Module 4:
Quantity Estimation of Sewage

Lecture 4:
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4.0   QUANTITY ESTIMATION OF SEWAGE

4.1   Introduction

The sewage collected from the municipal area consists of wastewater generated from the residences, commercial centers, recreational activities, institutions and industrial wastewaters discharge in to sewer network from the permissible industries located within the city limits. Before designing the sewer, it is necessary to know the discharge i.e., quantity of sewage, which will flow in it after completion of the project.

Accurate estimation of sewage discharge is necessary for hydraulic design of the sewers. Far lower estimation than reality will soon lead to inadequate sewer size after commissioning of the scheme or the sewers may not remain adequate for the entire design period. Similarly, very high discharge estimated will lead to larger sewer size affecting economy of the sewerage scheme, and the lower discharge actually flowing in the sewer may not meet the criteria of the self cleansing velocity and hence leading to deposition in the sewers. Actual measurement of the discharge is not possible if the sewers do not exist; and where the capacity of the existing sewers is inadequate and need to be increased, still actual present discharge measurement may not be accurate due to unaccounted overflow and leakages that might be occurring in the existing system. Since sewers are design to serve for some more future years, engineering skills have to be used to accurately estimate the sewage discharge.

4.2   Sources of Sanitary Sewage

1. Water supplied by water authority for domestic usage, after desired use is discharged in to sewers as sewage.
2. Water supplied to the various industries for various industrial processes by local authority. Some quantity of this water after use in different industrial applications is discharged as wastewater.
3. The water supplied to the various public places such as, schools, cinema theaters, hotels, hospitals, and commercial complexes. Part of this water after desired use joins sewers as wastewater.

4. Water drawn from wells by individuals to fulfil domestic demand. After uses this water is discharged in to sewers.

5. The water drawn for various purposes by industries, from individual water sources such as, wells, tube wells, lake, river, etc. Fraction of this water is converted in to wastewater in different industrial processes or used for public utilities within the industry generate wastewater. This is discharged in to sewers.

6. Infiltration of ground water into sewers through leaky joints.

7. Entrance of rainwater in sewer lines during rainy season through faulty joints or cracks in sewers.

4.3   Dry Weather Flow

Dry weather flow is the flow that occurs in sewers in separate sewage system or the flow that occurs during dry seasons in combined system. This flow indicates the flow of sanitary sewage. This depend upon the rate of water supply, type of area served, economic conditions of the people, weather conditions and infiltration of ground water in the sewers, if sewers are laid below ground water table.

4.4   Evaluation of Sewage Discharge

Correct estimation of sewage discharge is necessary; otherwise sewers may prove inadequate resulting in overflow or may prove too large in diameter, which may make the system uneconomical and hydraulically inefficient. Hence, before designing the sewerage system it is important to know the discharge / quantity of the sewage, which will flow in it after completion of the project and at the end of design period.

Apart from *accounted water supplied* by water authority that will be converted to wastewater, following quantities are considered while estimating the sewage quantity:

a. *Addition due to unaccounted private water supplies*

People using water supply from private wells, tube wells, etc. contribute to the wastewater generation more than the water supplied by municipal authority. Similarly, certain industries utilize their own source of water. Part of this water after desired uses is converted into wastewater and ultimately discharged in to sewers. This quantity can be estimated by actual field observations.

b. *Addition due to infiltration*

This is additional quantity due to groundwater seepage in to sewers through faulty joints or cracks formed in the pipes. The quantity of the water depends upon the height of the water table above the sewer invert level. If water table is well below the sewer invert level, the infiltration can occur only after rain when water is moving down through soil. The quantity of the water entering sewers depends upon the permeability of the ground soil and it is very difficult to estimate. While estimating the design discharge, following suggested discharge can be considered (Table 4.1).

Table 4.1 Suggested estimates for ground water infiltration for sewers laid below ground water table (CPHEEO Manual, 1993)

Unit	Minimum	Maximum
L/ha.d	5000	50000
L/km.d	500	5000
L per day per manhole	250	500

Storm water drainage may also infiltrate into sewers. This inflow is difficult to calculate. Generally, no extra provision is made for this quantity. This extra quantity can be taken care of by extra empty space left at the top in the sewers, which are designed for running ¾ full at maximum design discharge.

c. Subtraction due to water losses
The water loss, through leakage in water distribution system and house connections, does not reach consumers and hence, not appear as sewage.

d. Subtraction due to water not entering the sewerage system
Certain amount of water is used for such purposes, which may not generate sewage, e.g. boiler feed water, water sprinkled over the roads, streets, lawns, and gardens, water consumed in industrial product, water used in air coolers, etc.

Net quantity of sewage: The net quantity of sewage production can be estimated by considering the addition and subtraction as discussed above over the accounted quantity of water supplied by water authority as below:

Net quantity of sewage	=	Accounted quantity of water supplied from the water works	+	Addition due to unaccounted private water supplies	+	Addition due to infiltration	-	Subtraction due to water losses	-	Subtraction due to water not entering the sewerage system

Generally, 75 to 80% of accounted water supplied is considered as quantity of sewage produced.

4.5   Variation in Sewage Flow

Variation occurs in the flow of sewage over annual average daily flow. Fluctuation in flow occurs from hour to hour and from season to season. The typical hourly variation in the sewage flow is shown in the Figure 4.1. If the flow is gauged near its origin, the peak flow will be quite pronounced. The peak will defer if the sewage has to travel long distance. This is because of the time required in collecting sufficient quantity of sewage required to fill the sewers and time required in travelling. As sewage flow in sewer lines, more and more sewage is mixed in it due to continuous increase in the area being served by the sewer line. This leads to reduction in the fluctuations in the sewage flow and the lag period goes on increasing. The magnitude of variation in the sewage quantity varies from place to place and it is very difficult to predict. For smaller township this variation will be more pronounced due to lower length and travel time before sewage reach to the main sewer and for large cities this variation will be less.
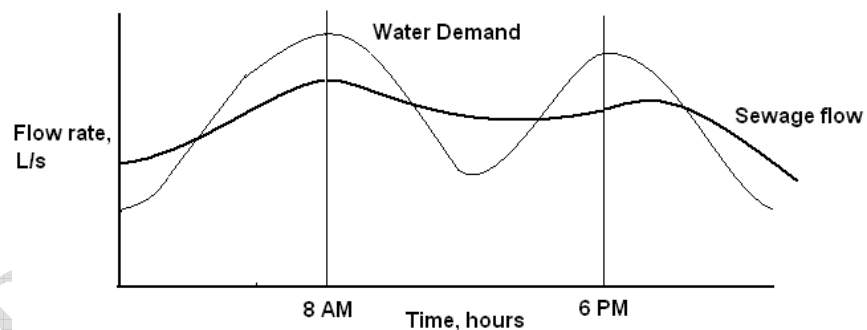

Figure 4.1 Typical hourly variations in sewage flow

For estimating design discharge following relation can be considered:

Maximum daily flow   =   Two times the annual average daily flow (representing seasonal variations)

Maximum hourly flow   =   1.5 times the maximum daily flow (accounting hourly variations)

                         =   Three times the annual average daily flow

As the tributary area increases, peak hourly flow will decrease. For smaller population served (less than 50000) the peak factor can be 2.5, and as the population served increases its value reduces. For large cities it can be considered about 1.5 to 2.0. Therefore, for outfall sewer the peak flow can be considered as 1.5 times the annual average daily flow. Even for design of the treatment facility, the peak factor is considered as 1.5 times the annual average daily flow.

The minimum flow passing through sewers is important to develop self cleansing velocity to avoid silting in sewers. This flow will generate in the sewers during late night hours. The effect of this flow is more pronounced on lateral sewers than the main sewers. Sewers must be checked for minimum velocity as follows:

Minimum daily flow = 2/3 Annual average daily flow

Minimum hourly flow = ½ minimum daily flow

                            = 1/3 Annual average daily flow

The overall variation between the maximum and minimum flow is more in the laterals and less in the main or trunk sewers. This ratio may be more than 6 for laterals and about 2 to 3 in case of main sewers.

4.6   Design Period

The future period for which the provision is made in designing the capacities of the various components of the sewerage scheme is known as the design period. The design period depends upon the following:

➢ Ease and difficulty in expansion,

➢ Amount and availability of investment,

➢ Anticipated rate of population growth, including shifts in communities, industries and commercial investments,

➢ Hydraulic constraints of the systems designed, and

➢ Life of the material and equipment.

Following design period can be considered for different components of sewage scheme.

1.	Laterals less than 15 cm diameter	:	Full development
2.	Trunk or main sewers	:	40 to 50 years
3.	Treatment Units	:	15 to 20 years
4.	Pumping plant	:	5 to 10 years

4.7   Design Discharge of Sanitary Sewage

The total quantity of sewage generated per day is estimated as product of forecasted population at the end of design period considering per capita sewage generation and appropriate peak factor. The per capita sewage generation can be considered as 75 to 80% of the per capita water supplied per day. The increase in population also result in increase in per capita water demand and hence, per capita production of sewage. This increase in water demand occurs due to increase in living standards, betterment in economical condition and changes in habit of people.

Questions

1.   Write about evaluation of design discharge for sanitary sewage.

2.   What is dry weather flow?

3.   Describe variation in sewage flow.   How design of different component of sewerage scheme will be affected due to this variation?

4.   What is design period? It depends on what parameters? Provide design period for different components of the sewerage.