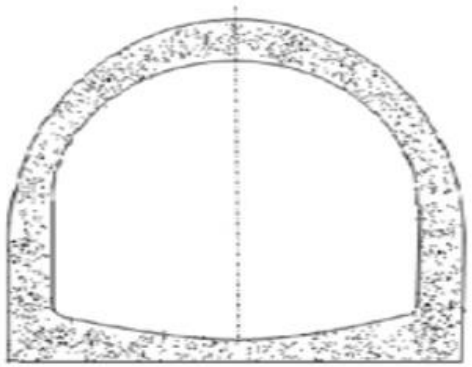
III. Easy manufacturing, transporting and laying ,

Circular Sewer Section

Shapes of Sewers

- Semi elliptical

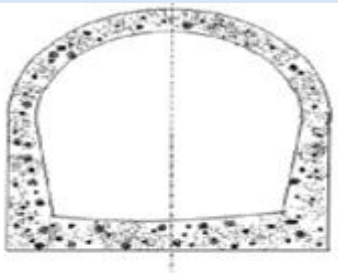
I. Suitable for large discharge



(v) Semi-elliptical section;

- Horse shoe type

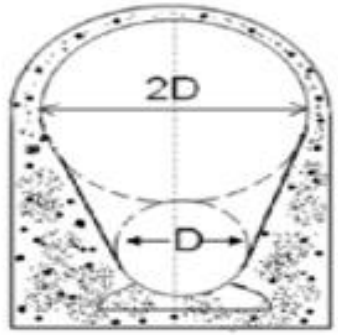
I. Suitable for large perennial discharge



(iii) Horse shoe sewer section

- Egged shaped

I. Suitable for combined and separate system but not in use due to difficulty construction



(i) Standard egg-shaped sewer

Hydraulic element of circular sewer

Circular sewer running full

- Area of flow section A= $\pi D^2/4$
- Wetted perimeter P= π D
- hydrulic mean depth = A/
- Velocity of flow v = $\frac{1}{n}$x $R^{\frac{2}{3}}$

Circular sewer running part

$\frac{d}{D}=\frac{1}{2}(1-\text{Cos}\ \frac{\theta}{2})$

Q. If a sewer is running 0.7

The hydraulic radius of a circular sewer of internal diameter 100 cm, running in fully occupied cross section is given by:

1. 100 cm
2. 25 cm
3. 50 cm
4. 75 cm

Hydraulic element of circular sewer…

Circular sewer running partially full

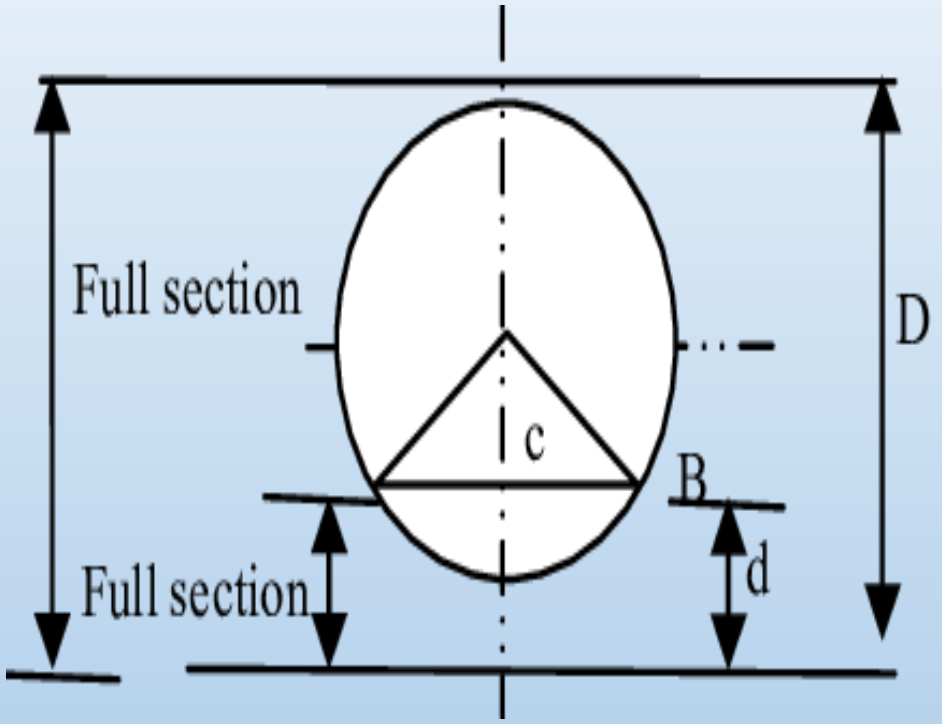
$$I.\quad \frac{p}{P} = \left(\frac{\theta}{360}\right)$$

$$II.\quad \frac{a}{A} = \left(\frac{\theta}{360} - \frac{sin\theta}{2\pi}\right)$$

$$III.\quad \frac{r}{R} = \left(1 - \frac{360sin\theta}{2\pi\theta}\right)$$

$$IV.\quad \frac{v}{V} = \left(1 - \frac{360sin\theta}{2\pi\theta}\right)^{2/3}$$

$$V.\quad \frac{q}{Q} = \frac{\theta}{360}\left(1 - \frac{360sin\theta}{2\pi\theta}\right)^{5/3}$$



Sewer Appurtenances

I. Man hole/inspection chamber/access chamber/ confined space

- Masonry or RCC chamber
- Cleaning, testing, inspection, maintenance removal of obstruction from the sewer line

Location of Man Hole

- At every change alignment(direction)
- At every change gradient(Slope)
- At every change size(dia)
- At every junction
- At regular interval (Dia. Upto 0.3 m =45 m) (As per indian standards)

Sewer Appurtenances

I. Man hole/inspection chamber/access chamber/ confined space

Size of Sewer	Recommended spacing of manholes on straight reaches of sewer lines as per IS 1742:1960
Diameter up to 0.3 m	**45 m**
Diameter up to 0.6 m	75 m
Diameter up to 0.9 m	90 m
Diameter up to 1.2 m	120 m
Diameter up to 1.5 m	250 m
Diameter greater than 1.5 m	300 m

Dimension of access chamber : 0.6 x 0.75 for rectangular

0.6 to 0.75 m for circular

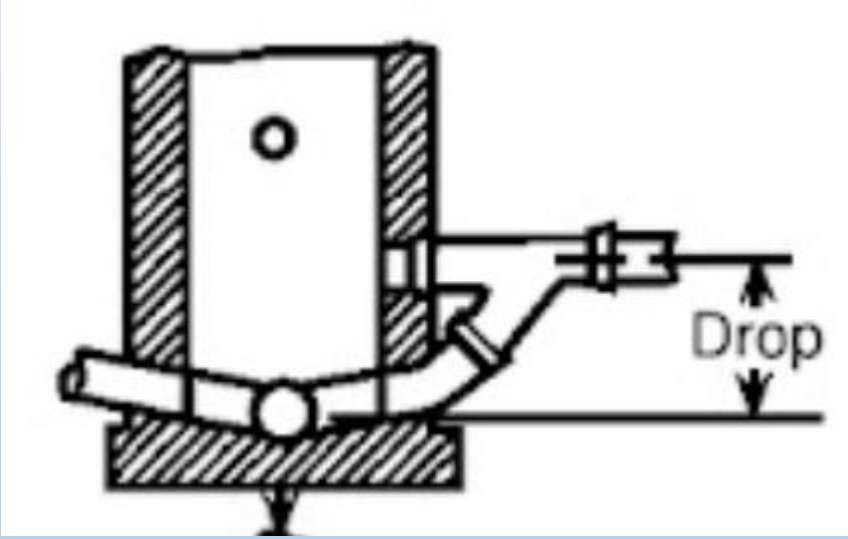
Dimension of working chamber: 0.9x 1.2 for rectangular

1.2 m for circular

Sewer Appurtenances

Drop Man Hole

- Special type of manhole and provided when elevation difference is more than 0.6m
- Connect high level branch sewer to low level main sewer



Sewer Appurtenances

Lamp Man Hole

- To join a hole in the sewer and the ground, for the purpose of lowering a lamp inside the sewer.
- Used for inspection , flushing and ventilation
- *Constructed when construction of manhole is difficult*
- Also known as fresh air inlet

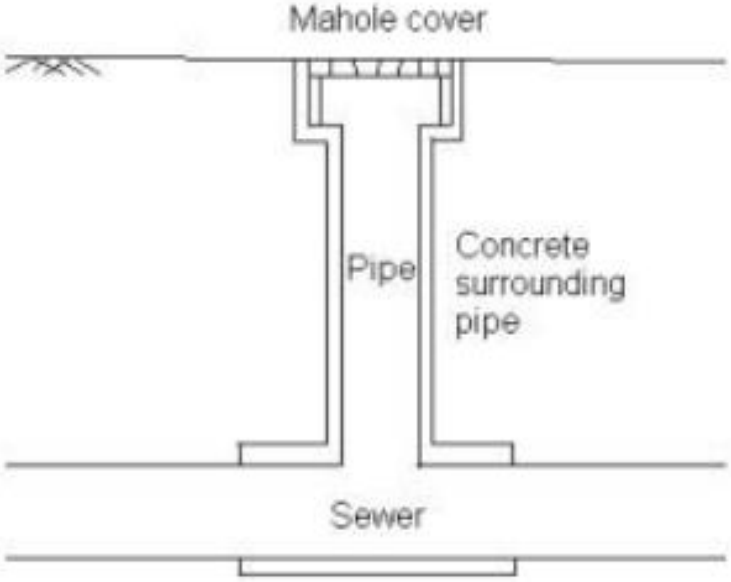
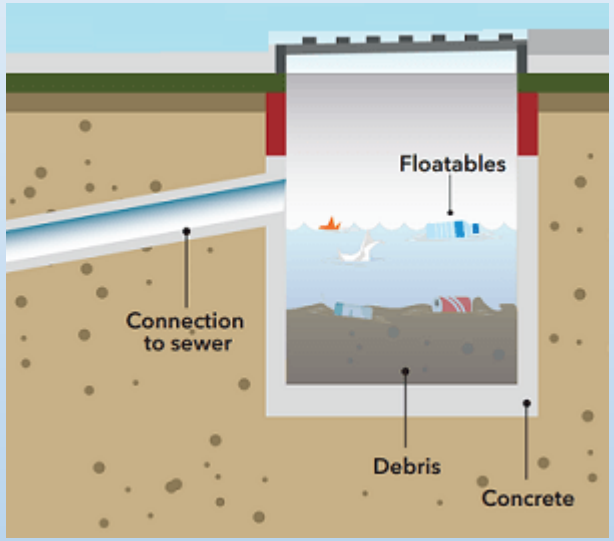


Figure 8.12 Lamp hole

Sewer Appurtenances

Catch Basin (Catch Pit)

- Provided for the retention of heavy debris and allow settlement and trap for sand grit.
- Settled material should be periodically cleaned.



Sewer Appurtenances

Street Inlet

- Device or opening in the in the street constructed to admit storm water in to the sewer line.
- it may be gutter, curb, or combined Street inlet

Construction of sewer

Steps

1. Setting out: The lay out and location of manholes are fixed by driving pegs or drawing offsets.
2. Alignment and gradient: The correct position of sewer line and levels of sewer are fixed by calculations. This is done with the help of boning rods, sight rails and levels .
3. Excavation of trench
4. Timbering of trench: When excavation depth exceeds 1.5 to 2 m
5. Dewatering
6. Laying of sewer and construction of joints: Laid from downstream. Mostly socket and spigot joints are used.

Note: Boning rod is used to check sewer level.

Testing of sewer pipe

7. Testing

a. **Straightness test :** Done to find out whether the sewer is laid in a straight line. Done using a light source and mirror .

b. **Obstruction test** : Done to find out irregularities in joints. A marble of diameter 13 mm less than sewer is used.

c. Water test : Done to find the water tightness of sewer. The loss in water should not be more than 0.2 litre/ mm diameter for 30 minutes of testing under head of 2.5 m at the u/s end .

d. Air test : Done to find water tightness of sewer when water is scarce. The air filled at pressure of 100 mm should not drop below 75 mm.

8. Back filing

- To be done by parent material .
- Filled in 15-20 cm and ramming each layer

MCQ Practice

3. Removal of oil and grease from sewage is known as

a. Screening
b. Skimming
c. Filtration
d. All of the above options

4.When the sewage is dropped from higher level to lower sewage line , the type of manhole is called [NEC]

a. Drop manhole
b. Deep manhole
c. Shallow manhole
d. Lamp hole

MCQ Practice

5. The instrument used to transfer the elevation from ground surface to the bottom of the trench is called

a. Normal rod
b. Levelling rod
c. Boning rod
d. Surveying pegs

6. Sewerage system is usually designed for

a. 7 years
b. 5 years
c. 100 years
d. 25 years

MCQ Practice

8. The sewer pipes have to be designed and checked for

a. only maximum flow
b. both maximum and minimum flow
c. only minimum flow
d. None.

MCQ Practice

9. Location of Man Hole

a. At every change alignment(direction)

b. At every change gradient(Slope)

c.At every change size(diameter)

d.At every junction

e.All of the above

10. Sewer are normally subjected to

a. Air test

b. Water test

c. Straightness test

d. Obstruction test

e. All of the above

MCQ Practice

11. The minimum size of sewer should not be less than

a. 12cm

b. 15cm

c. 19mm

d. 25cm

12. What is the facility provided to stop the entry of heavy debris present in the storm water into the sewers called?
a) Curb inlet
b)Gutter inlet
c) Catch basin
d) Clean-outs

The lamp hole cannot be used for the flushing of sewers.
a) True
b) False

What are the manholes having a depth greater than 1.5 m called?
a) Normal manholes
b) Deep manholes
c) Shallow manholes
d) Straight manholes

Explanation: The manholes having a depth of 0.7-0.9 m are called shallow manholes. The manholes having a depth of 1.5 m are called normal manholes. The manholes having depth greater than 1.5 m are called deep manholes

6.6 Concept of Environmental Assessment

- BES (Brief Environmental Study)
- IEE (Initial Environmental Examination)
- EIA (Environmental Impact Assessment)
- Government's act/rules/regulations/procedures for BES/IEE/EIA
- Types of disaster and its mitigation

Types of environmental studies

- Depending upon the nature, complexity and size of the proposal , the environmental studies are classified under the following types:

A. Brief Environmental Study (BES):

- BES should be done for the project mentioned in the Schedule 1 of Environment Protection Rules 2077

B. Initial Environmental Examination (IEE):

-IEE should be done for the project mentioned in the Schedule 2 of Environment Protection Rules 2077

C. Environmental Impact Assessment (EIA):

-EIA should be done for the project mentioned in the Schedule 3 of Environment Protection Rules 2077

History of Environmental Study in Nepal

- EIA started from USA in 1970. (National environment policy act)
- Need for EIA recognized in 6th five year plan in Nepal
- Environmental Assessment Guidelines formed in 1993
- First EPA (Environment Protection Act) – 1996
- First Environment Protection Rules – 1997

- *Current Environment Protection Act and Rules* → Date of Authentication 2076.06.24 (11th October, 2019)

  - Environment Protection Act (EPA) – 2019 (2076)

  - Environment Protection Rules (EPR) – 2020 (2077)