Urban Utilities Planning: Water Supply, Sanitation and Drainage
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Module - 08
Water carriage system
Lecture - 36
Water Carriage System and Sewerage Layout

Module 8 is about water carriage system and in lecture 36 Water Carriage System and Sewerage Layout will be discussed.

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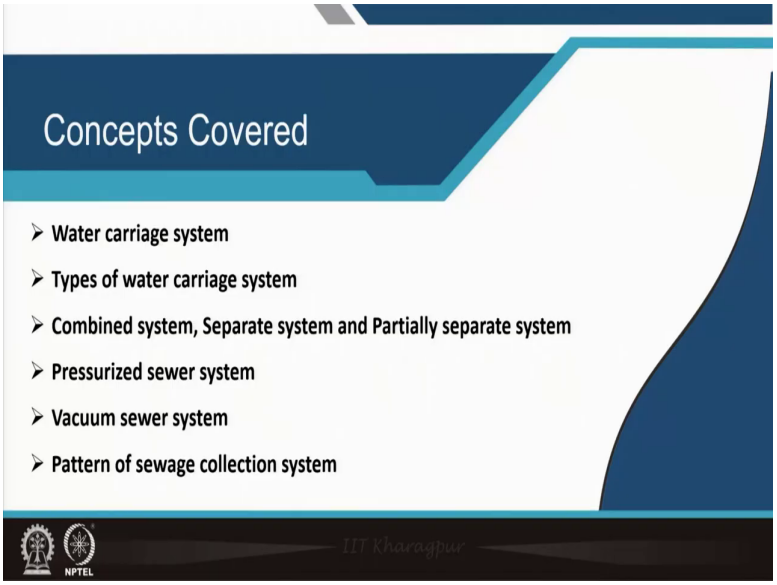

The different concepts that are covered in this lecture include water carriage system, types of water carriage system, combined system, separate system and partially separate system, pressurized sewer system, vacuum sewer system and patterns of sewage collection system.

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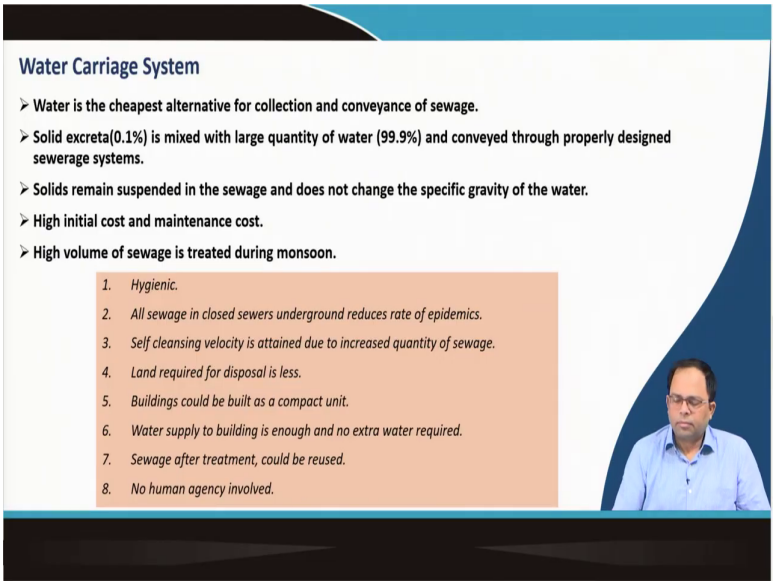

Water Carriage System

In the last module, the different kind of sanitation systems; decentralized system, on site system and water carriage systems were discussed. In this Lecture, water carriage will be discussed which is referred as the conventional sewerage system.

In water carriage system, as the name implies, it actually means that water is utilized for carrying the sewage. As water is the cheapest alternative, it is used for collection and conveyance of sewage. It is assumed that sewage is basically 99.9 percent water and solid excreta are just 0.1 percent. It means that the system is designed considering carriage of water throughout the system. Solids remain suspended in sewage and do not change the specific gravity of water. This conventional sewage system or water carriage system is much more costly and it is difficult to maintain as well.

During monsoon, high volume of sewage is generated because it comprises of both storm water as well as sewage that is generated from houses or industries. We have to also devise ways to handle this volume of sewage. In general, we can say that the water carriage system is much more hygienic because the sewage does not stay at the place of generation; it is immediately conveyed through underground channels.

This reduces the rate of epidemics because people are not in coming in contact with the sewage. In addition, self-cleansing velocity is attained because of increased quantity of sewage. The amount of land required for disposal is less because we are treating the sewage at sewage treatment plants and we are releasing the effluent into the river and only the sludge part has to be dealt with which can be dispose it the landfill or used as manure. When this system is adopted, buildings can be built as a single unit; that means, the toilet does not need to be designed separately and it can be designed within the building. For this system, water supply to building is adequate and extra water is not required. Whatever water is used in flushing systems, it is adequate to carry the sewage. When the sewage is treated in sewage treatment plants, the effluent can be reused for certain purposes and no human agency is also involved in this particular system.

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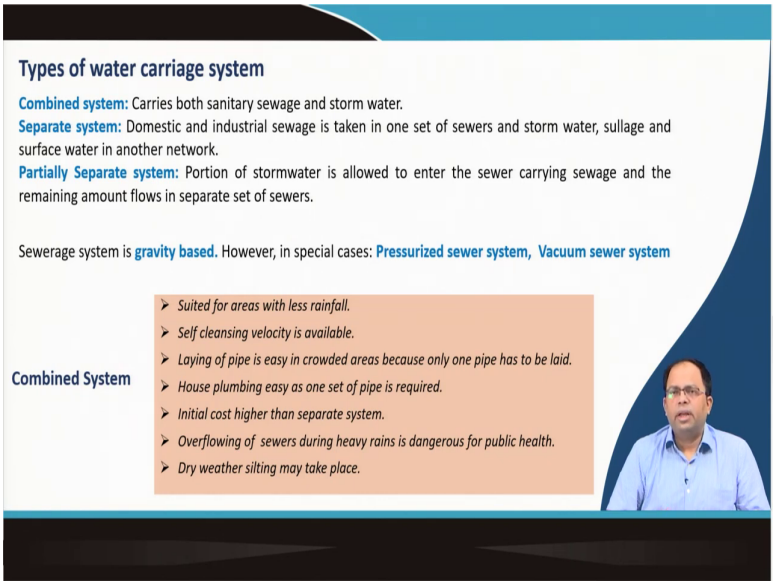

Types of water carriage system

There are three kinds of water carriage systems.

Combined system of sewerage system carries both the sanitary sewage as well as the storm water. In this case, the water generated in an urban area either from a storm event or a rainfall event or from the sewage from buildings is carried through a single pipeline.

In the separate system, the domestic and industrial sewage is taken through one set of sewers and storm water, sullage and surface water in another network. Storm water sullage and surface water is basically water that can be released to the rivers without much treatment and that is why it is taken separately; whereas, the domestic and industrial sewage needs to be treated and that is why it is taken separately.

In partially separate system, a portion of the storm water is allowed to enter into the sewer carrying sewage and the remaining amount flows in separate set of sewers. Thus, there are two set of pipelines, one set of pipeline is dedicated for storm water while another set of pipeline is dedicated for sewage. The storm water that is collected in roofs of buildings within particular plots or maybe the sullage from the toilets could be added to the sewer pipeline. Whereas, the storm water that is generated from the streets or from the surroundings or from parks and other places goes through the storm water drainage network. There are different variations to it because in many Indian cities, people do not maintain two sets of pipeline in their houses, they have only one set of pipeline for sewage as well as sullage which is connected to the sewage system.

In general sewage system is gravity based, but in addition to gravity based sewage system, we can have certain kind of pressurized systems such as vacuum sewer system or a pressurized sewer system.

In special cases these systems are used. For example, to lift sewage, instead of having lifting stations, pressurized sewer system can be designed or vacuum sewer system can be designed for small communities where there are lot of basements.

Combined system: This one pipe system carries of all the sewage that is generated in an urban area including storm water. So, it is suited for areas with less rainfall because, if we design a separate system in this kind of areas then there will be very little amount of water in either of the pipelines or particularly in the sewer line. So, it may result in lot of siltation and deposition. To prevent that, it is better to have a combined pipe or a sewer system. Usually in less landfall areas, we design combined system. As we are going for a combined system self-cleansing velocity does not becomes an issue because it is a single pipeline. It is easy to lay and for house plumbing, there is no other considerations, just one pipe is adequate.

As a higher diameter pipeline is designed, we need to have to have a higher diameter trench and usually the entire system will also require a sewage treatment plant which is going to handle a much higher load compared to a separate system. Thus, the overall cost will be much higher as compared to a separate system. Also, during heavy rainfalls, because huge quantum of storm water is captured this cannot be treated in sewage treatment plant because it would be uneconomical and during rest of the year the capacity would not be utilized. The excess storm water that is generated during the rainy season should be allowed to just pass without treatment. But because it is passed without treatment, it is dangerous for human health and it may create some other environmental and other health problems.

During dry weather, some amount of siltation may still take place in this kind of pipelines, because the pipe diameter is bigger and no storm water available during dry weather.

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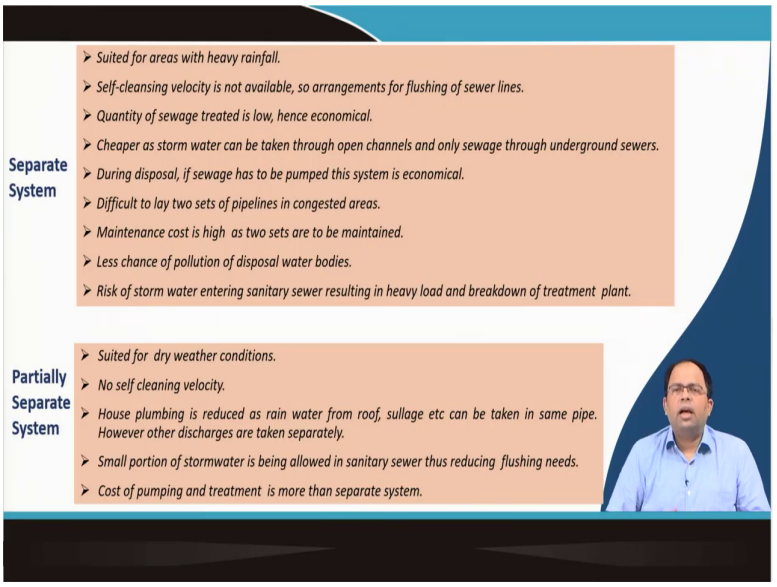

Separate system: This system is opposite of the combined system. For example, it is suited for areas with heavy rainfall, and the storm water is directly drained into the river.

During heavy rainfall, some amount of water may enter into the sewage network. Self-cleansing velocity in general is not available and during dry weather it may be a problem. Thus, we need to make arrangements for separate flushing system in the sewer lines.

Tanks should be installed in the sewer lines which could be used for flushing the entire sewer line.

The quantity of sewage is low, thus, the size of sewage treatment plant is much smaller and storm water is taken through different channels such as open channels and underground sewer pipelines. So, we may even save on constructing pipelines in that regard. As there are two sets of pipeline, it may create a problem and cost is also high for two pipelines even though the pipeline sizes would be smaller.

Maintenance is high, because two sets of pipelines have to be maintained. Pollution risk is less and thus, it is better to have a separate system in that regard. In addition, there is a risk of storm water entering sewer resulting in heavy load and breakdown of treatment plant.

Partially separate system: It is suited for dry weather conditions, when there is no self-cleansing velocity. That is why this extra storm water from roofs or sullage can be added into the sewer pipelines, that helps in attaining the self-cleansing velocity. The cost of pumping and treatment is usually more than the separate system, because more quantity of water needs to be treated.

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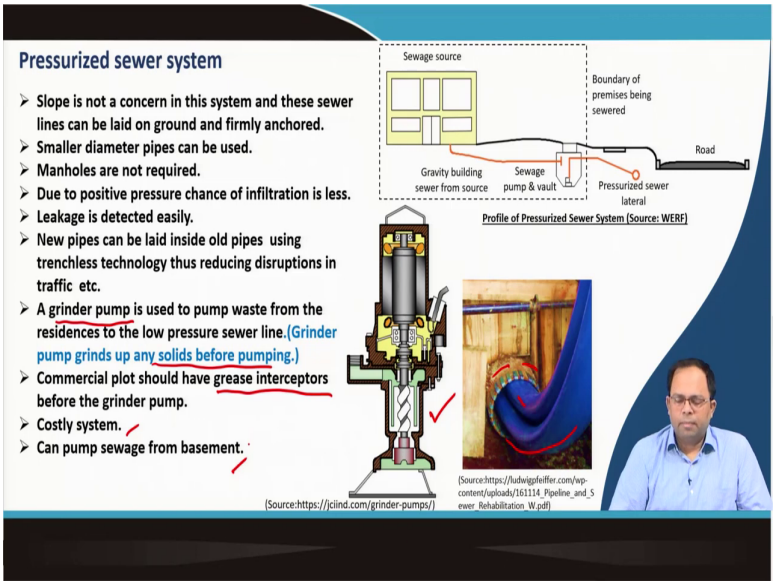

Pressurized sewer system

As seen in the given Figure, there is a building, sewage pump, vault and there is the pressurized sewer lateral which are designed below the foot path It is just a pressurized pipeline instead of gravity based flow. So, in a pressurized sewer system slope is not that much of a concern, because we are putting in some amount of pressure. These pipelines can be laid even over the ground and they need to be anchored.

Thus in case we are not able to put in the pipelines below ground, pressurized sewer system is used. In some cases, it is difficult to dig in rocky areas, thus, it is better to have a pipeline above ground and then pressurized sewerage system can be designed.

Smaller diameter pipes can be used because we are using pressure and manholes are not required. Due to positive pressure, chance of infiltration is less and leakage is detected easily. So, it is almost like pressured conduits of water supply pipelines.

Manning's formula cannot be used in this kind of pressurized pipeline. Thus, other formulas need to be used which are used for determining the size of water supply pipelines.

Whenever we are trying to improve a particular old sewerage network in a city, and we want to augment a pipeline or rehabilitate the sewage system, it is very difficult to again start constructing a totally new pipeline which require extra space. One way to resolve this is to keep using the existing pipeline and put another conduit in between that and because the conduit will be smaller in size, this could be a pressure conduit.

Instead of using the old conduit which creates some issues with blockages and chockages, we can clean it and put in a new small-sized line which could be under pressure. As it is under pressure the quantity of sewage that we can send through should require a lesser diameter pipeline. So, in that case, new pipes can be laid inside existing pipe using trenchless technology, thus reducing disruptions in traffic. This is being done in many cities right now. The pressurized system is different from a normal gravity based system; that means, there is a pump involved.

As there is sewage, a grinder pump is used as seen in the Figure. It pumps waste from the residences to the low pressure sewer line. This pump not only pumps the waste but also grinds up the larger solid particles to make into smaller particles before pumping into the

network. This will not change the flow characteristics and all the other parameters for determining flow velocity. It can also pump sewages from basement because pressure is being created.

Usually in case of larger plots or commercial plots, in addition to grinder pumps grease interceptors are placed before them so that oil does not get us into the system because if oil gets into the system, it will choke the pump eventually and operations might stop.

It is a costly system because pumps and other installations are involved. It is designed when there is no other option.

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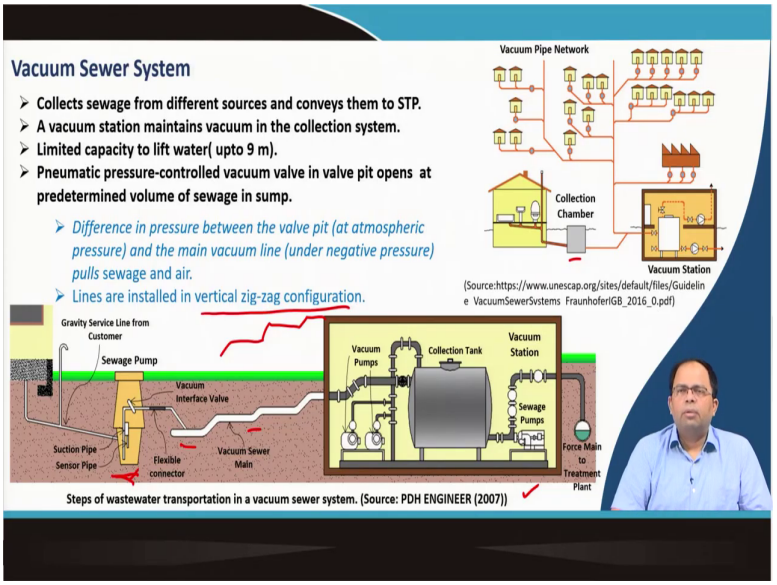

Vacuum Sewer System

Vacuum sewer system is another alternative to pressurized sewer systems. Vacuum sewer systems operates in a different principle and also the pressure that can be generated is limited in this vacuum sewer system. For smaller networks, it becomes more efficient because it does not require individual houses to have grinder pumps. It has a centralized system where we can control the sewage collection.

Vacuum sewer system collects sewage from different sources and conveys them to the sewage treatment plant. For this, we require a vacuum station in this particular network and that vacuum station generates the required vacuum in the collection system. The vacuum that is generated has the capacity to lift water up to 9 meter level, beyond this limit, this system is not feasible.

As seen in the given Figure, there are different houses and the grey boxes depict a collection chamber. From the collection chamber, the sewage goes into the main lines, from where it is sucked via vacuum into the sewage treatment plant.

The collection chamber has a pneumatic pressure controlled vacuum valve in a valve pit and it opens when a certain amount of sewage gets filled. When the pressure controlled vacuum valve opens then the sewage is sucked into the system.

The vacuum is always there, but this valve actually closes and there is no continuous suction pressure. That means, the building will not face any kind of suction at the WCs and other places.

There is difference in pressure between the valve pit which is at the atmospheric pressure and the main vacuum line which is under negative pressure. Thus, the negative pressure actually pulls the sewage and also air into the system. The sewage lines are installed in a vertical zigzag configuration which is different from standard sewer as seen in the Figure. It is also different from the pressurized system in a way that it requires collection chambers that could be installed from the municipal level. It could also be also installed at the building level that depends on the city and its bylaws.

Vacuum station is a centralized system which creates the suction, whereas pressurized system, the grinder pumps is required which is a responsibility of the user. This is the basic difference between these two systems.

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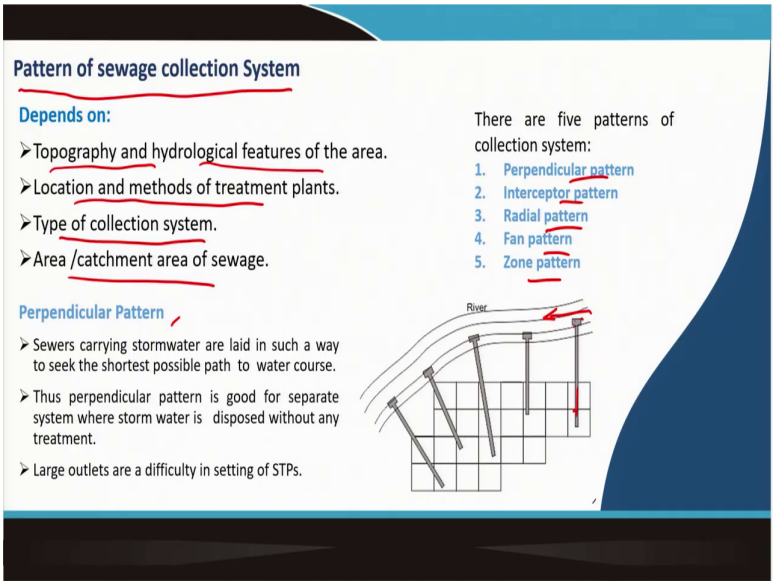

Pattern of sewage collection system

There are mainly five patterns of collection system that includes perpendicular pattern, interceptor pattern, radial pattern, fan pattern and zone pattern. Usually when we look into an actual urban area, it is very difficult to identify sewage collection pattern.

As sewerage network depends on the city's layout and other aspects, a given sewage collection pattern could be a mix of different patterns.

Sewage collection system differs from area to area and depends on the topography of the area and the hydrological features of the area.

These are the primary two concerns. The location and technology adopted in treatment plants also play a role. If we are using a sewage treatment plant which releases effluent into the river, then a given layout will be adopted. Whereas, if sewage farming is practised then, another kind of layout will be adopted.

Type of collection system and catchment area of the sewage play a role in determining the kind of system that we are going to lay.

Perpendicular pattern: Perpendicular pattern refers to the cases where sewer carrying storm water are laid in such a way so that it seeks the shortest possible path to the water course. This system may be designed along with other patterns as well.

As seen in the Figure, the city has river and storm water pipes are perpendicular and directly fall into the river. The storm water collected from different zones goes into this main storm water pipeline and the water is taken out directly to the river. It is done so that we can easily get rid of the storm water to prevent flooding. So, perpendicular pattern is good for a separate system, where storm water is disposed without any treatment. This kind of large outlets are difficult for setting STPs and water can be released without treatment. If we want to treat the water, large and multiple STPs needs to be set up for this kind of system.

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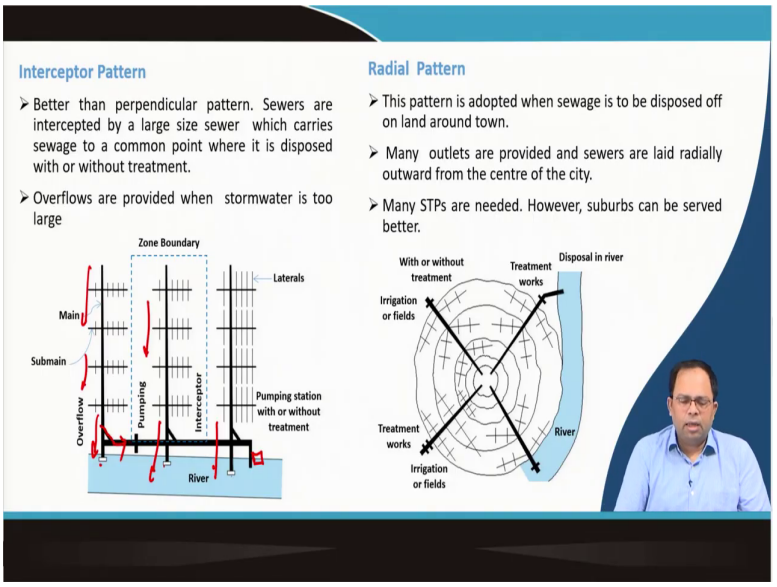

Interceptor pattern: This is better than the perpendicular pattern because sewers are intercepted by a large sewer which carries sewage to a common point where it is disposed with or without treatment. During rainy season, the sewage flows directly into the river, however during other seasons, the sewage goes along the interceptor sewer, to this particular point where it could be released with treatment or without treatment.

So, we can set up a STP that can treat the storm water, but during rainy season, it is not possible to treat the storm water since too much water is generated. Thus, in rainy season, it is disposed without treatment while during other seasons, it can be treated.

Radial pattern: It is adopted when sewage is to be disposed on land around town; that means, we are disposing sewage in all directions such as in the river or in irrigation fields where the sewage is being used for sewage farming.

In this case, many outlets are provided and the sewers are led radially outward from the centre of the city and many STPs are needed. Suburbs can be served better since suburbs are far away from the central core area as well as from the river and it is difficult to extend existing network or to carry the sewage over large distance.

If radial pattern is designed; it can grow in any direction and the sewage network could be also expanded gradually in those particular directions. When the water is traveling in opposite direction; the pipeline gradually becomes bigger. If we have fixed the size of the pipeline already, then it will not be possible to make it even bigger. It could be illustrated better with the fan pattern.

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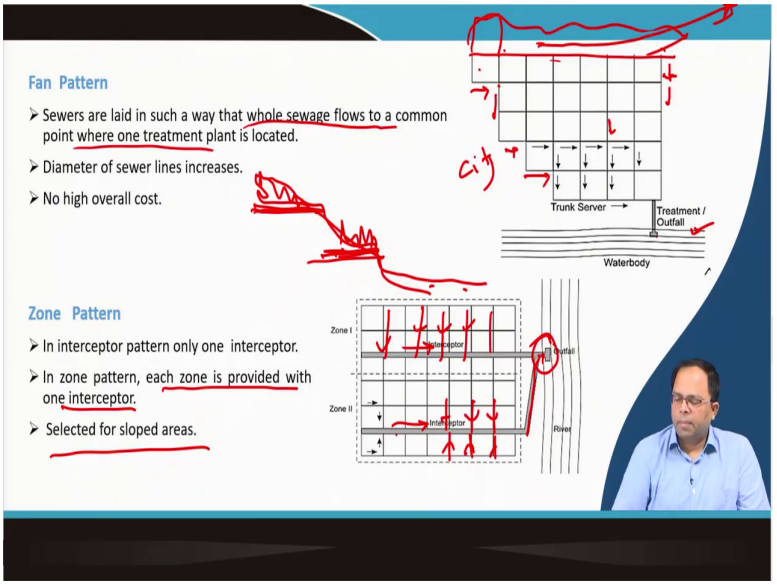

Fan pattern: The Figure shows the outfall of this city and the sewer network. The sewage gradually moves in a given direction and eventually it disposed in the water body. So, the

pipelines at the beginning are smaller. As more sewage line joins in, the pipelines become larger. If suddenly new growth happens in a given zone, it is impossible to expand the pipeline in that direction. Sewers are laid in such a way that the whole sewage flows to a common point where one treatment plant is located. Fan pattern can be found in many cities where there is no other option. A single treatment plant may be financially justified. Though diameter of sewer line gradually increases but the overall cost is low because there is one disposal point.

In radial pattern, there is a possibility of sewer network expansion which is the main benefit of this system. Whereas, in a fan system you as you can see this is not possible.

Zone pattern: Zone pattern is a modification of the interceptor pattern. Instead of one interceptor, there are multiple interceptors. Each zone is provided with one interceptor . Multiple interceptors are connected to a single outfall. This kind of a system is utilized where there are sloped areas such as mountainous area. Various settlement zones have their interceptors that eventually get connected and the waste is disposed.

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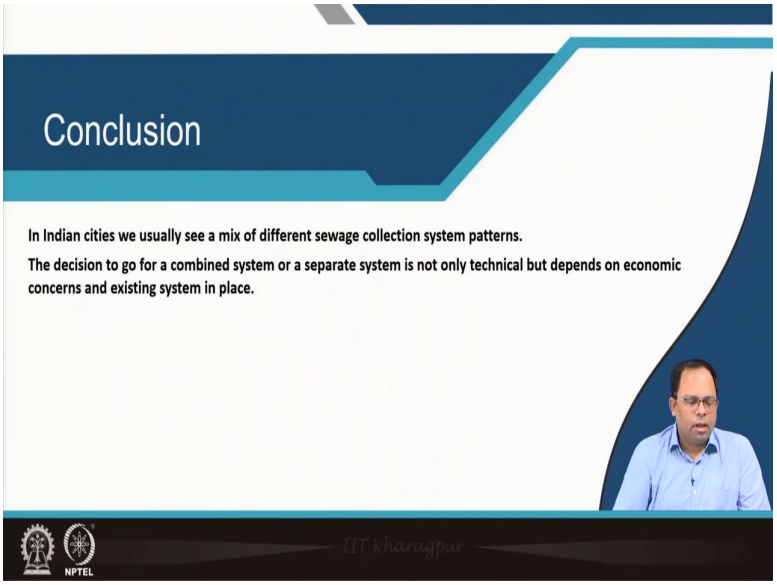

To conclude, in Indian cities, we usually see a mix of different sewage collection system patterns and usually it is beneficial to have a mix of patterns.

The decision to go for a combined system or a separate system is not only technical, but depends on economic concerns and also the existing system in place. Thus, sometimes, we usually continue to use the same existing system or augment the existing system.

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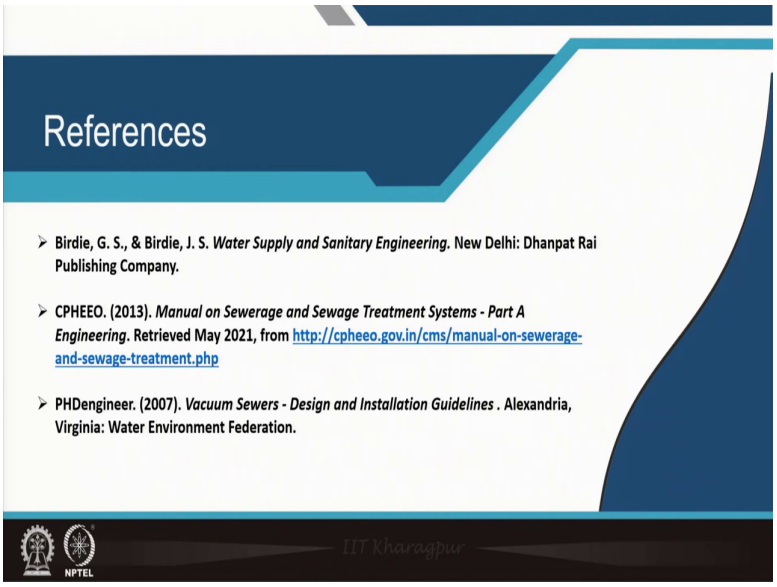

References

These are some of the references that can be used.