GOVERNMENT POLYTECHNIC

BHUBANESWAR-23

DEPARTMENT OF CIVIL ENGINEERING

LECTURE NOTES

Year & Semester: 3RD Year, 5TH Semester

Subject code/Name -Th-4, WATER SUPPLY & WASTE WATER ENGINEERING

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Quantity & Quality of Sewage

Quantity of Sanitary Sewage

- Sanitary sewage includes all the liquid waste generated from households & industries. This is also called Dry weather flow (DWF)
- Dry weather flow depends on the population of a community & per capita sewage flow.
- Per capita sewage flow is the amount of per capita water supply that turns into sewage. Generally it is assumed that 70 to 80 percent of water supplied turns into sewage

Therefore Dry weather flow is given by

$$Q_{DWF} = \text{Population} \times \text{Per capita sewage flow}$$

$$= \text{Population} \times \text{Per capita water supply} \times \text{factor}$$

where factor lies between 0.7 & 0.8

Variation in Sewage flow

- Max. Daily flow = 2 × avg. daily flow
- Max. Hourly flow = 1.5 × Max. daily = 3 × avg. daily
- Minimum daily flow = 2/3 × avg. daily
  Min. hourly flow = 1/2 × min. daily = 1/3 × avg. daily

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(Q1) The Projected Population of a city is 60,000 spread over an area of 50 hectare. Find the design discharge for separate sewer line by assuming rate of Water Supply of 250 lpcd & out of this only 75%. reaches in sewer as Waste water Make necessary assumption

Solution : Given

Population = 60,000

Rate of water supply = 250 lpcd

Percentage Converted into Sewage = 75% = 0.75

Q_{DWF} = Population × per capita water supply × factor

= 60,000 × 250 l/d × 0.75

= 11250000 l/d = $\frac{11250000 \times 10^{-3} \, m^3}{24 \times 60 \times 60 \, sec}$

= 0.13020 m^3/second

(Q2) The Projected Population of a city is 1 lakh spread over 100 hectare. find the design discharge in m^3/s for a separate Sewer line by assuming rate of water supply of 200 lpcd & out of this only 80% reaches in Sewer as Waste Water.

Solution : Given Population 100000

Rate of Water Supply 200 lpcd

Percent Converted in Sewage 80% = 0.8

Q_{DWF} = Population × Per Capita water Supply × factor

= 100000 × 200 l/d × 0.8

= $\frac{100000 \times 200 \times 10^{-3} \times 0.8}{24 \times 60 \times 60}$ = 0.185 m^3/s

of Sewer

sign of sewer includes fixing the cross section of sewer & gradient (slope)

- To find size of sewer and gradient 2 equations are generally used.

1. Continuity Equation $\boxed{Q = A \cdot V}$
2. Manning's formula $\boxed{V = \frac{1}{n} R^{2/3} \cdot S^{1/2}}$, where V = velocity of flow
   n = manning's coefficient
   R = Hydraulic Mean Radius
   & S = Bed slope.

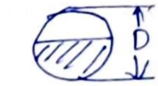
To find velocity of flow, Chezy's formula can also be used which is given by

$\boxed{V = C\sqrt{m \cdot i}}$ where m = hydraulic mean depth = A/P
V = Velocity of flow in m/s
i = Slope of sewer
C = chezy's constant.

- Hydraulic mean Radius = R = $\frac{\text{Wetted area}}{\text{Wetted perimeter}} = \boxed{A/P}$

Example (i) if sewer is running full  then

$$\boxed{R = \frac{\frac{\pi}{4}D^2}{\pi D} = D/4}$$

(ii) if sewer is running half full  then

$$\boxed{R = \frac{A}{P} = \frac{\frac{\pi}{8}D^2}{\frac{\pi D}{2}} = D/4}$$

Q1) Determine the velocity of flow in a circular sewer of diameter 150cm laid on a slope of 1 in 750 while flowing full. Take chezy's C = 67.13

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∴ The hydraulic mean depth $m = A/P = D/4$

$$m = \frac{1.50m}{4} = 0.375$$

given $C = 67.13$

& $i = 1 \text{ in } 750 = 1/750$

So Velocity of flow $V = C\sqrt{mi} = 67.13\sqrt{0.375 \times \frac{1}{750}} = 1.50 m/sec$

Q2) Determine the Velocity of flow in a sewer running one half full. The sewer is laid at 1 in 550 slope. The diameter of sewer is 150cm. Also determine discharge flowing through the sewer. Assume $n = 0.012$ in Manning's formula.

Solution :- Given data

Sewer running one half full so. $R = D/4 = \frac{1.50m}{4} = 0.375$

$n = 0.012$

$S = 1/550$

so Velocity $V = \frac{1}{n} R^{2/3} S^{1/2}$

$$= \frac{1}{0.012} \times (0.375)^{2/3} \cdot \left(\frac{1}{550}\right)^{1/2}$$

$$= 1.847 \, m/sec$$

Discharge $Q = A \cdot V$

$$= \left(\frac{\pi}{8} \cdot D^2\right) \cdot V$$

$$= \frac{\pi}{8}(1.5)^2 \cdot (1.847) = 1.63 \, m^3/sec$$

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WAR

Circular sewer 30cm in diameter was designed for a town with population 15000. If the rate of water supply is 150lpcd & 80% of water supplied is converted into sewage. What slope should be provided to the sewer if it is running full. Assume manning's $n = 0.01$

Solution: Given data

$n = 0.01$

$D = 0.3m$

Population = 15,000

factor = 0.8

$R = A/P = D/4 = \frac{0.3}{4} = 0.075m$

$A = \frac{\pi}{4} D^2 = \frac{\pi}{4}(0.3)^2 = 0.07 m^2$

Q = population × percapita water supply × factor

$= 15,000 \times 150 lpcd \times 0.8 = 18 \times 10^5$ lpcd

$= \frac{18 \times 10^5 \times 10^{-3}}{24 \times 60 \times 60} = 0.02 m^3/s$

Using Equation of continuity $Q = A \cdot V$

so $0.02 = (0.07) \times V \Rightarrow V = 0.28 m/s$

using manning's formula.

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

$\Rightarrow 0.28 = \frac{1}{0.01}(0.075)^{2/3} \cdot S^{1/2}$

$\Rightarrow S = \left(\frac{0.28 \times 0.01}{(0.075)^{2/3}}\right)^2 = 2.4 \times 10^{-4} = \frac{1}{4166.66}$

...ing Velocities of flow

Self cleansing velocity: It is the minimum velocity of flow at which settling of substances doesnot occur. At this velocity both floating & heavy solids gets transported easily.

Non-Scouring Velocity: It is the maximum velocity of flow at which no scouring of sewer occur. It depends upon the type of sewer. for example if it is a CC or RCC sewer then non-scouring velocity will be between 2.5 to 3 m/sec.

- Therefore the velocities of sewage flow in a sewer should be anywhere between self-cleansing velocity & non-scouring velocity.

Strength of Sewage

The strength of sewage is defined as the amount of dissolved and suspended matter present in sewage, as determined by biochemical oxygen demand or suspended solids.

AR stics of sewage

(1)

To find the pollution potential of sewage, various characteristics of sewage are studied. They are:-

(a) Physical characteristics
(b) Chemical characteristics
(c) Biological characteristics

a) Physical characteristics

The most important physical characteristics are

- Temperature
- Turbidity
- colour
- odour

Temperature :- Temperature of sewage is slightly higher than the water supplied to the community. If temp is equal to 30°c it indicates fresh sewage whereas if temp is greater than 30°c then it is septic sewage. At higher temperatures the sewage gets stale more quickly & septic than at lower temperature.

Turbidity :- Turbidity of sewage directly depends on the quantity of solid matters present in the suspension state. If turbidity is less it indicates fresh sewage else stale & septic sewage.

Colour : fresh domestic sewage has a soap solution colour whereas if the colour is brown to black then decomposition has already started & it indicates septic stale sewage.

Odour: fresh domestic sewage has slightly soapy or oily odour whereas stale sewage has foul odour of hydrogen sulphide or sulphur compounds.

characteristics

mportant chemical characteristice are

- Total solids
- pH
- Chloride content
- Nitrogen content
- Dissolved Oxygen
- Chemical Oxygen Demand & Bio-chemical Oxygen Demand

Total Solids

Its Amount of all solids present in sewage, includes suspended solids dissolved solids & settleable solids. The total solids percentage in sludge varies from 0.25% to 12% & the moisture content is from 88% to 99.75%. Hence estimation of solids will help in finding the degree of treatment to be given before disposing.

pH

The fresh sewage is alkaline in nature but as time passes pH tends to become acidic due to the production of acids by bacterial action in anaerobic process. Knowing the pH of sewage is important as the effeciency of certain treatment methods depends upon availability of pH.

Chloride

If chloride content in waste water is high, it indicates the presence of Industrial waste.

Nitrogen

Nitrogen may be present in waste water as free ammonia, Albuminoid nitrogen, nitrites & nitrates.

→ free ammonia indicates first stage decomposition of organic matter

→ Albuminoid nitrogen indicates quantity of nitrogen before decomposition of organic matter starts.

→ nitrites indicates presence of partly decomposed organic matter &

→ Nitrates indicates fully oxidised organic matter

- Determination of dissolved oxygen present in sewage [illegible] because while discharging the treated Waste Water into river it is necessary to ensure at least 4ppm of D.O else aquatic life may be destroyed.

Chemical Oxygen Demand

- It is the amount of oxygen demanded to decompose bio-degradable & non-biodegradable organic matter present in Waste Water. It is useful in determining the strength of Industrial waste water which cannot be determined by B.O.D test.

Biochemical Oxygen Demand (B.O.D)

Defined as amount of Oxygen demanded by microorganisms to decompose biodegradable Organic matter present in Waste water Under aerobic conditions. Knowing the BOD the Organic Strength of Waste Water is estimated.

(c) Biological Characteristics

The bacterial characteristics of Waste Water are due to the presence of bacteria and other living microorganisms, such as algae, fungi, Protozoa etc. They are useful & helpful in bringing oxidation and decomposition of Waste Water.

Sewage Sampling is collection of sample of sewage for testing. As the constituents of sewage continuously change with time & position in tanks. Therefore the samples of sewage are collected over a period of 24hrs after one hour intervals. All samples collected are kept in a cool place so that the bacteriological activities may not change the character of sewage before its examination.

Then each sample should be tagged with source, date, time etc.

Tests for solids, pH, dissolved oxygen, BOD, COD

Solids:

- Total solids present in sewage are obtained by evaporating a measured vol. of sewage & weighing the residue.
- Settleable solids are suspended solids, which will settle in one hour to the bottom of cylinder of specific height.

The Qty. of settleable solids can be measured volumetrically using an Imhoff cone. An Imhoff cone is a conical glass of one litre capacity, graduated at its bottom in millilitres. The sewage is filled in the cone & vol. of solids settled in the bottom after one hour is directly noted which gives qty. of settleable solids. The settleable solids usually indicate the vol. of sludge which will settle in the tanks.

PH

- In labs pH is determined using a pH meter.

dissolved Oxygen test

- Dissolved oxygen analysis measure the amount of gaseous oxygen dissolved in water or wastewater. Oxygen

dissolved in waste water encourages the growth of aerobic bacteria.
Dissolved Oxygen is measured by Winklers Iodometric method by titration.

BOD test

- Biochemical Oxygen Demand test is one of the most important & basic test used for waste water. It is essentially a measure of the biological & chemical component of the waste in terms of dissolved oxygen needed by natural aerobic biological systems (microorganisms) to break down the waste under defined conditions.
- BOD test is carried out by determining dissolved oxygen on the waste water or diluted mixture at the beginning of the test period, incubating the waste water mixture at 20°c & det. the dissolved oxygen after 5 days. The diff. of DO between the initial & fifth day represents BOD.

COD test

COD is measured by conducting test using Reflux apparatus or COD digester & using chemical reagents such as potassium dichromate (oxidant), Mercuric sulphate (Inhibitor) Silver Sulphate (catalyst) & conc. H_2SO_4 (Acidic medium). After 24 hrs of refluxation (boiling) the remaining Potassium dichromate measured by titration. & COD is estimated.

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