Soil and Water Conservation Engineering
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Lecture – 49
Chute Spillway Design – II

Hello, good morning. So, we in earlier chapter we studied design spillway or designing of the spillway the part I, now we are going to continue the Design of the Spillway the part II.

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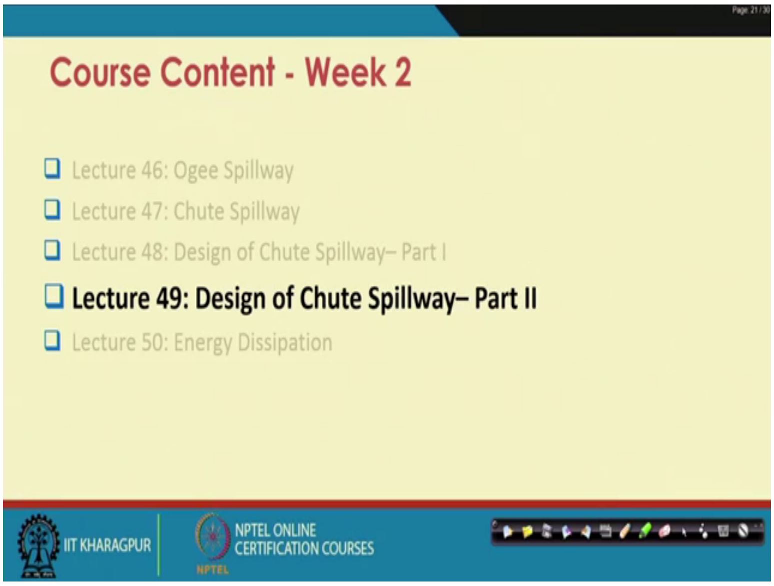

So, here we cover some of the basic concept and also the design problems that we completed partly at a design problem I.

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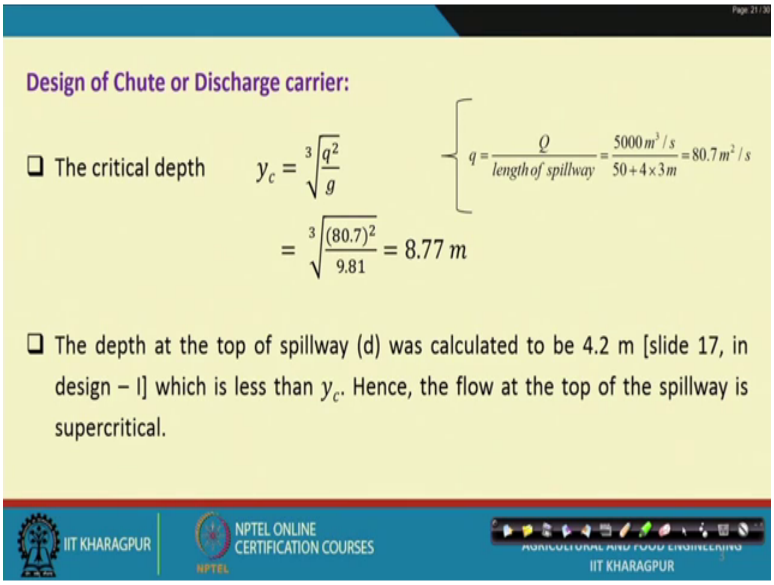

So, here we designed the component 3 that is chute or the discharge carrier; that is one of the component of the chute spillway. So, here we have to calculate the critical depth; so, critical depth is calculated using the discharge of the spillway and the length of the spillway using this equation.

So, y c or the critical depth as you know from the principle of fluid mechanics it is a quadratic square root and cube square upon g and this comes out to be 8.77 metre. Now the depth at the top of the spillway was calculated to be 4. 2 metre that is based on the slide 17 in design problem I. So, this 4.2 metre is less than the critical depth; hence the flow at the top of the spillway is supercritical.

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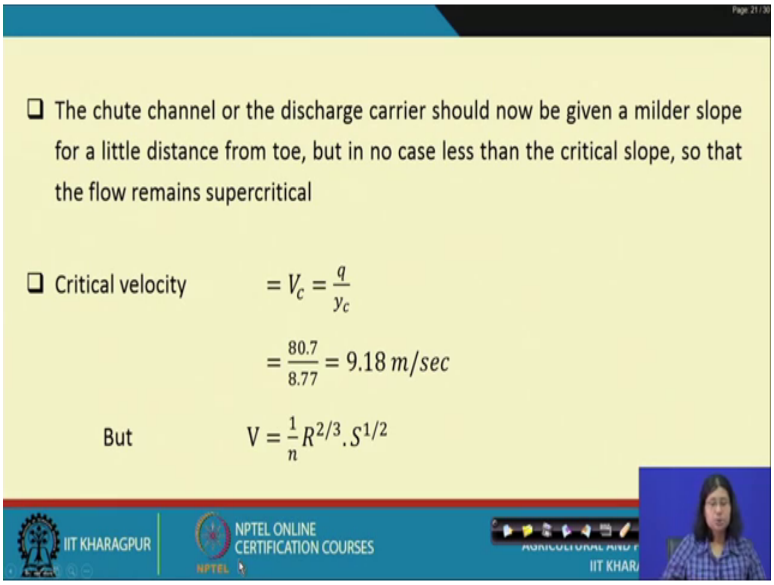

The chute channel or the discharge carrier should, now be given a milder slope for a little distance from the toe, but in no case this should be less than the critical slope. So, the flow remains to be a supercritical then the critical velocity V c is q the critical discharge divided by y c, which is the critical depth.

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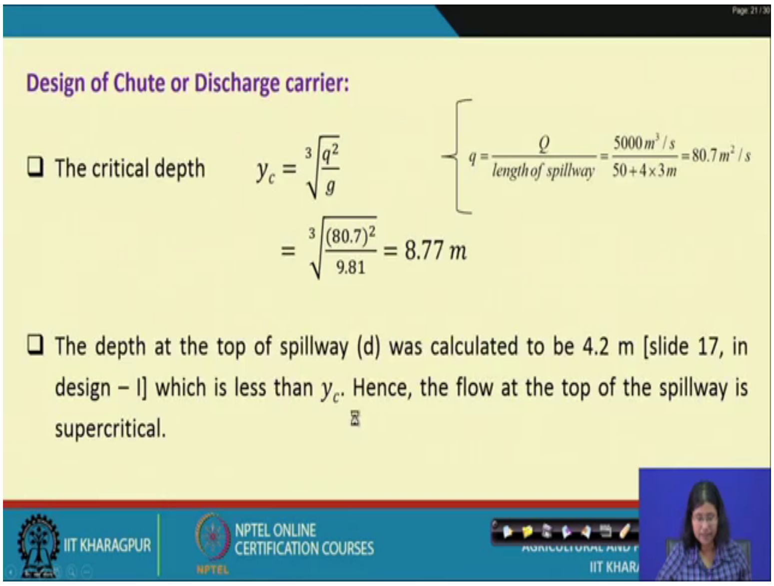

So, this is the critical discharge is 80.7 that we calculated in earlier step. And y c this one is around 9.18 metre per second, but what we know from the manning this one, from the floor in a channel. So, this relation V equal to 1 upon n R to the power 2 by 3; S to the power 1 by 2; so, we plug everything here.

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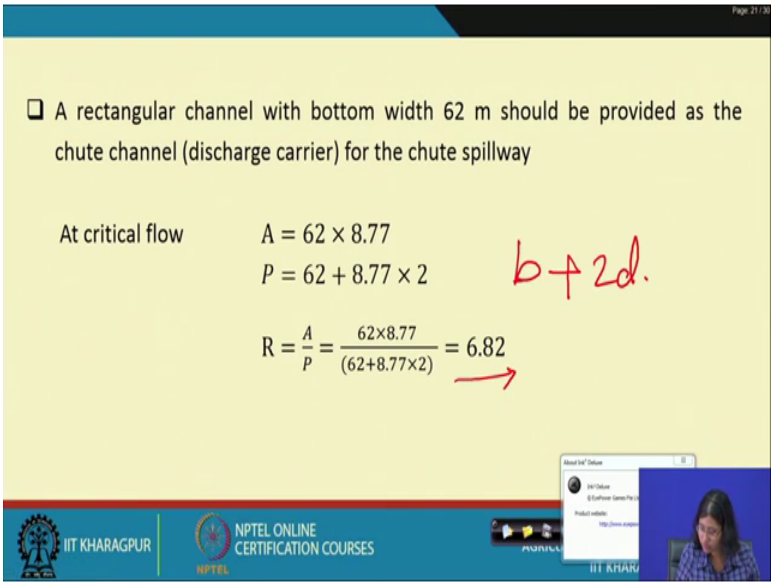

So, a rectangular channel with bottom width of 62 metre should be provided a chute channel for the chute spillway. So, at a critical flow; so, this is the area of the channel, so, b into d.

So, we calculated from earlier step this b that assuming the channel is a trapezoidal and a critical depth is 8.77 and weighted perimeter we calculate again the weighted perimeter which is again b plus 2 d we calculate here. So, the hydraulic radius is A by P; so, we everything going to plug into the equation.

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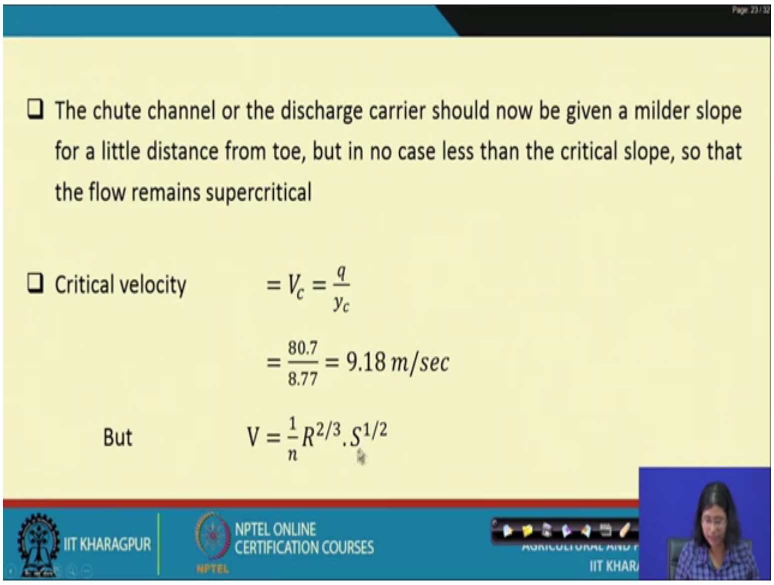

So, we everything plug going to plug here into the equation. So, we calculated the weighted perimeter and the area of the channel cross section.

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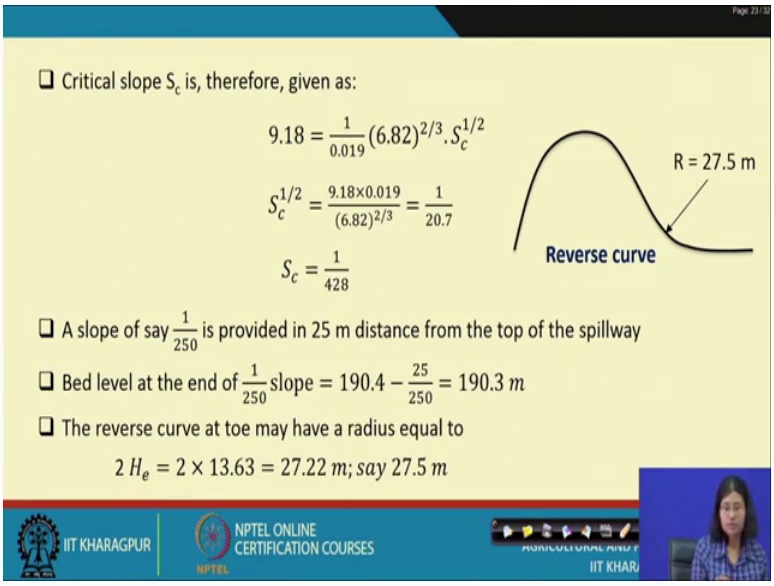

So, now the critical slope we like this we calculate the critical slope here. So, which is 1 upon 428 it is a reverse curve a slope of say 1 upon 250 used to be provided at a 25 metre distance from the top of the spillway. Since the critical slope is come out to be 1 upon 428, so we gave a distance of 25 metre at the top of the spillway and then we provide slope of 1 upon 250. So, bed level at the end of this slope is 190.4 from earlier calculation in design 1 divided minus 25 by 250, a 190.3 metre. A reverse curve at the toe may have a radius equal to twice H e, which is twice and H e was calculated from previous step; so, it is around 27.5 metre.

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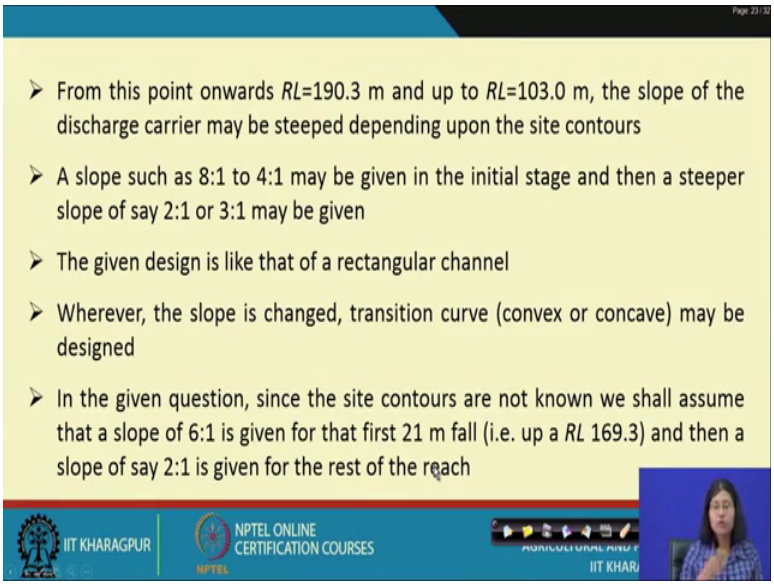

Now we have to construct a table for the design problem. So, from this point onwards relative level of 190.3 metre and up to relative level of 103 metre; the slope of a discharge carrier may be steeped depending upon the site contour.

A slope such as 8 is to 1 to 4 is to 1 may be given in the initial stage and then a steeper slope say 2 is to 1 and 3 is to 1 is to be given. So, the given design is like a rectangular channel whatever whenever the slope is changed, the transition curve as we learned earlier the convex or concave in shape maybe designed. In the given question since the site contours are not known before hand, so we shall assume that a slope of 6 is to 1 is given for first 21 metre fall, like up to a relative level of 169.3 metre and then a slope of say 2 is to 1 is given for the rest of the reach.

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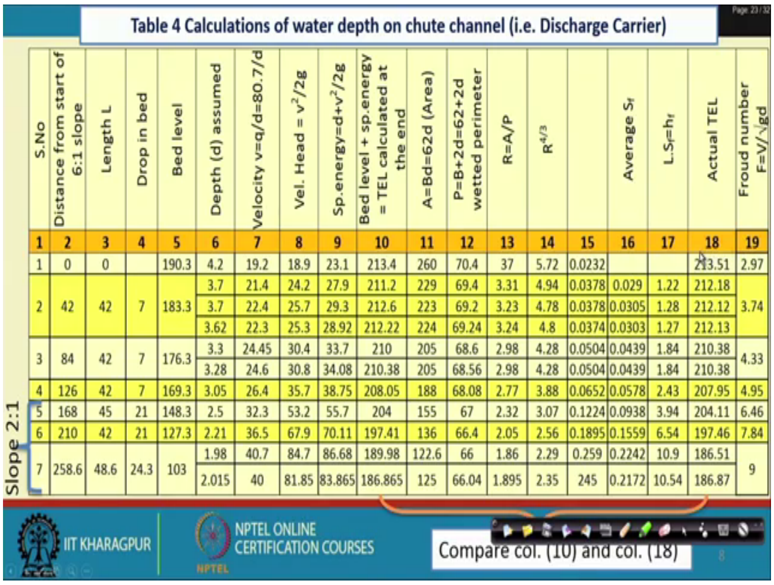

Table 4 Calculations of water depth on chute channel (i.e. Discharge Carrier)

S.No	Distance from start of 6:1 slope	Length L	Drop in bed	Bed level	Depth (d) assumed	Velocity v=q/d=80.7/d	Vel. Head = $v^2/2g$	Sp.energy=d+$v^2/2g$	Bed level + sp.energy = TEL calculated at the end	A=Bd=62d (Area)	P=B+2d=62+2d wetted perimeter	R=A/P	$R^{4/3}$		Average S_f	$L.S_f=h_f$	Actual TEL	Froud number $F=V/\sqrt{gd}$
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	0	0		190.3	4.2	19.2	18.9	23.1	213.4	260	70.4	37	5.72	0.0232			213.51	2.97
2	42	42	7	183.3	3.7	21.4	24.2	27.9	211.2	229	69.4	3.31	4.94	0.0378	0.029	1.22	212.18	3.74
					3.7	22.4	25.7	29.3	212.6	223	69.2	3.23	4.78	0.0378	0.0305	1.28	212.12	
					3.62	22.3	25.3	28.92	212.22	224	69.24	3.24	4.8	0.0374	0.0303	1.27	212.13	
3	84	42	7	176.3	3.3	24.45	30.4	33.7	210	205	68.6	2.98	4.28	0.0504	0.0439	1.84	210.38	4.33
					3.28	24.6	30.8	34.08	210.38	205	68.56	2.98	4.28	0.0504	0.0439	1.84	210.38	
4	126	42	7	169.3	3.05	26.4	35.7	38.75	208.05	188	68.08	2.77	3.88	0.0652	0.0578	2.43	207.95	4.95
5	168	45	21	148.3	2.5	32.3	53.2	55.7	204	155	67	2.32	3.07	0.1224	0.0938	3.94	204.11	6.46
6	210	42	21	127.3	2.21	36.5	67.9	70.11	197.41	136	66.4	2.05	2.56	0.1895	0.1559	6.54	197.46	7.84
7	258.6	48.6	24.3	103	1.98	40.7	84.7	86.68	189.98	122.6	66	1.86	2.29	0.259	0.2242	10.9	186.51	9
					2.015	40	81.85	83.865	186.865	125	66.04	1.895	2.35	245	0.2172	10.54	186.87	

So, like this we have to have to construct a table where calculation of water depth of the chute channel or the discharge career is to be solved.

So, this is in a slope of 2 is to 1 and then this is we again we calculate using the our assumed value and here we the column 18 the actual TEL level. So, we compare the value at column 10 versus column 18, so in the next slide we explain this.

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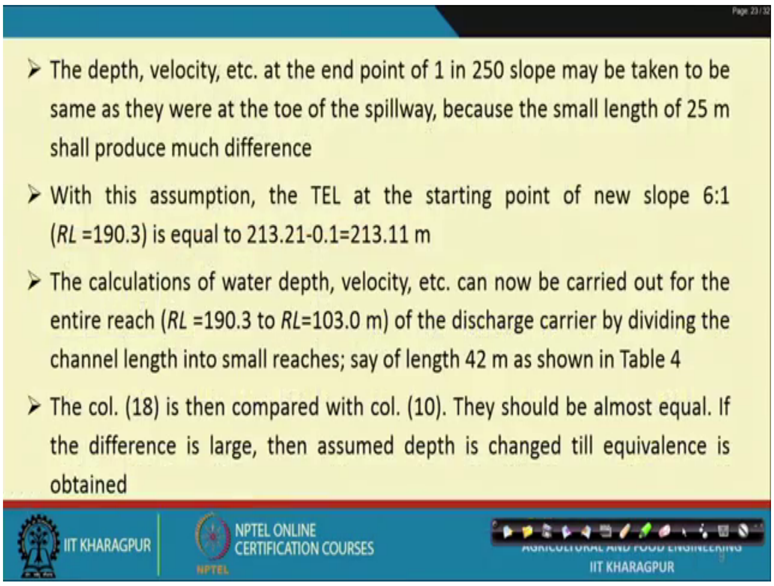

So, at the depth velocity etc at the end point of 1 in 250 slope maybe taken to be same as they were at the toe of the spillway because the small length of 25 metre shall produce a much difference. So, with this assumption that TEL at the starting point of new slope 6 is to 1 is equal to 213.21 minus 0.1 metre that is 213.11.

Now the calculation of water depth velocity etc now can be carried out for entire reach. So, the relative level of 190.3 to relative level of 103 metre of the discharge carrier and now we divide the entire channel length into small small reaches. So, we divided the entire channel length here in a small small reaches say at an interval of 42 metre and we calculate each of these quantity the velocity; velocity heads specific energy and we compare this with the column 8, the actual TEL water level.

Now the column 18 as I explained earlier is then compared with column 10 and they should approximately equal. If the difference is larger than the assumed is depth is changed till a equivalence is obtained. So, it is a trial and error procedure and once this one say the actual level is similar to the calculated levels; so, our design is almost accurate. So, here you can see at the last end of the channel means we divided at a small small interval of 42 metre. So, at the end; so the column a 10 is approximately equal to column 18; so, now these assumptions our assumptions are correct.

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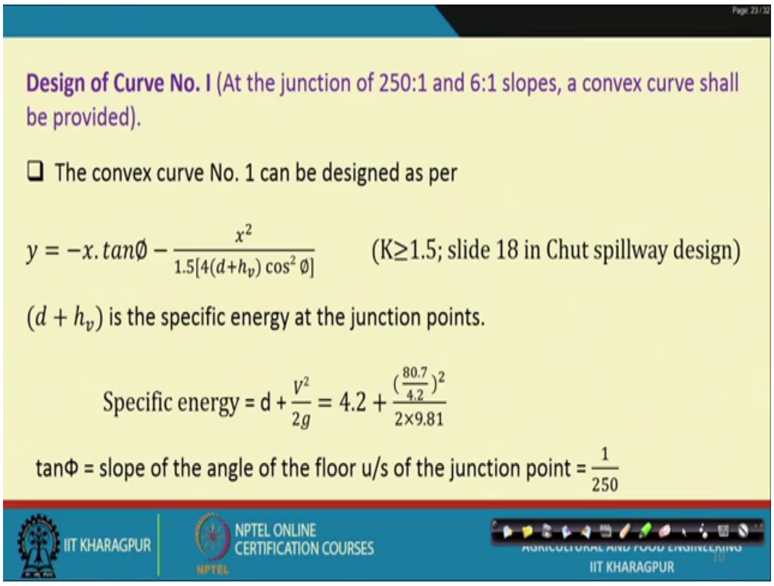

Now, the design of curve number 1 at the junction of 250.1 and 6 is to 1 slope since the slope is now from my steeper to milder, a convex curve shall be provided. So, the convex curve is designed as per the equation. So, this was the equation given earlier and K is assumed as 1.85; so, which is also given in slide 18 in chute spillway design part 1.

And d plus h v is the specific energy at a junction point, hence the specific energy as you know it is given by the d plus v square the kinetic head. So, we plug it here and tan phi is the angle the slope of the angle of the floor upstream of the junction point which is the slope 1 is to 250.

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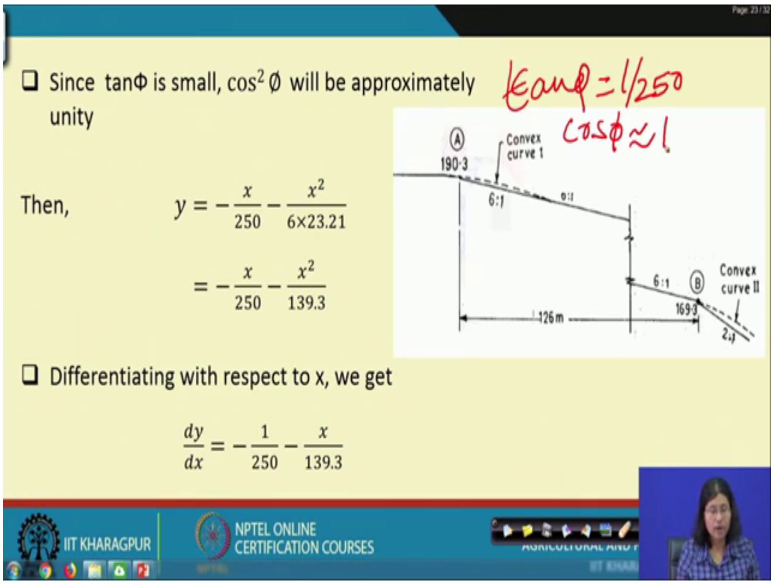

Now since the tan phi is very small now cos square phi is also approximately unity since tan phi is here is 1 upon 250, cos phi is also we can approximate it as 1 and here you get a convex curve and then the slope profile is.

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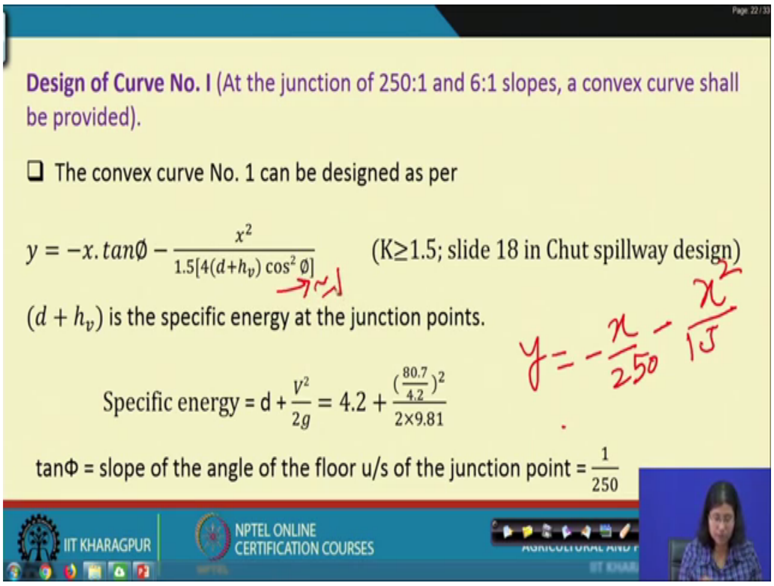

So, we plug everything here; so, we get here x tan phi is 1 upon 250 in this case x square 1.5 and we assume this one also as unity.

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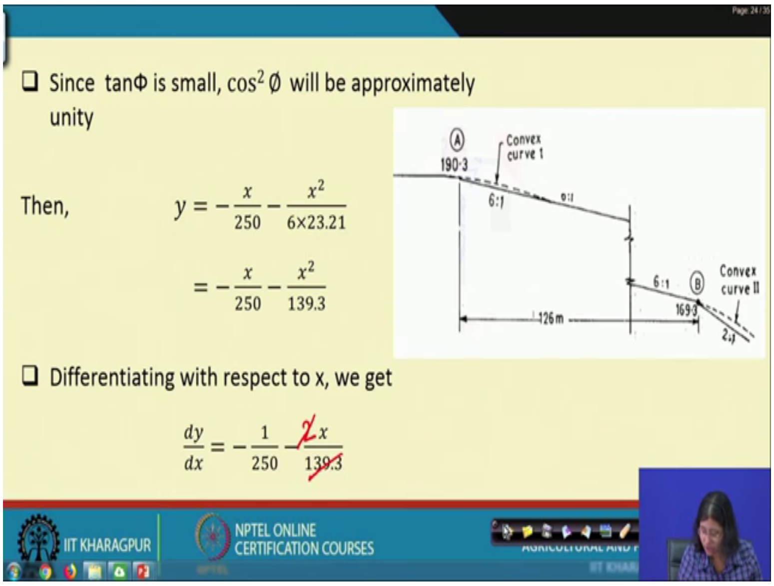

So down to this form of the equation it is a quadratic equation; now since we are dividing the channel reach into small small section, so, we differentiate y with respect to x.

So, we get a d y by d x since it is we differentiate its 2 x and then we get into this form of equation.

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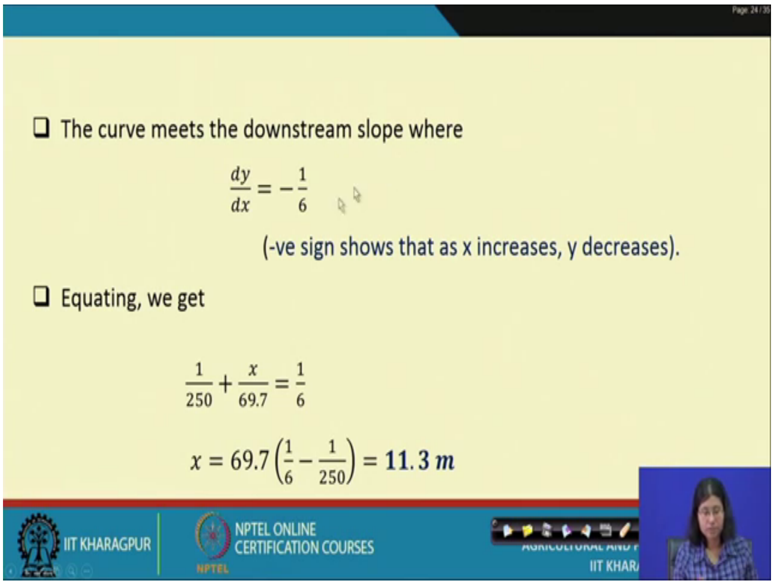

The curve meets the downstream slope where d y by d x is minus 1.6; the negative sign shows that as x increases the y also decreases. So, we plug it here sorry this; this thing will be 2 x it is a small correction. So, it will be 69, 68 point something there is a small correction here please note. So, we plug it everything here and we get the value of x as 11.3 metre.

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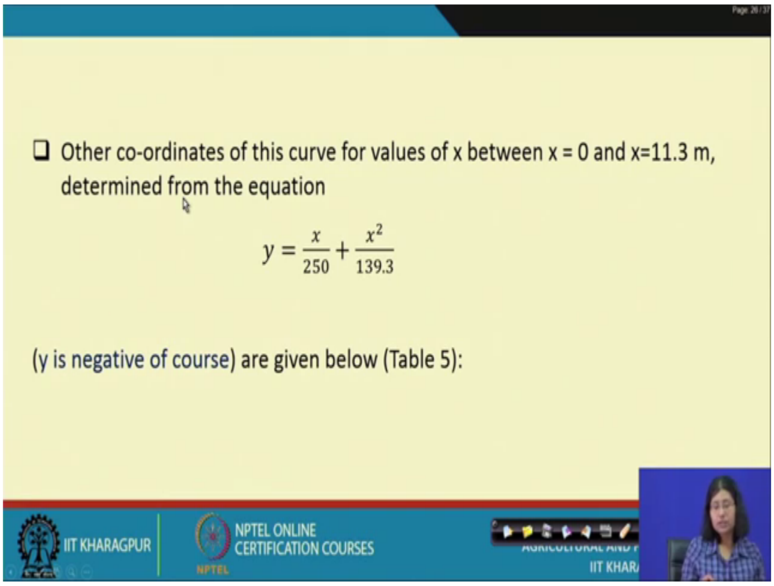

So, other coordinates of this curve for values of x is between 0 to 11.3 metre is determined based on this equation; so, y is negative of course as given below in the table 5.

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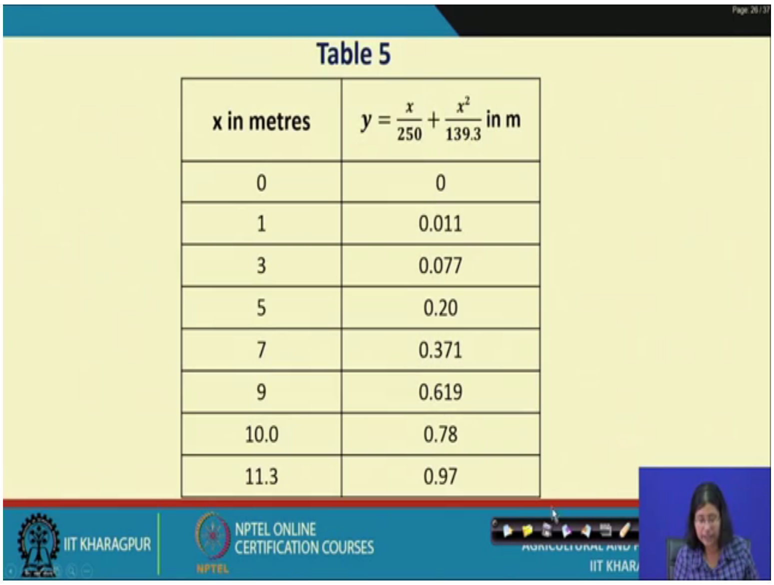

x in metres	$y = \frac{x}{250} + \frac{x^2}{139.3}$ in m
0	0
1	0.011
3	0.077
5	0.20
7	0.371
9	0.619
10.0	0.78
11.3	0.97

So, it comes out like this.

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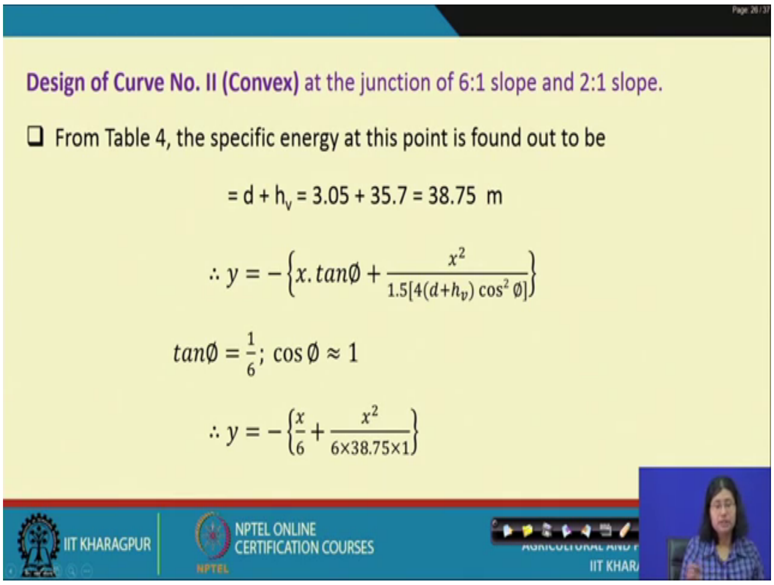

Now the design curve number 2 at the junction of 6 is 1 slope and 2 is to 1 slope. From table 4 the specific energy at this point is find out to be d plus h v that is 38.75 metre. Now since tan phi is 1 by 6 the cos phi is approximately 1; so, y equal to minus x by 6 with plug everything here.

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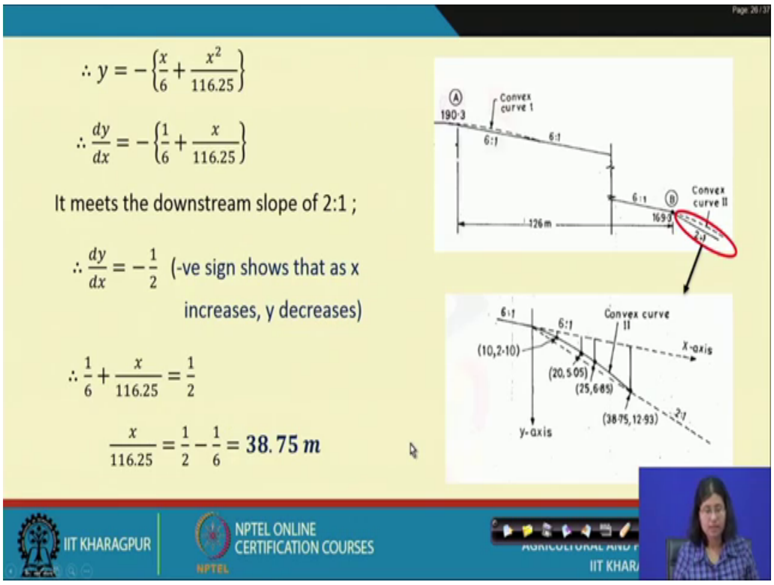

And we the equation and then after getting y value we differentiate with respect to x here. So, it meets the downstream slow at slope of 2 is to 1 and since d y by d x is minus 1 by 2 we solve it like this.

So, it comes out to be 38.75 metre; so, this portion here.

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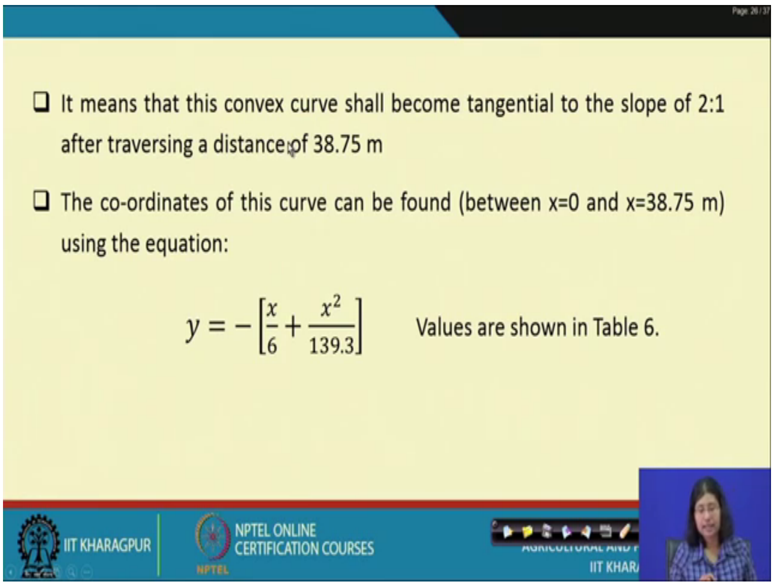

It means that the convex curve shall become a tangential to the slope of 2 is to 1, after traversing a distance of 38.75 metre. The coordinates of this curve can be found out from x equal to 0 to x equal to 38.75 metre using this equation and the values are shown in table 6.

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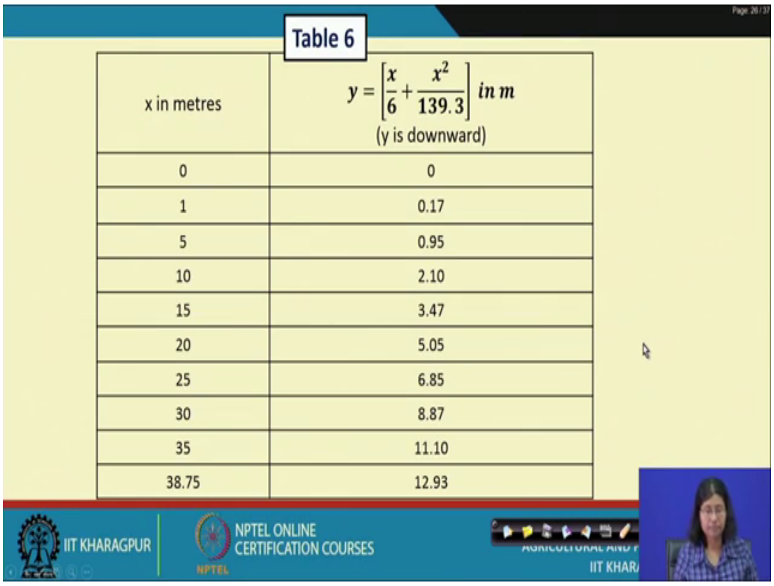

Table 6

x in metres	$y = \left[\frac{x}{6} + \frac{x^2}{139.3}\right]$ *in m* (y is downward)
0	0
1	0.17
5	0.95
10	2.10
15	3.47
20	5.05
25	6.85
30	8.87
35	11.10
38.75	12.93

So, this is the value as shown in the table 6 at x equal to 0 metre; what is the corresponding value of y; so, y will be in downward shape.

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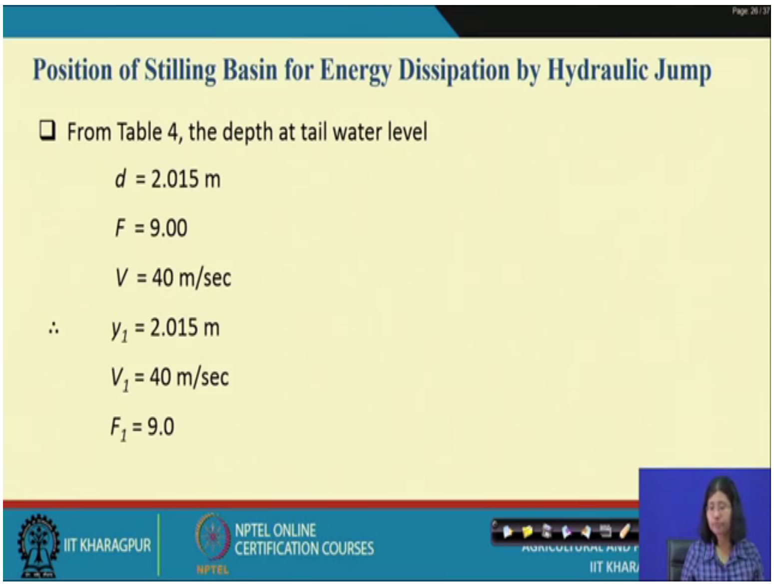

Now the position of the stilling basin for energy dissipation by hydraulic jump from table 4 the depth of the TEL water level. So, d equal to 2.015, F is Froude number and F 1 is 9 metre.

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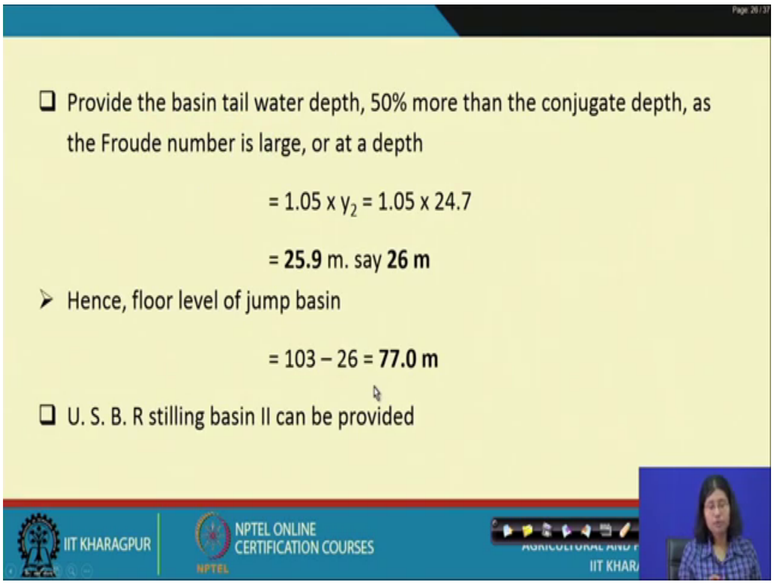

So, provide the basin tail water depth 50 percent more than the conjugate depth; conjugate depth as we remember y 2 and y 1 both as the Froude number is large at a depth 1.05 into y 2.

So, we assume that we designed that tail water depth as 50 percent more than the conjugate depth or the y 2. So, 1.05 y 2; so, y 2 is 24.7 and if I increase it 50 percent more; it will be around 1.05 oh this; so it will be around 26 metre.

Hence floor level of the jump basin is 103 minus 26, that is 77 metre and USBR stilling basin is to be provided here.

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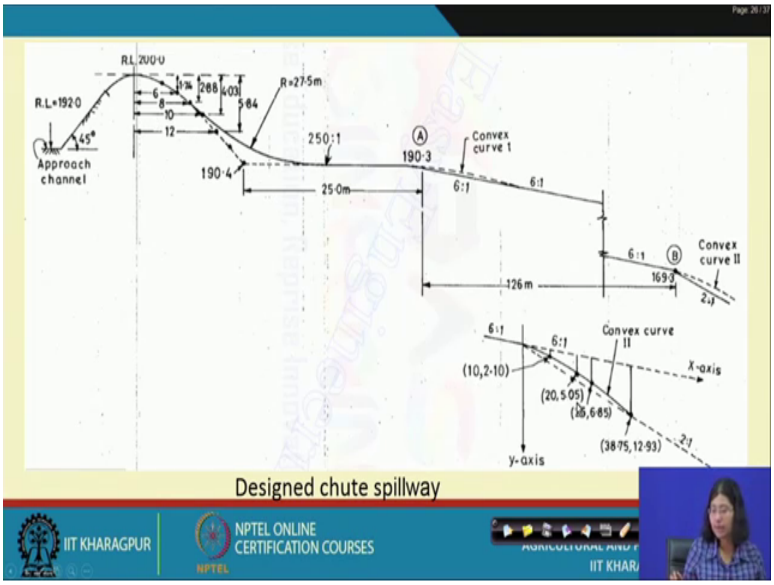

So, this is the complete design. So, first we designed profile this one and then the control structure or the ogee where. And then we sorry then we proved the convex curve here that is slope of 6 is to 1 and first convex curve and then we provide a second convex curve that is 6 is to 1. And this is the curvature and the slope of this convex curve is shown here. So, this completes your design chute spillway.

Thank you.