Soil and Water Conservation Engineering
Dr. Poulomi Ganguli
Department of Agricultural and Food Engineering
Indian Institute of Technology, Kharagpur

Lecture – 48
Chute Spillway Design – I

Hello. In the lecture 47, we studied the Design of Chute Spillway Principle. Now, we are going to solve some design problem, so that you understand how to design the chute spillway. So, this lecture is again divided into two parts that is part 1 and then part 2. And now, we are going to start the part 1 design problem.

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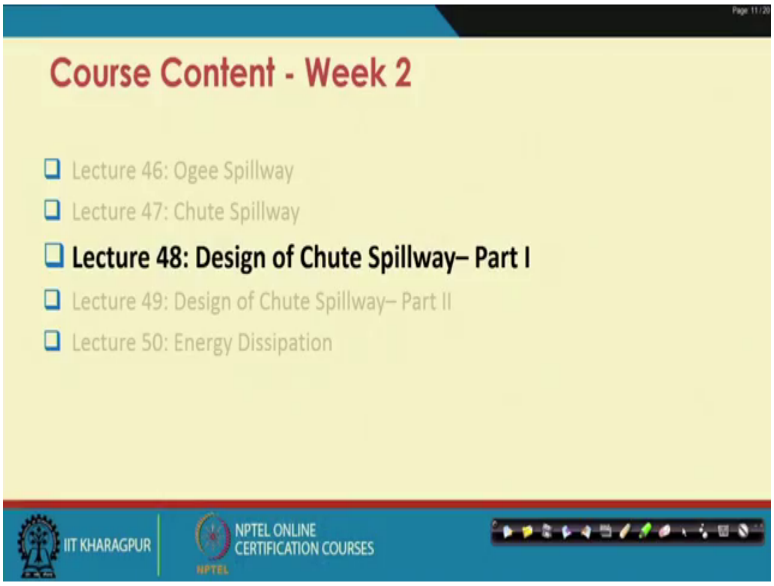

So, Chute Spillway Design Part 1.

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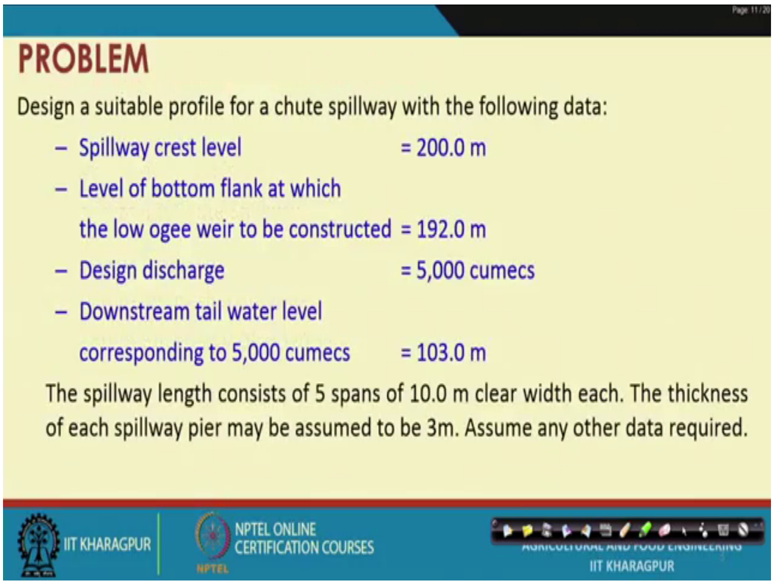

Now, the coming to the problem in the first what are the dimension given, the spillway crest level is 200 meter, and the level of bottom flank at which low ogee weir is to be constructed is 192 meter, design discharge is 5,000 cumecs, downstream tail water corresponding to this discharge is 103 meter. The spillway length consists of 5 span of 10 meter clear width. And the thickness of each spillway is to assume 3 meter and assume if there is any data needed.

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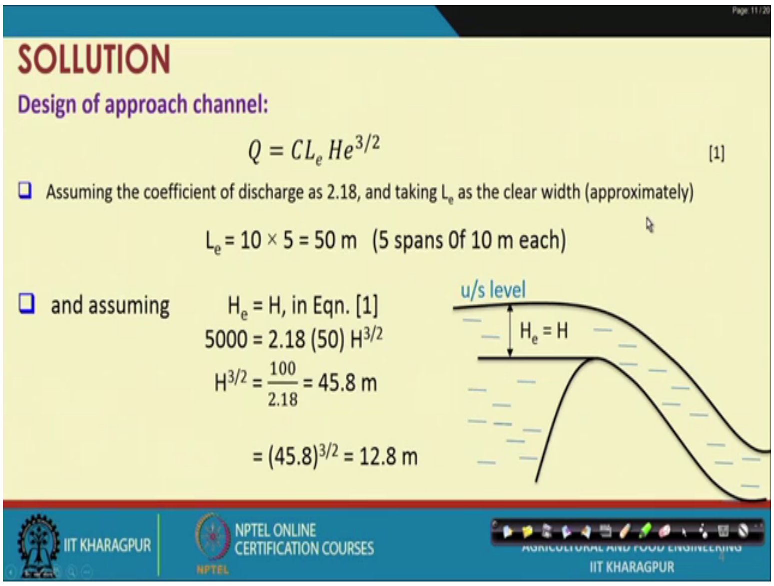

So, first we go for the discharge, and we go for the trial and error method here first. And see how the our assumption is correct or not. And if it does not follow the correct assumption, then we have to redesign our problem. So, first we calculate the design of the approach channel, so the first component of the chute spillway. So, we first calculate the Q using this equation, so H e is the height total height that combination of design height as well as the velocity of approach.

And assuming the coefficient of discharge as 2.18, and taking L e as the clear width which is again an approximate. So, L e as given in the data, we have a 10 meter span is the spillway span of 5 spans are located here. So, 10 meter of each width and the 5 spans, so this come out to be 10 multiplied by 5, so 50 meter that way going to plug here. And C is the coefficient of discharge. And in that way after plugging this one to equation 1, we have H as 12.58 meter. So, this is the H e is upstream level is designed here.

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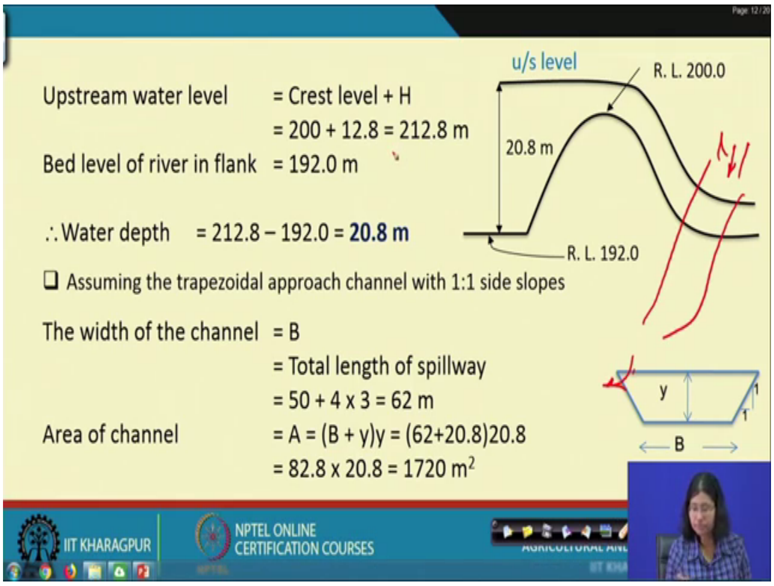

Now, the upstream water level this one is a combination of the crest level plus H. So, the crest level is given in the problem as 200 meter the spillway crest level, which is located here. So, 200 meter plus our calculated height, now it comes out to be 212.8. Now, bed level of river in a flank, it is given as 192 meter in the problem. The level of bottom flank at which low ogee weir is to be constructed is 192 meter. So, we plug it here, so total water depth what will be it is? This is the subtraction of the upstream water level minus the bed level in the river flank, so which comes out to be 20.8 meter.

Now, we assume that the channel is 1 is to 1 of the side slope. Now, the width of the channel B is total length of the spillway that is 50 meter. And since, we assumed it as a trapezoidal, so 50 plus 4 into 3, so 1 is to 1 slope, so it is the total width of the channel is if we assume it is as a plane, so it is trapezoidal channel.

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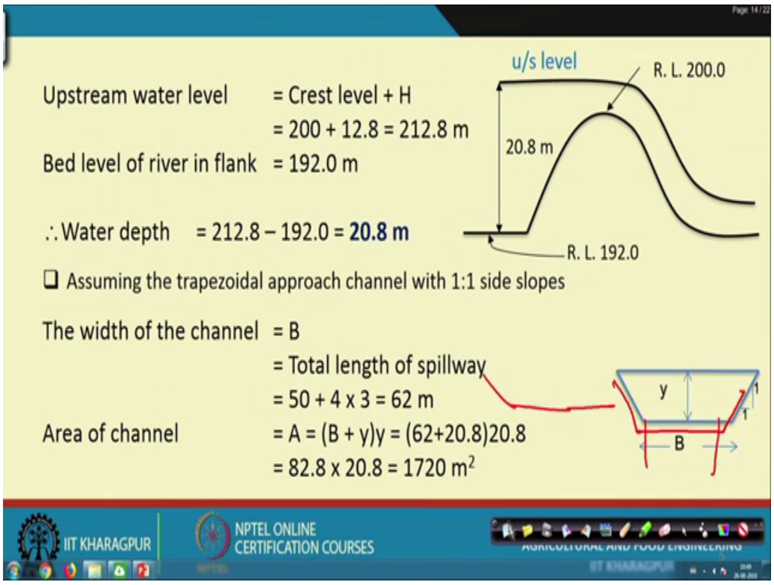

So, we have this, so this is the 50 meter and 1 is to 1 slope, so we calculate this as 50 plus 4 into 3 62 meter. Now, coming to the area of the channel, it is a B plus y into the depth or the y thickness here, so it comes out to be 1720 square meter is the area. So, this is the total dimension of the channel.

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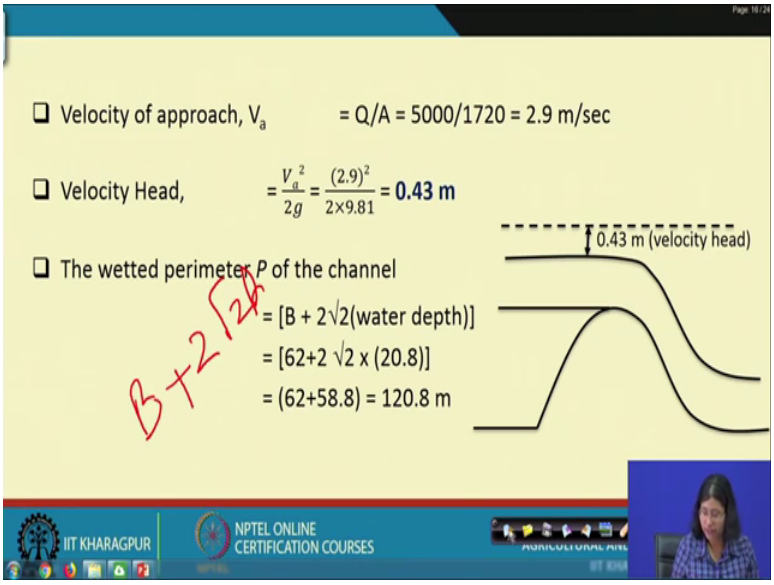

Now, coming to the velocity of approach, which is cube the discharge divided by the area total area of the channel. So, since the discharge is given in the problem is 5,000 cumecs and a calculated area is 1720 square meter, we divide this and we get the velocity of approach, which comes out to be 2.9 meter per second. Now, the velocity head is V square upon 2 g, which is again a calculation from the kinetic head, so this is now comes out to be 0.43 meter.

So, once we have this, we calculated the calculate the wetted perimeter of the channel. So, this is the velocity head here 0.43 meter and now, coming to the calculation of wetted perimeter. Since, we assume that channel as the trapezoidal, so it is the formula is B plus 2 root 2 d, where is d is the water depth. So, B is the thickness of the channel that we calculated in previous step in 2 root 2 and 2 d that we calculated early earlier. So, the depth of water is coming out to be here in calculation of the wetted perimeter. So, the wetted perimeter of the channel comes out to be 120.8 meter.

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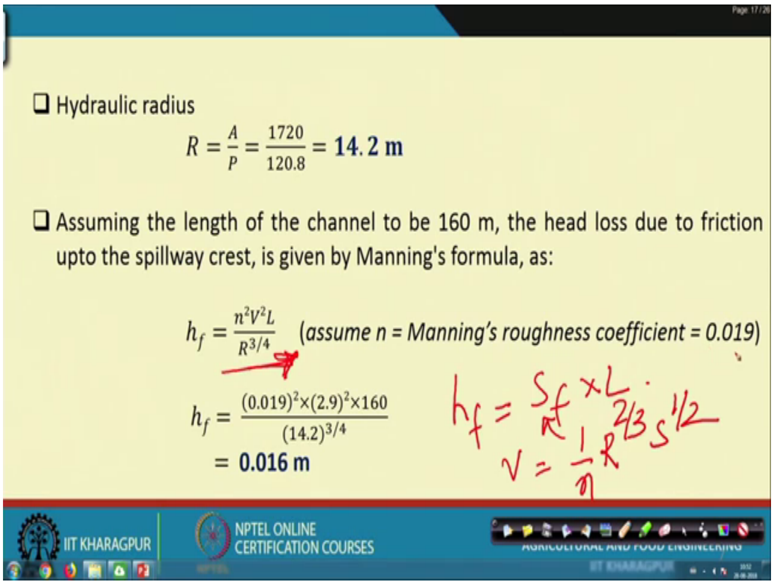

Now, we plug this into equation of hydraulic radius, so since it is trapezoidal channels. So, R equal to A upon P, so this comes out to be 14.2 meter. So, this is the hydraulic radius. And now, we calculate the frictional head. So, assuming the length of the channel as 160 meter, the head loss due to friction upto the spillway crest is given by the Manning's formula. So, the head loss is calculated using the Manning's formula that we also calculate studied in the spillway design.

So, here we use the equation. So, here the s comes from the Manning's formula. So, this one after plugging this, we comes this it the equation reduced to this form. And here we calculate the h f the head loss due to friction, where we assume the Manning's formula roughness coefficient as 0.019, which is an approximation or the value for a natural bed channel.

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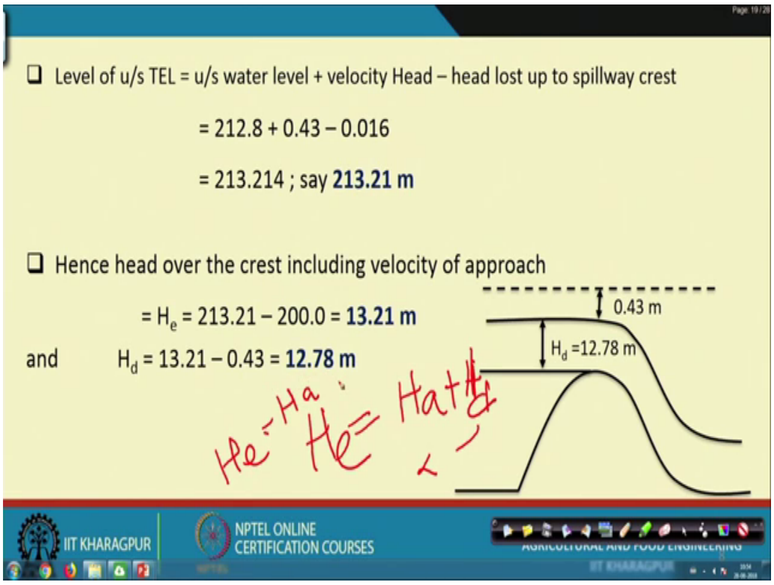

Now, the level of upstream water level. So, upstream water level plus the velocity head minus head loss up to the spillway crest. So, here the upstream water level was calculated as 212.8, and velocity head we calculate as 0.43, and head loss due to friction was 0.016 that we calculate here, and that comes out to be 213.2 meter.

Hence, the head over the crest including the velocity of approach is 213.2 minus 200 meter, which is given in the problem that is spillway crest level, if you remember. So, this comes out to be H e as 13.21 meter. And now, the H d is a combination of H a and H e sorry, so H e is a summation of H a plus H d. So, from that we can calculate the value of H d as H e minus H a, so that comes out to be 12.78 meter.

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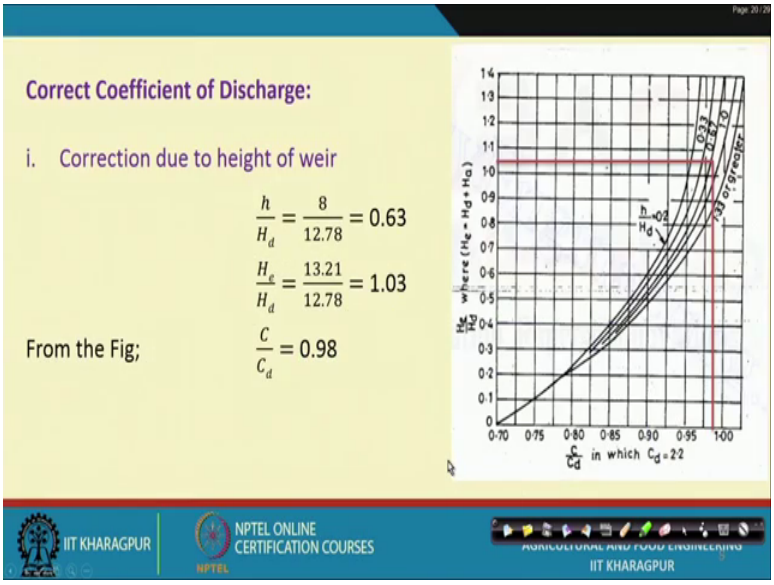

Now, we have to correct a coefficient of discharge. So, how we calculate coefficient of discharge? So, there will be correction in number of way, so correction due to the height of the weir. So, this kind of graph is always given with along with the designed problem. So, h upon H d is now we calculated h as 8 meter is given in the problem, and H d we calculated as 12.78, so it comes out to be 0.63. And H e upon H d is again we calculate as one 1.03. So, now, we have the ratio between H e by H d, which is 1.03 here. So, if we click our pen here and we take the value here upon the C by C d, we find that C by C d is comes out to be 0.98. So, here is the value.

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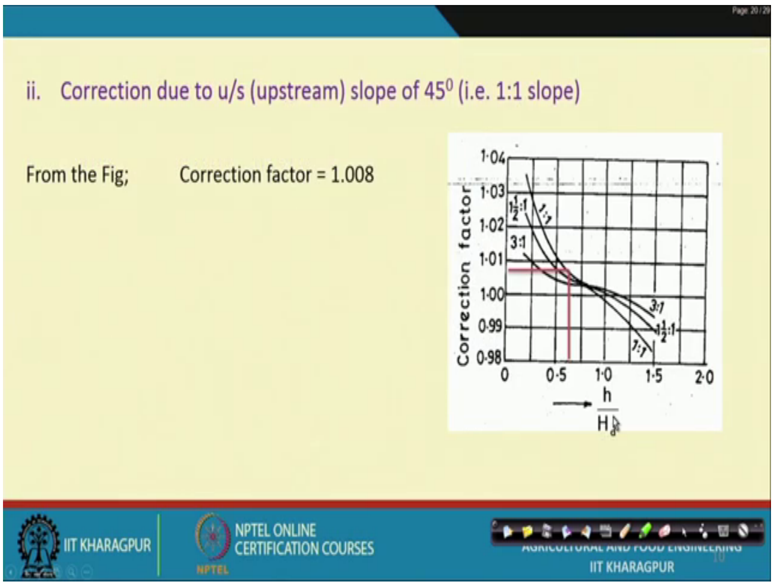

Now, we correct for h upon H d, this is given. And this is the corresponding slope at 1 is to 1 we assume that trapezoidal channel with 1 is to 1 slope, and the corresponding correction factor comes out to be 1.008.

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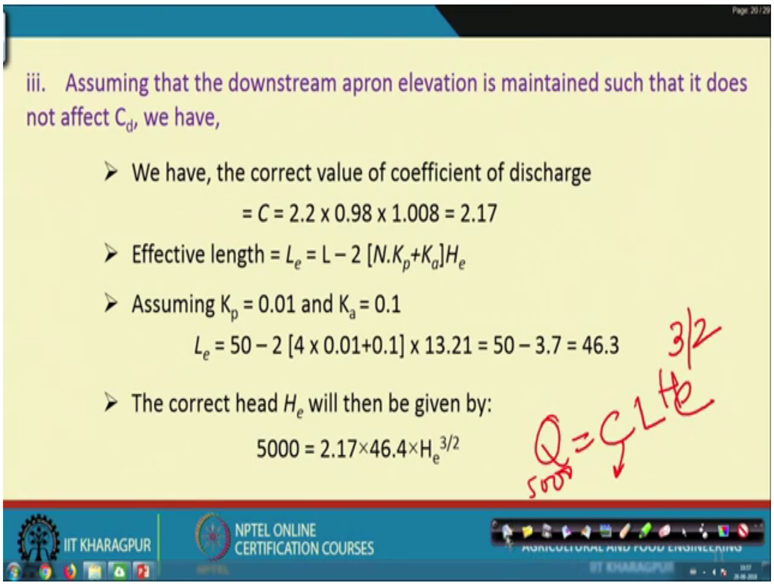

Now, the total correction factor is now combination of C is 2.2 multiplied by 0.98, and then 1.008, so the value of correction factor comes out to be 2.17. Now, coming to the effective length of the spillway crest. So, L we use this equation here. Now, we go for the calculation of L e. So, assume we assume that K p as 0.01, and K a as 0.1. So, now we calculate the L e as this is the 50 meter, and we plug this in the equation, and L e comes out to be 46.3 meter. Now, the correct head will H e is given by following equation. So, we plug everything back in the equation of discharge that is Q equal to. So, we plug everything here, so C is 2.17, L of the channel is 46, and the discharge is 5,000 and then we solve for H e.

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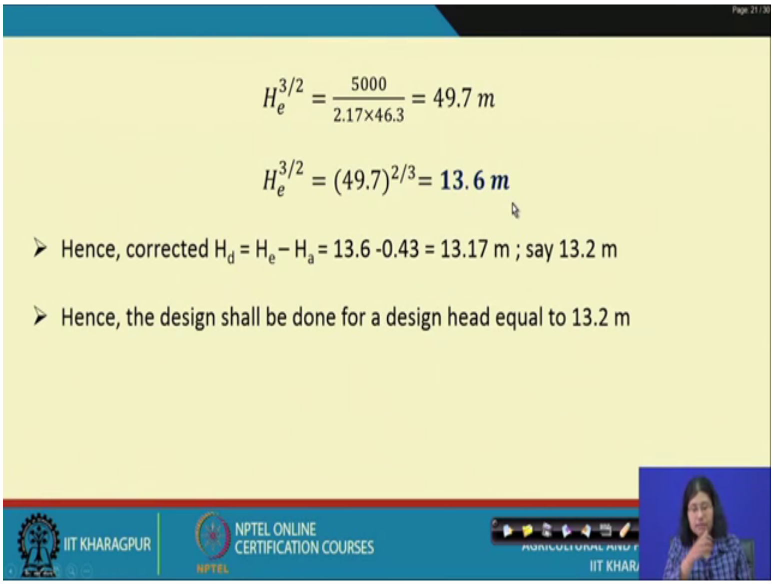

So, the H e is comes out to be 13.6 meter. Hence, corrected design height is a subtraction of H e minus H a, where H a is the velocity of approach, now it comes out to be 13.2 meter. Hence, the design shall be done for a design head equal to 13.2 meter.

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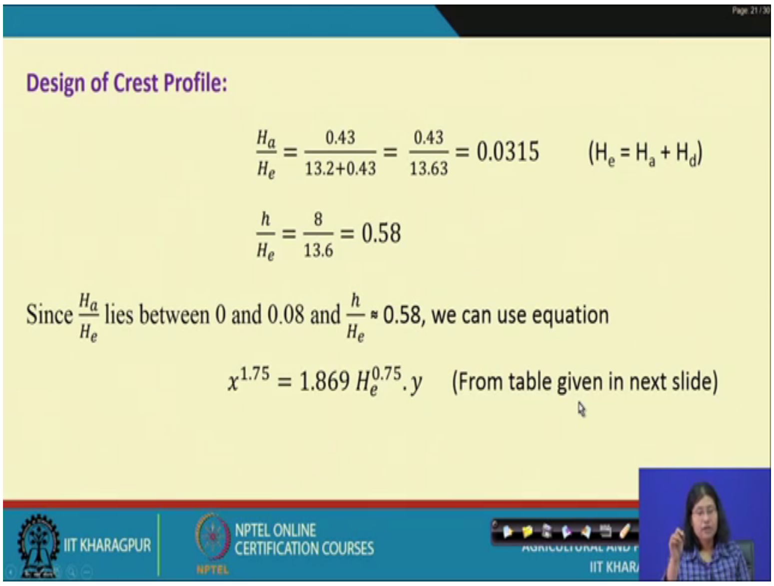

Now, design of the crest profile. So, design of the crest profile is the ratio between H a by H e. So, we have the H a as the velocity of approach, and H e is again a combination H a plus H d, which comes out to be 0.0315. And now we calculate h by H e, which comes out be 0.58. Since, H a by H e lies between 0 to 0.08, it is the value is 0.0135 which is between this. So, and h by H e is 0.58, we can directly equation use this equation. So, these equations are given in the next slide.

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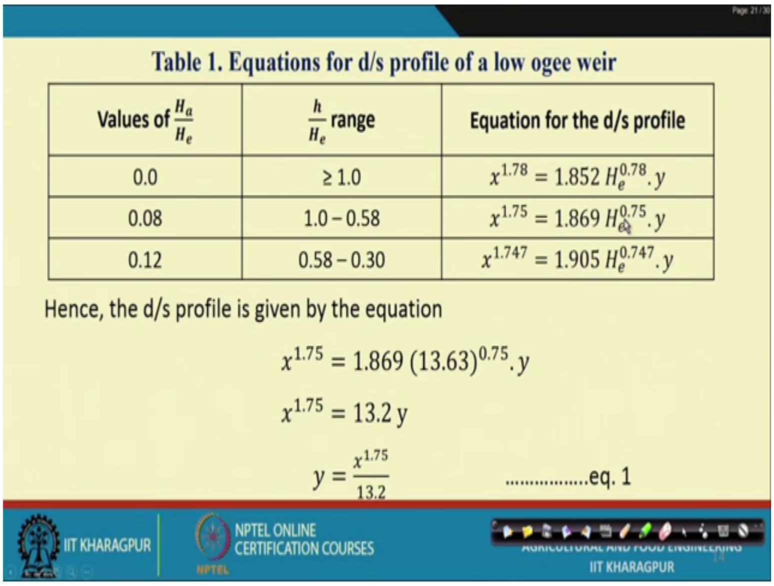

So, as we say from the previous slide that a downstream profile of the low ogee weir is given based on the h by h by H e value and if how much is the ratio of h by H e ranges, and depending upon H a by H e, we change the equation of the ogee downstream profile, so we use this kind of equation. So, we plug everything into this equation, and we get a value of y reduced to like this.

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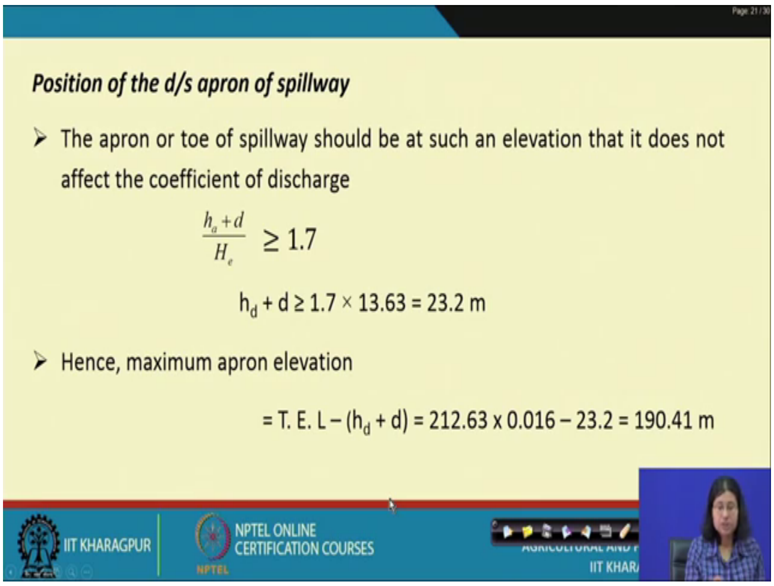

And a position of now we coming to the position of the downstream apron of the spillway so, the apron or the toe of the spillway should be at such an elevation that it does not affect the coefficient of discharge. So, this is the coefficient of discharge. Hence, the maximum apron elevation is that T E L, the TEL water level, and which is subtracted by design height and the depth, so which is comes out to be 190.41 meter.

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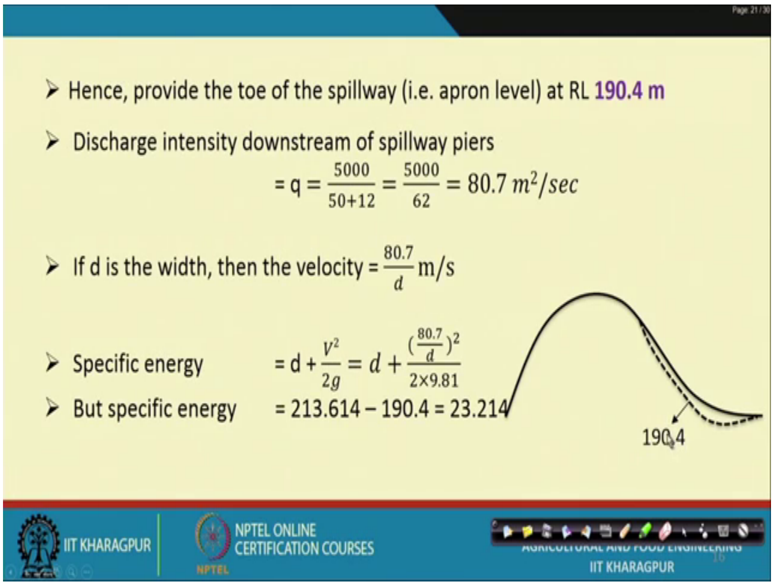

Hence, provide the toe of the spillway at a level of 190.4 meter. Now, we can calculate the discharge intensity downstream of the spillway piers, which is again a ratio of discharge divided by area. So, area we calculate early, so this is around 80.7 meter square per second. So, this is the specific discharge, so the unit is in meter square per second. Now, if d is the width, then the velocity head will be 80 the discharge divided by the depth in meter per second.

Now, we calculate the specific energy. Now, we going for the stilling basin design, so we need the specific energy, which is the depth plus the kinetic head. So, d divided V square by 2 g, where we calculate from here V, and the 2 g g is the acceleration due to gravity. But, the specific energy of the spillway is 213 meter minus 194.4, so it comes out to be 23.214. So, we plug everything in the equation of the specific energy, we have given the specific energy as 23.21 and specific energy using the equation here, so we can calculate d here.

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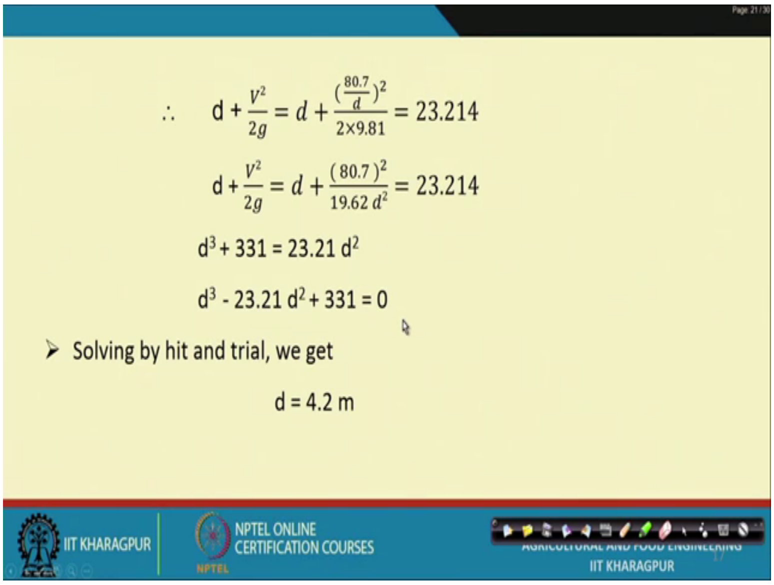

So, it is a quadratic equation, and by we can calculate by trial and error method, the quadratic equation or we can use a numerical method or computer programming to solve this kind of equation, and we comes the d value as 4.2 meter.

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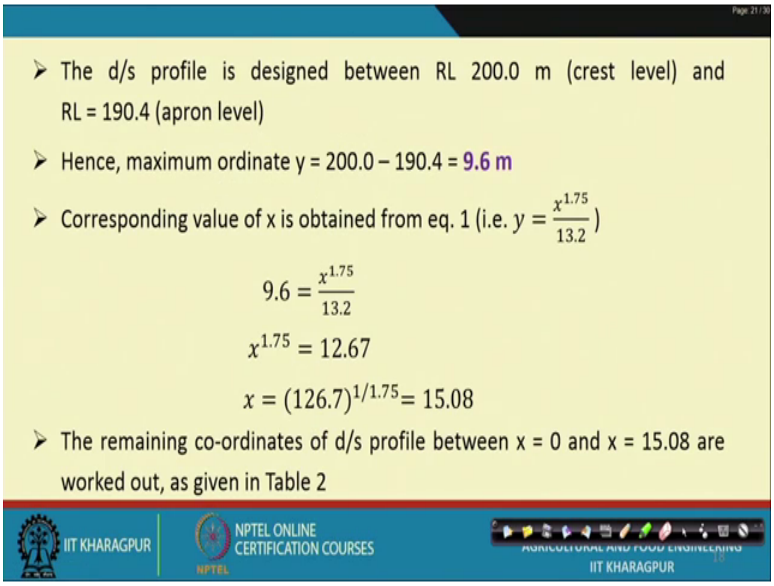

Now, the downstream profile is designed between the relative level 200 meter and the relative apron level 190.4 meter. Hence, the maximum ordinate y is given is the subtraction between 200 and this 190.4, which comes out to be 9.6 meter. Now, since we are calculating the profile, we plug everything into this equation, which we calculated earlier, so x comes out to be 15.08. Now, the remaining co-ordinates of the downstream profile will vary between x and 15.08, which can be worked out in table 2.

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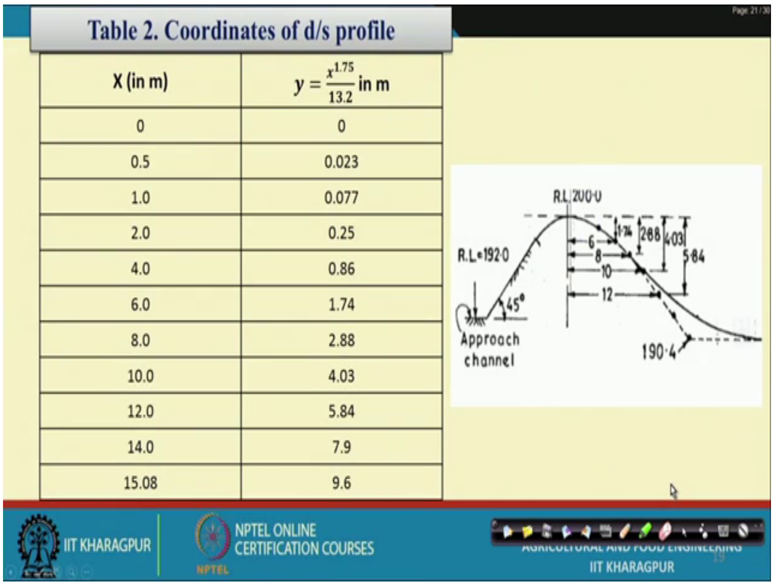

Table 2. Coordinates of d/s profile

X (in m)	$y = \frac{x^{1.75}}{13.2}$ in m
0	0
0.5	0.023
1.0	0.077
2.0	0.25
4.0	0.86
6.0	1.74
8.0	2.88
10.0	4.03
12.0	5.84
14.0	7.9
15.08	9.6

So, this is the coordinates of the downstream profile. Here as you can see this is the x level, this is the x the horizontal and the vertical axis, it is like a projectile. So, once you plug this values here, you get the x value corresponding y value the related to x value, you will get this one this curve. So, this is the downstream profile of the coordinates.

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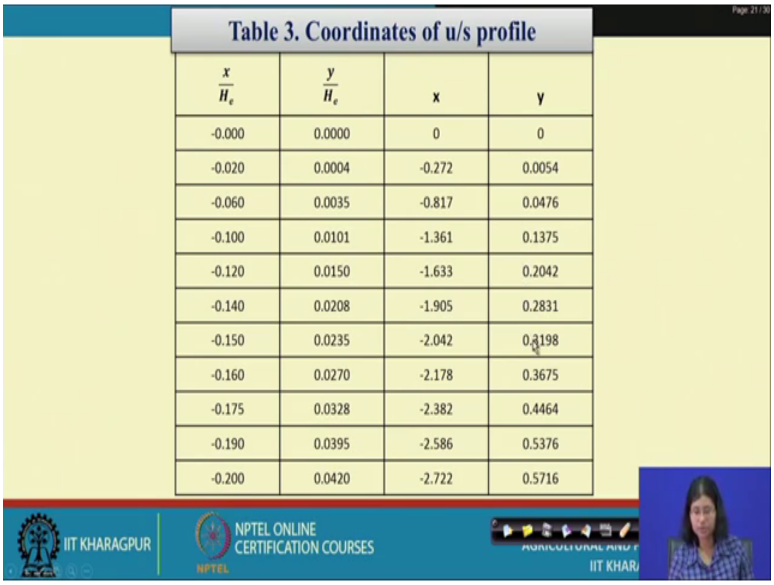

Table 3. Coordinates of u/s profile

$\frac{x}{H_e}$	$\frac{y}{H_e}$	x	y
-0.000	0.0000	0	0
-0.020	0.0004	-0.272	0.0054
-0.060	0.0035	-0.817	0.0476
-0.100	0.0101	-1.361	0.1375
-0.120	0.0150	-1.633	0.2042
-0.140	0.0208	-1.905	0.2831
-0.150	0.0235	-2.042	0.3198
-0.160	0.0270	-2.178	0.3675
-0.175	0.0328	-2.382	0.4464
-0.190	0.0395	-2.586	0.5376
-0.200	0.0420	-2.722	0.5716

Now, the coordinates of the upstream profile it is vary according to this. So, this is listed here. So, this way, we can design the complete design a spillway.

So, thank you.