Hydraulics
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Lecture - 3
Computation of Uniform Flow Part-1

Friends, today we shall be discussing on the computation of uniform flow. In the last class, we could see what uniform flow is. And of course, we could see that how the resistance flow formula we could derive or other, it is an empirical relation with some analytical base. So, how we could get those formula? And today we see by using those formula, how we can compute the required parameter of uniform flow. Well, just to recapitulate what we did in the last class, let us see that, we studied development of uniform flow.

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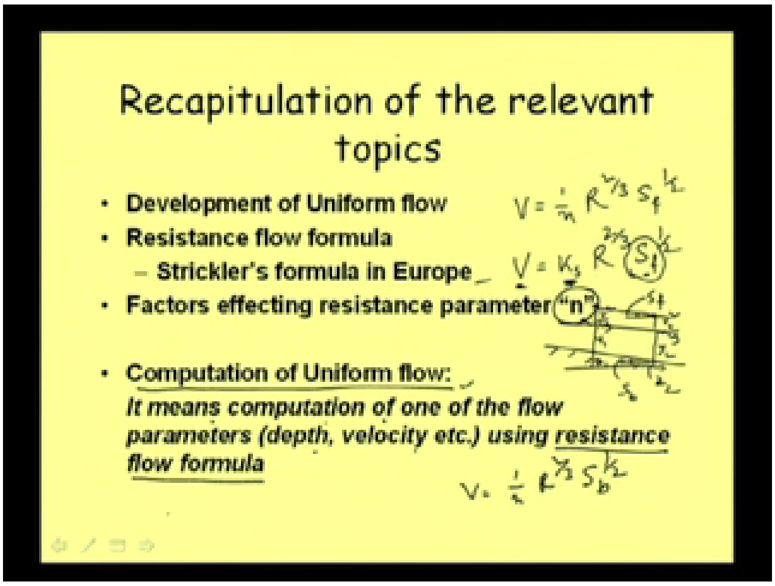

Well, that means, there we did discuss that we need some, before developing the uniform flow or before the uniform flow gets developed some portion, there may be transition and then, gradually it is coming through uniform flow pattern. In a channel, when there is some changes then the flow get disturbed again and then again, when there is a long reach having without any change and then normally, we get that uniform flow and that depth of flow, we refer as normal depth. Well, then of course, we did discuss about resistance flow formula and there we could see, that several uniform flow formula have been developed and in different part of the world people have used different formula and out of that, we can say that Manning's formula is more widely used. Of course, the Chezy's formula is also used but Manning's formula is more widely used. And some of the formula like Gangguillet and Kutter formula, that is used in channel design also. Like that, these formula could find its own application in different areas and of course, here I am just mentioning about one formula, that is Strickler's formula in Europe.

In Europe, a similar formula that is say V is equal to, all these formula try to relate that velocity, try to find one expression of velocity, that is the velocity is equal to some other parameter. This velocity is equal to K s, another coefficient K s then R to the power 2 by 3 and S f to the power half. Well, that formula is called Strickler formula and as you can see that this formula is just similar to the Manning's formula, if I write here that V is equal to 1 by n R to the power 2 by 3 S f to the power half. Then, you can see, this is nothing but this K s is equal to 1 by n. Of course, the value of K s again, different people worked on this value of K s like Jaeger is one person who worked on that and then, he gave some relationship for finding this K s. That way different people worked in different line and here, one point I want to again reemphasize that, in these formula of velocity, we are using here S f.

In fact, the formula is including the value of friction slope and we remember what we mean by friction slope or the slope of the energy grade line. Just, if we somehow have forgotten that, just to mention about that, if this is the bed and if this is the depth of flow, I am not, now not drawing a uniform flow say, if this is the depth of flow, say, it may be changing then, here we get depth of flow then, we get total V square by twice z energy. Of course, the alpha can be there, now, we know about that. And then, here suppose V2 square by twice z and then it is y2, this is y1, then there are may be some z value, here it is z1 z2 like that; that means, this point is stating about the total energy and we are writing in the form of energy head and the line joining these points of different energy level at different point, we got this slope as energy slope or friction slope or we write this as a S f.

Well, now in non-uniform flow, as the velocity will change and depth will change. So, this S f and this angle we can write as S b bed slope. So, this S f and S b can be, will be rather different. But in uniform flow this S f and this S b, that is bed slope and the friction slope remain same. Because our depth is same in that portion where we are considering this as uniform flow in that channel reach, this is constant, then velocity is same and as such our energy and everything remain same. So, when we get this uniform flow, then our S b and S f is same, similar value, same value. And that is why, many a time, we write this formula, uniform flow formula in terms of S b, we write this formula in terms of S b, that is we write that V is equal to 1 by n R to the power 2 by 3, then we write S b to the power half. Why I am emphasizing this point, because when we will be dealing with non-uniform flow like that gradually varied flow, then also for some of the situation we approximate a small channel reach may be considered as uniform though the entire flow reach is non-uniform and in those portion, we consider that uniform flow formula is valid. Well, but in that case we cannot use S b, we will have to use S f. So, that is why, these sort of minor points we need to be careful.

Then of course, we did discuss the factors affecting resistance parameter. So, resistance parameter and got affected by many factors. And that parts also we did discuss in our last class and we could see that although for a particular channel, we may specify some definite value of Manning’s and or may be Chezy’s, but in reality this sort of constant value is not possible. Say with the change of depth, when the depth changes these value changes and then when suppose your, I mean bed characteristic is remaining same, bed material characteristic I mean, but suppose somehow the scouring is occurring in some portions, scouring is occurring in the channel list, then your n value changes. And then similarly when siltation is there, it will be changing. If you are putting some bridge across the river, some obstruction are there, the n value will be changing.

So, while doing this computation of uniform flow, we need to understand that, though we specify some n value in reality or to be in more accurate, to have a more accurate calculation we should know, that this value will change and when some changes are occurring we need to change our n value accordingly. Then, we started with computation of uniform flow and that you can see, what we mean, that it means computation of one of the flow parameters. One of the flow parameters means, it may be depth velocity and etcetera. Using resistance flow formula, that is what we generally mean by computation of, I mean uniform flow.

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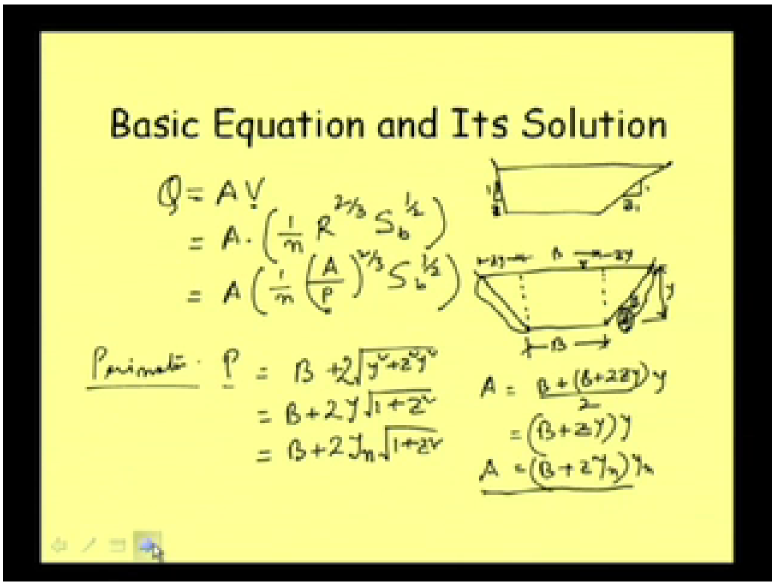

Now, let me go to the next slide- Basic equation and its solution. Well, now by basic equation what we mean, that we know that suppose in a particular channel, we know that how much discharge is coming. So, that Q is known to us. Sometime, it may be known to us and sometimes, it may happen that we know the depth, we know some other parameter of that channel and we need to compute how much discharge is actually flowing. So, it can be either way, but from our very continuity equation what we know that, Q we can write as A V. Q we can write as area into velocity. Now from that say, we can have an expression for this area and we can have the expression for this velocity from the any of the resistance flow equation, resistance equation or say Manning's equation we can use. Well right now, I will be using manning's equation for all these calculation and of course, you can have Chezy's equation also. Now, say this V is nothing but, that we can write as this is equal to area into this velocity, we can write as using manning's equation, we can write 1 by n then R to the power 2 by 3 and S b. S b to the power half. Again, I am repeating that S b means it is because uniform flow, we are talking about, that is why we are writing as S b. Well, then what is R again, we can write that R is nothing but A by P. So, we can write 1 by A then, 1 sorry, A 1 by n then A by P to the power 2 by 3 and S b to the power half.

Now for a different section, this area and perimeter will be different. Well, let me take one section say trapezoidal section, let me take one section, let me consider that this is a trapezoidal section. And say my flow depth is this much, this depth let it be y. And if it is uniform flow, we can write it as of course, y n, that is normal depth. Well, for the time being, let it be y and then for this section, say this is my bed width B. And then side slope we specify as z is to 1. That is for one height, this slope increases thus width increases by z. So, 1 is to z. Now, what will be the area? Area of this section, that area of this section, we can write that this is equal to nothing but B plus the top width. Now what will be the top width? If I go like this, then from here to here, again it is B and then here to here, it is z into y and here also, it is z into y.

Well, now normally, you will be finding that we write that area as this plus that means, B plus say, we can write B plus twice z y divided by 2 into the depth or this we can write as B plus z y into y and of course, writing normal depth we can write B plus z y and into y n, if I write this as a normal depth. Well, but here though we use this equation for area, this is a simple equation of area from the any trapezoidal section, but we should remember one point. This equation we are writing, when we are considering that our slope, that is the side slope, but this slope do not confuse there will be always in trapezoidal section, there will be two slope we talk about, one is the side slope. So, that z what I am writing is you can concentrate in the slide, that z what has been written, it is z is we are talking about the side slope. But along the excess of the channel, the slope what is existing that we call as bed slope. So, that generally we expresses as S b. And in this section, this expression we are getting A is equal to B plus z y into y n, considering that the side slope in both the side is equal. Both the side is equal and otherwise, if suppose there is a section, where it is not symmetrical. May be in one side, it is like that and then it is going like that and in another side it is like that.

Then, suppose it is say, it has trapezoidal section that is fine. But, if you use this relation directly, you will not be correct. You will have to use here a different z1 and here you have a z. Small z value, say z is to 1. So, like that if it is unsymmetrical section, then you will have to use a different formula. But, the problem in, why normally we do not discuss about this sort of section in open channel flow, because these channels suppose are manmade in most of the case or even if in some natural channel also, the side slope depends on if it is natural, depending on the soil characteristic here, the erosion take place and somehow it get into a particular shape. And generally, when the channel is flowing the material of both side will be same and that way, we can have always say almost equal slope, equal side slope in both channel. And say if it is manmade, definitely, if we are giving lining, then for our convenience itself, we can always make similar slope on the both side and when with that, that will also depend basically, suppose if it is a manmade canal, when we are cutting that channel, then also it will depends on the type of soil.

Suppose, if it is a very rocky terrain and through the rocky terrain, we are making a channel. Then, the side slope that we can make is almost vertical, because in a rock if we cut a vertical slope, there is no chance of fail. But, if it is in a alluvial soil and then if we make a vertical cut, it will definitely fail. So, there is no meaning in making that. So, we need to know that at what side slope, what inclination that side will be stable, that there will not be slight the side should be stable. So, there should not be any slide and that way we decide this should be our side slope and normally, when it is a manmade channel, it will be passing through a similar soil having on both side and that is why it is we go like this.

Well, then what is our perimeter? This is what about the area. Then, what is our perimeter? Say this perimeter we can write as perimeter, that we can write, perimeter P, this is nothing but B plus say, what this length is, say this is z y and this is y. So, this incline length will be root over say y square plus z square y square and that sort of length we have two. Here is this one and here is this one. So, this B plus this into 2. So, that will be our B plus twice then y square bringing out of the root sign, we can have y and root over 1 plus z square. Then, again writing for uniform flow, we can write B plus twice y n. This is nothing but, we are writing in a symbol, that it is a normal depth root over 1 plus z square. So, like that we can have our expression for perimeter and area. Now, substituting these values in this equation, let us see what form we get, what form of equation we are getting.

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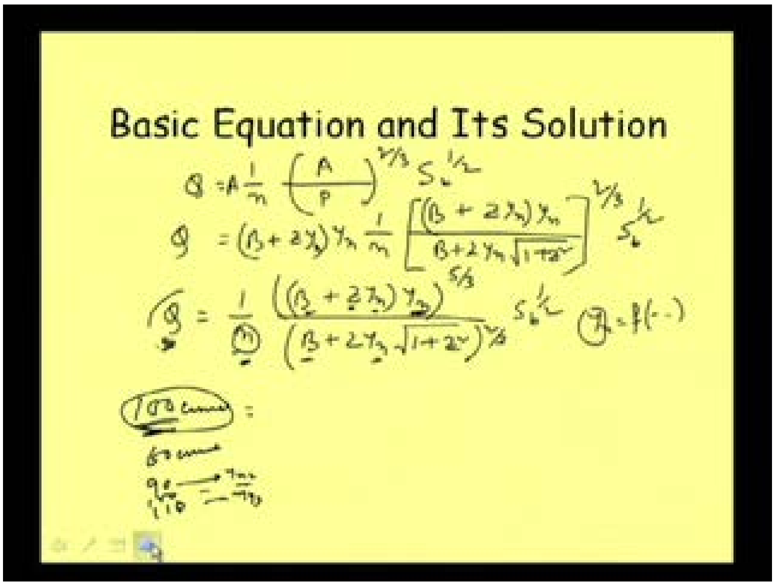

Q is equal to 1 by n then, say A to the power 2 by 3 was there and then, there were another A here. So, we can write A to the power say, let me write it here itself. 1 a b here and A by P to the power 2 by 3. Let me keep it in this form, then S b to the power half. So, just writing this expression what we can have A is equal to just bringing in a term, B plus z y into y n. So, you can write B plus z y into y n then 1 by n then, again we will be writing B plus z y n and into y n then, here as you can see, this is B plus twice y n root over 1 plus z square B plus twice y n root over 1 plus z square and then, whole to the power 2 by 3. In fact, we could have written this to the power of 5 by 3 covering this, bringing this here and then it is S b to the power half. Now, in this expression let me put all y s y n, let me put y s y n and then it is Q. Q is equal to say 1 by n and we can write like B plus z y n into y n and then, whole to the power we can make say 5 by 3. Just multiplying this by that and here, it will be B plus twice y n root over 1 plus z square and whole to the power 2 by 3 S b to power of half.

Now see, in this expression suppose, we know the discharge. So, given the discharge if we want to calculate y n then, we have a problem. We have a problem means, we cannot separate out y n. Say because here we have say y n as a product with this part. But here we have y n with this one as well as with this one. So, we cannot bring out y n, we cannot separate y n as a single parameter here and then, say we cannot express from this equation in the form that, y n is equal to function of those things directly. Making it separate, we cannot write it like that, it is function of other things, other known parameters. So, knowing the Q, knowing the B and we cannot calculate the y n directly. So, that is the problem, but of course suppose for a channel, if you know the normal depth, say y n is known, side slope z is known, bed width B is known, say everything are known, in that case, if you are asked to find, and of course, Manning's and from the characteristic of that channel, that is also suppose known. Then, you do not have any problem in finding the Q.

So, if someone ask you what is the discharge, you can directly put the y n value, knowing that. And then we can calculate the discharge. But, if you are ask that Q is given, bed width is given, then your normal depth also, sorry this, I mean manning's n is also given, in that case to calculate y n directly, you cannot calculate and that is why it calls for some other methods. Say many a time we can go for trial and error procedure or some other methods are there and let us see what are the methods, that we follow for computing this uniform flow.

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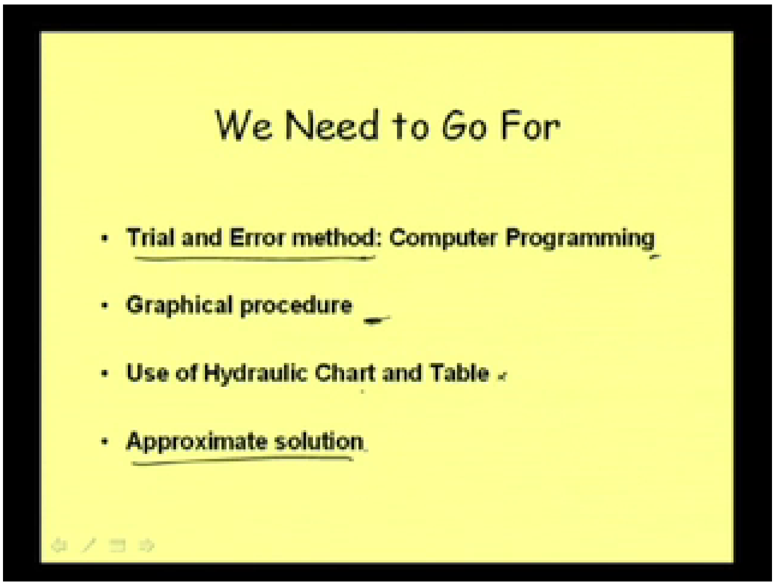

So, because of this nature of this equation, we need to go for say trial and error method. You can concentrate on to the slide that we need to go for trial and error method. So, what we mean by trial and error method, very simple. That you put some value of y n in this equation, you can put some value of y n and you can see suppose your calculator discharge, your discharge you know that say it is 100 suppose, 100 cumec should be the discharge and these parameters, you know some value and then say you put some value of y n and you check other value you are putting then, you check whether your discharge is becoming 100 cumec or not. If not, suppose it is, it has become 60 cumec, suppose it has become 60 cumec; that means, it is less than what it should be. That means, what depth you are considering or in the first trial what depth you are considering is say not sufficient. I mean you need to increase this depth, you need to increase this depth.

So, you are putting a second trial, which is second trial value for normal depth which is higher than this one and then, with the higher value of y n again you are calculating then suppose you are getting 90, then suppose you are calculating another third value, then suppose your value is you are getting 110. That means, this time in the third trial what value of y n you have put is more than, what it should be. Then, again you reduce the value between the corresponding value of y n to what you are trying, then y n 3 what you are trying, you put the in-between value and you try to arrive at the value of 100.

So, this is what is trial and error procedure. But people nowadays, no more go for this sort of trial and error by putting one by one value in hand calculation. It will be, it is quite tedious. And then people use a very simple computer programming, can be used for that purpose. Say, in the computer program you can make to change this y n and then you can see that when your value of y n and when your calculated value of Q discharge is becoming equal to your calculated, your actual value of Q or may be very minor difference because getting exactly equal value is not possible. So, it is a very minor difference, then you stop the iteration. So, that sort of iteration, we normally do in computer and of course, some people prefer to use an excel sheet. Well, what they do this formula they write in a, you can write in a say excel sheet and then you can put different y value and directly the formula is written there.

So, you are getting the Q value for different y value, just you need to type y different value and you can check that whether you are Q value that you required is matching or not. So, that way either we go for computer programming or say some people use excel sheet, that way we do go by trial and error method. Then, sometimes we go for graphical procedure, I will be coming to this. Some sort of graphical procedure also we adopt. Then, earlier of course, some hydraulic chart or table were there and now people hardly use these things. So, we will not be discussing about this particular method and then we have fortunately some approximate solution also. Approximate solution means, as you could see that from the formula, from the shape of the formula, the direct exact solution you cannot get explicitly but we have some method by which, we can get some approximate solution for the normal depth. For particularly say, for rectangular channel we have some approximate solution which gives almost correct result. Although, the name is approximate solution but it gives almost correct result. Similarly, in trapezoidal channel we have some approximate formula which give correct result but of course, it need finer correction by again trial and error. So, that way some formulae are there, that will be discussing. Now, when we were saying that we need to go for trial and error procedure or we need to go for all these different methods, now is it required for all sort of channel or for some cases, we may have direct solution of y n also. So, let us see that.

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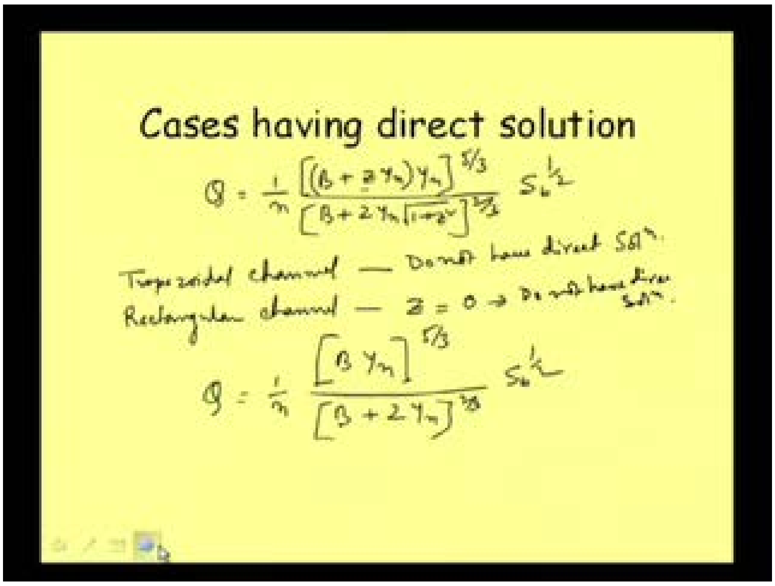

As we could write the formula just let me start from this one, that is Q is equal to say 1 by n then, B plus z y n into y n. So, we can write this B plus z y n into y n, this is to the power 5 by 3 and then, we could see that B plus twice y n root over 1 plus z square. So, B plus twice y n root over 1 plus z square and then, this is to the power 2 by 3. S b to the power half. Well, now let me take the case of, one point is clear that if it is a trapezoidal channel, then our we do not have direct solution. That point we have seen. Now, let us see if it is a rectangular channel, what will be the case.

See, when it is rectangular channel, it means thus this z value, that is the side slope z is equal to 0 and then, for that if we write this expression you can see that Q is equal to 1 by n then, B into y n, simple. Because we all know and the this will be 5 by 3 and what is the side slope, that is also simple, that is B plus twice y n to the power 2 by 3 and S b to the power half. Now, the formula has took a very simple form, but here also you can see that you cannot separate this y n because it is in product with B and here, it is again in a one single term. So, you cannot bring it common or that way you cannot have a expression that y n is equal to, in terms of other parameter. Because of that this formula, that means, for rectangular channel also we cannot have a direct solution. As we cannot separate it out. So, what we make that, this do not have direct solution. We can write that this do not have direct solution. Now let us see that for some other peculiar case; that means, one can be wide rectangular channel.

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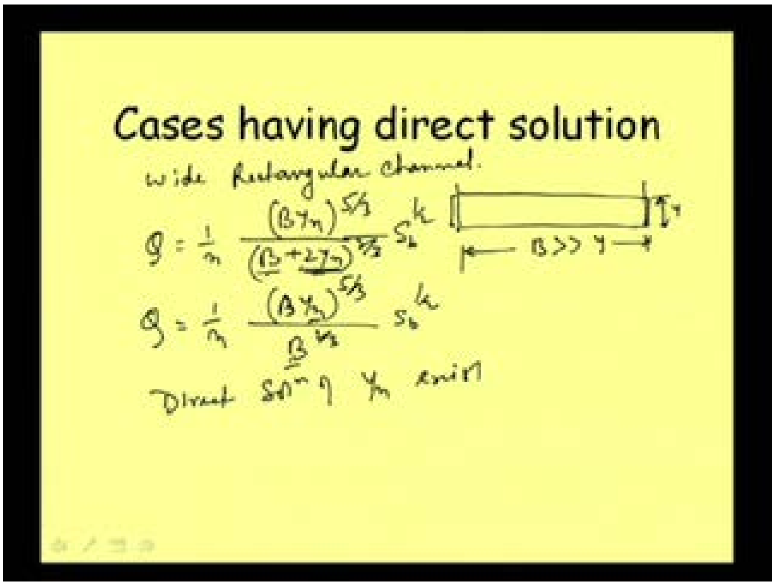

In wide rectangular channel what we mean, that this is very wide that we did discuss earlier also, that is B is very greater than the depth y. So, like big river. So, this is y and this is B and this B is very greater than y. For this sort of channel the same formula, for it is basically rectangular formula. So, Q is equal to 1 by n, area is equal to B y n side is equal to B plus twice y n. I mean perimeter is equal to and this to the power of 5 by 3 and this to the power 2 by 3 and then it is S b to the power half. Area to the 5 by 3.

Now, in this, if it is wide rectangular channel, what we can write that B plus twice y n, this twice y n being very small, twice y n being very small in comparison to B. So, how you can write B plus twice y n to the power something, that we can write as, that mean this part we can neglect, twice y n we can neglect as compared to the value of B . So, we can write Q is equal to 1 by n, then B y n to the power 5 by 3 and this we can write as B. That means, this small distance or small length this plus that. That we can neglect and we can write B to the power 2 by 3 s b to the power half. Now, you can see that y n can be separated out. This will become B to the power 5 by 3 divided by B to the power 2 by 3 and that we can definitely separate out and y we can separate out, that way we can get y directly. So, for wide rectangular channel, direct solution of y n exists. Direct solution of y n exist, means here though we did discuss that trial and error procedure or graphical procedure or approximate formula for all those, whatever it may be those procedure are not required for a wide rectangular channel we can go directly.

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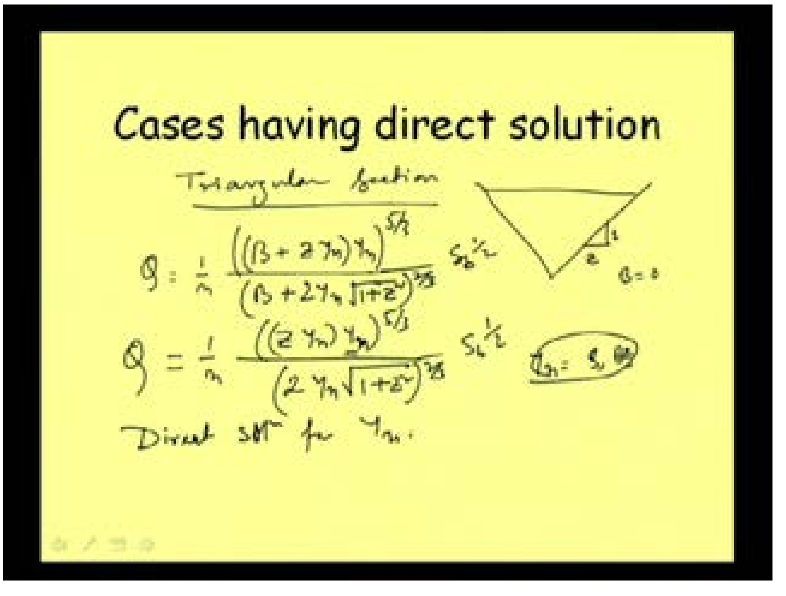

Then, Let us see another case, suppose triangular section, say triangular section. By triangular section, here it is like that. Say our channel is triangular and we have z, but here our B is equal to 0. And if you put the same equation Q is equal to 1 by n, means say B plus z y n into y n, you can write B plus z y n into y n that to the power 5 by 3 and this you can write as B plus twice y n root over 1 plus z square, the perimeter and that to the power 2 by 3 S b to the power half. Now, what you can see here, that when your B become 0 for triangular section, you will be having the expression like 1 by n, then it is z y n, we can write z y n square to the power 5 by 3 or let me write it like that, y n let me remain it like that and 5 by 3 and then, this we can write as twice y n root over 1 plus z square, whole to the power 2 by 3 S b to the power of half. Now, in this expression also it is interesting to see, that y n as I could say that this will become y n to the power say 10 by 3 and this will become y n to the power 2 by 3. Now, these are in product term.

So, what you can do, that you can just bring y n out of this equation and then, you this and you can make a, you can express this directly as y n in terms of some other variable that is Q B and directly. So, that means, as you can bring y n explicitly, B and z. So, as you can bring y n explicitly and you can solve for y n, here also when it is triangular section, you can have direct solution for y n normal depth. That means, that although we have all other procedure, different procedure that we just said about, but for wide rectangular channel and for triangular section, we do not require to go for all those method or we can directly calculate for the value of normal depth. Well, having said that now, we can move, that means, we know that we need to go for trial and error procedure or other graphical procedure only when our channel section is trapezoidal or rectangular or may be parabolic and other things can always be there. But I am talking about only the simple sections which we normally get, in that case only these two sections channel sections are coming and now graphical procedure are there.

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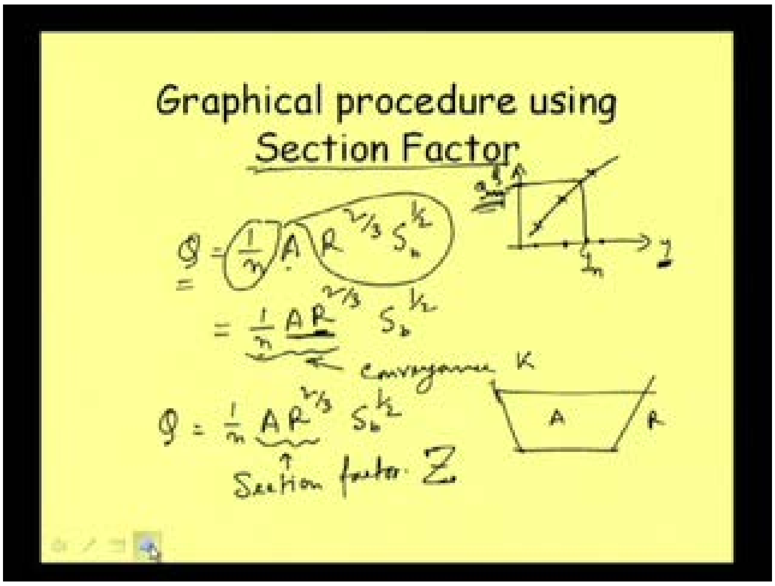

Of course, one graphical procedure can, people can say that when we need trial and error procedure, you can always have some y value and then suppose in that expression you are having some y value. You put that y value, putting that y value, we can calculate, suppose for this y value, we are arbitrarily putting and this is the Q value we are getting.

We know that this is not our Q, but putting some y value, we are getting a Q value for another y value, suppose we are getting another Q value. Again let me try another y value, we are getting another Q value. You should be careful that our required Q is suppose somewhere here, Q required. Now, once we have points, on the point larger than this required Q and smaller than this required Q. And we have few more points and then we can just draw an approximate graph like this joining this point. And then we can see that for our required Q, what will be our y. That is of course, the simple procedure is basically nothing but trial and error sort of thing. That we are using different y we are calculating Q and then we are plotting a graph from that graph we are getting what will be our y n. For that given Q other things being same, that is your other section sectional parameters are remaining same. B and n these things are remaining same, B z these are remaining same.

But there are some graphical procedure that is which use a term called section factor and then some graphs are plot of course, now as I told that graphical procedures are not that much in use because we have computer in our hand. So, with simple calculator also using approximate solution we can solve it and then, again some programmable computers are also there, you can directly calculate there. So, graphical procedure are losing its importance but still I will be discussing this graphical procedure which use section factor because it has some important factors and that we need to discuss.

Now, what is section factor? Now say let me write, first Q is equal to say 1 by n then, we can write it in a different form that A R to the power 2 by 3, means including this area into velocity A R to the power 2 by 3 and to the power half. This discharge is equal to area into velocity. Velocity means this part and this 1 by n and this part basically is the coming from Manning’s equation and this area into velocity. So, this we can write as, out of this actually, 1 by n A R to the power 2 by 3. Now, for a given section, this component S b I am writing here separately, is call conveyance of the section. This part is called conveyance of the section, that we will be coming later again. Conveyance this is called. Conveyance k, generally k is the notation that is used for that purpose.

Now, here in this conveyance there are factors suppose area and then hydraulic radius. Hydraulic radius is nothing but again area by parameter perimeter. So, these factors are basically related to the sectional size of the open channel. And then, this n it is not related to the sectional size of the or not related to the size of the channel section, rather it is related to the roughness characteristic of the channel and of course, some other parameter what we did discuss earlier that influences the n value. But definitely not the sectional size of the channel. So, we can again separate out from here, that is Q is equal to say 1 by n then A R to the power 2 by 3 this and then S b to the power half. This we call as a section factor.

So, for a particular channel this section factor for different depth, given the depth, suppose whatever the section may be, if we do not consider the other things then given the depth, we can find area, we can find radius, then we can find the hydraulic radius R and then we can find out what the section factor is, for different depth we will be getting different section factor. And for section factor generally a symbol Z is used. Of course, do not confuse this with the side slope z, this notation is use a capital Z is used for section factor and then, we can have that is,

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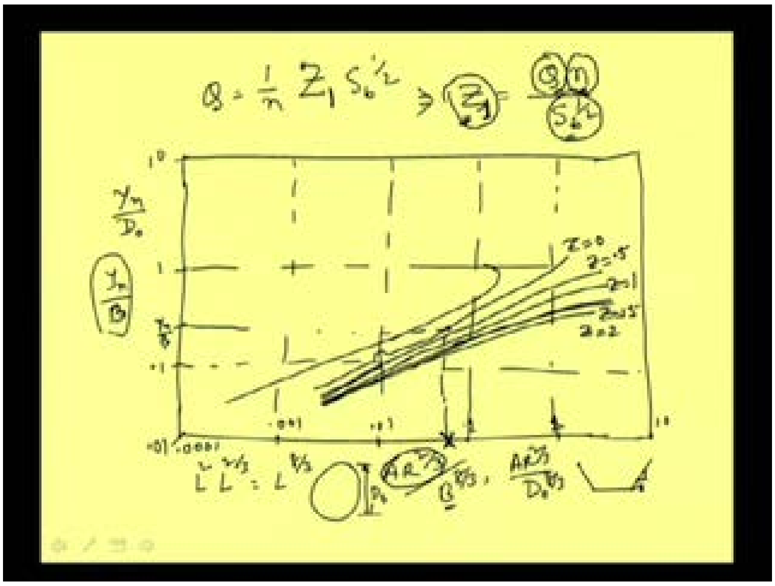

We can write it as Q is equal to 1 by n then A R to the power 2 by 3, I am writing as section factor Z and then S b to the power half. So, from that what is, what can be this is equal to, say section factor Z that we can write as Q n and S b to the power half. Well, what it mean that though section factor Z is a parameter which is related to the sectional dimension of the channel and of course, sectional dimension of the flow section rather. But this we can get indirectly as when we know a Q discharge is known, then say Manning's roughness coefficient is known, bed slope is known, then by this expression also we can find out, what is the section factor Z. Now, using these advantage what was done? Some graphs were plotted. And then that graphs was basically made non-dimensional graph. Well, that I will be coming. And then from that graph, we could calculate the uniform flow depth. So, let me just draw the graph. This was plotted in log-log scale and then, so, our value will be like that, say it is 0.1, on the y axis we were plotting, we can plot say non-dimensional depth means, this is say y is the depth and then y n is the depth suppose and then, for y if we divide it by B, if we divide it by the B or let me write at S b, b means the bed width of the channel, then this we can call as a non-dimensional depth. And then this value suppose 0.1, then we are writing 1 and then, we are writing say 10.

So, it is 0.1 and 10, that way we are dividing it. And here it is starting from in this side we are writing the section factor, that is A R to the power 2 by 3 and this in fact, has the dimension, say area will be having a dimension of L 2 the power 2; that means, L square, length square is the dimension. R hydraulic radius. So, its dimension is also length. So, it will be length to the power 2 by 3. So, what is its dimension say, we can write L to the power 2 by 3, for this R that is length parameter and then, it is L square. So, this will become L to the power then, it is 8 by 3. So, it is dimension is basically length to the power 8 by 3. So, to make it non-dimensional, if we divide it by again B to the power 8 by 3, this become non-dimensional. So, on this side we are putting A R to the power 2 by 3, that is section factor divided by B to the power 8 by 3. Well and this start from 0.0001 then, it is becoming 0.001 then, it is 0.01, 0.1 then it is 1 and then it is becoming 10. This is becoming 10.

So, this within this range, we can plot these value. Now, let me draw some line as a guiding. So, this B it is divided by B when it is A, I mean B to the power 8 by 3. The section factor were dividing by B to the power 8 by 3, when it is a trapezoidal section like this one. But this graph, that is graph of section factor that was also plotted for circular section and in that case, we do not have any B. So, in that case for circular section, we can plot here y n by D, that is the diameter of the circular section. This, D 0 normally is use and then, here also it is plotted either these or say A R to the power 2 by 3 divided by D 0 to the power 8 by 3. What is D, when we take a circular section then, this diameter is considered as D 0.

Well, now just putting these value, if a graph is plotted then, for circular section what we get the graph is like this. For circular section we are getting a graph like this. It goes like this and then just after crossing these value, it is coming like that. Now, why I am plotting this, just to emphasize what these portion mean. I will come back to that. And for trapezoidal, trapezoidal means if we make z is equal to 0, then it become rectangular. So, for rectangular section also it was plotted and for that, we can write that for rectangular channel, this graph goes like that one. It goes like that. And then this is say for z equal to 0. Let me draw it properly. This is going like z equal to 0, say z equal to 0. Then, with the increase of z value, say z equal to 0.5, we are getting it like this, then suppose z is increasing, then it is going like this, z equal to 1 then, this part it is becoming narrow, this is not changing that much, but here it is changing z equal to 1.5 and z equal to, it is further increasing z equal to 2 like that, with the increase of z value. That means, the side slope z, well, do not confuse this Z and that z. I should have used a different symbol here.

Well, here in this graph, say for section factor, let me put it Z 1 and this z is representing side slope well. So, this z is side slope and section factor I can write as Z 1. Here of course, I am not writing any symbol for section factor, I am writing A R to the power 2 by 3 directly. So, that way we can have this curve. Now suppose a discharge is given to you and that roughness parameter, that is the resistance parameter, roughness parameter that we call, that n is known to us and then slope bed slope is known to us. That means, these three, you can concentrate into the slide. These three parameters that is Q n and this S b, these three parameters are known to us. Then, we can calculate, what will be the z 1 section factor, what will be the z 1 value of that particular flow and for that z 1 value now, we know that what is the side slope. Suppose, it is rectangular channel then what we will do? We will first see in this graph then, we know the B value. So, we can have b z divided by z 1 to the power 2 by 3 divided by this B. So, that value you will be getting here, suppose this is this much. For our particular problem, it is this much. If it is rectangular, we will be going to this particular graph and then we are getting, what that y n by B value, we are getting y n by B value now, we know the B. So, we can calculate what the y n is. Once we know the y n by B value from this graph, then we can calculate what the y n value is.

So, that way knowing this (( )) we can calculate the normal depth. If you Z is suppose 1, all Z is 1.5 then from the same point you will be going to the another, after corresponding curve (( )) y n by B value. Now, the problem if you Z value, suppose it is a circular channel, suppose it is a circular channel. Now, if it is a circular channel, and say you Z value has come up to (( )), Z one value I am talking about section spectral value. Then you your coming to the curve of circular, if you are here it is no problem, if it is circular curve you are going the and your finding the (( )) here, you are going to discuss and if you are getting a value here. So, for these point this no problem. But when you are going to a very higher value of J, that means your Q value is increasing and then your your Z value is increasing, Z 1 value is (( )) section factorial value is increasing. Then your coming to a point this portion, the non dimensional section factor this divided (( )) 8 by three and then your problem arises, because in this curve you have two point, you have two point.

Once you have two point here, that means for this Z, you can have these value as well as you can have these value. For this value you are getting one normal depth. One y n by B (( )) non-dimensional depth first, and then for these value you are again another non dimensional depth both these value will give you one different normal depth. Of course this depth difference in depth is very small, difference in depth is very small. But in reality also in circular channel that is why you say that for (( )) we can have two normal depth.

You will remember when we started it uniform flow, when we start it uniform flow computation, whether we have discussing about uniform flow a normal depth then we will discussing the delg exceptional keys in circular channel. In other channel we can get for given the (( )), we can get one uniform flow depth, that is for a given section there can be one normal depth only for a given (( )). For a given slope, for a given slope, given (( )), given section you can have one normal depth. One uniform one depth (( )) uniform flow can occur, and that we called as a normal depth.

But for a circular section, when it is just above to (( )), the surface, top of this, this above to become complete, so when Z value is very high then we can have two (( )) of uniform flow depth computationally we could see there. And of course one think is very clear, that if it is a circular channel, if it is a circular channel, and suppose the surface is (( )), if it exit a particular limit, that means when there is no, suppose no space on the top when it is completely (( )) then the underflow itself we have to deal as a different type of flow. Then it will no more be a open channel flow and another it will become a pipe flow concept, and then we have to think about other theories, other relations, and that way that is another issue, but here what when till it is open channel flow, it is not completely covered, pressure is there, we can have two normal depth (( )). About this uniform flow formula what (( )) it is may be Celsius formula, Manning's formula all these.

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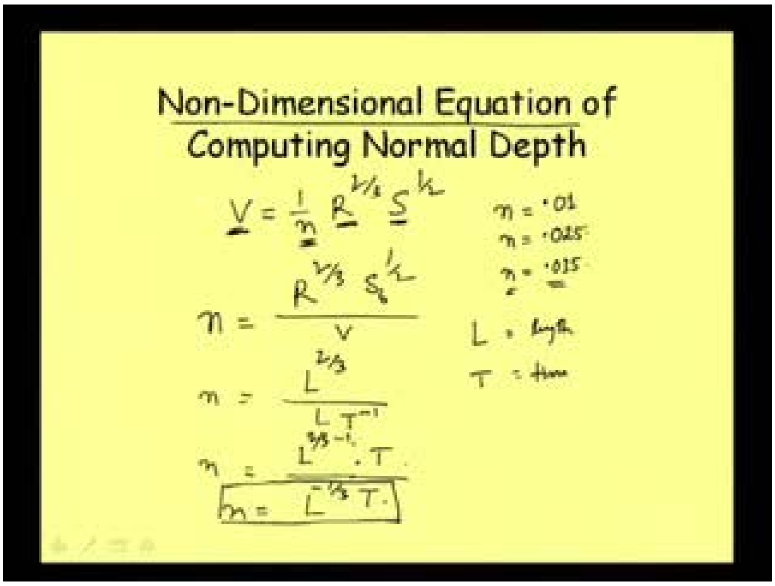

Then see let me write the manning's formula, if this v is equal to 1 by n R to the power 2 by 3 then s to the power half S be (( )) whatever it is, well. Now here we are using the value of n, and then n value is given normally as a just digital value; digital value I mean that a numerical value is given. Say for a smooth channel, very smooth channel, you can say for n is equal to it can be suppose 0.01; for a rough channel n can be say 0.025, then if it is further, suppose very rough bed and side, then we can write it has 0.035; like that it can keep on increasing. I mean, just this is I am putting some arbitrary value without mentioning, what the type of channel are? Well.

Now, when we are using this value, we are not putting any units for this value; we are not putting units for this value. Means, suppose when we write about velocity, we write velocity is equal to (( )) meter per second or drift suppose (( )) meter. But here we are just writing some value. So we will have to be very much careful in using these some formula. That is in fact this n is not a non-dimensional term, it has some dimension; though we are not writing the unit on the side. And that is why when we are using this, we have already knowing that this we are using n or a particular value of V or a particular unit of V that means V is suppose n meter per second, R is in meter and S is of course the bed slope is not having any unit. So so that we are knowing the unit of R and V, if it is in meter and second, then we can say n value like this.

If this V and R value are in suppose (( )) and second, then this our n value will be different, n value will be different. So we need to know that the dimension has a rule to play in this sort of equation. And ok and if we say what will be the dimension of n that also we can find out in this well, say n we can write as n is equal to we can write R to the power 2 by 3, S to the power half divided by say V. Now if I write the length dimension as L and say the time dimension as T, this is say length dimension, and this is say time dimension. Then we can write n is equal to, I mean not equal to basically we are talking about dimensions, what is the dimension of n or that we can write length to the power 2 by 3, and then S whether it is bed slope or whether it is friction slope this is not having any dimension as we know.

And then V velocity will be having the dimension of meter per second, so it is length by T; so L T to the power minus 1 we can write. And that (( )), what will be the dimension; that will be L to the power 2 by 3 minus L , L to the power 2 by 3 minus 1, and then it is T, we can write. So this is equal to we can write the L to the power minus 1 by 3 and T. So this will be the dimension of N. Well, now with using this dimension and putting considering this dimension, also we can develop a equation of the uniform flow what we have already written for trapezoidal channel. Then the same equation we can write in a different form that we call as a non-dimensional equation of open channel flow. And using these non…Then there will be coming a non dimensional (( )) and of course you will be talking about non dimensional depth like y by b. So using that, you can have a relation n taking advantage of these relations, we can have some formula that we initially discussed that the approximate formula of computing normal depth, and depth of course will be discussing in the next class.

Well, let us get ready for the next class whatever we can start with the fresh mind to see how this approximate formula can be used; and how we can using this, what is the advantage of using this approximate formula.

Thank you very much.