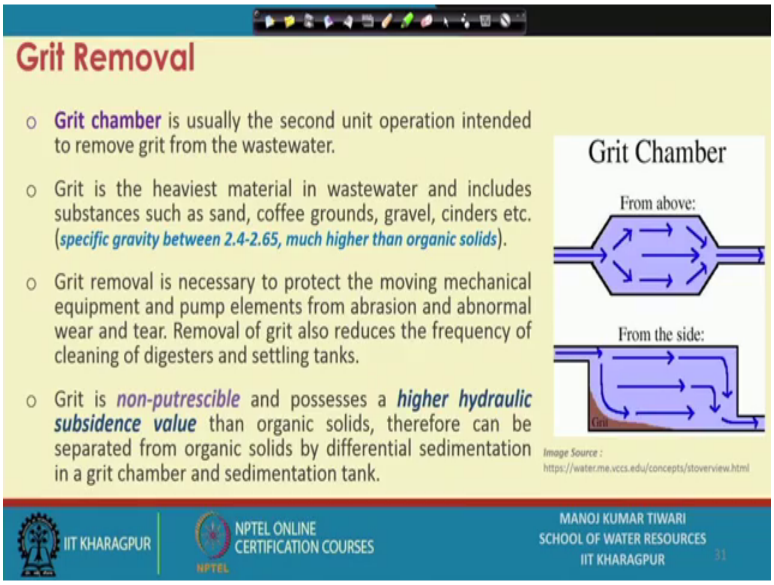
Wastewater Treatment and Recycling
Prof. Manoj Kumar Tiwari
School of Water Resources
Indian Institute of Technology, Kharagpur

Lecture - 25
Wastewater Treatment Units: Grit Removal and Equalization

Hello friends. So, we discuss about couple of preliminary treatment options in the earlier lectures, we did talk about this screening. Today in this lecture, we will be discussing the subsequent treatment, which is Grit Removal and then Equalization, which actually is an optional treatment system optional treatment unit. To begin with, so in the screening that we discussed earlier, by screening, we have already trapped the large floating materials ok, those who are coming along with the wastewater stream through the appropriate screens.

(Refer Slide Time: 01:04)



Now, these large floating materials, when I have already been retained, then we intend to in the next unit, which is grit, grit chamber. Grit chamber is usually the second unit operation, which is intended to remove grit from the wastewater. Now, grit is the heaviest material typically, and that includes substances such as sand, coffee grounds, gravel, cinders with a significantly higher specific gravity. The specific gravity typical specific gravity of grit materials is of the order of 2.6 or so, the range can be between somewhere between 2.4 to 2.65, which is much higher than that of typical organic solids.

Now, grit removal is necessary to protect the various equipments, pumps that are there in the treatment plant in the subsequent units, because you know that when because up to history is screening the water may be coming in open channels or pipe or mostly by the gravity, but beyond this point forwards, when we need to put water into the reactors, at a controlled flow rate, at a controlled discharge, so we need to pump water, we need to have several mechanical equipments, like when the water goes to the aeration through we need mechanical aerators or those kind of systems.

So, if we do not remove these heavy materials these larger particles, then they may cause a disturbance or even a damage in the these mechanical equipments which will be operated subsequently, the your pumps may get faulty, there might be abrasion or abnormal wear and tear, so that is why the removal of grit is essential.

For that, it also reduces the frequency of cleaning of the digesters and settling tank. Because, subsequently we will see that we go to the when we go to the primary sedimentation in the following lectures, so there the target is to settle the final settle able solids, grit which can be easily settled because of very high specific gravity. If we allow them to go through there, so significant mass of this sludge will consist of grit only, and we need to because frequently clean the sludge zone of the subsequent systems, so that also creates another problem.

So, since grit possesses a higher hydraulic subsidence value than typically organic solids, so it can be easily separated from organic solids by differential sedimentation in grid chamber and the subsequent sedimentation could take place in the sedimentation chamber ok.

(Refer Slide Time: 04:00)

So, the idea of grit removal is to basically trap those grit particles and settle them quickly. Now, both quality and quantity of grit varies based on various factors. These factors could include the type of street surface encountered, because wastewater typically flows in open channel. Now, if it is a lined system, unlined system what kind of surfaces it is being generated from the type of inlet and catch basins. What is the kind of inlets? And are we protecting any are we having any protection at the inlet point, so are we having any catch over there, those kind of things also effect.

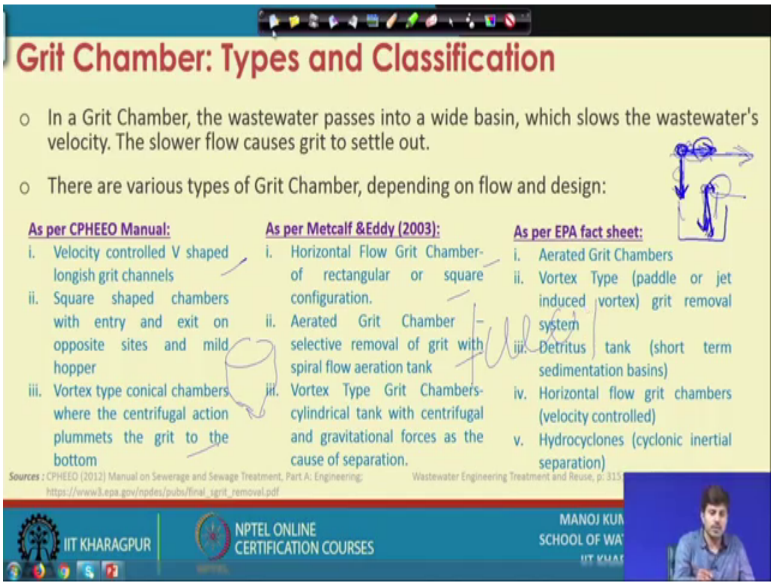
Then the construction and condition of the sewer system; if it is a well lined system, where no additional or there is covering from the say top also, so there is no additional material coming in over there. It will have lesser, but if it is exposed system or there is a lot of erosion, because erosion of the your sewer system also adds lot of grit in the sewage. So, these are in the factor, then ground and groundwater characteristic. If there is any seepage from groundwater, those kind of points will also be considered. The amount of storm water diverted through the through over the flow points and your night soil and other solids admitting into the sewer through the dumping chutes and pail depots. So, these are there.

Then there are relative area served, how large area is being served, what are the climatic conditions, what are the sewer grade and slopes, whether there are industrial wastes incoming ok, what is the social habit of the people, what kind of waste they are releasing into the sewage system. So, there are these variety of factors that in combination leads to the quantity and characteristic of the grit, which actually comes in the sewage.

However, the grit is usually limited to municipal wastewater and generally not required for industrial effluent treatment plants, except some industrial wastewater which may have grit, because otherwise industrial processes are pretty much organized, and the kind of solids the kind of materials expected to coming in those systems are fairly standard.

So, in order to control in order to have an ion like if your processes are coming from the control systems, and you know that there is no possibility of such grit materials coming into the flow, coming into your industrial effluent, one may actually (Refer Time: 06:49) grit removal from the industrial systems. However, in municipal sewage, it is almost a certain unit that needs to be provided, because our municipal sewage typically comes from open channel or the sewer lines, and contains lot of grit material over there.

(Refer Slide Time: 07:07)



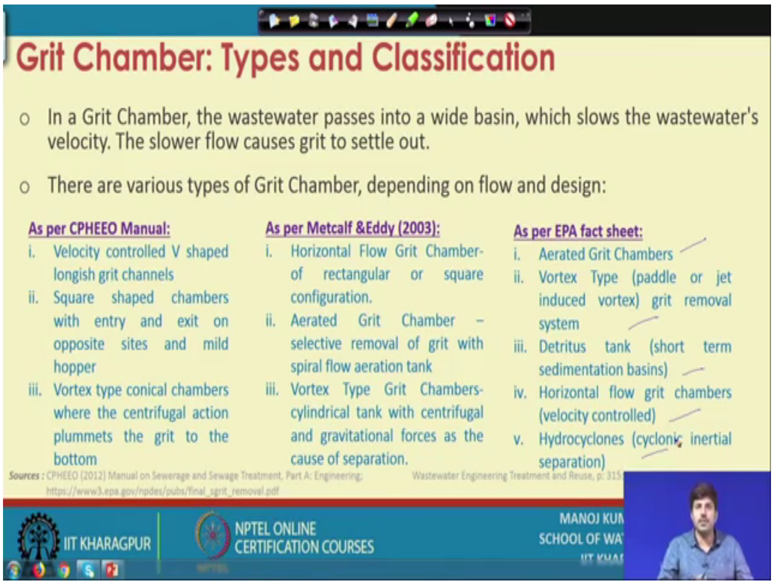
The grit chamber can be classified in several ways ok. And the wastewater in grit chamber what actually happens that wastewater is passed into a wide basin, which slows the wastewater velocity. The slower flow causes the grit to settle out, because if you are having any particle any heavier particle for a for say is likely to settle by the virtue of gravity ok, there is a gravitational force on these particles, which tend to pull it down ok. However, when this particle is into a chamber or into a horizontal flow condition so there is a horizontal flow velocity also acting on this ok. If your this will depend on its specific gravity and weight, whereas this will depend on the rate of discharge or the flow velocity of the system.

If your flow velocity is substantially higher as opposed to its settling velocity, the net movement of the particle will be something like this, and actually particle will keep on flowing. But, if you reduce this velocity component substantially low, so let us say this is your net magnitude of the settling velocity, and this is just magnitude of horizontal flow velocity, so your net velocity component or movement of direction become like this, and then particle will eventually try to settle down and will not pass through. So, this is what is the basic principle behind the detention of suspended materials in the grid chamber or subsequently even in the sedimentation basin.

So, this velocity the horizontal flow velocity is slows down slow down ok, and we allow the particles to settle. The various types of grit chamber depends on the flow and design, there is based on sources if you follow the CPHEEO manual, so there is velocity controlled V-shaped longest grid channel. There is square shaped chamber with entry and exit on the opposite site of the mild hopper. There is vertex type conical chamber ok, so which basically works on a vertex action the conical chamber like this ok. So, you can have various designs and various sort of flow patterns in a grit chamber.

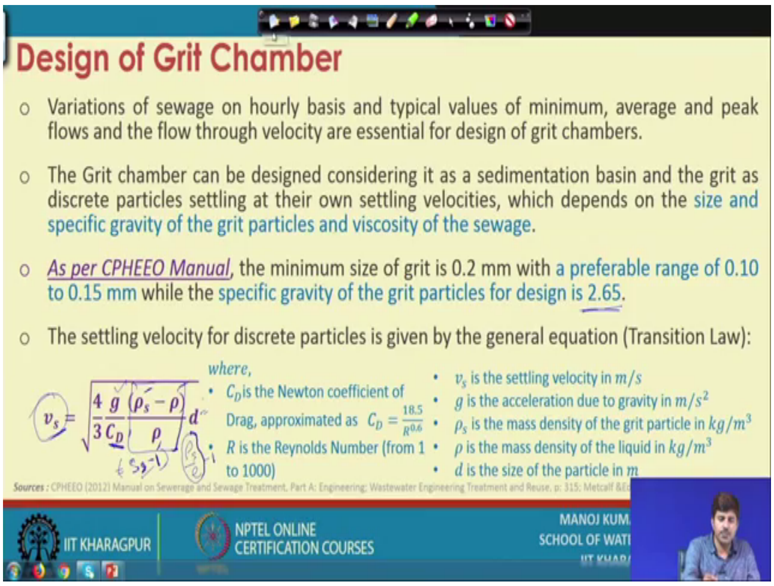
Several books one of the like Metcalf and Eddy's I have there is horizontal flow grit chamber or which is rectangular or square in the configuration. There could be aerated grit chamber, which is for the selective removal of grit with spiral flow aeration tank. So, there will be tank, where basically there is a variation spiral aeration kind of things will take place. There is vertex type grit chamber, again the one that was there in the CPHEEO manual as well.

(Refer Slide Time: 10:11)



EPA fact sheet proposes few more types of grit chamber. So, there is aerated grit chamber, there is vertex type, which could be paddle or jet induced vortex. There could be detritus tank, which is short term sedimentation basin kind of thing. Horizontal flow grit chamber, which is based on the velocity control and there could be hydro cyclones, which is cyclonic inertial separation of the grit from the water. So, there is various principles, which work on such systems for the removal of grit.

(Refer Slide Time: 10:42)



Now, if you go for the design of grit chamber, the design of grit chamber is primarily based on the settling of the particle, because as we discussed, it is the prime objective of a grit chamber or grit removal system is to let the heavier grit particles settle in the chamber. So, variations of the sewage on hourly basis and typical value of minimum, average and peak flows are first estimated ok, and then the velocity essential for the design of grit chamber is calculated based on that.

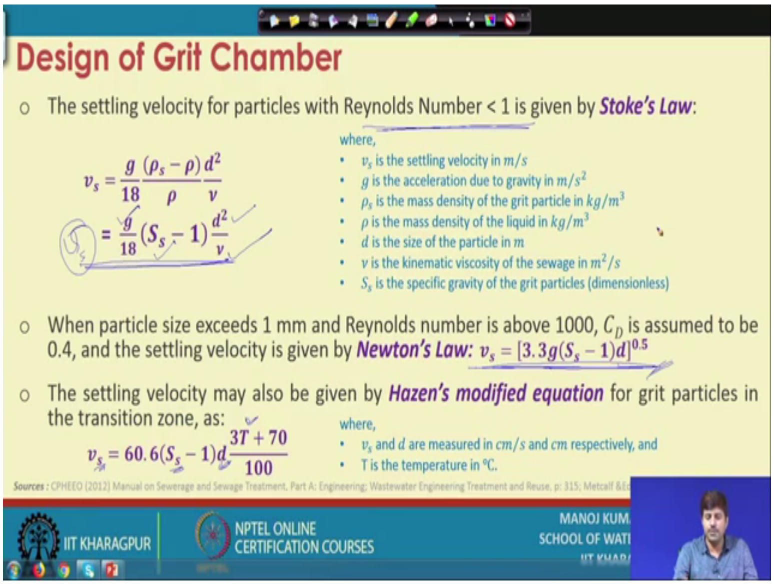
So, grit chamber can be designed considering it has a typical sedimentation basin this design is more or less similar ok, the only thing is that a specific gravity changes over here. So, grit settles as a discrete particles settling, we will discuss this different type of settling in the next lecture. So, it settles as one independent individual particle at its own settling velocity, which eventually depends on the size and specific gravity of the particle ok. And of course, what is the viscosity of the water or viscosity of the sewage, where it is trying to settle. So, if you see the guidelines presented in the CPHEEO manual, the minimum size of grit is 0.2 mm with a preferable range of 0.1 to 0.15 mm, while the specific gravity of grit particles for design purpose is typically taken as 2.65 ok.

Now, the settling velocity for discrete particle is generally given by the Transition law, which is the general equation for settling. So, settling velocity of a grit particle v s can be estimated as 4 by 3 g by C D rho s, which is the density of the grit particles, minus rho which is the density of the water divided by rho into d ok. So, this way you can actually particularly this element if you see here, so this can also be written as rho s by rho minus 1, and this is the specific gravity of the grid particle. So, this can also be written as say if you denote a specific gravity by S s, so S s minus 1 ok. So, this can this formula then become 4 by 3 g by C D S s minus 1 into d ok.

Now, here if you see the C C is the drag coefficient ok, which is typically approximated as 18.5 by R to the power 0.6, where R holds the Reynold number, which is from 1 to 1000 in the transition scale. The v s is the settling velocity, which we are trying to estimate. The g is the acceleration due to gravity in meter per second square. And as I said the rho s is the density of the grid particle, and rho is the density mass density of the liquid or density of the water ok. And d is of course, the dia of the particle, which we intend to settle. So, how we design it, we know that what size of particle we want to settle.

So, let us say if you want to settle the grid particles of size 0.2 mm and higher, so we our dia becomes 0.2 mm. Of course, we need to convert that in meter, and then we know the specific gravity we take or consider a specific gravity of the particle say it is 2.65. So, then we know the 2.65 minus 1, so we know the d, we know the specific gravity, we know the g. The C D is the one, which is unknown to us. So, if we know the C D, we can estimate the velocity settling velocity of the particle ok, so that is how typically the estimation is done.

(Refer Slide Time: 14:39)



Now, for the design practices, because we do not know the C D in the we just were seeing that slide earlier here. So, since C D is not known to us ok, we are we do not know what is actually the value of C D over here So, without C D, we cannot estimate the settling velocity. So, we start from an approximation, and to begin with, we consider the settling velocity of the particle with Reynold number less than 1, which is typically given by the Stoke's law.

So, then our velocity becomes if because if we follow the Reynolds number if we follow Reynold number less than 1, so then we our equation typical equation reduces to this, which is a typical Stoke's law equation. So, g by 18 S s minus 1 d square by v, d square by mu which is mu is the kinematic viscosity.

So, if you see here, we have the we know the dia of the particle, we know the specific gravity, we know the viscosity, we know the g, So we can estimate a settling velocity of the particle. But, remember, this settling velocity is not correct or may not be correct. Why it may not be correct, because this is based on an assumption that our Reynold number is less than 1, which may not be the case. This based on assumption, when our Reynold number is less than 1, and Stoke's law is valid, which may not be the case, and that is why the settling velocity may not be the correct one.

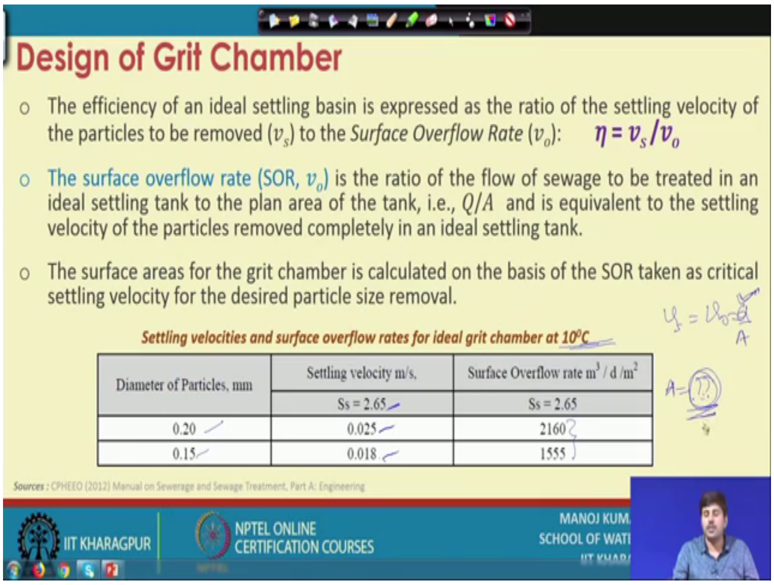
So, when particle size exceeds 1 mm and Reynold number is typically above 1000, the C D is assumed to be 0.4, and the settling velocity then can be obtained from the Newton's law, so this formula can also be adopted. If we know that the particle sizes are big enough, and we want to sort of settle down in the turbulent stage, when your Reynold number is above 1000. And then this formula can be used here also, we know d, we know g, we know S s, so velocity can be computed.

The settling velocity may also be obtained from the Hazen's modified equation for grit particle that is in the transition state. So, it is basically a temperature based equation. So, your settling velocity becomes 60.6 S s is known to us, dia of the particle is known to us, and then based on the temperature what temperature we want the process to be take place, we can estimate the settling velocity. Now, these are the ways through which we can directly get the settling velocity, but these are based on certain assumptions that our Reynold number is less than 1 or more than 1.

And as we know that Reynold number is our rho v g by mu. So, since you need you need the knowledge or the number of velocity, you need the value of the velocity also in order to estimate the Reynold number, and here we are estimating velocity based on the Reynold number ok. So, it is a basically cyclic this thing, and if we do not know what is the as as the case is that if we do not know what is the actual velocity, we cannot estimate the Reynold number. If we do not know the Reynold number, we cannot estimate the drag coefficients, and we cannot actually get the correct value of the settling velocity.

So, for the purpose, we begin with say assuming a Reynold number less than 1 or if we know we knew we can apply Hazen's formula or Newton's formula also, but if we are applying let us say the Stoke's law for Reynold number less than 1, and we are getting a velocity, we need to once we know the velocity, we need to cross check the Reynold number. We need to estimate the Reynold number again, and see if Reynold number is matching that criteria or not. If Reynold number is matching that criteria our estimate is correct if not, we have to use this velocity and compute the Reynold number. And then based on Reynold number, compute the drag coefficient, and put that drag coefficient into the equation in order to get the settling velocity. And do these cycles until unless the value of the velocity or value of the drag coefficient stabilizes.

(Refer Slide Time: 18:41)



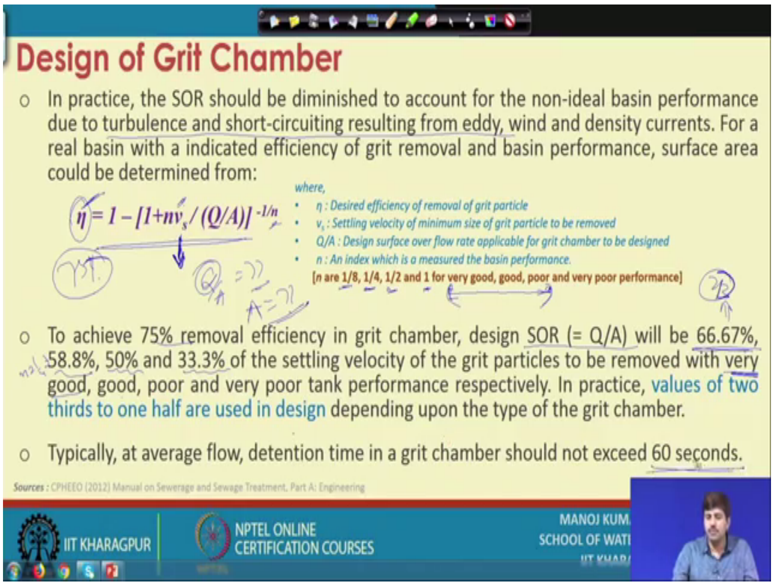
Now, the efficiency of a ideal settling basin or ideal grit basin will be expressed based on the settling velocity of the particle to be removed to the surface overflow rate. So, this efficiency is typically the ratio of these velocities. The surface overflow rate which is SOR or we refer to it as v 0 also is actually the ratio of flow of sewage to be treated in a ideal settling basin or ideal grit basin to the plan area of that tank, which is equal to Q by A, because flow is Q, and plan area is A. And it is equivalent typically to the settling velocity of the particle removed completely in an ideal basin.

Now, the surface area for the grit chamber is calculated on the basis of the surface overflow rate taken as a critical settling velocity for the desired particle size removal. So, once we know the settling velocity once we know the settling velocity, we can consider the our surface overflow rate as equal to settling velocity for ideal case. So, because if we assume this 100 percent removal, so our v s actually becomes equal to v 0 now, if we know the v s from the equations that we basically computed earlier based on the dia and specific gravity of the particle, and we know v 0 is equal to Q by A. So, from here knowing the discharge, how much discharge is coming, we can actually estimate what is the plan area required for the grit chamber ok.

So, settling velocity and surface over flow rates for an ideal grit chamber at 10 degree Celsius as basically given in the manual would be something like this. Your for particle size 0.2 mm, your in the specific gravity 2.65, we have settling velocities at 0.25 meter per second, and for smaller particle it is 0.018. And the surface over flow rates would be of this order, so that way we can estimate the surface overflow rate and there we can actually get the area of the tank ok.

And then once we know the area of the tank, we can basically dimensionalize, it put a length, width or if we consider a circular basin, so we can determine the dia, but that is for the ideal settling basin. And our settling tanks are not or our grit chamber or settling basins are not always work based on these idealized principles.

(Refer Slide Time: 21:29)



In practice what happens that surface overflow rate has to be diminished to account for non-ideal basin performance as there would be some degree of turbulence and short-circuiting, which is resulting from the eddy, wind or density currents. So, in real basin in actual basin which deviates from an ideal settling tank, we can use this expression as suggested in the manual for the purpose of design.

Now, if we assume, here this is the desired efficiency. So, let us say if we assume 75 percent removals or desired efficiency becomes 0.75 will be equal to 1 minus 1 plus n v s, which is the settling velocity estimated for the particle ok, and Q by A which is your kind of overflow rate minus 1 by n. Now, here n is an index, which is measured of the basin performance ok. So, again it is a sort of empirical value that has to be assumed. So, one can assume n as 1 by 8 for very good performance, 1 by 4 for good performance, half for poor performance, and n is equal to 1 for very poor performance.

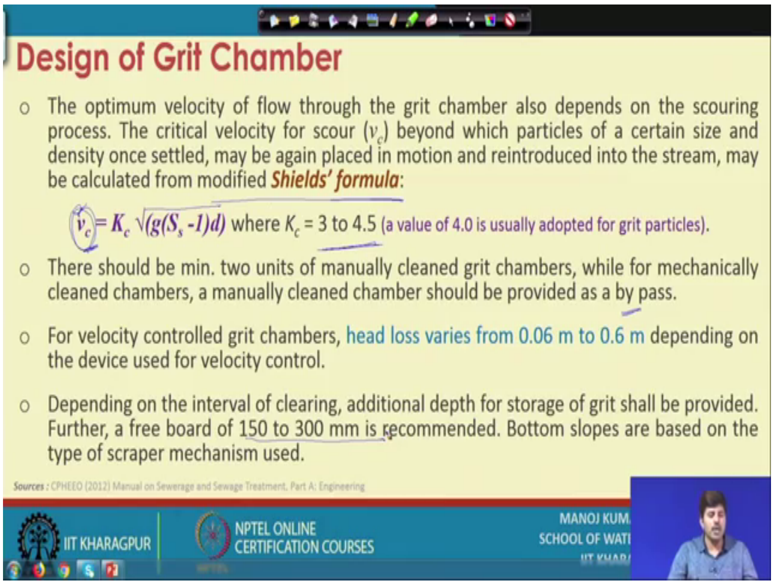
So, based on these values if we assume and if we assume this efficiency ok, so we know the n, we know the efficiency, we know the settling velocity. So, from this equation, we can get the Q by A. And knowing the discharge, we can determine the actual area of a real basin ok. Earlier we were discussing about the ideal basin, but this is about the real basin.

So, like taking an example to achieve say 75 percent of removal efficiency in a grit chamber if our design surface overflow rate or Q by A comes to be around 66.67 percent of the settling velocity of the actual settling velocity. Earlier it is like in for an ideal basin, it is equal to the settling velocity, but for a real basin for 75 percent removal efficiency, it will be 66.67 percent, when the performance is very good or n value is equal to 1 by 8. When this performance is good, so or n is equal to 1 by 4, then it is going to be around 58.8 percent. For a poor performance, it is going to be around 50 percent. And for a very poor performance, it is almost going to be one-third ok, so that way.

In practice, the value of anywhere between two-third to one-half are used in the design. Now, you see the two-third is 66.67 percent is actually two-third ok. So, this is your two-third, and half is this. So, you practically we assume our tank to be performing between some very good; good or poor, we do not consider very poor performance. But, somewhere if even if our tank is performing from somewhere between very good to poor what we get is typically between two-third to one-half of the design depending on the type of grit chamber, which is being used or which is being considered.

Typically, an average flow and detention time in grit chamber should not exceed 60 seconds, because the process is pretty fast. And within a minute, we can let the grit particles settle down.

(Refer Slide Time: 25:47)



There is another criteria, which needs to be seen when because we are allowing the particle to settle and we are the retention time is quite small, so there has to be there will be some velocity component horizontal velocity component. This horizontal velocity component should not be that high, so that it leads the scouring or the grit material, which has settle down should not come back in the suspension. So, in order to prevent this scouring process, the critical velocity of this scour is also estimated, which is the velocity beyond which particle of certain size and density actually may again come in the motion, and we will get reintroduced in this stream or will come back again in the suspension.

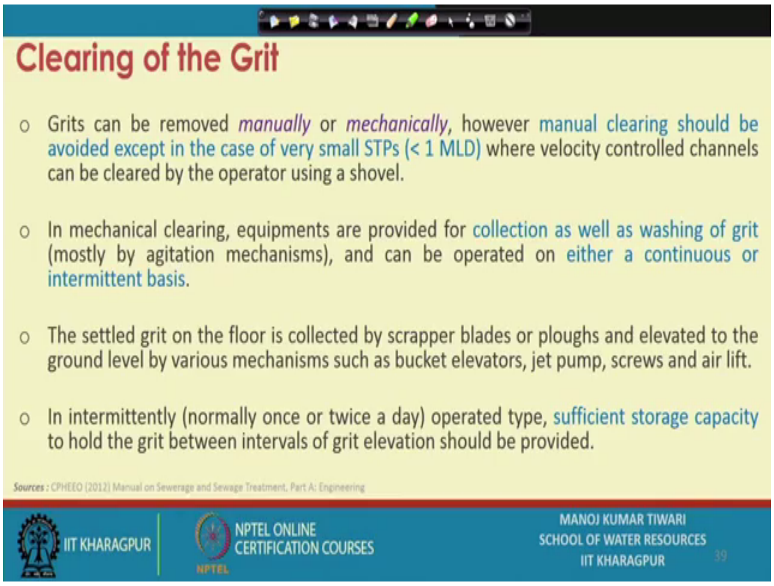
And this critical velocity of scouring is typically calculated based on the modified Shields formula. Now, this modified Shields formula if you see is the critical velocity of scouring is equal to K c square root of your g S s minus 1 into d, where the K c values has taken between 3 to 4.5. And we know what g S s and d means, so that check needs to be performed. And we need to see that the horizontal velocity in the tank should actually remain lower than this critical scouring velocity, because if your will horizontal velocity is reaches over critical scouring velocity, you may see the scouring of the particle happening.

There should be minimum two units of manually cleaned grit chamber, while mechanically cleaned grit chamber manually grit in for the mechanically cleaned grit chamber and manually cleaned grit chamber should also be provided as a bypass. Because, if you are just having say one unit mechanically clean unit and if there is a failure of the equipment, one unit may be enough, but if there is a failure of the equipment, then how you are going to remove the grit. So, as a bypass channel, a manual grit cleaning chamber is also provided.

For the velocity controlled grit chamber, head loss varies from 0.06 to 6 meter depending on the device used for the velocity control. And the depending on how frequently it is being cleaned, what is the interval of cleaning, what is the additional depth for the storage of grit, needed can be estimated ok.

If your frequency of cleaning is quite high, you can leave a (Refer Time: 27:51) depth for storage, but if your cleaning frequency is quite low, your cleaning let us say after several days, so there has to be sufficient storage provided for the grit, which is being settled out ok. And towards the top of the tank are typically 150 to 300 meter free board is recommended. Bottom slopes are also based on the kind of scraper mechanisms, which is being provided in the grit chamber.

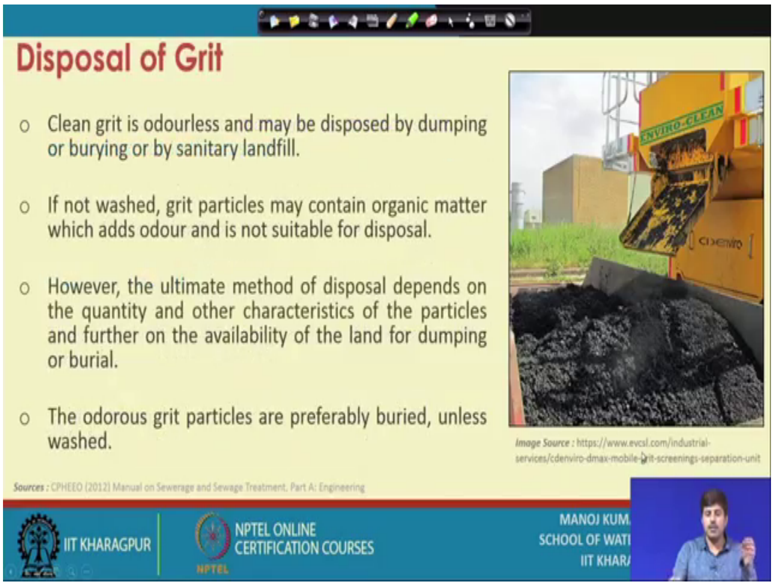
(Refer Slide Time: 28:17)



Now, how we clean grit. Typically, can be removed manually or mechanically; however, manual cleaning manual clearing of the grit should be avoided in case of a large STPs. If your STP is very small say less than 1 MLD, so the amount of grit deposited is not that high. And one can go for manual cleaning, but in the larger STPs or larger treatment plants, when there is a lot of grit depositing, so manual cleaning becomes quite difficult. So, one should go for mechanical cleaning in such systems, and the equipments that are provided for collection as well as washing of grit. By agitation mechanism typically, can be operated either on a continuous or intermittent basis.

The settled grit which basically settles on the floor is collected through scrapper blades or plugs and then elevated to the ground level by various mechanism, which can include bucket elevators, jet pumps or screw and airlift. In intermittently operated type, when we are not operating the grid chamber on a continuous mode ok, we just operate grit chamber only normally once or twice a day, there has to be sufficient storage capacity to hold the grit between the intervals of grit elevation, and accordingly provisions should be given.

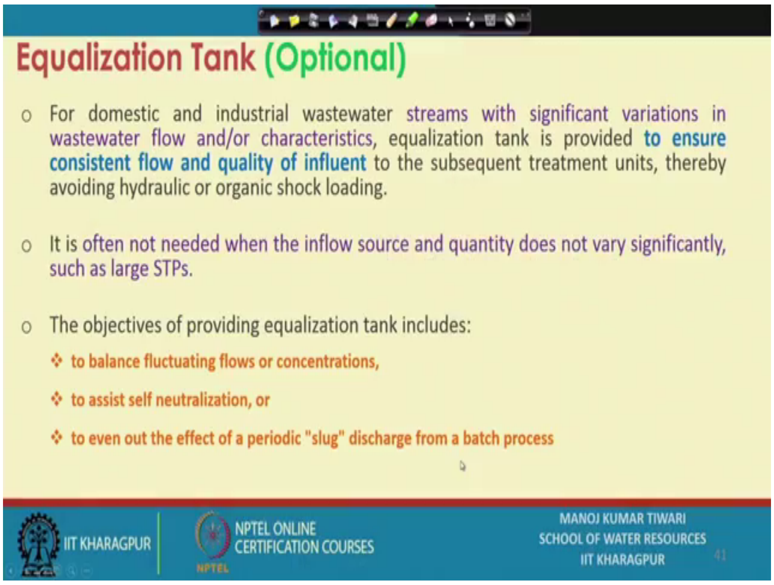
(Refer Slide Time: 29:35)



The cleaning of grit is basically the is essential. And if you see the clean grit, because typically grit materials are what, the sales clan larger those kind of particles, and they generally do not have any order. So, clean grit is typically odourless, and may be deposited by dumping or burying or by going for sanitary landfills ok. If not washed, it may contain certain organic matter also, because wastewater contains lot of organic matter and some (Refer Time: 30:14) settle. And those organic matter may add some sort of odour, and then it is not suitable for disposal. So, grits is typically washed before disposal.

The ultimate method of disposal will depend on the how much quantity is being generated and what is the characteristic of those particles and further how much what kind of facilities, what kind of infrastructure, what kind of land is available. If there is sufficient land, you can just go for dumping or burying ok. But, order less grit particles are typically buried, because it is anyway those kind of sediment material, so they can be typically buried, unless you wash them properly ok. The one which is having odour needs to be buried subsurface, and otherwise you wash them and then you can go for like open dumping or other processes, because you need to be careful about the order arising as well.

(Refer Slide Time: 31:17)



Now, there is let us quickly discuss another unit, which is equalization tank, it is actually an optional unit ok. The domestic or industrial wastewater streams, where there is a significant variation in terms of wastewater flow as well as quantity as well as quality or characteristic. Then we provide the equalization tank to ensure the consistent flow and quality of the influent, which is passed through subsequent treatment units, and thereby avoid hydraulic and organic shocks coming on to the subsequent units.

Now, equalization tank is optional, because often the larger STPs, there is already significant or continuous inflow coming in, the characteristic does not change too much, because the reason or the sources are municipal, primarily the municipal effluents, municipal wastewaters. So, there is no large variation in terms of quality or quantity, and that is why the equalization tank can easily be avoided for the large STPs. But, if it is a smaller STP, then the kind of flow coming in may vary a lot or particularly industrial process or depending on the process, when there is a operation going on, you will see very little discharge; when the operation is completed, lot of wastewater is released at once.

So, there is possibility of such kind of variations in terms of quality as well as in terms of quantity, because many times you see the quality also varies the kind of if particularly from the industrial processes, you are have when you are just washing floor and those kind of things, so the water which is coming is of very like mildly contaminated or very little contaminated, but the water which comes out of industrial processes may have substantial degree of contamination in it.

So, there is this possibility of having these variations ok. Now, we provide an equalization tank in order to control this, in order to balance the fluctuating flows and concentrations, it also helps in assisting the self neutralization of this, and even out the effect of periodic slug, which discharges in a batch processes, because many places in particularly in the industry many times this waste is discharged in the batch processes, and that needs to be even out.

(Refer Slide Time: 33:47)

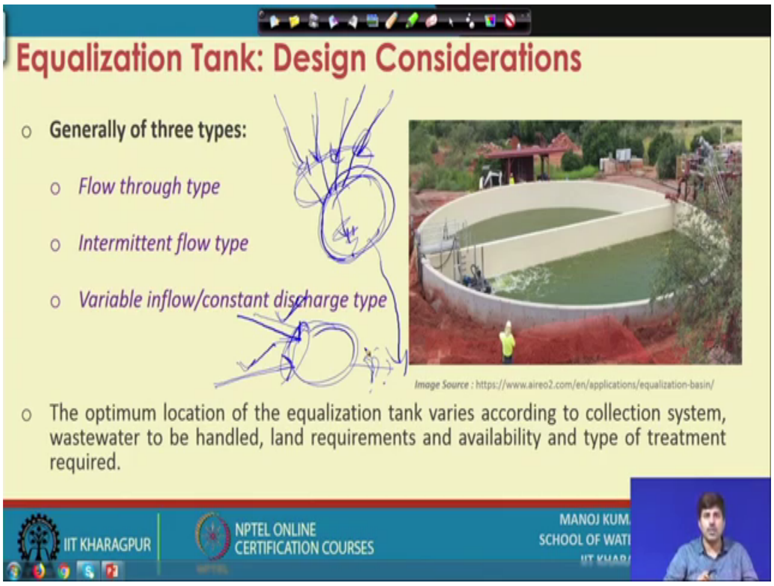
The benefits is that shock loading is eliminated or minimized, and therefore the subsequent biological processes are enhanced. This fairly important, because otherwise your biological processes or the microorganisms or subsequent like bacteria and those things will be susceptible, sometime they will get very high organic load, there might be some toxicants also available in it ok, and they have to deal with it. And sometime they will get very diluted waste and probably not of enough of the organic matter present in the waste to fulfil their metabolic demands.

So, they basically remains in a state of shock and their performance dips. So, their performance of this such processes cannot be consistent in that case, if they are getting shocked loadings in terms of flow or in terms of quantity, in terms of quality.

The effluent from biological treatment have better quality and improved thickening, if we put through a equalization tank or put through a controlled flow. Effluent filtration surface area requirements are reduced with improved filter performances. The important ones are that the particularly the chemical feed control processes becomes more reliable. The risk of the plant failure reduces.

And the protection against the higher level of toxic loads is also reduced, because if there is toxic load coming in a very high concentration, and you put through an equalization basin, allow the larger flow coming in, and then there is an self neutralization takes place. And by the time, you pump that water to the subsequent units that the effect of that periodic slug or very high concentrations has already almost diminished.

(Refer Slide Time: 35:33)



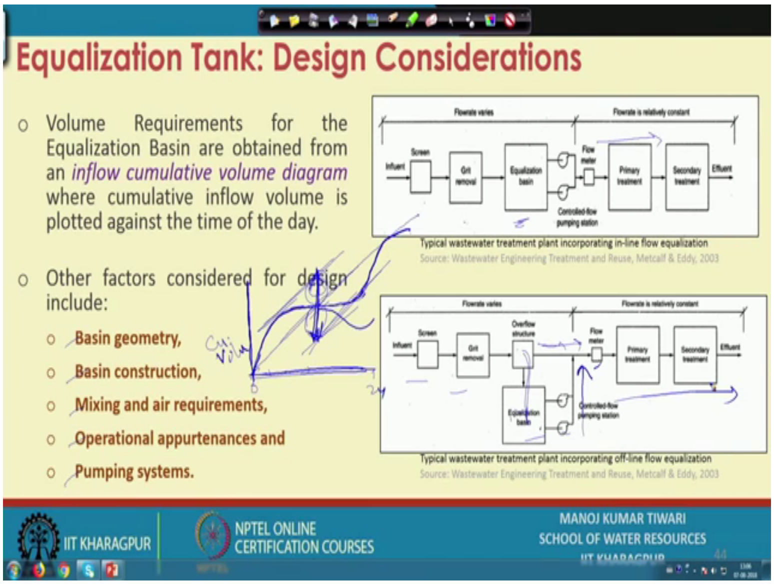
Typically, there are three types of equalization tank. There is one flow through type equalization tank ok, which is kind of the water that is coming in will actually be it is a kind of in line system ok. So, one side water keeps on coming, and another side water keeps on going out. There is intermittent type flow tank ok, where is we can have intermittent inflow or intermittent outflow with a constant inflow against constant outflow. And there are variable inflow and constant discharge type, so inflows are variable. Many times actually these equalization tanks becomes essential, when your sources of water is different.

So, let us say in CETPs, when your in common effluent treatment plants, when you are getting waste in flow say from five different industries. Now, these five have different characteristic, if you do not equalize them. So, when this passes to your subsequent unit, your process are going to be different, because the nature of the contaminants are different, when this passes your nature of contaminant becomes different. So, it is better to basically keep them have them in a mixed unit. Let them homogenized, and then you pump a sort of standardized quality of waste or stabilized quality of waste further to the subsequent units.

Many times you are getting let us say industrial discharge and a domestic sewer line also. So, there are like you in Kanpur, we have a treatment plan, where these are treated together. The problem is that industrial will have high load, this will have very low load, this will have very high volume, this will have relatively lower volume. So, until unless you neutralize them, you mix them, the subsequent process again will become very risky. So, these are the important aspects.

The optimum location of the equalization tank will vary according to the collection of the system, according to the wastewater that needs to be handled, what is the land requirement, what is the availability and type of subsequent treatment is being plan. So, all these are needs to be considered.

(Refer Slide Time: 37:48)



If you see the volume requirement for equalization basin, again this will depending this typically is estimated based on the cumulative inflow cumulative volume diagram, and where basically cumulative inflow volume is plotted against the time of the day ok. So, it will be like this. If let us say this is my time, so this is my 0 hour, this is my 24 hour, and this is my cumulative volume. So, what happens traditionally that at the time of there is no volume or very low volume, and then in the morning hour, the cumulative volume increases, and then the increase will not be much say in the afternoon ok, in the evening, again you will see this cumulative volume increasing ok, and then in the night, again it might be get subsidized.

If you see the average of this, you will find something like this that is like if you plot a linear this thing, you may find like this, but this is obvious that in the morning hours, we have high demands, so cumulative volume will increase this way. And in the later on, it can decrease this way.

So, we take the slope of this peaks maximum and minimum peak, and the difference in this slope is actually the volume of the equalization tank needed, because this is the maximum storage volume that will be needed. If you are pumping through this way, so this is the additional volume or the required volume that needs to be pumped, so that way this the this becomes the volume of the equalization tank, which for which it needs to be designed. Of course, there would be retention time criteria, for how long you want to retain it ok.

Now, there are other factors that considered for design. What is the basin geometry, what is the construction, what is the mixing and air equipments, if there are any operational appurtenances, and what are the kind of pumping system. So, these are the additional this thing. You can we can have inline equalization basin. So, we are having let us a screen, then grit removal, and then we can have a equalization basin.

And from here through flow meter, we can supply water for subsequent processes or we can have an offline equalization basin, where let us say if this is your effluent, this is grit chamber. So, we can have a overflow structure. And the overflow of them is coming to the equalization tank. And from here, we can have a control flow pumping system; here also we can have a pumping system. So, depending on whether we need this or we do not need this, we can operate it or if not required, we can omit it also, and then the flow can be pump directly through the flow meter to the subsequent treatment systems. So, this is the kind of importance of equalization tank. And this is how it is designed based on its cumulative flow that it needs to retain over a period of day.

The typical retention time could be something from 2 to let us say 8 hours or so, for the equalization tank. The location of equalization tank also varies depending on the objective of the equalization tank. Normally, if even if you are let us say having different streams, so the screening and grit is done independently, and then we can put through equalization. And from this point forwards, we can have a controlled release to the subsequent treatment systems many not many, but a few places equalization tank is even placed after primary sedimentation basin ok. So, after primary settling, when we go for the biological or secondary treatment systems, we can opt for the equalization basins from that point forwards.

So, we will stop the discussion for the time being. And in next class, we will have discussion on to the primary settling or primary sedimentation, which is one of the very prime units for the wastewater treatment under the primary treatment category.

Thank you.