**Soil and Water Conservation Engineering**
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**Lecture - 47**
**Chute Spillway**

Hello, good morning. So, we in the previous lecture we studied about Ogee Spillway. Now, we are going to work on the Chute Spillway.

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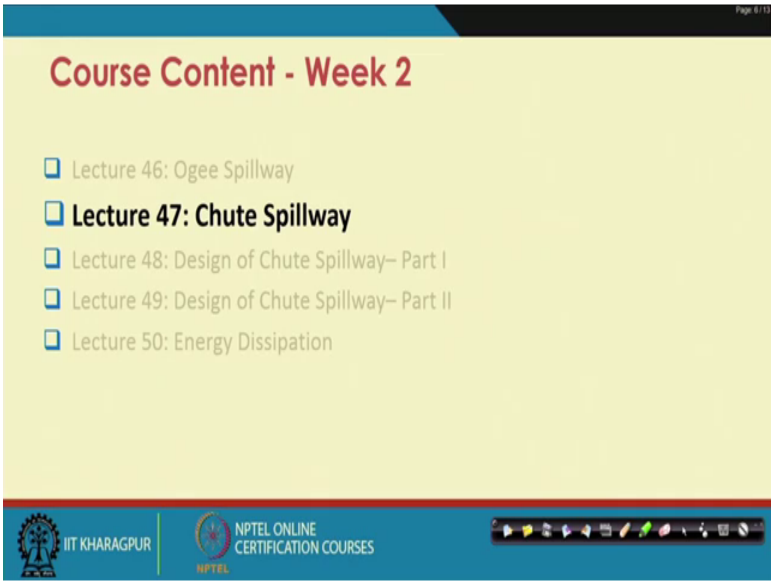


And a chute spillway has the some design is in the lengthy design. So, we are going to split a lecture into two part that is chute spillway part 1 and the part 2; and at the end we are going to cover the energy dissipation of the spillway.

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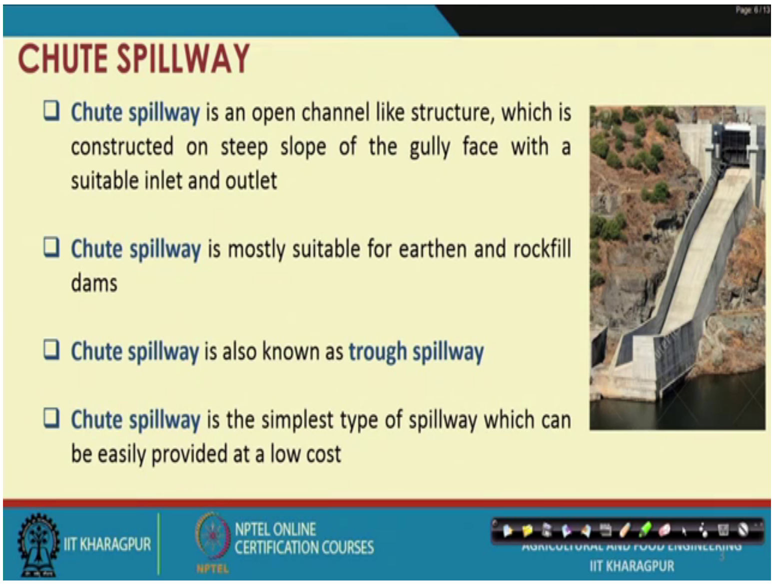


So, the chute spillway is an open channel like structure, which is constructed on a steep slope of a gully face with a suitable inlet. So, here is the inlet point and outlet. So, chute spillway is mostly suited for earthen and the rockfill dam. And it is also known as an alternate name trough spillway. And chute spillway is a simplest type of spillway which can be easily provided at a rural area at a low cost.

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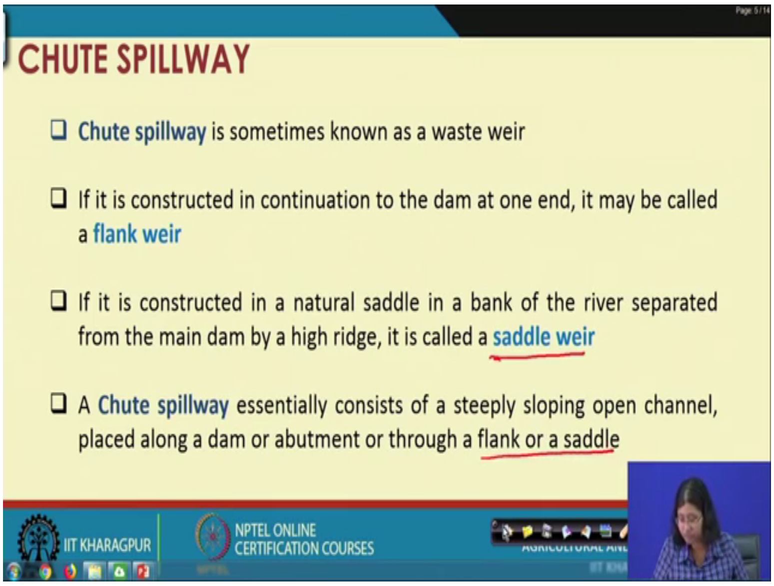


So, chute spillway is also known as the waste weir. And it is constructed in continuation to the dam at one way, and it may be called as a flank weir. So, if there is damn here, so it can be constructed at a end of the damn, so here it is called as the flank weir. And it is also constructed in a natural saddle at the bank of a river separated from the main dam by a high ridge; in this case it is known as saddle weir. So, this is the saddle weir here. And chute spillway is essentially consists of a steeply sloping open channel, placed along the dam or abutment through a flank or a saddle.

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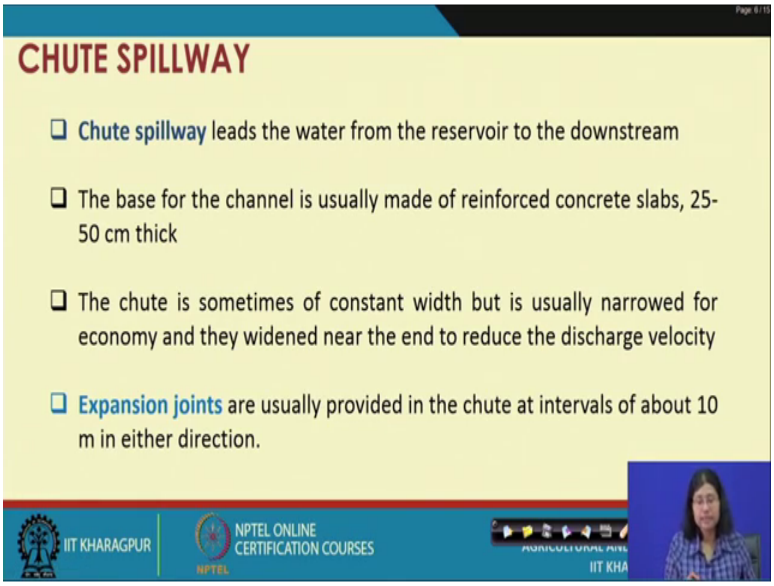


So, the chute spillway generally leads water from the reservoir to downstream. The base for the channel is usually made of reinforced concrete slab around 25 to 50 centimetre thick. The chute is sometimes of constant weight but is usually narrowed for economy for there to trade off between economy and the best design construction and they have a widened near the end to reduce the discharge velocity. Now, in for designing a chute spillway, we also need an expansion joint which is usually provided in the chute at an interval of about 10 meter in either direction.

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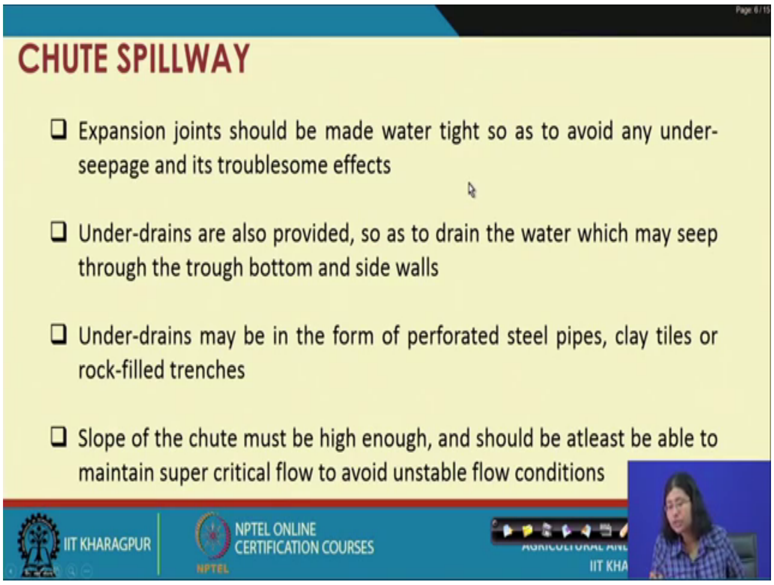


So, the expansion joints should be made of water tight so as to avoid any under-seepage page or any troublesome effects. So, under-drains are also provided; so, as to drain the water which may seep through the trough bottom and a side walls. The under-drain maybe in the form of perforated steel pipe or clay tiles or rock filled trenches. And the shape of the chute must be high enough, and should be at least be able to maintain a supercritical flow to avoid any unstable flow condition.

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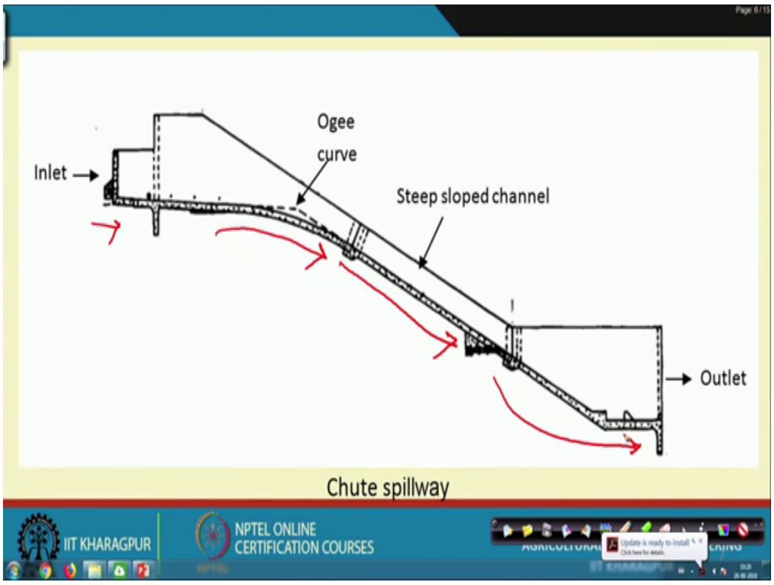

So, here sample chute spillway is shown. So, this is the inlet of this spillway. And here a ogee curve is placed here. And this is the steep slope channel, and this is again flow to outlet. So, this is a way a chute spillway looks.

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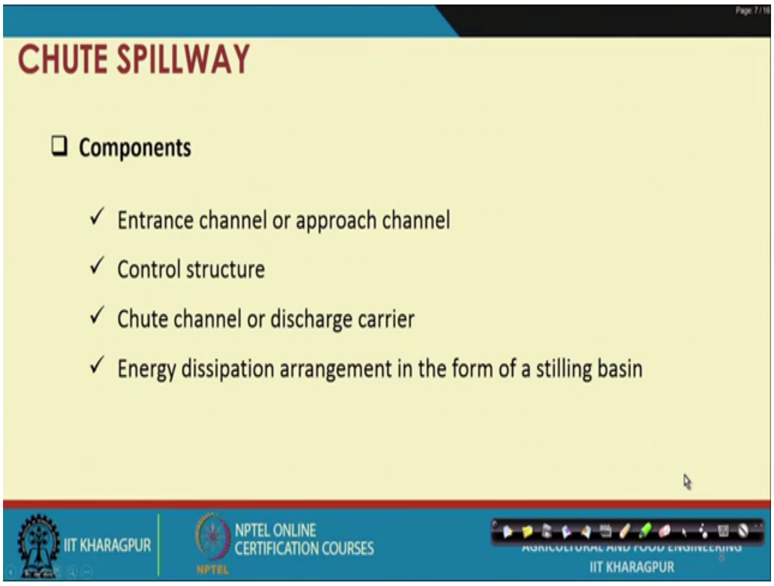


Now, the basic component of the chute spillway as you can see this structure here, the entrance channel or the approach channel. Then there were control structure which is here and ogee curve is placed, and there are many control structure, but here shown as you ogee curve. And then chute channel or the discharge career which is this part the steep slope channel. And the energy dissipation arrangement in the form of a stilling basin, so this is this part the energy dissipation arrangement is here. So, there are four basic component for the chute spillway.

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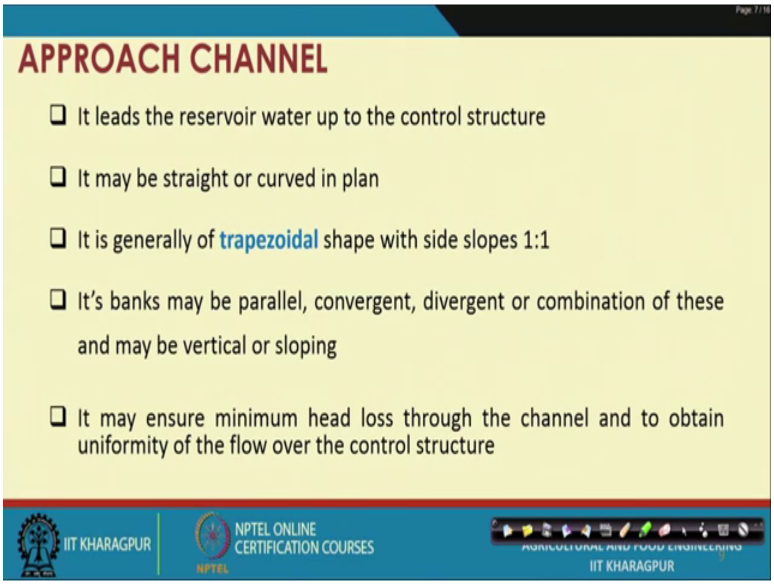


Now, coming to each of this component one by one; first we will start with approach channel. So the, what is approach channel here? It leads the reservoir water up to the control structure. It may be straight or curved in a plane. And it is generally in trapezoidal shape, and the slope is kept as one is to one. And it is banks may be parallel, convergent, divergent or combination of these and maybe vertical or sloping. It may ensure minimum head loss through the channel and to obtain uniformity of the flow over the control structure.

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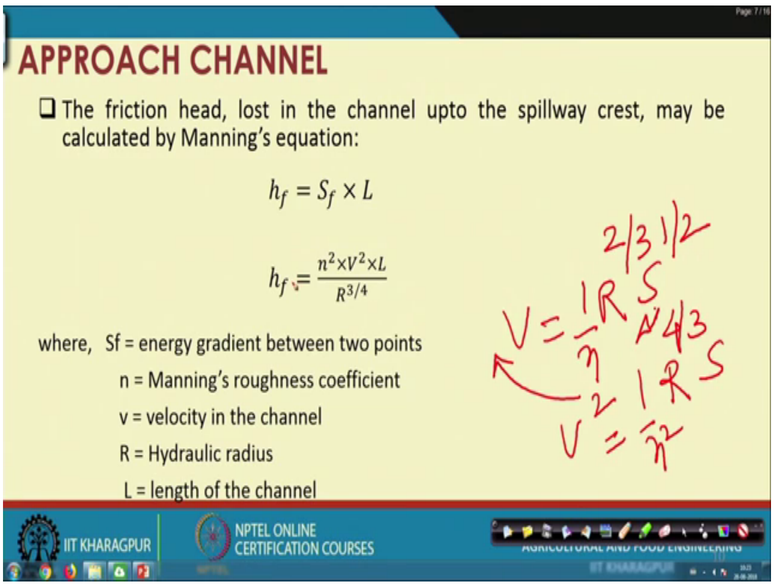

Now, how to design the approach channel? The friction head lost in the channel up to silver crest may be calculated by Manning's equation which is it h f is the friction in head, S f multiplied by L, where S f is the energy gradient between two points, n is the Manning's roughness coefficient and velocity v is the velocity of the channel. So, this is by simple equation here, v equal to 1 upon n R to the power 2 by 3 and S to the power 1 by 2 which is plugged here as a the so here it is shown. So, you plug here it is v square n square and then the S you calculated here. So, if you square it, so it will be 1 upon n square R to the power 4 by 3. And you get a value of a S, so where S is plugged here. So, in this way, you can get a h f value.

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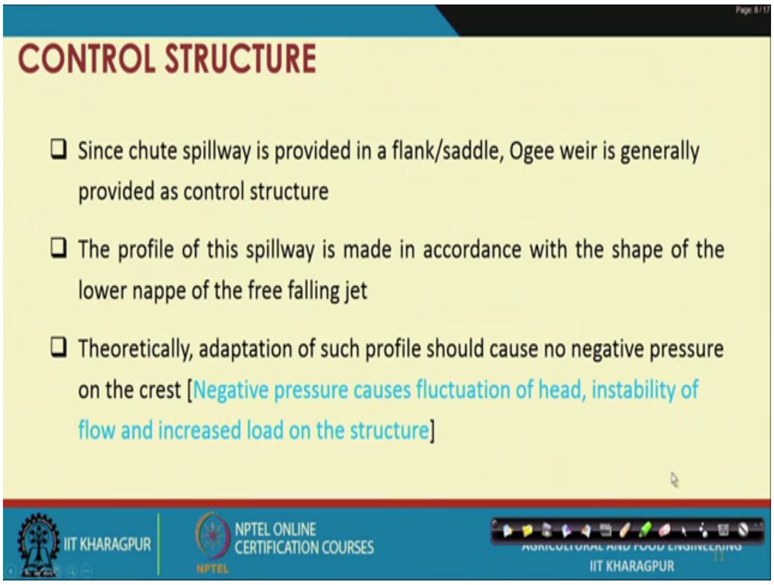


Now, the control structure, so there are different controls structure. Since the chute spillway is provided in a flank or saddle, ogee weir is generally provided as a control structure. The profile of this spillway is made in accordance with the shape of the lower nappe of the free falling jet. So, theoretically, adaptation of such profile should cause no negative pressure on the crest. And negative pressure causes what the fluctuation of head, and thereby instability of the flow and increased load on the structure.

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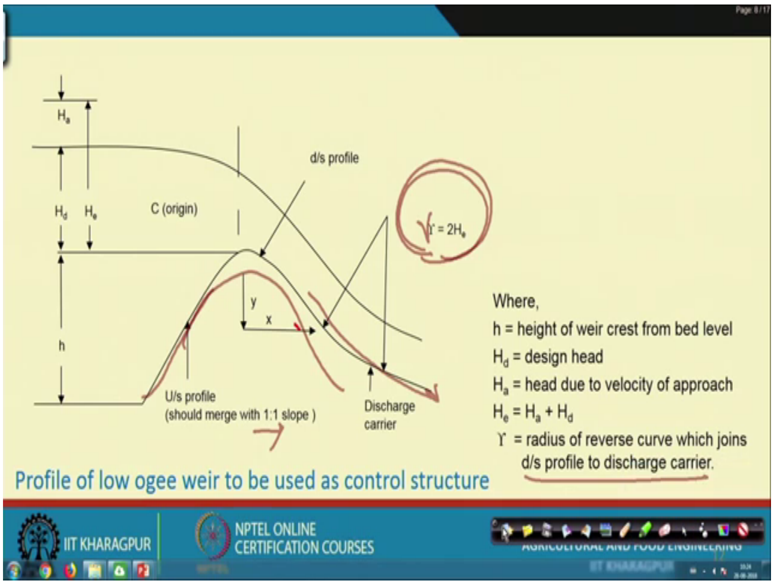


So, here you can say the profile of the ogee weir to be used as a control structure. So, here h is the height of the crest from the bed level as we explain this also in the design of ogee spillway. H d is again the design head, H a is the velocity of approach. So, H e is combination of H d and H a and this is the downstream profile here. The downstream profile here and the upstream and a upstream profile should merge with downstream profile at an one is to one slope. And here this there will be a discharge carrier and a gamma is the radius of reverse curve which joins the downstream profile to discharge carrier. So, this is calculated using this term gamma.

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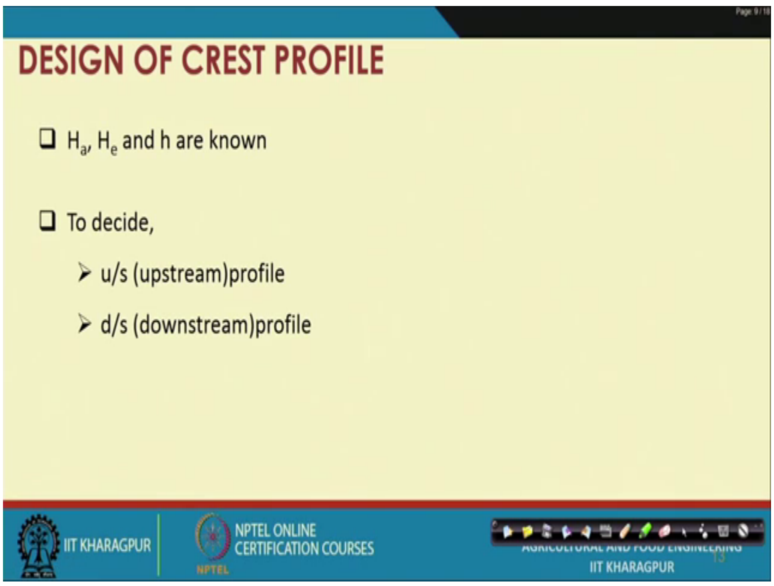

Now, design of the crest profile. So, now, if H a, H e and h are known, then we have to decide the upstream profile and the downstream profile.

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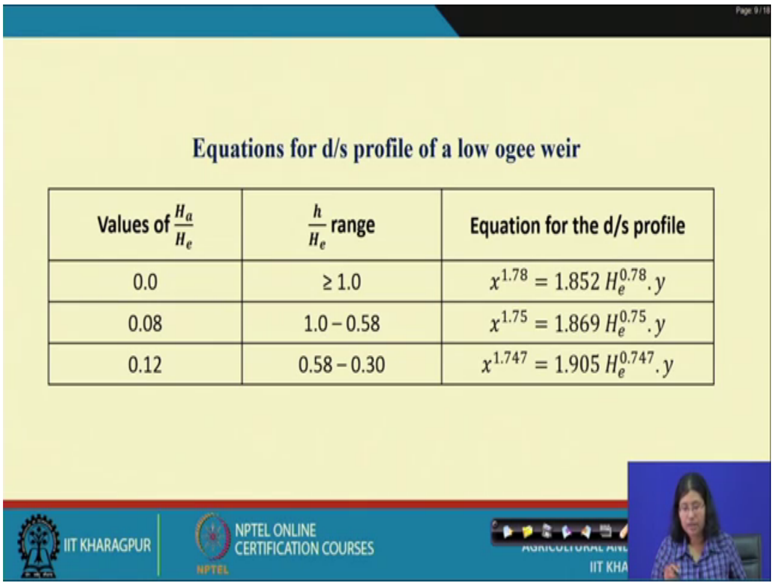

Equations for d/s profile of a low ogee weir

| Values of $\frac{H_a}{H_e}$ | $\frac{h}{H_e}$ range | Equation for the d/s profile |
|---|---|---|
| 0.0 | ≥ 1.0 | $x^{1.78} = 1.852\ H_e^{0.78}.y$ |
| 0.08 | 1.0 – 0.58 | $x^{1.75} = 1.869\ H_e^{0.75}.y$ |
| 0.12 | 0.58 – 0.30 | $x^{1.747} = 1.905\ H_e^{0.747}.y$ |



So, the equation for downstream profile of the low ogee weir is given in this following equation. These are all empirical equation which is fix by US army of course, through some studies. And h by H e a range of values are given here sorry. And for different values of H a by H e, there are different value of h by H e and corresponding equation for downstream profile are given here.

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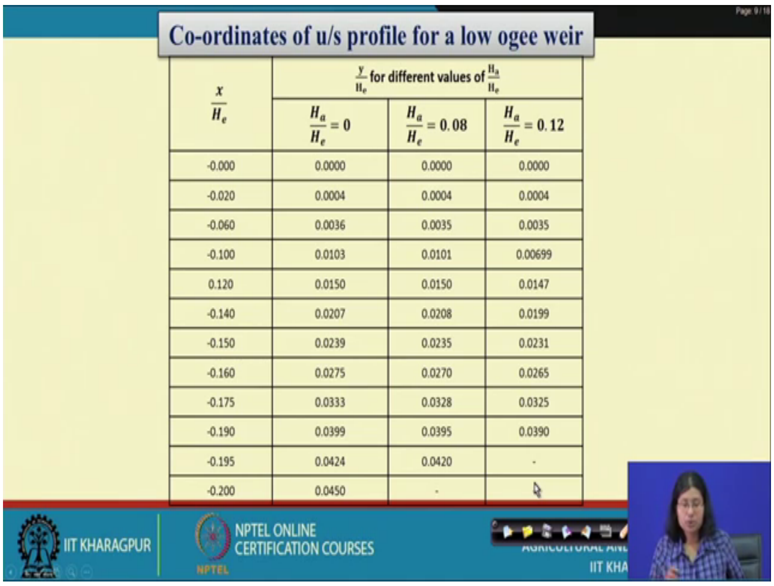

Co-ordinates of u/s profile for a low ogee weir

| $\frac{x}{H_e}$ | $\frac{y}{H_e}$ for different values of $\frac{H_a}{H_e}$ | | |
|---|---|---|---|
| | $\frac{H_a}{H_e} = 0$ | $\frac{H_a}{H_e} = 0.08$ | $\frac{H_a}{H_e} = 0.12$ |
| -0.000 | 0.0000 | 0.0000 | 0.0000 |
| -0.020 | 0.0004 | 0.0004 | 0.0004 |
| -0.060 | 0.0036 | 0.0035 | 0.0035 |
| -0.100 | 0.0103 | 0.0101 | 0.00699 |
| 0.120 | 0.0150 | 0.0150 | 0.0147 |
| -0.140 | 0.0207 | 0.0208 | 0.0199 |
| -0.150 | 0.0239 | 0.0235 | 0.0231 |
| -0.160 | 0.0275 | 0.0270 | 0.0265 |
| -0.175 | 0.0333 | 0.0328 | 0.0325 |
| -0.190 | 0.0399 | 0.0395 | 0.0390 |
| -0.195 | 0.0424 | 0.0420 | - |
| -0.200 | 0.0450 | - | |

Now, the coordinates of the upstream profile for the low ogee weir, so x by H e and if H a by H e is zero and H a by H e is 0.08, and H a by H e is 0.12. How this profile varies, so this kind of table is given and for calculating the design problem.

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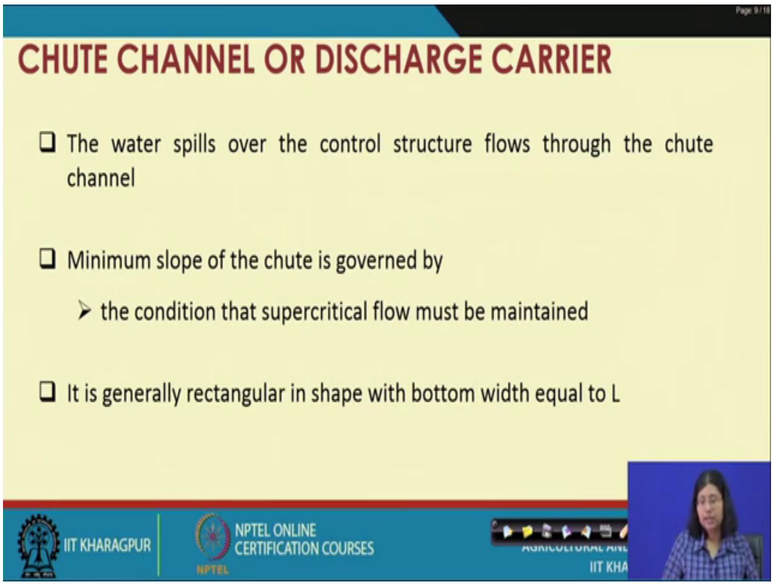


Now, chute channel or the discharge carrier design. The water spills over the control structure flows through the chutes channel. And the minimum slope of the chute is governed by the condition that the supercritical flow must be maintained. So, it is generally rectangular in shape with a bottom width is equal to L.

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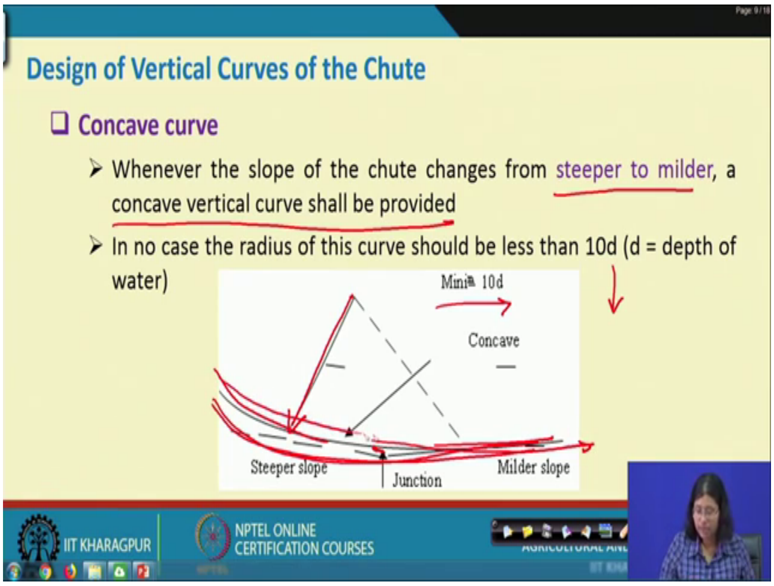

Now, coming to design of the vertical curve of the chute, so this is a concave curve. So, in this case a concave curve was assumed. So, this is the concave shape. Whenever the slope of the chute changes from steeper to milder, a concave vertical curve shall be provided. So, here we given a concave vertical shape. And in no case in the radius, so this is a concave. So, this is a curved surface. So, this the radius in no case this radius should be less than 10 d, where d is the depth of water here. So, minimum this curvature is given as 10 d. And this is a steeper slope, this is a junction point, and this is a milder slope. So, it will gradually go like this from steeper to milder.

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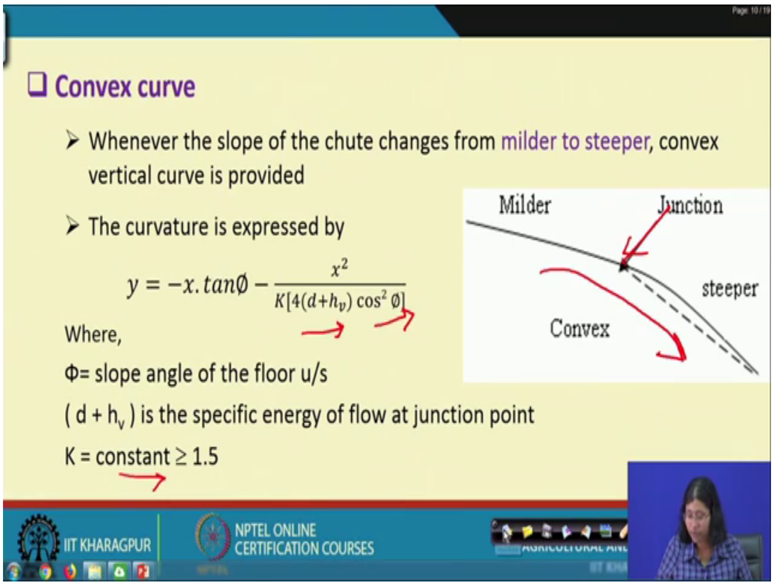


Now, the convex curve.; so, this case whenever the chute changes from steeper to milder concave curve shall be provided. Now, in which case the convex curve, so whenever slope of the chute changes just opposite milder to steeper in that case a convex vertical curve should be provided. So, this is the convex shape here. So, here the slope going from milder to steeper; and this is a junction point. So, the equation for this is given as y equals to minus x tan phi and minus x square of 4 h d plus h v and cosine square of phi, whereas phi is the slope angle of the floor at upstream, and d plus h v is the specific energy of flow at junction point, K is assume generally as constant is 1.5. So, using this equation we can calculate the slope the y at a given x.

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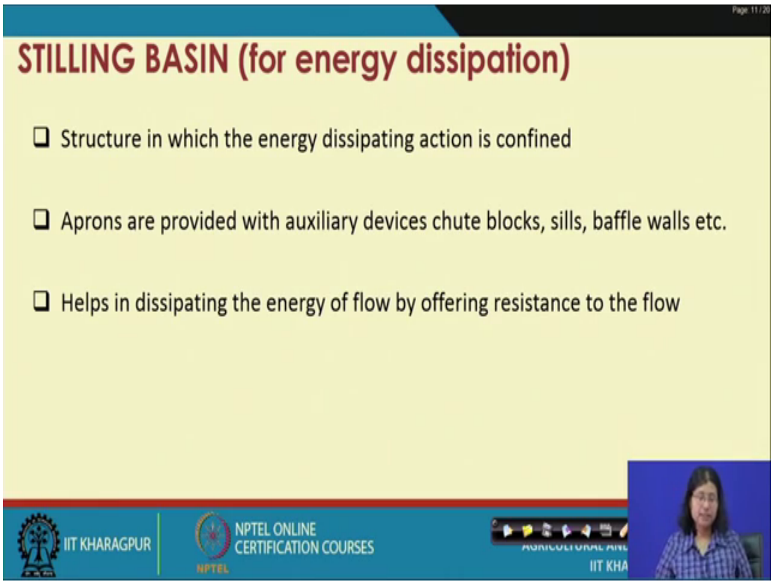


So, stilling basin, stilling basin we keep it for energy dissipation which is the last component of the spillway. So, this is a structure in which energy dissipation action is confined. And in this energy dissipation structure and approach a aprons are provided with auxiliary devices. So, what are the auxiliary devices here chute blocks sills and baffle walls, these are usually worked as an auxiliary devices. And it helps in dissipating the energy of flow by offering resistance to the flow. So, this is for the stilling basin.

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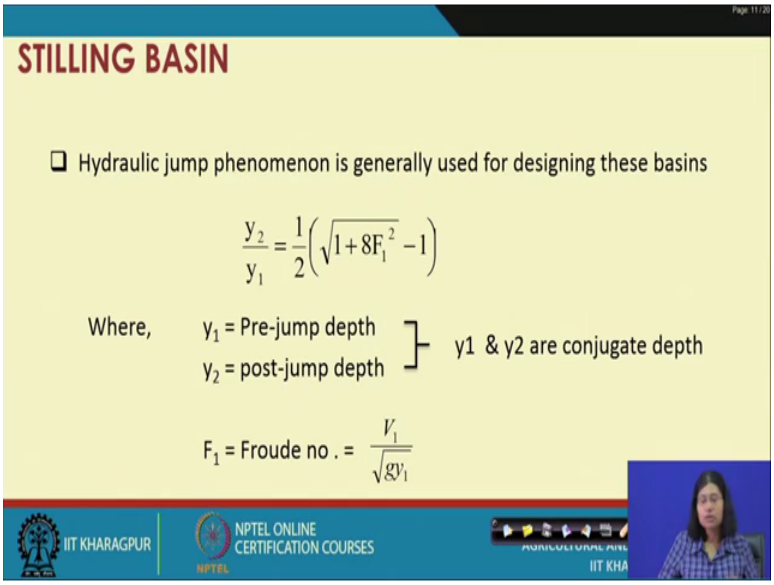

Now, what happens to the stilling basin? So, once the flow of water at a high speed is falls and there is a occurrence of hydraulic jump as you know from the principle of fluid mechanics. So, hydraulic jump principle the it is the ratio between y 2 and y 1, where is a critical depth and which is again a function of the Froude number. So, y 1 is pre jump depth and y 2 is the post jump depth, where y 1 and y 2 are the conjugate depth. And a Froude number is given by the ratio between v divided by acceleration due to square root of acceleration due to gravity and y 1 what is the pre jump depth. So, depending upon the Froude number, the velocity of flow can be critical, subcritical or the supercritical. And based upon the velocity of flow and we can design the stilling basin.

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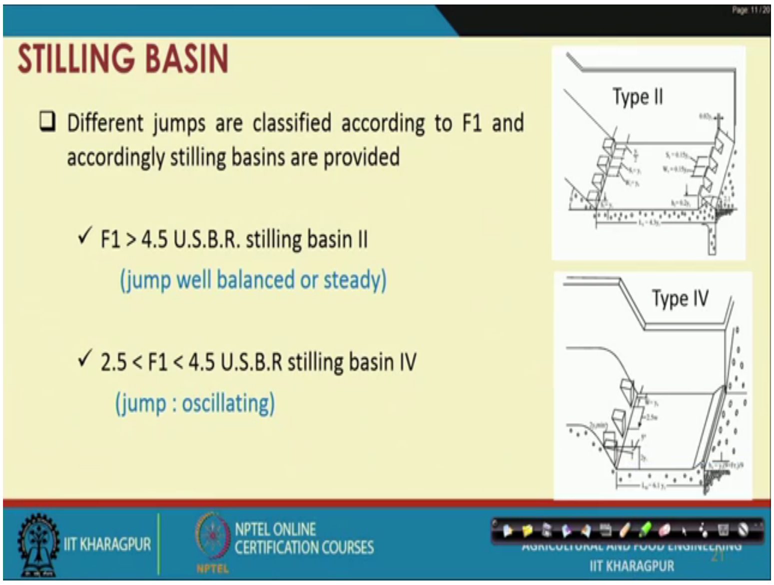


So, different jumps are classified according to F 1 or the Froude number and accordingly stilling basins are provided. So, F 1 if it is 4.5, it is a supercritical flow and U.S.B.R stilling basin 2 is used in this case. So, this is the kind of stilling basins are provided and sorry. So, if F 1 is 4 greater than 4.5, the jump is well balanced and steady. So, in this case the stilling basin 2 is provided. And however, if the jump is between 2.5 to 4.5, it is oscillating and in this case the stilling basin 4 is provided.

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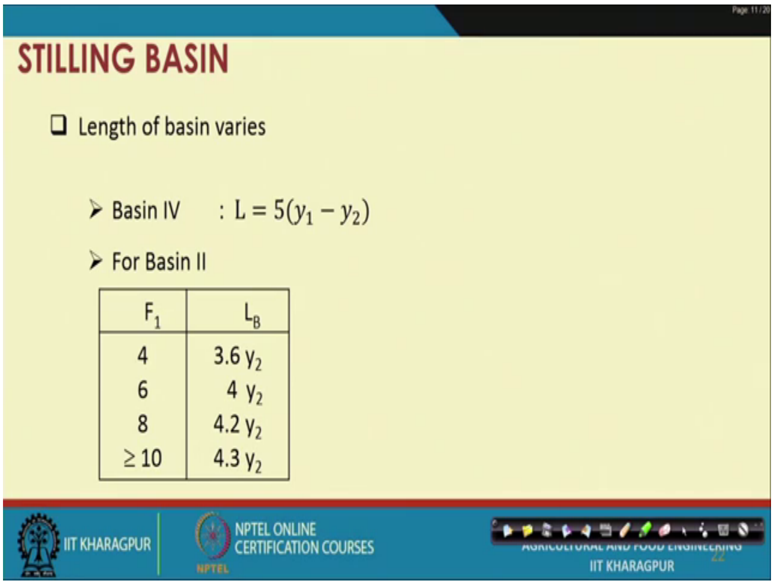


Now, the length of the basin varies between L this is the equation how that we design the length of the basin which is a difference between y 1 that is pre jump, and y 2 is the post jump and which is multiplied by 5 is the length of the basin. And for basin 2 depending upon the Froude number, we again fix the length of the basin like this. So, if the Froude number is 4, so we generally kept as 3.6 of y 2. If the Froude number is 6, we kept is a 4 times of y 2. If it is 8, 4.2 y 2; and if it is more than 10, then we generally kept as 4.3 of y 2 where y 1 is the pre jump height or a depth, and y 2 is the post jump depth of the stilling basin.

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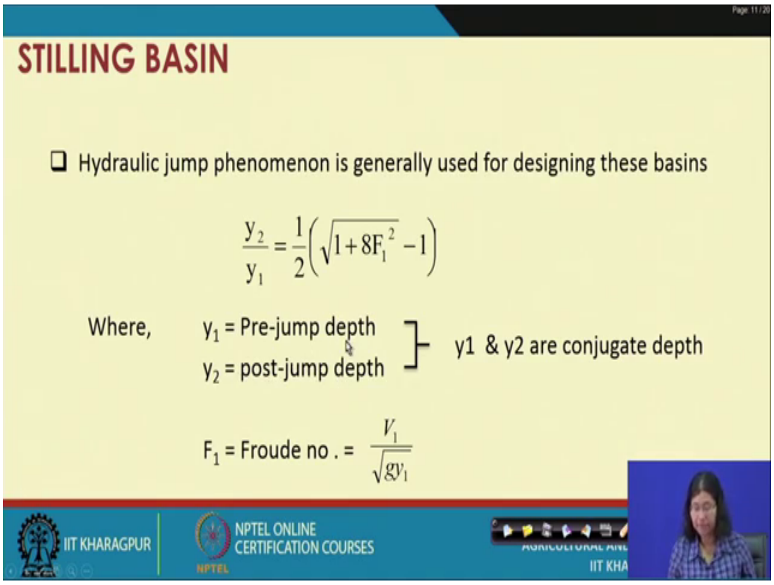

So, thank you.