Water Quality Management Practices

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Week-04

Lecture-16

Screens

Hello everyone, welcome to this NPTEL online certification course on Water Quality Management Practices. My name is Gourav, Professor Gourav Bhowmick. I am from the Department of Agriculture and Food Engineering of Indian Institute of Technology Kharagpur. So, in this fourth module we will be starting on the discussion about the Physico-Chemical Operations and Processes and we will be starting with the discussion about the screen and we will also be discussing about the how we can design the screens. So, this fourth module and fifth module will mainly be focusing on the primary treatment units, then we will in the consecutive modules we will be discussing about the secondary tertiary and some case studies as well. So, if you see the concepts that we will be covering in this particular lecture video are the screens as a unit as an unit operation.

You requirements in the specification for bar screen that what are the types of screen, the quantities of screening, screen chamber design and the disposal of disposal of those screenings. And this disposable screenings means nothing, but the screened particles the filtered particles will actually need to dispose in the scientific way. So, that is called the disposable of screening. If you see the screen if you remember when at the very beginning when we were I was discussing we were discussing about the different type of primary treatment units.

Screen is one of the major and one of the very important one that we need to be at least employed during the municipal wastewater treatment. Even in some kind of industrial wastewater treatment also we normally in use or introduce the screen at the very first stage of treatment in a treatment plant. So, if you see this particular picture if you see in the left side when it is like in the in the I mean like the if you see in the picture which is in the upper side upper picture it is written the bar it is dense that is the bar screen. And after the bar screen you see the draw this draw is nothing, but if you use the rack or some by say like if it is like in a not the mechanized one it is like you know the human drag one. So, we can use it we can clean it by using a rack and we can just put those the screenings or the those screen particles and all we can put it in the draw.

And whatever the water level if you can see in the just before the screen the water level is quite higher than the after the screen right because there is a change of head. There is a change of head or because of the change of head is like you know what is the reason behind it if I ask you what is the reason why there is a change of head in the it happens during the screen. Because of the obstruction the restriction that the screen is providing and because of the there is a chance there is some amount of foreign particles can get clogged on to the into this bar screens it can actually influence to the screen clogging and it will eventually increase obviously, influence to the head losses. In order to counter the head loss what we need to do we need to provide some additional head in the downside of the screen. If you see just in the upstream side in the downstream side there is a direct drop this drop is nothing, but this drop is actually purposefully provided in order to nullify the head loss that may cause because of the introduction of the screen you understand.

So, we will discuss about it we will be doing it in a numerically we will prove that why this head loss is important will be numerically prove it in this lecture video only at the later slide. So, now, I just want you to be having a over overview of how it will look like ok. And those screens if you see the plane view now the inlet if you see the channel is quite narrower the moment it enters the screen the cross sectional area becomes quite higher. That is one thing what is the reason behind it to reduce the flow to reduce the there is a chance of any scouring or any eddy flow current that can generate and which will actually kind of you know influence the screening phenomena that is happening there. Another thing if you see from the plane view plane view if you see it has this bars continuously placed like you know parallelly placed bar one after another which actually helps us to clean the wastewater as this is the first level of treatment that actually wastewater is actually introduced I mean like wastewater is facing when it introduced to the wastewater treatment plant.

So, normally it used to remove the larger size of particle which is floating or suspended in nature. And we normally place this set of inclined parallel bars fixed at a certain distance apart in a channel and the screens can be circular or rectangular opening in nature. And if you if you realize this screens these are like parallel rod right it can be rod it can be bar this rod that it can be of any metallic rod this rod can be rectangular in size if you cut the if you cut that ah rod I mean like the cross section will be either rectangular or circular you can have a circular rod you can have a rectangular shaped rod. So, this is called the racks this ah this continuous system is called the rack and this screen is what what is it doing what is the basic purpose to protect the palm, valve, pipe plants and other accessories from ah damaging or clogging by racks and the other larger size particles. And also it also helps us to get rid of those particles which may either other way influence or may create a quite a bit of a nuisance in the follow up treatment unit.

So, that is why we need to introduce the screens. So, as I was discussing this cross section of the screen chamber is always greater than the ah incoming sewer almost 200 to 300 percent if you can see in the ah ah bottom right picture the incoming sewer line is thinner, but the actual ah the the the concentration area available for the screen chamber is quite higher almost 200 to 300 percent is higher. Because to prevent the eddy current that can generate it makes this because of this eddy current it can actually influence the flow influence the operation in the screen. There are the different different types of screen depending on the opening size it can be coarse screen or the bar screen that I was discussing and there is can that can be another one can be the fine screen. Depending on the cleaning operations we can have manually cleaned one or the mechanically cleaned one manually cleaned one we just simply have a rack like structure we just go and do it by ourselves that is also possible or you can have a continuous mechanical cleaning there will be periodical mechanical rack is there which will naturally clean it after a certain period of time.

The coarse screen if you see this picture they that is how like it looks like in general it can have a like you know it may be ah coarse woven wire screen also or maybe sometimes we the communitors we I will show you what is communitors what it is like and how it looks like and this is the the example is given right side that one is the bar screen. In general this bar screen are provided ahead of the pump or grid removal facility and so, to and it can be manually cleaned or the mechanically cleaned and the size the average I mean like this clear spacing in between two rack if you can see the spacing you can see those spacing are normally in the range of 15 millimeter to 40 millimeter ok. So, what is grinder and communitor this grinder communitor is nothing, but it is used normally in conjunction with coarse screens to you know grind or cut the screenings. Sometimes those screenings can be of you know higher sized and which can actually clog the screen in a very faster rate. So, that is why we normally introduce this communitor communitor or grinders which will actually thread like you know having this shredding tooth and all which will actually cut those additional this higher sized larger particles and actually make it easier for you know the fine screen or the coarse screen associated with it to clean it properly.

So, normally the thin opening in this like you know which are having the size I mean like in general the this any any particle which is having 0.6 to 1 centimeter in size can actually be shredded by normally it is shredded during using this grinders and all. What is this fine screen? Fine screens you can you can easily understand coarse screen this this grinder and then this fine screen. Fine screen obviously, the screen size will be screen opening will be much lesser in the normally less than 20 millimeter less than 6 millimeter is like quite typical if you see in this picture this is the this is how the coarse like fine screen looks like. So, it normally can be fixed or static wedge wire type it can be drum type it can be step wire type and centrifugal screen is also possible.

Normally fixed or the static screens are permanently set in vertical inclined or horizontal position and it must be clean with the racks or like teeth or like brush like structure with the you know metallic teeth in it or metallic nails in it. Moveable screens are normally cleaned continuously using operation using an additional rack or the baffle like structure and co centrifugal screens are there which normally utilize the rotating screen and separated out the effluent and the solid particles you know. Then there are different types of medium and fine screen based on the the the way it is inclined like you know ah the one which we call the inclined or the fixed one in it can be ah flat ah type it can be disc type or it can be cage type normally it is inclined at a certain angle. So, this ah normally have a like opening of 0.25 to 2.5 millimeter and they are used for primary treatment of industrial effluent in in general. There are type of ah screen which we call band what happen it nothing it it has this endless perforated bands ah that passes over ah you know upper and the lower sprockets and there is a sprockets and the brushes are installed to remove the material. So, it is keep on keep on rotating and the brushes are keep on removing the materials which is retained by this kind of screens. There are drum screens and strainers in the drum screen in all the other screen that we have discussed till now normally water passes directly through it, but in this kind of drum screen it this water like you know flows radially. So, this is like the drum and water is flowing through radially towards the ah like you know like you know towards the radial direction and because of then this rotating cylinder it has some ah circumfacial area which actually has nothing, but the screens.

So, from the screen you can see the water will try water will try to pass through the radially and water will obviously, seep through the screen and it will be attached to a certain row or like in the which will which is there in the bottom and all the coarse particle will be screen on the surface I mean like all the coarse particle will be filtered on this rotating drums ok. So, these are very much easier and sometimes it is easy to clean also this kind of drum screens and the strainers which we call. If you see this ah chamber there are normally we try to have at least 2 unit of screen at a time in case one get gets clogged. So, we can have one additional or one spare ah screen to use. So, this arrangements can be done in different ways you can have it in the one that you can see in the very top you can have the racks you can see the stop gate ah arrangements.

So, you can just open one of the stop gate and you can let it pass through one side and then once that is choked you just completely close that gate and use the open the other gate ok. So, the water will flow from the other side now you can that you will get enough time to clean the ah I mean like the screen on that side. The same way you can it can be done in the bottom you can see in the bottom side also there are different other arrangements that can be made ah to an actually clean the this screen I mean like the clean the screening in periodically in case of an emergency in case it gets clogged. So, these are the different design recommendations that I am having like if in case in future like you know you will be ah designing any ah structure any treatment plant for your ah client you have to make sure that it follows there are either of these 4 designs. In general it should follow either of these 4 designs and you have to have one backup screen ready with you in case of an emergency.

Normally the the if you see the the if the rectangular channel if it you are having the floor of the screen chamber this that should be at least 7 to 15 centimeter lower than the invert of the incoming sewer. You remember in the very beginning I I told you why this ah this gap is there why there is this additional gap to you know somehow nullify the head gap a head loss that can occur ah because of the introduction of the screens. The bed of the channel it may be flat or slopey and also the straight approach length should be provided to uniform distribution of the screening over the entire screen area and at least 2 bar racks as I was designing. As I I told you ah to each design for the to carry the peak flow must be provided and arrangement of a stopping of the flow and the draining the channel should be made for routine maintenance and also the entrance structure should have the smooth transition and the divergence to avoid the excessive head loss and the deposition of solid. Also you have to make sure that the effluent structure at the end of the if you see the end side the right hand side the effluent side.

So, there also the structure has to have a uniform convergence. So, the effluent in the from the individual rack may be combined or kept separately as necessary ok. So, when we will be designing a bar screen we will be discussing now ah very important part of this ah particular I mean like ah the lecture video is like the when we start the designing the actual design part. So, I would like you to be ah having a notebook with you with a pen and or pencil whatever you have to please note down some very important informations that I will be discussing with you now onwards. Because these are very important ah numbers or these are very important ah idea that you need to be implementing when you will actually design a screen ok.

So, let us start with that. So, first thing is the velocity of flow. The lower the velocity through the screen the greater the amount of screening that would be removed. However, it will also encourage the more amount of clogging. So, we have to null we have to somehow optimize the flow.

How we can optimize the flow? There are certain ways of doing it. So, to start with the approach velocity. We have to make sure that the bar screen should not have ah the the velocity should not be below then 0.42 meter per second that is done by some standard literatures and all. So, what they what the scientist have done they they do some they do some iterations or different iterations and they found out key 0.42 meter per second of flow is quite okish. You can actually if you are maintaining this flow it is ok for you to actually ah make sure that your rack is cleaned periodically I mean like not periodically it will take optimized amount of time for you to clean it for the next time. I mean like in between this periodical maintenance time has to be as elongate like you know as long as possible ok. So, in general if there are the wastewater having a good amount of grids you have to have approach velocity at least 0.6 to 0.75 meter per second what will happen otherwise if you do not have higher flow it will start accumulating on the ah on the screen itself. Remember the grids if it is not larger sized most of the cases the by definition the grids can easily pass through the screens ok. So, this grids, but if you wait for some time this flow is small flow is I mean like the slow it will enter it will interact with the screen and it will start a depositing on this on that is a level itself and it may create additional amount of nuisance for us. So, our target is to accelerate the flow a little bit during in case of grid bearing waste waters. In case of hand cleaned bar screen you can have a maximum velocity of 0.3 meter per second at average flow. So, that you can actually control in in this case, but mechanically clean bar screen you have to have a normal maximum flow of at least 0.75 meter per second in case because it is not in your hand anymore like it is has to mechanically done you have to make sure the all the parameters are well it where at place.

The velocity of 0.6 to 1.2 meter per second ah through the screen opening for the peak flow normally gives the ah satisfactory result. Now, let me tell you one ah a very crucial information that is what is peak flow here try to understand there are various definitions of it. So, in general if you see ah even if I tell you in a diurnal basis in a say like in ah in a day basis in one day what happen? Remember last lecture also we discussed that the flow that your waste water treatment plant is receiving it is not equal all the time. It goes up and down based on the time of the day that we are talking about isn't it. And also if during the during the monsoon during the monsoon season if your drainage if your sewer line is actually it is a combined sewer what will happen it will also experience the storm water runoff.

So, that is also something very important because if your storm water runoff is actually a influencing your sewer line influencing like you know ah introduced to the sewer line it will also go to go and put a put a additional put an additional pressure in your treatment plant. So, all these things so, this peak flow normally we consider that on an average flow is there that ah you can have the hourly average you can have the daily average you can have the yearly average. And what is peak flow? It is like daily peak flow there is what is the maximum peak that you may experience based on the historical ah evidences that flow at that particular time what is the maximum waste water that your treatment plant can actually receive based on the historical evidences and based on the ah anthropogenic practices that is happening there. So, based on that you can actually get it.

So, this peak flow normally we take 1.2 1.25 times higher than the average flow sometimes it may be 2 times higher than the average flow also. So, either this values will be given to you or either this values has to be you have to justify it based on your ah based on the the values the historical data that you can find out ah from your target ah city or select target industry or select target ah research ok. So, this is very important for you to understand what is a peak flow there is a average there is a peak flow and there is a minimal flow like maximum flow minimal flow ok. So, this peak is very important ah for you to understand like at least the gross idea you should at least have.

So, that you can actually implemented in real life ah scenarios. So, the head loss as I was saying because of the installation of the rack that there is a chances of the head loss. And this head loss can be easily calculated using the Kirchner's equations this h equal to beta w by v to the power 4 by 3 h v into sin theta whereas, this h is the head loss in meter beta is the bar shape factor if it is like a sharp edge at rectangular bar rectangular cross section bar it will be 2.42 1.83 if it is like a rectangular bar, but upstream side it is semi-circular ok.

$$h = \beta (W/b)^{4/3} h_v Sin\theta$$

It is a semi circular, but in the downstream side it is like normal ah with a 2 sharp edges you understand. And 1.79 if it is a circular bar I mean like like a cylindrical bar you understand. And 1.67 for rectangular bar bar with both up side and the upstream side and the downstream side faces as semi-circular.

So, it is not necessary it is complete cylinder, but it is a like a rectangular bar it goes up to like this, but then it does not have the sharp edge it has upstream and downstream is quite ah circular I mean like semi circular in nature you understand. So, in that case the bar shape factor is minimum 1.76 ok. What does that signifies this value the drop in the value that means, shape significantly ah influence the head loss is not it. Then we have the w which is like the width of the bar facing the flow width of the bar individual bar b is the clear spacing in between 2 bars ok h v is the velocity head of the flow approaching the bar which is in which you can easily find find out this velocity head by v square by 2 g ok.

This v is capital V is the geometrical mean of the approach velocity in meter per second and g obviously, you know the accession due to gravity and theta is the angle of inclination of the bar with the horizontal.

$$h = 0.0729(V^2 - v^2)$$

So, if it has certain angle say like you know if it is like a straight line and you have a the place the bar is placed in a certain angle. So, this this value is actually represents the angle of inclination of the bar with the horizontal. So, normally it is a very acceptable practices to provide a head loss of provide a additional 0.15 meter of ah excess head in case if it is like you know because it does not normally go more than 1.15 meter like almost 150 millimeter it is quite a big amount of jump. So, that is why what we do we have a normal sewer line incoming line coming then you install the bar after then you have a certain drop then you it goes to the effluent line this drop should be somewhere around 150 millimeter you can you can go ahead with the 150 millimeter most of the cases as a thumb rule it goes ok. So, it can be ah for the hand clean if you see the ah normally for the hand cleaned screen it should not be exceeding 0.3 meter it is like quite high 300 millimeter is actually quite ah like you know huge. So, you you do not have to go up to that in case of mechanically clean screen sometimes ah if your mechanical cleaning ah frequency is less.

So, in that case you may have to provide high amount of head in because just in case your screen will start clogging and your ah you started experience a high amount of head loss just in order to nullify that loss you need to have at least 0.6 meter of drop at the end. So, you can how you can ah get the formula get the height loss with the different formulas as well for the clean or partially clean clogged flat bar screen you can see it is 0.0729 ah capital V square minus small v square that is that h is the loss of head and capital V is the velocity through the screen and small v is the velocity before the screen. Obviously, through the screen what will happen the area is small it will the velocity will be much higher.

The head loss can also be for the fine screen can also be calculated using ah 1 by 2 g into C D multiplied by Q by A square where g is the acceleration due to gravity meter per second square C D is the coefficient of discharge 0.6 for the clean rack and Q is the discharge through screen which is meter cube per second and A is the effective open submerged area and square meter.

$$h=\left(\frac{1}{2g\times C_d}\right)\left(\frac{Q}{A}\right)^2$$

In general the clear spacing between the bar may be in the range of 15 millimeter to 75 millimeter maximum normally we do not put it more than that. So, in case of mechanically cleaned one that is the standard practice in case of manually clean we can have it in between 25 millimeter to 50 millimeter ok. So, in general for industrial waste water where there is a less chance of having ah larger size particles they provide as low as 6 millimeter ah gap in between the bar which is quite small ok.

This in case of hand clean ah screen the slope should be around 30 to 60 degree for horizontal with the horizontal and ah for mechanically cleaned it should be 45 to 85 degree because to make it as slopey as possible. So, that in case the frequency is low for your mechanically cleaned device it can still you know sustain like reduces the chances of having clog clogging. The submerged area as I was discussing should be at least 200 times more in case of processional in I mean like to the surface of the screen and 300 time 300 percent is more in case of combined systems because of you know the layer higher chances of peak flow and higher chances of storm water influence there. The width of the bar facing the flow may vary from 5 millimeter to 15 millimeter and the depth may vary from ah 25 millimeter to 75 millimeter with size less than 5 millimeter and 255 millimeter are not used. You understand right this what depth we are talking about this depth is nothing, but suppose you have a ah say like ah one bar iron bar you are placing a lot of iron bar that iron bar it looks like a rectangular shape ok.

In this rectangular shape iron bar the one that is facing the waste water is obviously, the smaller one the width will be small almost in the range of 5 to 15 millimeter and the depth I mean the other side of it if you make a cross section the width and the ah the the height it will be like an if you consider in that sense. So, it will be 25 millimeter to 75 millimeter. In general our standard consideration we put it either 5 millimeter to 25 millimeter ah in this is standard practice. What is the quantities of screening you can see the with time the screenings will start deposited on the surface of the screen or on the bottom first which slowly it grows on the surface. So, this quantity of screening which should be removed by the bar screen it should be in the range of 0.0035 to 0.0375 meter cube per 1000 meter cube of waste water being treated and typical value is around 0.015 meter cube per 1000 meter cube of waste water. And in case of combined systems the this is quantity of screening increases during the storm and it can be as high as 0.225 meter cube per 1000 meter cube per water waste water.

So, that also you have to keep it in mind. How we can dispose it normally we discharge we use this ah grinders you know for to disintegrate to disintegrate that ah screenings and we can also if for the larger sewage treatment plant we can also incinerate that ah treatment unit this solid waste and this small treatment plant we normally ah dispose it off to the burial or the plant sites and all. Let us do one ah design by ourselves ok. So, to boost our confidence that we can actually do the design by ourselves we can actually design a screen by ourselves for any wastewater treatment plant to start with let us see what this problem says. It says that design a bar screen chamber for average sewage flow of 20 MLD you guys know what is MLD? Million liter per day million liter means 10 to the power 6 liter per day if it is a 10 to the power 6 liter in 1000 liter it is 1 meter cube. So, that means, it is 10^3 meter cube you understand 1 million liter means 10^3 meter cube.

That means, 1000 meter cube 1000 meter cube per day and 20 MLD means 20000 meter cube per day. So, 20000 meter cube per day. So, how many seconds are there in a day 86400 is not it 60 into 16 to 24. So, if you divide it that 20000 meter cube divided by 86400 you will get the value as 0.231 meter cube per second you understand how we get to this value. So, what is the flow rate here average flow 20 million liter per day it is the 0.231 meter cube per second ok in liter if I say it is 231 liter per second ok. What is the maximum flow here it is see almost 1.5 times to the average flow average flow was 20 maximum flow was 30 almost 1.5 times. So, peak factor is 1.5 here anyway. So, that is just for you to understand the peak factor maximum flow is now 30 MLD same do the calculation by yourself 30 MLD means 30000 meter cube per day 30000 divided by 86400 it will become 0.347 meter cube per second. The same for the minimum flow it is point for 12 MLD 12000 meter cube per day 12000 divided by 86400 it will become 0.139 meter cube per second. Now, assume the manual cleaning and then angle of inclination of the bar with the horizontal as 30 degree and assume the size of the bar is 9 millimeter by 50 millimeter each bar is 9 millimeter in thickness and having a width of around 50 millimeter ok.

And assume the flow rate velocity of the flow is around 0.3 meter per second at average flow please remember this assumptions ok. So, now what is the net submerged area of the screen what is the flow here 0.231 what is the if you divided with the the velocity of the flow normal to the screen which is 0.3 meter per second what is the net submerged area what does that mean net submerged area mean the total area available for the wastewater to pass through the screen total area available for the wastewater to pass through the screen. So, we are not considering the cross sectional area area that is facing the the area that is available for each screen I mean like each bar we are only talk of talk about the available area that is the the you know the the water line right next to right in between both the bar.

So, like that you have say like 100 of bars. So, 100 into say like you have ah that particular cross sectional area say like 1 square meter. So, your net submerged area is 100 into 1 square meter. So, 100 square meter. So, that is your net submerged area and what is gross submerged area you can also calculate the gross submerged area gross submerged area is net submerged area plus the area which is actually taken by which is actually influenced by the I mean like ah occupied by the individual bar. So, now, you have net submerged area which like the water area plus the bar area.

So, from there you can get the gross submerged area ok. So, let us talk about the net submerged area first net submerged area you know you can easily understand the flow rate is 231 meter cube per second divided by the flow velocity you can get the area ok which is coming as 0.77 square meter. Now, assume the velocity of flow normal to the screen is 0.75 meter per second in case of maximum flow that is the standard standard flow actually.

So, even if the maximum flow is 0.75 meter per second what should be the net submerged area in case of peak flow because for peak flow we know what is the peak flow here 30 MLD that means, 0.347 meter cube per second divided by the velocity of flow normal to the screen is 0.75. So, what should be the net submerged area 0.46 meter square. So, that tells k in case of peak flow in case of maximum flow the net submerged area is rather less than the average flow here in this particular case. So, that is why which area we should take the maximum one you know for the for the safety purpose. So, we will take the maximum one say 0.77 square meter. So, we need to provide at least 0.77 square meter of submerged net submerged area that means, you have the rack. So, these are the say like water particle which is water which is going from one side to another. So, height of this water is say up to this. So, this area the this in between area is the net submerged area this area is 0.77 square meter. Now, how you can get the gross submerged area just try to understand the gross submerged area and you need the net submerged area ok. So, if you find out try to find out that gross submerged area which is nothing, but if you try to make a ratio say in here say you have n number of bar you are not sure that what is the number of bar that needs to be given right. So, if you have a n number of bar. So, what is the total area that you will get n if you have a n number of bar what will happen how many what is the number of opening that you can have you understand. So, if you have a n number of bar you have a n plus 1 number of ah opening in the both the side you understand if you have a n number of bar you have a n plus 1 number of opening.

Now, for each opening say you have ah say now you have say like ah 30 number of ah what is it called ah if you say like 9 millimeter of facing and 30 millimeter of spacing in between. So, what will happen? So, you take n plus 1 multiplied by 30 that is the spacing in between the ah both the bar. Now, for in the numerator what will happen total number of submerged area total net submerged area will be n plus 1 multiplied by 30 that will be the net submerged area divided by what will happen n plus 1 30 n plus 1 30 is the net some total ah some net submerged area plus n into 9, 9 is the area 9 is the I mean like the width of the each ah bar. So, now, if the n is the width of the each bar facing the flow multiplied by n.

So, that is n into 9. So, that is the that should be the ah total ah that is the total total ah width I would say the gross width. So, this ratio will be around 0.77 if you do it. So, randomly you can take 30 bar or you can say 20 bar still whatever number you will put in the in place of n you will always get the value somewhere near to the 77 0.77 you understand let me do it again to make it more easier for you. Suppose you have a 5 number of bar say 4 number of bar 1 2 3 4 4 number of bar. So, that this is like a flat screen ok. So, in this each flat screen you have a this water some amount of water here. So, ah if you have say like ah 4 number of 1 4 number of bar in between and there is a wall on the both side. So, what will be the total number of ah cross sectional area 1 2 3 and half here half here.

So, total how much 4 you understand. So, not only we have this ah 4 number of ah a multi this area across I mean like available area that is ah available to you ah sorry 5 number of area that is available to you 1 2 3 4 5 5 number area that is available to you multiplied by 30 30 is the spacing in between this both 2 of the finger. So, divided by total gross gross width what is the gross width here n plus 1 multiplied by ah 30 plus suppose each bar has a thickness of 9 millimeter. So, n into 9. So, 9 into n plus 9 plus n plus 1 into 30 that is the total width. So, if you have this ratio you understand the net submerged area and submerged width divided by gross submerged width it is always coming around 0.77 you you put 20 in this equation or you put 30 number of ah instead of n you put 30 still you will get the 0.77 this same ratio you understand. So, if you get the same ratio all the time that means, the net submerged area ah we know it is 0.77 and the gross submerged area is what we need to find out. So, this gross submerged net submerged area divided by gross submerged area is equal I mean like this ratio this ratio we are already known that it is 0.77 that means, the gross submerged area is equal to 0.77 that we already find out as a net submerged area divided by this equation this ratio that we got like 0.77 this value that means, the gross submerged area that you require is 1 square meter that means, including this bar including this bar from this say like wall this wall to this wall including the if you have a water level up to this the whole area is the gross gross submerged area which will be 1 square meter. I hope you understand net submerged area is the only the water level this area which is occupied by the water and gross submerged area is the total area water area plus individual rack ok. So, now, if you have a now once we know once we have already understood the gross submerged area that is required is 1 square meter and we know that the say like now the angle that is there for each I mean like the angle at which the the bar is placed the bar screen is placed say like 30 degree degree. So, what will happen? So, total submerged vertical cross section area that is there this x value how you will get the x value if you know we know the y gross submerged area which is 1 square meter very good.

So, now, we need to understand the value of x how we can find out the value of x x is nothing, but y into sin theta what is this theta here 30 degree. So, that means, y is known to us y is what 1 square meter multiplied by sin theta. So, that means, the x value will be 0.5 square meter ok. So, from here that means, we know the vertical cross sectional area vertical cross sectional area of the submerged vertical cross sectional area of the screen as 0.5 square meter. Now, we know the flow we know the flow rate and we also know the vertical cross sectional area now ok submerged vertical cross sectional area and the flow rate is how much 0.231. You remember 0.231 20 MLD and the vertical cross sectional area is 0.5. So, if you flow rate divided by this vertical cross sectional area you will get the velocity you will get the ah the velocity of flow in the ah screen chamber which is nothing, but 0.462. So, the velocity is greater than the self cleansing velocity which is good because you remember we it needs to be at least more than at least 0.42 meter per second as we were discussing in the last slide. So, now, our design is good. Next is now we say take for 30 number of bar. Remember we discussed either 20 to 30 randomly you can take it, but still the ratio is coming as 0.77. So, now, let us take 30 number of bar.

So, what will be the gross width 30 into 9 millimeter that is 0.009 meter plus 31 that is the amount of space available because 30 number of bar and 2 wall in the last in the in the both the side. So, in between wall and bar also there is another 1 gap another 2 gap in the both side. So, total number of gap will be n plus 1 ok. So, 31 number of gaps are there 31 number of gaps and 30 millimeter is the gap in between both the bar so that means, 0.03 ok, 0.03 meter. So, now, what is the total gross width 1.2 meter. Now we know the we already know the liquid depth what is the liquid depth submerged ah depth is 0.5 meter 0.5 square meter and we also know the gross width which is 1.2. So, how we can find out the liquid depth? We know the cross sectional area remember submerged cross sectional area vertical cross sectional area 0.5 square meter divided by the total width gross width 1.2. So, we can get the what we will get this value is nothing, but the liquid depth you understand. So, we know the in the earlier picture in the earlier ah slide we already get to know about the size I mean the area the vertical cross sectional area there which is 0.5 square meter and this slide we actually get the vertical depth I mean like the liquid depth.

So, now, we need to provide some free board say another 0.3 meter. So, total will be somewhere around 0.75 meter. So, what will be the size of your channel? 1.2 meter in width and 0.75 meter in depth there you can place your ah I mean like your ah screen. Now, how we can find out the bed slope? The slope that you need to maintain in your channel simply using the Manning's formula you can find out the hydraulic radius R equal to ah area available and divided by the weighted perimeter area is 0.416 is a liquid depth multiplied by the the gross width 1.2 meter divided by weighted perimeter. Weighted perimeter means only the areas which are actually kind of in order to for you to easily remember is the area which is available say for rectangular channel which is connected to the surf connected to the some of the surfaces on the side on the side of it. So, in the both the side it is like 2 into b. So, 2 into b is one side is say water is connected to the one side this side like you know.

So, if the liquid depth is ah liquid depth I mean like the water depth is say like 0.416 meter. So, 416 on the right side 416 on the left side plus the distance. What is the distance here? The gross width 1.2. So, how we can find out the P here? 2 b into ah normally the formula is 2 b into d say like 2 b plus d.

So, 2 b is the like here the depth and d is the distance. So, 2 x 0.416 + 1.2. So, hydraulic radiance is become 0.246 meter. Now according to the Manning's formula $V = (\frac{1}{n})R^{2/3}S^{1/2}$ from there you can easily find out the value of S ok.

So, value of S ah is coming how much? It is coming as a 0.0153. Therefore, the bed slope has to be 1 in 4272 meter that should be the slope that you need to provide. And this head loss ah it is that you have calculated that this value S is now ah bed slope is around 1 in 4272 meter. Now suppose the head loss through the screen when the screen is not clogged that is the value in case of the how we can find out the age value then. You remember that equation we find out that

$$h = \beta(W/b)^{4/3}h_v Sin\theta$$

we know everything we know the it is a rectangular bar screen.

So, we know the shape factor 2.42 W is known to us ah 9 which is like the width of the individual bar ah we know the gap 30 millimeter 4 by 3 h_v is known to us V square by 2 g V square equal to 0.462 we already find out divided by 2 into g acceleration due to gravity 9.81 sin into theta theta is 30.

$$h = 2.42(9/30)^{4/3}[(0.462)^2/(2 \, x \, 9.81)]Sin30$$

So, from there we get the 2.65 millimeter is the head loss that only 2.65 millimeter even if the screen is half clogged that means, value of b is now 1 ah 15 millimeter earlier the gap was 30 now say it is 15 millimeter half half of the portion is clogged half of the bar is already clogged. Now, it is ah like half of the bar area is already clogged for the whole whole I mean like the for the whole gross area. Now, it is become the area available ah for the water to pass through is 15 millimeter even for 15 millimeter of also if you again ah use the value of b as 15 millimeter in this equation you will find out the value of H is 6.67 millimeter still it is quite less than the 150 millimeter which is a standard practice.

So, we can easily provide 150 millimeter of drop without worrying without worrying about anything ok. So, if this head loss is excessive this can be somehow reduced by providing bar of rounded edge on the upstream or by reducing the width of bar from 6 millimeter to ah see ah like normally reducing the width of 6 to 8 millimeter or ah by slight reduction in the velocity ok. So, in general what we have understood ah in this ah problem I would ah in this particular lecture video I would really like to request you to go through this lecture video more and more time to you know for you to understand it very ah I mean like in in in depth it is very important for you to understand this ah this problem statement specially the numerical that you should follow. So, that it will be easier for you to design in future for any other purposes for ah I mean at for your client. So, different type of screens we discuss the design also we discuss the various elements and requirements and specification also we ah discussed several methods in general for consideration for disposable screening also we discuss that it is a grinder, incineration or the burial in the sanitary landfill. These are the references that you should follow and I hope you understand the design of screen understand the all the ah important information regarding screen in this lecture if you have any queries please reach to me I will be very happy to help you with that ok. Thank you so much see you in the next video.