Hydraulics

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Module No. # 01

Introduction To Open Channel Flow

Lecture No. # 05

Practical Use of Velocity Co-Efficient In Channel Flow

Friends, we have discuss about the velocity co-efficient in the last class, I mean why did we use this velocity co-efficient, and of course, we have discuss some of the special cases where the pressure may not be hydrostatic in a flowing fluid. Now, today we shall be taking up some problem of the real field just to have a feeling that why we are doing all these things and where these things can find its application. Of course, we are taking a problem that is practical use of velocity co-efficients in channel flow well, and before going to that, let us recapitulate what we did in the last class.

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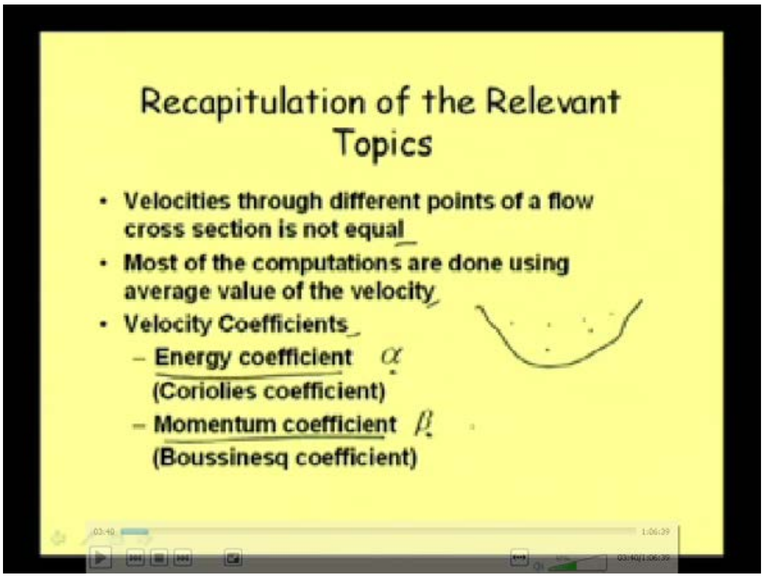

First, we did discuss that velocity through different points of a flow cross section is not equal. What we mean by that? Velocities through different points of a flow cross section are not equal. That is what we did discussed, and by that what we mean that, if this is the cross section, velocity at different point will be different, fine. That was discussed in the last class then, but most of our computation, most of our computation, say suppose we want to calculate energy of flow or we want to calculate what is the mass flowing through a particular section, or when we want to calculate, say what is the momentum of that flow and different sort of calculation we do in all those things. In all those calculations our velocity is an important parameter and that velocity we use always as the average velocity, because in real situation, we do not find, I mean it is not possible to have the velocity of each and every point separately and that is not possible.

So, most of the computations are done using average value of the velocity well. Now, so to take care of that, that in reality the velocities are different, but we are using a average velocity; so we use some co-efficients that we term as velocity co-efficient, and say one of those co-efficient is energy co-efficient that we use energy co-efficient alpha; that we use for calculating energy. Then, another co-efficient is momentum co-efficient beta which is used for calculating momentum.

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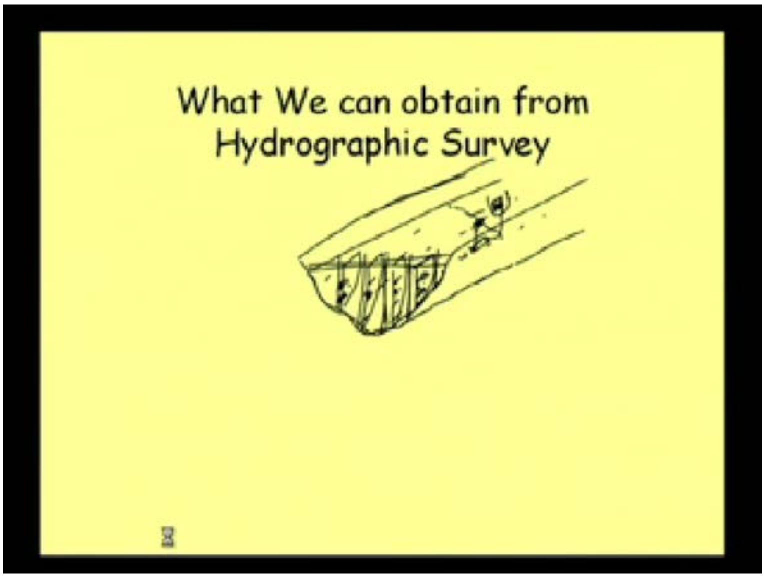

Well, with this discussion, we can go ahead to a real problem. Say in a field, suppose in the field in a river we want to compute energy or mass or the momentum, then what we will be basically getting from our observation in the field? In the real field, we need to carry out hydrographic survey. So, by hydrographic survey, what we can get? Let us see. I am just explaining this in this slide. Let say our river is this one; this is the river, and water is flowing at this level. This is the bed, fine.

Now, there are different methods of conducting field experiment or field observation. Say if we want to know, what will be the, as you have seen what will be the velocity at different point? Then we can go by one procedure that, say we can have a section from here to here. Suppose this is our, the, the, section what we have in form that is the section; let this be the section, and in this section, we have some equipment that we call as say current meter. Earlier, the procedures were like this. Earlier means why I am saying earlier, because now, it is lot of sophisticated devices has been developed and that way the procedures are becoming more simple.

Earlier it was very much cumbersome. Say we need to decide. Suppose this is the section from here to here. First, we need to decide that this is our alignment, and in this alignment, we need to move. Suppose we are carrying a boat and we are moving to this point and we have a equipment, suppose current meter. Then putting the current meter at this point, we can measure the velocity or some other equipment also we can put of course. So, say one equipment I am saying about this current meter. Suppose we are putting the current meter and we are measuring the velocity here. Then, we can put the current meter here; again we can measure the velocity.

So, there will be current meter, will be mounted on some vertical rod, so that and we know the distance or depth at which we are putting the current meter, and then, what velocity we are measuring. Then when we are moving in this direction, then we are putting it here and here or may be here. So, like that at different point, we are putting the current meter and we are measuring the velocity.

Well, now, from this record, from this record, now what sort of problem we can have? When we are moving along this point, we need to keep our boat fix here. That is one problem. Then sometimes, we keep on moving then measures, then we need to make lot of correction in those measurement because there is will be a speed of the boat also. So, anyway by some measures, we, we, can measure the velocity at this point.

Then we have observed that, in this vertical section, some velocity we are getting and there may be when we plot this thing again on surface also we can measure velocity. That surface velocity we can measure by putting a float on the surface. That float we are putting and we are observing that how many, what distance it is moving in a given time. So, that we are getting velocities, and then, suppose in surface, this is the velocity at this point some amount of velocity. So, if we plot all those things, we can get a velocity vertical velocity variation in the vertical section.

Similarly, here, we can have another velocity diagram; here, we can have another velocity diagram with different velocity; here, we can have another velocity diagram like that. Then we can have say average velocity of this section, we can have average velocity of this section, of a particular section, and for obtaining the average velocity, we have already discussed in the last class that how we can derive the average velocity.

So, for that section, we can have a average velocity. Then what we can do? We can say find a, we can just divide the intersection into several subsection, and then, what we can do? For each vertical, we can find a average velocity; here also we are finding an average velocity; here also we are finding an average velocity, and then, again considering these average velocity, that is, this become the velocity of the average velocity here become the velocity of the this section.

That means, now this is becoming suppose elementary section, this bigger section. Then for this velocity is becoming the velocity for this section, these velocity is becoming velocity for this section. Like that, again we have a set of velocity and area, and from that, again we can find the average velocity of the entire section, we can find the average velocity of the entire section, by say considering this velocity into area, this velocity into area, this velocity into this area, this velocity into this area, and then, dividing it by entire area, entire area, dividing this by the entire area, we can find the average velocity of all the section. So, this is one way of doing or one way of finding the average velocity.

Now, based on this average velocity, we can calculate what energy, what kinetic energy is flowing through this section. Now, as we did explain already in the last class that, if we just calculate the energy based on the average velocity, here again we introduce some error and that is why we need to know what is the value of alpha, that is, the velocity co-efficient of this section, but when in the practical field, when we are measuring, what we are getting is that velocity at different point we are getting. Of course, this is the procedure of measuring velocity which was done earlier. Now a days the systems are of course changing because we have today for location, for position where we are measuring the velocity to know that we have equipment like global positioning system.

So, when we have a gps, then it is not necessary that we need to move in a particular direction. Say we can move in this direction and then we are suppose measuring the flow velocity at this point, then we know that where we are measuring. We have a global positioning system. So, we can record our position in terms of latitude and longitude, and once we record our position in terms of latitude and longitude, then we can measure the velocity.

Again for measuring flow velocity also, we have equipment like say some sensors are there. I do not want to go to into more detail of that part, but we have flow meter now. That flow meter means say digital flow meter we have, where say some sensors are there. If you put that sensor at a particular depth or rather we need not even put it in a particular depth, say if we put the sensor, this sensor will automatically show you at what depth this is being placed, and this principle is very simple. Say we are putting our sensor here, we are putting our sensor here.

Then there will be a pressure of this much on the sensor, and then, because of that pressure, it can calibrate at what distance it is, and suppose there will be some wire which is connected, your, your, boat may be here, and then, here you are having that observation meter or record you can keep here, and so, you are getting at what depth it is, and again, the same time using some other principles this flow is coming here. So, it can measure what the velocity of flow is. Like that we can move and we can measure the flow velocity.

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I am just giving you one example how it is done in the real field. How it can do? Say here, this is, this stick is carrying a sensor at the bottom is not seen here and this wire is connected to this sensor which is being placed at the bottom, and then, this is connected to this flow meter, and say we are enquiring our boat and then we can see that, if the flow is, what is the flow of this river, what is the flow velocity of this river at a particular depth. That way we can keep on measuring. This boat can be moved, and with gps we are recording our positions.

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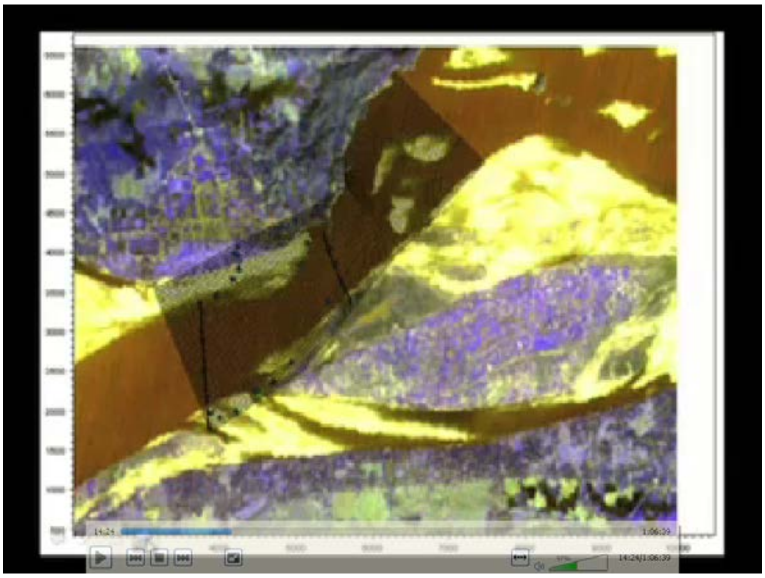

So, that way we can keep on going, and similarly, then you can see these are the points say where we have recorded our velocity, where we have recorded our velocity at different point. Now, from these information, we are getting some idea that where the flow velocity is how much, and from that, if we take a section, suppose we can now take a section along this line, these points are there and we can take some section along this line where we have some points there. So, we can know that what is the velocity at different point, and of course, now it is more sophisticated devices are coming.

This is the, I mean devices is same, that is, we are having gps; we are having say flow meter. Again we can have echo sounder. Echo sounder what it do, because here, with the sensor the depth at which we are placing, we are getting the flow depth and we are getting the velocity at that particular depth, but along with that, if we carry a echo sounder, then from that point, we can record at what is the total depth of the channel. So, total depth of the channel also we can get, and then, velocity in terms of depth ratio; that means, what depth we are measuring the velocity and what is the total depth. With that ratio what, what, the position that way also we can see well.

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So, combining all these things, now we can have a very sophisticated vessel also like this. Say survey vessel, this sort of survey vessels are well equipped all those devices than say our direction also we can just fix here. You can see that here, if we have, we have all those devices where we can record the velocity and we, this sort of vessels are equipped itself compass also. So, if we want that in particular direction, we want to move; we can follow the compass and we can move in that particular direction, and then, there is a system that automatically the depth we can adjust that depth after a given time, automatically after certain time, this depth are recorded, and similarly, if we can have a flow meter, we can record the velocity also.

And then this sort of vessels are of has of course limitation like that. If your channel depth is very narrow, then a this sort of vessel may not be able to narrow or I mean shallow. If your channel is shallow, then this sort of vessel may not be able to move. Then also this entire device can be put in a small boat and we can carry that for measuring the flow velocity.

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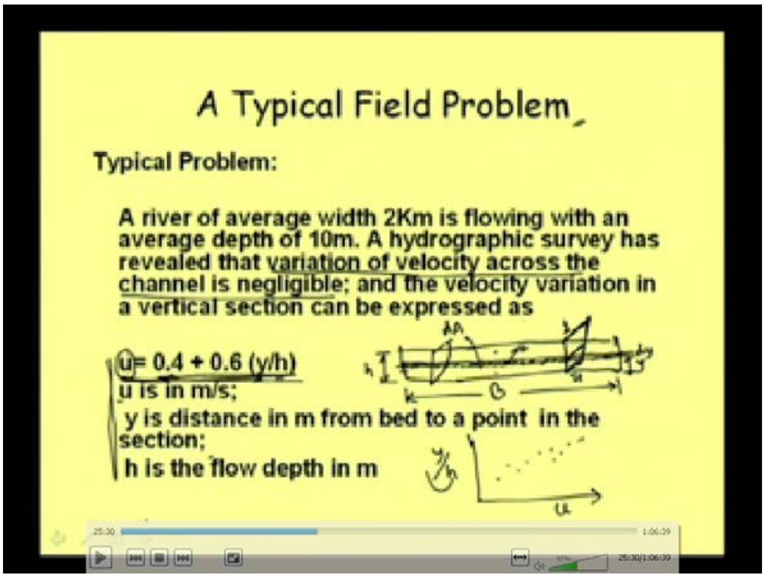

So, that way with all these system, now we can measure velocity and we can see that how the velocity at, in a channel at different point are varying. Now, of course, let me take a typical field problem. Suppose by this measures, we have measured the velocity. Well, now let this problem what it state. Let us just concentrate on the slide here that, a river of average width 2 kilo meter. Well, I am talking about a very large river. A river the photographs of which I have already shown say it is of that kind.

So, a river of average width 2 kilo meter is flowing with an average depth of 10 meter. Please note that in a actual river, we cannot have a very specific depth of this much meter. In a manmade cannel we can have, but in a actual river we cannot have a say specific depth. So, it is always we talk in terms of average depth. Then a hydrologic survey was has revealed that variation of velocity across the channel is negligible.

Now, what these statement mean? That I will come later Velocity across the channel is negligible, and the velocity variation in a vertical section can be expressed as this. Suppose u is the velocity at a particular point, or rather we can say that at a particular level in a vertical direction, then this can be expressed as 0.4 plus 0.6 into y by h. Of course, we can have different expression for this sort of velocity. This is just one I am showing, and then, u is in say meter per second we are measuring. This is the velocity and y. What this y is it is the distance in meter from bed to a point in the section, and what this h is, h is the flow depth in meter, h is the flow depth in meter.

Well, I would like to explain these things by a diagram. Well, here itself we can draw the diagram. Say this it is a velocity across the channel, variation of velocity across the channel is negligible. By that, what we mean? This is a very wide channel say 2 kilo meter width and only, 10 kilometer, 10 meter depth. I mean 10 meter depth is not small, but when we compare with a 2 kilo meter width, then it is of course smaller, and then, as it is a wide rectangular channel; that means, we are assuming this to be rectangular; in reality it will not be exactly rectangular, but we are assuming this to be rectangular.

Now in wide rectangular channel, in wide rectangular channel, what we could draw earlier also the velocity diagram or the velocity variation across the channel is negligible means, if we are observing a particular velocity at this point, of course very near to the bed, there may be some variation, but little apart from the bed when we are coming, little away from this bed bank when we are coming, this depth or at any level at this level if we measuring velocity, then say velocity at every point are equal. In reality by equal, we mean that it is more or less equal, but for our computational purpose, we will be considering this as equal. Of course, on the side very near to the bank, it will be different, but that we are neglecting.

So, not significant that. That is why we are neglecting and that is why it is negligible. There is velocity variation, but it is negligible, but when we measure a velocity at a point here and at a point here, this will be different from the velocity of this point and that point, that is, in a vertical section, there is variation of velocity and that variation of velocity is being expressed as u is equal to point four plus point six y by x.

Now, in this channel, what y is? So, u is the velocity in this particular section if I take a very small strip, if I take a very small strip suppose say a small strip I am taking and this depth from the bed of the channel to this particular section is say y. What y means the distance up to the section from the bed and h is the total depth. Say this total depth is h, and let me consider this small strip as say thickness dy, and then, we can say that this entire cross section, that is, elementary cross section width wise it is more, but this we can call as a elementary section because it thickness is less and this area is suppose dA, this area is dA and width of the section let this be B, width of the section that is be B, and what we are writing the velocity at this point, velocity at this point, is u, velocity at this point is u.

So, that is what we are talking about what this u velocity that is like that, and suppose we have measured this u velocity in a vertical point. In reality we have measured the velocity at different point, and then, when we have plotted this velocity, we are getting this sort of variation, that is, say for different depth, we are putting the, we are recording the velocity; then we are putting suppose y, that is, at what depth and of course, we are just reducing this the by dividing it by h that is the total depth. Total depth is of course, we are giving as 10 meter. This is average, but in reality, at different point, it may be different average value is a 10 we are considering.

So, at every point, we are using putting y by h, and on this side, if we put the u velocity, actually which is being observed, then we are getting a relationship between u and y and that curve say u is equal to, for y is equal to 0 you can see. When y is equal to 0, that is, for when we are at the bed, when we are at the bed, then your velocity is in fact not equal to 0; it is equal to 0.4 when y is equal to 0, and when we are on the surface, when we are on the surface, then say y become equal to h. So, h by h become 1 and then the velocity become 1.4 plus 0.6 equal to 1. So, what I mean by putting these value and that value, we may get some point in, we may get some point, and then, when we relate this point, we will be getting a line, straight line; that means, we can approximate these by a straight line because we are, we can see this relationship is linear; this velocity is varying linearly with y.

Well, let me draw a graph here itself. Say this is the velocity and dimension I am writing. This is, this is, the e value, and then, suppose here let me take a vertical section. Here, the velocity I am mentioning like this, and as I have explained that at the surface when your y is equal to h, your velocity become equal to 1, your velocity become equal to 1. You put y is equal to h; you are getting 1, and at the bed, when your y equal to 0, you put y is equal to 0, you are getting u is equal to 0.4. So, your velocity is 0.4 here. So, you are getting 0.4 velocity here and you are getting 1 velocity here, suppose this much is one, and between this 0.4 velocity to 1 velocity, it will be varying linearly because our relation is linear here, but not necessarily that it will always vary linearly, because earlier we were drawing the velocity diagram in this form that, say this is something and then we are drawing a curve.

But of course, here after putting this value, suppose we have seen that the points are coming like this and this cluster is like that very well we can approximate this as say straight line or that is why we are considering, that we are fitting a line which is taking this shape well. So, these are, this is how from the practical situation we are coming to a position like this. Now, with this understanding, with this understanding, we can go to the things that what we really need; from this, what is our objective and what we need.

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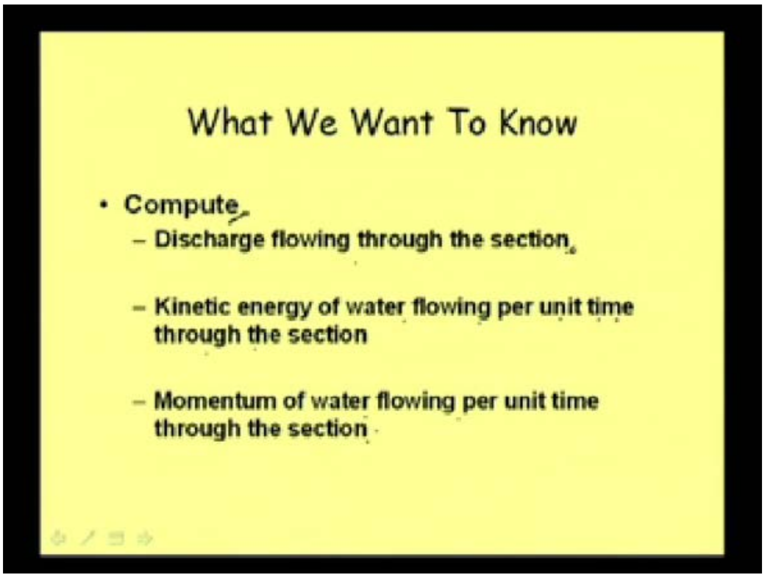

Well, say what we want to know is that, our target is that compute what we want to compute - the discharge flowing through the section. We are measuring all those things and we need to know what is the discharge flowing through the section. This is one point, and then second, we want to know the kinetic energy of water flowing per unit time through the section.

When we are talking about fluid energy, I was already explaining that we are talking it terms, in terms of per unit time. Again when we talk that kinetic energy per unit time per unit area, that we call as a energy flux. Now, here, we are not talking about energy flux; we are talking about total kinetic energy flowing through the section per unit time. Similarly, suppose we want to know the momentum of water flowing per unit time through the section. So, this is or these are our interest. Let me see how we can solve this problem.

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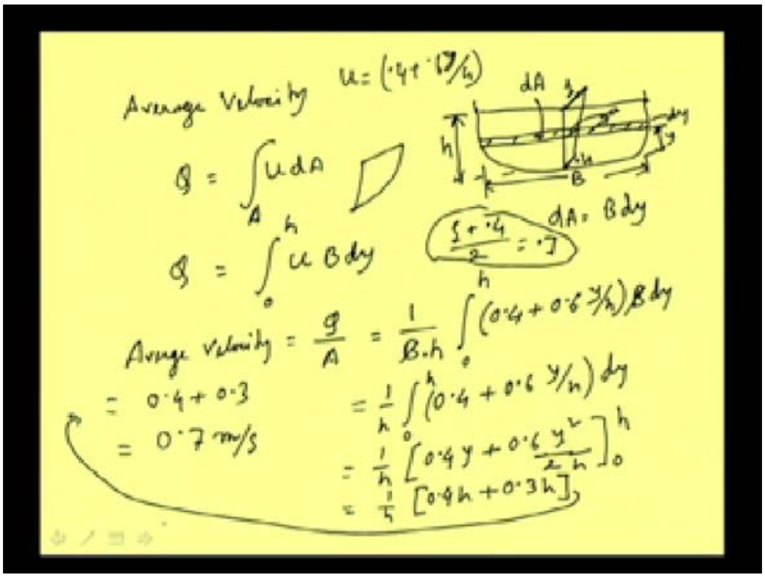

Let me keep the diagram in my front, so that we all can appreciate say this is the expression and this is what we have already drawn, and then, at any point, any section at depth y, this velocity is u; that means, this segment is u and this is d y; this distance is b. Now, what is our average velocity? First, to calculate the quantity flow discharge or mass, if we want to calculate, then we need to know the average velocity. So, let us compute first the average velocity.

Well, to compute the average velocity as we know that, what will be the discharge flowing through this small section velocity is u and area is say dA. So, u velocity into the area dA; d A means this area we are talking about dA. That will give us the discharge, and as this is varying, we can write that integration of this over the entire area, integration of this over the entire area. This will give us the total discharge Q, total discharge Q, but of course here we know that what is dA.

That in our case dA is nothing but B into d y which is approximated, which can be approximated as B into dy this which is suppose B. So, B into d y is the area. So, what we can do? This we can just as this is uniform; across the channel, it is uniform. So, we can integrate it from 0 to, say 0 to h depth wise we can integrate, and then we can write u and then dA we can write as B into dy. This is what the Q. Then what is average velocity? Say average velocity will be is equal to Q by the entire area, Q by the entire area.

So, what we can write that this is equal to area is nothing but again equal to B into h; entire area means this B into the depth h. So, B into the depth h is the area. So, 1 by B h into integration of 0 to h. Then u we can replace this as the expression already given to us that is equal to say 0.4 plus 0.6 y by h. That expression already we have and B dy. Of course, B being constant, we can just cancel this B and this B bringing it out. So, this we can write as integration of 0 to h 1 by, 1 by, h integration 0 to h 0.4 plus 0.6 y by h into dy, fine.

And now, this problem become simple integration problem and we can write it as 1 by h. Then 0.4 dy integration of these we can write as 0.4 y plus say 0.6 y square by 2 and already this h is there with us and this is from 0 to h. So, we have integrated that. Then putting the limit, we can write that 1 by h, then it become 0.4 h plus this also become say 0.3 and then it is y square will become a square. So, it is h. Then this let me write in this table itself, in this slide itself. So, this we can write as this h and h getting cancelled, this is equal to 0.4 plus 0.3 this is equal to 0.7.

Now, see average velocity we are getting as 7.7, we are getting as 0.7 meter per second, 0.7 meter per second, but of course, as this, in this case we are considering, I have just shown how in a systematic way through integration process considering the flow velocity in an elementary area. Finally, we can get the velocity, but here as the velocity is varying linearly, we can straight way also in fact find this value. Say here the velocity is one; already this was discussed that here the velocity is one, because when y is equal to h, this value become one from this equation that u is equal to 0.4 plus 0.6 y by h. So, from this we can have that.

So, here, it is 1, and here, when y become 0, it become 0.4. So, average velocity it is a regular shape. So, we can find out what will be the average velocity - it will be 1 plus 0.4. So, maximum is 1 plus say 0.4 divided by 2; this is equal to 0.7. So, that way also we can straight way find, but why I have done this part? Just to understand what is the, how we can do it by this procedure, and of course, as it is simple we can do it, but if there are discrete value, we cannot do it this way, and if the variation of velocity is not straight, suppose variation of velocity is different is, is, parabolic or some other shape it is taking. Then we cannot do in the straight way. So, we need to go for integration. So, that way we need to see. Well after knowing the average velocity, after knowing the average velocity, we can find out discharge we can find out discharge.

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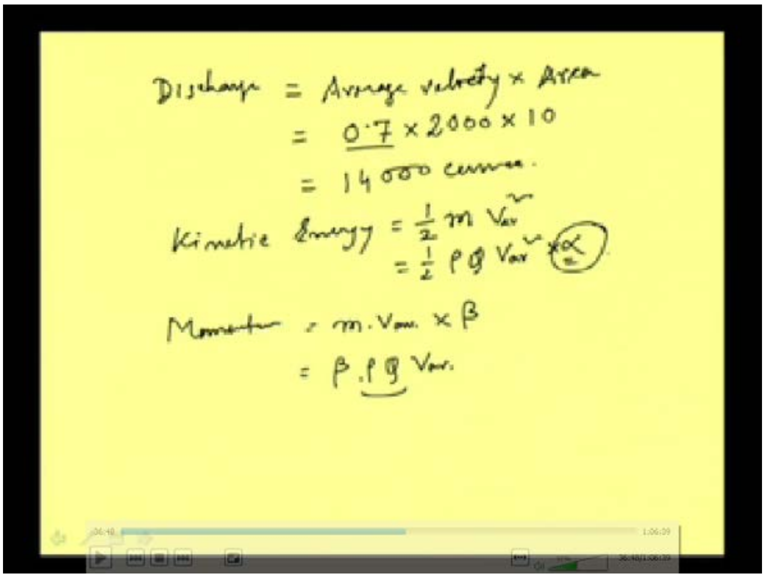

So, we can find out the discharge is equal to say average velocity, average velocity, multiplied by the sectional area. So, that average velocity already we have got 0.7 and sectional area as we know that average which we are considering this to be 2 kilometer. So, it is 2,000 meter and then depth is 10 meter. So, we can find this to be say 14,000 cumec, 14000 cumec, cumec, and once we get the discharge, if we need to calculate mass, here just we need to multiply it by rho to get the mass.

Now, let us see that our first part is over that how to calculate the discharge. Then the next question is to find out the energy. We need to compute what the energy can be. Now, for that, we need to calculate again energy suppose. Well, if this is the discharge then, we can, in a sense we can calculate directly like that kinetic energy I am talking about, say kinetic energy. If I calculate like this, kinetic energy is equal to half into mass into say velocity square half m v square. Now, this v is I am talking about average velocity what we have got already 0.7. So, this mass is nothing but half of rho into the Q value rho into Q into say v average square. Now, if we calculate the energy straight way like this, it will not be correct, it will not be correct. The reason is that already we know because the velocity is varying, we need to multiply it by alpha. So, our correct kinetic energy will be this multiplied by alpha. Now, our problem is to find out this alpha.

Similarly, if we calculate momentum, if we calculate momentum, momentum also we can calculate say mass into velocity, average velocity, but in reality, this will not be correct. So, we need to multiply it by the co-efficient of beta. So, you can write beta mass is equal to again rho into Q into v average. So, that way we can have this mass and velocity and multiplied by the beta, we can calculate momentum. Well, now, let us see how we can calculate this alpha value from the given information.

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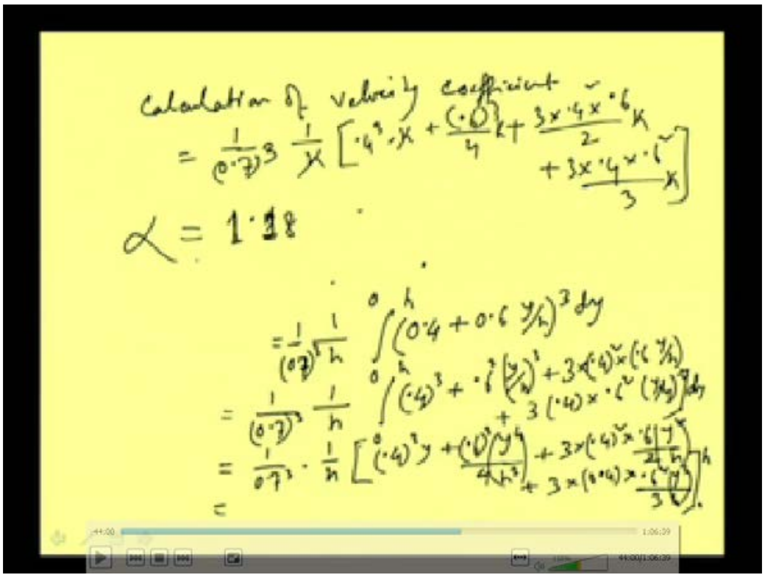

So, we are now discussing about calculation of velocity co-efficient. Well, velocity co-efficient alpha we already have discussed this expression. We can recall what we did discuss in last class that we can write as j 1 by A into integration of v, or here, we are using the time u, u, by say v average, u by v average, whole cube and this integration is over the entire area. Now, in this case, again coming to the same point as the variation of velocity across the section is negligible. We are considering this as say B area is nothing but 1 by B into y. Then we are considering u cube, and this v average means already we have say 0.7 cube dA we can write as B into d y, and then, when we are expressing it like that, we need to integrate it from 0 to h, we need to integrate it from 0 to h.

Well. So, we can write the expression as, this is not y, this is the total depth, this is the total, depth B into h, B into h. So, we can write this as 1 by h this B and this B get cancel as it is constant. So, 1 by h into integration of 0 to h. Then this 0.7 cube that we can bring out say 1 by 0.7 cube. That is the velocity, average velocity cube that we have bringing here, and then, u we can write as with this using this equation 0.4 plus 0.6 into y by h this whole cube into dy, this whole cube into d y well. So, this if we simplify, if we simplify this 1 by 0.7, after this your problem is just simple integration and arithmetic calculation.

So, let me express this as 0 to h, then just a plus b whole cube formula all of you know from your childhood. So, you can just express it as 0.4 cube a cube plus say 0.6 into y by h. Let me write it like that this cube and then this cube a cube plus b cube plus a thrice into 0.4 square into 0.6 into y by h plus thrice a b square 0.4 into 0.6 square into y by h square. So, this is how we can express and dy; this is dy.

Now, it is a straight way we can do the integration. Let me keep it like that and then 1 by h. In fact, this can be written directly, because you see when you bring here, it will become say 0.4 cube, 0.4 cube, into y plus, and then when you put the limit, this will become h and everywhere this will become h and h and h we can in fact cancel. So, this is 0.6 cube and this will become y to the power 4 by 4 and h cube.

So, ultimately, this when we put the limit, this also become h just then plus say 3 into 0.4 whole square into 0.6 into this will become y square by 2 and then h plus say 3 into 0.4 into 0.6 square. Then it become y cube by, sorry, this is square; so, it will become y cube by 3 y cube by 3 into h. So, that way we can put and we can put the limit from 0 to h, and when you put the limit from 0 to h, then well in this sheet itself I can make the correction that or let me write one more step. Let me write it here.

It will be better, where this can be written as say 1 by 0.7 cube, then 1 by h and then it will become 0.4 cube h plus other factors will be there and then this term will become h again, say h to the power 4 divided by h cube. So, everywhere in fact, this h this term will become h, everywhere this term will become h when we put the limit h here, and then, we can just put the value directly and. So, let me just cancel this 1 and this h we can cancel with this h here. This h can be cancelled with this h. Then just numerical value we need to put 0.6 cube by 4 here plus say 3 into 0.4 square into 0.6 by 2 plus this is say 3 into 0.4 into 0.6 square by 3. So, when we put all this value, this h everywhere actually 1 h was there and this h h h we can cancel with this h, and putting these value, we can just calculate the value of alpha. Now, everything is known, that is, only the digital value are there and this value is equal to we can put 1.18. This calculation if we do, this value become 1.18. So, our alpha is equal to 1.18.

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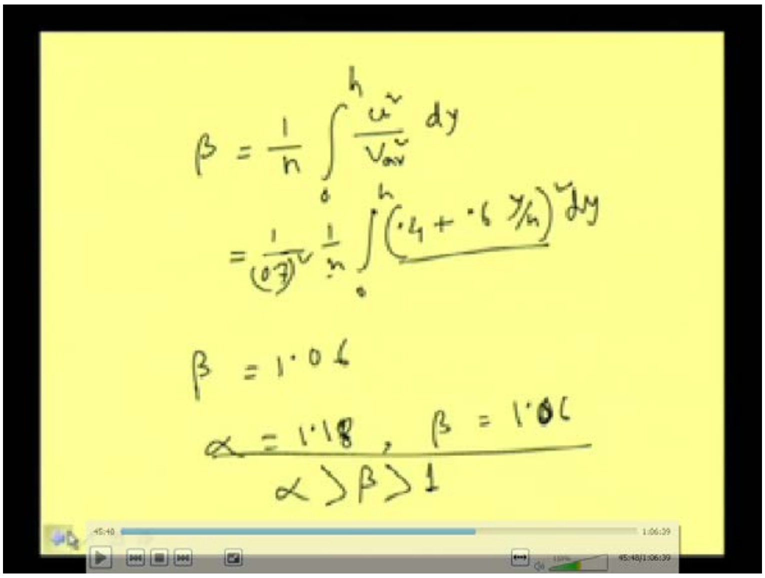

Similarly, for beta also we can calculate in the similar way and then we know that beta. Now, I am, I am, straight way say beta is equal to you can express say 1 by h directly say we are writing 0 to h. Then here, u square by v average square into dy. That we can write directly in this form, and here, again if we put the value of u and other thing say it is 1 by 0.7 whole square v average square and it is 1 by h, and then, inside it is becoming say integration of 0 to h 0.4 plus 0.6 y by h whole square into dy.

And from these, again this part we can express in the form of say a square a plus b whole square. So, we can just break it and we can do integration. We can put the limit from 0 to h, and then again, this h and that h will get cancel, and finally, we can get the value of beta as equal to 1.06. So, what we have seen that alpha value is 1.18 and, sorry, 1.18 and beta value is equal to 1.06, 1.06. So, that way discuss in our last class that alpha is greater than beta is greater than one that we have seen in actual calculation.

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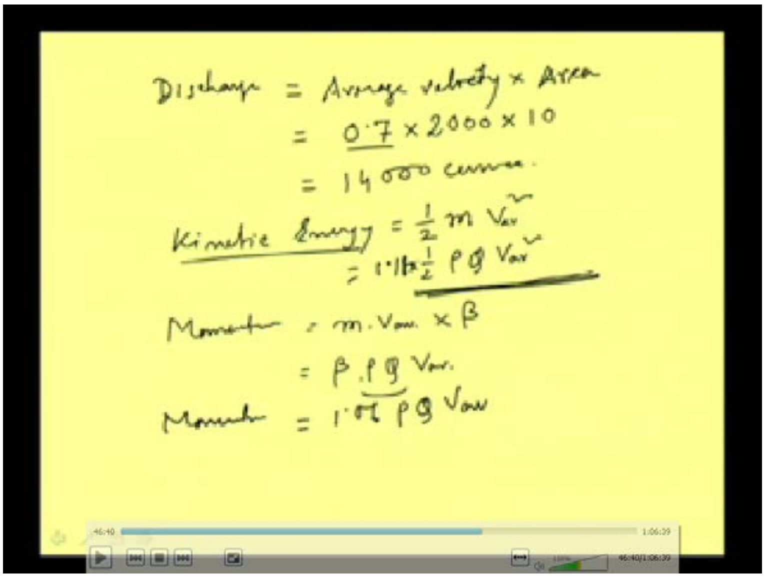

So, now, what we mean that, if we calculate our, if we go to our last slide, if we go to our earlier slide, that we if we calculate this kinetic energy by simply using this formula, then it will not be completed rather it will be less by 1.18 time actually our alpha value is. So, if, if, we just forget about this term, then it will be less. So, our actual alpha value or actual kinetic energy value will be this multiplied by alpha means we need to multiply it by 1.18. Similarly, beta value will be say this will be 1.06 and then it is rho Q and then v average. So, that way we can calculate momentum, that way we can calculate momentum. Alpha, in place of this alpha we need to multiply this by 1.18 into this part.

Well, so, we have seen how from the practical field we can acquire data, and then using those data, how we can derived this sort of co-efficient, that is, velocity co-efficients and then how these velocity co-efficient help us in getting the computed value of momentum corrected. So, are energy corrected.

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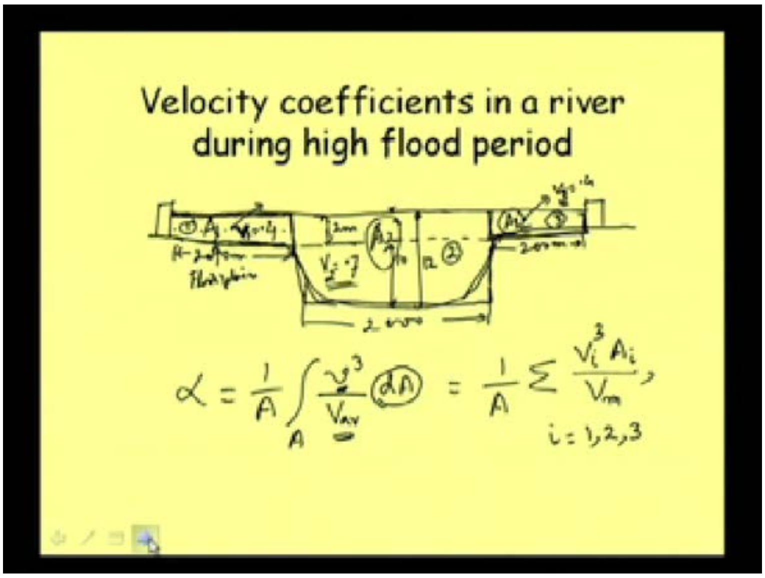

So, that way let me take another example. This is one situation I have shown. Suppose the same river I am considering. You can just concentrate on the slide that say velocity co-efficient in a river during high flood period well means, suppose let me consider a river the same river suppose like this as we did consider earlier and it is a flood plain in this form, and suppose we were talking about a, we were talking about a river of this kind and where we could see. Suppose the flow depth when it is up to this much, then say we could compute, say depth is 10 meter as we did consider here, and then, this width we did consider as suppose 2,000 meter 2 kilo meter very wide river, because we are considering intentionally wide river, so that we can consider these to be a rectangular one well. Now, up to this much, we can do in the way what we have already discussed.

Now, say during flood time, that means, if the water exceed this bank, exceed this bank, during flood time, water level will be exceeding this bank level and then flood will be spreading into the flood plain. So, this is flood plain; these are flood plain and water will be spreading to this level. So, to prevent the flood, some time many a time what we do? We put some embankment here. Suppose the embankment is at a distance of 200 meter from the bank and let there also we are putting some embankment. Let this be also at 200 meter from the bank. Of course, my diagram is not proportionate because you can see that here it is 2,000 I am writing and this distance is 200, but anyway, let us consider this as 200, then what will happen? When water is moving above of the flood plain, suppose it has come up to this much height, then you will be getting water level in these form.

So, whatever velocity co-efficient, we calculated for the river during the period when there were no over flooding that will not be valid now because the situation has completely changed and say flow depth. Now, we can consider here to be say 12 meter; let this be 2 meter, let this be 2 meter. Water level has risen up to 2 meter from this bank level, and so, this is 12 meter, and one thing we must appreciate at this point that this section we can now consider as three distinct part.

Suppose one is let me consider this as again rectangular. Suppose approximating this as rectangular say this is one. Of course, we can always consider these to be a trapezoidal also there is no harm, but our calculation will be little more complicated. So, let me consider this as a rectangular like this and this is one portion. This is suppose the part one and then this part I am considering as part two and this part I am considering as part three.

Well, now, as the depth of flow here will be very less. As the depth of the flow here will be very less as compared to the depth of flow here, because here only it is 2 meter. So, the flow velocity here will be significantly less than the flow velocity of this part. We are considering symmetrical; that means, this side also same say, this side also same and this is different well. Suppose we got the average flow velocity of this section as 0.7. Let me again consider this average flow velocity as 0.7.

Suppose v of this section two is say 0.7; of course, it will be a little different, but for this calculation purpose I am considering this as 0.7, and then a velocity of the flow here will be very less say we are considering the flow velocity here to be say v 1 is equal to 0.4, and here, we are considering the v 1 to be equal to 0.4 v 3, v 3, also equal to say 0.4 we are considering, and this sectional area say we are considering as A 1. A 1 is the sectional area this one. A 2 is the sectional area this portion, entire sectional area I am talking about and A 3 is the sectional area of this portion well just like integration.

Now, of course, it is approximating this area and approximating that this velocity average velocity. What I am giving as v 2 here; v 2 means actually we are talking about average velocity. v 1 also we are talking about the average velocity of this portion. Now, we are, we are, just making one assumption that in this portion, in this portion, that is, say area A 1, this average velocity is 0.4 and we are assuming that variation of velocity within this section in vertical as well as horizontal in the entire cross section is not that much and we are considering that this is the…

So, I mean individual velocity co-efficient for this area is not that much important or not that much, that is not required to that extent. So, we are considering velocity here. We can consider as v 1 0.4 which is say velocity which represent the velocity at all point here. Then v 2 is the velocity, suppose which is representing velocity at all point; v 3 is the velocity which is representing the velocity in this entire section.

Well, now, if we then go to the alpha value, if we then go to the alpha value, well now we know the alpha that velocity co-efficient expression we can write as say 1 by A not, I mean I am writing the conventional expression 1 by A, then say when we integrate it over the area, we can write that average velocity v, sorry, v through a small section. Then, we were, we were, writing v average and then we are writing this as A dA, well. This is the expression what we have already used.

Now, when we have distinct part, this we can write in the form of summation also. How we can do this? Say 1 by A. Now, this small v what we are writing earlier for a, you can just refer to the slide this small v what we were writing earlier for a small area. Now, that we can write for a small section, say section one, that is, one velocity; section two that is one velocity; section three that is one velocity. So, what we are writing this is an v average means average velocity, v average means average velocity, of all these section.

So, what we can do say we can write a summation of this v I can write v i means, for each section and then this delta A, this delta A, now for me is a individual section, a individual section, means say section one, section two, section three like that. So, v i cube A i, and here, I can write v average, here I can write v average, or well, let me use a different symbol v m say nil velocity.

Well, now, already we know that, here, I is in this problem, I is varying from say I equal to 1 2 and 3, and of course, in general, if we have several of this section, this sort of section, we call as a compound section; this sort of section we call as a compound section, and there can be say several sections up to n number we can go well.

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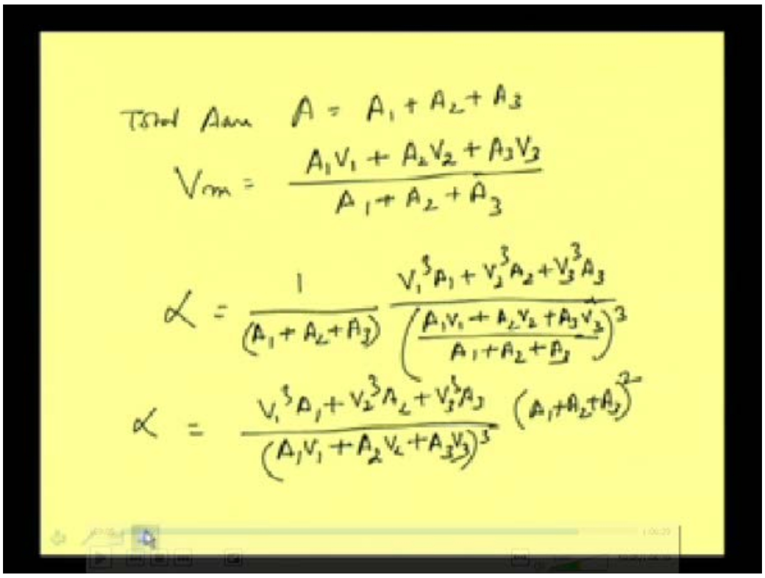

Now, let me just write this in a more simpler form like that. What is our total area? Total area we know very well now it is not a problem. Say total area A is equal to A 1 plus A 2 plus A 3 well, and then, what is our mean velocity, what is our mean velocity? If we just go back to the slide, then what is the discharge flowing flow this section one? If area is A 1, velocity is v 1, then the discharge flowing through this section is A 1 into v 1, and that way discharge flowing through a section will be A 2 into v 2, and similarly, this search flowing through section three will be A 3 and v 3.

So, average velocity we can write as say A 1 into v 1 plus, that is, discharge flowing through this section A 2 into v 2 plus A 3 into v 3. In fact, in reality, what we are doing? This is q 1 plus q 2 plus q 3, this is the total discharge we are getting and divided by the area say A 1 plus A 2 plus A 3 means the total area. So, this is what the expression for our velocity.

So, when we talk about now alpha, what we can write that? We can see that alpha now we can write as 1 by area means 1 by A 1 plus A 2 plus A 3. This is the total area. Then, we had that v 1 cube A 1 v 2 cube A 1 those things we can write say v 1 cube A 1 plus v 2 cube A 2 plus v 3 cube A 3, and then we have mean velocity here and mean velocity as we know that we can write is A 1 v 1 plus A 2 v 2 plus A 3 v 3 divided by A 1 plus A 2 plus A 3 and we know that this is whole cube, this is whole cube.

So, this is what the expression for alpha. We can simplify it into the form that v 1 cube A 1 plus v 2 cube A 2 plus v 3 cube A 3, and then, there is one total area. Here is total area cube. So, if we just cancel this one, we will be getting A 1 plus A 2 plus A 3 whole square this cube and this will get cancel one, and here, we will be having say A 1 v 1 plus A 2 v 2 plus A 3 v 3 whole cube, whole cube, well.

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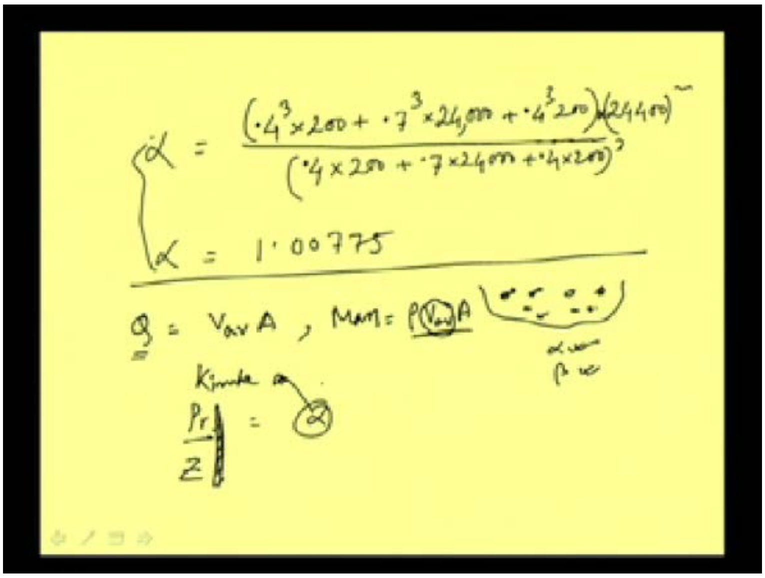

So, that way our expression become simple, and now, we can compute the value like that. Say this is equal to we already considered that velocity in the section one is 0.4. So, it is 0.4 cube, and then sectional area that with which is considered as 200 or 100 meter what we did consider let me see. Let me, suppose this is 100 meter; let me consider this as 100 meter, then it will become more simple say this is 100 meter.

So, depth is 200. So, depth is 2 meter. So, the sectional area will be 200 and plus say 0.7. This is the average velocity of the section two into and depth area is of course we are considering the 2,000 meter width and depth is 12 meter. So, it will be 24,000 plus then 0.4 is again this one and we will be having 200. So, this part is there, and then, what is the total area? Total area is say we are getting 200 plus 24,000 plus 200. So, it will be say 24,400, it will be 24,400. This is total area square we will have to multiply total area square.

So, that way we are getting this total area square, and then, here we are writing 0.4 into 200 plus that is what this area into velocity A 1 v 1 0.4 even into 24,000 plus say 0.4 into 200 again and that is cube. So, that is what our alpha is. Then alpha value if we just simplify this part, then we get a value of 1.00775 like that. We can also calculate for beta, we can also calculate for beta, and you can see that this sort of situation; that means what I want to emphasize that, when we calculate a value of alpha for a particular channel section, and if you use the same alpha, when it is in flooding condition or may be when it is in very lean period, so these two should not be same; it will be different.

So, we should be careful in using this value. You should know what the practical significance is. Well, now, I would like to concentrate on this, I would like to draw your attention to this value. when we are talking about this alpha, why we are using this is because it is the average velocity is not equal and velocity is different in a section, velocity is different in a section, and then we are considering the average velocity. Then we are computing energy and say then we are computing momentum.

So, we were using alpha and we are using beta. Now, in the calculation of average velocity itself, whether we need any co-efficient; that means, suppose using the average velocity, we are calculating say discharge Q is equal to average velocity into area. Now, this discharge, now say when we are or suppose when we talk about mass, say mass, if we talk about mass, mass will be equal to rho into v average into area. Now, for calculation of energy, we are using a co-efficient alpha; calculation of momentum, we are using a co-efficient beta. Now, for calculation of mass, do we need any co-efficient here?

We do not because the very basic value of v average that we are calculating, that is, here itself we are considering the variation of velocity and we are dividing it by the total discharge. We are considering through area; we are calculating individual discharge. We are summing up the total discharge, then we are dividing it by the total cross sectional area. So, here, we do not require that. Then again, another point I want to say that say energy co-efficient alpha. We are calculating what energy we are talking about that we are talking about the kinetic energy.

Now, if we say that energy, there are different type or say in a in the total energy we have three distinct part - one is say kinetic energy; one is say potential energy; then energy due to which elevation. That is also there and pressure energy is there. I mean potential energy and energy due to elevation the same thing. Then we have that say pressure energy. So, all this different energy are there.

Suppose we are calculating total energy. Now, in the calculation of total energy, there will be a pressure energy also. Now, do we need a alpha value for calculating that energy? Say pressure energy we are calculating some amount pressure energy, and do we need any co-efficient there alpha or say some other co-efficient? Yeah, definitely not. The reason is that when we are calculating pressure energy or when we are talking about the potential energy z, in these case, we, our velocity is not coming into picture.

Velocity is coming into picture only when we are talking about the kinetic energy, only when we are talking about kinetic energy, and that is why these value of alpha is coming only when we are talking about kinetic energy. In this case, it is not there. That is why this sort of co-efficients are not coming. Well with this introduction to the practical use of this co-efficients, we could understand that how we should be careful in considering this co-efficients, and of course, we have seen that we are using this for calculating mass; we are using this for calculating momentum and energy. Now, these momentum and energy are very important topic basically in open channel hydraulics and…

So, based on some of the principle like the very fundamental principle of physics like momentum and energy conservation, we derive some equation and those equations are very much useful for our computational hydraulics also. So, about all those things, we will be discuss in the next class, and with that, let us hope that, with the very basic understanding of this topic, we will be able to grasp the discussion of our next class in a much better way. Thank you very much.