UNIT IV PLANNING AND DESIGN OF SEWERAGE SYSTEM **12**

Characteristics and composition of sewage - Population equivalent - Sanitary sewage flow estimation - Sewer materials - Hydraulics of flow in sanitary sewers - Sewer design - Storm drainage- Storm runoff estimation - Sewer appurtenances - Corrosion in sewers - Prevention and control – Sewage pumping-drainage in buildings - Plumbing systems for drainage

Sanitary Engineering
(Branch of Public Health Engineering)
↓
To Maintain & preserve the health of the individual and ~~Maintenance~~ community & to prevent communicable diseases

Important Terms and Definitions

- Refuse

General term to indicate what is rejected or left out as worthless. It may be in liquid, semi-solid or solid form and many be divided into six categories :- i) garbage ii) rubbish iii) sullage iv) sewage v) Subsoil water and vi) Storm water.

2. Garbage :-

Dry refuse is called garbage. It includes waste paper, decayed fruits and vegetables, grass and leaves and sweepings from streets, markets and other public places. Thus, garbage contains large amounts of organic and putrifying matter.

3. Rubbish

Rubbish indicates sundry solid wastes from offices, residences and other buildings. It also includes waste building materials, broken furniture, paper, rags etc. Rubbish is dry and is of combustible nature.

4. Sullage

Wastewater from bathrooms, kitchens, washing places and wash basins etc. It doesnot create bad smell since organic matter in it is either absent or of small amount.

5. Sewage

Sewage is liquid waste from the community. It includes sullage, discharge from latrines, urinals, industrial waste & surface storm water. It is extremely putrescible; its decomposition produces very unpleasant o...

and it contain Pathogenic or disease producing bacteria.

6. Sub-soil water

It is the groundwater that finds it entry into sewers through leaks.

7. Storm water

It is the rain water of the locality.

8. Sanitary Sewage

Sanitary sewage or domestic sewage is sewage from residential building and industrial buildings. It is extremely foul in nature. sanitary sewage is classified as i) domestic sewage ii) industrial sewage.

9. Domestic Sewage

It is the sewage obtained from the lavatory basins, urinals and water closets of residential buildings, office building, theatres and other institutions. Since it contains human excreta and urine, it is extremely foul in nature.

10. Industrial Sewage

It is wastewater obtained from the industrial and commercial buildings.

11. Night soil

It is a term used to indicate the human and animal excreta.

12. Sewer

It is an under-ground pipe to carry sewage. There are two types

i) Separate sewer

It carries only household and industrial wastes.

ii) Combined Sewer

Carries both sewage and stormwater

13. Sewerage

Science of collecting and carrying sewage by water carriage system through sewers.

Composition of sewage

* The composition of sewage depends upon the source from which it is found.

* Sewage consists of small percentage of solids and huge amount of water.

* Liquid content of sewage is 99.9% & total amount of solids is only 0.1%.

* The organic and inorganic matter may be in dissolved, suspended and colloidal state.

* The inorganic matter consists of ash, sand, grit, mud

* Inorganic matter may be nitrogenous or nitrogen-free.

* Sewage may be strong, medium and weak depending upon the concentration of these constituents.

Constituent	Concentration		
	Strong	Medium	Weak
1. Solids : Total (mg/l)	1200	720	350
Dissolved (mg/l)	850	500	250
Fixed (mg/l)	525	300	145
Volatile (mg/l)	325	200	105
Suspended, total (mg/l)	350	220	100
Fixed (mg/l)	75	55	20
Volatile (mg/l)	275	165	80
2. Settleable Solids (mg/l)	20	10	5
3. Biochemical oxygen demand (BOD_5, 20°C) (mg/l)	400	220	110
4. Total organic carbon (mg/l)	290	160	80
5. Chemical oxygen Demand (COD) (mg/l)	1000	500	250
6. Nitrogen (Total as N) (mg/l)	85	40	20
organic (mg/l)	35	15	8
Free ammonia (mg/l)	50	25	12
Nitrites (mg/l)	0	0	0
Nitrates (mg/l)	0	0	0
7. Phosphorus (Total as P) (mg/l)	15	8	4
Organic	5	3	1
Inorganic	10	5	3
8. Chlorides (mg/l)	100	50	30
9. Alkalinity (as $CaCO_3$)	200	100	50
10. Grease (mg/l)	150	100	50

Characteristics of ~~Wastewater~~ sewage

- Physical characteristics
- Chemical characteristics
- Biological characteristics

Fresh domestic sewage is slightly alkaline but become acidic as it becomes stale.

S.NO	Characteristic	Sources
1	Physical Characteristics	
	i) Colour	Domestic and industrial wastes; natural decay of organic materials.
	ii) Odour	Decomposing wastewater; industrial wastes.
	iii) Solids	Domestic water supply; domestic and industrial wastes; soil erosions; inflow-infiltration.
	iv) Temperature	Domestic and industrial wastes.
2	Chemical Characteristics	
	a) Organic	
	i) carbohydrates	Domestic, commercial and industrial wastes
	ii) Fats, Oils and greases	Domestic, Commercial and industrial Wastes

iii) Pesticides	Agricultural wastes
iv) Phenols	Industrial wastes
v) Proteins	Domestic and commercial wastes
vi) Surfactants	Domestic and industrial wastes
vii) Others	Natural decay of organic materials
b) Inorganic	
i) Alkalinity	Domestic wastes, domestic water supply, groundwater infiltration.
ii) Chlorides	Domestic water supply, domestic wastes, groundwater infiltration, water softeners.
iii) Heavy metals	Industrial wastes
iv) Nitrogen	Domestic and industrial wastes
v) pH	Industrial wastes
vi) Phosphorus	Domestic and industrial wastes, natural runoff.
vii) Sulphur	Domestic water supply, domestic and industrial wastes
viii) Toxic compounds	Industrial wastes.
c) Gases	
i) Hydrogen sulfide	Decomposition of domestic waste
ii) Methane	Decomposition of domestic wastes
iii) Oxygen	Domestic water supply, surface water infiltration

3.	Biological Characteristics	
	i) Animals	Open water courses and treatm
	ii) plants	Open water courses and treatme
	iii) protista	Domestic wastes; treatment pl
	iv) viruses	Domestic wastes.

Physical Characteristics

* Colour
* odour
* Temperature
* Turbidity
* Solid contents

1- Colour

* Fresh domestic sewage is grey
* With time, as putrefaction starts, it begins to get black
* Septic sewage is black or dark in colour
* Industrial Wastewater colour depends on the Chemical process used in the industries

2- Odour

* Fresh sewage has a musty odou but as it starts to get stale, it gives offensive odour.
* Within 3 to 4 hours, all the oxygen present in the sewage gets exhausted & starts emitting offensive odour.

Offensive odours is harmful as *

* reduction in appetite for food

* lowering in water consumption

*. Impaired respiration, nausea and vomiting

* cause for mental perturbation.

Major categories of odour are

Compound	odour quality
1-Amines	Fishy
2-Ammonia	Ammoniacal
3-Diamines	Decayed flesh
4-Hydrogen sulphide	Rotten eggs
5-Mercaptans	Skunk
6-organic sulphides	Rotten cabbage

3- Temperature

* Temperature of sewage is higher than that of water supply.

* Average temperature of sewage in India is 20°c.

* Temperature affects sewage by

a) Increasing viscosity

b) Bacterial activity increases upto 60°c.

c) Solubility of gases decrease with rise in temperature.

d) affects aquatic life

4. Turbidity

* Turbidity depends on quantity of sol[id] matters present in suspension state

* Stronger sewage has high turbidity

* Turbidity can be measured by turbi[dity] rod or by Jackson's turbidimeter.

5. Total Solids

* Total Solids are of 3 types

✓ Suspended Solids

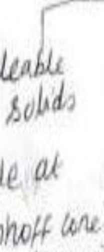
✓ Colloidal solids

✓ Dissolved solids

Suspended solids are solids that can be filtered out in filter paper

Suspended Solids

- Settleable solids [settle at Imhoff cone] in 2 hour period
- Non-settleable solids [do not settle do[wn]]



Total Solids

- Fixed Solids (Inorganic)
- Volatile Solids (organic matter)

Chemical Characteristics

1. pH value
2. chloride content
3. Nitrogen content
4. Fats, grease and oil content
5. Sulphides, sulphates and H_2S gas
6. Dissolved oxygen (DO)
7. Chemical oxygen Demand (COD)
8. Bio-chemical oxygen Demand (BOD)
9. Stability and relative stability

1. pH value

* To test whether sewage is acidic or alkaline

* Fresh sewage is alkaline (pH between 7.3 to 7.5)

* But after some time, the sewage becomes acidic.

* A high concentration of either an acid (pH <<7) or alkali (pH>>7) in sewage indicates industrial waste.

2. Chlorides Content

* Chlorides are mineral salts

* Chlorides in domestic sewage is from kitchen wastes, human wastes and urinary discharges etc.

* Ice cream plants, meat salting industries give large amount of chlorides in sewage.

3. Nitrogen Contents:

* The presence of nitrogen in sewag indicates the presence of organic matter in it. Nitrogen appears in the following five diffe forms in sewage:

i) Ammonia nitrogen or free ammonia

ii) Organic nitrogen

iii) Albuminoid Nitrogen

IV) Nitrites Nitrogen

V) Nitrates Nitrogen.

i) Ammonia Nitrogen or Free ammonia

The age of sewage is determined by the amount of ammonia that is present. The presence of free ammonia indicates stale or old sewage

ii) Organic Nitrogen

organic nitrogen in wastewater is determined by Kjeldahl method

iii) Albuminoid nitrogen

Free ammonia indicates the very first stage of decomposition of organic matter.

Albuminoid nitrogen indicates the amount of undecomposed nitrogenous material in the sewage.

iv) Nitrites Nitrogen

Nitrites indicate the presence of partly decomposed organic matter

V) Nitrate Nitrogen

* Nitrates indicate the presence of fully oxidised organic matter.

* Nitrates indicate the most stable form of nitrogenous matter

* presence of Nitrate indicate the well oxidised and treated sewage.

* Nitrates may vary in concentration from 0 to 20 mg/l as nitrogen in wastewater effluents.

4. Fats, grease and oils

* Fats and oils are mainly contributed from kitchen wastes

* Grease and oils are also discharged from industries like garages, workshops, factories etc

* Fats and oils are compounds of alcohol or glycerol with fatty acids. such matters float on the top of sedimentation tanks, choke pi[illegible] in winter and clog filters.

* They interfere with functioning of normal treatment plants.

* The particles interfere with biological action and cause maintenance problems.

* Fats are among the more stable of organic compounds and are not easily decomposed by bacteria.

* Fats, grease, mineral oils and lubrication oils are soluble in hexane or ether

5. Surfactants:

* Surfactants come from synthetic detergents

* These are discharged from bathroom, kitchen, washing machines etc.

* Alkyl-benzene-sulfonate is more troublesome since it is not biodegradable

6. Phenols, pesticides and agricultural chemicals

* Phenols are mostly found in industrial wastewater.

* Phenols can be biologically oxidized if the concentrations are upto 500mg/l.

* pesticides, herbicides and other agricultural chemicals result from surface runoff from agricultural, vacant and park lands

7. Toxic compounds

* copper, lead, silver, chromium, arsenic and boron are some of the cations which are toxic to micro-organisms

* Toxic compounds come from industrial wastewater.

8. Sulphates, sulphides and H_2S gas

* Sulphates and sulphides are formed due to decomposition of various sulphur containing substances in wastewater.

* Anaerobic bacteria chemically reduce sulphates to sulphides and to hydrogen sulphide,

$$SO_4^{-} + \text{organic matter} \xrightarrow{\text{bacteria}} S^{-} + H_2O + CO_2$$

$$S^{-} + 2H^{+} \rightarrow H_2S$$

* H_2S cause bad smells & odours

* H_2S oxidised to sulphuric acid which cause corrosion in pipe.

9. Other gases.

* Nitrogen, oxygen, CO_2, Hydrogen sulphide (H_2S) Ammonia and methane are the gases present in wastewater.

* Methane gas is the by-product of anaerobic decomposition of organic matter in wastewater.

* Methane is colourless, odourless and highly combustible

* Manholes should be well ventilated.

10. Oxygen consumed

* oxygen required for the oxidation of carbonaceous matter

* This test is made to determine the relative strength of sewage

11. Dissolved oxygen (DO)

* Amount of oxygen in the dissolved state in the wastewater.

* DO in wastewater indicates that it is fresh.

* While discharging the treated water into waters, ensure that atleast 4 P.P.M of DO is present in it.

* If D.O < 4 P.P.m, fishes will die.

* DO of wastewater decreases as the temperature increases.

12. Oxygen Demand

* presence of oxygen is essential for the organisms.

* oxygen is demanded in wastewater for the oxidation of both inorganic as well as organic matter.

Demand of oxygen may be expressed as

i) Biochemical oxygen Demand (BOD)

ii) chemical oxygen Demand (COD)

iii) Total oxygen Demand (TOD)

Biochemical Oxygen Demand (BOD)

Oxygen required to oxidize the organic matter present in a sample.

The oxygen required for the micro-organisms to carry out biological decomposition of dissolved solids or organic matter in the wastewater under aerobic conditions at standard temperature.

Organic matter present in wastewater belong to

i) carbonaceous matter

ii) Nitrogenous matter.

5 day period is chosen for standard BOD test, during which oxidation is about 60 to 70 percent complete.

within 20 days period, the oxidation is about 95 to 99 percent complete.

Constant temperature of 20°C is maintained during the incubation.

BOD_5 → 5 day BOD.

BOD can be performed by two methods

i) Direct method

ii) Dilution method

Dilution method

* Commonly used method

* Sample is diluted with dilution water

* Initial DO of this diluted sample is measured

* Diluted sample is then incubated for 5 days at 20°C in an air tight glass vessel

* DO of the sample is then again measured.

* The loss of oxygen or the oxygen consumed during incubation is found out by calculating the difference between initial content of DO and final content of DO.

$$BOD_5 = [\text{oxygen consumed}] \times \text{dilution ratio}$$

$$\text{dilution ratio} = \frac{\text{Vol. of diluted sample}}{\text{Vol. of undiluted sewage sample}}$$

BOD is expressed either in ppm or in mg per litre.

Values of BOD for raw and treated sewage

Nature of sewage	5 day BOD at 20°C (ppm or mg/l)
1. Strong sewage	450 to 550
2. Average sewage	350
3. Weak sewage	250
4. Standard filter sewage effluent	20
5. very good filter sewage effluent	5 to 10

Chemical Oxygen Demand (COD)

* BOD test takes a minimum of 5 days time

* COD can be determined only in 3 hours in contrast to 5 days BOD test.

* In COD test, a strong chemical oxidising agent is used in an acidic medium to measure the oxygen equivalent of organic matter that can be oxidised.

* COD test is more suitable to measure organic matter present in industrial wastes having compounds that are toxic to biological life.

COD > BOD

... value of COD of wastewater is 250 mg/l

Total Oxygen Demand ...

* Another method to measure the or[ganic]
content of wastewater.

* It is a direct measure of oxyge[n]
demand of the sample

Relative Stability

Relative Stability, S_R = Available oxygen / Required oxyg[en]

$$S_R = 100\left(1-0.794^{t_{20}}\right)$$

$$S_R = 100\left(1-0.605^{t_{37}}\right)$$

t_{20} - number of days of incubation at 20°C

t_{37} - number of days of incubation at 37°C.

Population Equivalent, P_E

$$P_E = \frac{\text{Total } BOD_5 \text{ of the industrial wastewater (kg)}}{BOD_5 \text{ Value per capita / day}}$$

BOD Contribution per capita per day may be taken as 80g/day (0.08 kg/day)

If total BOD_5 of an industrial wastewater is 800 kg/day and BOD_5 Value is 0.08 kg/capita/d[ay]

Population Equivalent, $P_E = \frac{800}{0.08} = 10,000$

Population equivalent is used to indicate the strength of industrial wastewater, to estimate the treatment required at common treatment plant.

1) The domestic sewage of a town was tested for total solids and following results were obtained:

Weight of sample of sewage = 1000gm

Weight of solids after evaporation of liquid = 0.952 gm

Weight of dry residue after ignition = 0.516 gm

Determine i) total solids ii) fixed solids iii) volatile solids.

Total solids, $S_T = \frac{0.952}{1000} \times 10^6 = 952 \text{ ppm}$

$\boxed{S_T = 952 \text{ ppm}}$

Fixed solids, $S_F = \frac{0.516}{1000} \times 10^6 = 516 \text{ ppm}$

$\boxed{S_F = 516 \text{ ppm}}$

∴ Volatile Solids, $S_V = S_T - S_F$

$= 952 - 516$

$\boxed{S_V = 436 \text{ ppm}}$

2) In order to conduct a 5-day BOD test, the sample of wastewater was diluted with specially prepared dilution water, with a dilution factor 150. The contents of dissolved oxygen in the beginning and end of test were found to be 11 ppm and 7 ppm respectively. compute the 5 day BOD. What is the nature of the wastewater?

$$BOD_5 = [\text{oxygen Consumed}] \times \text{dilution Factor}$$

$$= (11-7) \times 150$$

$$\boxed{BOD_5 = 600\ ppm}$$

Hence the wastewater is very strong and requires heavy treatment before disposal.

3) 5 ml of raw sewage was diluted by specially prepared water, in a 300 ml capacity BOD bottle. The DO concentration of the diluted sample at the beginning of the test was 9 mg/L and 6 mg/L after 5-day incubation at 20°c. Find the BOD of raw sewage

$$\text{Dilution ratio} = \frac{\text{Vol. of diluted sample}}{\text{Vol. of undiluted sample}}$$

$$= \frac{300}{5} = 60$$

$$\text{Loss of DO} = 9-6 = 3\ mg/l$$

$$BOD_5 = 3 \times 60$$

$$= 180\ mg/l$$

4) A 1% solution of sewage sample is incubated for 5 days at 20°c. The depletion of oxygen was found to be 3 ppm. Determine the BOD of raw sewage.

$$\text{Dilution ratio} = \frac{100}{\text{Percent of solution}} = \frac{100}{1} = 100$$

$$BOD_5 = 3 \times 100 = 300\ ppm$$

Sewer Materials

Sewers may be made of one of the following materials:

i) Asbestos cement

ii) Plain or reinforced cement concrete

iii) Vitrified clay or stoneware

iv) Brick

v) Cast iron

vi) Steel

vii) Plastic

While selecting sewer material, the following factors must be considered.

1) Hydraulic efficiency

* Value of Manning's coefficient N is as low as possible.

2) Resistance to abrasion

For longer life, the sewer material should possess enough resistance to corrosion

3) Resistance to abrasion

Sewage has more grit and sand particles. At high velocity, erosion of sewer material may take place due to abrasion.

4) Strength

Sewer that are underground should be

strong enough to resist all external forces

5. Durability

Sewer material should be durable

6. Cost

Cost of material should be less

7. Weight

The Material should be light in weight for easy handling & transportation cost is less

8. Imperviousness

There should not seepage from the sewer.

1) Asbestos cement Sewers

* These sewers are made from a mixture of asbestos fibre, cement and silica.

* Asbestos fibre is a reinforcing material

* These pipes are available in various sizes from 75mm to 500mm in diameter and 3 to 4m in length.

Advantages:-

* Strength against internal pressure

* Light in weight

* Easily handled

* Easily cut and easily joined

* Good resistance to salts

* Inside surface is smooth

Disadvantages:-

* They are brittle

* Less strength against heavy external forces

* Susceptible to sulphide corrosion.

2) plain or reinforced cement concrete

* Cement Concrete pipes can either be plain or reinforced

* Plain cement concrete pipes are used from 80mm to 450mm, with their thickness varying from 25 to 35mm.

* For bigger diameters, these are reinforced, consisting of longitudinal and transverse reinforcement in the form of rings or elliptical cage.

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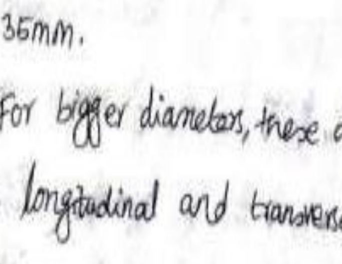
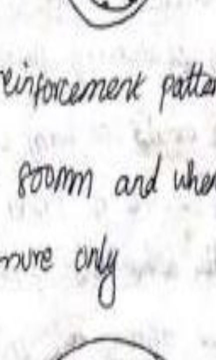
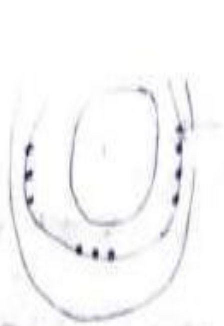


This reinforcement pattern is suitable upto diameter of 800mm and when pipe is subjected to internal pressure only



This reinforcement is suitable for greater diameter pipes when they are subjected to internal & external pressures



This Pattern uses elliptical cage and is suitable for large diameter pipes which are subjected to external pressure only.

* Rich quality cement concrete should be used.

* Usual Mix is 1:1½:3

* Max. size of aggregates limited to 6mm

* Water cement ratio varies between 0.5 to 0.7

R.C.C pipes can be manufactured by the following three different process:

i) the concrete is poured by ordinary method around the reinforcement cage and tamped. This is known as stationary method.

ii) The mould or form containing fabricated reinforcement & concrete of proper grade is made to rotate rapidly about the pipe axis. The centrifugal force so created throws the concrete outwards and spreads it in uniform layer over the internal surface of the mould, embeding the reinforcement. such a pipe is sometimes known as the centrifugal type pipe.

iii) The pipes may be made by lining thin cylindrical steel shells, both internally and externally with cement concrete. such pipes are known as cylinder type pipes. Hume steel pipes are also fall under this category. They are available in size varying from 100mm to 2400mm in dia. and 900mm to 2400 mm in length.

Advantages

1) Strong under internal & external pressures.

2) can be made of any desired strength.

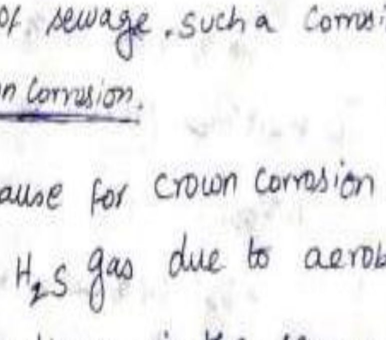
3) can be manufactured in site.

4) They are economical.

Disadvantages

1) They are easily corroded because of the corrosive action of sewage. such a corrosion is called as crown corrosion.

The cause for crown corrosion is the formation of H_2S gas due to aerobic and anaerobic conditions in the sewage.



The sulphates are reduced to sulphides and to hydrogen sulphide.

Methods of reducing crown corrosion

1) Lining the concrete pipes by vitrified clay blocks

2) Ventilating the sewers

3) Making the sewers run full

4) Pretreating the sewage so as to reduce sulphate contents.

5) prohibiting the entry of wastes containing sulphides.

6) Aerating and Chlorinating sewage

7) Neutralising sulphides by addition of Chemicals.

390
320
710

3) Vitrified clay or Stoneware sewers

* These pipes are manufactured from clays and shales of special qualities and grades

* pipes are then formed in pipe press, at a specified pressure in desired diameters and lengths.

* The vitrification achieved at a higher temperature of 1200°c.

Advantages

1) highly resistant to sulphide corrosion

2) Resist grit and silt

3) Smooth interior

4) highly impervious

5) High Compressive strength

6) Cheap & easily available

Disadvantages

1) They are weak in tension.

2) Brittle in nature

3) Heavy.

4) Brick sewers

* Large size combined sewers can be made of brick

* Should be plastered from outside, so it will be impervious against ground water

* Also lined inside with stoneware & that sewer will be smooth & hydraulically more efficient.

5) Cast iron sewers.

* High strength

* Strong to withstand tensile, compressive & bending stresses

* Diameter ranges from 150mm to 750mm & lengths upto 3 to 3.5m

* Costlier

* These pipes are used under heavy external loads, high internal pressure, crossing low level areas, under expensive road surface, protection against contamination, Temperature

variations, vibrations, wet ground conditions.

6) Steel sewers

In high external or internal pressure these pipes can be used

* Impervious
* Light in weight
* Absorb vibrations & shock load.
* Easily welded
* cost is high.

7) plastic sewers

* Corrosion resistant
* Available in longer lengths.
* In India, its use is started recently in the form of domestic sewers.

Sewer Appurtenances

* Inlets
* Catch basins
* Cleanouts
* Manholes
* Drop manholes
* Lamp holes
* Flushing Tanks
* Grease and oil traps
* Inverted siphons
* Storm regulators

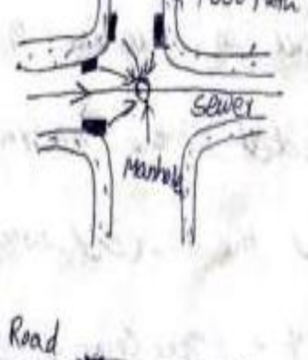
1) Inlets

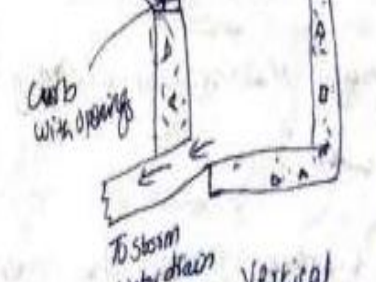
* An inlet is a device used to admit storm water and convey it into storm sewer or a combined sewer.

* Inlets are not necessary in separate sewers.

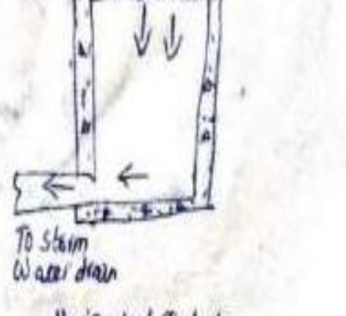
* Inlets
  - Curb inlet or vertical inlet
  - Gutter inlet or horizontal inlet
  - Combination inlet

* A maximum spacing of inlets is 30m
* Inlets are located at street intersections
* Inlets are connected to nearby manholes by pipelines





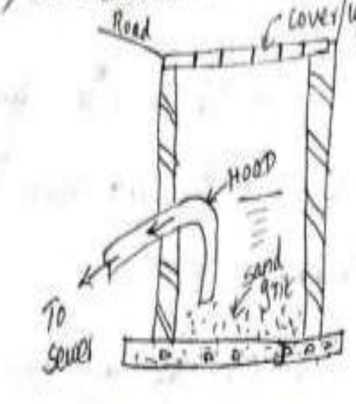
Vertical



Horizontal Inlet

* Curb inlet does not interfere with the flow of traffic

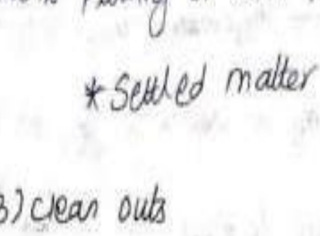
2) Catch Basins or catch pits with



* It is a special type of inlet, in which a basin is provided which allows grit, sand and debris flowing in with storm water, settle out.

* Settled matter is taken out periodically.

3) Clean outs



* Cleanout is an inclined pipe with its one end connected to the underground sewer line and the other end brought upto ground level, with a proper cover at the top

* They are meant for cleaning out the lateral sewers.

* For cleaning purposes, the cover is taken out and water is forced into cleanout pipe

* For larger obstruction, flexible rod may be inserted

4) Manholes

* Masonry or R.C.C Chamber for providing access to the sewer for inspection, testing, cleaning and removal of obstructions from the sewer line.

* They also help in joining sewer lines or in changing the direction.

* Manholes are provided at every bend, junction, change of gradient or change of diameter.

* The larger the diameter of the sewer, the greater may be the spacing between two manholes.

Spacing of Manholes

Size of sewer	Spacing
1) Dia. upto 0.3m	45m
2) Dia. upto 0.6m	75m
3) Dia. upto 0.9m	90m
4) Dia. upto 1.2m	120m
5) Dia. upto 1.5m	250m
6) Dia. greater than 1.5m	300m

Shallow Manholes

* 0.75 to 0.9 m in depth.

* constructed at the start of a branch sewer

* Also called as inspection chamber

Normal Manholes

* 1.5m in depth

* Either square (1m x 1m) or rectangular (0.8m x 1.2m)

Deep Manholes

* Deeper than 1.5m

* Size is larger at bottom & reduced at top

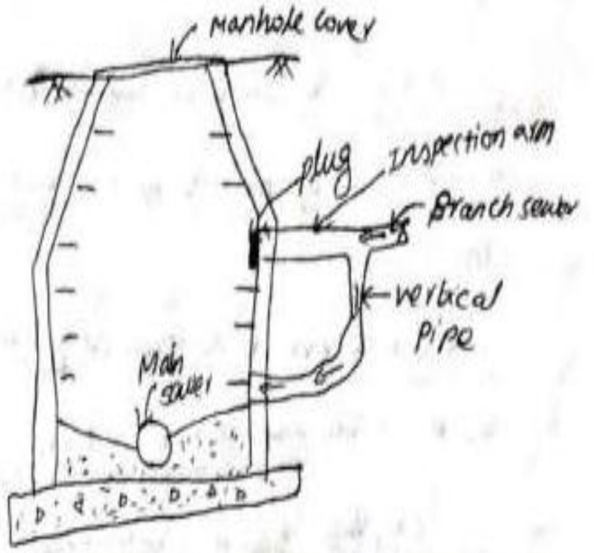
* Steps are provided on one vertical wall of the manholes to enable the workers to go upto bottom.

5) Drop Manhole

* A drop manhole is a special type of manhole on a sewer line which is constructed to provide a connection between a high level branch sewer to a low level main sewer.

* When a branch sewer enters a manhole by more than 0.5 to 0.6m above the main sewer, the sewage is not allowed to fall indirectly into the manhole.

* The sewage of the branch sewer is brought into the manhole of the main sewer through a down pipe called drop manhole.



* The branch sewer is joined to the manhole of main sewer through a vertical pipe.

* The sewage coming from the branch sewer trickles down in the vertical pipe and emerges out through a horizontal pipe.

* A plug is provided at the point where the branch sewer, intersects with the vertical wall of the manhole.

7) Lampholes

* Opening, constructed to join a hole on the sewer and the ground, for the purpose of lowering a lamp inside the sewer

* A lamphole may consist of Concrete or Stoneware pipe connected ~~the~~ to the sewer through a Tee-junction

* A manhole cover with suitable frame is provided on its top to take up the load of the traffic.

* Vertical pipe is surrounded by concrete to make it stable and give it strength.

Lamphole may be located when

i) there is change in direction or gradient of the sewer in between two closely spaced manholes

ii) Construction of manhole is difficult.

iii) spacing of manhole is considerable.

Lamphole purposes

1) Inspection

2) Flushing

3) Ventilation

8) Flushing Tanks

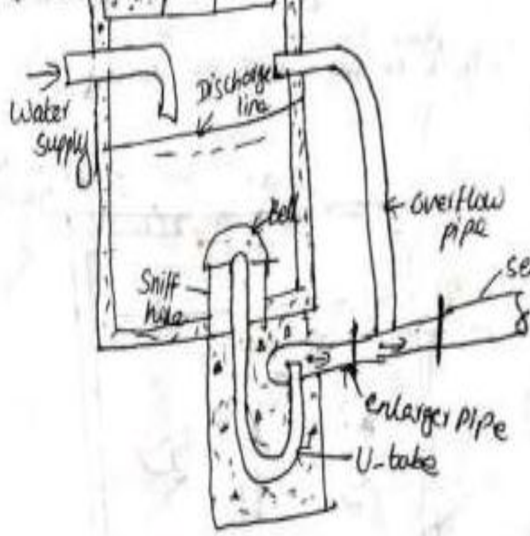
* Device which holds water and then throws it into the sewer for the purpose of flushing it.

* Sewers laid on flat gradients may not produce self cleansing velocity and may get blocked frequently

* They can be cleaned with help of such flushing tanks.

* Flushing tanks are also provided near the dead ends of sewers.

*



* The tank consists of a masonry or Concrete chamber filled with a water tap for filling the tank with water

* A U-tube in the bell cap at its one end connects the chamber with the enlarged end of the sewer pipe.

9) Grease and oil Traps

* To exclude grease and oil from sewage

* located Near automobile repair workshops, garages, ~~etc~~ kitchens of hotels, oil & grease

* Oil & grease will stick to the ...

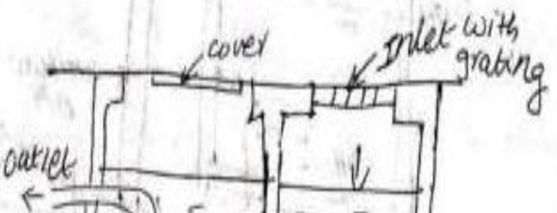
the sewer.

* increases the possibilities of explosion in the sewer lines

* Floating matter stick to the sides of sewer

* Cause difficulty in the treatment of waste water.

* Prevents oxygen to penetrate due to which aerobic bacteria will not survive.



* oil & grease will float on the surface of water

10) Inverted Siphons

* When a sewer dips below the hydraulic grade line, it is called an inverted siphon.

* The purpose is to carry the sewer under the obstruction such as roadway, railway etc.

Sewer Design

The design of the sewers is done on the basis of these formulas

1) Chezy's formula
2) Kutter's formula
3) Bazin's formula
4) Manning's formula
5) Crimp and Bruge's formula
6) Hazen and William's formula

The factors that influence the flow of sewage in the sewers are

* Slope of sewer
* Geometry of sewer
* Roughness of interior surface of sewer
* Bends, transitions, obstructions etc.
* Flow conditions
* Characteristics of sewage

1) Chezy's formula

$V = C\sqrt{RS}$

V = velocity of flow (m/s)

S = hydraulic gradient or slope of the sewer

R = Hydraulic mean radius (A/P)

A = Area of cross-section

P = Wetted perimeter

C = Chezy's constant

2) Kutter's formula

$$C = \frac{23 + \frac{0.00155}{S} + \frac{1}{N}}{1 + \left(23 + \frac{0.00155}{S}\right)\frac{N}{\sqrt{R}}}$$

R = Hydraulic mean radius

S = Slope

N = Rugosity coefficient.

3) Bazin's formula

$$C = \frac{157.6}{1.81 + \frac{K}{\sqrt{R}}}$$

K - Bazin's constant

4) Manning's formula

$$V = \frac{1}{N} R^{2/3} S^{1/2}$$

5) Hazen & Williams formula

$$V = 0.85 C R^{0.63} S^{0.54}$$

Minimum velocity of flow

To keep the solid matter in suspended form, a certain minimum velocity is required, otherwise the solid particles will settle in the sewer, resulting in its clogging. Such a minimum velocity is known as self-cleansing velocity.

Self cleansing velocity is the velocity at which the solid particles will remain in suspension, without settling at the bottom of the sewer.

Maximum velocity of flow

The maximum velocity at which no scouring action or abrasion of interior surface of the sewer takes place is called non-scouring velocity.

Circular Sewers.

Advantages

1. They are very easily manufactured
2. Gives maximum area for a given perimeter, ∴ it is the efficient section at these flow condition,
3. Most economical section.
4. Less opportunities for deposits

1. calculate the velocity and discharge in a sewer of circular section having diameter of 1m, laid at a gradient of 1 in 500. Use Mannings formula taking N=0.012, Assume that the sewer is running half full.

$$V=\frac{1}{N}R^{2/3}S^{1/2}$$

When $d=0.5D$ $\theta=180^\circ$

$$A=\frac{1}{2}\frac{\pi}{4}D^2$$

$$=\frac{\pi}{8}D^2$$

$$P=\pi D.\frac{\theta}{360^\circ}=\pi D\frac{180}{360}=\frac{\pi D}{2}$$

$$R=\frac{A}{P}=0.25m$$

$$V=\frac{1}{0.012}(0.25)^{2/3}\left(\frac{1}{500}\right)^{1/2}$$

$$=1.479 m/s$$

$$Q=A\times V=\frac{\pi}{4}(1)^2\times 1.479$$

$$=0.581 \text{ Cumecs}$$

Egg-shaped Sewers

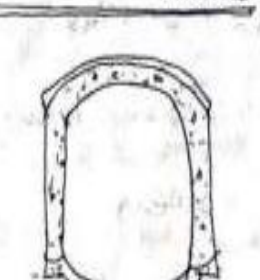
* Circular sewers are suitable only where variation in discharge is not large.

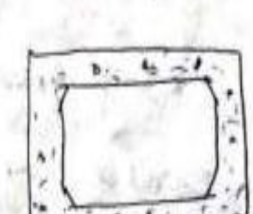
* For combined system, egg-shaped sewers are more suitable.

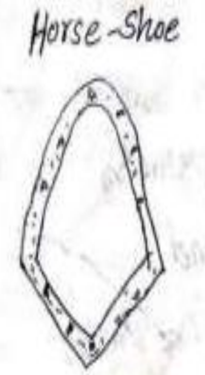
Disadvantages

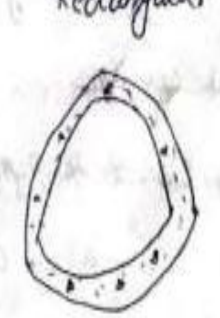
1) Egg-shaped sewer is unstable
2) Difficult to construct
3) Expensive, cost of construction is high
4) Not self-cleansing.

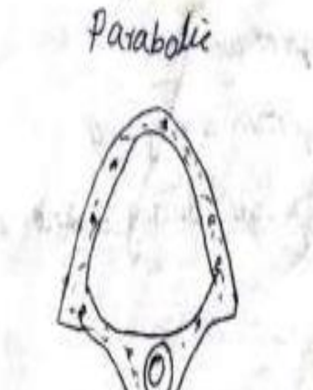
Other Sewer Sections


Horse-Shoe


Rectangular


Parabolic


Semi Elliptic


Semi-elliptic with underdrain


Horse Shoe with underdrain

Sewage pumping

Necessity

1) Area of a town is so low lying

2) Flat country

3) Outfall sewer is at a lower level

4) When a sewer has to go across a high ridge

5) To take sewage from sub-basements of building

Pumping stations

1) Location

* Study the area to be served

* Large quantity of sewage means, the site should be near a stream

* pumping station should not be flooded at any time

2) Elements of pumping stations

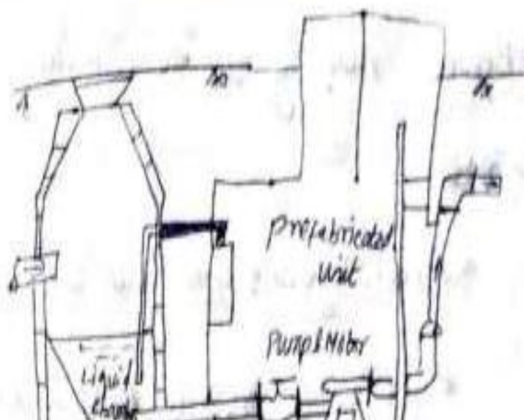
a) Grit channel

b) Coarse or fine screens

c) Sumps or wet-well

d) pump room or dry well

e) pumps with driving engine or motor



sewage pumping stations

3) Pump house structure

* pump house should withstand flotation forces.

* Internal walls and floors should take the weight of machines along with a live load of 5 kN/m2

* The building should be planned and designed keeping in view the future requirements.

* Building should contain wide passages

* The ventilating equipment should have a minimum capacity of six air changes per hour.

* In designing the sub structure, allowance should be made for earth pressure, water pressure and uplift pressure.

4) Grit chamber or detritus pit

* Grit, rags, sticks, faeces etc. will be in suspension as long as the sewage is

* Before pumping all these matter should be removed.

* After screens, grit can be separated

* pit is designed to have a detention Period of about 30 seconds.

* The grit collected is removed manually once in a week.

5) Screens

* Rags, sticks, papers are removed by screens.

* Two types of screens

a) Coarse screen

b) Fine screen.

* Coarse screen have 50 to 100mm clear spacing between them

* Fine screens have opening less than 25mm

6) Sump well

* pumping stations are provided with two separate wells

* Wet well for receiving the incoming sewage and dry well for housing the pumps.

* The sump is provided either below the floor of a pump house or by the side of dry well.

7) Rising mains, valves and fittings

* pumped sewage is led to high levelled gravity sewer through rising mains.

1) Calculate the combined flow discharge of sewage for the following data. Area to be served = 150 hectares, population of the locality = 50,000, Time of entry = 5 minutes, time of flow = 20 minutes, rate of water supply = 135 litres/capita/day impermeability factor = 0.45. Assume 80% of water supplied turns into sewer and peak factor as 1.5.

Population = 50,000

Time of entry = 5 mins

Time of flow = 20 mins

Rate of water supply = 135 Litres/capita/day

Impermeability factor = 0.45

Assume 80% of water supplied turns into sewer

Peak factor = 1.5

Area to be served = 150 hectares

Quantity of sewage produced in a day

$= 80\%$ of water supply

$= \frac{80}{100} \times 135 \times 50{,}000$

$= 5400\ m^3/day$ (or)

$= 0.0625\ m^3/sec$.

Maximum discharge = peak factor x Average discharge

$= 1.5 \times 0.0625$

$= 0.09375\ m^3/sec$

By using rational formula,

$Q_p = \frac{1}{36} k \cdot P_c \cdot A$ and

$P_c = \frac{100}{T_c + 20}$

T_c - Time of Concentration

$= T_i + T_f$

$= 5 + 20 = 25$ mins

$= \frac{100}{25+20} = 2.222$ cm/hour

$Q_p = \frac{1}{36} \times 0.45 \times 2.22 \times 150$

$= 4.16625\ m^3/sec$

For Combined Sewer,

Total Peak discharge = Maximum Sewage discharge + Max. Storm runoff

$= 0.09375 + 4.16625$

$= 4.26\ m^3/sec$.

2) BOD of a sewage incubated for one day at 30°C has been found to be 120mg/l. What will be its 5 day 20°C BOD, if k at 30°C is 0.16 per day (base 10).

BOD of sewage at one day at 30° $= (BOD)_{1,30}$

$= 120 mg/l$

k at 30°C, $K_{30} = 0.16$

$(Y_t)_{30} = L_0 (1 - 10^{-k_{30} \cdot t})$

$(Y_t)_{30} = 120\ mg/l$ at $t = 1$ day

$120 = L_0 (1 - 10^{-0.16 \times 1})$

$L_0 = \frac{120}{(1 - 10^{-0.16})}$

$= \frac{120}{0.308} = 389.4 mg/l$

$(Y_5)_{30} = L_0 (1 - 10^{-K_{30} \cdot 5})$

$= 389.4 (1 - 10^{-0.16 \times 5})$

$= 389.4 (1 - 10^{-0.8}) = 327.6$

Drainage in Buildings

Aims:-

i) To maintain healthy conditions in the building

ii) to dispose off waste water as early and quickly as possible

iii) to avoid the entry of foul gases from the sewer or septic tank.

iv) To collect and remove waste matters systematically

Principles:-

1. The Lavatory blocks should be so located that the Length of drainage line is minimum
2. The drainage pipes should be laid by the side of the building rather than below the building
3. All the drains should be aligned straight between successive inspection chambers
4. Slope of drain should be sufficient to develop self cleaning velocity
5. All the connections should be watertight

Soil pipe

Pipe through which human excreta flows.

Waste pipe

Pipe carries only liquid waste.

Vent pipe

pipe provided for ventilation. It is open at top and bottom, to exit foul gases. It is carried at least 1m higher than roof level

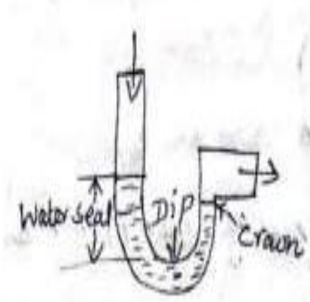
Rainwater pipe

Pipe carries only rain water

Anti-siphonage pipe

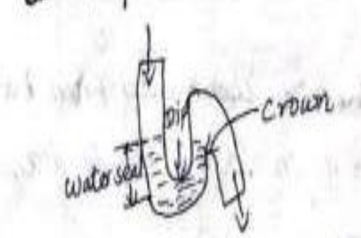
To preserve the water seal of traps

P-Trap



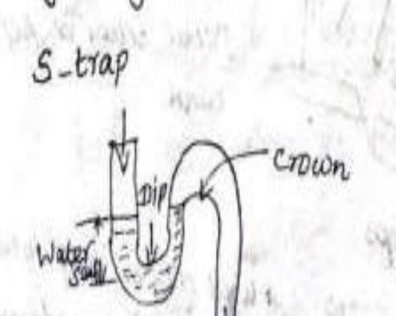
Legs are at right angles to each other

Q-Trap or half S-trap



Two legs meet at an angle other than a right angle.

S-trap



Both the legs are parallel to each other

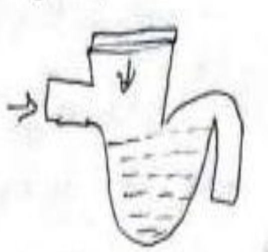
Floor Trap or Nahni Trap

* Used to collect waste...

Kitchens and bathrooms

* It forms the starting point of waste water floor.

Gully Trap

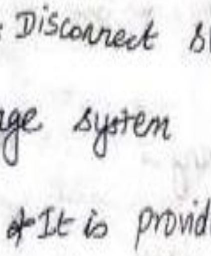


* Disconnect sullage drain from main drainage system

* It is provided at the external face of a wall.

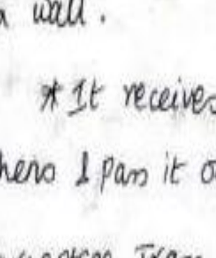
* It receives wastewater from baths, kitchens & pass it on to the house drain.

Intercepting Traps



* provided at the junction of house drain with the public sewer or septic tank.

Grease Traps



* used only in large hotels, restaurants or industries

* If oil, grease not separated, it will stick to building drainage system results in formation of ugly scum

Sanitary Fittings

1. Wash Basin

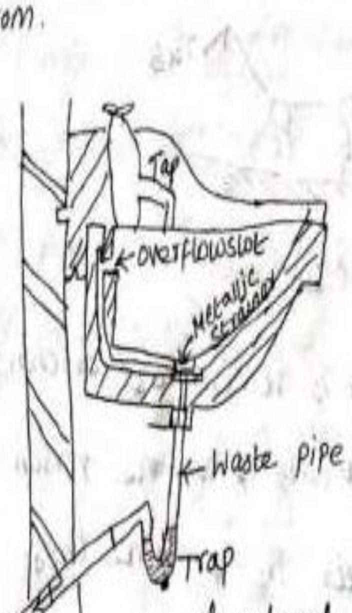
* Made of pottery or porcelain ware

* Mounted on brackets on wall

* It has an oval shaped bowl, with an overflow slot at the top.

* The waste pipe with a metallic strainer is provided at the bottom of the bowl.

* The waste pipe has a trap at its bottom.



2. Sink.

* Sink is used in kitchen or laboratory

* May be made of glazed fire clay, stainless steel, metal porcelain

* Rectangular shape is common in kitchens.

* The outlet pipe, may discharge over a floor trap or nahni trap.

resistant or high alumina cement may increase pipe life by 3 to 5 times

* RCC pipes are manufactured with sulphate resistant cement when the soil contains sulphur.

* Depth of flow of about 0.8D will minimize the chance of corrosion.

* Good ventilation is necessary.

* periodic flushing of sewers is efficient.