Soil and Water Conservation Engineering

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Lecture – 31
Hydraulic and Structural Design of Gully Control Structures of drop Spillway

So, welcome students to our next lecture it is on a Hydraulic and Structural Design of Gully Control Structures of drop Spillway. So, we will design by using many number of examples in the subsequent slides. So, this lecture is solving many examples first our design is for free flow condition.

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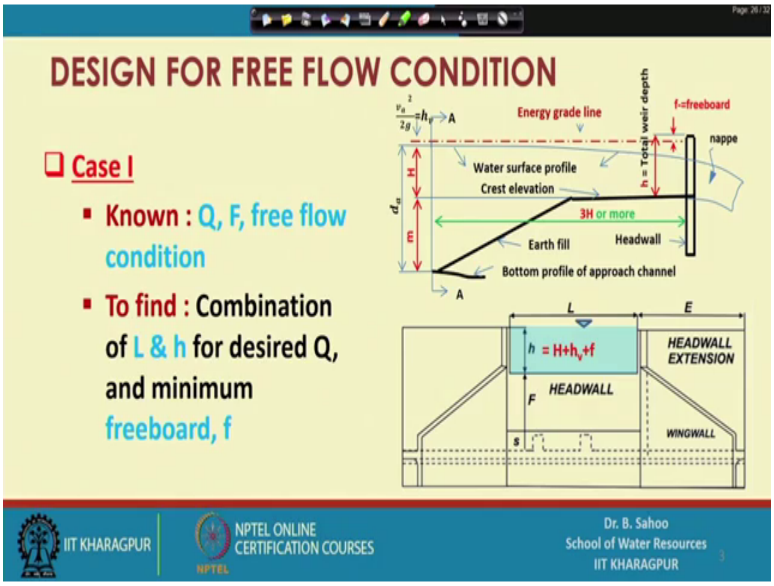

So, the first case can be the values of Q, F are known on way to find the combination of capital H and small h for desired Q and minimum freeboard. If you will see this figure small h is nothing, but the summation of capital S that is the depth of water in the above the crest of the weir h v is here is a kinetic head loss and small f is the freeboard.

So, in this case the design discharge Q is known, capital F is known from this figure you can see and you have to make a combination between capital H and small h. So, the value of capital H or the length of the weir generally considered depending on the width approach channel or the existing site.

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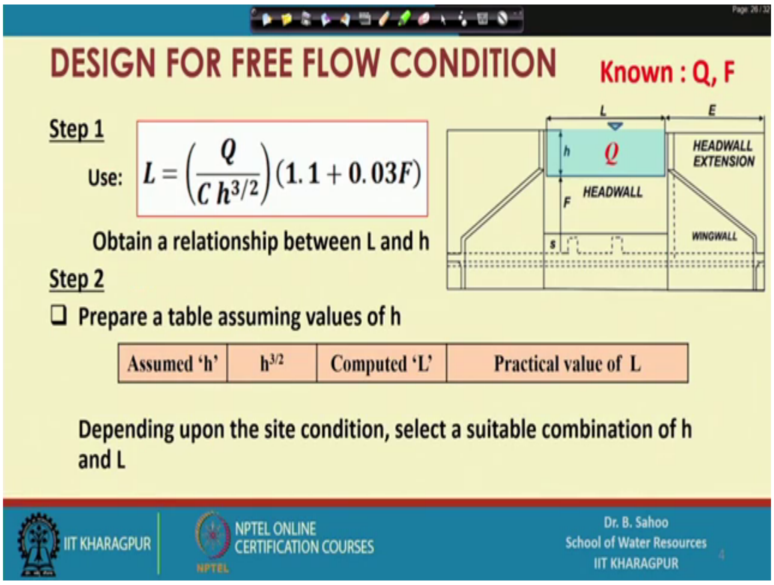

So, for this in the step 1, you have to use the formula as you have talked in the previous class, L equal to Q divided by C h to the 3 by 2 into 1.1 plus 0.03 F, this is for SI unit and then you have to obtain a relationship between L and small h.

We can do it by using some trial and error approach, in this case you have to first assume small h then you have to compute the value of L by using this equation. Then you have to check whether this is tallying with the practical value of capital L that is the length of the weir. And depending upon the site condition you can select the suitable combination of small h and capital L.

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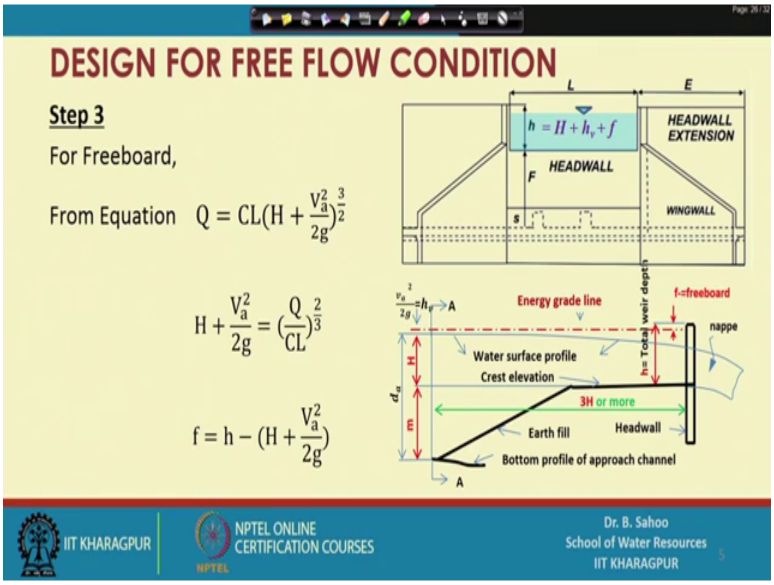

In the step 3, for freeboard you can use the weir equation that equal to that is given by Q equal to CL H plus V a square divided by 2 g whole to the power 3 by 2. And from this you can get the kinetic head of this water that is a h v that equal to H ah V a square divided by 2 g plus the capital H we can get that equal to Q divided by CL whole to the power 2 by 3. And from this we can get what is a freeboard? That is small h minus capital H plus V a square divided by 2 g.

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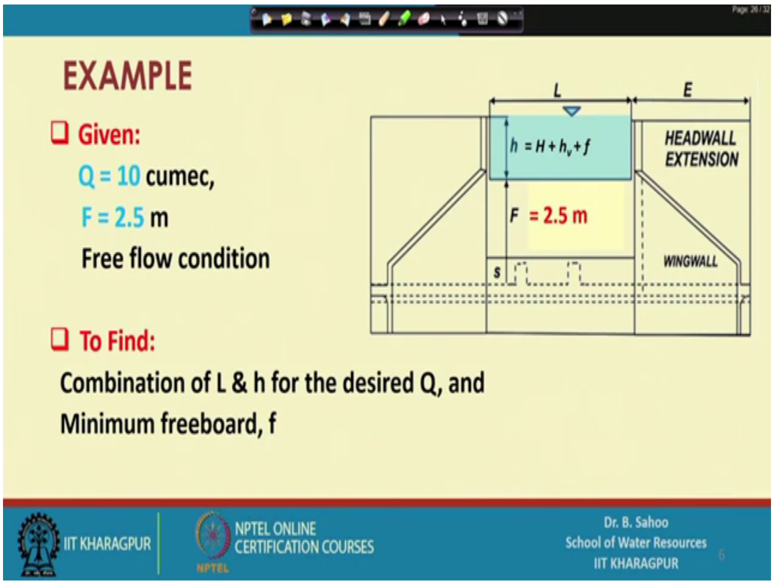

So, this will be more clear when will be solving some problems. Suppose this one example, Q is given as 10 cumec, capital F is 2.5 meter and this is a free flow condition. So, the tail water is not obstructing and we have to find a combination of the length of a weir L and h is the depth of weir for the desired Q and the minimum freeboard that is small f.

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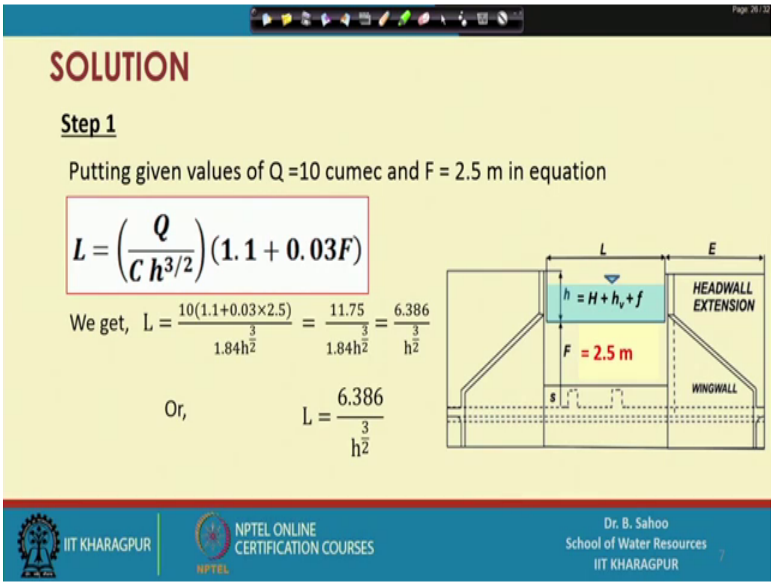

For the solution you have to use this formula and by putting the known values Q and capital F and C is known that 1.84 for rectangular your F is 2.5. So, you can get one relationship between L and h. So, your L equal to 6.386 divided by h to the power 3 by 2. So, you have to make a combination between L and h. So, in this case your assume the value of h and get the value of capital L.

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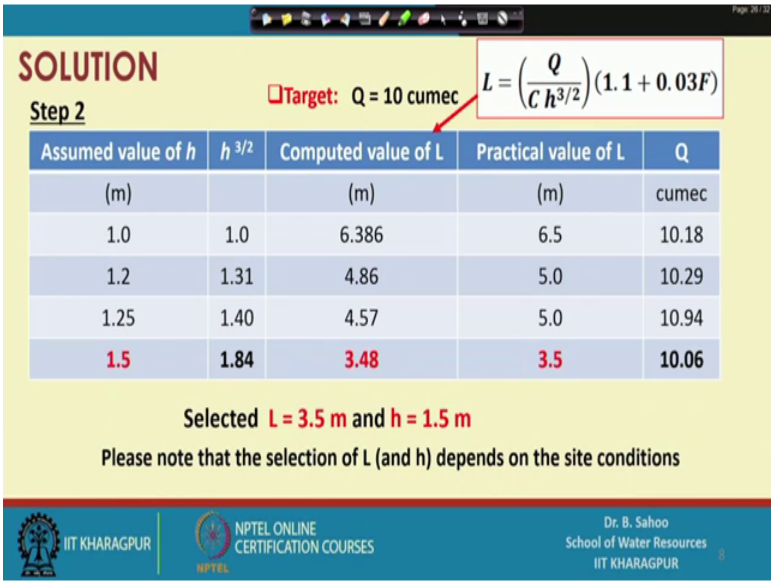

So, this is shown in this figure in this table, you can see that different trail values are of h we have started from h equal to 1 and up to 1.5. So, when I am using h equal to 1.5, I am getting the computer value of L as 3.48 meter. And that is almost matching with the practical value of L that is your edge consider as 3.5 meter and the corresponding discharge is about 10.06, which is nearly equal to the target that is your given discharge of 10 cumec. So, in this case we can select the length of weir as 3.5 meter and the depth as 0.5 meter and we should not that the selection of L and h that depends on the site conditions.

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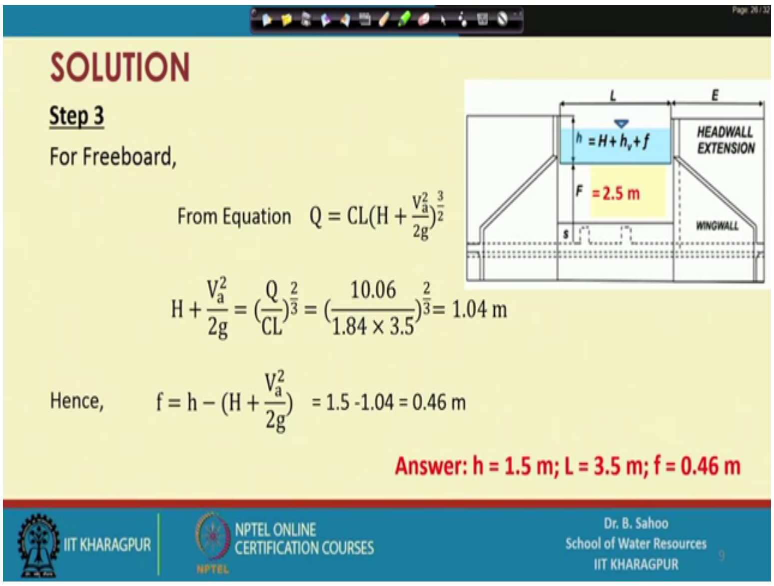

In the step 3, you have to use the weir formula to estimate what is your freeboard, the small f. So, you have to estimate what is the value of small f, so, that equal to small h minus the kinetic energy weir plus the depth weir.

So, before that for that you have to calculate what is the value of capital H plus V a square by 2 g by using the your formula. So, here we get it is 1.04 because, Q is known it is 10.06 and C is 1.84 and L is 3.5 meter. So, by putting this values we can get small f equal to 0.46 meter. So; that means, you have to provide 0.46 meter of freeboard, h equal to small h equal to 1.5 meter and L equal to 3.5 meter.

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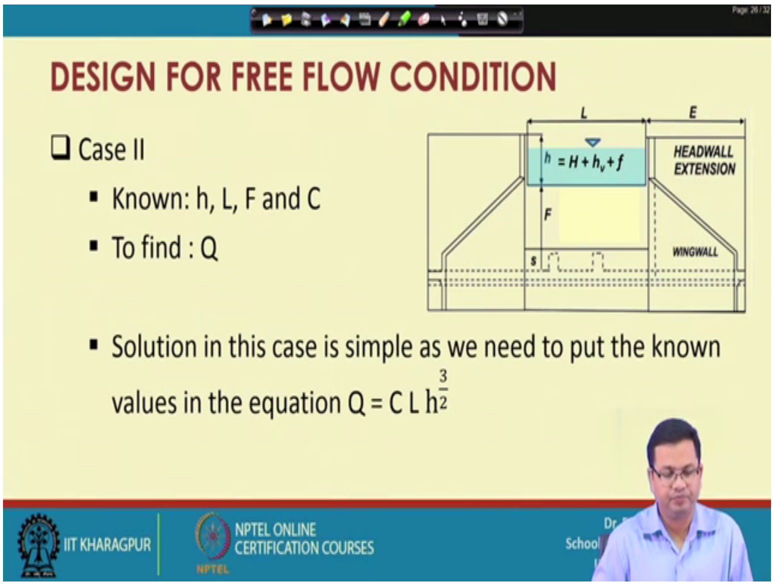

For the design of free flow condition, this is case 2 suppose the known values are small h that is the depth of weir length of weir L capital F and C, C is equal to 1.84 that is known for rectangular and you have to find the design discharge that equal to Q. The solution in this case is simple as we need to put the known values in the equation that is Q equal to C L h to the power 3 by 2 by using weir formula.

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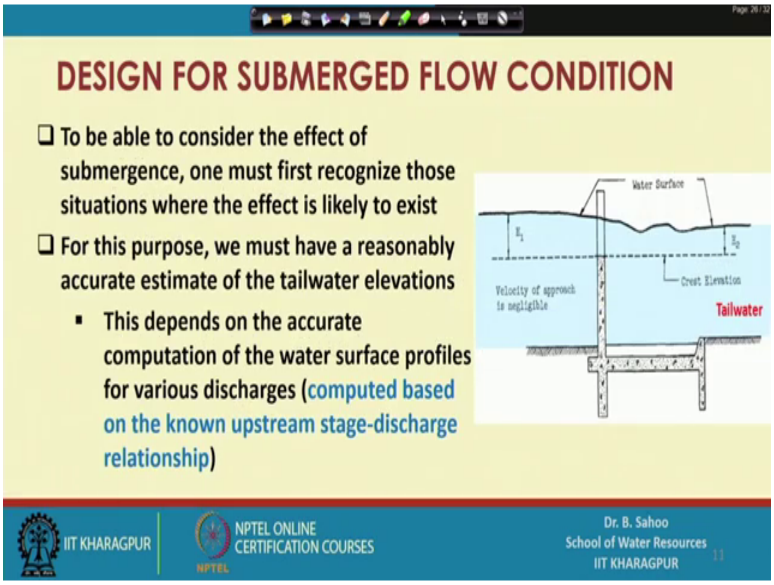

For design under submerged flow condition, you can see this figure the tail water is above the crest level. That means what about H2 height is there that is above the crest level. So, you are getting submerged to be able to consider the effect of submergence one must first recognize those situations where the effective likely to exist for this purpose.

We must have a reasonably accurate estimate of the tail water elevations. So, this depends on the accurate computation of the water surface profiles for various discharges which are computed based on the known upstream stage-discharge relationship which are called as also called as normal rating curves. So, many times we have the normal rating curves and by using those rating curves so, generally convert the stage value into discharge or vice versa.

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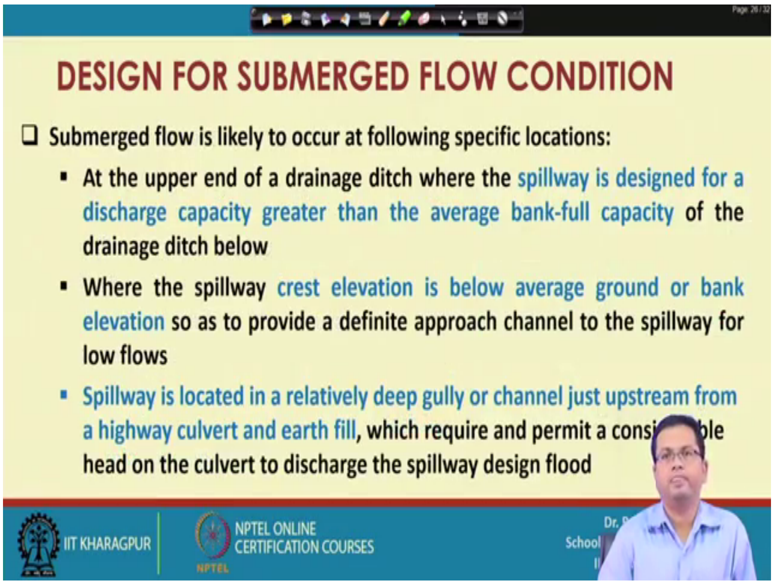

The design for submerged flow condition is likely to occur specifically the submergence is likely to occur because, at the upper end of a drainage ditch where the spillways design for a discharge capacity greater than the average bank full capacity of the drainage ditch below.

Where, the spillway crest elevation is below average ground or bank elevation so as to provide a definite approach channel to the spillway for low flows. And the spillways is located on a relatively deep gully or channel just upstream from a highway culvert and earth fill where which require and permit a considerable head on the culvert to discharge the spillway design flood.

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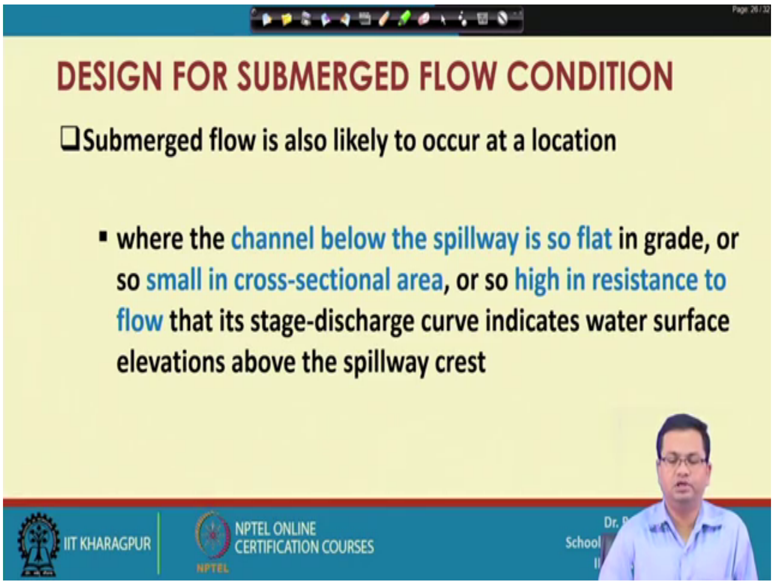

The submerged flow is also likely to occur at a location where the channel below the spillway so flat in grade, or so small in cross sectional area, or so high resistance to flow that it is stage discharge curve indicates water surface elevations above the spillway crest.

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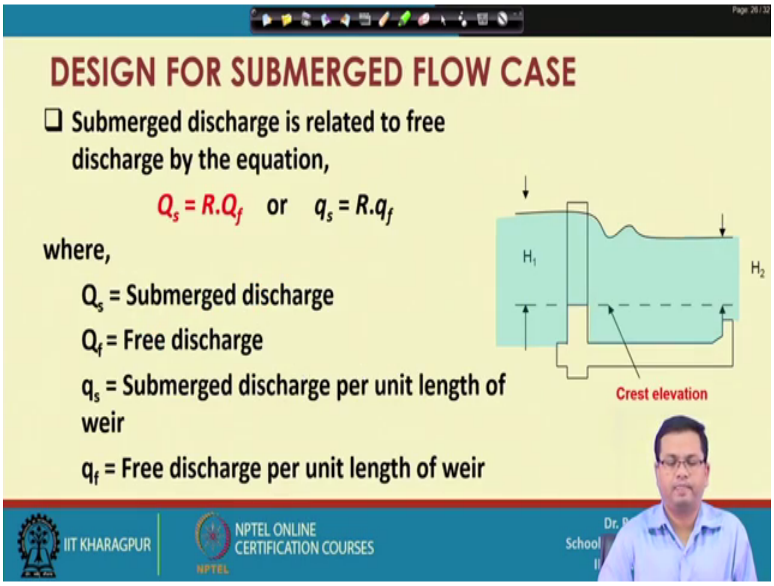

For the design of submerged flow case, the submerged discharge is related to free discharge by using the equation Q s equal to R into Q f. Where Q f is the discharge in the free flow condition and Q s is the discharge under submerged flow condition. So, in this case you will get a specific ratio so, that ratio the Q s divided by Q f equal to R and similarly, small q s is a submerge discharge for unit length of weir and small q f is the free discharge for unit length of weir.

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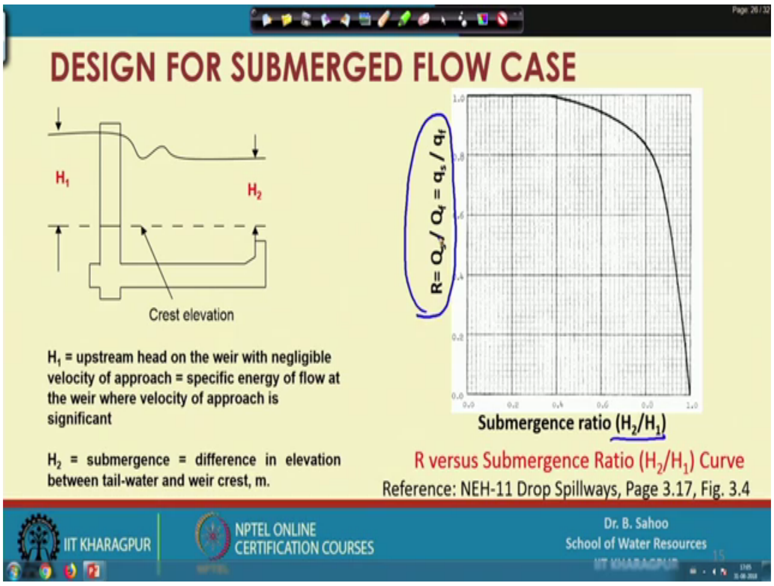

You can see this plot, in this plot in the x axis you will get H2 minus H1 that is the ratio of submergence or submergence ratio and the y axis we are getting R. So, that is equal to Q s divided by Q f and for a specific channel you can get such type of rating curves.

So, this is a plot between R versus submergence ratio that it is H2 by H1 curve and here you can see H1 is the upstream head of water and H2 is the submergence which is above the crest level. So, this is the crest level.

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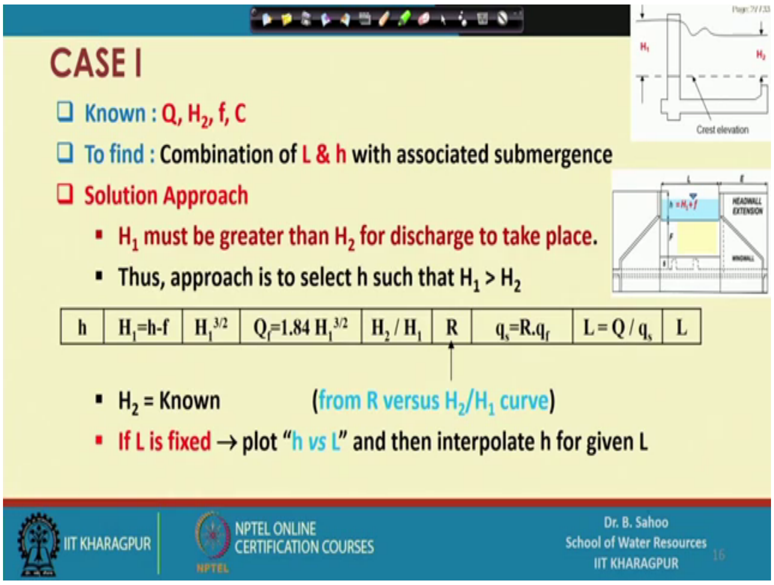

In this case, the known values are the design discharge Q, the tail water height H2 is known, small f the freeboard is known and C is equal to 1.84 for the rectangular weir. We have to find the combination of L and H with the associated submergence. For the solution one should remember that to for flowing water generally H1 should be greater than H2, the upstream water level should be always greater than that of the downstream or tail water level that is H2.

So, H1 equal to in this case small h minus f because, H1 is the depth of flowing water and small h is the depth of the weir depth and small f is your freeboard. So, naturally you will get if small h is assumed you will get what is the value of H1 so, that equal to h minus f, you can see this table.

And by the weir formula you can get Q f and the freeboard condition free flow condition that equal to 1.84 into H1 to the power 3 by 2. And you can calculate what is the value of H2 divided by H1?

So, once you have calculated this value H2 divided by H1, you can estimate that is the value of R. So, R equal to H2 divided by H1, then by using the R versus H2 divided by H1 curve as well shown in the previous slide you can estimate the value of q s that equal to R into q f. And from here you can get what is the value of L.

So, L equal to capital Q divided by Q s this capital Q is given and you have estimated the value of Q s from the graph, so, you can get what is the value of L.

So, in this case H2 is known, if L is fixed then plot small h versus L and then interpolate small h for given L.

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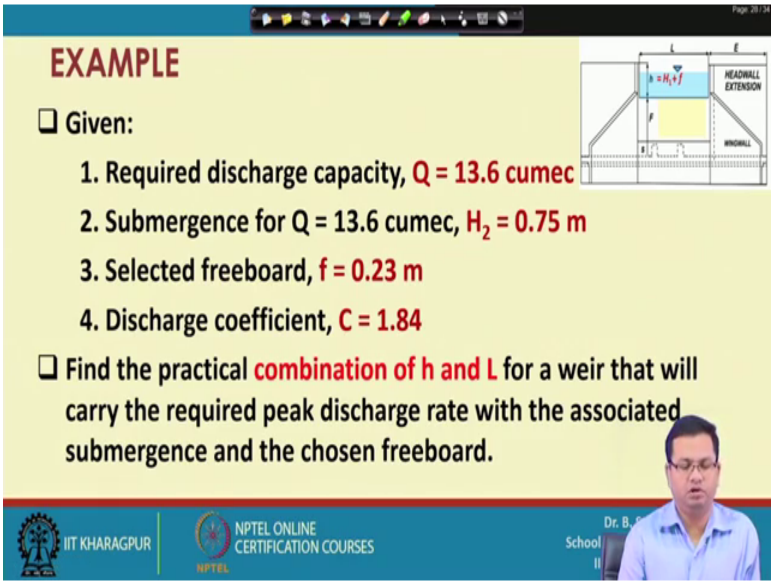

So, this is your solving one example, suppose the required discharge capacity is given as 13.6 cumec, submergence for Q 13.6 is given 0.75 meter that equal to H2 equal to 0.75 meter. Selected freeboard that your small f that equal to 0.23 meter and the know the discharge coefficient for rectangular is 1.84.

So, the following that to find the practical combination of small h and capital L for a weir that will carry the required peak discharge of 13.6 cumec with the associated submergence then the chosen freeboard. So, that you have to find out.

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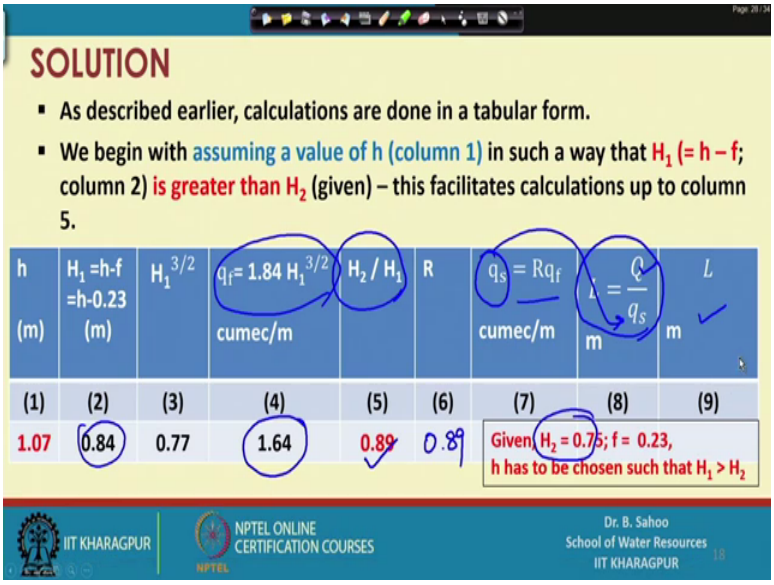

So, this is a solution approach, the solution is carried out by using trial and error method in a tabular format. With begin with assuming a value of small h in column 1 we can see we are assumed value of 1.07 meter, in such a way that H1 is greater than H2. So, the value of H2 is given that is 0.75 so, we have selected small h 1.07 so that H1 equal to here 0.84. Then we have estimated the value of q f that is your free flow condition. So, that equal to 1.64 by using this formula.

Now, you can get the value of H2 divided by H1, here H1 is 0.84 and H2 is given point 7 5. So, by using that you can estimate what is the value of H2 divided by H1 and the equal to R so, R equal to also 0.89.

Then, by using this R you can estimate what is the value of q s by using the graph between R and the ratio between q s and q f. So, you will get q s equal to R into q f and then you can get the length of weir equal to capital Q that is your given discharge divided by the estimated q s value ok. So, by that way we can solve for L.

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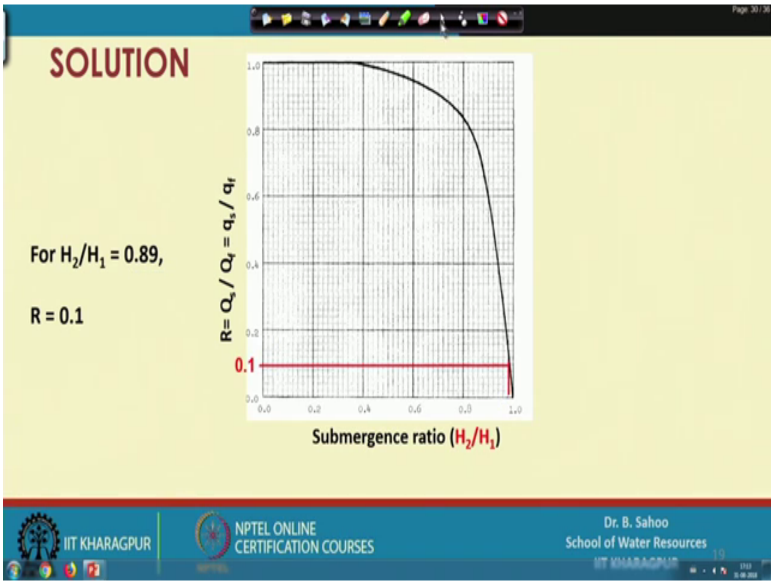

So, here you can see this is a solution approach for H2 divided by H1 equal to 0.89, this is 0.89 and we got R equal to 0.1. So, here you will get H2 divided by H1 0.89 here and correspondingly you are getting R equal to 0.1.

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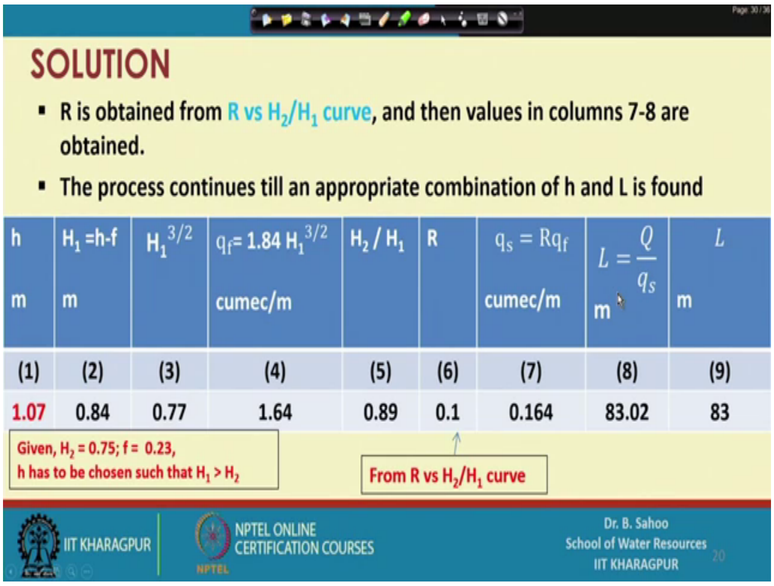

So, R is obtained from R versus H2 divided by H1 curve and then values in column 7 and 8 are obtained. You can see the values in 7 and 8 are obtained we have filled up the table whatever we have shown for and in this case we are getting L equal to 83.02 or approximately it is 83 ok. So, this is the solution for submergence.

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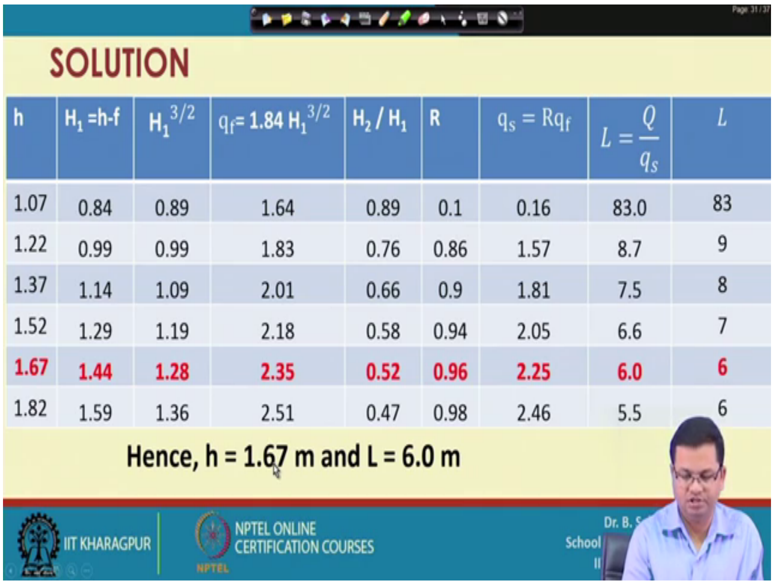

So, in this case we got the that if you have assume small h equal to 1.67 you are getting L equal to 6 meter. So, are L is given as 6 meter so, you will get h equal to 1.67 and L equal to 6 meter in this case.

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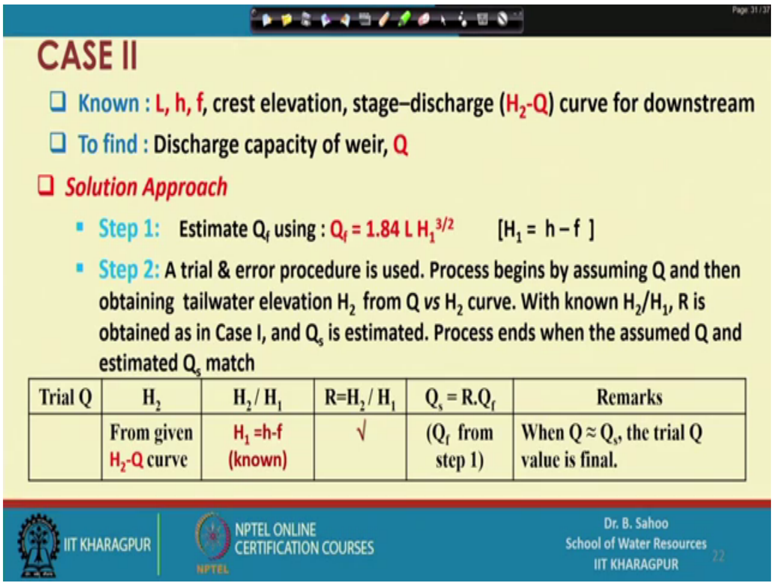

The 2nd case the known values are L, small h, small f, crest elevation, the crest elevation is generally given to estimate what is the upstream water depth above the crest level from the stage discharge relationship. Then you have to find the discharge capacity Q. The solution of Q involves different steps, in step 1; you have to estimate what is the value of Q f by using the weir formula.

So, Q f is the free flow condition discharge so, that equal to 1.84 into L H1 to the 3 by 2 and here H1 equal to small h minus f, f is the free board. In a 2nd step you have to go for trial and error method as you have done before. The process begins by assuming Q value and then obtaining tail water elevation H2 from the Q versus H2 curve. With known H2 divided by H1 that equal to R whatever we have obtained as in case 1, we can estimate Q s that is the submerge flow discharge.

The process ends when the assumed discharge and estimated Q s match. Will see this table, first you have to estimate or you have to go for a trial value of Q you have to assume some value of Q, get the value of H2 from the given H2 and Q curve, get the value of R which is nothing, but H2 divided by H1.

Where H1 equal to small h minus f and that is known and you will get Q s equal to R into Q f as you have done in step 1 by using the weir formula Q f equal to 1.84 into L H1 to the power 3 by 2 and when Q is nearly equal to Q s the trial Q is the final value.

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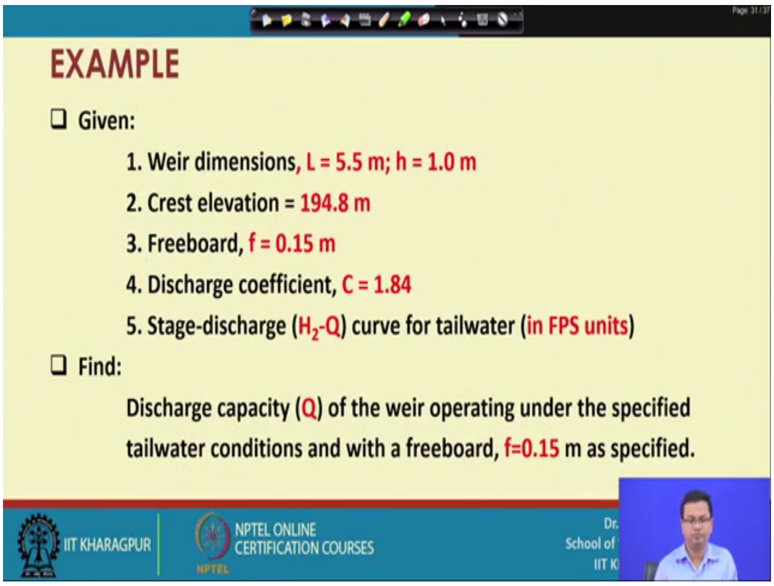

So, this is one example you can see the weir dimensions are given L equal to 5.5 meter and the depth is 1 meter, crest elevation is 194.8, freeboard is 0.15, discharge coefficient 1.84 and the given discharge H2 Q is given in FPS unit we have whatever plot is given that is in FPS unit. You have to find the discharge Q of the weir operating under the specified tail water condition with a freeboard f equal to 0.15 meter as specified.

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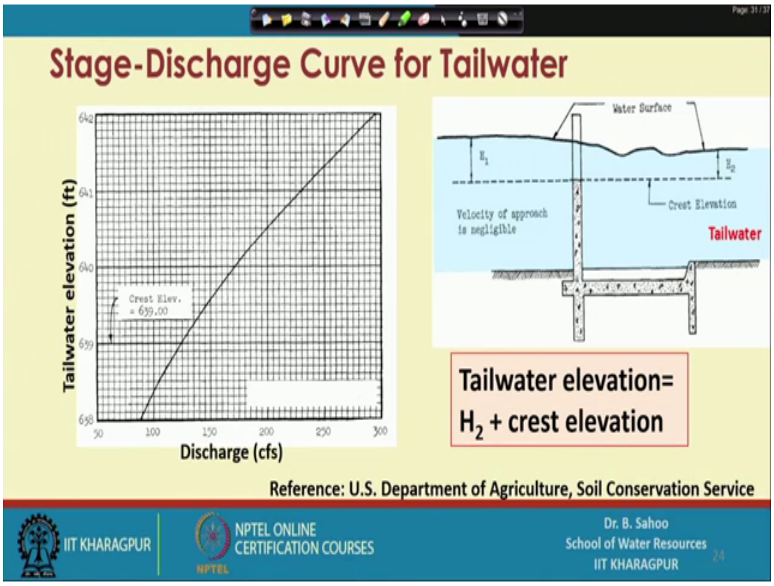

You can see this plot whatever given the rating curve is given between tail water elevation and discharge this elevation is not the water depth H1. Rather this is H1 plus the crest level, the crest level elevation.

You can see this the crest elevation is given 639 feet and here all are in feet, the tail water elevation is in feet and here the discharge is in c f s. So, here the tail water elevation equal to H2 plus crest elevation. So, here the tail water elevation this height is equal to the crest elevation plus the value of H2.

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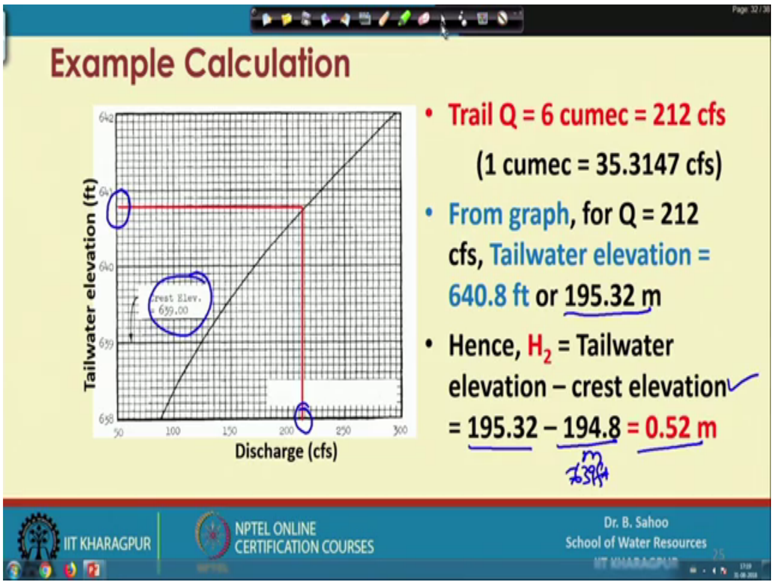

So, for this calculation you have to go for a trail value of Q that if you have taken here 6 cumec, which equal to 212 cubic feet per second and from this graph you can get for Q equal to 212 c f s here I can get the tail water elevation this value which is approximately 195.32 meter.

Hence, H2 equal to tail water elevation minus crest elevation so, that equal to 195.32 minus 194.8 in meter and which equivalent to 639 feet. So, this is equal to 639 feet so, 194.8 meter equal to 639 feet so, you will get approximately 0.52 meter. So, the tail water elevation is 0.52 meter.

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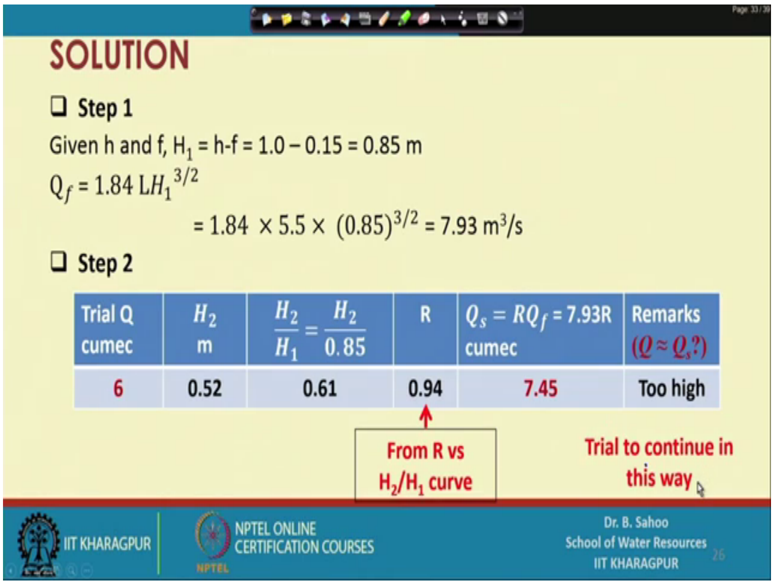

So, in the step 1, the given value is h and f so, you will get H1 equal to small h minus f that equal to 1 minus 0.15 so, that equal to 0.85 meter. And Q f by using weir formula you can get 1.84 L H1 to 3 by 2 so, that equal to 793 meter cube per second.

And in this case you have to assume the assume value is 6 you got H2 equal to 0.52, the value of R that equal to 0.62 sorry 61. So, H2 divided by H1 equal to 0.61 so, that equal to H2 divided by 0.85 and R you can get from the curve R versus H2 divided by H1 curve ok. So, you can get Q s equal to R Q f that equal to 7.93 R so, that equal to 7.45. But in this case you will see this is very high because, Q is not matching with Q s.

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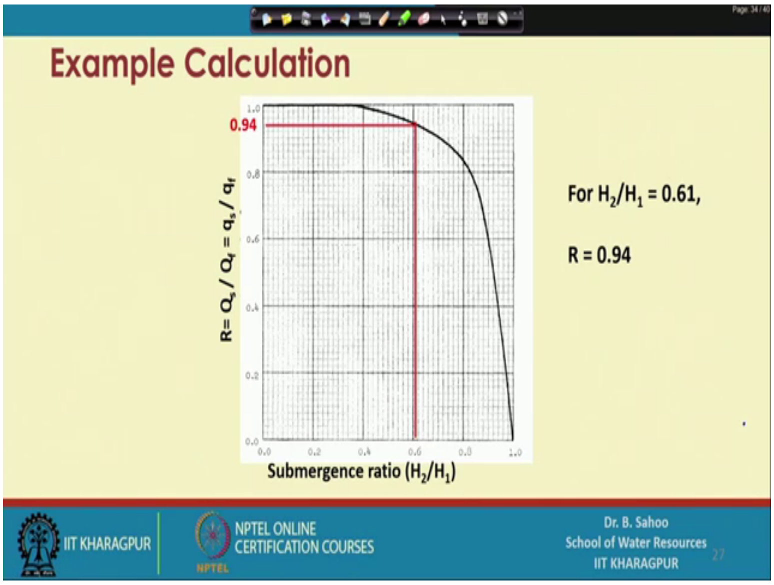

So, you have to again continue the trial and error process. For this you can see we have got H2 divided by H1 equal to 0.61, here H2 divided by H1 equal to 0.61 in this table and correspondingly you got R equal to 0.94. So, you can get the R value of 0.94 from this plot and that we are using in the calculation.

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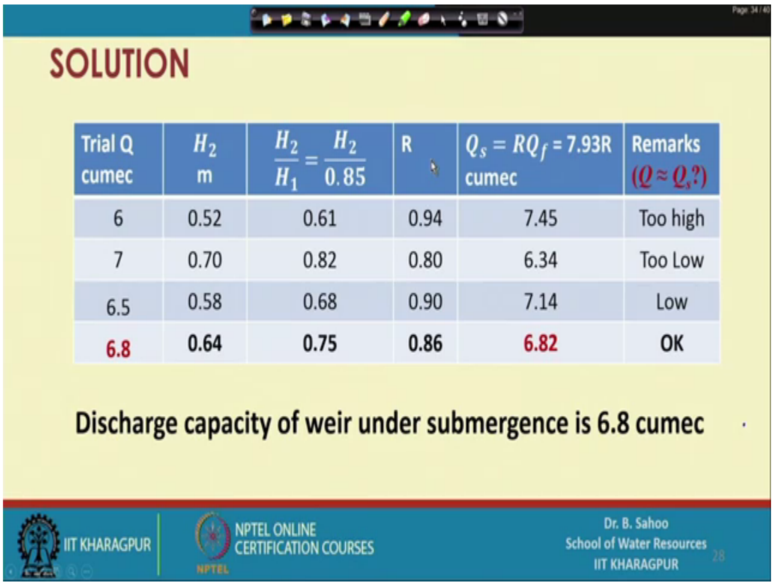

Now, for different trail values of Q in this table you can see that if I am taking Q equal to 6.8 cumec then, I am getting Q s equal to 6.82 and that is nearly equal to design discharge is Q. So, in this case I can use Q s value as 6.8 cumec.

Thank you.