Urban Utilities Planning: Water Supply, Sanitation and Drainage
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Module - 10
Sewer appurtenances
Lecture - 47
Sewer Appurtenances Part II

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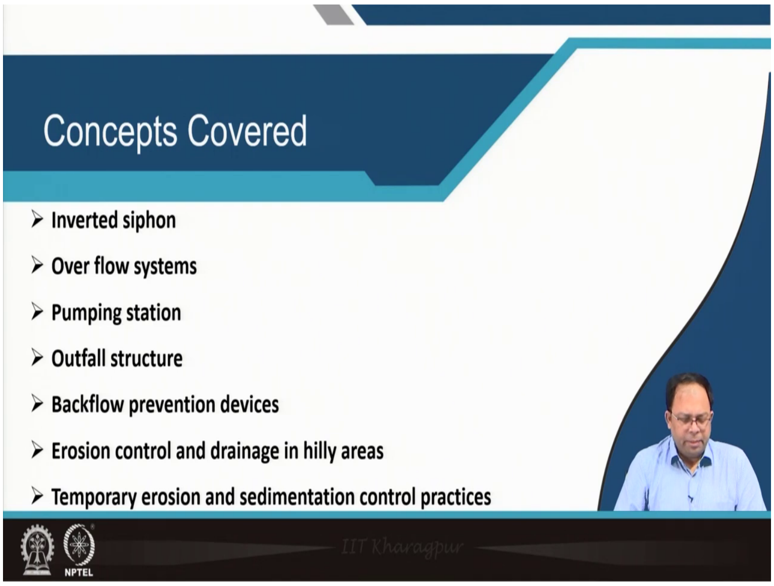

In lecture 47, the second part of Sewer Appurtenances will be covered. The different concepts that will be discussed are inverted siphons, overflow systems, pumping stations, outfall structure, back flow prevention devices, erosion control, drainage in hilly areas and temporary erosion and sedimentation control practices.

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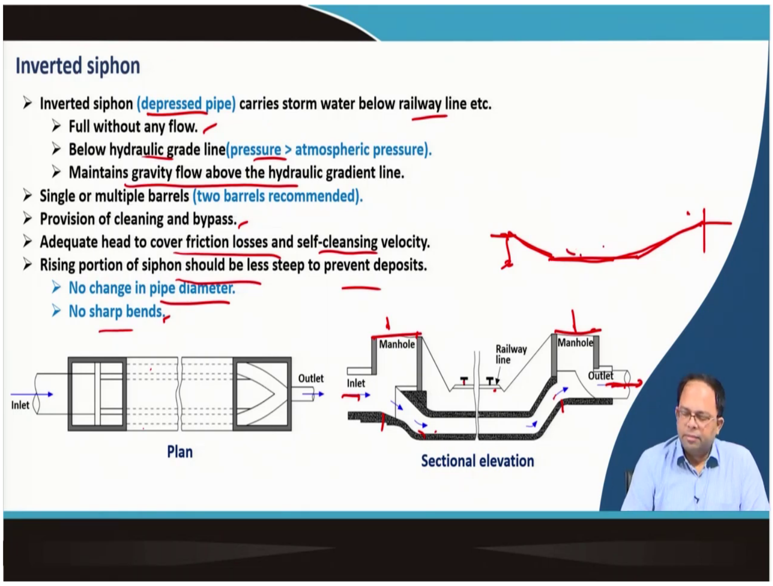

Inverted siphons

Inverted siphons is a sewer appurtenance to allow passage of water below railway lines etc. That is where the water line or the drainage way has to pass below that particular railway line or some other similar kind of structure. This is where inverted siphons come into play.

Inverted siphon is basically a depressed pipe. As seen in the Figure, through the inlet, the water goes down and then again the water rises up and comes out of the outlet. Manholes are provided at two sides so that if there is some obstruction, it can be addressed.

This siphon is primarily designed to carry storm water and particularly used in case of railway lines and where two storm water channels intersect.

As it is lower than the normal level, it is always full even if there is no new flow. Since it is below the hydraulic grade line of a particular area, the pressure is greater than the atmospheric pressure in this particular line. On the other hand it maintains gravity flow above the hydraulic gravity line. It can have double barrel or a single barrel system. Usually two barrels are recommended in case when one get stuck, the other one can be operated.

In case it is a single barrel line, a bypass is created so that cleaning could be taken up simultaneously with normal flow. An adequate head is given so that friction losses and the self-cleansing velocity in the siphon can be taken care of. To facilitate this, usually the rising portion of the siphon is made less steep and this also prevents the deposition of sediments. The pipe diameter remains the same all throughout and there are also no bends in the siphon. The slope of the entry is as shown in the Figure and the slope is much flatter.

An adequate head is ensured so that a given distance or friction resulting from the siphon as well as the self-cleansing velocity along this channel is adequate. These are the basic design considerations for siphons.

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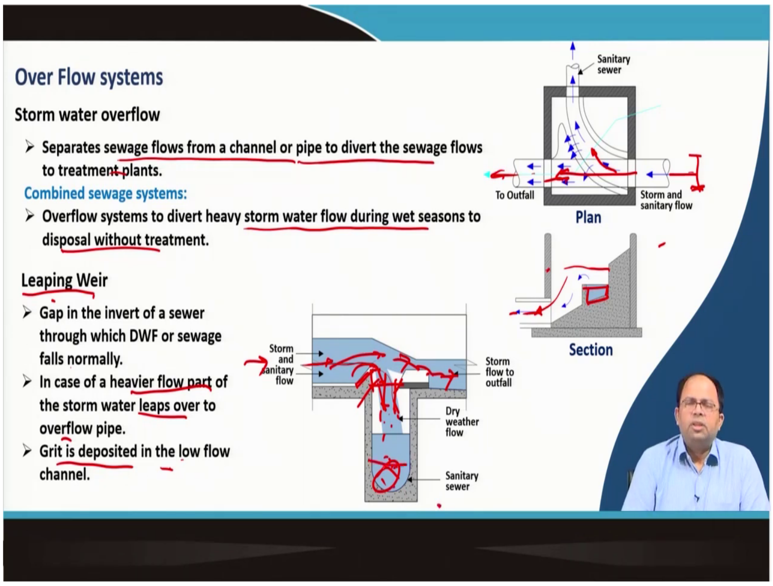

Over flow systems

Overflow systems are an alternative to weirs. As shown in the Figure, sewer line/combined sewer line carries the storm or sanitary flow that goes towards the outfall where the sewer is leading into a water body or land.

As the entire sewage from the combined flow cannot be treated particularly during rainy season because of high cost, limited capacity of the tanks, etc. Thus, the system is designed in such a way so that the excess water will flow in other direction as shown in the Figure. That is why it is called an overflow system.

In the main channel, the water will flow and go to the sewage treatment plant. In case there is excess; the water will travel through another pipeline to the outfall and then is disposed off.

So the storm water overflow system separates sewage flows from a channel or pipe to divert it to treatment plants. In case of combined sewage, overflow systems divert heavy storm water flow during wet seasons to disposal without treatment. That is the primary purpose of overflow system.

One alternative design for this overflow system is a leaping weir. Normally when the level of flow is low, the water flows along the edge of that weir into a particular channel (dry weather flow along sanitary sewer line) and goes into the treatment plant.

Whereas, when there is excess water, this water will flow along to the weir and then part of it jumps while the rest comes down and go to the sewage treatment plant. Most of the water however goes into the outfall and gets disposed off without treatment.

So, a leaping weir is a gap in the invert of a sewer through which DWF or Dry Weather Flow or sewage falls normally and goes into the treatment plant. The heavier flow part leaps over to the overflow pipe.

So, that is why it is called a leaping weir because the water is jumping over a particular block. Weir is a type of block head. Usually, we find deposits of grit in this low flow channel that has to be cleaned eventually.

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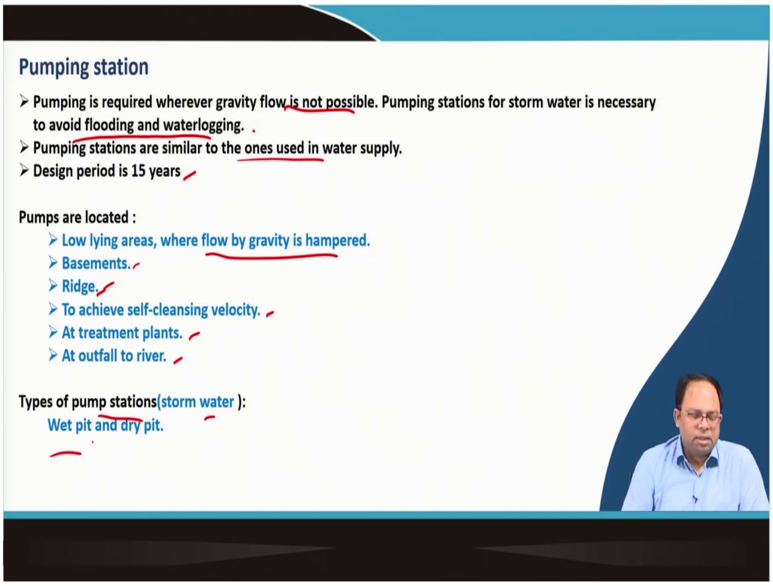

Pumping station

Pumping stations can be used for any kind of storm water, normal sewer or for drainage canals or drainage channels.

The basic principle of pumping station for sewerage network is same as that used for water supply. It is required where gravity flow is not possible. Pumping stations are necessary to avoid flooding and water logging. If the pumps do not run during the rainfall events then the excess water cannot be pumped out and that can create flooding.

During rainy seasons, these pumps are operated because during heavy rainfall, the volume of water in the channels are very high. Pumps are operated in cases where the water has to be lifted to a certain height and then to the next channel to facilitate the movement of water. Otherwise the sumps will also get filled in pumping station also. So, we have to keep pumps running during rainfall events.

The design period of the station is more or less same as in case of water supply, i.e., 15 years. These storm water pumps or the sewer line pumps are located in low lying areas where flow by gravity is hampered. In various cases, the sewage has to overcome a particular ridge or the river may be protected by certain raised banks or ridge structures where pumps are used. These pumps are also used to achieve self-cleansing velocity in the sewer pipelines. We use pumps at the treatment plants to lift the water from one treatment unit to another, and also at the outfall of the river.

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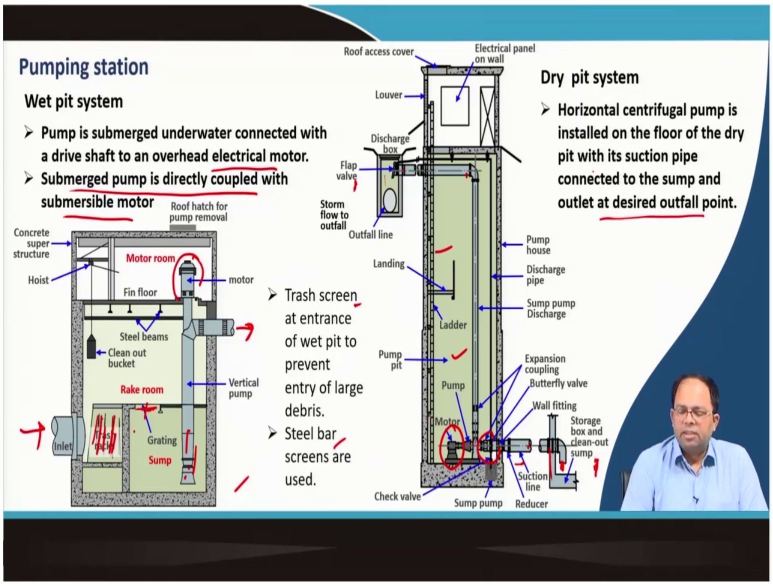

Storm water pumping stations can have wet pit system or dry pit system. The Figure shows the design of a wet pit system which shows the inlet and the bar screen through which garbage can be screened. Then the water goes into the next section where there is a grating through which water comes in and then there this is a sump.

In this system, there is a vertical pump which is put inside a sump and the motor is kept at an upper level. The suction pipe is put into this sump and the water is pumped out and through the outlet, the water goes into the main pipeline or the sewer pipeline which takes the water to the outfall.

The pump is submerged under water connected with a drive shaft to an overhead electrical motor. The pump is of centrifugal type in which the impeller rotates. All these things are inside the sump. The shaft which connects it to the motor is above the water.

There is a trash screen at the entrance of the wet pit to prevent the entry of large debris because the pump is also in the sump. Thus, steel bar screens are used.

In dry pit system, the pump is outside the water sump. A horizontal centrifugal pump is installed on the floor of the dry pit with its suction pipe connected to the sump and outlet at desired outfall point.

The outlet point is raised; that means, the level of water is raised.

The suction of the pump is used to suck in the water from the sump, pump it upwards and then dispose it into the outfall line via outfall chamber. As the entire area is not filled with water, it is called a dry pit system.

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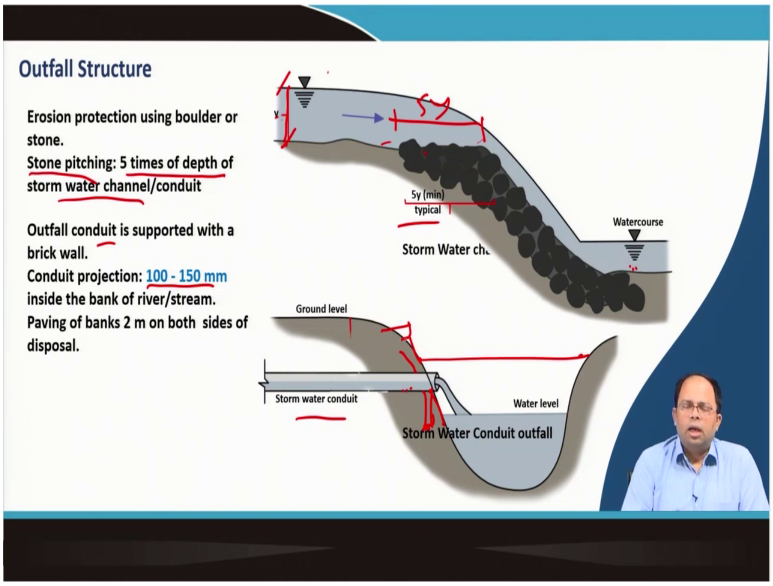

Outfall structure

The outfall structure helps to disposes the sewer water into a water body or land.

Figure shows the section of the storm water channel with depth of the storm water flow y. If this water fall directly into the water body or a bank of a particular river, it would lead to erosion over time.

Thus, to prevent erosion, some protection needs to be given through some large boulders or stones provided at the side of the banks of the water body. It is extended a little inside the channel so that it does not erode the surface. The stone pitching (arrangement of stones in layers) is five times of the depth of the storm water channel or conduit.

Thus 5y is the distance for which the stone pitching is extended that controls the erosion at the bank. The outfall conduit is an extended pipeline which disposes the water into the water body. The extension is about 100 to 150 mm and inside the river. The banks are paved 2 meter on both sides of the disposal. Also, some support structure such as brick wall is provided to support the conduit.

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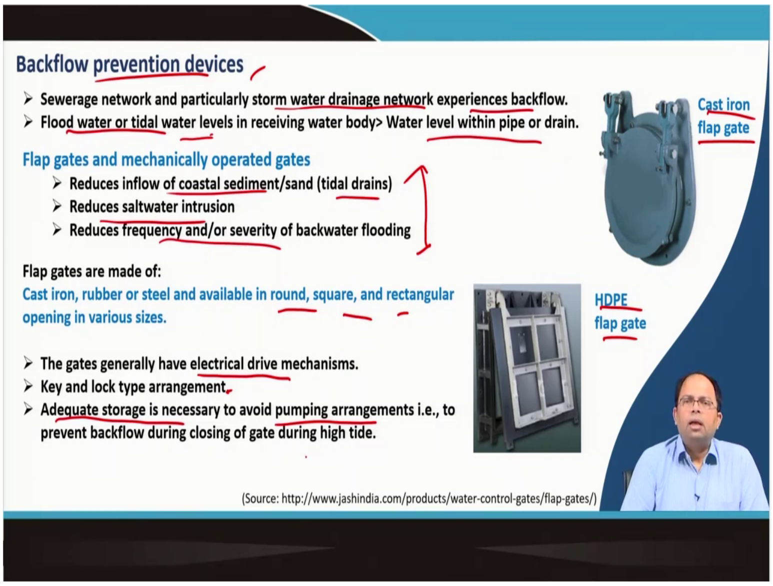

Backflow prevention devices

In the outfall also there could be cases where the water level goes above the pipeline level for tidal rivers during high tide. It is not possible to raise the pipeline to a level which is even higher. This requires designing of only a pump house, but also large sumps where the incoming sewage can be stored. However, it involves lot of cost.

As high water level is only during limited to high tides and only for a small period, back flow prevention devices can be installed instead of constructing a large pump houses. These are like a caster and flap gate which is fitted at the mouth of the outfall and during certain time periods or high tide, these can be closed so that water does not get inside and there will not be any backflow through the given sewer.

In case, sewage comes when the gate is closed, it needs to be stored. This requires a sump in which the sewage can be temporarily stored that can be disposed when the gate would be open.

So, sometimes when the sewage network or the storm water drainage network experiences back flow, we install a back flow prevention device and particularly for flood water or tidal water. When the levels are higher compared to the water level in the pipe or drain, then back flow happens and these flap gates and mechanically operated gates reduces the inflow of coastal sediments (sands in case of tidal drains). It reduces salt water intrusion and reduces the frequency or a severity of backwater flooding. Flap gates could be made of cast iron, steel or HDPE or high density poly ethylene. These are available in round, square, or rectangular opening in various sizes. There are various ways to operate them and could be connected to an electrical drive mechanism.

These can be controlled automatically by pressing some buttons or key-lock arrangement; that means, manually we can close it and put in a lock and key so that it does not opens up. We also need to make sure that there is adequate storage to avoid pumping arrangement. Otherwise, we have to lift the sewage from a sump. The excess sewage that is collected when this device is closed eventually goes out when it opens. That is how we could use a back flow prevention device in a sewerage network.

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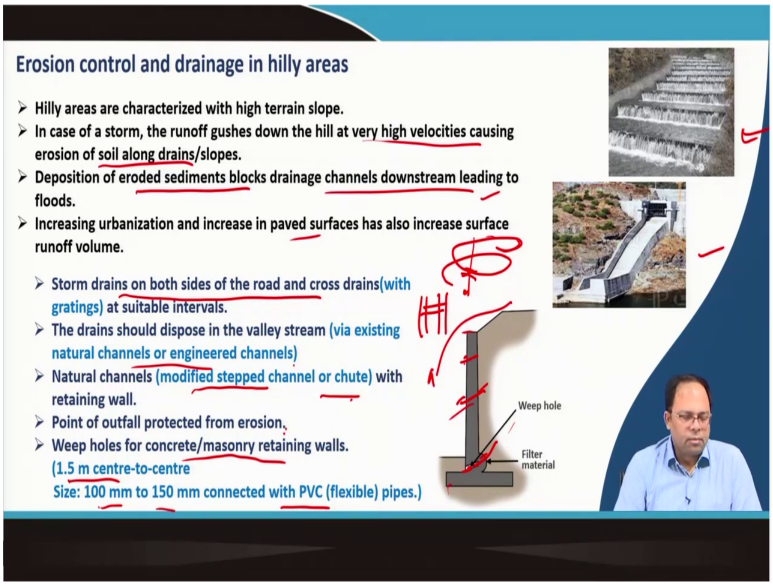

Erosion control and drainage in hilly areas

In hilly areas, a lot of erosion is experienced because of the terrain. Since, water moves fast and takes away all the material on the surface, erosion is experienced.

In case of storm, the run-off gushes down the hill at very high velocity causing erosion of soil along drains or slopes. There could be different ways to prevent this. When the eroded sediments are taken down in the downstream channels, it can block the channels and that can lead to floods.

And, because of increasing urbanization in hilly areas and increased amount of paved surfaces, the run-off volume has increased and that is creating even more erosion. That is why erosion control needs to be done in hilly areas. To achieve this, storm water drains should be constructed on both sides of the road with cross drains at suitable intervals. In this way, water will come down along the road instead of coming down straight and also these can be connected at suitable intervals sometimes because of slope differences, the flow in one channel exceeds another. It makes the height of the water in both the channels more or less similar.

The drains should dispose in the valley stream via existing natural channels or engineered channels. One can go for stepped channel or a chute. As shown in the Figure, a step channel has been designed. A chute can be also provided and point of outfall is also protected.

Sometimes along vertical surfaces protective structures as shown in the next figure are present. We usually allow the water to get in through these. The weep holes are provided in these concrete and masonry structures or retaining walls structure through which water can pass through. These could be at 1.5 meter centre to centre with size around 100 to 150 millimetre connected with PVC pipes at the back.

These are artificial design channels, natural channels and retaining walls that are present along the roads in hilly areas.

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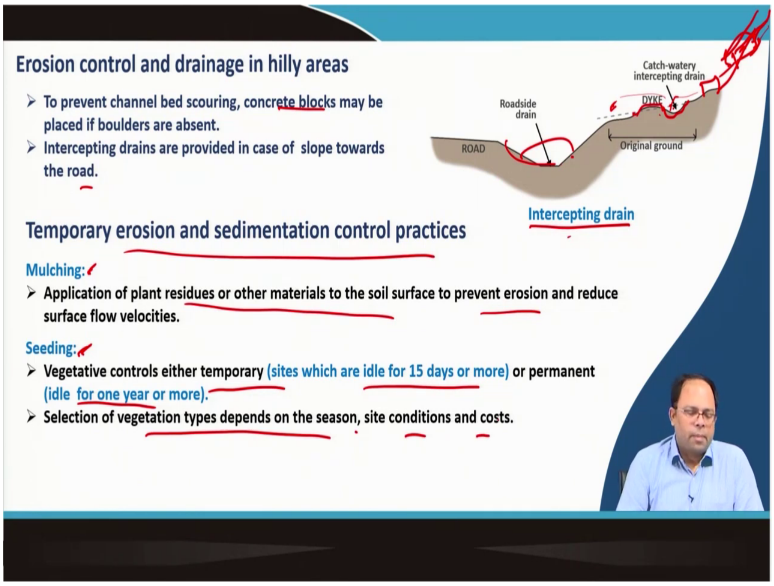

We can also provide intercepting drains. The water that is coming down the hill to a given channel carries lot of erosion. If the channel is blocked it will create floods.

Instead, intercepting drains and dykes can be designed so that the sediment is trapped here and then only the water flows over this dyke and then goes into the main channel. So, to prevent channel bed scouring concrete blocks may also be placed.

Along this particular channel, the concrete blocks can be provided to slow down the flow of water. Whenever water hits, it flows over. The speed of that flow actually is reduced and erosion is actually reduced.

Other temporary practices of preventing erosion and sedimentation control practices include mulching and seeding. Mulching refers to application of plant residues or other materials to the soil surface to prevent erosion and to reduce surface flow velocity. Seeding involves spreading of seed of grass or other plants/trees that provides a good vegetation cover to stop the flow or reduce the speed of flow. Vegetation from other areas can also be planted to provide vegetation cover. This could be either temporary where sites are idle for 15 days or permanent if idle for one year or more. The selection of vegetation type depends on season, site conditions and cost.

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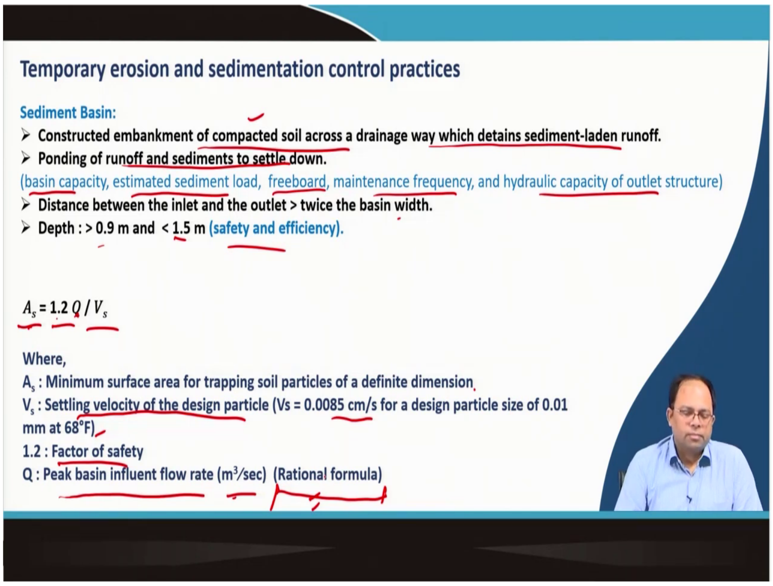

Sediment basin can also be designed. Sedimentation basin can be considered as a detention basin where we stop the water for a certain amount of time or allow ponding of water. This allows the sediment to settle for some time that can be dredged form the basin. Else, the sediment would be carried through the drainage channel. In this way it prevents erosion.

These are naturally constructed embankment of compacted soil. It detains sediment-laden run-off for a certain time. Ponding of run-off happens and the sediments settle down. To design this kind of sediment basins, we need to understand what should be the size or capacity of the basin.

Then the total estimated sediment load for which we have to design this basin, has to be estimated. Free board refers to the free space that has to be provided in this particular basin above the level of water and depends on the maintenance frequency and hydraulic capacity of the outlet structure.

The distance between inlet and the outlet is twice the basin width. The depth of the basin is more than 0.9 meter and less than 1.5 meter which increases safety and efficiency of this kind of basins. The rest has to be taken care of by the surface area.

For a certain particle-size based on its specific gravity it takes a certain time to deposit. Settling velocity determines the time it takes for a particle to sediment or settle. It is the time period when we should hold the water because that is the time required for the water to allow its sediments to settle.

The surface area is determined by the Equation shown below:

$$A_s = 1.2*Q / V_s$$

where

A_s : Minimum surface area for trapping soil particles of a definite dimension.

V_s : Settling velocity of the design particle (Vs = 0.0085 cm/s for a design particle size of 0.01 mm at 68^0F)

1.2 : Factor of safety

Q : Peak basin influent flow rate (m^3/sec) (Rational formula)

Thus, one can estimate the total volume of water using the rational formula using the same calculations that was done earlier to determine the rainfall intensity. The duration period is determined and accordingly the total volume of flow can be determined.

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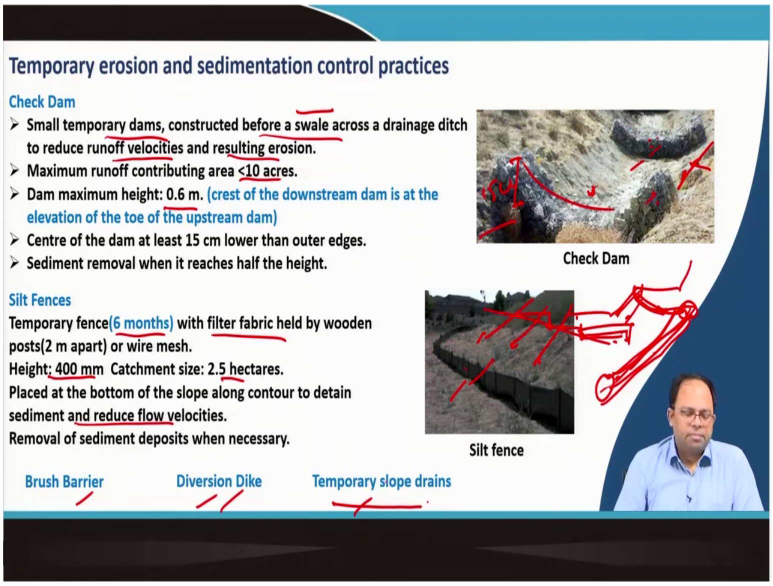

Temporary erosion and sedimentation control practices

Other structures can be check dams, silt fences, brush barrier, diversion dike, and temporary slope drains. Check dams act similar to that concrete blocks that are placed along the path of a drainage channel. These are small temporary dams constructed before a swale across a drainage ditch.

Figure shows the ditch through which water passes. It falls down into a drain or a swale. These structures reduce the run-off velocities and the erosion as well. Some amount of sedimentation happens within the gaps as well.

These kind of dams are provided where maximum run-off contributing areas is less than 10 acres because if there is too much amount of run-off, then this will probably not have much of any effect. The height of this kind of structures or dams can be around 0.6 meter and the crest of the downstream dam is the elevation of the toe of the upstream dam.

The centre of the dam is at least 15 centimeter lower than the outer edges which give it a curve.

The sediment is removed by dredging when it reaches half this particular height. That is how a check dam is constructed along a natural drainage ditch or a natural drainage channel before it joins bigger channel or a swale.

Other structures are also used such as silt fences. As shown in this Figure, it is a temporary fence considering 6 month of operation. Filter fabric is held by wooden post that are 2 meters apart or by wire mesh and because this filter fabric is present the water flows down, but the sediment is captured.

The height of this fence is around 400 mm, catchment size is something around 2.5 hectares. So these fences are relevant for smaller catchments and are placed at the bottom of the slope along the contour to detain sediments and to reduce flow velocities. The purpose is same - water is allowed, the sediment is retained.

In addition, there are other temporary erosion and sedimentation control structures such as brush barriers, diversion dikes and temporary slope drains.

Brush barriers are basically vegetation that create similar kind of fencing. Diversion dikes are the structures that help to transport water to a necessary place.

In case of bench terracing, we can create some amount of dikes and we can take them to some other locations from where we can provide a temporary slope drain from where the water could be transported. So, instead of the water flowing over the given surface, using a dike, we can take it to a point from where we can provide a circular conduit through which the water can go out. This could be provided separately or it could be provided together as well.

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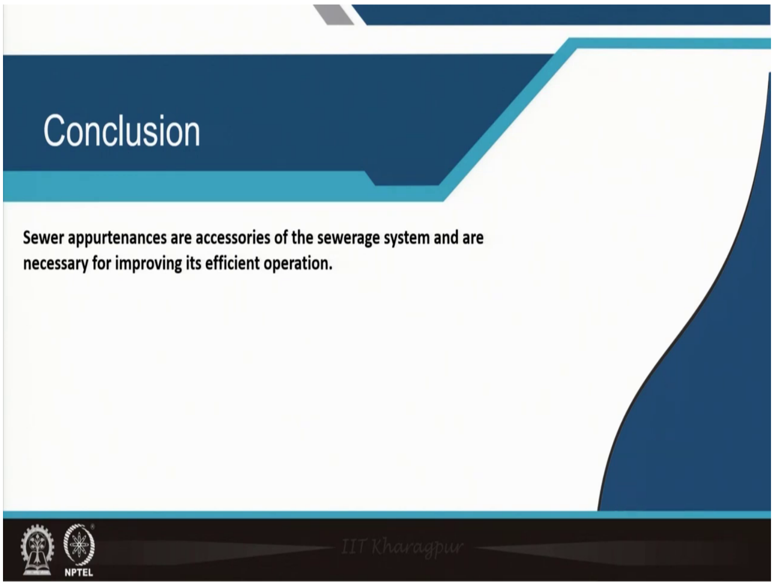

Conclusion

To conclude, sewer appurtenances are accessories of the sewerage system and are necessary for improving its efficient operation. There are different kinds of appurtenance, and each of them needs to be designed following proper engineering guidelines. The appurtenances could be provided at suitable areas according to the need. The selection of appurtenance is more important than the design of the appurtenances because the standard designs can be followed using existing guidelines.

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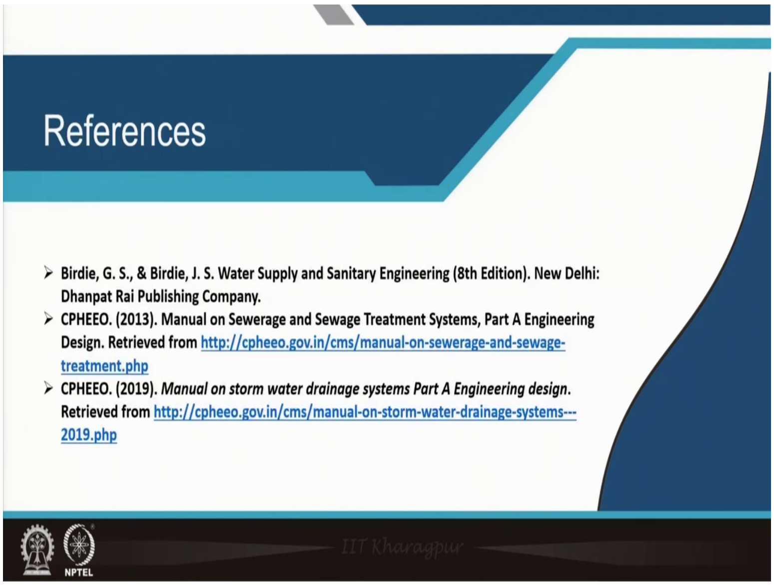

References

These are some of the references that can be followed.