Urban Utilities Planning: Water Supply, Sanitation and Drainage
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Module - 08
Water carriage system
Lecture - 37
Quality of Sanitary Sewage

Welcome back. In lecture 37 we will talk about Quantity of Sanitary Sewage.

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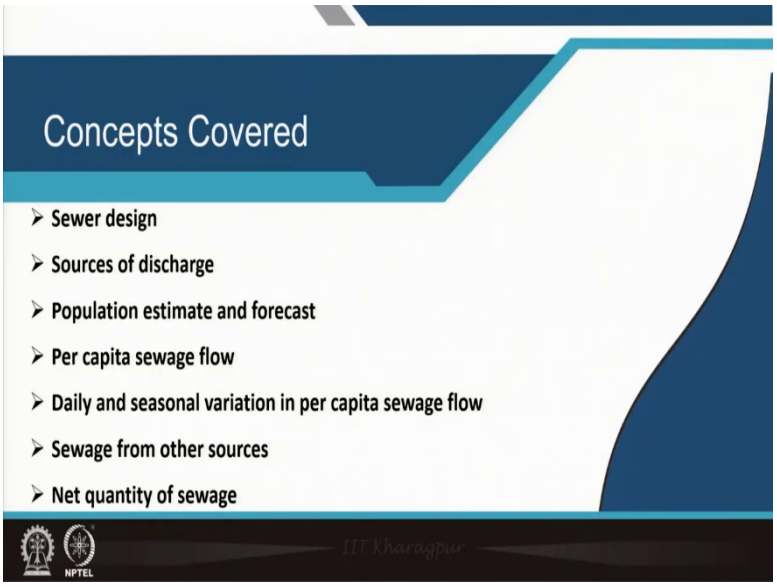

The different concepts that we will cover are sewer design, sources of discharge, population estimate and forecast, per capita sewage flow, daily and seasonal variation in per capita sewage flow, sewage from other sources and net quantity of sewage.

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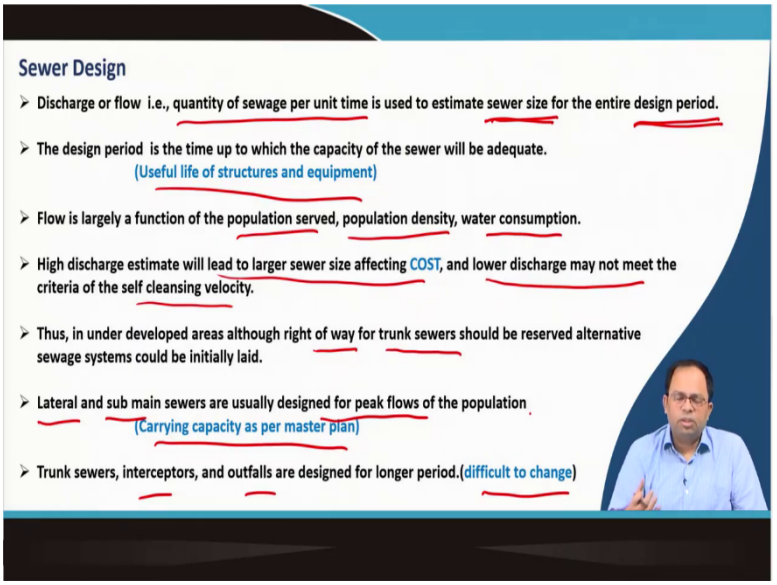

Sewer design

In sewer design, the discharge or flow i.e., the quantity of sewage per unit time, is used to estimate sewer size for the entire design period. The quantity of sewage per unit time is measured in cubic meter per second. The pipelines have to be designed considering the maximum or the peak flow rate.

Because we have a large network, it involves many sewer lines. So, gradually all lines reach a point where the sewage is actually disposed into the river. So, we will need to be careful about the depth of the lines. We use manholes to change the slope or sometimes for lifting sewage. Velocity is more or less fixed because of scouring and the design period is the for the timeline for which we are designing the system.

If the design period is for 30 years, the sewer should be capable to take the sewage load till the end of that design period. After this period we have to replace the pipelines.

Flow is largely a function of population served, population density and water consumption. The flow varies as per water that is supplied to that particular area, the total population that is served and also on the population density or how concentrated that population is. When we have too many people living in a smaller area; the flow rates would be higher. This will lead to larger sewer size which in turn increases the cost. Whereas, if discharge is lower, then it

may not be able to meet the self-cleansing velocity criteria. Sometimes in under developed areas, we should consider alternative sewage systems such as decentralized or on site systems in case the flow is on the lower side. We should have utility corridors along the roads along which many utility line pass and we should reserve spaces for trunk sewers.

Lateral and sub main sewers are usually designed for peak flows considering population carrying capacity as per master plan. Smaller areas are served by laterals or sub mains.

Trunk sewers, interceptors, outfalls are designed for longer period because these are difficult to change. So, even though there is a chance that we may be able to lay some new pipelines for some laterals in some areas of the city, the trunk sewers, the interceptors and the outfall points where the sewage actually falls into the river cannot be changed. So, pipelines in those areas are laid once and it has to serve the entire design period.

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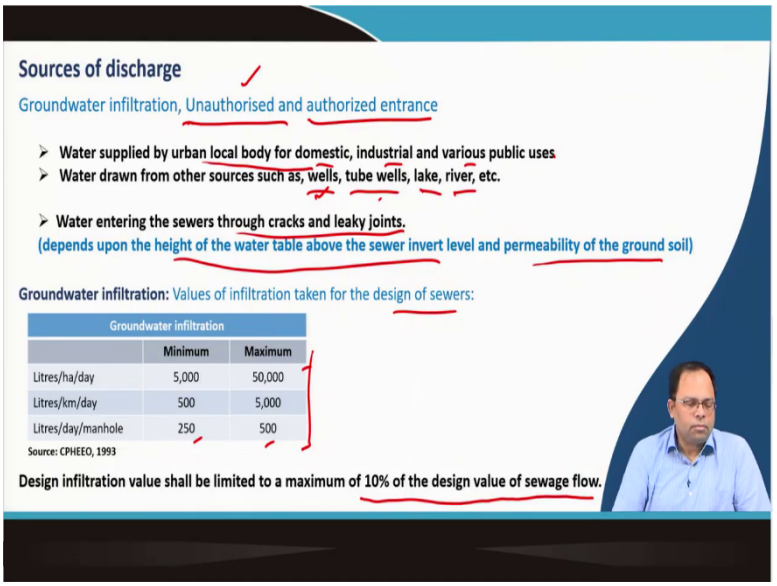

Sources of discharge

Sources of the sewage that is being generated in urban areas include three sources: groundwater infiltration, authorized entrances and unauthorized entrances.

Groundwater infiltration: Lot of groundwater enters into the sewage pipeline.

Authorized entrances: Connection to the sewer pipeline from authorized residences or businesses.

Unauthorized connections: There is no record of these connections because they have done it on their own.

The water that comes in through both authorized and unauthorized connection of the sewage along with groundwater infiltration has to be actually estimated. The water comes from the water supplied by the urban local body for domestic industrial and various public uses. However, municipality in most Indian cities supply cannot supply 135 lpcd per capita per day. So even though some residential units get adequate water, many other area and even in slums, the required water quantity is not available and people use other sources. Some people get this extra water from wells, tube wells, lakes and rivers. Many of the real estate projects in urban areas actually draw their water from underground using deep tube wells.

Since the municipality is not supplying them, we do not know exactly how much water is being drawn from the tube wells. All of this amount of water will also go into the sewerage network which have to be considered in the design.

Groundwater infiltration in the form of water entering the sewers through cracks and leaky joints depends on the height of the water table. If it is above the sewers invert level or the lower level of the sewer and permeability of the soil is adequate, in that particular case we will have lot of groundwater entering into the system.

So, we use certain standards or thumb rules in this regard. The values of infiltration taken for designing of sewer is around 5000 to 50000 litres per hectare per day or it could be 500 to 5000 litres per kilometre per day. It could also be estimated based on manholes because lot of groundwater enter via the manholes. Design infiltration value shall be limited to a maximum of 10 percent of the design value of sewage flow.

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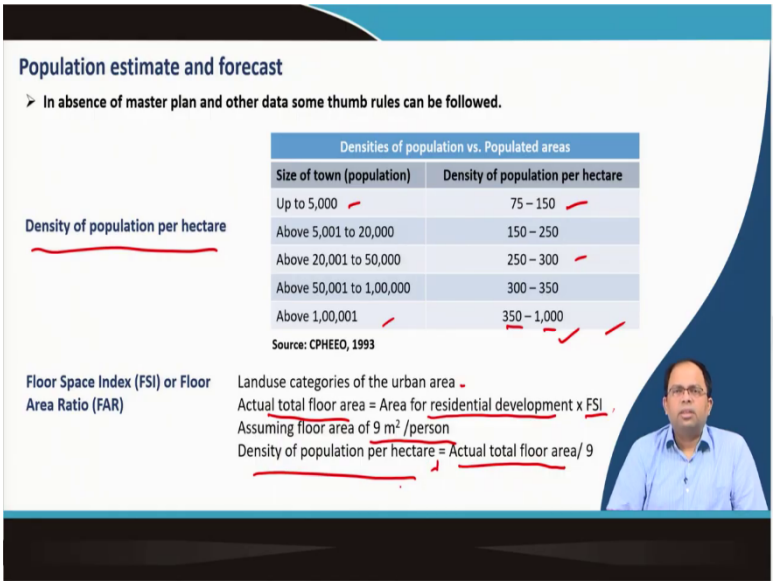

Population estimate and forecast

Usually, we use population forecast methods and in absence of master plan and other data some thumb rules can be utilized. The master plan gives us estimate of zone wise population, carrying capacity. In case of its absence, we can utilise density of population per hectare. The other way is to consider the floors space index (FSI) or floor area ratio (FAR).

In developed cities with high rise buildings, making using of population density will give incorrect estimate. In that case, FAR is a better indicator provided that we have land use categories of that particular zone to delineate the residential buildings, commercial buildings and so on.

For residential areas, we can assume that the area of the residential development multiplied by the FAR give us total floor area for residences and then assuming a floor area of around 9 square meter per person, we can determine the total amount of people living in a particular area.

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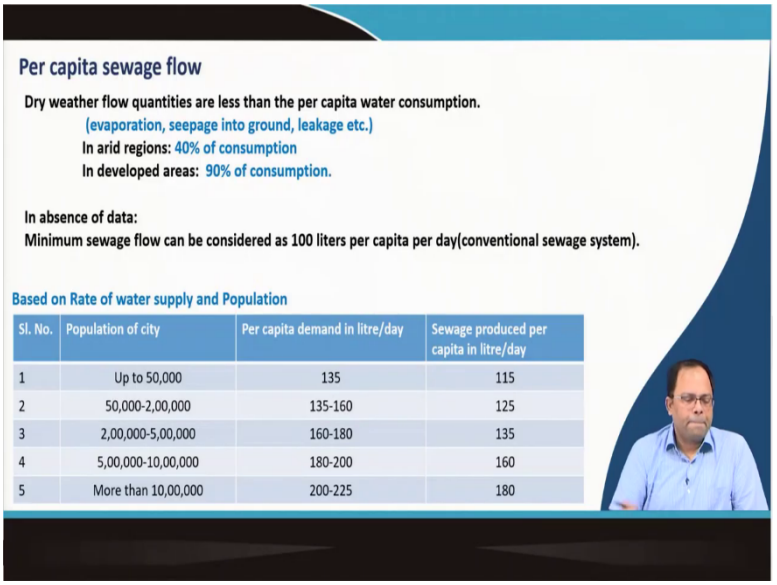

Per Capita Sewage Flow

Once we know the population for a particular area, we have to estimate the total per capita sewage flow, i.e., how much sewage is generated by a single person. So, if we are going for a conventional sewage system or a water carriage system then we have to assume that at least 100 litres per capita per day would be generated in minimum. In many cases real estate projects have their own water supply system along with the municipal supply of 75 litres per capita per day. So, we have to take at least 100 litres per capita per day. The entire water that is being utilized either from municipal sources or tube wells in a particular urban area is much higher than the actual sewage flow or particularly the dry weather sewage flow. This is because of loss due to evaporation; since we use water for watering our lawns and other purposes. Seepage into ground or infiltration is another loss. So, these are the different losses in the system.

In arid region, we can say that 40 percent of what is being consumed actually becomes sewage whereas, in developed areas (non-arid region), 90 percent of consumption becomes sewage since the percentage of open area is low and hence rate of infiltration is also low. Therefore, 90 percent of the consumption goes into the sewage network.

Depending upon the population and per capita demand, using certain thumb rules, we can estimate the sewage produced as shown in the table below.

Sl. No.	Population of city	Per capita demand in litre/day	Sewage produced per capita in litre/day
1	Up to 50,000	135	115
2	50,000-2,00,000	135-160	125
3	2,00,000-5,00,000	160-180	135
4	5,00,000-10,00,000	180-200	160
5	More than 10,00,000	200-225	180

If the population is from 5,00,000 to 10,00,000, the supply is around 180 to 200. This is municipal supply plus all other supplies and the sewage generated will be around 160. For more than 10,00,000 people, we have 200 to 225 in water supply. And then the sewage produced should be something around 180 litres per capita per day.

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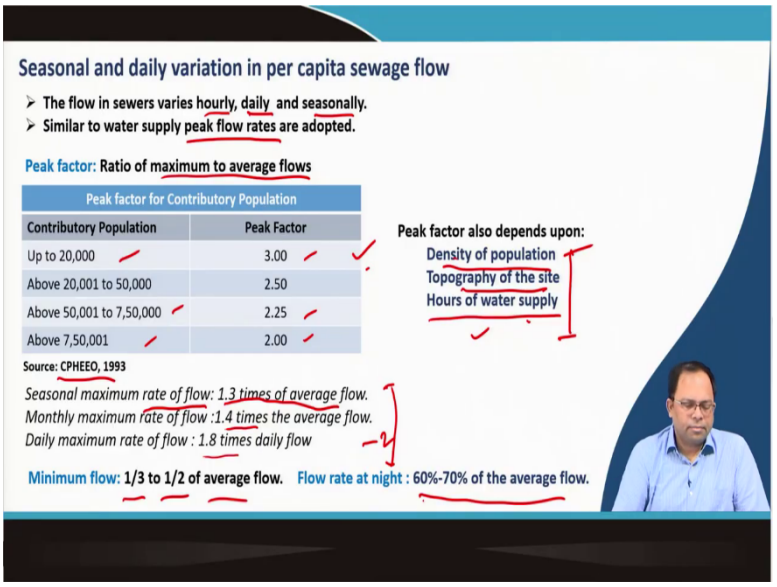

Seasonal and daily variation in per capita sewage flow

Similar to water supply, sewage is based on the water that is consumed and is generated out of the water that is being consumed. So that means, the more we consume water more would be the sewage.

Similarly, if there is variation in the consumption of water it could also reflect in the variation in the sewage flow as well. The flow in sewers varies hourly, daily and seasonally same as the water supply as well. Similar to water supply, we have to add up peak flow rates for sewage as well. So that means there would be certain times of the day when there will be peaks in the system that means the flow is much more than the average flow.

Peak factor is a ratio of maximum to average flow which is based on the kind of population that is housed in this particular city. If it is up to 20000 peak factor is 3, if it is 50000 to 7,50,000 it is 2.25, if it is more than 7,50,000 it is 2. The basic rule is: higher the size of the city, lower the peak factor.

If sewer pipelines are of smaller size, the peak factor is higher and not lower because it is serving a smaller community. Similarly, for a smaller city the variation is more. Usually, in larger cities, the peak factor is lower. Similarly, in larger sewer pipelines the peak factor is lower. So, for trunk sewers the peak factor that we will assume is much lower compared to branch sewer. In addition to this, peak factor varies based on the hours of water supply.

That means, it can vary based on if the water is being supplied in a 10 hour period for the entire day or 6 hour period in the entire day because of the variation in water consumption. Topography, slope of the site and population density will play a role.

In certain areas which has higher density, the peak factor would be also higher. So, these are also some of the factors which will influence peak factor. However, we can use the standard rates as given in the CPHEEO manual. We need to be cautious in certain areas if any factor is having an influence on the peak factor.

The seasonal maximum flow rate is around 1.3 times of average flow. Monthly maximum flow rate is around 1.4 times the average flow and daily maximum flow rate is around 1.8 times the daily flow.

The flow rate at night is around 60 to 70 percent of the average flow and the minimum flow which is around one-third to half of the average flow.

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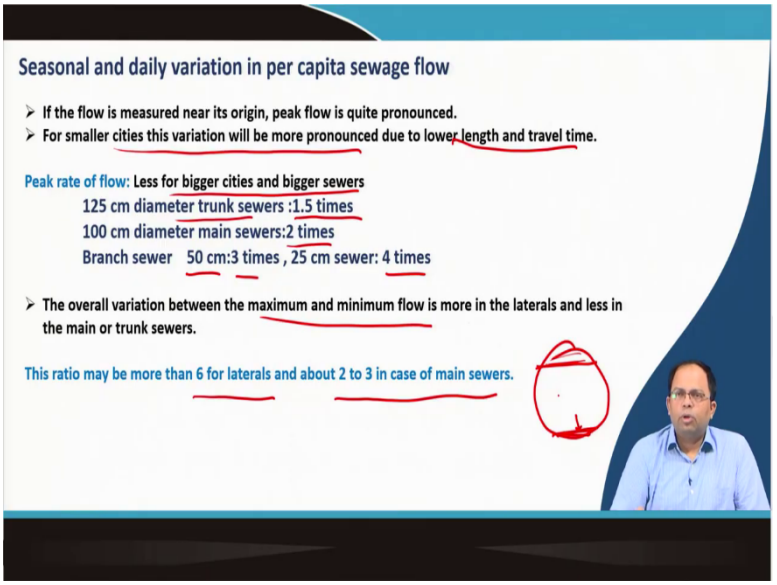

If the flow is measured near its origin, peak is more pronounced. The more we go towards the upper levels of the network, the more would be the peak flow. The diameters of the pipeline would be smaller and the variation would be also higher.

In smaller cities the variation will be more pronounced due to lower length of pipelines and lower travel time. We can also determine peak flows based on the diameter of the sewers. For trunks sewer with 1.25 meter diameter, we can assume peak flow is 1.5 times. For 100 centimeter diameter main sewers, we can assume 2 times. For branch sewers of 50 centimeter diameter 3 times, and for 25 centimeter diameter branch sewers 4 times.

The overall variation between the maximum and minimum flow is more in the laterals and less in the main or trunks sewers and the ratio could be even 6 for laterals and 2 to 3 in case of main sewers. So, this is the amount of variation in sewage flow.

If we have a circular sewer sometime it would be flowing half full, completely full or 3/4th full. So, we have to design our pipeline considering these kind of flows.

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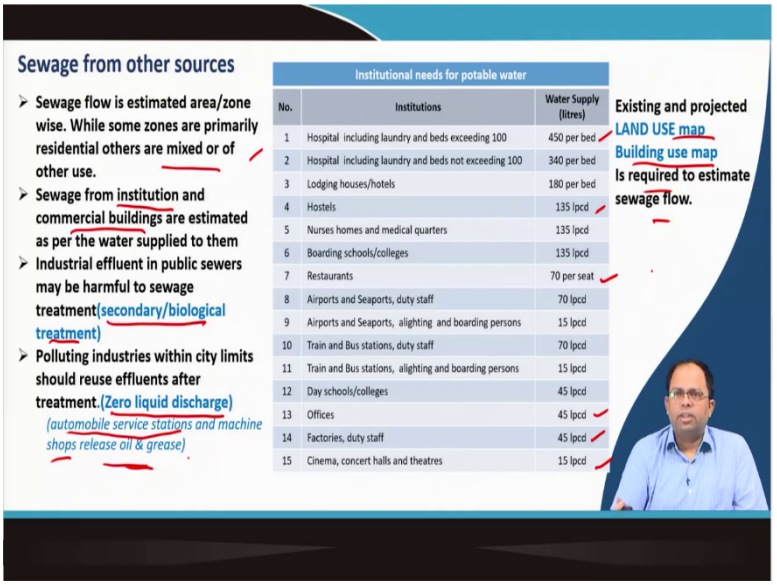

Sewage from other sources

In addition to residential areas, where does the sewage from the non-residential areas go to? For non-residential areas, sewage flow is estimated zone wise and for mixed use zones or for other zones sewage from institutions commercial buildings are estimated based on the water that is supplied to them. Different institutions like hospitals, hostels are supplied with different quanitites of water. For hostels, it is supplied at the rate of 135 lpcd, for hospitals including laundry and beds exceeding 100; 450 lpcd per bed, for restaurants 70 lpcd per seat, cinema hall lpcd, factories 45 litres per capita offices.

Using these figures, we can assume that whatever is being consumed in this particular building would become sewage in addition to some losses. So, based on that we need to determine what kind of sewage would be generated.

Industrial effluent in public sewage may be harmful for sewage treatment. We follow a zero-discharge policy; that means, most of the industries are not allowed to dispose their effluents. But if they have an effluent treatment plant, then the effluent treated to certain standards could be allowed to be released in the municipal drains.

But if the industry directly disposes the discharge into the sewerage pipelines, it may actually affect the biological or the secondary treatment in the sewage treatment plants. Polluting

industries within the city limits should reuse effluents after treatment. This has to be maintained especially for automobile service stations, machine shops and others releasing large amounts of oil and grease into the sewage system which actually messes up the entire system. Even though in Indian cities we try to follow a zero discharge policy, sometimes these rules are not followed. This is one big challenge that we have to overcome.

If we want to do these kinds of detailed estimates, we need to have the land use map, the building use map and based on these we need to determine the sewage flow. The maps are required to determine the total sewage that is generated from an urban area. We cannot assume just the municipal supply and take 80 percent as the sewage flow. This will end up with entirely wrong estimates. We need to do detailed calculation to estimate zone wise sewage flow.

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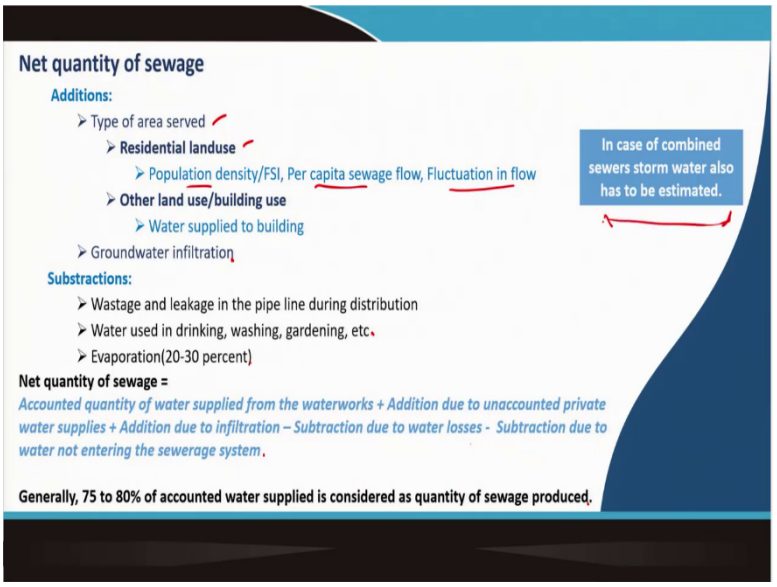

Net Quantity of Sewage

The net quantity of sewage depends on the type of area served. Population density or FSI, per capita sewage flow and fluctuations in flow needs to be considered when we determine the sewage that is generated from residential land uses.

For water supplied to other land use and building uses, we can assume a factor of 80 to 90 percent and that gives us the total quantum of sewage generated from these particular

buildings. Groundwater infiltration can be accounted using thumb rules and general assumptions. Other subtractions include wastage and leakages in the pipeline during distribution, water used in drinking, washing, gardening, evaporation (around 20 to 30 percent) etc.

Usually, we assume 80 to 90 percent of the total water that is consumed in the city becomes sewage. The net quantity of water includes water supplied from water works or municipal supply and additions from unaccounted private water supplies such as tube wells, wells etc.

Then addition due to infiltration, subtraction due to water losses and subtraction due to water not entering the sewer system.

Overall, 75 to 80 percent of the accounted water supply is considered as quantity of sewage produced. In certain season this is accurate, but during rainy season and in certain other seasons this value actually increases to even 90 percent.

In case of combined sewer system, storm water also has to be estimated. In that case, we have to do detailed estimates for storm water.

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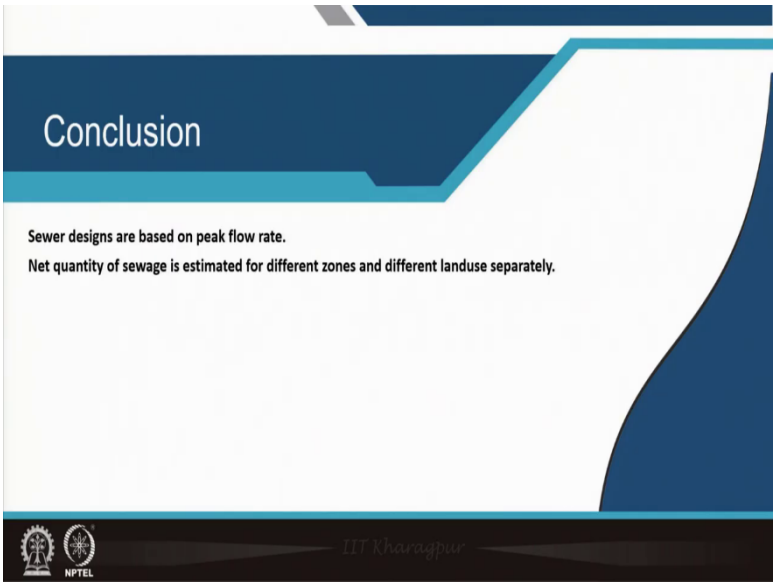

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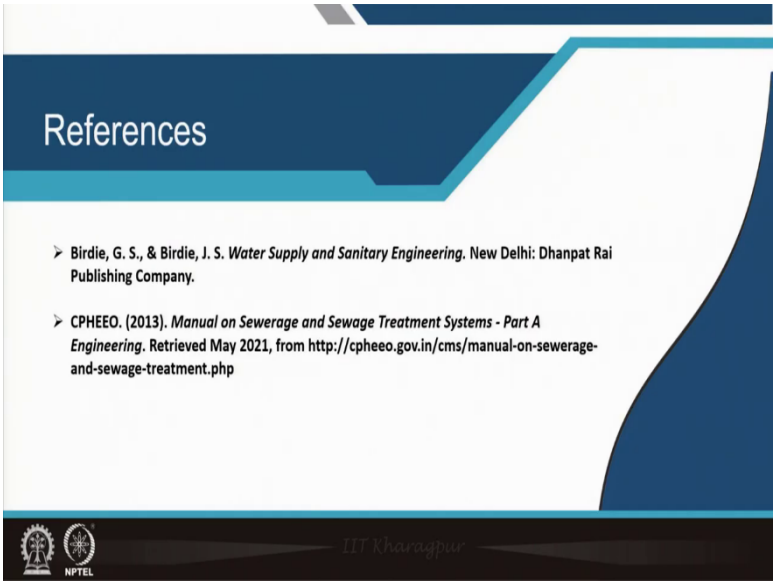

Conclusion

Sewer designs are based on peak flow rate. Net quantity of sewage is estimated for different zones and different land uses separately. So, these are the references.

Thank you.