Soil and Water Conservation Engineering
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Lecture – 50
Chute Spillway

Hello this lecture is about the last component of the Chute Spillway Design that is the energy dissipation part. So, this is the last component the energy dissipation.

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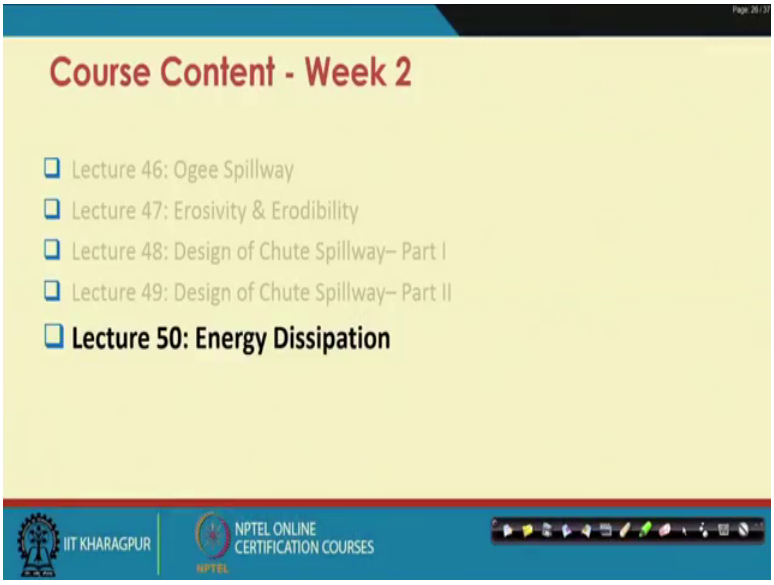

So, first we went through the ogee spillway then the design principle of part one part two the last component is energy dissipation.

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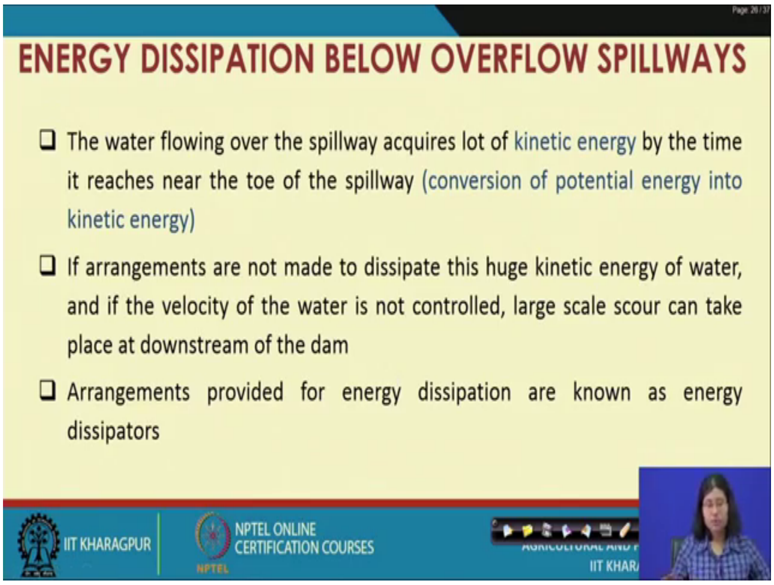

So, what is the energy dissipation of below the spillway? Since water is flowing over the spillway it requires lot of kinetic energy by the time it reaches near the toe of the spillway. That is since the water is flowing from the top so, conversion of potential energy is into the kinetic energy.

If the arrangements are not made to dissipate this huge kinetic energy of water and if the velocity of water is not controlled large scale squad or the erosion occurs at the point place at the downstream of the dam. So arrangements is to be provided for energy dissipation, which is widely known as energy dissipaters.

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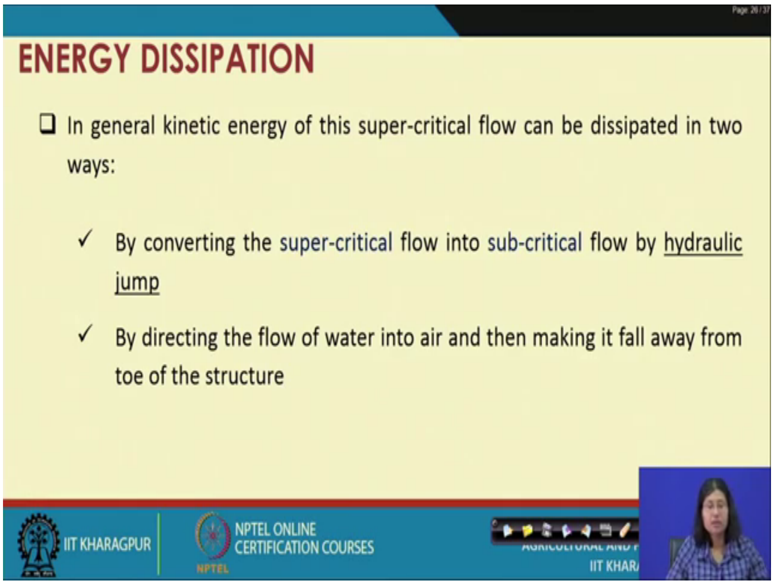

In general the kinetic energy of the super critical flow can be dissipated in two ways. So by converting the super critical flow into sub critical flow, by hydraulic jump or by directing the flow of water into air and then making it fall away from the toe of structure. So, these are the two ways in which we can dissipate the energy.

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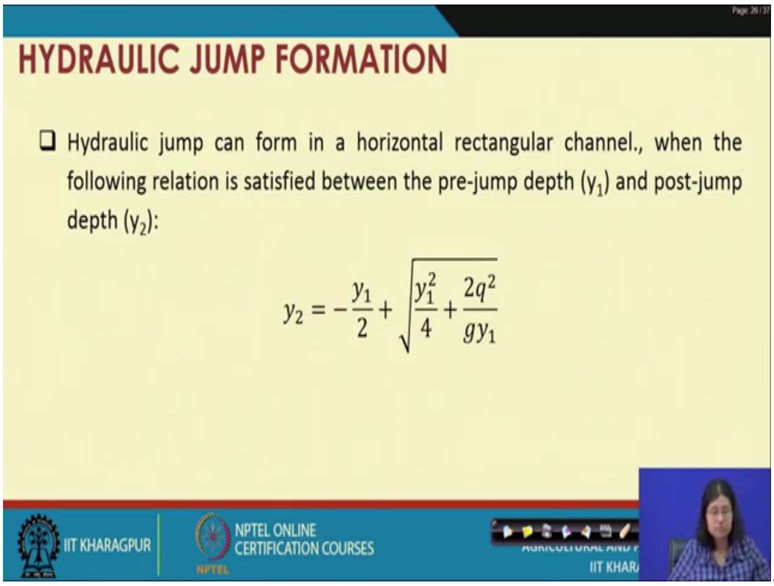

So, hydraulic jump formation so, hydraulic jump can form in a horizontal rectangular channel when the following relation is satisfied between pre jump and a post jump depth. So, pre jump is y 1 and the post jump depth is y 2. So, all of you know that hydraulic jump can be created and then we can get conjugate depth equation. So, this is the basic form of equation to be used for y 2 and y 1.

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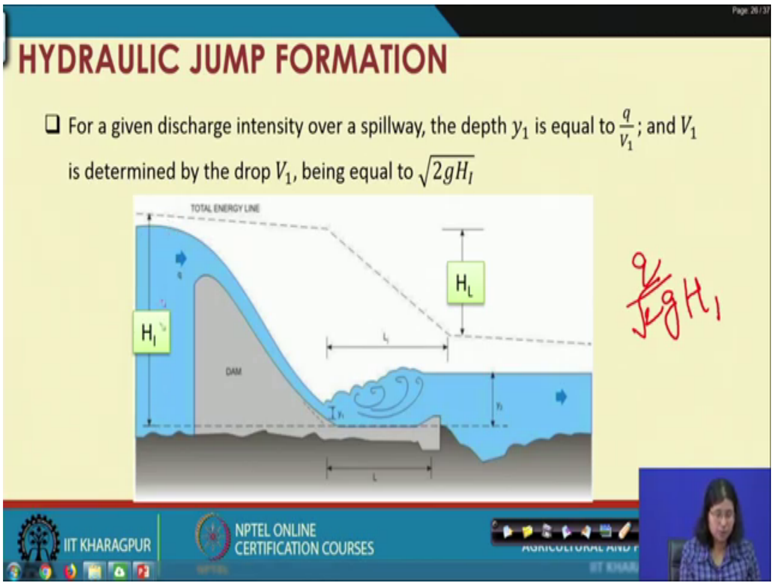

So, for a given discharge intensity over the spillway and at a depth of y 1 so, this is the first conjugate depth y 1 is equal to q by V 1. So, this is the discharge this is the total energy line this is H L the gradient and H 1 the discharge is a y 1 is the ratio of the critical discharge divided by V 1.

And V 1 is determined by the drop V 1 and equal to root under 2 g H. So, the entire equation comes out to be q upon 2 g H 1 the H 1 is the height and total energy line height of the total energy line from the dam bottom to this point.

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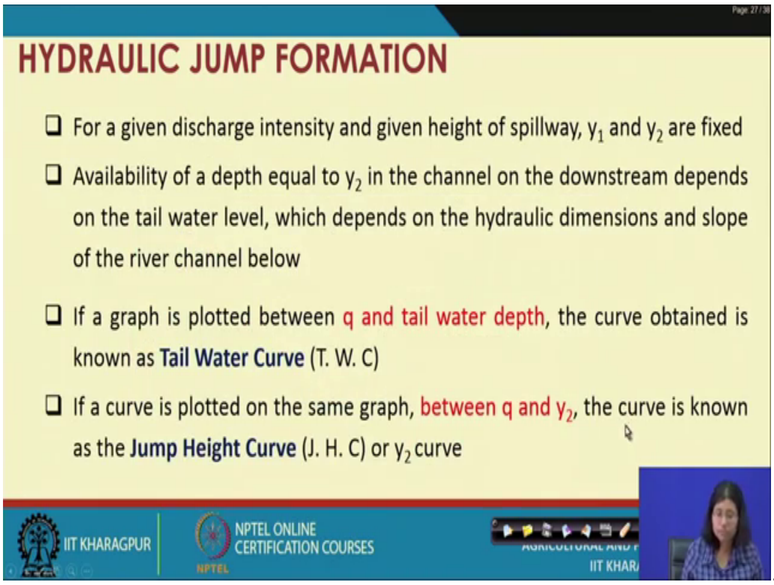

For a given discharge intensity and given height of the spillway generally y 1 and y 2 are fixed. Availability of depth equal to y 2 in the channel on the downstream depends on the tailwater level which depends on the hydraulic dimension and the slope of the river channel. If a graph is plotted between discharge and tail water depth a curve is obtained this curve is called sorry; this curve is called a tailwater Curve.

The graph between discharge critical discharge and tailwater depth like if a curve is drawn this is called tailwater curve and if a graph is plotted in the same graph between q and conjugate depth y 2, the curve is known as jump water height curve so, this is called T W C and this is called J H C or the y 2 curve. So, these are two different curve which is related to hydraulic jump formation.

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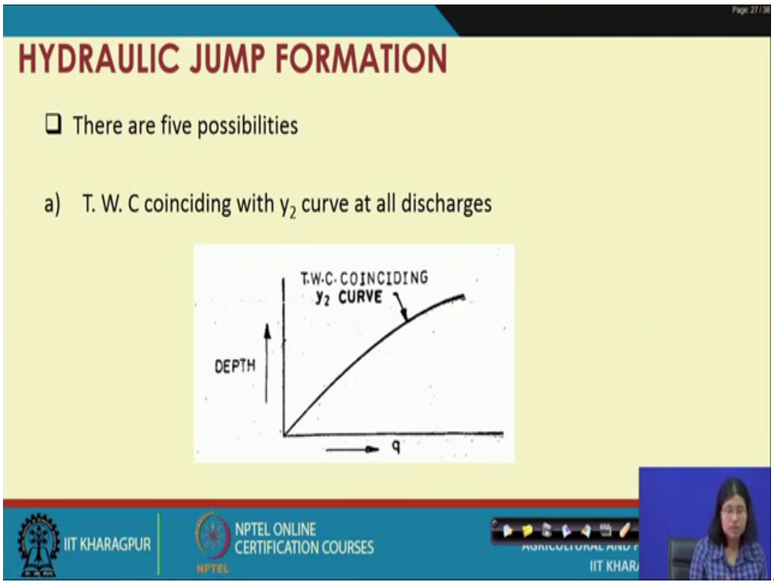

So, there are five possibility in this case. So, the T W C or the tailwater curve when coinciding with y 2 curve or the J H C curve so, this looks as a on the same point. So, this one is coinciding with this where T W C is coinciding with J H C this depth and this is the critical discharge.

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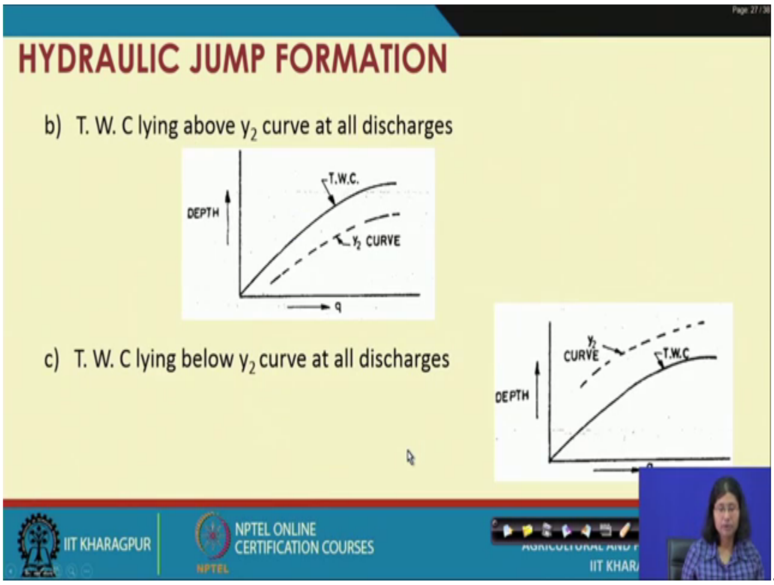

And the second possibility is when T W C is laying above the y 2 curve. So, this is T W C curve this is y 2 curve and a third possibility can be if T W C is lying below the y 2 curve at all the discharges. So, first one is T W C is above this and the second one is just reverse the situation.

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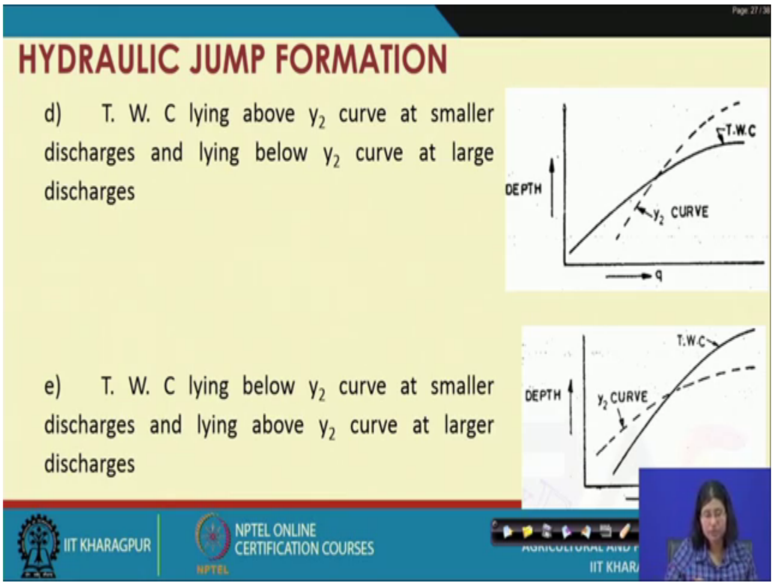

There is a fourth condition when the T W C is lying above the y 2 curve at a smaller discharge and laying below the y 2 curve at a large discharge. The condition where both are intersecting y 2 curve is below and T W C to curve is in the next stage it is above.

And the fifth condition is just reverse of this situation where T W C curve lying below y 2 curve at smaller discharge and lying above the y 2 curve at a large discharge. So, these are the five different possibility that a hydraulic jump can generate a huge amount of energy.

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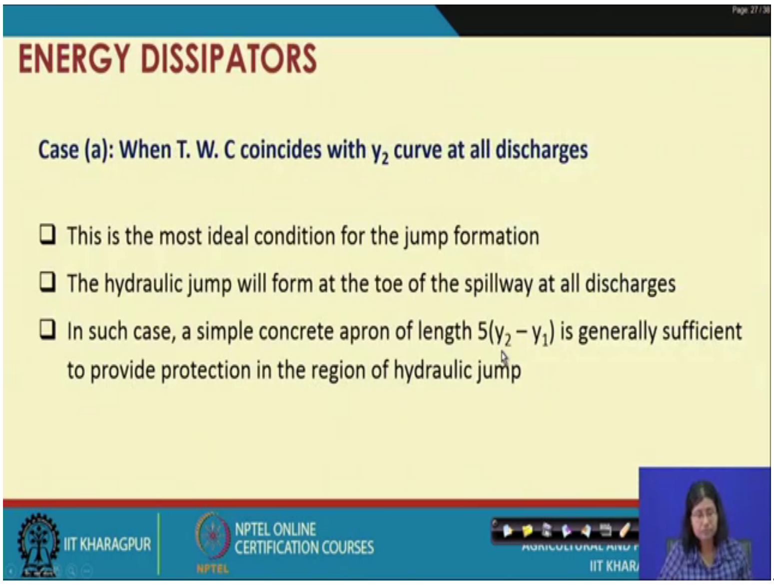

So, how to dissipate this energy? So, we will first go for case one when both the graphs are coinciding when T W C coincides with y 2 curve at all discharges. This is the most radial condition for the jump formation the hydraulic jump will form at the toe of the spillway at all discharges. And in such case a simple concrete apron of length 5 times Y 2 minus Y 1 is generally sufficient to provide protection in the region of hydraulic jump. So, this concrete length is if you provide concrete length this is the simple solution for this.

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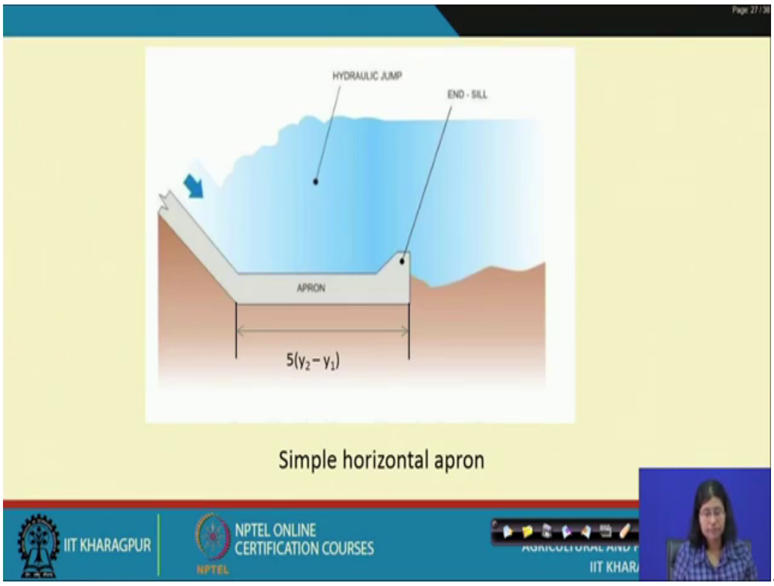

So, this is the condition here there is a formation of hydraulic jump and you provide a simple horizontal apron in this case and this is sill end still here.

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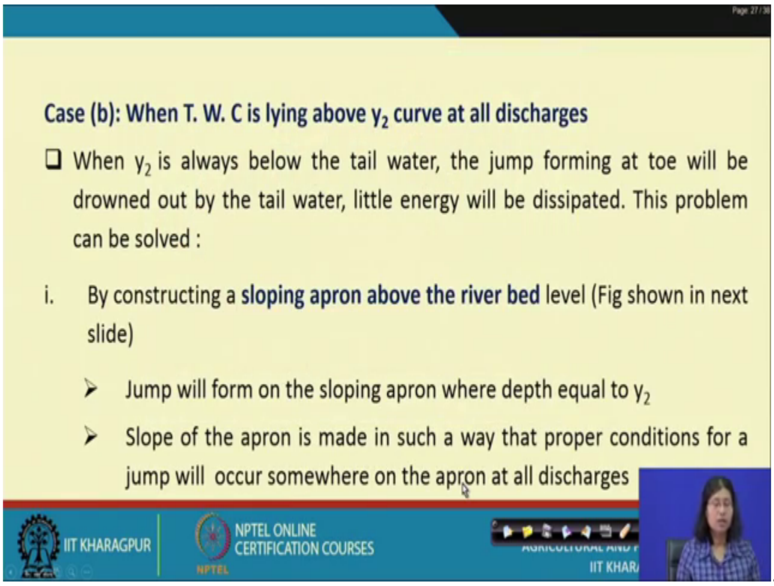

Now, coming to case two when the T W C is lying above the y 2 curve at all discharges when y 2 is always below the tail water, the jump farming at the toe will be drowned out by the tailwater and in this case what happened a little energy will be dissipated. This problem by is can be solved by two or three ways. So, first will go by constructing sloping apron above the river bed; this will going to show in the next slide.

So, Jump will form fall on the sloping apron where depth equals to Y 2 second Slope of the apron is made in such a way that the proper condition for a jump will occur somewhere on the apron at all discharges.

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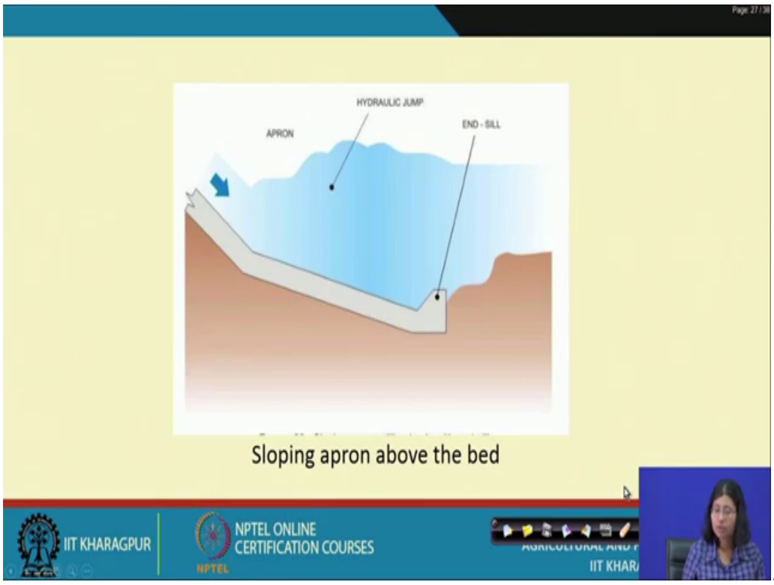

So, this is a sloping apron is provided above the bed. So, like this and this is the end sill and this is the hydraulic jump this is the apron is going like this and is slope.

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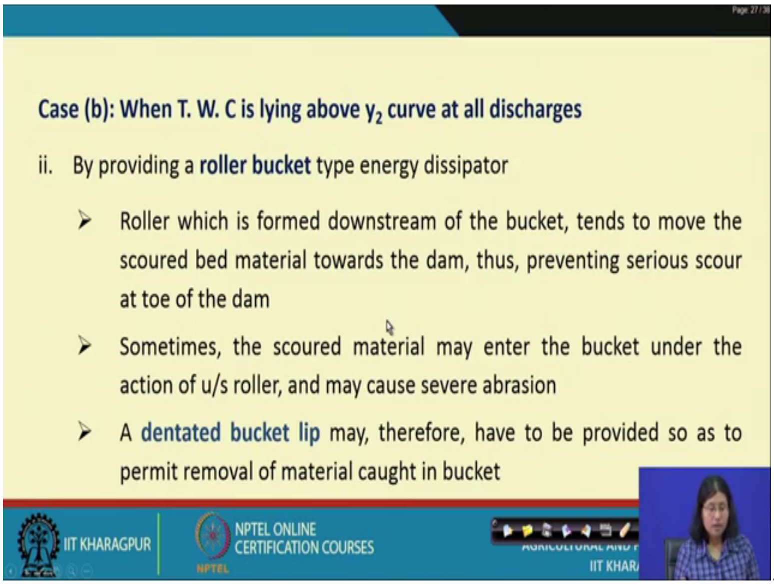

Now, the second way to solve this by and we are continuing the same case when T W C is lying above the y 2 at all discharges the case two second solution is to provided roller bucket type energy dissipator. Roller which is formed downstream of the bucket tends to move the scoured bed material towards the dam thus preventing the serious scour at a toe of the dam. Sometimes, the scoured material may enter the bucket under the action of upstream roller and may cause severe abrasion. So, what we can do in that case a dentated bucket lip may therefore, have to be provided so, as to permit removal of material caught inside the bucket.

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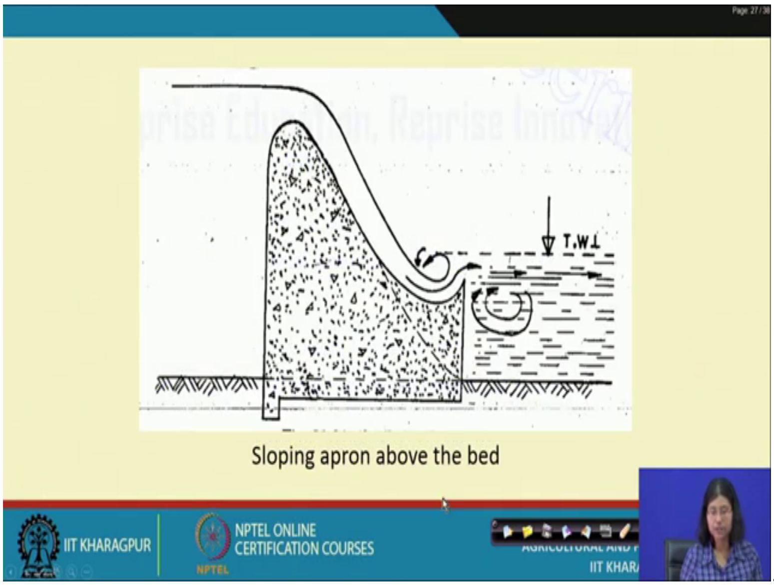

So, in the next slide I am going to show the structure. So, like this a bucket kind of arrangements is to be provided and is a sloping apron above the bed here is there is a formation of whirlpool and this bucket kind of arrangement here.

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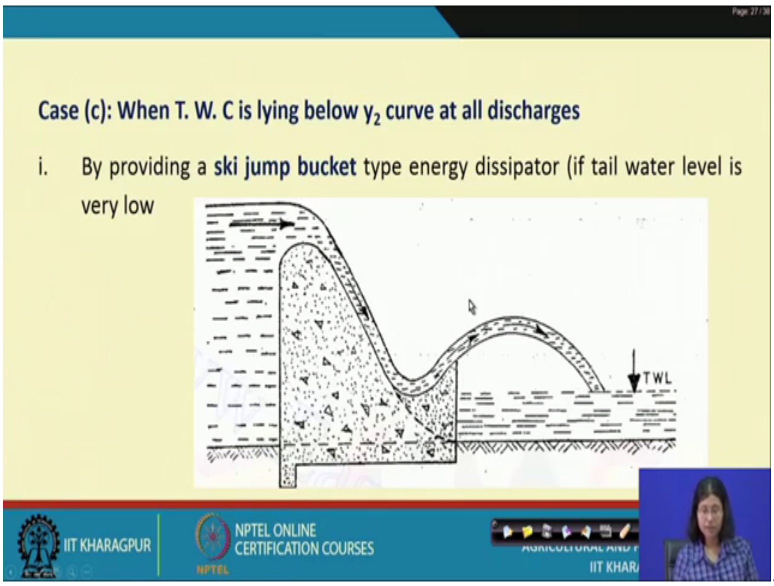

Now, when the T W C is lying below y 2 curve at all discharges. So, here case this is the case three. So, by providing a ski jump bucket energy dissipator if tail water level is very low so, if provided a ski jump kind of bucket here.

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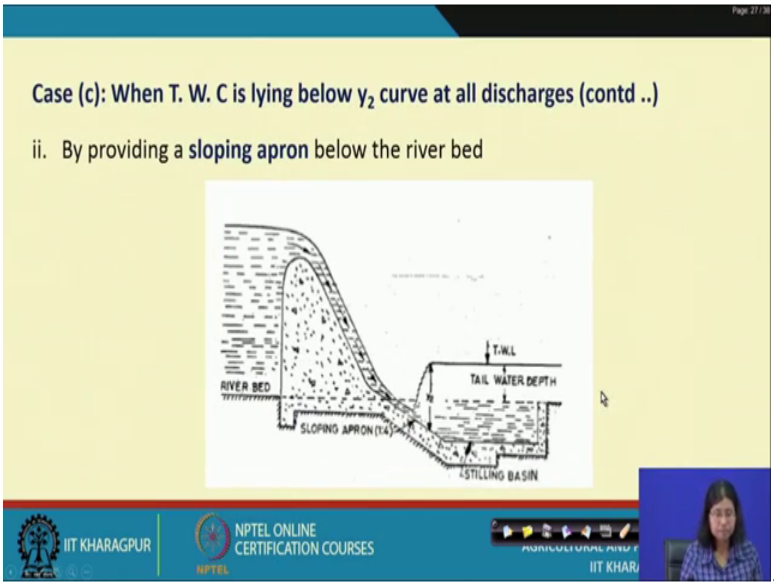

The second way to solve this is by providing a sloping apron below the river bed. So, the same case three is continuing that is when T W C is laying below the y 2 curve at all discharges. So, a sloping apron is provided below the river bed here.

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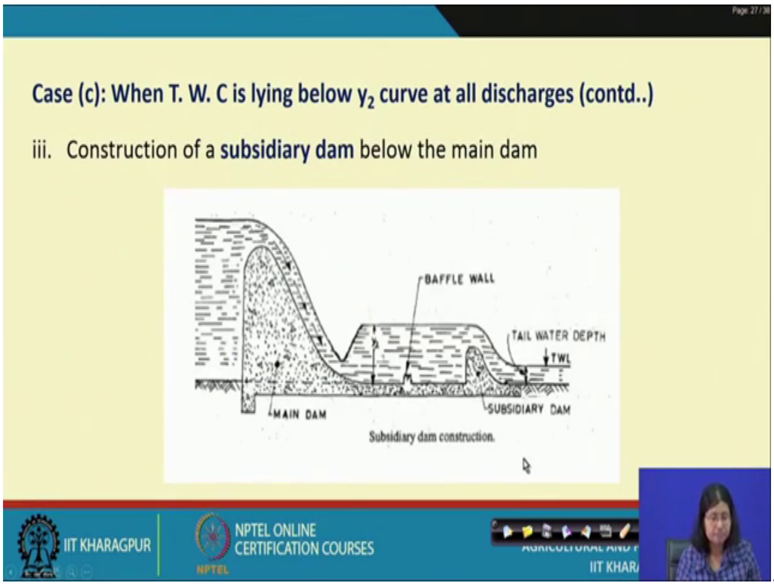

Now, the third way to solve this construction of a subsidiary dam below the main dam is subsidiary dam is to be constructed and that can take care of this energy dissipation problem so, subsidiary dam is here.

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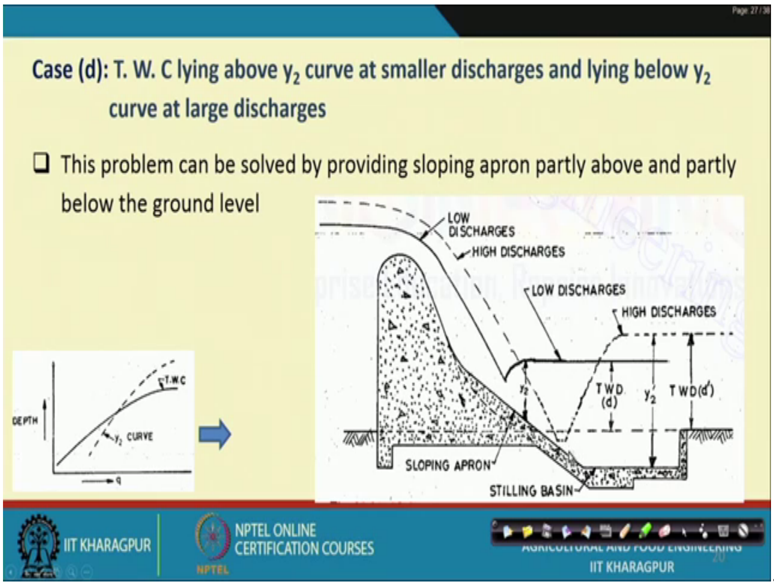

Now, we are see the case four when the T W C curve as the y 2 curve and both are coinciding and a T W C is lying about the y 2 curve at small discharges and lying below the y 2 curve at all large discharges. So, this problem can be solved by providing a sloping apron partly above and partly below the ground level.

So, this is my case four and this is a combination of case one and case two. So, here it provide sloping apron partly above and the partly below the ground level. So, this way we can solve this kind of energy dissipation problem.

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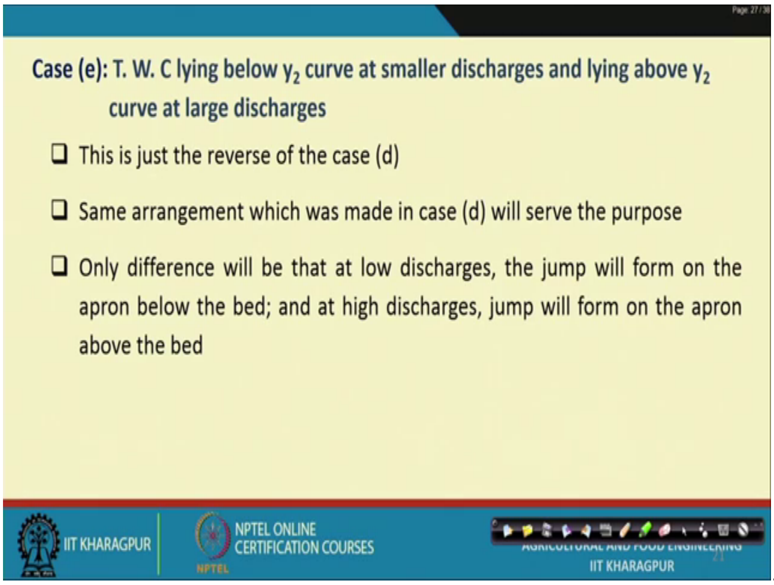

And now that last case the last case is when this also the case when T W C and y 2 curve both are intersecting where the case is just opposite of case four, that is a T W C is lying below the y 2 curve at smaller discharges and lying above the y 2 curve at large discharges.

So, here the arrangement will be same; the same arrangement which was made in case d will serve the purpose, only difference will be that at low discharges, the jump will form on the apron below the bed; and at high discharges, the jump will form the apron above the bed.

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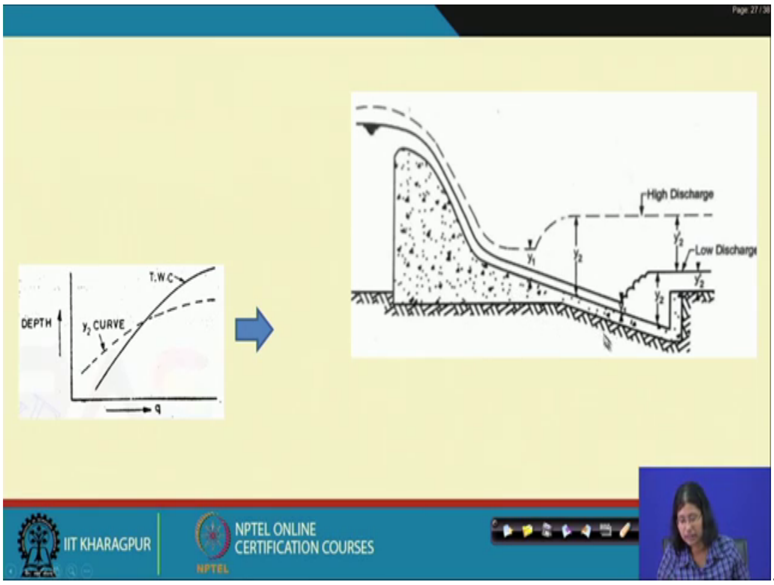

So, this is the case five just that is a rivers of case four and this is the jump here is forming above the bed below the bed and at high discharge the jump will form on the apron above the bed, the last case. So, these are the five ways we can solve the energy dissipation problem.

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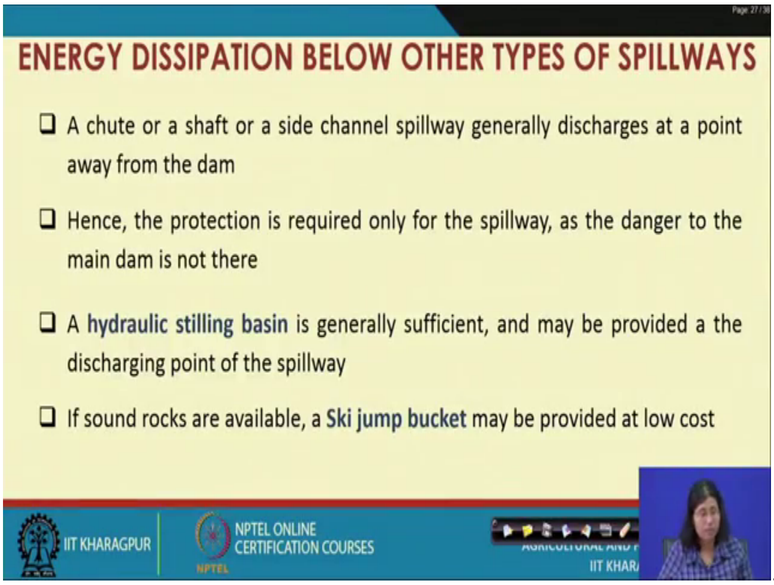

Now, coming to energy dissipation below other type of spillway so, if the spillway are some other type how we can solve this energy dissipation problem. So, first a chute or a shaft or a side channel spill way general discharges at a point away from the dam. Hence the protection is required only for the spillway as the danger to the main dam is not here. So, in this case a hydraulic stilling basin generally sufficient and may be provided at discharge point of the spillway. So, hydraulic spill stilling basin is sufficient to solve this kind of problem; however, if there is a rocks are available, in that case a ski jump bucket may be provided which is at a low cost ok.

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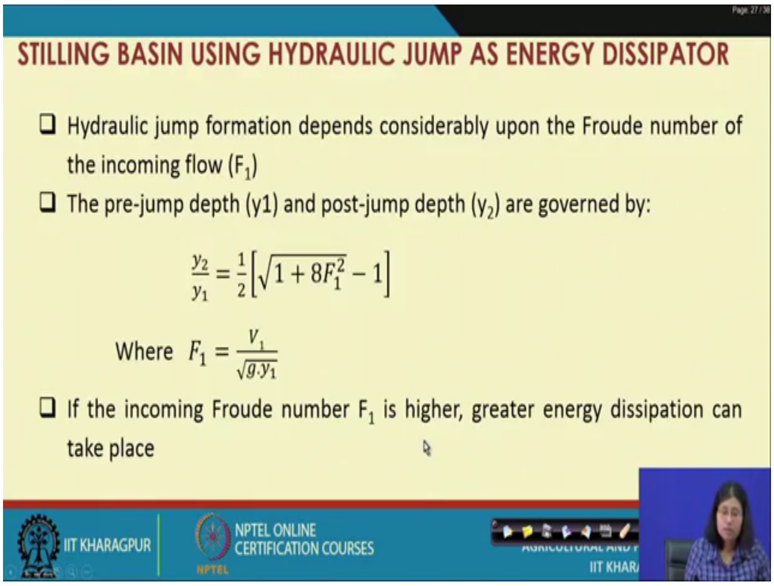

So, and stilling now the design now hydraulic jump formation depends considerably upon the Froude number of the incoming flow. So, the pre jump depth and post jump depth or the conjugate depth are given by this formula. So, this is a Froude number here and the Froude number is the ratio between V 1 up on root g y 1 this two depth. If the incoming Froude number F 1 is higher the greater energy dissipation can take place.

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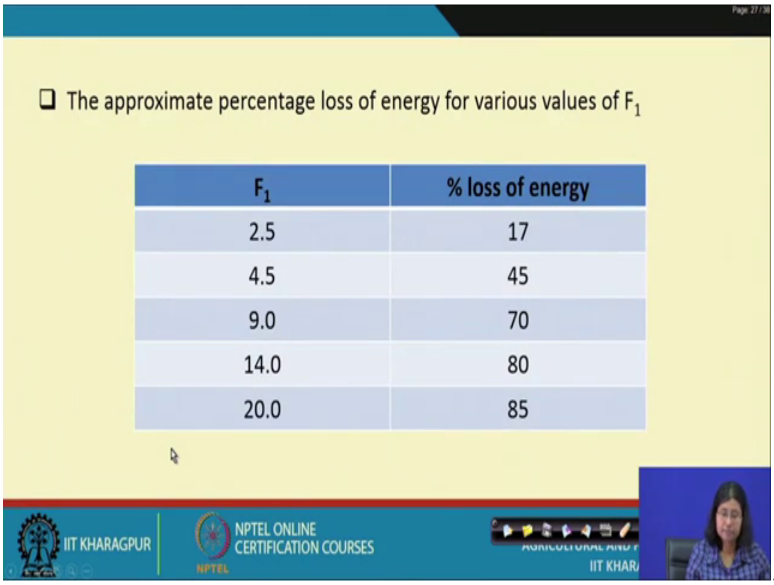

F_1	% loss of energy
2.5	17
4.5	45
9.0	70
14.0	80
20.0	85

So, here we have given the range of Froude number and corresponding percentage of energy loss. So, from Froude number range from 2.5 to 20 so, 2.5 is the Froude number is low in number on 17 percent loss of energy happen; however, if it is 20 around 85 percent losses can happen.

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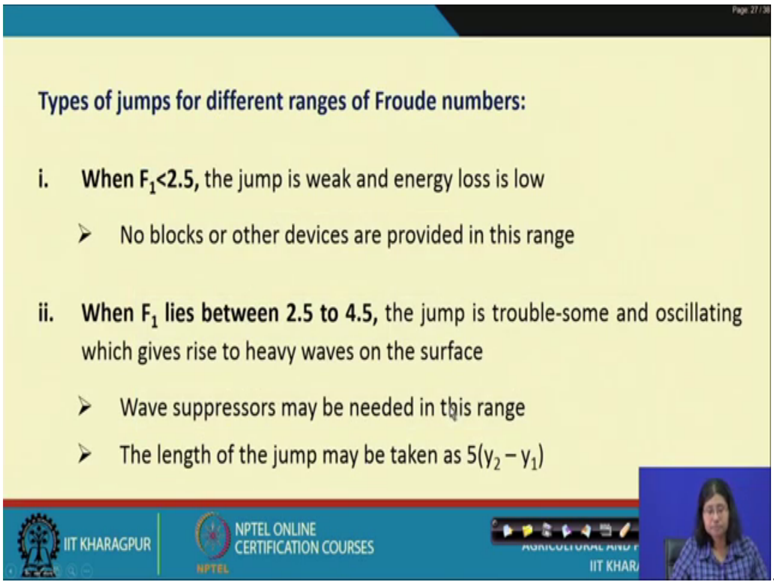

Now, coming to types of jump for different ranges and their Froude number: when F 1 is less than 2.5, the jump is weak and energy loss is low. So, no blocks or other devices are provided in this range. So, we are basically safe in this range; however, when F 1 lies between 2.5 to 4.5 the jump not troublesome and oscillating and which gives rise heavy waves on the surface. So, in that case wave suppressor maybe needed in this range and the length of the jump may be taken as a difference between y 2 minus y 1 and 5 times of this difference.

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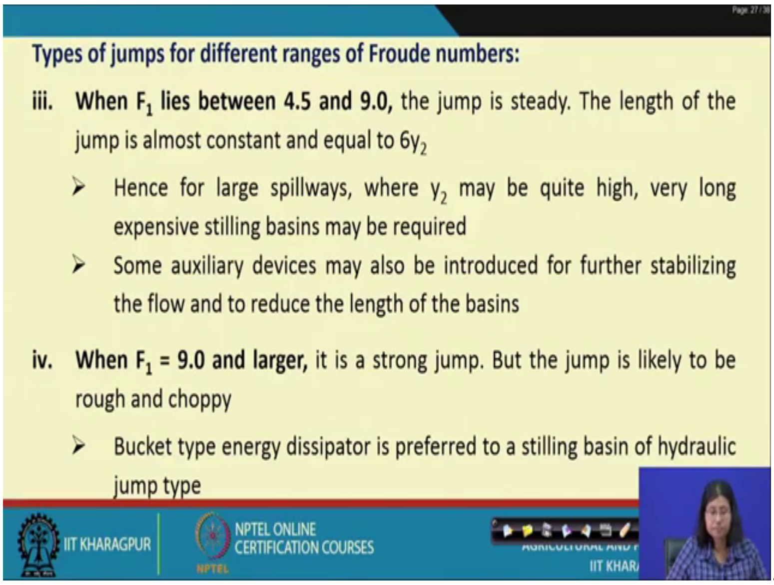

When F 1 lies between 4.5 and 9 the jump is steady. The length of the jump is almost constant and equal to 6 of y 2. Hence for large spillways, where y 2 may be quiet high very long expensive stilling basin may be required.

Some auxiliary devices may also be introduced for further stabilizing the flow and to reduce the length of the basin. When F 1 is 9 and larger it is a strong jump, but the jump is likely to be rough and choppy bucket type energy dissipater is preferred in this case and of this hydraulic jump type.

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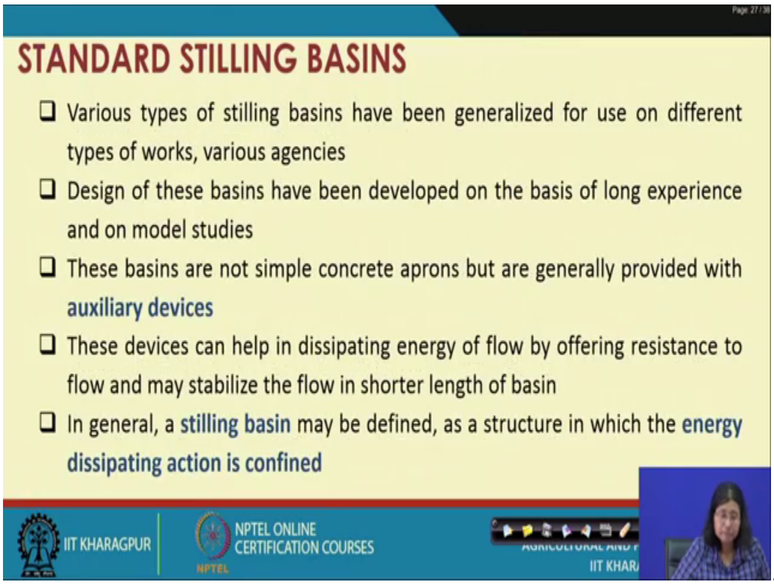

Now, the kind of stilling basin; so, various kind of stilling basins have been generalized for use on different types of work and various agencies. So design of this basin have been developed on the basis of long experience and model studies. So, these basins are not simple concrete apron, but generally provided with an auxiliary devices this device can help in dissipating energy of flow by offering resistance to flow and may stabilize the floor in shorter length of the basin.

So, in general a stilling basin may be defined as a structure in which the energy dissipation action is confined. So, stilling basin is a kind of structure in which energy dissipation can be taken place.

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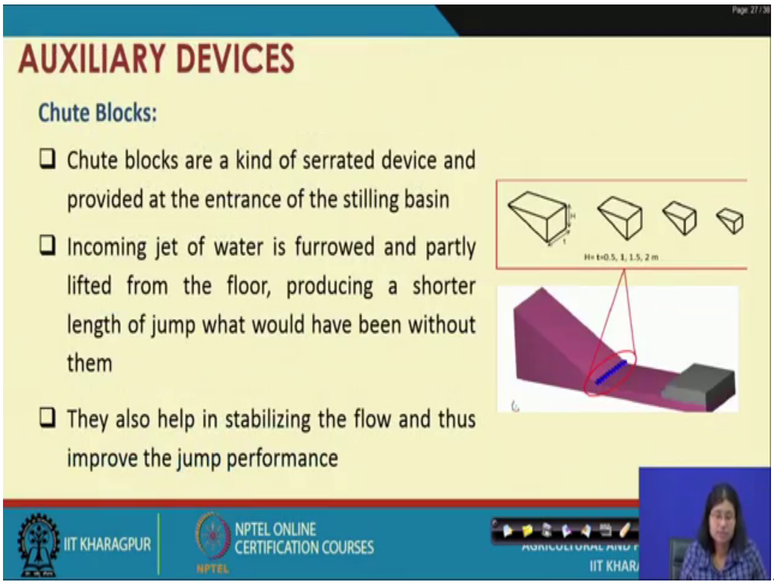

So, this kind of auxiliary devices are designed for energy dissipation. So, one of them is chute blocks. So, chute blocks are a kind of serrated device and provided at the entrance of the stilling basins. So, you can see this point here at the entrance of the stilling basin this small small chute blokes are provided. So, incoming jet of water is followed and partly lifted from the floor a producing a shorter length of the jump and which would be produce here and they also help in stabilizing the flow and then they can improve the jump performance in presence of this small small blocks.

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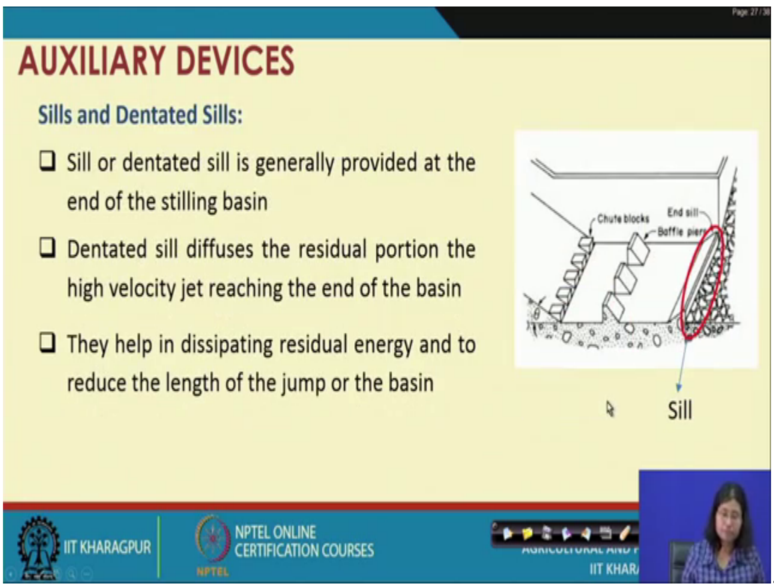

Now, the other way of is to provide sill and dentated sills here sill or dentated sill is generally provided at the end of the stilling basin. So, dentated sill diffuses the residual portion of the high velocity jet reaching at the end of the basin. They help in dissipating residual energy and to reduce the length of the jump or the basin. So, these are the stilling basin here.

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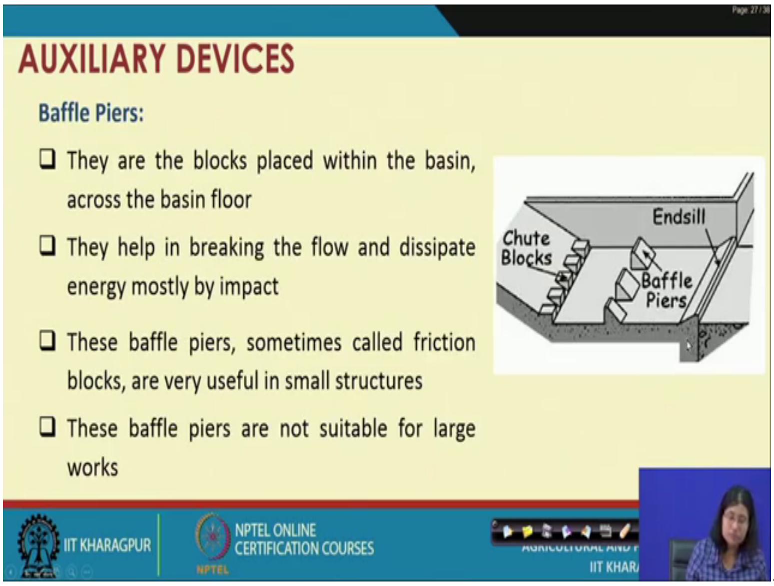

The third way is to provide the baffle piers. So, baffle piers are like this is the end sill and this is the chute blocks and now you have the baffle piers. So, they are the small blocks placed within the basin and across the basin floor. So, they help in breaking the floor and dissipate the energy impact mostly by the impact. So, this baffle piers sometimes also called as friction blocks, are very useful for the small structure; however, for large structure these are not suitable.

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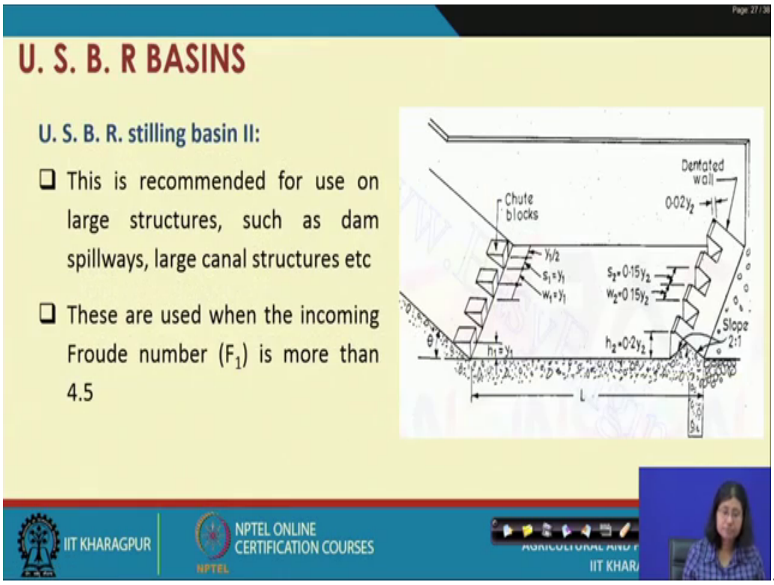

Now, another way is U S B R silling stilling basin two. So, this is the stilling basin two structure; this is recommended for use on the large structures such as dam spillway and large canal structure. These are used when the incoming Froude number is more than 4.5. So, a large structure these are the basic device to we use.

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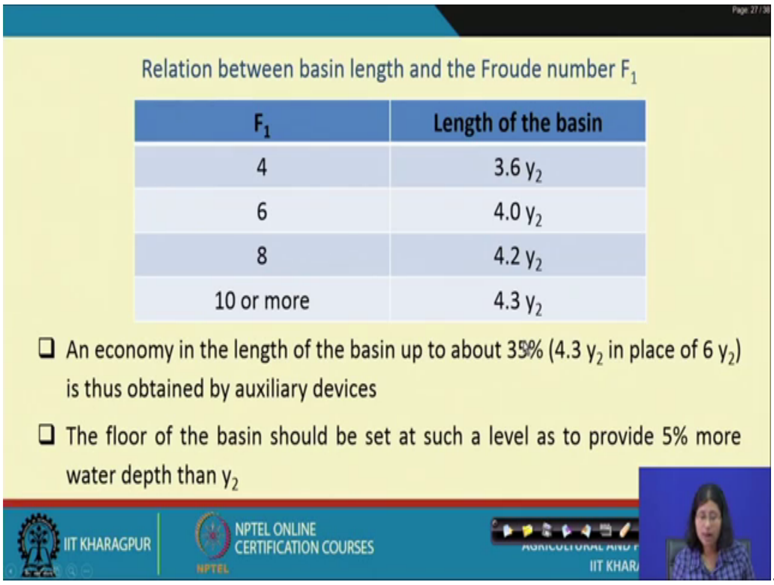

Now the relation between basin length and the Froude number; so, if the Froude number is 4 so, the length of the basin is to be kept as 3.6 times of y 2 then at a two interval if it is 6 then 4 times y 2, 8 4.2 times y 2, 10 or more 4.3 times y 2.

An economy in the length of the basin up to about 35 percent so, 4.2 3 y 2 in place of 6 y 2 is thus obtained by this auxiliary devices. The floor of the basin should be set at such a level as to provide 5 percent more water depth than y 2 . So, if you remember the design we did we kept as 5 percent more of y 2 in the water depth in earlier slides.

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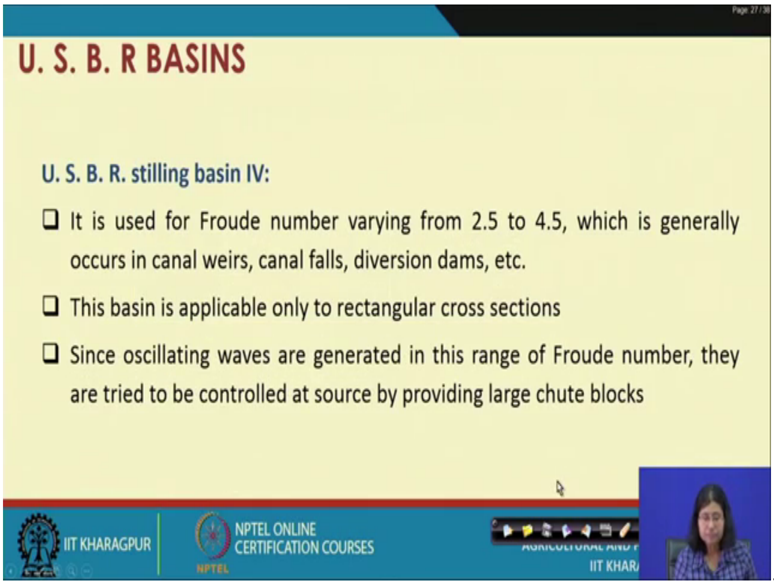

So, U S B R stilling basin four; it is used for Froude number varying from 2.5 to 4.5, which is generally occurs in canal weirs, canal falls, diversion dam, etc. So, this basin is applicable only to rectangular cross section. Since oscillating waves are generated in this range of Froude number, they are tried to control at a source by providing large chute blocks.

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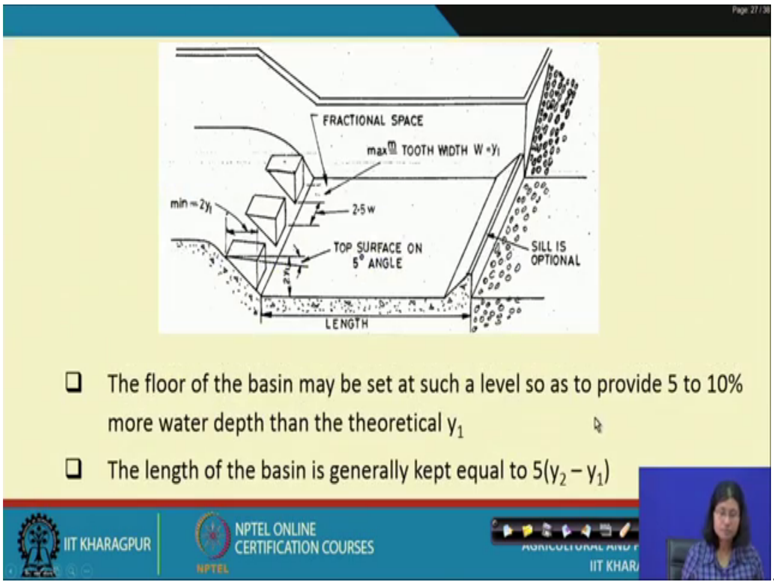

So, this is U S B R stilling basin four here. So, this is the top surface of the 5 degree angle. So, length of the basin and sill is optimum optional and floor of the basin must be set in such a way that level provide 5 to 10 percent more water depth and its theoretical y 1 value. So, the floor is to be kept in such a way it can provide 5 to 10 percent more water depth and the length of the basin is generally kept as the 5 times the difference between y 2 and y 1 the conjugate depth and the pre jump depth, so,

Thank you.