Urban Utilities Planning: Water Supply, Sanitation and Drainage

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Module - 10
Sewer appurtenances
Lecture - 46
Sewer Appurtenances Part I

In module 10, Sewer Appurtenances and other Sewerage Infrastructure Part 1 will be discussed.

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The different concepts that will be discussed are manholes, drop manholes, flushing manholes, sand silt and oil traps, gutter and inlets and culverts.

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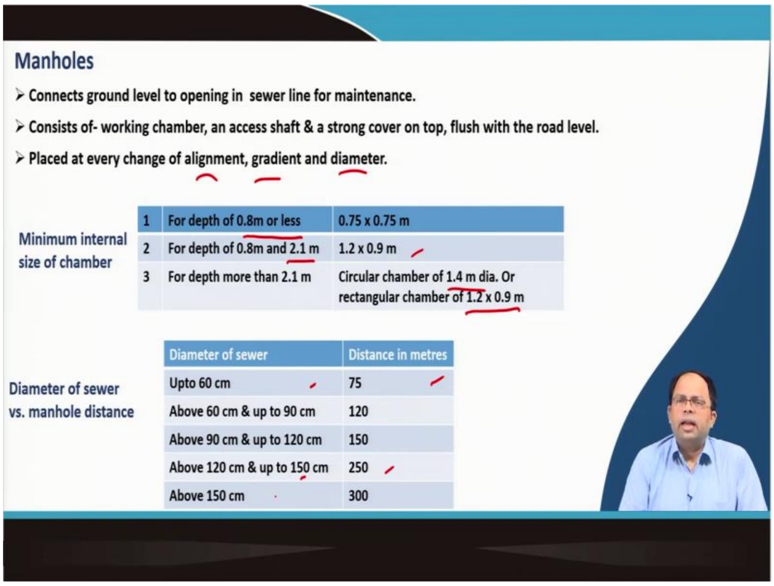

We have learnt about the basics of designing sewerage networks, different kinds of pipes, different kinds of joints, designing of a sewer line, different kind appurtenances. In this Lecture, some other appurtenances will be discussed.

Manholes: Manholes can be seen at different intervals along the road. These manholes are the connections to the sewer pipelines. Manholes connect the ground level to opening in sewer line and these are usually provided for maintenance of the sewer lines. Manholes are the ways to access the sewer lines.

Manhole thus needs to have a working chamber; that means, a person can go inside and work there or do some cleaning or inspection. Thus, there has to be an access shaft with an opening because sewer pipelines are below ground. And because there is an access shaft and in most cases, sewer lines run in the middle of the road, there has to be a strong cover on the top which is able to withstand the load of traffic and it has to be flush with the road level. Sometimes road maintenance and paving of roads lead to rising of the road height compared to the manhole. This is where rectification is needed as this situation creates problems where the manholes becomes too low or the manhole is higher from the road level.

Manholes are placed at every change of alignment of the sewer line; that means, wherever it changes direction, when there is a change in the gradient or the sewer line has a sudden drop or a raise; there is a connection between two sewer lines; and there is an change in diameter that means, two sewer pipelines of different diameters meet or the diameter has to be increased in the next pipeline.

The minimum internal size of the manhole chamber depends at what depth the sewerage line is present. As shown in the table, for depth of 0.8 meter or less, the size of 0.75 m *0.75 m is appropriate for the internal chamber.

For depth between 0.8 m and 2.1 meter, the size is around 1.2 m *0.9 m. For depth more than 2.1 meter, both circular and rectangular manholes can be designed. The circular chambers can have a diameter of around 1.4 meter while rectangular chamber can have a size of 1.2 m * 0.9 m.

As already discussed that manholes are provided at any change of gradient or diameter or alignment. But even though there is no change, we provide it at certain intervals. This is because it facilitates inspection and cleaning of the lines. The next Table shows the spacing of the manhole pertaining to the size of the sewer pipes. For a small-sized sewer pipes of diameter up to 60 centimetre, adequate distance between manholes should be 75 meter.

For larger diameter sewer pipeline above 120 centimetre and up to 150 centimetre, the distance could be 250 meters. The gap between two manholes increase as the sewer diameters increase.

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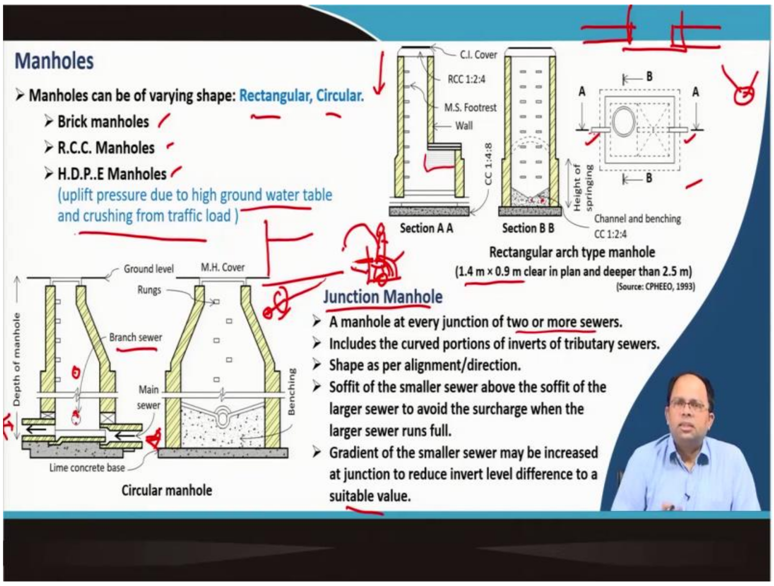

A shown in the Figure, this is a section of a rectangular arch type manhole of size 1.4 m * 9 m. A person goes down along the shaft by placing their foot on the M S footrest. Figure also shows the channel in the dotted line, and benching. In the plan of the manhole, there are two connecting sewer pipelines and the access at the top.

Manholes could be a varying type such as rectangular or circular. These could be made of different materials such as bricks, R.C.C and H.D.P.E (High Density Poly Ethylene) which is a form of plastic.

In the given case of HDPE manholes, it is much lighter and this manhole is put below ground. In addition to the surrounding load of the soil, there is also uplift pressure due to high ground water table and crushing pressure from traffic load.

For the junction manhole, the sewer line diameter increases in the next stage. That is why junction manhole is installed where there are multiple lines coming to one point. Figure shows the sewer line coming in and the sewer line going out with a given flow direction. The main sewer can be of bigger diameter but there can be another sewer that joins in the manhole. In this branch sewer also, benching is done. It provides a support for both the sewers. We need to ensure other things such as branch sewer will connect as near as possible to the main line. We can also change the gradient of this branch sewer and bring it down to reduce this distance(height).Soffit of the smaller sewer is above the soffit of the larger sewer. The reason is, in case the main sewer is filled, then automatically the branch sewer would be flooded and there would be a back flow. Thus, to prevent back flow, the soffit of the branch sewer should be above the main sewer.

Gradient of smaller sewer may be increased at junction to reduce invert level difference to a suitable value. If it is too above, then the sewer will spill in the working chamber. That is why the design is set so that it creates the least amount of disturbance.

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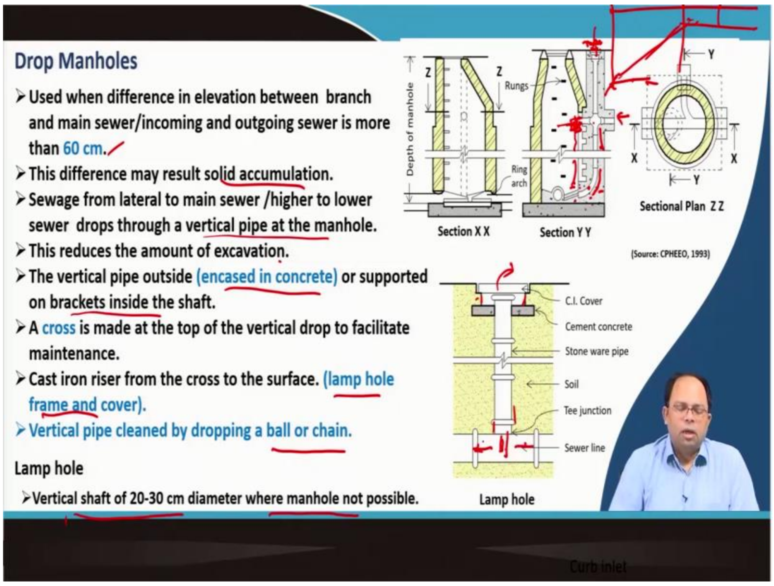

Drop Manholes

Drop manholes are a kind of sewer if the branch is supposed to join much higher because of the levels of the sewer. These are used when the difference in elevation between branch and main sewer is more than 60 cm or 2 feet. This drop may result in deposition of solid material. If the difference is not too much, a grade can be provided to bring it down. But this is not possible in case of high-level difference. Thus, drop manholes are provided. As shown in the image, the branch sewer drops to the main sewer through a vertical pipe. It reaches at a level which is almost at a same level as the existing main sewer line. Sometimes, we can keep a opening so that cleaning can be done if required by opening the plug. For inspection purposes, a lamp hole is provided at the top.

Drop manhole, reduces the amount of excavation. Because the alternative is to bring down the branch line gradually and then connecting it with this sewer. This would have resulted in lot of extra excavation. That is why it is better to design a drop manhole instead of giving it a grade, or laying the branch line at a higher grade.

The vertical pipe outside is encased in concrete, as shown in this case or it could be supported on brackets inside the shaft. A cross/clean-out is made at the top of the vertical drop to facilitate maintenance and cleaning. It have a plug which is taken out for cleaning. There is a cast iron riser from the cross to the surface where we can have a lamp hole frame and cover. We can put in a light through it and then we can observe where the blockage has happened. We can use it not only as a lamp hole, but also to clean the sewer by dropping a ball through it.

Lamp hole is an appurtenance or a sewer structure which is provided along the pipeline and not only in case of drop manholes, but in many cases. Usually it is provided where it is not possible to provide a manhole. It to inspect the sewer line and clean it as well.

A lamp hole is a vertical shaft of 20-30 centimetre diameter. As shown in the image, it is connected to the sewer line via a connecting pipe. There is also an opening at the top, a cast iron cover, and bedding.

Through the lamp hole, one can drop a lamp and a mirror as well that helps to look at both sides of the line and to see if there is a blockage or not.

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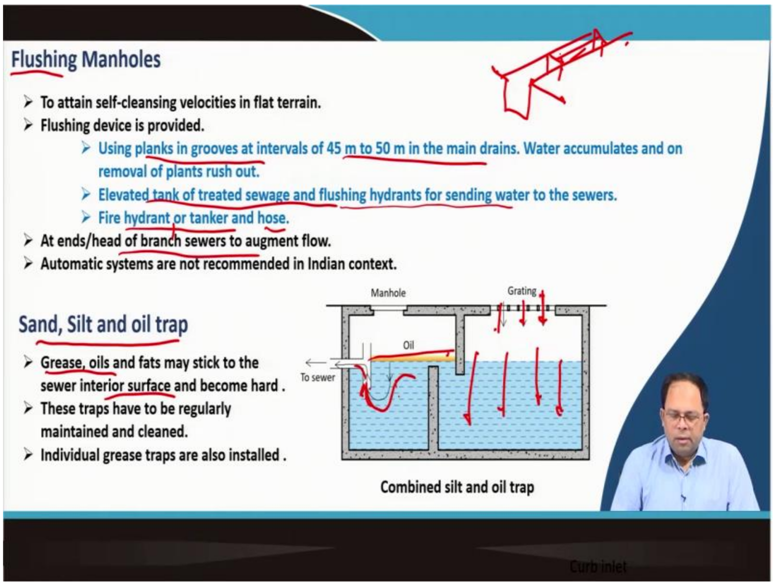

Flushing Monholes

Flushing manholes are installed to achieve self-cleansing velocity in pipelines in cases where it is not possible to achieve self-cleansing velocity based on the amount of water that comes into the pipeline or based on the sewage that comes into the pipeline.

It is a simple device where water is stored and when the water is released, it cleans the particular pipeline. That is the basic purpose of a flushing manhole. Flushing can also be achieved by using planks or groups at intervals of 45 to 50 meter in the main drain or the main line. If the planks are removed, the accumulated water rushes out and cleans any kind of blockage in that particular channel. Another method is to use an elevated tank or flushing hydrants for sending water to the sewers. We can directly use water from a fire hydrant or tanker using a hose to put water into the sewer line as well.

Water flushing manhole is usually at the end or the head of branch sewers to augment the flow, i.e., at the starting of the branch lines. In Indian context, usually because of maintenance and other issues, automatic systems are not recommended. Cleaning is done when required.

In addition to manholes, sand, silt and oil traps are also used. These are installed in urban areas where there are automobile workshops and petrol pumps or for water that comes out of the kitchens where there are greasy and oily impurities.

The system is designed in such a way that gives some space for sedimentation which allows the grit to settle. The outlet of the water is designed in such a way that the oil that floats on water can be trapped and the cleaner water can enter from below into the outlet and then go out to the sewer line. Usually these are installed within premises so that oil and grease does not enter into the sewer network. The grease and oils needs to be prevented from entering the sewer lines because they will stick to the sewer interior surface and this will gradually become hard. Oil will attract further impurities and the sewer profile will get reduced. These traps could be at certain places in the sewer network or it could be at the entry of the sewage treatment plant as well. Thus, multiple sand silt and oil traps can be installed. These need to be cleaned at certain intervals.

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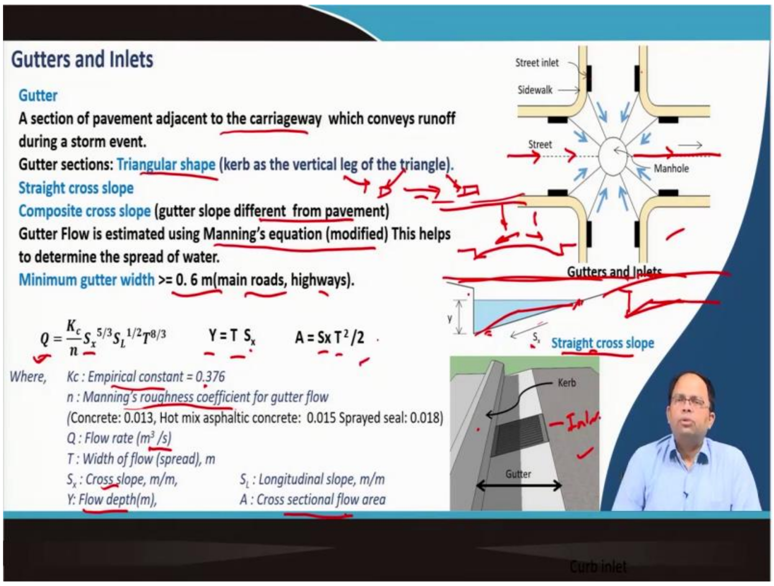

Gutters and inlets

When rainfall happens in a catchment area, it first travels over ground and reaches the street network and then it flows along the streets and gets into the sewer network via certain inlets. Gutters are the channels along the roadways through which the water flows till it enters into an inlet.

The considerations to design these include the amount of rainfall and the sewage that comes from the surrounding catchments. The sewer line is designed to take care of a certain volume of sewage, but to allow entry of the sewage or the storm water into this particular sewer line, we can design inlets or gutters.

Usually water goes towards the side of the street. This water then travel along the street for a certain distance till it enters into the inlet. If this design is not proper in terms of gutter size and/or the number of inlets, it will lead to flooding of the streets.

There has to be adequate number of inlet and the entry of water has to be smooth otherwise ponding will happen; that means, water will accumulate in front of the inlet points. Also, the size of the gutters or the drains as shown in this image, has to be adequate so that the water which comes down to the streets can enter properly through the inlet.

Even though the size of sewer lines is adequate, it can lead to flooding because water cannot properly enter into the sewer lines. That is why the design of gutters are important.

As shown in the image of the intersection where two roads are meeting, combined sewer line is running along the middle of the street and inlets are present at the four corners at certain interval. The water that is collected in this area comes into the inlet via gutter (drain at the side of the street).

As shown in the image, the gutter profile looks like a triangle. y is the depth of the gutter and S_x is the straight cross slope and S_L is the longitudinal slope that has to be provided to a particular gutter. A gutter is a section of pavement adjacent to the carriage way which conveys runoff during the storm event. So, gutter is considered as a section of the pavement and not of the carriage way. It is a kind of drain channel and profile of the drain is like a triangle. In this case, Manning's equation is used to determine the quantum of flow through that particular drain channel.

Apart from a straight slope, a composite slope can also be provided. So, instead of a straight line, it could have a break in that as well. Gutter slope in case of composite cross slopE is different from the pavement slope.

As drain channel could have any profile like rectangular or circular, the formula has to be modified. Usually, we assume that the minimum gutter width should be greater than 0.6 meter for main roads and highways. For smaller roads, it could be less than 0.6 meter.

The formula for determining the flow in that particular gutter that is flow rate in meter cube per second is a variant of the Manning's equation. It is shown below.

$$Q = \frac{K_c}{n} {S_x}^{5/3} {S_L}^{1/2} T^{8/3}$$

K_c = Empirical constant = 0.376

n = Manning's roughness coefficient for gutter flow (Concrete: 0.013, Hot-mix asphaltic concrete: 0.015, Sprayed seal: 0.018)

Q = Flow rate (m3/s)

T = Width of flow (spread), m

S_x = Cross slope, m/m

S_L = Longitudinal slope, m/m

This is how we estimate the quantum of flow in a gutter. If the gutter flow is not adequate; probably it will lead to flooding in the particular region. That is why the gutter width has to be designed properly. Also, the slope has to be designed properly. The formula for determining the flow depth and cross sectional flow area is given below.

$$Y = T\, S_x$$

$$A = \frac{S_x T^2}{2}$$

A = Cross sectional flow area

Y = Flow depth, m

So,

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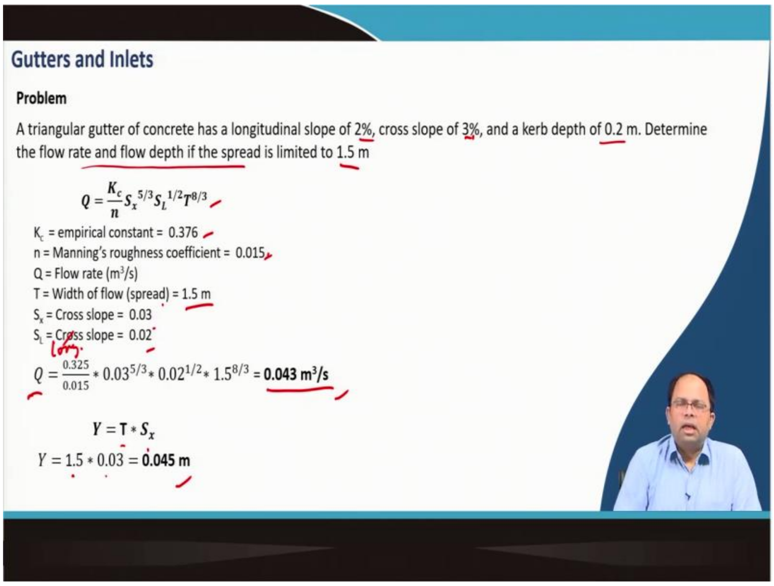

A triangular gutter of concrete has a longitudinal slope of 2 percent, cross slope of 3 percent, and the curve depth is of 0.2 meter. Determine the flow rate and the flow depth if the spread is limited to 1.5 meter.

$$Q = \frac{K_c}{n} S_x^{5/3} S_L^{1/2} T^{8/3}$$

Kc = empirical constant = 0.376

n = Mnning's roughness coeffient = 0.015

Q = Flow rate (m^3/sec)

T = Width of flow (spread) = 1.5 m

S_x = Cross slope = 0.03

S_L = Longitudinal slope = 0.02

$$Q = \frac{0.325}{0.015} 0.03^{5/3} 0.02^{1/2} 1.5^{8/3} = 0.043\, m^3/s$$

$$Y = T * S_x$$

$$Y = 1.5 * 0.03 = 0.045\, m$$

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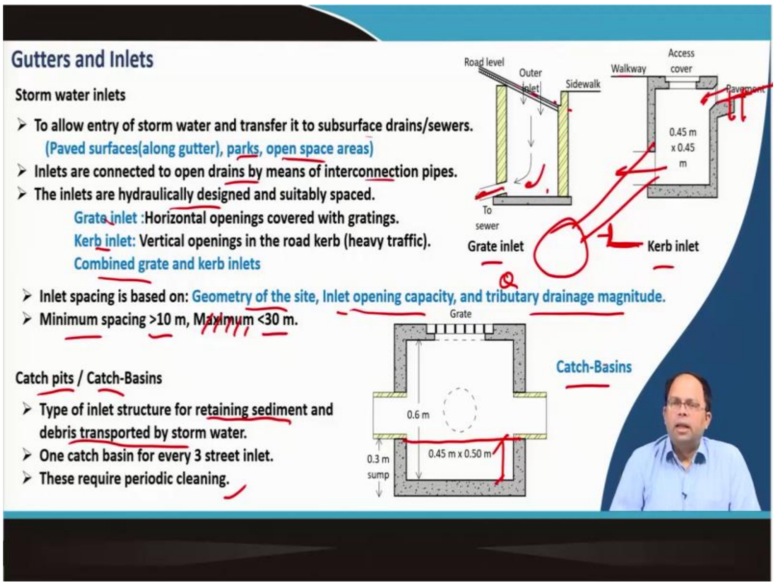

Gutters and inlets

Inlets are designed along the surface of the gutter and shown in the Figure. Water travels through the surface grates into a particular chamber and from there the water goes into the sewer line.

Similar to grate inlet, water can also go through a kerb inlet. Kerb inlets are designed along the edges of the footpaths from where the water enters horizontally instead of vertically. Then water goes into the chamber and then to the sewer line similar to the grate inlet. Figure shows the size of the inlet as 0.45 m * 0.45 m. It also shows the connection to the sewer pipeline. This is how an inlet is designed. Storm water inlets allow entry of storm water and transfer it to the sub surface drains or sewers.

These kinds of inlets are not only provided along the roads or along the pavements, but also provided in places like parks, open spaces where lot of water gets collected during rainfall. Inlets can be connected to open drains by means of interconnecting pipes. We can connect it either to drains or to sewers. The inlets are hydraulically designed and suitably spaced.

The size of the inlets, spacing of the inlets and the number of inlets is also important. There can be grate inlets, kerb inlets and combined grate and kerb inlet. If there is an opening on both sides, then it is combined grate and kerb inlet. So, all the three designs are possible and inlet spacing depends on the geometry of the site and slope, the inlet opening capacity (amount of water that can pass through a given opening) and that tributary drainage magnitude.

Minimum spacing of inlet should be around 10 meter and upto at maximum distance of 30 meter.

Instead of an inlet, a catch pit or a catch basin can be designed.

A catch basin or catch pit is a special type of inlet where we provide some more space where water can be collected. This extra space is where the sediments and debris transported by storm water can be retained. There should be one catch basin for every 3 street inlets. As it is designed to retain some sediments, it requires periodic cleaning as well.

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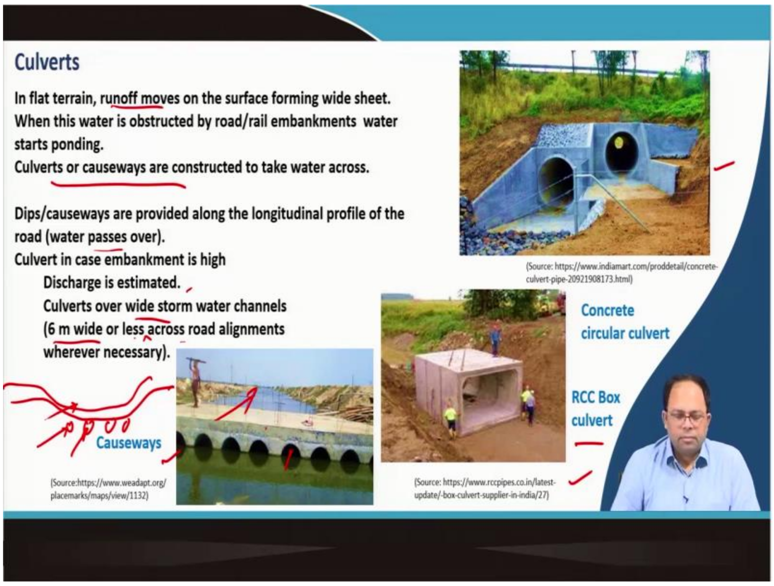

Culverts

The culverts are seen particularly along highways. In case of flat terrain, the rainfall runoff moves on the surface forming a wide sheet of flow and that is how water moves on the surface. And usually because of the raised nature of the highways or the rail lines, the water get stuck and ponding starts.

As seen here at one side of the railway line there is flooding and the other side is dry. That is possible because the water is coming from one side because of the slope. That is why at certain intervals, we have to provide some openings through which the water can travel from one side to another.

Because this rail line is an artificial barrier that we are creating along the path of the water, culverts or causeways are constructed. When the water level is low and water can travel through the openings below but when water level is high during rainy season, water can flow over the entire structure.

Vehicles can pass but it has to go through water. So, that is how a causeway is actually designed, but if the water level is too high then probably this road cannot be used.

Causeways are provided along the longitudinal profile of the road and water passes over. Culverts are provided in case the embankment is pretty high and we cannot bring it down. In that case, we can estimate the amount of discharge that has to pass through.

Usually it is designed for storm water channels and these are 6 meter wide or it could be less as well and across road alignments wherever it is required. These kinds of structures are designed where a concrete circular culvert or R.C.C box culverts can be designed as well.

This is why culverts are planned for floods. For flood mitigation or flood planning, in softwares, we have to put in values for culverts at certain locations. Thus, culverts are very important in drainage design.

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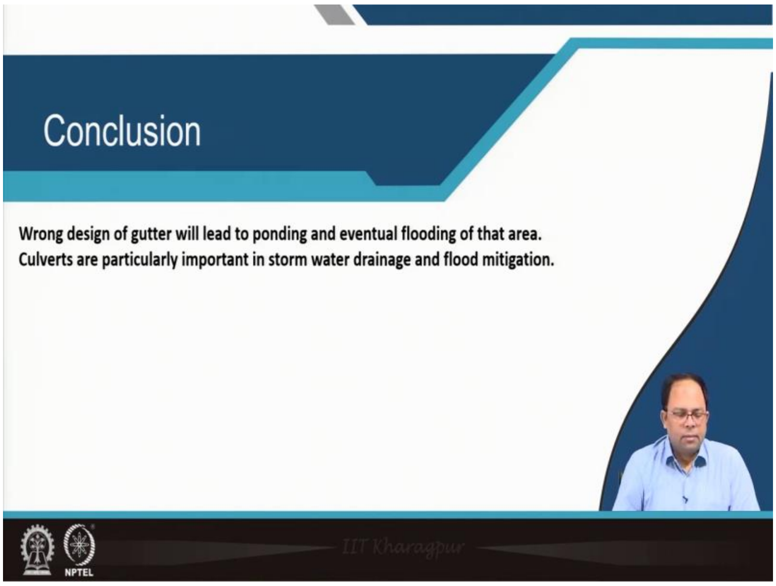

Conclusion

To conclude, wrong design of gutter will lead to ponding and eventual flooding of that area. Culverts are particularly important in storm water drainage and flood mitigation.

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References

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