

**Water Quality Management Practices**  
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**Week – 04**  
**Lecture – 17**

Hello everyone, welcome to this NPTEL online certification course on Water Quality Management Practices. My name is Gourav, Professor Gourav Dhar Bhowmick. I am from the Department of Agriculture and Food Engineering of Indian Institute of Technology Kharagpur. In this particular lecture video, I will be discussing you about the grid chamber and its classification. In the follow up lecture video also I will be continuing with this with this particular topic only. So, as you know that we have already started and very integral part of this course that is the designing and so that we will all be able to understand, we will all be able to actually have some basic idea and not even basic in even in the engineering knowledge enough to actually design by our self a treatment unit, a treatment plant the actual waste water treatment plant for your municipality or say like for your for the industry for which you are working on for or for any other purposes.

So, in this particular lecture video, I will continue with the discussion of the grid chamber. The major concept that I will be following the classification of grid chamber the constant velocity horizontal flow rectangular grid chamber and their design guidelines and also the different velocity control devices available for horizontal flow or rectangular grid chambers. In general you know this grid chamber its one of second important unit operations in any waste water treatment plant. The first one is screen and as you know you can see in the picture the screening we screen out the maximum of the larger size particles then there comes the grid chambers where the grid particles can easily pass through the screen.

So, then they will start accumulating on the grid chamber. Why how they are how it is happening simply because of the gravity. So, because of its higher specific gravity thus this set this grids are getting sedimented on the surface on the bottom of on I mean like on the bottom of on the floor of grid chamber. So, and the next step of stage of treatment which we call the sedimentation tank primary sedimentation tank that is also somehow very important as well, but you need to remember this difference. First difference is grid chamber we target the suspended inorganic solid ok.

In case of sedimentation tank we target the suspended organic solid try to understand this two difference ok. First are the much easier to remove the suspended inorganic solids are much easier to remove having much higher specific gravity. Whereas, the the suspended organic materials having little bit less specific gravity and because of that

it takes little bit longer time for it to settle down on the surface on the on the bottom of the sedimentation tank. So, that is the very basic difference between a grid chamber and the sedimentation tank primary sedimentation tank ok. That first one is for settleable or suspended inorganic material the second one is for suspended organic material ok.

So, now, in general the grids that we normally design our grid chamber in such a way that it can remove the inorganic particles or the grids of size of around 0.2 millimeter with the smallest particle size can be as low as 0.2 millimeter. Also the specific gravity of those grids can be as high as 2.

65. So, if it comes under this category like sand, gravel, cinders and any other heavy particles they can easily be collected they can easily be sedimented on the bottom of I mean like sedimented and collected from the grid chamber and it can be easily disposed of and easily it is easy to handle in the and also it will not make an nuisance in the follow up treatment units by actually releasing them into the follow up treatment units it can actually cause a complete seize of this units this follow up units. So, that is why we need to protect it we need to actually have this grid chambers to actually get rid of this grids at the very early stage of your treatment plant. Not only that this grid chamber is very crucial for protecting the pumps and the equipments for a from abrasion and wire caused by this grid particles. There are different types of grid chamber the horizontal flow rectangular grid chamber are the most famous one and the most simply simple to design. If you see there is a inlet line there is a inspection port from there you can check there is a inlet buffer where the water actually go and it actually collides and actually then it the the the sludge accumulation is actually you can see in the bottom it starts accumulating on the bottom.

Then you have this continuous zone mixing zone or the I mean like this not mixing zone I would say like you know the actual the working area then there is come the outlet area from the outlet T the we collect the effluent. So, if you see on the surface the scum or the grease also you can see it starts settling with that with time. This this is nothing, but the oil the fat oil and grease which can also be there and can be easily collected the scum can be lifted easily collected using a proper racks and all. And on the bottom this grids can also be collected with periodically and we can actually get rid of the grid from the surface from the here. There is another type which you call as square grid chamber.

So, which is like a square in shape and it is it has a it normally has a continuous grid removal arrangement. If you see a proper I can show you you see there is this blades this scrapper blades are available and there is this grease washing mechanism is available from where actually we are collecting the grids. Then there comes the vortex flow grid chambers in the vortex flow it normally it is a cylindrical or conical

in nature and if you can see it is normally the flow the wastewater that enters it goes tangentially ah from the top and creating a vortex flow ok. Because of this vortex flow grids can be easily collected and it can be easily settled on this on the this central line and can be collected for in for further purpose. So, in then there is the aerated grid chamber if you see in this aerated grid chamber we have the aeration line and it creates its bubble and it because of its bubbling there is a tiny tiny bit of ah movement you can see in the wastewater system.

Because of that what is happening the sand particles will actually it makes it easier for us to collect the grids on this ah grid chamber on this grid ah removal line. So, from there the sand you can collect those sand or the grids and it can be easily collected for further uses and all. So, we will be designing the vertical ah this velocity ah constant velocity horizontal flow ah rectangular grid chamber ok. So, just in order for us to have a understanding the basic understanding how to design a grid chamber and what are the conceptual ah details that we need to understand the to start with. If you see in general what is happening in the grid chamber we know the grids are getting settled right.

So, this settling is known as the type 1 settling because the it it is more like it looks like it is a individual settling individual grid particle will start settling that does not that does not make the flock that does not make a additional ah any ah any they do not adsorb to each other. They simply settle like a individual this is called individual settling or zone 1 or type 1 settling I mean a type 1 settling ok. So, this type 1 settling in general it happens in the grid chamber and in this grid chamber if you see it can be divided into 4 different zone. The inlet zone normally it distribute the water uniformly across the chambers cross section. Then the outlet zone this number 2 you can see it is normally positions from the settling zone to prevent the turbulence disturbance ah during the wastewater exit.

So, that there the it can be completely the supernatant can be flow without any ah turbulence. Then we have a settling zone which is like major portion of the major body of the grid chamber where most of the functionality occurs. And then there comes a sludge accumulation zone or the sludge zone where the sludge is getting accumulated or the grid is getting accumulated on the bottom. So, in general if you see the sludge accumulation zone can be almost 0.

25 to 0.3 meter additional that you need to provide sometimes. So, once you get to the get the value of h during we can do the we will do the numerical. So, we can easily get the value of h. Once we know the value of h we have to add a little bit of ah another additional free board obviously, on the top and also we have to add the sludge accumulation zone that is that all the sludge zone that we call. So, which is normally comes into 0.

0.25 to 0.3 meter additionally that you need to add. So, that will be the total height of your grid chamber ok. And also total length of your grid chamber will also you can calculate based on this  $ah/v_c$  and the  $v_0$  settling velocity and the critical velocity from there with the there is a equation or there is a way we can actually find out the total length. The length I mean like actual length of the settling zone. So, we can get the length of the settling zone then then we have to add another 1.

1 to 1.25 ah percent 1.25 times we have to multiply that ah that length that we will find in order to get the total length. So, this capital L if you can see this is the length of the settling zone only. If you want to find out the total length this total length will be almost 1.1 to 1.

25 times L understand. So, this is the total length that inlet and outlet also you have to add portion also you have to add when you design the actual grid chamber. And also the depth wise depth plus sludge accumulation plus free board of 0.3 to 0.25 meter additional and another 0.

0.25 to 0.25 meter anyway. So, in general ah our system is designed for a smallest grid particle of 0.22 millimeter in diameter. So, our aim is to completely remove any particle which is size equal to or greater than 0.2 millimeter in their size ok. And the horizontal velocity has to be should be sufficient to resuspend the organic solids if it starts settling because our target is not to settle the not to let the organic solid to settle down on the grid chamber ok.

The purpose is to do it in the primary sedimentation time ok. So, now, the settling velocity  $V_0$  of a particle is obviously, greater than the surface overflow rate then the then only the particle will settle isn't it because settling velocity it should be higher than the surface overflow rate then only it will start settling ok. If the settling velocity is less than the  $V_0$  I mean like in this case it should it is wrong it should be  $V$  then what will happen it can be only partially removed. So, please remember this this has to be this is actually  $V$  ok it is not  $V_0$ . This required retention time for this grid chamber is estimated using the equation retention time equal to length of the settling zone  $L$  multiple divided by the horizontal velocity equal to obviously, it will give you the detention time isn't it total length divided by the horizontal velocity suppose the length is 100 meter and the horizontal velocity 10 meter per second.

So, what will be the detention time 100 meter divided by 10 so, 10 second. So, the water will stay there for 10 seconds. So, this is how we calculate the detention time. Same way we can also calculate the detention time using other equation height of the settling zone ok say capital  $H$  and the settling velocity the velocity at which the particle is settling. So,

if the height of the settling tank is settling zone is say like 10 meter and the settling velocity 1 meter per second same.

So, 10 divided by 1 meter per second it will also give us 10 second. So, that means, detention time equal to length of settling zone divided by horizontal velocity and the height of settling zone divided by the settling velocity ok. So, this way we can see  $L$  by  $H$  also we can say  $v_c$  by  $v$   $v_0$   $v_c$  is nothing, but the horizontal velocity or the critical velocity divided by the settling velocity ok. So, horizontal velocity it should be below than the ah obviously, the critical scoring velocity and this critical scoring velocity this horizontal critical scoring velocity can be easily calculated ah using this equation ah root over of  $8\beta$  by  $Bg$  into  $s s$  minus a 1 multiplied by the capital  $D$ . Whereas, this  $\beta$  is the constant  $f$  is the Darcy Weisbach friction factor friction factor  $g$  is the acceleration due to gravity  $s s$  is a specific gravity of the grid particle what is the value of it 2.

65 in general and diameter of the grid particle if say like if it is like point 0.02 meter we it is when 0.02 millimeter as we were discussing if in the yes 0.2 millimeter as you can as we were discussing in the last slide if you use those values here what will happen you can easily get the value of  $v_c$  it normally comes as around 0.226 if I am correct if it is it will come be it will be around 0.

228 meter per second ok. So, if you put those values it will come around 0.228 anyway. So, this  $\beta$  value it can be 0.04 for uni granular sand and it can be 0.06 for non granular sticky grating matters ok this value you can use it.

So, what are the basic design guidelines? So, first the design concept we have to have a long narrow channel design for the plug flow conditions and yet has to maintain the velocity near the critical scoring velocity. So, that the the the the it will actually follow the detention time that we design the length to width ratio the higher ratio we have to provide the higher length to width ratio which will ensure the plug flow condition it will minimize the mixing condition it will maintain the plug flow condition you remember the plug flow reactor that we discussed in last module. The chamber dimension normally width should be 1 to 1.5 meter shallow flow with a free board of around 0.3 meter on the top is provided grid accumulation zone or the sludge zone we discussed around 0.

25 to 0.3 meter we can provide and inlet and outlet we have to provide additional 20 to 50 percent of the theoretical length detention time somewhere around around 30 to 60 seconds do not wait for the more than that if it is like detention time is more than 60 second it will be problematic. So, we will only want the grid chamber to grid particle to settle and 60 second is more than enough you can have the parallel operation. So, that it

will make sure that you will make sure that you will be having enough you know free board in hand anyway. So, as you can see this is the design I would request all of you to do it and this particular design where you can see it is given that designer rectangular grid chamber for treatment of sewage generated from a population of 70000 persons with an average per capita water consumption of 130 liter per capita per day. 130 liter per capita per day if you see what does that mean? That means, people are using for each person the water their consumption is 130 liter per day.

So, on an average if you use in central pollution control board in India also they also say like normally we use somewhere around 130 to 170 liter like you know per capita per day in general the water consumption it depends actually based on city to city and on an average the sewage generation is around 135 liter LPCD or liter per capita per day. So, anyway so, average sewage we can how we can calculate we can calculate the average sewage that can be generated from your household say like almost 80 percent of the total water that you receive. So, water you receive is almost 130 liter per capita per day and 70000 like water consumption is 130 liter per capita per day and the 70000 percent is there considering the 80 percent of the water supply contributes to the sewage generation the average sewage generated will be  $130 \times 70000 \times 0.8$  into 10 to the power minus 3 why 10 to the power minus 3 to convert this liter into meter cube you understand. So, now, we will get the 7280 meter cube per day.

So, this 7280 meter cube per day what you can do you can actually divide it with 86400 you know 86400 how we are getting this 86400 we are getting it because of the value that we are getting through the calculating the second in a day you know 60 to 60 multiplied by 24. So, now considering the peak flow factor of say like 2.5 you remember last we discussed peak flow factor that means, the peak to the actual flow in the average flow. So, average flow is say like 0.

084 meter cube per second multiplied by 2.5. So, that will be the maximum sewage flow that you may experience in your treatment unit. So, based on that it is like coming around 0.21 meter cube per second. So, the flow velocity should be less than the scouring velocity what is the scouring velocity in general 0.228 meter per second that we know we discussed in the scouring velocity calculation with for a grid particle of 0.

2 millimeter in size and also 2.65 specific gravity it will give us the value this value scouring velocity of 0.228 meter per second. And we recommend a detention time between 30 to 60 let us say like 30 centi second in this particular case or say 45 second in this particular case and we say a horizontal velocity will take say 0.2 meter just for the safe side scouring velocity is 2 to 8 will take only 0.

2 meter per second for the safe side. Now see this is the design. So, first what we need to calculate we need to calculate the dimension of the grid chamber we need to find out. So,

the length of the grid chamber we can easily find out by horizontal velocity what is the horizontal velocity that we have taken 0.2 meter per second and what is the detention time 45 second.

So, you multiplied by 45.2 you will get the total length the length of the grid length of the grid chamber mainly the settling zone ok. So, we are still getting the settling zone we are only try to find out the values for the settling zone here ok. So, the number of the volume of the chamber is flow into detention time which is flow is how much 0.21 meter cube per second remember for grid chamber we are designing it for peak flow ok.

So, 0.21 meter cube per second multiplied by 40 45 seconds which is coming as 9.45 meter cube that is the volume of the chamber. So, once we know the volume of the chamber and we know the length we can easily get the cross sectional area cross sectional area will be volume divided by length what is the volume 9.45 meter cube what is the length 9 meter.

So, if you divided 9.45 divided by 9 it will become 1.05 meter square. So, 1.05 meter square is the cross sectional area that means, the height multiplied by the width is 1.05 meter ah meters square meter. So, now, the width of the grid chamber is kept below 1 and 1.

5 meter. So, let us take a width of 1.5 meter. So, now, the depth of the waste water will be how much 1.05 divided by 1.

5 you know. So, it will it becomes 0.07 meter. So, the depth of the waste water in the grid chamber is which one which depth we are talking still you want try to understand this depth is nothing, but the depth of settling zone that is 0.7 meter. So, what we need to add we need to add the sludge accumulation zone which is say like another 0.

3 meter and some free board which is point ah say 0.25 meter. So, 0.7 meter is length 0.3 meter grid accumulation 0.

25 meter of additional free board. So, total it will become 1.25 meter you understand also length wise also length wise also we know the length is 9 meter we can provide another 25 percentage length for inlet and outlet zone. So, now, it will become 9 into 1.25 it will become 11.25 meter.

So, what will be the final dimension of the grid chamber 11.25 meter by 1.5 meter by 1.25 meter that should be the actual dimension of the grid chamber ok you understand. So, now, velocity control device is very important. So, in grid chamber we need to control the velocity to so, that we have to it will not reach to the scoring velocity or you know also we have to make sure that this velocity is maintained.

How we can do that normally we design this grid chamber to handle the maximum maximum daily dry weather flow. What is this dry weather dry weather flow it is in case the rainfall is there is no rainfall. So, in this rainfall like you know 0 rainfall ah season also this flow that we can maintain that the minimum flow that will be there that has to be there and this is called the dry weather flow. So, even in when the 2 chambers are present each should be designed for the peak flow that also we understood. Also incoming sewage flow variations can lead to the varying velocity in the grid chamber causing the turbulence and the scouring of the settling of the settled solid that we that is why we provide proportional flow where or the partial flow.

These 2 are the standard velocity control devices that is utilized in all over like in different engineering aspects. So, this proportional flow where or the partial flow we normally use to control the. So, proportional flow where if you see ah we it is very standard ah we already we already know if you have understood if you you have if you are from the engineering background you already know because we use it in a very ah regularly this proportional flow where and the partial flow mean different other devices as well ah it is a very standard ah velocity control device. So, this a proportional flow where in it combines the ah wire and always the also the an orifice maintaining a constant velocity in a chamber by adjusting the cross sectional area of the flow and ensuring the depth of depth is proportional to the flow.

So, you see this truncated area this truncated area. So, or ah you can see this truncated area this is the wire opening this is the truncated area that means, if this part is cut. So, this value in general this value it can be almost ah point I mean like almost the value can be 0.25 to I mean like 25 to 35 millimeter this height of this vertical edge and the discharge that is that is through this ah like you know this proportional wire can be easily calculated using this equation  $Q = C \sqrt{2g} A H^{3/2}$ . So, this equation where Q is the flow rate and C is the constant with the value of 0.61 in standard for symmetrical sharp edges where and A is the height of the vertical edge which we know 0.

25 to 35 35 to 35 millimeter and B is the width of the wire and the edge denotes the height of the water above the rest of the wire. Same stands for partial flume what is the advantages of partial flume it has a minimum head loss the function as a discharge measuring device self cleansing is possible in case of if you see in case of partial flume the self cleansing is possible and also work in submerged section approximately in parabolic cross sectional area in general and it consists of 3 main part the converging section the throat section ok. If you see this throat section and then there is the diverging section ok. So, in general this dimension of all sections to be fixed to facilitate the transportation of flow from supercritical where the Froude number is less than 1 to the supercritical flow where the Froude number is more than 1 achieving the free flow condition. The transition of this free flow condition allow the wastewater to be you know

wastewater to be minimalized minimized and I mean like also requiring the measurement of only the upstream depth to determine the discharge value.

This the discharge through the partial flume can be easily determined by using the following equation you can see this  $Q$  into equal to  $C$  into  $W$  into  $h_u$  to the power 1.52 to the power like you know  $W$  to the power 2.26. So, here if you see this  $Q$  is the rate of flow through partial flume in meter cube per second  $C$  is the discharge coefficient depending on that throat width and the  $h$  is the primary head point measured at the convergence section and  $n$  is the discharge exponent depending upon the throat width ok. So, in general we have understood the the basic working principle of grid chamber and not only that we also perform one design of how the this horizontal chamber grid horizontal flow grid chamber is actually like how we can design it and actually how we can actually perform I mean like perform the design by ourselves for in a real life situation.

And also we understand the the different velocity control devices and we know about this partial flume and also where. So, we go ahead with the with this follow up follow up lecture also we will be discussing a little bit about this grid chamber only. So, please refer to this references for your better for better understanding. So, in the coming lecture also we will continue with this grid chamber discussion. So, as of now thank you so much.