S.S.T

Unit - I

⊠ System of Sewage :→

The water carriage system can be divided into the following types :-

1) Separate System
2) Combined System
3) Partially Separate System

1) Separate System :→

- It provides two separate systems of sewers - the one intended for the conveyance of foul sewage only, such as domestic wastewaters and the other for the rain water, including the surface washing from certain streets, overflow from public baths and foundations etc.
- The sewage from the first system of sewers can be led to the treatment works, while the flow from the second system of sewers can be discharged directly to natural streams etc without any treatment.

Advantages :-

(a) The cost of installation is low
(b) The load on the treatment units will be lowered.
(c) The sewages will be of more uniform character.
(d) There is no necessity of providing automatic flushing tanks, for use in dry weather.
(e) Rain water can be discharged into streams or rivers without any treatment.

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Disadvantages :→

(a) Since the sewers are of small size, it is difficult to clean them.

(b) They are likely to get chocked

(c) Two sets of sewers may ultimately prove to be costly.

(d) Storm water sewers or drains comes in use only during the rainy season.

(e) Because of lesser air contact in small size sewers, foul smell may be there due to the sewage gas formed.

2) Combined System :→

- This provides only one sewer to carry both the foul sewage as well as the rain water.
- The sewage and rain water are carried to the sewage treatment plant, before its final disposal.
- This is advocated on the ground that the street surface washings are as impure as the sewage itself, and should therefore be suitably treated before being allowed to enter the natural stream.

Advantages :→

(i) The system requires only one set of sewers. Hence the maintenance cost is lowered.

(ii) The sewers are of larger size, and therefore the chances of their choking are rare. Also, it is easy to clean them.

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(iii) The strength of the sewage is reduced by dillution.

(iv) There is more air in the larger sewers than in smaller ones of the separate system.

Disadvantages:→

(i) The cost of construction are very high

(II) Because of larger size of sewers, their handling and transportation is difficult.

(iii) During heavy rains, the sewers may overflow, and may thus create unhygienic conditions and cause pollution problems.

(IV) Storm water is unnecessarily polluted.

(V) The large sewers get easily silted if not properly designed

(Vi) Large sewers are more difficult to be ventilated than the smaller ones.

3) **Partially Combined System:→**

- In this system, only one set of underground sewers is laid.
- These sewers admit the foul sewage as well as the early washings by rains.
- As soon as the quantity of storm water exceeds a certain limit, the storm water overflows, and is thus collected and conveyed in open drains to the natural streams.

- The foul sewage, however, continues to the flow in the sewers.

Advantages:-

i) The sewers are of reasonable size. Their cleaning is not very difficult.
ii) It combines the advantage of both the separate as well as the combined systems.
iii) The storm water permitted in the sewers eliminates its chances of chocking
iv) The problem of disposing off storm water from homes is simplified.

Disadvantages:→

1) During the dry weather, when there is no rain water, the velocity of flow will be low.
2) The storm water increases the load is ~~no~~ on treatment units.
3) The storm water also increases the cost of pumping.

Factors governing choice of separate system:-

(a) Financial aspects (b) Flat topography
(c) Rainfall Pattern (d) Outlet Conditions
(e) Pumping aspects (f) Steep topography
(g) Subsoil Conditions (h) Development pattern

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* Combined System:
(a) Space considerations ~~(b) Etc~~
(b) Integrated development
(c) Even rainfall pattern
(d) Pumping requirements

* The total wastewater flow can be divided two components:
(a) Dry weather flow (D.W.F)
(b) Storm water flow or Runoff

* Dry Weather flow :→
• It is that quantity of wastewater that flows through a sewer in dry weather when no storm water is in the sewer.
• The dry weather flow is also sometimes called as "Sanitary Sewage", and is obtained from the following sources:
(i) Domestic wastewater :→
A certain quantity of water is being supplied daily by the Water Works Department, for domestic use. This water gets consumed in various ways, and therefore all of it does not reach the sewer. The wastewater reaching the sewers will be that part of water which is used for flushing water closets, etc.

(ii) Industrial Wastewater :→
This is the wastewater generated by the industry after consuming water for its manufacturing processes.

(iii) Waste Water from public facilities :-
This is the wastewater from schools, cinemas, hotels, railways stations, street washings.

(iv) Ground Water infiltration :
Depends upon the soil type, material of sewers, nature and condition of sewer joints, depth of sewer and position of water table

Factors Affecting Dry Weather Flow :-
(i) Rate of water supply
(ii) Population growth → Arithmetic & all methods
(iii) Type of area served
(iv) Infiltration of ground water

(b) Storm Water flow :→
Runoff or storm water flow depends upon the following factors :
(i) Catchment area (ii) Ground slope
(iii) Permeability of ground
(iv) Extent of impervious area
(V) Rainfall duration

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(vi) Climatic factors.

Estimated by (a) Rational Method
(b) Empirical Method

Variations in Rate of Sewage :→

- The rate of sewage flow is not constant.
- The variations in the flow may be due to several factors, such as habits of the people, working hours of the office, climatic conditions, timings of supply, type of industries etc.
- In the residential areas the sewage flow rises by about 6 AM and reaches the maximum between 8 AM – 10 AM. The rate of flow then rises again.
- The relation b/w the max. & the avg. rate of flow of sewage for residential area can be given by:

(i) Babbit's formula:

$$Q_{max} = \frac{5 Q_{av}}{P^{0.2}}$$

(ii) Harmon's formula:

$$Q_{max} = \left(1 + \frac{14}{4 + P^{0.5}}\right) Q_{av}$$

Where,

Q_{max} = Max. rate of flow

Q_{av} = Avg. " " "

P = Pop. in thousands

- The first formula is restricted to max. value of P = 1000 & a min. value of P = 1.
- There is no limitations in 2nd formula

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Shapes of Sewer :→

(1) Circular Shaped

(2) Egg Shaped

1) Circular Shaped :→

This is most commonly used.

Advantages :–

(i) They are very easily manufactured

(ii) It gives max. area for a given perimeter, and thus gives the greatest H.M.D when running full or half full.

(iii) It is the most economical section

(iv) It has uniform curvature all around

2) Egg Shaped Sewers :→

- Circular sewers are suitable only where variation in discharge is not large. They are suitable with separate sewerage system.
- For combined system, egg shaped sewers (also called ovoid sewers) are more suitable.

Advantage :–

(i) Has slightly higher vel. for low flows over than circular sewer of equal capacity.

Disadvantages :→

(i) Unstable bcoz its small end is down.

(ii) It is more difficult to construct

(iii) It is expensive

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(iv) In the absence of adequate gradient, it is not self-cleansing.

Forms:→

(a) Standard or Metropolitan Section

(b) New shaped section.

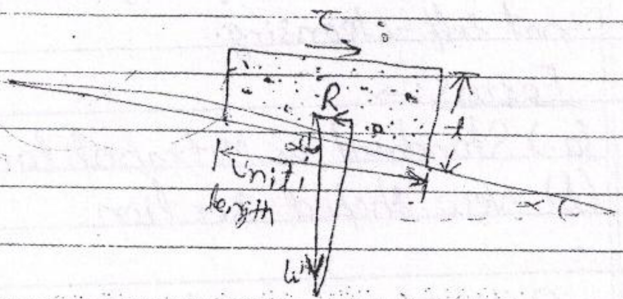
[*] Self Cleansing Velocity and Slopes:→

- A self cleansing vel. may be defined as that vel. at which the solid particles will remain in suspension, without settling at the bottom of the sewer.
- Also it is that velocity at which even the scour of the deposited particles of a given size will taken place.
- It is not possible to maintain this self-cleansing vel. throughout the day because of fluctuations in sewage flow.
- During min flow of sewage, the vel. of flow is less than the self cleansing velocity.
- Hence, self cleansing vel. should be maintened atleast once in a day.

[*] Shield's Expression for self-cleaning velocity:—

N Shield, the vel. required to transport water borne solids is the self cleansing velocity

Diagram shows forces acting on Sediment



Consider a layer of ~~unit~~ sediment of unit length, unit width and thickness t, deposited at the invert of the sewer. Let the slope of sewer be α. The drag force or the intensity of tractive force (τ) exerted by the ~~following~~ flowing water on a channel is given by:-

$$\tau = \gamma_w . R . S \quad \text{--- (1)}$$

where, γ_w = Unit wt. of water

R = Hydraulic radius of filled section

S = Slope of the invert or head loss per unit length

The submerged unit wt. of the sediment is

$$\gamma_{sub} = \gamma_w \left(\frac{G_s - 1}{1+e}\right) = \gamma_w (G_s - 1)(1-n) \quad \text{--- (2)}$$

G_s = Sp. Gravity of Sediment

e = Void ratio " " deposit

wt of sediment is given by

$$W = \gamma_{sub} \times 1 \times 1 \times t$$

$$\therefore W = \gamma_w (G_s - 1)(1-n) t \quad \text{--- (3)}$$

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Frictional Resistance R is given by

$$R = W\sin\alpha = \gamma_w (G_s - 1)(1-n)t \cdot \sin\alpha \quad — (4)$$

where, α is the friction angle

when the sediment is just on the pt. of sliding.

$$\tau = R$$

$$\therefore \gamma_w \cdot R \cdot S = \gamma_w (G_s - 1)(1-n) \cdot t \cdot \sin\alpha$$

Putting $(1-n)\sin\alpha = k$, where k is the imp char. of the sediment, to be determined by experiment,

$$S = \frac{k}{R}(G_s - 1)t \quad — (5)$$

For Single grains, d_s = dia. of the grains = t

$$\therefore S = \frac{k}{R}(G_s - 1)d_s \quad — (6)$$

Eq(6) gives the invert slope at which the vel. will be self-cleansing.

Now from Chezy's eqn

$$V = C\sqrt{RS}$$

$$\text{or, } V_s = C\sqrt{R}\sqrt{\frac{k}{R}(G_s - 1)d_s} \quad [\because V = V_s]$$

$$\text{or } \boxed{V_s = C\sqrt{k(G_s - 1)d_s}} \quad — (7)$$

By Darcy-Weisbatch,

Let H_L = Head Loss

$$H_L = \frac{fLV^2}{2gD} \quad (\text{where } D = \text{Pipe dia.})$$

$$\therefore S = \frac{H_L}{L} = \frac{fV^2}{2gD}$$

Now $V = C\sqrt{RS}$

$$\therefore C\sqrt{R} = \frac{V}{\sqrt{S}} = \sqrt{\frac{2gD}{f}}$$

For circular pipes running full, $R = \frac{D}{4}$

$$\therefore C\sqrt{\frac{D}{4}} = \sqrt{\frac{2gD}{f}}$$

$$\text{or, } C = \sqrt{\frac{8g}{f}} \quad \text{—— (8)}$$

Putting value of C in eq. (7)

$$\boxed{V_S = \sqrt{\frac{8\beta}{f}(G_S - 1)\,g\,d_s}} \quad \text{—— (9)}$$

where,

V_S = Self cleansing vel.

β = char. of solids flowing in the sewage

= 0.4 for initiating scour of clean

= 0.8 for full removal of sticky grit

f = Darcy-Weisbatch friction factor = 0.03

G_S = Sp. Gravity of sediments/solids

= 2.65 for inorganic sediments

= 1.9 " organic "

g = Gravitational acc. constant

d_s = dia. of solid particles

IX Construction And Layout of Sewer Lines :→

(1) Settling out (2) Alignment & Gradient

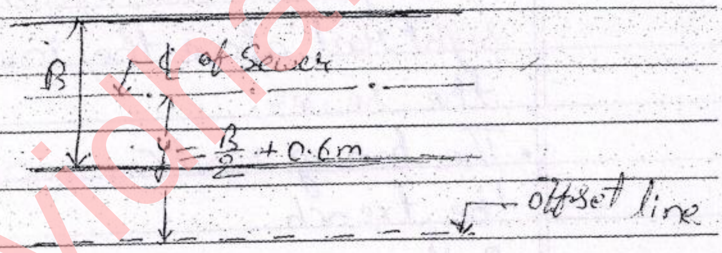
(3) Excavation of trenches, timbering and dewatering

(4) Laying & Jointing (5) Testing and

(6) Backfilling

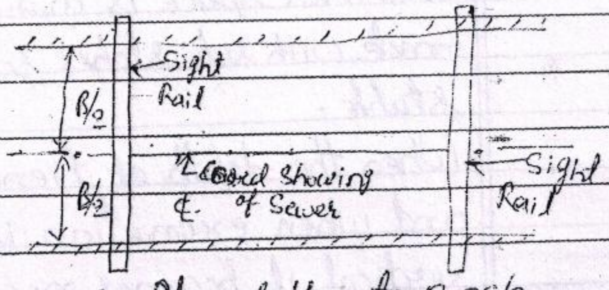
(7) **Setting Out :→**

- The setting out in the sewage work is carried out, starting from the tail end or out-fall end, and proceeding upwards.
- The advantage of this is the utilization of tail sewers even during the initial period of construction.
- If on the contrary, this is done from head-end the function of the sewerage scheme has to wait till the completion of the entire scheme.



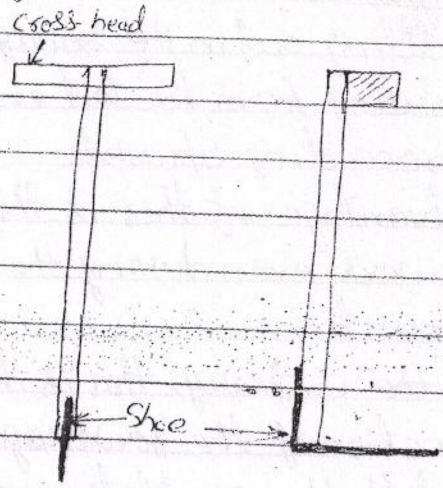
(9) **Alignment and Gradient :→**

- The sewers are laid to correct alignment and gradient with the help of boning rods and sight rails.



(a) Plan of the trench

- A boning rod or a traveller is a vertical wooden post suitably shod with shoe iron and fitting fitted with a cross-head or tee.



(b) Boning Rod

- Its length is made equal to the ht. of sight rail above the invert line of the sewer.
- The boning rod can move to and fro in the trench.
- ~~Both~~

(3) Excavation of trench, timbering & dewatering:

- The work of excavation is usually carried out in open cutting.
- Wherever space is available, excavation is made with side slopes so that the slopes are stable.
- When the depth of trench exceeds 1.5 to 2m and when excavation is made with side vertical, it becomes necessary to support the side by sheeting bracing. This operation is known as timbering of trench.

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which may be done by:-
(i) Stay bracing (ii) Box sheeting
(iii) Vertical sheeting (iv) Runner sheeting
(V) Sheet pill piling
- Excavation can be carried out by dewatering the subsoil water and is done by:
(i) Ditches and sumps (ii) Well pt. system
(iii) Shallow well system (iv) Deep well method
(V) Vaccum method (Vi) Electro-osmosis method.

(4) **Laying and jointing:→**

Stone ware
- Pipes are laid with sockets facing up the gradient on desired bedding.
- The R.C.C. pipes are laid in position over proper bedding, the type of which may be determined in advance, the abutting faces of the pipe being coated by means of a brush with bitumen in liquid condition.
- The finished joint should be protected and cured for atleast 24 hours.
- Spigot and Socket R.C.C. pipes are laid and jointed in a manner similar to stone ware spigot and socket pipes.

(5) **Hydraulic testing of pipes:-**

Before backfilling, the pipe are hydraulically tested.

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(6) **Backfilling the trench :→**

- Trenches should be backfilled immediately after the pipe is laid and tested.
- No water should be permitted to rise in the unbackfilled trenches.
- Filling is done at diff. stages, at each stage the filling should be well, rammed, consolidated and completely saturated with water and then only further line should be continued.
- Where trenches are in fields, the backfilling above the 600mm level is not tamped.

[*] **Testing of Sewer Lines :→**

Following tests are performed:
(1) Test for straightness and obstruction
(2) Water test (3) Smoke test
(4) Air test

1) **Test for Straightness and obstruction :→**

- As Tested by two methods
(a) At the high end of the sewer (or drain), a smooth ball of dia. 13mm less that the pipe bore is inserted. If there is no obstruction in the form of yarn or mortar projecting through the joint, the ball will roll down the

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invert of the pipe and emerge at the lower end. (Alternatively a double disc or solid or closed cylinder 75mm less in dimension than the internal dimension of the sewer may be run through the stretch of the sewer to ensure that it is free from any obstruction)

(b) A mirror is placed at one end of the sewer line and lamp at the other end. If the pipe line is straight, the full circle of light will be observed. If the pipe line is not straight this would be apparent. The mirror will also indicate any obstruction in the pipe barrel.

2) Water Test :→

- This is done to find out the water tightness of the joints.
- This is carried out after giving sufficient time for the joints to set.
- The sewers are tested by plugging the upper end with a provision for an air outlet pipe with stop clock.

3) Smoke test :→

- This is carried out for drainage pipes located in buildings.
- The smoke is produced by burning oil waste tar paper etc in the combustion chamber of a smoke machine.

- The pipes are approved gas-tight by the smoke test conducted under pressure of 25 mm of water, maintained for 15 minutes after all traps/seals have been filled with water.

4) **Air testing:→**

Air testing becomes necessary, particularly in large dia pipes when the required quantity of water is not available for testing.

- It is done by subjecting the stretch of pipe to an air pressure of 100 mm of water by means of a hand pump.

⊠ Maximum Velocity of flow or Limiting Velocity

- At higher velocity, the flow becomes turbulent resulting in continuous abrasion of the interior surface of the sewer, by the suspended particles.
- Hence max. vel. of flow is also limited.
- The max. vel. at which no such scouring action or abrasion takes place is known as non-scouring velocity.
- Such a vel. depends upon the material used for the construction of sewers.
- Abrasion is max. at the bottom of the sewer, because the sand etc. are heavy and travel along the invert.

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