**Advanced Hydraulics**
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**Module - 4**
**Hydraulic Jumps**
**Lecture - 7**
**Surges (1)**

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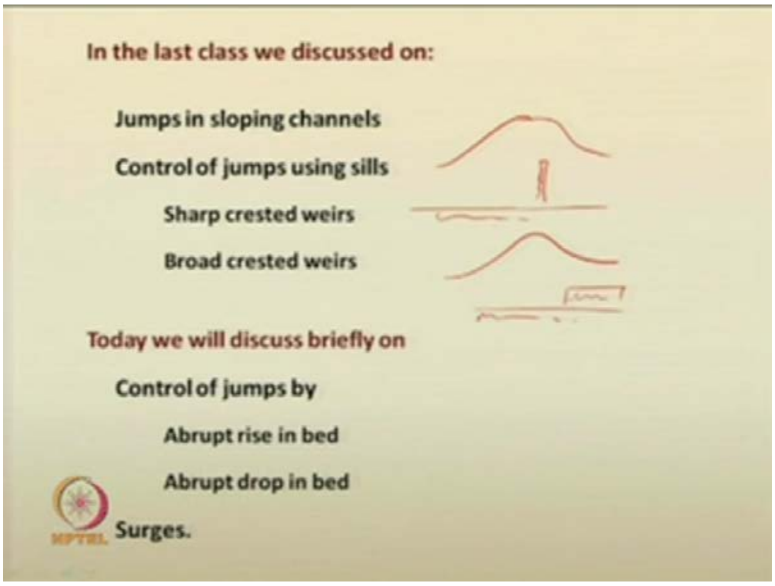


Welcome back to our lecture series on advanced hydraulics as we are in the fourth module on hydraulics jump. We have been dealing for last four 5 lectures on this topic. Especially in the last class we had discussed on jumps in sloping channels. We have also discussed on controls of jump using sills. We have also discussed how you can control the jumps using sharp crested weir? For example, like this if you have sharp crested weir. How you can control the jump? This was discussed. Broad crested weir also we had discussed it in the last class. So, jump can be controlled using broad crested weir. So, today, we will discuss briefly on control of jumps by abrupt rise in bed also how to control the jumps by abrupt drop in bed? So, these things we will just briefly go through them, we will not have detail discussion on them. Then, we will also discuss briefly on surges.

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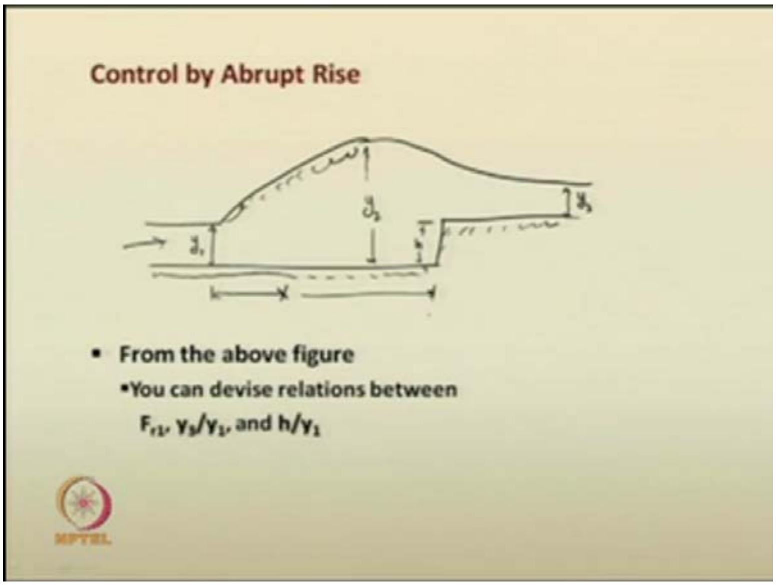


So, control of jumps by abrupt rise, what is meant by control of jump by abrupt rise? Say if the channel flow which is being subjected to hydraulic jump. If there is a hydraulic jump then, if you are providing an abrupt rise of the bed then, how the properties behave or what are the properties in such control phenomenon? So, in this case, you have the upstream or pre jump depth as y 1 then, the jump with the proper rollers, and all it is there. You have the sequent depth of this pre jump depth as y 2. Then, you have the height over the sill that is the depth of water, over the sill or the channel bed which the channel bed is raised here so that is y 3. So, you have the height of the sill as h.

So, with these following parameters you can easily see that the non dimensional parameters you can visualise for such a condition is there can be an incoming for the incoming flow, what is the Froude number? You can device y 3 by y 1 1 ratio; you can device h by y 1 as one ratio. And based on those things also you can suggest the length up to the toe of the sill as X.

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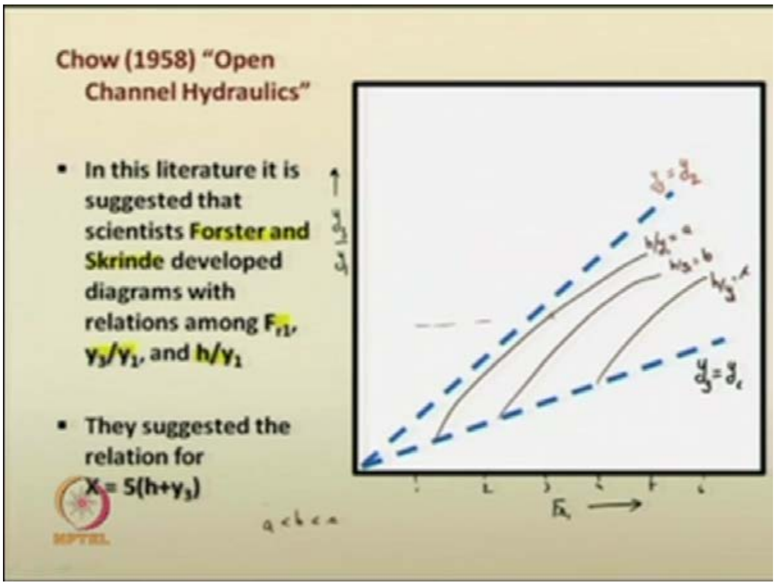


So, from Vent Chow's book on open channel hydraulics he has suggested the some of the literature works in which certain relationships of Froude number with respect to the other non dimensional numbers were given that can be used for the design purpose, especially for control of jumps by abrupt rise in the section.

So, these phenomenon they for example, Forster and Skrinde they have suggested relationships with Froude number as well as y 3 by y 1 and h by y 1 they can be given in the following. They suggested it especially at a length X is equal to 5 times h plus y 3. So, this thing here, if I can plot them the equations or the graph, that can be used for design. Here on the X axis on the horizontal axis you can have Froude number Froude number it can be 1 2 3 4 5 6 like that it can extend. Then, you have the non dimensional number y 3 by y 1 in the white coordinate 2 hash lines are drawn here, here the first one suggest I will just change the colour for your benefit.

This line suggest for the depth y 3 which is equal to critical depth if you recall the figure earlier figure this is y 3. So, if the flow over the sill if it is critical that is after the channel bed has been drawn elevated whatever flow depth if it is critical. Then that could be the minimum possible means you cannot go beyond that in such a situation. But for whatever elevation it is there for a such control for measure. Definitely it cannot go into the super critical condition means, you are providing jump for from super critical to sub critical conditions. Later on, it cannot come back into the super critical again so that is not advisable. So, critical depth is a minimum possible condition here.

So, here y 3 is equal to y c that condition can be incorporated then I can suggest one more line here, here the depth y 3 is same as the depth y 2. So, just go back into the figure, this depth y 3 is same as y 2, what does that mean? That means there is no elevation in the bed here at the section X, the elevation provided is 0 then, only you can have y 2 same as y 3 in such a situation. So, these are the maximum condition or the maximum possible phenomenon for such a thing. So, with in this you can plot, you can plot various curves that can be used for designed processes.

For example, this one particular curve I would like to draw is, say on curve it starts from here it goes on like this, another curve goes on like this. So, these are all individual curves for various ratios of h by y 1. So, say this is h by y 1 is equal to some numerical value a h by y 1 equal to some numerical value, b h by y 1 is equal to some numerical value c. So, definitely a is less than b it is less than c in this design criteria. So, you if you have such things then, for the given condition you can easily plot, or you can easily find what could be the post jump means? What could be the tail water depth? Easily say for h y h by y 1 curve if one curve it is given to you. And if the incoming Froude number is somewhere here just check, what is the depth? So, you will get the corresponding y 3 by y 1 ratio or y 3 like that you can infer for the design purpose.

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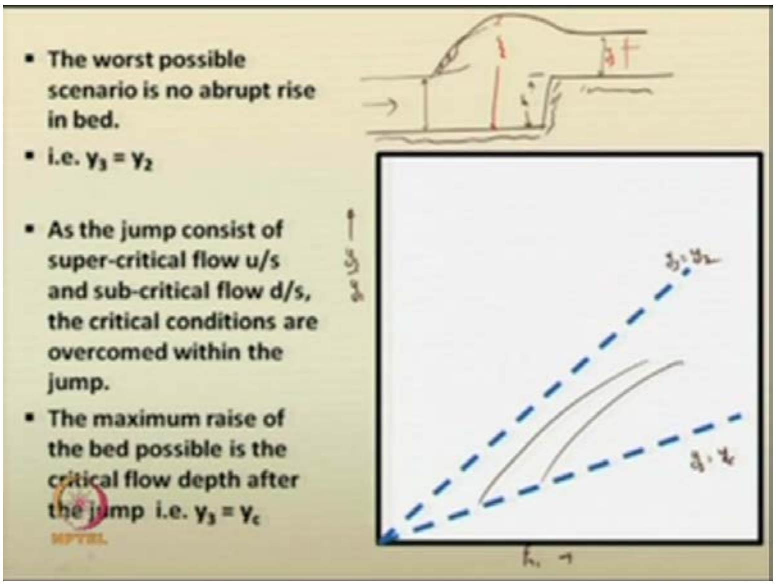

So, the worst possible scenario in this case is abrupt rise in abrupt scenario in the abrupt rise in bed is y 3 is equal to y 2 that is there is no elevation in the bed now as a jump. So, this is y 3 is equal to y 2 curve, and as said earlier y 3 is equal to y c curve these are Froude numbers and y 3 by y 1 on this X axis. So, the jump consist of super critical flow upstream. Now, if you just see for any of this curve as we draw I have drawn several curves what happens y 3 is equal to y c at y 3 is equal to y c. The jump consist of super critical flow at the upstream I am just again redrawing the thing here.

So, super critical flow jump occur and the subsequent flow is denoted like this. So, this is the jump so you have supercritical flow before the jump, sub critical flow after the jump. So, the critical conditions are overcome within this jump it is transforming from sub super critical to sub critical in the jump. So, the maximum raise of bed is possible is the flow depth here should be critical you cannot design any raise of the bed beyond this thing. If it goes beyond this thing, it may affect the hydraulic jump considerably. So, that is one criteria, you need to remember always.

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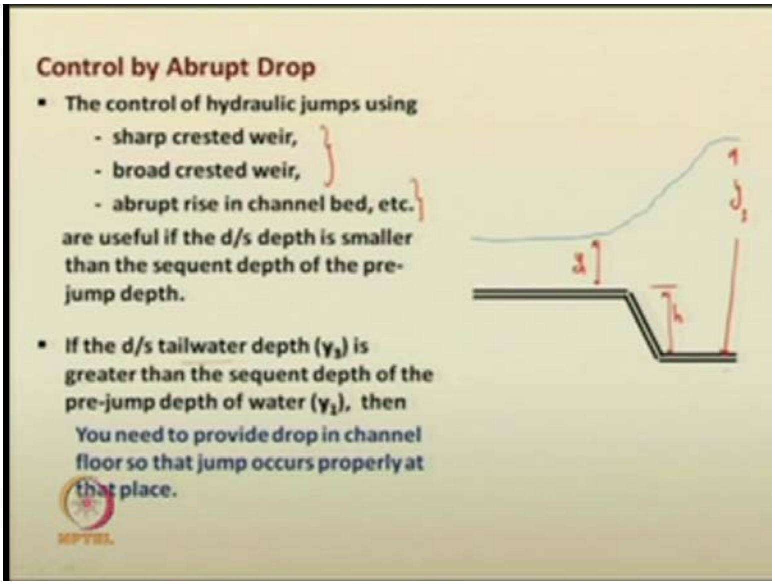


Next, which we would like to deal is the next topic which we are interested is control of jump by abrupt drops as we have studied in the abrupt rise case. Similarly, abrupt drop cases are also used for controlling various hydraulic jump for example, just recall the things in the sharp crested weir, broad crested weir as well as the abrupt rise in channel bed. What were the situations that for which all situations you used these mechanisms to control the hydraulic jump? Usually if the downstream depth for previously you just go through it. If the downstream depth these cases if they are less than the sequent depth of the hydraulic jump. You can definitely see here, here this is y 3 is less than y 2 here. So, if such situations are there, mostly in most of the cases if the downstream depth is smaller than the sequent depth then, the above mentioned sharp crested weir broad crested weir or abrupt rise in channel beds are used.

What happens if it is the other way? You have already studied how the hydraulic jumps are affected by the tail water condition so if the tail water depth or if the post jump depth, if it is higher than the sequent depth of the, if the tail water over the downstream tail water depth is greater than the sequent depth. Then, the pre jump depth of the water how it can be related with the hydraulic jump. So, you have the pre jump depth as y 1 here now this jump this depth is y 3 and the bed dropped is h. So, with these following cases you need to provide a drop in channel flow. So, that this jump occurs, if you are not providing such a drop in the channel flow like this then, this jump cannot occur in this place it may get shifted to some other place that you have already seen. So, that way to ensure proper occurrence of hydraulic jump in this location, you have to provide the drop in elevation.

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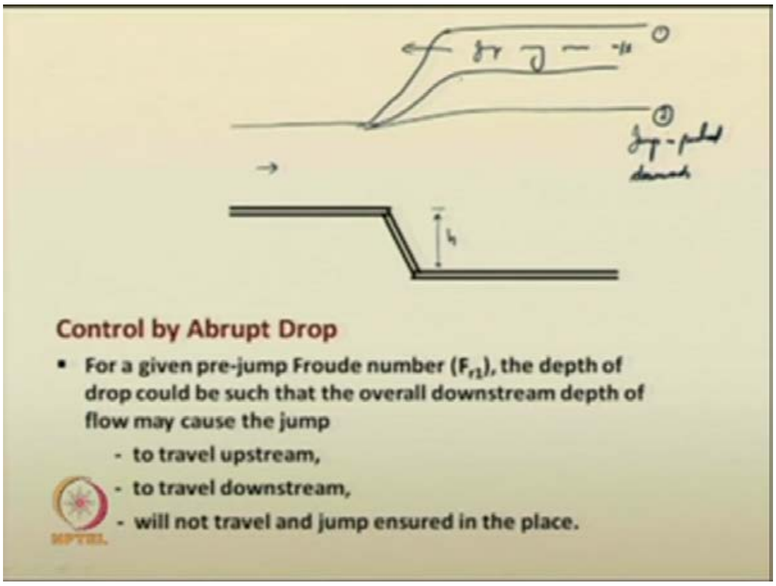


When you do the control of hydraulic jump by abrupt drop in the bed? You need to remember the following things; you need to remember for example, say if I just draw the water surface elevations. So, you have the water surface elevation so jump, if it is goes like this very much upstream, if it is like this say if this is the maximum elevation possible. Suppose, if the jump is occurring in this way, there are chances that this jump may move upstream. So, this jump may move upstream, there are chances for that then, there are certain jumps where the jump may be like this, when you are provides a such a drop it may the jump may have just occurred like this. So, here the jump is pushed downwards so here the jump may travel upstream.

In another case, for the same Froude number that is what for the same incoming flow based on the rise, based on this elevation, the jump may be either moving upstream or it may be pushed downwards, or it may be held within this section. So, for the first condition 1 here and the second condition given here for the first and second condition definitely the control by abrupt drop cannot be used, because your jump may be either pushed downwards or it may be well it may travel upstream.

So, you have you cannot use these particular control measures. So, these jumps are only feasible for the conditions where the hydraulic jump is within certain limit. So, it is not undulating it is not too high something. So, for those case only you can use these where if the stilling basin is provide along this reach. And all you can ensure that the jump occurs in this region only so with this we would like to conclude the control of hydraulic jumps. Now the next topic which we are going to deal is.

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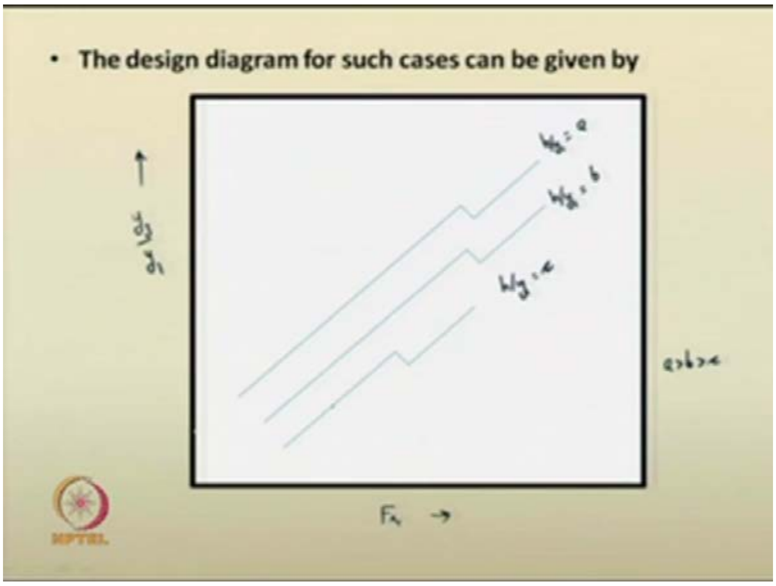

May I beg pardon I just forgot to mention; you can also device design curves for abrupt the control of hydraulics, control of jumps by hydraulic jumps by drops. So, here also we can say for the incoming flow Froude number, or the pre jump Froude number ratio y 3 by y 1 for the various cases say h by y 1 is equal to a h by y 1 is equal to b h by y 1 equal to c for different values of this particular ratio h by y 1 a b c where a is greater than b it is greater than c like that.

So, if you have such design, if you have such standard curves, and all these curves can be employed for the design of the design of the sills and all. So, that then jump occurs in that particulars location. So, you can easily if say for the given Froude number if the h y h by y 1 is some values c. You can see that the corresponding by 3 by y 1 ratio is so and so the y 3 depth is like this. Like this you can easily manipulate and use for design purpose.

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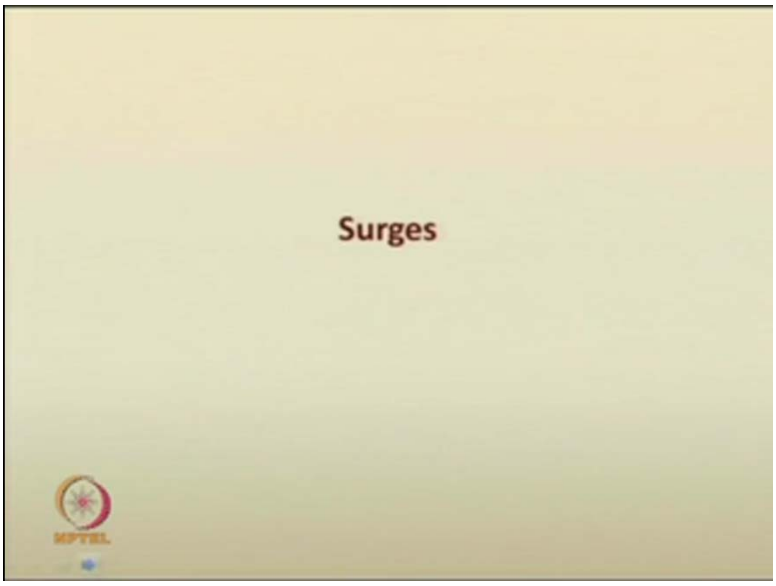


So, next as I told earlier we are going to go through the concept called surges.

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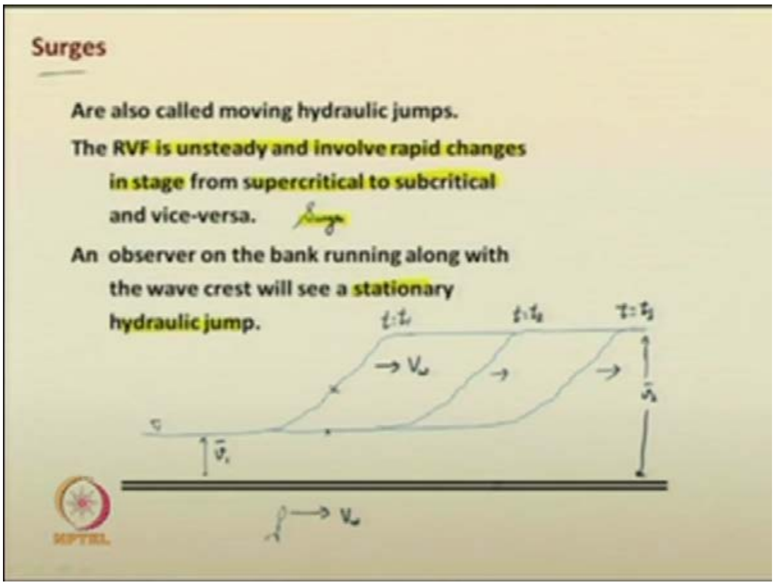


What is meant by a surge? Surges are also called moving hydraulic jumps. Precisely for that particular reasons only, we have incorporated this topic in this particular module. Actually for frankly speaking, this could have been means we could have made another module of this course where unsteady flow could have been incorporated in the entire course this thing. However, as per the syllabus given or as per the syllabus device for this course and all a separate module on unsteady flow is not being suggested. But still we will be dealing with this topic called surges that are called moving hydraulic jumps.

The rapidly varied flow in the earlier cases we have studied the rapidly varied flow in steady state conditions. So, if the rapidly varied flow is in unsteady condition and rapid changes for super critical to sub critical then, such quantities are called hydraulic surges. So, such quantities, that is the rapidly varied flow is unsteady it is unsteady and involve rapid changes in stage from super critical to sub critical and vice versa. So, those are called surges or usually it is called surges. Waves in waves it is more gradual in nature. So, that we are not going to study right now here, what is the peculiarity of surge? If there is an observer, say if there is an observer standing here on the banks. And if he moves with the same velocity of a wave say here you can see that the water is rising like this at this instant. And then, it is travelling like this. So, after a few minutes this would propagate up to here right.

So, in this case, this is called a wave or the water height it is not constant, it is not steady at all the times. At this same location you will see that at time t is equal to 0, we had a water elevation here at time t is equal to something else you have a water elevation here. So, you see that some wave or some mass of water it is just flowing above a certain water surface or a certain level of water it is being pushed. So, this is called as surge or a wave surge, because the water surface profile is rapidly varying. So, after that if you say this is at time t is equal to t 1; this is at time t is equal to t 2, time t is equal to t 3 the water surface profile will be like this.

So, if you have such profiles so an observer now running with the same speed, he will see a stationery hydraulic jump, he will see a stationery hydraulic jump. So, whichever topic you have studied earlier hydraulic jumps and all. So, those things will be applicable for him, because he is moving with same velocity. So, we suggest that let him move with a velocity V w velocity at which this wave of water is moving. Then, this person is also moving with the same velocity V w, and although the water velocity here say here it is v 1 bar, here it is v 2 bar like this you can have. Still he can observe it in a stationary form.

So, what are surges? Surges are formation of waves they are formation of waves. So, when a sluice gate is suddenly lowered or raised, such waves are formed. You I hope you know what is meant by sluice gate.

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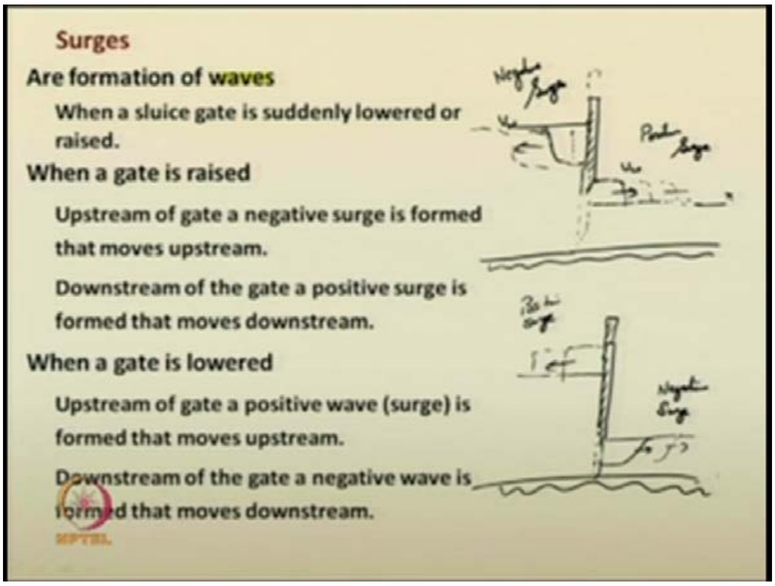

So, if a sluice gate is suddenly raised say for example, if you have a such sluice gate so either so it can be lowered or it can be raised. So, due to this phenomenon there will be a wave that will be propagated along the surface of water, a wave of wave of water will be propagated. So, this how this wave or how the open channel flow in those situations are analyzed for example, in this case surges are formed say when the gate is raised upstream like this when the gate is raised definitely the water here will get lower. So, here there will be a formation of a wave like this due to the when the gate is raised like this. And this thing will be propagated as time goes on this will propagate like this.

So, this, what is happening here? As the wave is moving from here to this position the depth of water is getting reduced. Now, the wave is propagating in this direction V w the depth of water is getting reduced so such surges are called negative surges. And what happens in the downstream? Due to the raising of this gate water which was initially at this level will now suddenly raise like this, say after a few seconds it will go like this. So a wave will be propagated in this downstream direction not only that, during the propagation of wave in the downstream direction the depth of water depth of water depth of water also increases so this is called positive wave or positive surge. So, when a gate is raised upstream of the gate a negative surge is formed that moves upstream like this. So, a negative surge is formed that will move in the upstream direction like this. Downstream of the gate a positive surge is formed that moves downstream like this so these things you need to visualize.

Similarly, when a gate is lowered, what happens? You are lowering the gate now initially its position was like this. Now, due to lowering of the gate suddenly this water height will increase and it will raise like this, and simultaneously earlier the water level was like this it will get dipped and it will go like this. So, this wave will propagate like this in the downstream direction, this wave will propagate in the upstream direction like this. So, here when a gate is lowered, positive surge will be formed that will propagate in the upstream direction it will go like this. And negative surges form in the downstream of the gate, and that will propagate in the downstream direction. So, these phenomenon’s occur so surges are formed due to sudden raise or lowering of the sluice gates.

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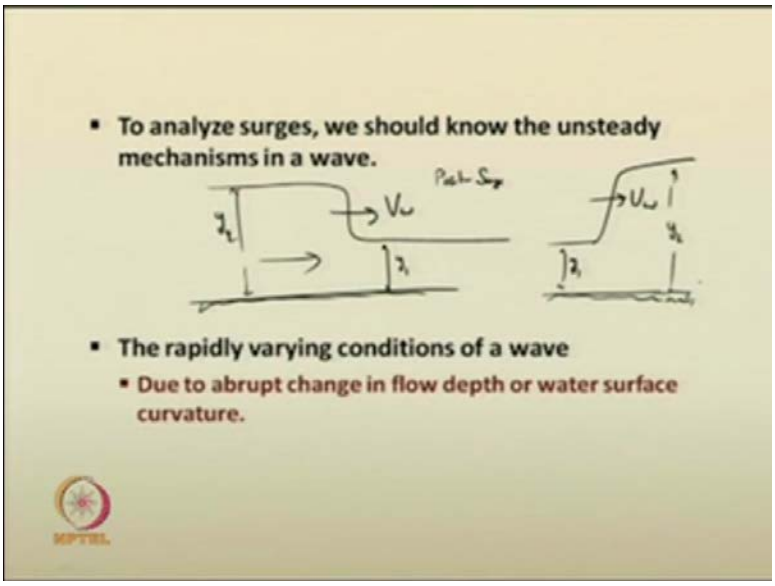


So, how do you analyze these surges? You need to understand the unsteady mechanism in a wave. So, you have, say all of a sudden wave travelling like this in the flow direction. So, this is a positive surge or you have a negative surge that is the wave is getting pushed downstream. So, as the water flows in the downstream direction the flow or the, the depth of water get reduced. So, such criteria's you can easily visualize y 1 or y 1 y 2 I will tell you why this is called y 1 here, y 2 here and all. So, how do you analyze this thing? You can see us rapidly varying condition, say the front of the water in the wave it is almost vertical that is why it is called a surge.

So, due to abrupt change in flow depth or the water surface curvature the unsteady mechanisms are prevailing in those situations. And you need to analyze surge using unsteady flow mechanisms, but how far is the requirement of unsteady conditions? Therefore, the analysis of open channel flow for surges.

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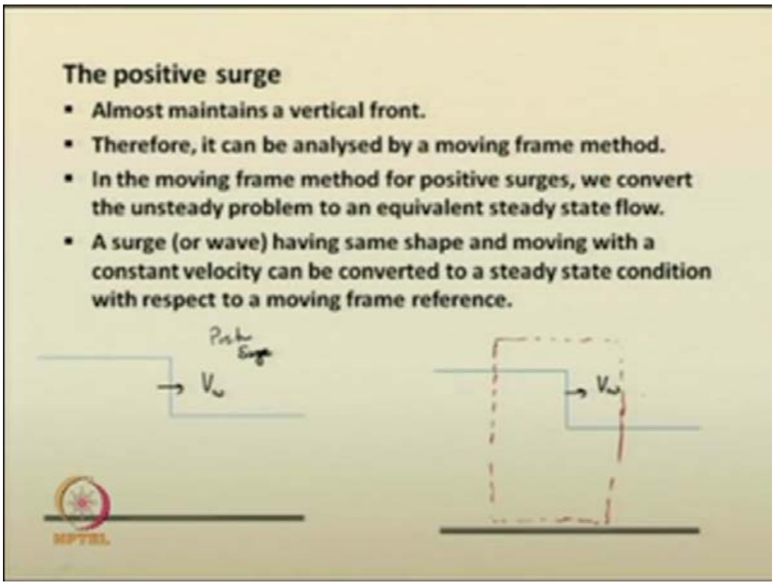


For example, consider the positive surge I am just giving a positive surge here consider a positive surge. So, it has almost a vertical front. Now, just by simplifying the situation, as we told earlier in this particular case, as the wave is getting propagated in the downstream direction. And the person if it is he is moving with the same velocity of wave then, he will be observing a stationary hydraulic jump. So, the same crude phenomenon or the crude principle we are going to adopt it. And it will be now more scientifically called as moving reference method.

So, here the person if he was stationary he would have seen different fluctuations in the water surface at that location, but as he is also moving. Now, he is the reference object and as he is a moving object, moving reference object you were able to identify the wave or the surge in the water in the channel as a stationary hydraulic jump. So, the same phenomenon if he incorporate again. For example, in the positive surge using the moving frame method we can analyze the positive surge, say this is a positive surge. So, in the moving frame method we what we are doing is that we are converting the unsteady problem to an equivalent steady state problem. You know the stationary hydraulic jump it is a steady state problem. So, as the reference of frame now the frame reference as it is moving you were able to visualize a equivalent steady state condition for the surge, say surge having same shape and moving with a constant velocity can be converted to a steady state condition with respect to the moving frame reference. So, if, for the moving frame reference in this case, if I identify them now the frame reference itself is moving.

So, we will be moving along with this way. So, if I take a control section, if I take a control section now what happens? So, I am taking a control section like this now. And now this control section will also be moving with a velocity V w. So, this entire control section it is moving with a velocity V w. And you can now easily apply the principles of this control volume Reynolds transport theorem you have already studied the same principles you can use them and try to analyze the things.

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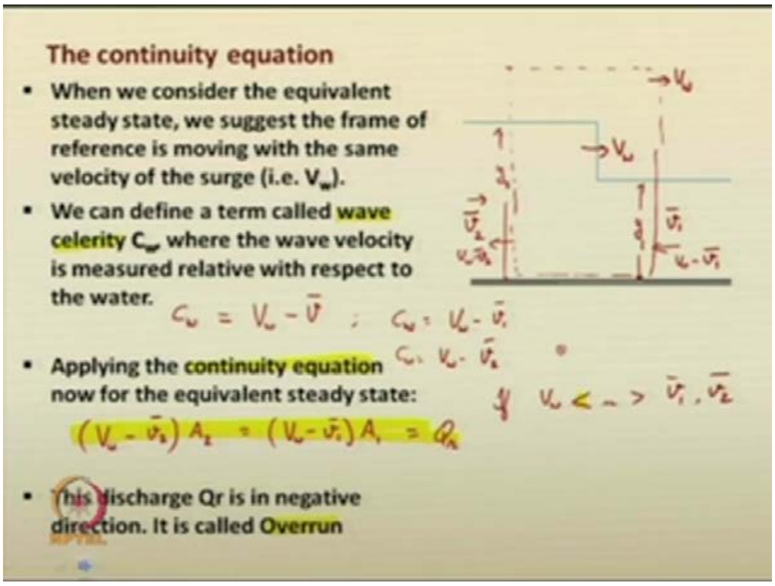


So, the continuity equation in the moving frame analysis, let us apply them before that it is better, let me give you the control frame now in this case a wave is moving with velocity V w. So, actual velocity of water in this section it is say v 2 bar average velocity, in this portion it is v 1 bar. Let us suggest this depth as y 1, let us suggest this depth as y 2. Now, why I am using y 1 on the right side, y 2 as in the left side? For this cases, that you recall the hydraulic jump in the steady state condition. So, the y 1 usually you used it for the super critical condition, or for example, lower depth condition, and y 2 for the higher depth conditions it is corresponding to its sequent depth or like that.

So, in this case also, we are now suggesting in that same way the lower magnitude of depth is generally given as y 1, higher magnitude of depth of flow is given as y 2. So, the frame of reference, now this frame of reference is also moving with a velocity same as the surge velocity V w. You can define a term called waves celerity I can now define as term called waves celerity C w, such that the velocity of the wave is now measured relative to the velocity of water. So, instead of measuring the velocity of wave to a stationary object on the banks or anything I am now measuring the velocity of wave with respect the velocity of water. So, what happens? C w I can just give it as velocity of wave, relative velocity of wave v bar so C w it can be V w minus v 1 bar or C w can be V w minus v 2 bar like this if you are able to visualize, if you are able to define this wave celerity term as defined here the wave celerity.

Now I can proceed for the next quantities to analyze the thing. So, what happens to the wave here? If V w, if it is greater than v 2 then, you have a direction in this case, if V w is greater than v 1, you have a quantity in this direction, or if V w is less than v 1 you have a quantity in this direction; you have quantity in this direction. So, we do not know the actual situation so V w, we do not know whether it is greater than v 2 or it is less than it is greater than v 2 or it is his greater than v 1. So, in that way you cannot try to analyze the quantities I can apply the continuity equation for this entire control volume, the continuity equation is now applied it is applied for the equivalent steady state condition. So I am going to use the relative velocity term so the relative velocity term. So, we do not know so we will just write it this quantity V w minus v 1 bar, we are assuming it in this direction. Similarly, V w minus v 2 bar we are assuming it in this direction.

So, in this entire moving frame method now the continuity equation if I apply for the relative terms for the using the relative terms, we can have the continuity equation in the following form the, you we are using the relative velocities now. So V w minus v 2 bar as we have already taken the steady state approach. So, V w minus v 2 bar into a 2, the cross section in the upstream portion here. This is equal to V w minus v 1 bar into A 1 that is there is some discharge and that using the relative terms and that discharge. Let us define it as Q r so this discharge Q r is now in the negative direction it is also called the overrun it is called the overrun due to the wave propagation.

So, here what we have studied that due to the moving frame difference the relative terms were taken into account. And due to this relative term as we suggested we are not quite clear if V w is greater than, if V w is less than or greater than v 1 bar and v 2 bar. So, we are not quite clear. So, we are assuming that let us let V w be less than v 1 and v 2 in that condition we will be having V w minus v 1 bar in the negative direction, V w minus v 2 bar also in the negative direction and that is that has been taken into care here. So, the equivalence in the equivalence steady state the continuity equation will be given in the following form.

So, this discharge Q r is now in the, this it is due to this thing the additional discharge of whatever discharge is occurring it is called the overrun due to the moving frame of reference.

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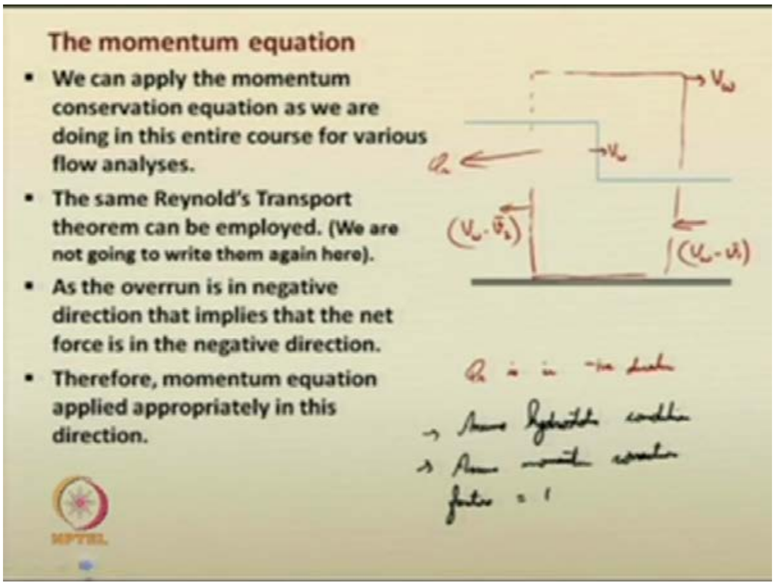


You can similarly use the momentum equation also to analyze the fluid flow due to search. So, same control volume method, if I apply now I can consider, say consider the following control section now or the control volume. So, this is the portion so the wave is moving with a velocity V w. So, we are suggesting this frame is also moving with a velocity V w. So, you have a relative velocity in this direction V w minus v 1 bar here, you have a relative velocity in this direction V w minus v 2 bar in this direction.

So, the one dimension as this is the dimensional one dimensional case, the we are using the same Reynolds transport theorem as mentioned earlier here I am not going to write it means we have written it for many cases. So, the overrun Q r is in negative direction so your Q r is in negative direction. So, what does that mean? So, if the overrun is in the negative direction the net force is also in the negative direction? Therefore, I am taking the momentum equation I am applying the momentum equation for the net force in the negative direction, based on that we can write the momentum equation. For that I am just assuming hydrostatic pressure condition.

So, we have to assume for the momentum analysis, assume hydrostatic condition now also assume momentum correction factors as 1, momentum correction factors equal to 1. So, that way if I consider these things I can write the momentum equation as follows.

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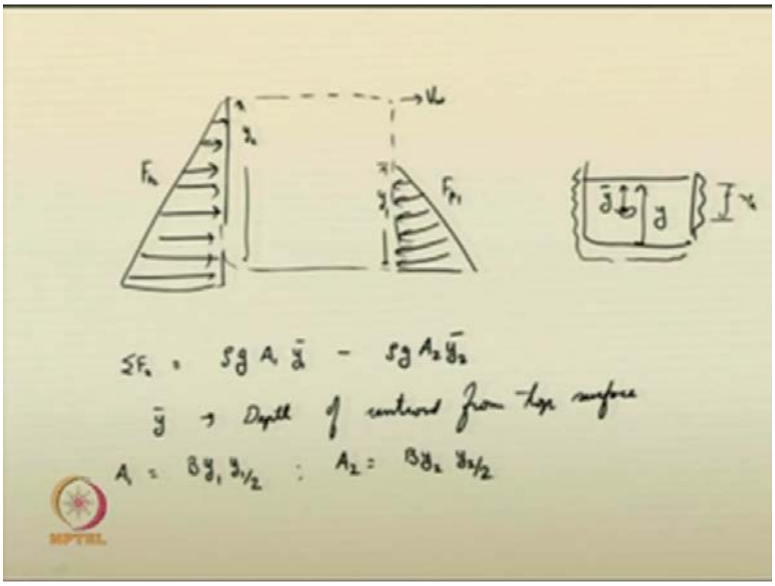

So, the net force say in this control volume now will be, such that here you have the hydrostatic force on these walls. You have the hydrostatic force on these walls like this. So, this is F p 1, the force will be in this direction I will just rube it again. So, here the hydrostatic force is in this direction. So, this is F p 2 F p 1 the weight as we are considering horizontal channels, the weight effect of weight and all that is being neglected here.

You have the depth of flow here as y 2, here this is depth of flow is as y 1, the frame is moving with A velocity V w. So, the net force acting here the net force acting here is, it can be given by rho g A 1 into y 1 bar minus rho g A 2 into y 2 bar where y bar, this terms y bar suggest depth of centroid, any section you take say if I am taking a rectangular section say if this is the depth of flow y. Then if the centroid is at this depth this particular quantity is called depth of centroid from top surface, from top surface of water so that is this quantity. So, for a rectangular channel you know the centroid is same as y by 2.

So, same thing we are going to apply. So, the hydro static force on the left side and on the right side. So, the net force it can be given by the following things. So, rho g A 1 y 1 bar minus rho g A 2 y 2 bar as we have net force in this direction we are taking so rho g A 1 y 1 bar is the first quantity you are taken minus rho g A 2 y 2 bar. So, this is nothing but equal to rho g A 1 y 1 bar and rho g A 2 y 2 bar.

So, you have A 1 is equal to B 1 into B into the width of the channel we are assuming it same. So, B into y 1 into y 1 by 2, A 2 is equal to B into y 2 into y 2 by 2 so these are the areas. So, effect due to these things we can write it now in the effect due to the control surfaces means you remember.

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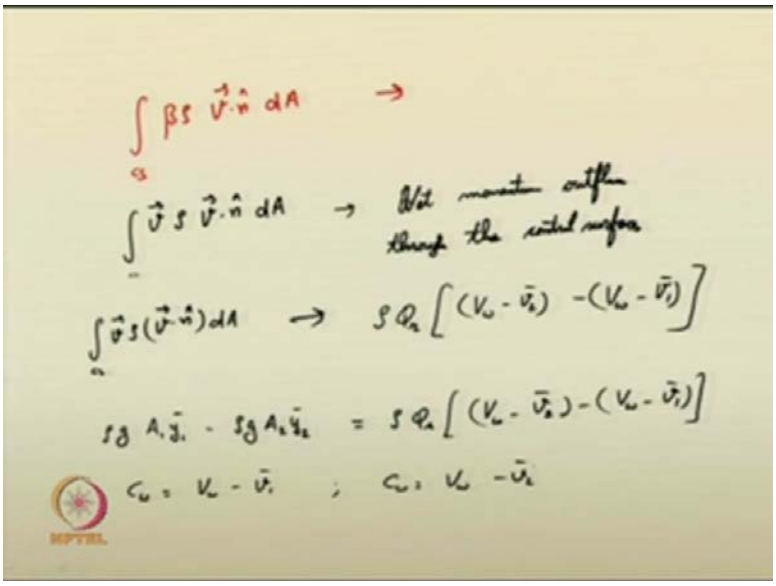

The quantities beta rho v dot n d A was the net outflux of the extensive property across the control volume, this you have studied it continuously over this course. So, in the case of momentum, we have beta as velocity so v rho v dot n d A for momentum net, momentum out flux through the control surfaces. So, for this case, you have on the left side depth of water as on the left, left side you have the depth of water as y 2, right side you have the depth of water as y 1, those two are the control surfaces that allow flow through it. So, we can now suggest this quantity in this is equal to v rho v dot n, this is vectorial form. This can be easily represented it I am not writing it as equal to please note that. So, this is represented by the following quantity.

So, v rho into d A in each of the control each of the area surface areas of those control volume, what does that mean? So, the left hand side as well on the right hand side those quantities denote discharge. So, you have the discharge in this net discharge in this moving frame method as rho Q r is into V w minus v 2 minus V w minus v 1 bar.

So, we have the following quantities so this will be incorporated there this control quantity we will incorporating our. We will be equating them this is equal to say rho g A 1 y 1 bar minus rho g A 2 y 2 bar is equal to rho times Q r into V w minus v 2 bar minus V w minus v 1 bar, like this we will be equating them. So, recall the wave celerity as V w minus v 1 bar or C w is equal to V w minus v 2 bar. So, based on those things we will now suggest the following form. Substitute these quantities substitute C w in the expressions here everywhere.

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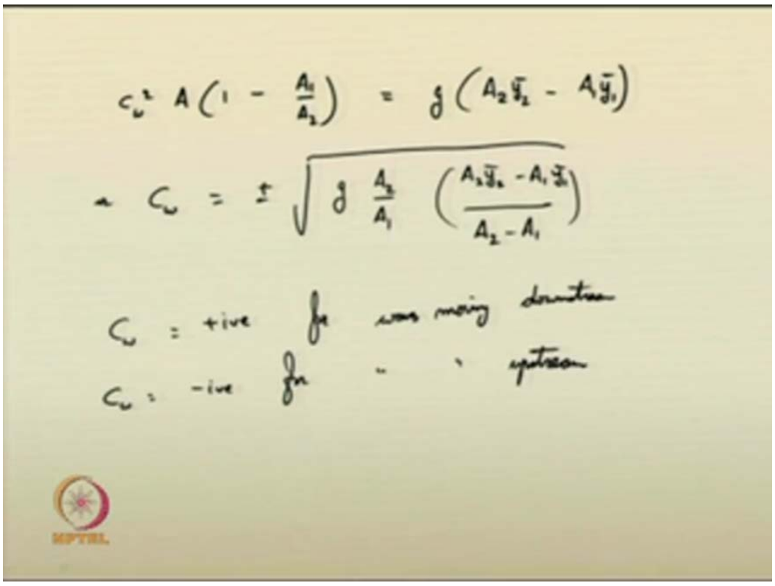


So, we will now suggest the quantity as C w square into A into 1 minus A 1 by A 2 is nothing but equal to g times A 2 y 2 bar minus A 1 y 1 bar, or the wave celerity can be found from this momentum method as square root of g into A 2 by A 1 into A 2 y 2 bar minus A 1 y 1 bar by A 2 minus A 1, like this you can find the wave celerity. So, C w will be positive for positive for waves moving downstream. So, whichever waves moving downstream we consider C w as positive, C w is negative for waves moving upstream. So, then using this thing, we will quickly do on numerical problem we will just solve that.

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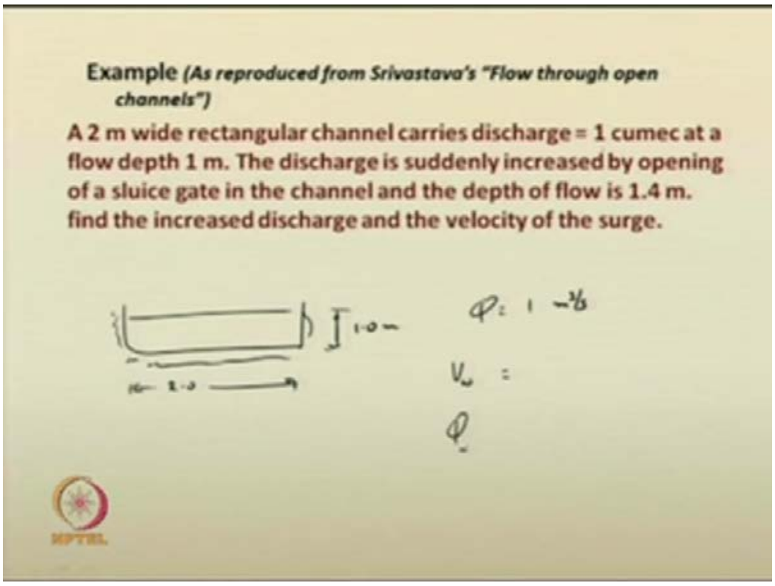


And this particular example is taken from Professor Srivastava's book on "Flow through open channels" The question is a 2 meter wide rectangular channel A 2 meter wide rectangular channel carries discharge Q is equal to 1 meter cube per second cumec at a flow depth 1 meter. So, flow depth is 1 meter the discharge is suddenly increased by opening of a sluice gate in that channel, and the depth of flow has now become 1.4 meter. Find the increased discharge and the velocity of the surge? Find this increased discharge and the velocity of the surge? How will you measure say we need to find the velocity of surge V w and also we need to find the increased discharge? How do you solve this particular problem?

So, again we will just go through the basics thing we have at the upstream at the as we have suggested the sluice gate in the channel is open. So, the discharge is suddenly increased by opening of a sluice gate in the channel. So, what happens if you open sluice gate in the channel? What type of wave is being propagated when you open the sluice gate? You remember that so it is a positive surge.

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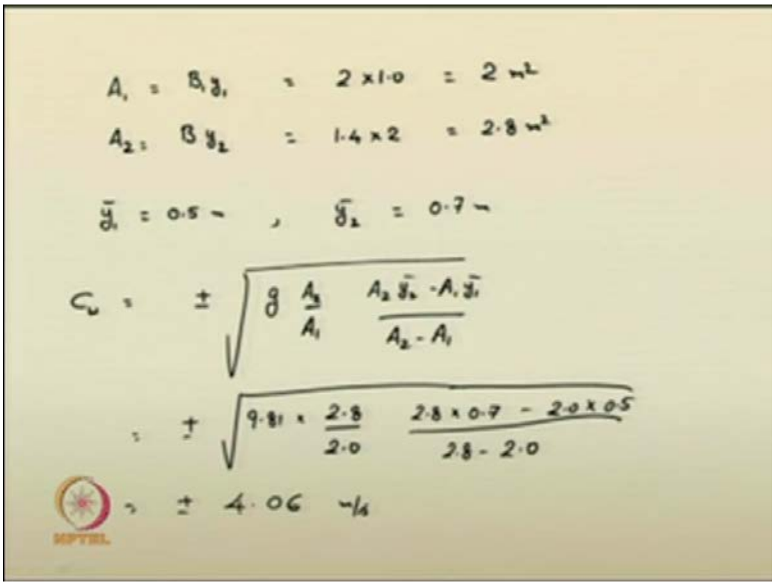


So, the same thing A 1 is equal to B 1, A 2 is equal to again B into y 2. This is nothing but 2 into 1 is equal to 2 meter square A 2 is equal to the new height is 1.4 and the width of the rectangular channel is same. So 2.8 meter square, you have the depth of centroid y 1 bar as 0.5 meter depth of centroid in the downstream section as 0.7 meter. So C w is given as plus or minus root of g times A 2 by A 1 A 2 y 2 bar minus A 1 y 1 bar by A 2 minus A 1, we will be applying the same formula. So, g you know it is nothing but 9.81, A 2 is 2.8, A 1 is 2 so 2.8 into 0.7 minus 2 into 0.5 divided by 2.8 minus 2. So, this quantity it is coming as plus or minus 4.06 meter per second.

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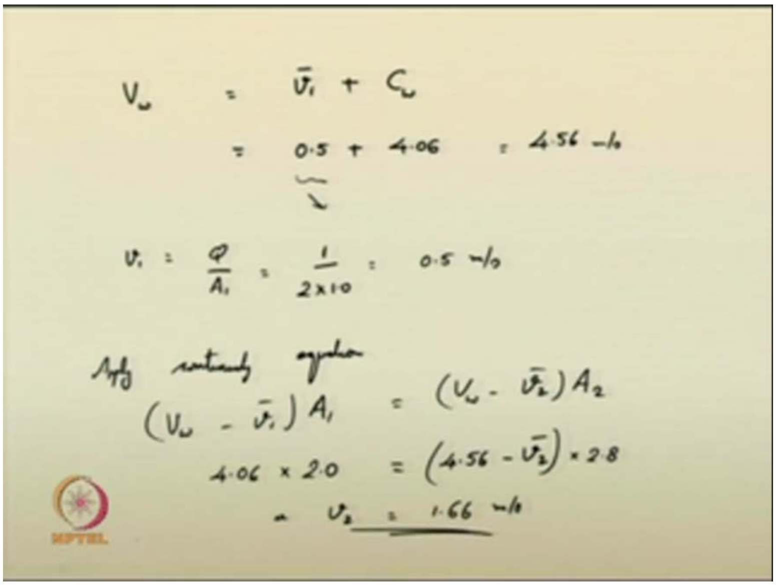

So, you have now celerity, celerity C w as 4.06 meter per second. So, the velocity of the surge will be equal to v 1 plus C w so this is nothing but equal to 0.5 plus 4.06. How did you get this 0.5? You know v 1 is equal to Q by A 1 so 2 into A 1 is 2 into 1. So the Q, Q is 1 cumec per meter. So, this is 0.5 meter per second that I have incorporated it here so 4.56 meter per second.

So, apply continuity equation now. Apply the continuity equation V w minus v 1 into A 1is equal to V w minus v 2 bar into A 2. So, you will get V w minus v 1 bar is nothing but celerity 4.06 into 2, this is equal to V w is 4.56 minus v 2 bar into 2.8 or v 2 rearranging the terms you will get this as 1.66 meter per second.

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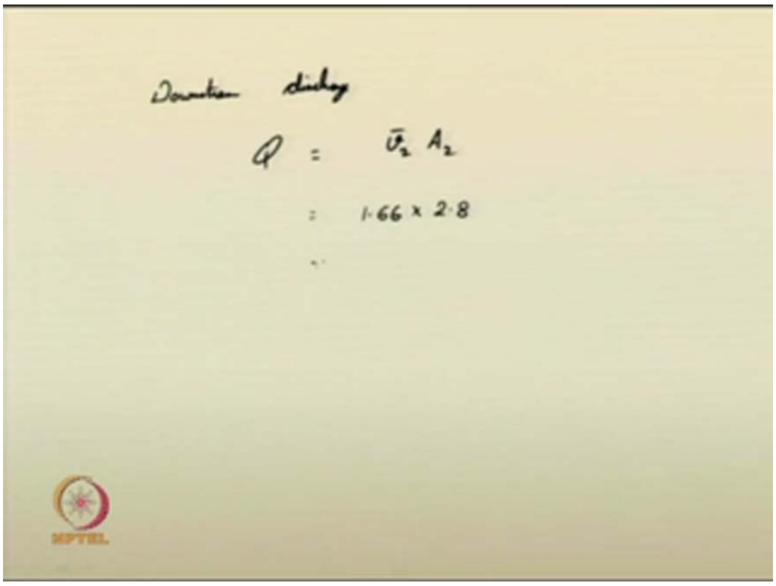


Similarly, downstream discharge increased discharge Q, you will get it as v 2 bar into A 2, by multiplying this I think I there is no need to for me to do this thing, because you already got this thing. So, two point, A 2 is 2.8, substitute this you will get the modified discharge. So, that way we would like to conclude the following portion. We will continue with this topic in the next class also.

Thank you