Course Name: Industrial Wastewater Treatment

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Week - 01

Lecture 04: Design Aspects of Equalization Tank

Hello everyone, today we are going to deal with the design aspects of Equalization Tank. If we recall in the previous lecture, lecture 3 which is based on the basic concepts of equalization tank, equalization concentration, the mass load concepts, then mass load factors. So how these design aspects they are implemented in design of equalization tank that we will be dealing in this lecture. So, briefly we will be covering in this lecture the design aspects of equalization tanks like flow, how much the flow it should be designed, what should be the equalized volume of the tank required for design of a equalization tank, then size of the equalization tank and whatever the food print required for this equalization tank. So volume of the equalization tank as we have discussed this has to be designed for equalized volume and this volume we can determine by two methods that is graphical methods, another is analytical methods and then we will be comparing both of these two methods for their comparative merits and demerits and then we have taken and designed examples also which will deal with the real examples on the design of equalization tank and then we will be also looking the effect of this equalization process on the mass loading or BOD mass loading or various types of peak mass loads. Later we will be also talking upon the effect of equalization on the mass loading, what is the effect of equalization on dampening the shock loads along with its design example.

So one by one let us talk about the design aspects. So if we say that design flow for this equalization tank is basically is the equalized flow that is to be designed and then the HRT basically this equalization tank equalize the characteristic and flow of hourly variations and hence the HRT for this equalization tank must be taken as 24 hour. Similarly the volume of the tank it should be designed for optimized volume but be determined by graphical and analytical methods we will be dealing in subsequent lectures. Then it also facilitate the process of neutralization so we will be dealing with the various methods which can be used for neutralization of wastewater.

Then as we have discussed in the objective of equalization tank it also helps in removal of volatile organic compounds so design of variation systems and design of various pumps required for this operations so that all will be taken into subsequent lectures. Let us talk

about the determination of the size of the tank that is two methods as we have discussed one is the graphical method another is the analytical methods. So one by one we will be dealing with the graphical methods and analytical methods both. So here this is the steps involved in design of equalization tank so first of all we should have the hourly flow variation of the data for entire day. So we have to find out the cumulative volume of the inflow and then also the outflow.

Then once we have determined the cumulative volume of the inflow and outflow then we can plot the respective mass curves of inflow and outflow versus time in a graph. Then we have to identify the peak and draw the tangents at the peaks of these mass curves of the inflow which is parallel to the mass curve of outflow and then finally we measure the vertical ordinates which is the peak value the maximum vertical ordinates between the mass curve of outflow and the tangent drawn on the mass curve of inflow. So this maximum vertical offsets that will basically decides the volume and size of the equalization tanks. So how this process is done we will be looking by taking an design example in the subsequent slides. So then we will discuss about the analytical methods which also is used to determine the size of equalization tank.

So here also we do the same thing we first analyze the cumulative volume of the inflow and outflow then we determine the deficit or surplus if there is a cumulative volume of inflow is more and cumulative volume of outflow is less then there is a surplus of water and in case if the cumulative volume of the inflow is less compared to the cumulative volume of the outflow then this would be taken as a deficit and for deficit because there is a deficiency of the flow so we should take as the negative sign and then for surplus we take as a positive sign. So any of the sign convention can be used to indicate the deficit or surplus between the cumulative volume of inflow and the outflow and then once we calculate the deficit or surplus for each individual hours in a day then we have to find out the peak value of this deficit and surplus. Then finally we can determine the volume of the equalization tank by adding these two peaks if there is only one peak then that peak will be equal to the volume of the equalization tanks. So how this process is performed? Let us take and design example to describe this process. So this basically you see this for individual time there is a flow variation data is given there is a BOD mass concentration is given that is mg/L and then for different time duration from 13 to 24 again these two data is given data for flow data for BOD concentration.

So this is the given data which indicates the hourly variation in the flow and the BOD concentration. So for this if we need to design the volume of the equalization tank by using two methods like graphical methods and analytical methods so we will be doing one by one both the methods to illustrate how these two techniques can be used for design. So let us start with the process so first of all we have to determine the cumulative volume of

inflow and outflow for that we need to have the flow data for the individual hours. So this is the individual hours of a day like starting from 1, 2, 3, 4 up to 12 hour. So this is the flow data that is 0.275, 0.22 then 0.165 like individual hours flow data is given then we have to first calculate the volume of the inflow simple volume of the inflow that the data is given in m^3/s. So if we multiply for 1 hour volume so this will be multiplied by 60 into 60 so it will give you hourly volume of the flow that will be 990 m^3 for the first hour then similarly we calculate for second hour and each individual hours and then we need to calculate the cumulative volume of inflow. So this is say for first hour this is 990 then for second hour this is 792 so we have to say for first hour cumulative volume is 990 that will be added to get this cumulative volume. So this comes around 1782 similarly for third hour cumulative volume so this plus this if we do we get this 2370.

So similarly for each individual hours we have to find out the cumulative volume of inflow and then you see for another hour from starting from 13 to 24 hour similar way the flow rates are given and then we have to find out the volume of inflow similarly that the cumulative volume of inflow. Then if we see the average of the 24 hour flow that comes to 0.307 so if we determine this volume of inflow for each individual hour we take the average we get this is the average volume of the water generated per hour. So this should be taken as the outflow because the outflow must be the average flow that should be the constant because any treatment plant we design for a constant flow so this must be maintained as a constant flow. So for all outflow you see this starts from 1106 then again for cumulative outflow this is double, triple, four times, five times like that individual hours we find out the cumulative volume which is going out.

Then after doing this exercise what we need to do in a graphical method if we see we have to plot the mass curve of outflow, mass curve of inflow. So for this the cumulative volume you see this is plotted on the y axis against the time hourly time that is starting from 1 to 24 hours. So this if we see this is the plot for a mass curve of inflow and this shows for the mass curve of outflow. So mass curve of outflow if you see this is a straight line so because this flow is constant so the outflow curve that will be a constant line, straight line and while the mass curve of inflow it has lot of fluctuations so it makes a concave shape. So here if we see what is the peak value, what is the vertical ordinate which is the next step in determining the volume of the equalization tank which is required.

So we measure the vertical ordinate between the tangent which is drawn parallel to the mass of outflow curve so this is the tangent A which is drawn at the peak point A which is equal to the vertical ordinate on the y axis which if we measure this ordinate say its value is A. So here finally we measure this A value which is equal to 8.5-4.5 if we see from this graph and which is equal to 4 into 1000 m^3 so equal to 4000 m^3 because this value is plotted

in 10^3. So this the whatever the difference of the two this vertical ordinate multiplied 10^3 that will give you the equalized volume of the tank.

So this comes to 4000 m^3 in this method. So if we do the same calculation and say for another conditions in this case what we have got is only one peak. So if we see there is this kind of curve where there is a two peaks there is one peak A there is another peak point B so this both convex and concave type of curve if we get then we have to measure both this vertical ordinate A and B in the curve and which has to be added A plus B that is equal to 2 plus 3.5 in this case that will be equal to 5.5 and this will be the capacity.

So this is just to illustrate you that how this process can be used for other type of flow variations if we have different types of curves for inflow. So this is an illustration of the graphical methods having different types of inflow curve which may have one or which may have more than one peaks one for deficit one for surplus. So because in this case if we see this is saying the mass curve of inflow it means the cumulative volume is more than the outflow volume. So there is always surplus so this ordinate says that is basically the surplus and here in this case what we this is concave shape so here it means that mass volume of this inflow that is less than the mass volume of outflow so there is a deficiency and that gives the deficit value. So both these ordinates are measured and they are added to get the required capacity of equalization tank.

So this is the method we use for determination of equalization capacity of the tank. Then there is another method to determine the same we have analytical method now as we have discussed here also we have to do the first step determination of cumulative volume of inflow and outflow. So you can see here the same value and same data is here just to illustrate you this is the flow for different times of hour and this is the volume of inflow at individual hours this is cumulative volume and this says the cumulative volume of outflow and in this case similarly we find out for another 13 to 24 hour the volume of inflow for different hour then cumulative volume then we have volume of outflow and then in this case we need not to plot anything we can directly calculate the deficit or surplus. So here the deficit if we see here for first hour if we see cumulative volume of inflow is 990 cumulative volume of outflow that is 1106 so there is a difference of 116 and since cumulative volume of outflow is more and compared to the cumulative volume of inflow so there is a deficit and so for this we have given a negative sign. So for all this we get the negative signs and this is for the deficit or surplus value for another 13 to 24 hours then the next step in this is to identify the peak values of deficit or surplus.

So here we see there is a only deficit from hour 1 to hour 24 so we have only one type of peak and that is 4098 so this is basically the peak value of entire 24 hour which should be

basically the equalization capacity of the tank. So in this the peak of the surplus peak value of the deficit that has to be added and that will give you the value of the volume of the equalization time needed. So this in this case the value comes 4098 and in the previous case like graphical methods this value came to around 4000. So here what we can see this is the more exact value compared to this 4000 meter cube which we have determined earlier. So this gives basically more accurate estimation of the volume of the equalization tank compared to the previous method that is graphical method.

So this is the comparison of the two methods like graphical method if it is C this is a very old method and does not provide any much accurate information about the volume of the tank. So let us talk about the comparative assessment of these two methods. So as we know this graphical method is very old and does not provide more accurate information about the estimation of volume of the tank compared to the analytical method and this because graphical method requires lot of drying of crops then tangents so it may involve the various types of manual error compared to the analytical method which is a simple analytical technique based on calculations. So this graphical method if we see that is more complex more time consuming compared to the analytical method. So for all design purpose nowadays we use this analytical method for determining the capacity of equalization tank.

So let us take an another example which will illustrate the effect of equalization on the mass loading rate. So this is the same problem which is rearranged like the timing for the flow that is started from 9 hour when the equalization tank is most empty so this is taken as the first hour and this is the volume of inflow individual hours whatever the volume is coming into and then this is the volume of water which remains into the equalization tank after the average flow of the water is taken out. So this is at any moment of time at the end of hour this will give you the volume of the water in the tank and similarly this is the BOD mass concentration that is given for individual hours it is already given in the design problem and this equalization concentration while the equalized BOD concentration that we have to determine by the concept as we have discussed earlier for each individual hours starting from 9 to 8 so this is the equalized concentration for each individual hours and then this is the mass load of BOD without equalization, and this is the mass load of BOD after the equalization and this is determined by taking the respective volume and the respective concentration of BOD in case of without equalization we have to take the BOD concentration as given for individual hours while for calculating the mass load after equalization we have to multiply with the equalized concentration of BOD at individual hours so we get this value for mass BOD load without and after the equalization. So here the same exercise we performed for another 9 to 8 pm till 24 hours so this is incoming volume at each individual hours this is the volume remaining at each at the end of every

individual hours and then this is the BOD concentration for each individual hours this is the equalized concentration so we can calculate similarly the mass BOD loading with and without the equalization this is without the equalization this is after the equalization. If we analyze this mass BOD loading for individual hours you see here in this the peak value comes here that is 341 in this case the peak value in this page is not basically found in the second page if we see the peak mass load without equalization that comes around 439 kg/hr whereas after the equalization this peak value that is 272.

So now similarly we find out also the minimum BOD load that is without equalization that is around 17 kg/hr whereas for after the equalization this value comes to this 134 basically comes to the minimum value, minimum BOD mass loading rate. So now if we analyze and compare this ratio like this is the ratio for peak to average mass BOD load this is minimum to average mass BOD load ratio this is peak to minimum mass BOD loading rate ratio. So for different peaks and average ratio minimum to average ratio peak to minimum ratio we have got the different values so this is peak value this is average value and this is the minimum BOD load then the wastewater is not equalized and this is after equalization the peak value comes 272 the average value will be same and where the minimum value here in this case that is 134. So if we take the ratio of these two before equalization and after equalization we will have the Q_p/Q_a value 2.06 whereas in case of equalize this is 1.27 so here we can see the peak load is considerably like 50% times it is reduced. So here similarly minimum BOD load to average BOD load that is 0.08 where in this case is 0.62. In case of unequalized the peak and minimum BOD mass load ratio is very very high that is around 25.82 around 26 times whereas after equalization you can see this peak loads are dampened and that is merely 2.09. So this example shows how this peak loads they are dampened because of equalization. So after equalization we can see there is no much fluctuation whereas before the equalization there is a lot of fluctuation between the peak and the minimum value the peak and the average value so this shows the effect of equalization on the mass loading rate this can also be seen in this curve if we see this is plotted for the average mass loading rate this is after equalization this is the mass loading rate for after equalization this green color whereas this yellow color shows the BOD mass loading curve without equalization. So here we can see the peaks here they are not very high as compared to the BOD mass load without equalization.

So here also you can see there are the peaks that is much higher than these peaks of equalized BOD mass curve so this shows how this equalization process helps into equalizing the BOD mass loading rate in the secondary treatment process. So this is another design examples you can practice there is a time duration starting from 0 to 1 then again for 12 to 24 hour this flow data BOD concentration and suspended solid concentration is given similarly for another rest of the hour this these values are given so

for this you can again do the same exercise you can find out the volume of the equalization tank using both the methods like graphical and then analytical method and then you can also look upon the effect on to the mass loading rate on equalization. So these are the references I hope this finish your equalization tank design concepts basics mass loading concepts all the things we have covered and maybe in the next lectures we will be dealing about the another tools and techniques which are on the neutralization and proportioning which are used in in the industry abroad for management of industrial wastewater.

So thank you guys.