Computational Hydraulics
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Lecture 43
Steady Channel Flow: Channel Network with Reverse Flow (Contd.)

If I consider this condition now in this case if I open my scilab so I can open this cfg steady 1D channel network with reverse cfg 1 that is configuration 1 which is the base configuration.

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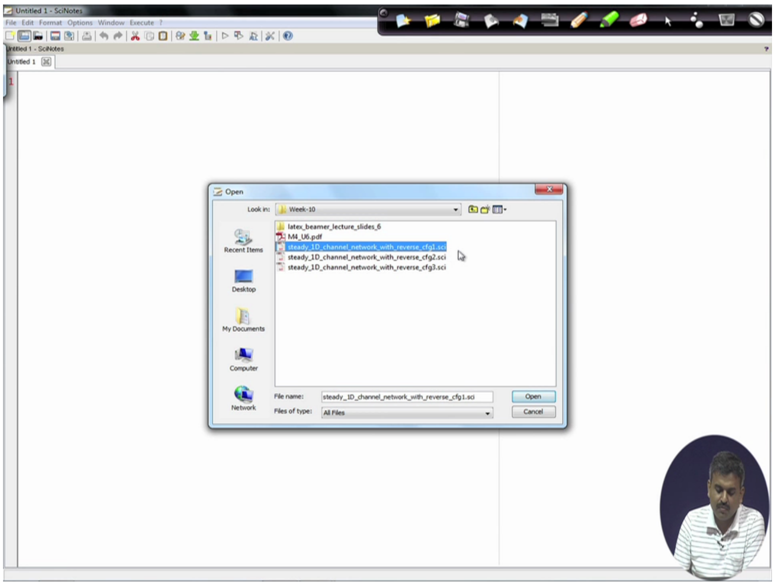

Now in this case the first line starts with clc, next line is clear that means clearing the console, clearing all the variables here. Next one is area calculation. This is dA by dy calculation. This is general one for trapezoidal section.

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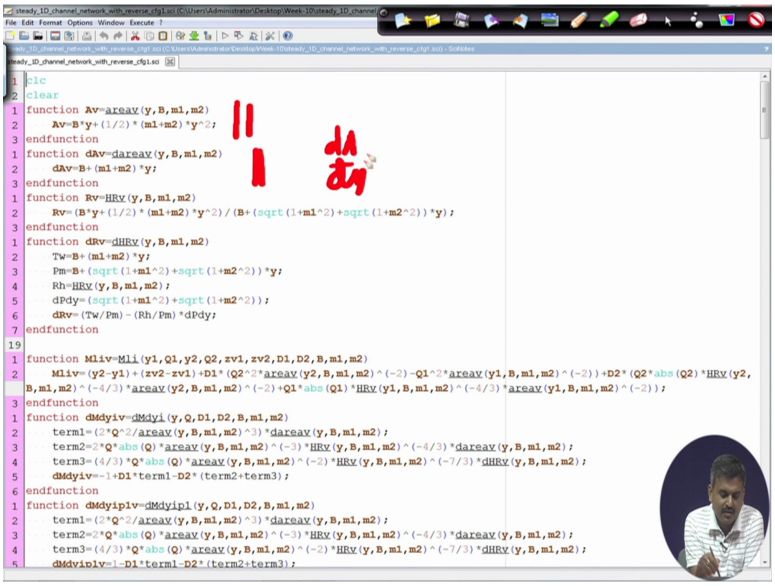

We will be utilising m1 equals to zero, m2 equals to zero for our problem but still we can use this subroutines or functions for our problem. So this is hydraulic radius, this is dR by dy again.

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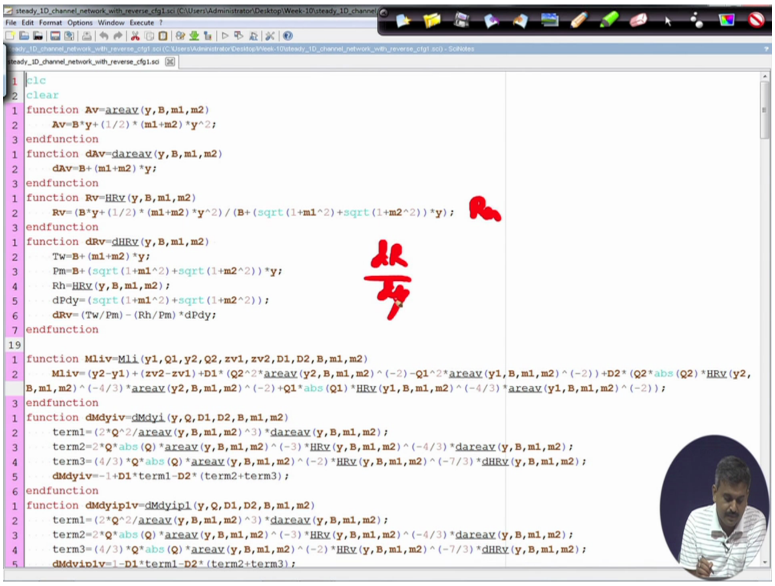

Now this one is a M L i, this is dM L i divided by dy i or dy L i. Now interesting thing in this M L i is that for Q2 square we are not changing Q2 into abs Q2. Q1 square we are not changing it to Q1 into abs A2 but for friction slope this is changed to Q2 into abs Q2. This is again Q1 into abs Q1. In dM by dy this is the terms which are related to fictions slope. I have changed those values to Q into abs Q. This is Q into abs Q.

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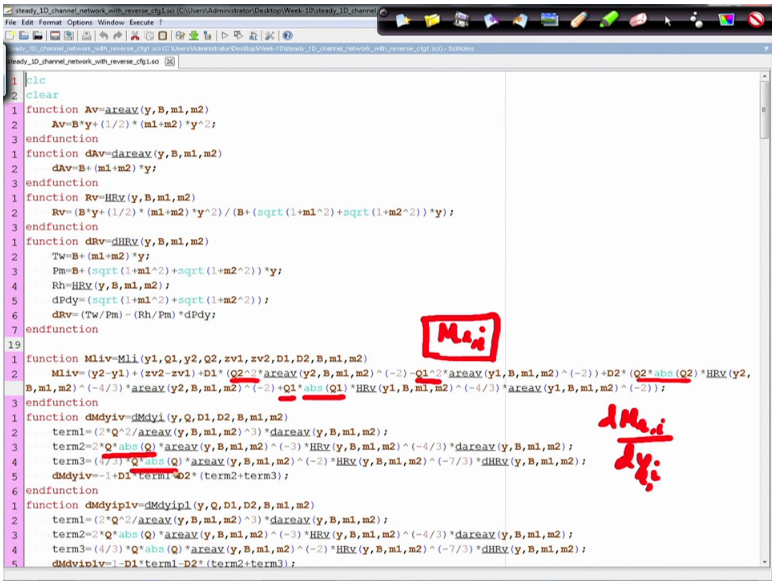

Similarly for dM L i divided dy L i plus 1 again this is changed to Q into as Q, Q into abs Q. But for dM L i divided by dQ L i plus 1 I have changed this Q in the term 2 as abs Q. And dM L i divided by dQ L i I have changed into abs Q here.

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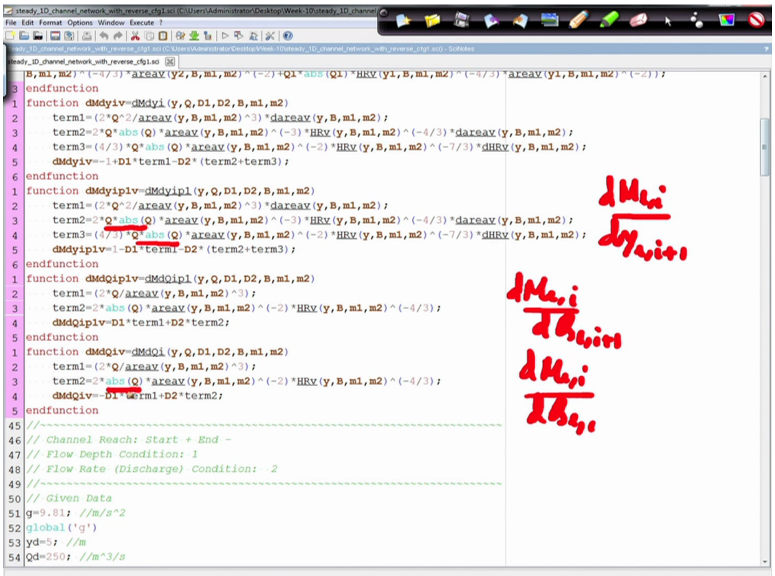

Now after writing these functions I can start the main program here. So channel reach, convention is that channel reach start is plus, it is ending with minus and flow depth condition 1 means that is (condi) number 1 and flow rate or discharge condition is 2.

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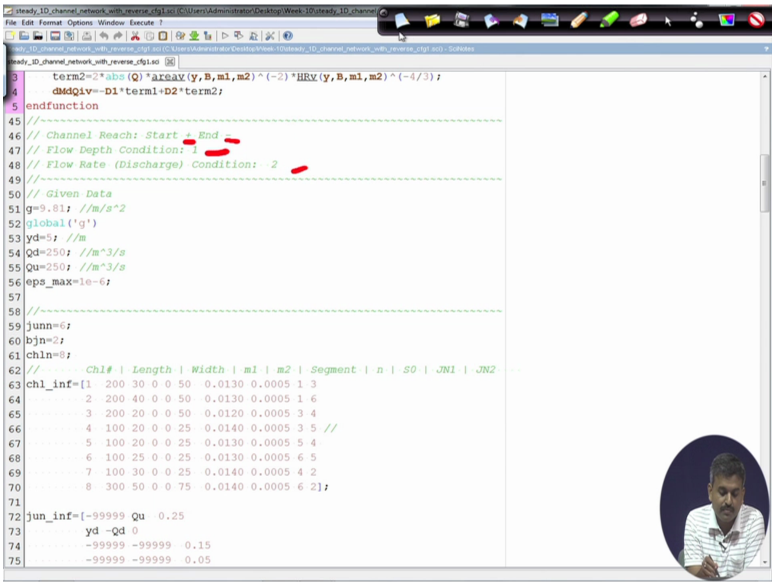

Now given data g is 9 point 8 metre per second square, g is global, yd is the flow depth, Qd is 250, Qu which is specified in the upstream that is 250, epsilon max this is required for Newton Raphson iteration 1 into 10 to the power minus 6 here.

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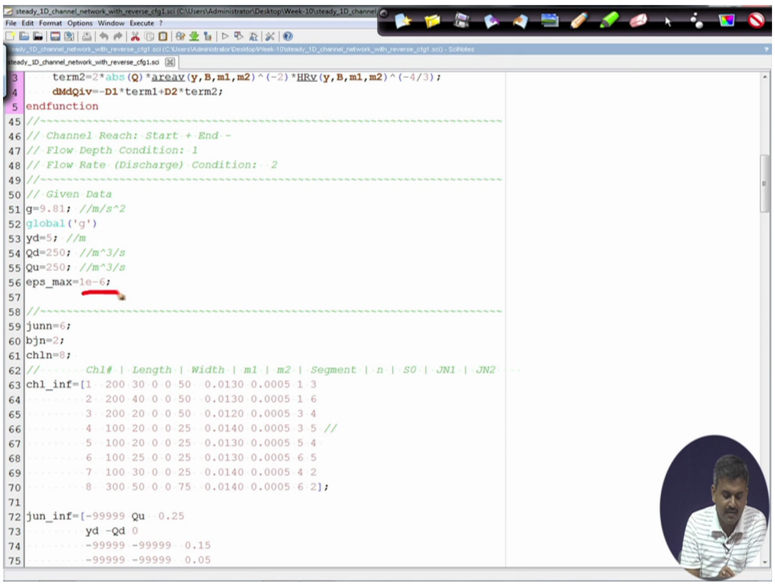

Now we have these junction numbers. So we have all total 6 junctions and 2 boundary junctions. So out of this 6 we have 2 boundary junctions. So in this case let us consider this one as red one. This is 1, this is 2. Blue ones, 1 this is 5, this is 6. So obviously if I connect it properly so this is entry exit and if I name it this is junction node number 3, 4, 5 and 6 in this case. This is node number 2 and 1, okay.

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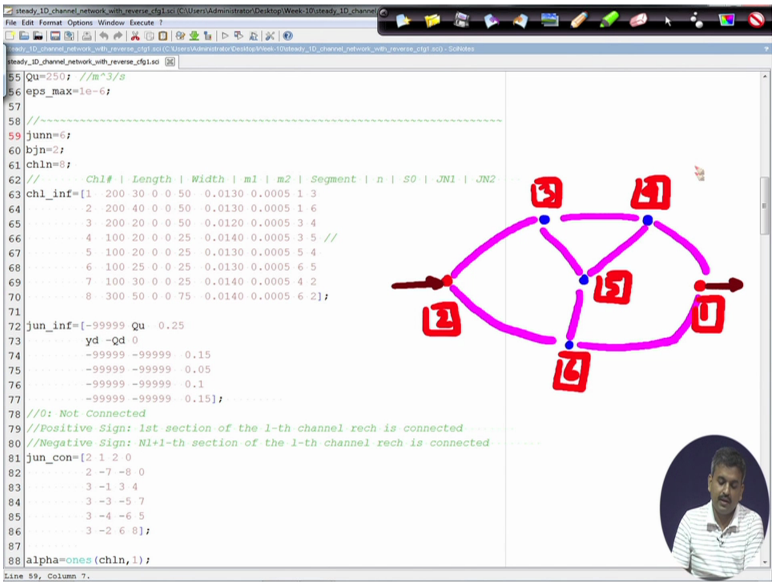

Let us see how we can utilise this during our programming. This is channel in matrix. This is channel, this is junction information matrix. First column is your specified depth conditions, second column is specified, this is 1 2 for discharge and third one this is for elevation.

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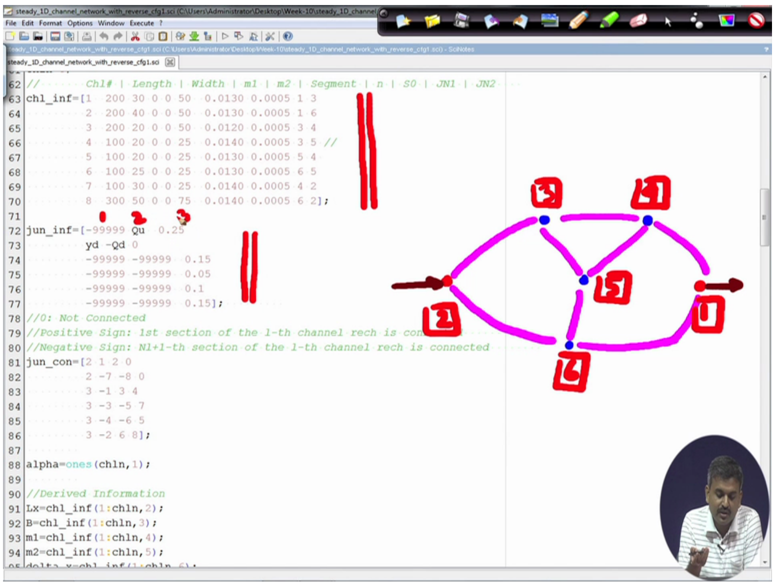

Now for this one if I consider here we have this junction connectivity. Then alpha values, alpha values once in to channel number comma 1. That is for each channel reach we have considered alpha equals to 1. Now I can transfer these values directly to Lx. Lx is the second column, B is the third, m1 is the fourth, m2 is the fifth, Lx is sixth, n is seventh, S not is eight one. Now after transferring these values I can calculate this mnode. Mnode is Lx divided by delta Lx plus 1. So number of segments plus 1.

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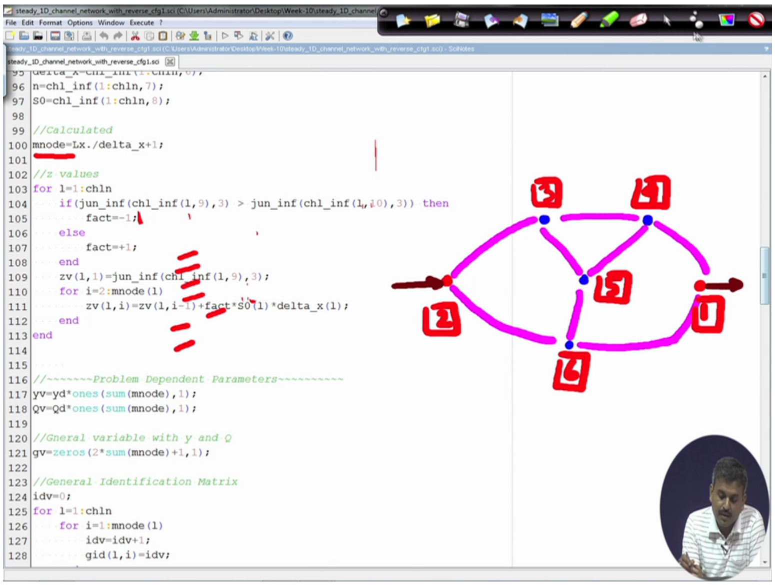

Now in this case we need to calculate this z value, this is important. We have zero elevation at this junction point 1. So this is junction information and in junction information we are asking for values from third column and this is for channel information L 9. This is JN1 and JN2. We are asking information for this 9th and 10th column.

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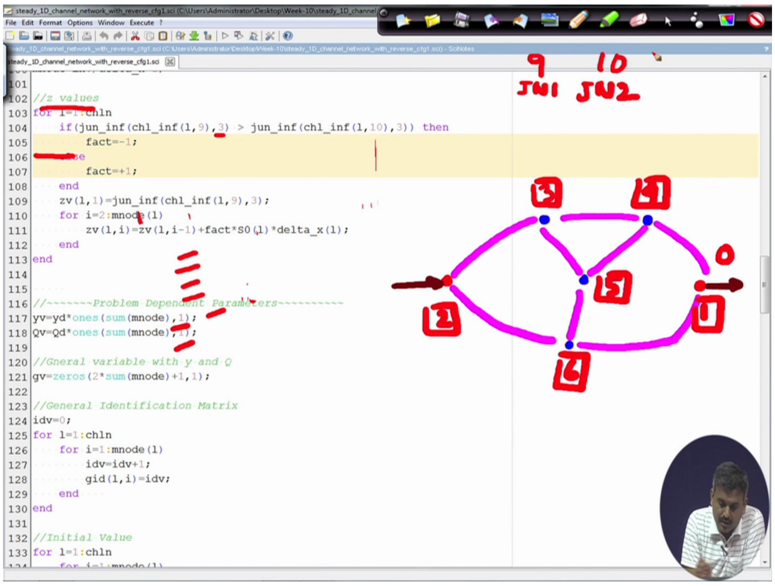

Now let us say that my channel is 1. For 1 if I take this channel information L9, I will get 1. In this case I will get 3. That means junction information 1 3. What is the elevation? This was point 25. This was having a value of point 25. Now for our problem if this upstream elevation is greater than the downstream junction elevation so obviously this is the natural flow direction.

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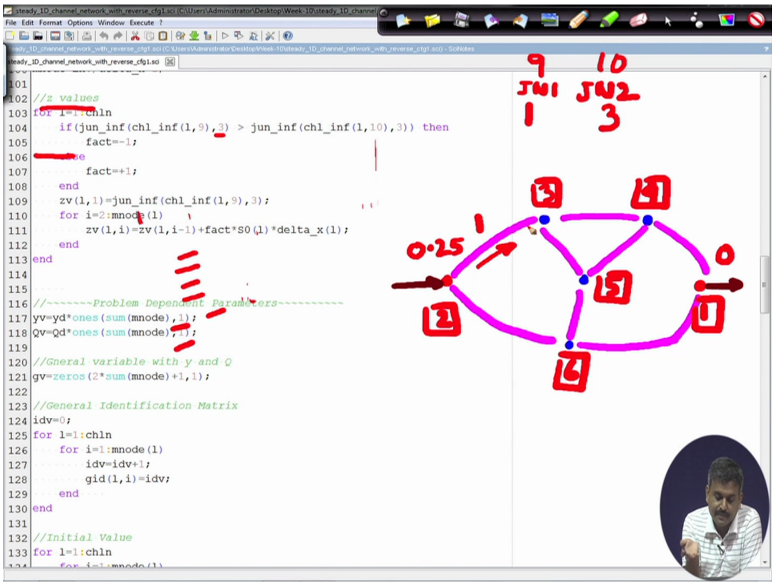

So we will consider this factor, factor is minus 1. If the elevation is decreasing obviously I should multiply this factor with S not into delta x so that I can reduce this value here. So starting with this elevation which is channel information L9 3 that means from junction information matrix from third column I am considering that at the first node what is the elevation. That is L1. Is that elevation? Now whether I should reduce it now for consecutive section or I should increase to get the downstream section.

So downstream node maybe at a higher elevation or at a lower elevation depending on the direction of flow under consideration. So in this case negative means we are considering as per our channel bed slope. And if we have considered the flow from 3 to 1 here. This is 1 this is 2, 3 to 1 here so obviously natural one was 1 to 3 this will be 3 to 1 so obviously this is at a lower elevation, this is at a higher elevation.

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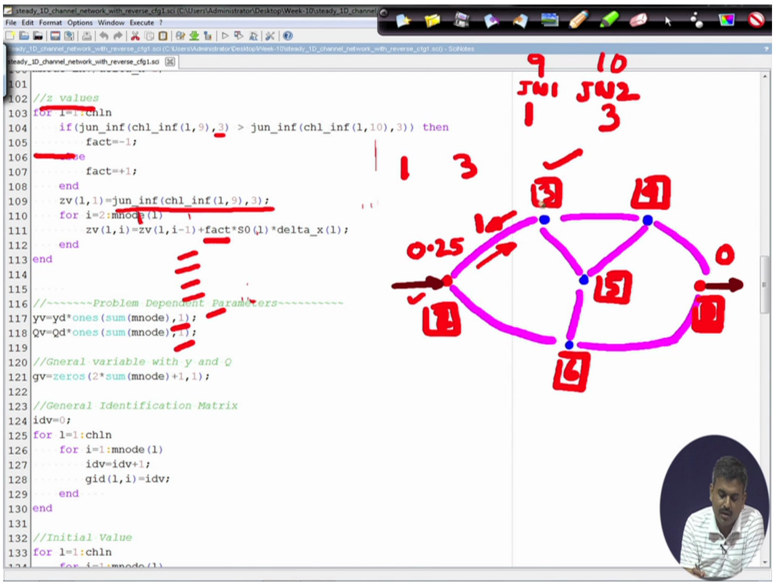

So I should start from 3 and I should increase the section elevation by S not into delta x. So like that I can calculate the z values for different sections for different reaches. Now in this case after calculating the z values I can assign initial guess value for yv and Qv. This is similar to our previous code that we have utilised in our previous lecture class. But just see this numbers so we have sum into mnode. Sum into mnode considers all sections for all channel reaches. Qv also considers all sections and all channel reaches.

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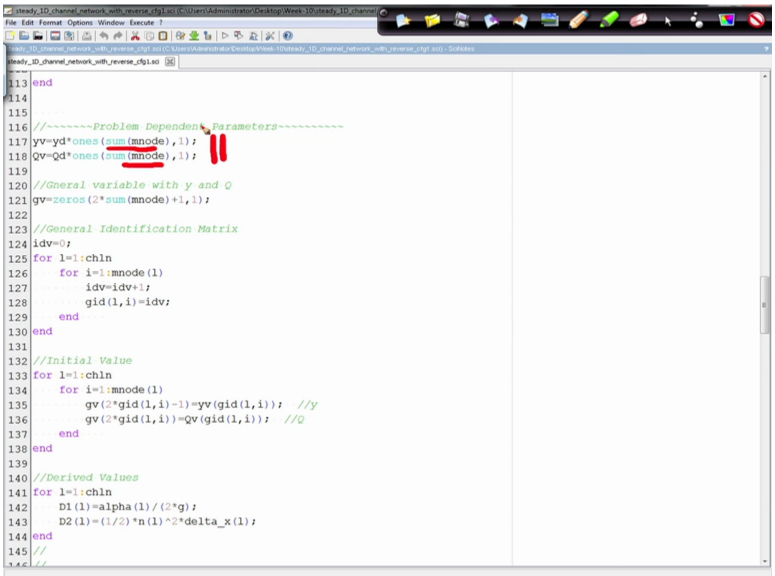

Now in this case we have a general variable which is gv and gv should be 2 into sum mnode and we can consider this as 2 into sum mnode as unknowns.

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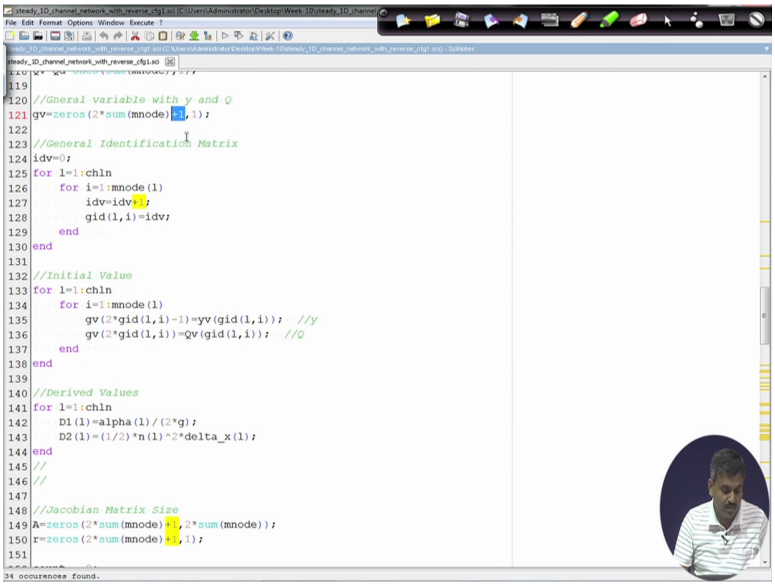

Now in this case we need to define general identification matrix and as per our convention. This general identification matrix is similar to the matrix we have discussed in our previous lecture class which is gid L i. This is for Lth channel and ith section.

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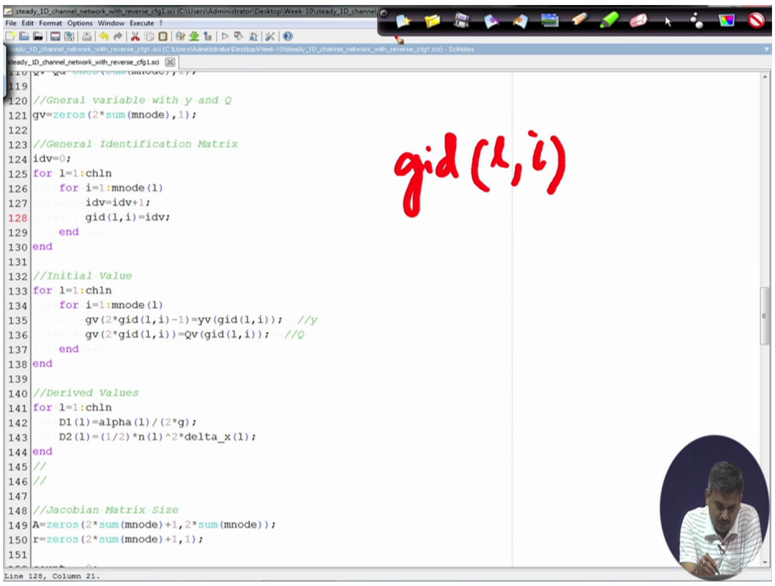

So we will have unique number for this one gid and we can utilise this information for construction of Jacobian matrix. Now this is the initial value. We can assign these initial values. the y information we can transfer it to 2 into gid into minus 1. So we (ha) have arranged this y1 Q1, y2 Q2. So in this particular case for each channel sections or channel reaches we have 5 sections.

Now all total we will have 1 to 40. So 1 will be the starting gid and ending value will be 40. Depending on the flow direction we can change the numbers but the total number of gid or unique ID that will be up to 40.

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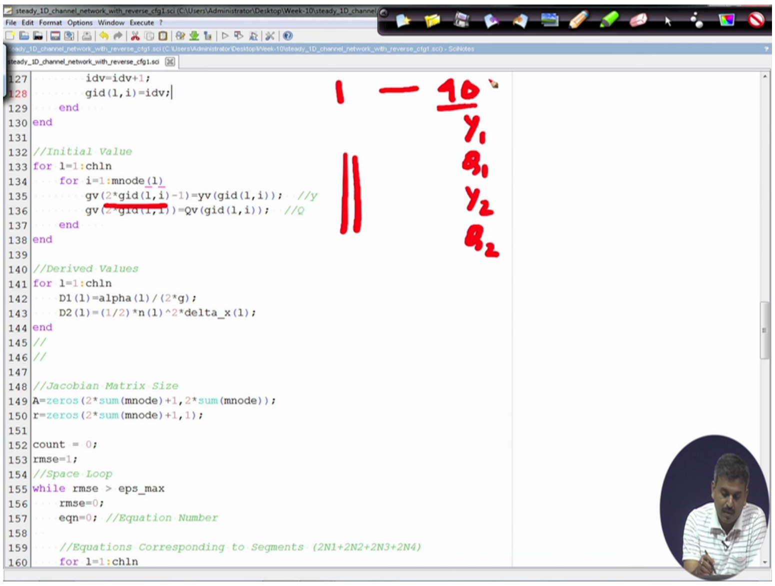

Now derived values we can calculate this D1 D2 in this case. And in this case we will get eqn equals to 80 plus 1 where 40 into 2 plus 1 unknown. For 1 unknown also we will get equation but we have utilised Qu as specified value in our case. So we have only 80 unknowns in terms of y and Q values. But equation number will be of 81.

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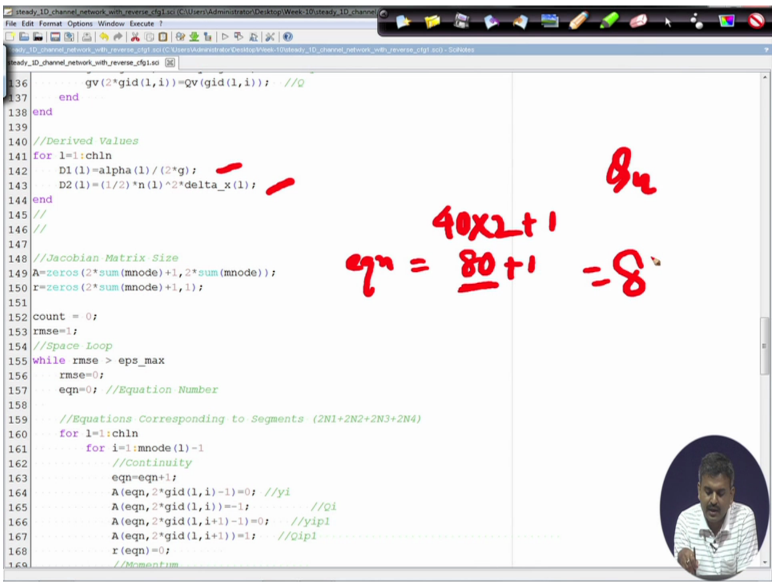

Now I will discuss how to solve this problem. Now in this case this is count equals to zero, rmse equals to 1 and after entering into the loop I have changed it into rmse equals to zero. Equation number starts with a zero value for each channel reach because we have 2N1, 2N2, 2N3, 2N4 plus 2N5 plus 2N6 plus 2N7 plus 2N8.

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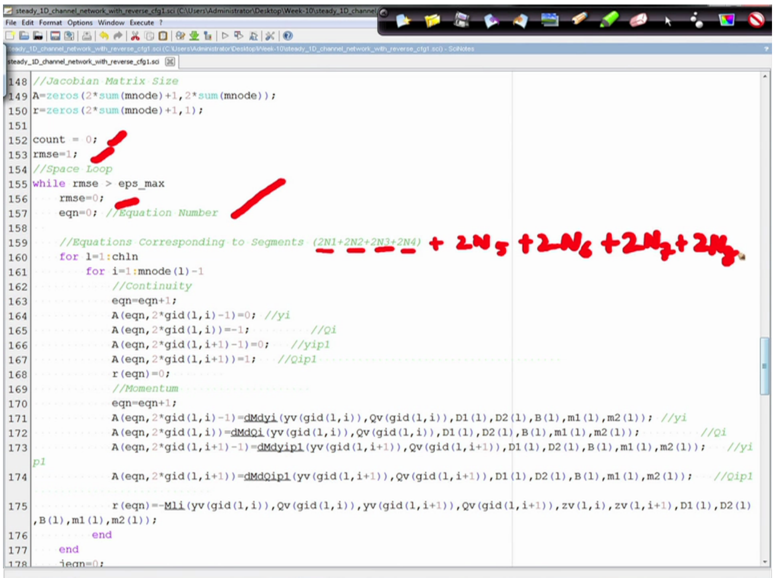

Now after generating these many 64 equations I can start including the junction continuity conditions. So junction continuity condition for each junction there will be one condition. So j equals to junction number. For each junction number we have one condition. This junction information j2 which is the second column this is not equal to minus 999 5 9s.

So that means we have a specified value present there then we can add that for equation number. Equation number equals to eqn plus 1 and this is a junction equation number. This is r equation number equals to junction information j2. That means we are directly specifying r or right hand side equals to that specified value.

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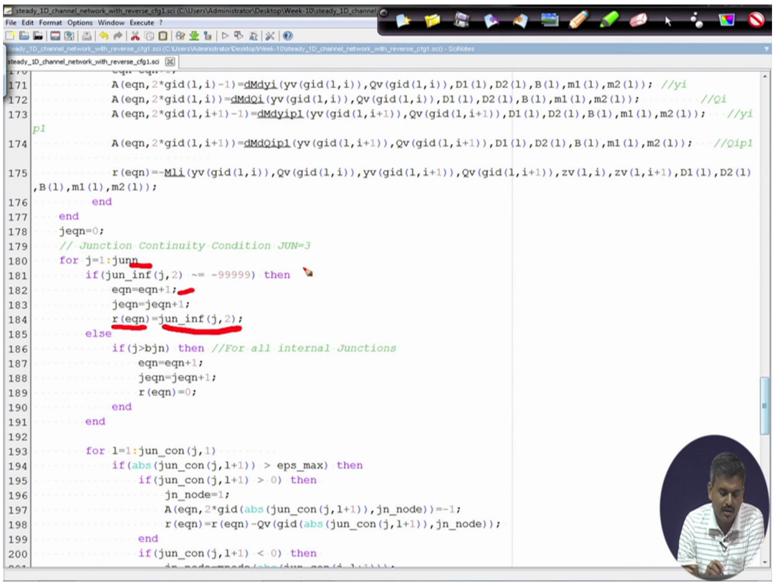

Now after specifying that value we need to consider starting from L equals to 1 to junction continuity j1. That is first column contains the number of channels present in the junction. So in this case we will get or we have to add these values. If abs junction condition, if absolute value of junction condition L plus 1 starting from the second column we can extract the information about junction connectivity. And this is epsilon max. Obviously if zero value is specified so this condition will not be satisfied.

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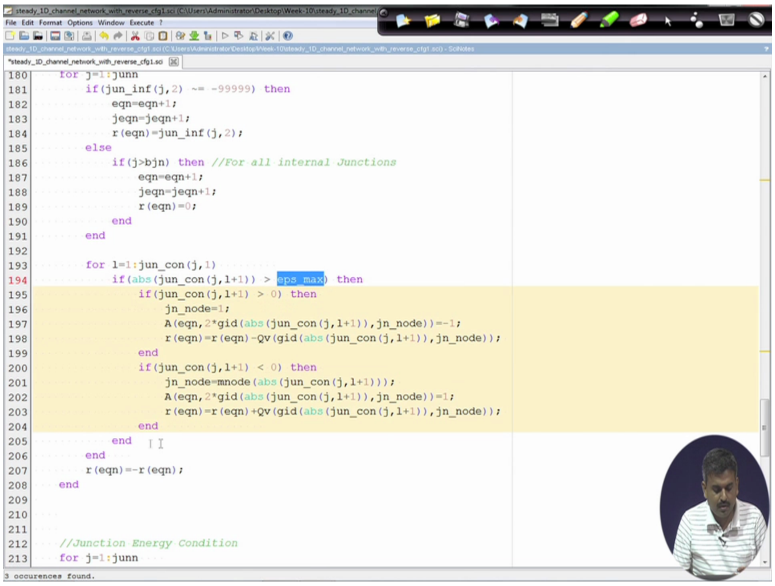

Now if junction continuity j L plus 1 this is greater than zero. Obviously if it is greater than zero that means we are starting from the starting node. That means j underscore node this is 1 and we can specify this condition and this should be negative because we are starting at that junction. So it should be negative discharge value as per our convention.

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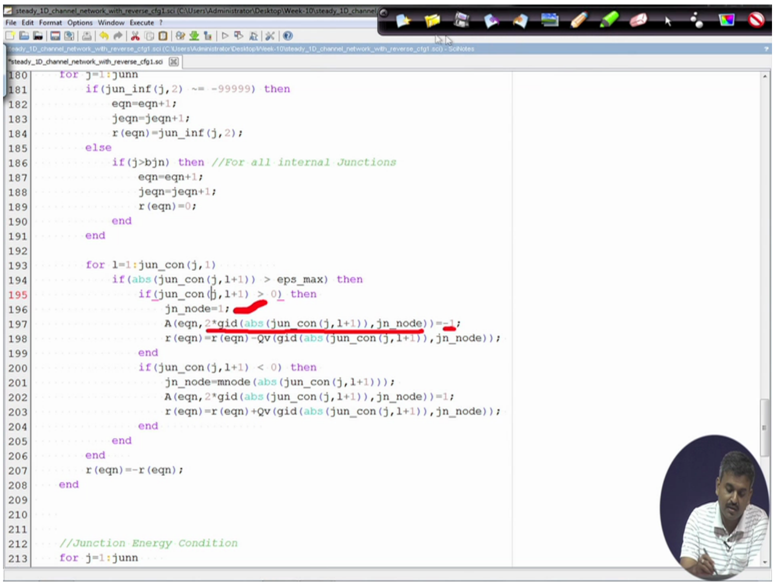

This junction connectivity if this is negative so obviously we are talking about the terminating node here. So junction node equals to mnode absolute junction connectivity jL plus 1 and we are adding discharge to our junction. So that is why coefficient is 1 and this is r eqn plus Qv in this case. Interesting part is that if this junction condition is not specified here obviously j greater than bjn.

Bjn means number of boundary junctions. If j value crosses for boundary junctions then we should start calculating the discharge conditions for other nodes.

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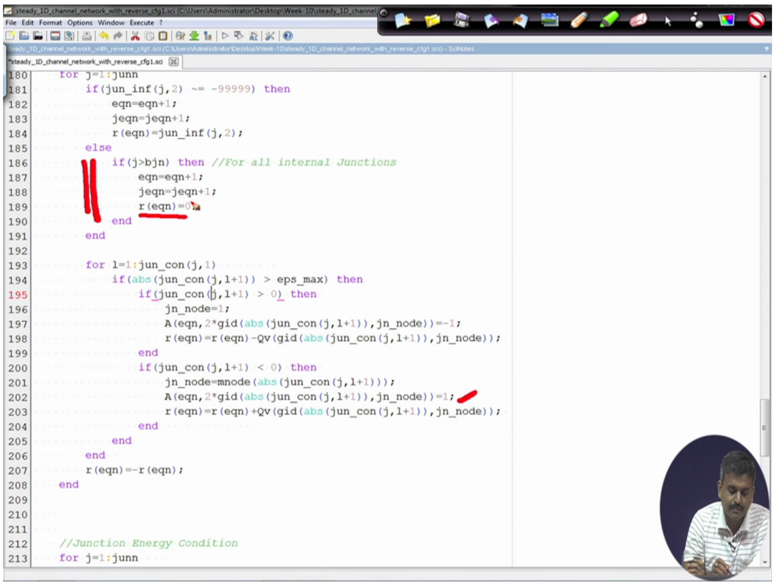

So in this case r eqn equals to zero in this case. At the end we should write r eqn equals to minus r eqn. Obviously minus of function value is required on the right hand side. That is why I have written it. Now let us consider junction energy condition. Energy condition if some value is specified if junction information j1 this value is not equal to minus 5 9s then eqn equals to eqn plus 1. And if it is positive first node, in the second column if it is negative obviously it is mnode. So accordingly we can specify our conditions.

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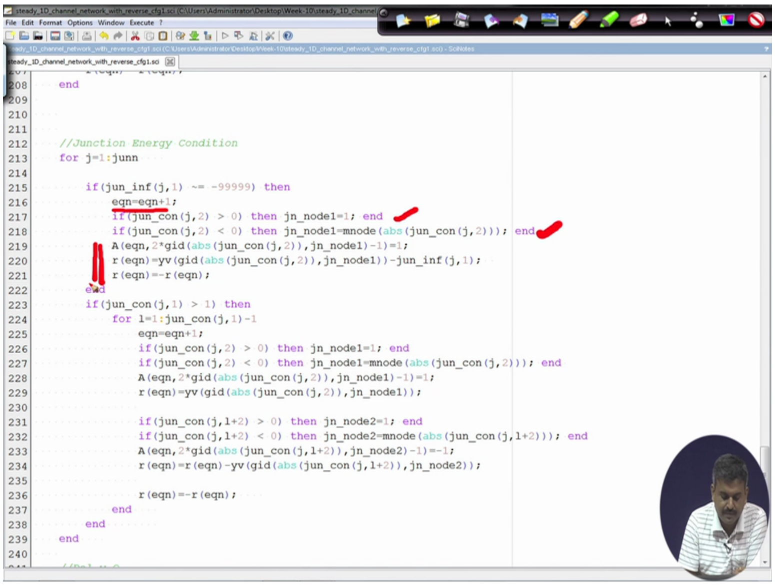

Now after considering this we can include this junction connectivity j1 greater than 1. If it is greater than 1 then only we should iterate. This is starting from L to junction connectivity j1 minus 1. And this is the first node or the element which is there in the second column we will consider that as a fixed and we will start our calculation by considering the elements from the third column.

So from the third column we will get information about the starting or ending node. Accordingly we can enter the values there and finally we need to perform this operation.

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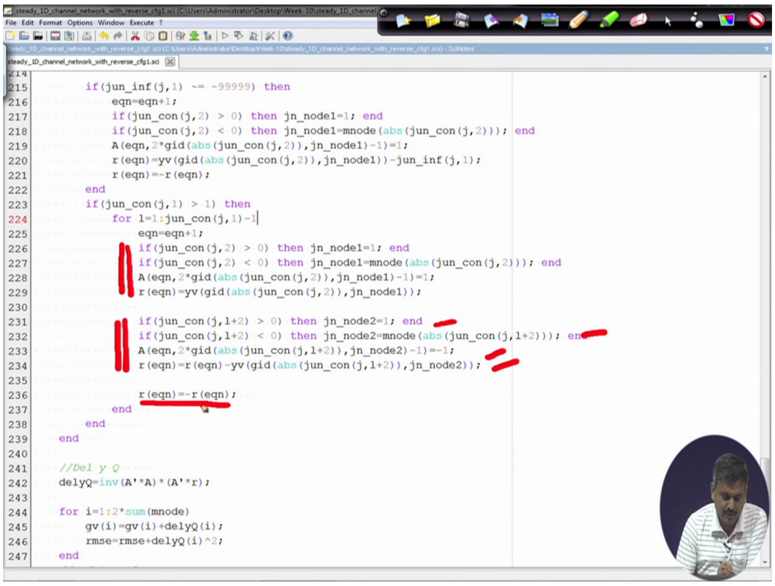

So obviously in this case we have calculated all the things. Now interesting part here is that A the size is we have 81 equations but we have our 80 unknowns because I have already specified Qu value there. So in this case this is del yQ which is of size 80 into 1 and right hand side is r again 81 into 1.

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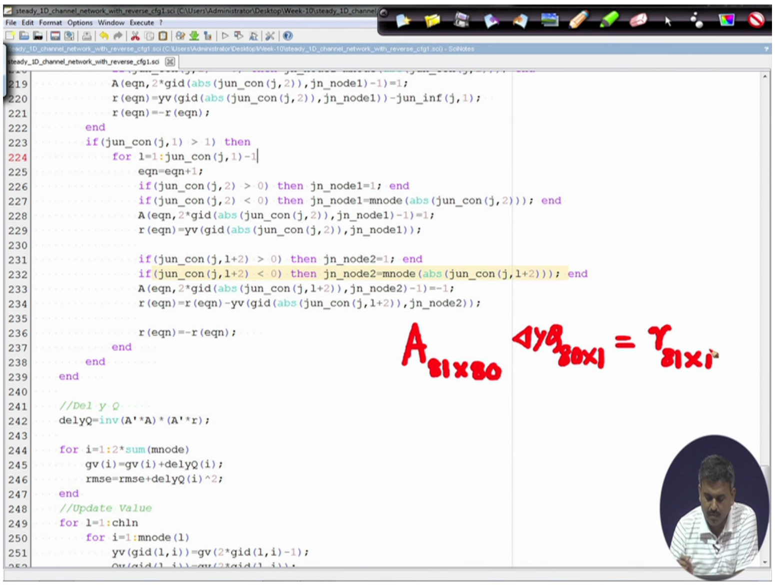

What I can do? I can just multiply A transpose on both the sides so obviously this is A transpose. Now after multiplying A transpose obviously the size will be 80 into 81. So the resultant size is 80 80. Now del yQ 80 into 1 this is equals to A transpose A inverse into A transpose r. So size is 80 into 1. So after considering this, this is the calculation here.

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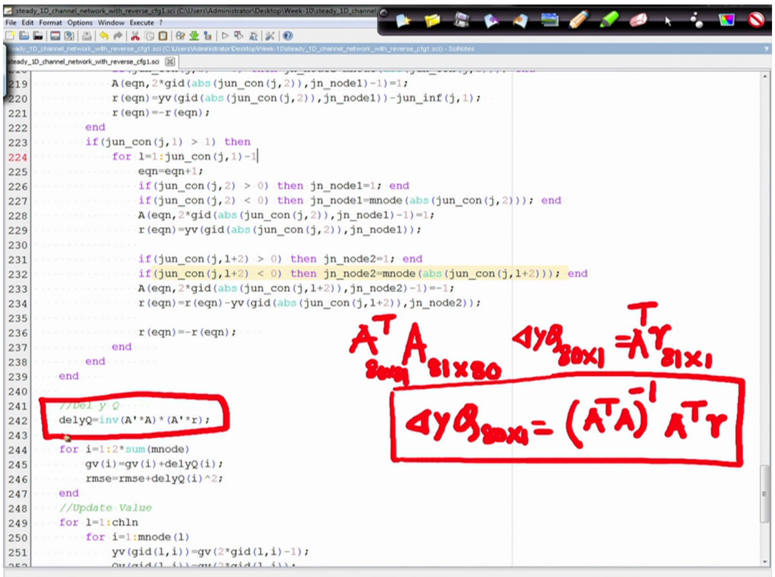

We are considering inverse of this one. Now finally we need to transfer these gv values. Gv values we should add gv previous or value del yQ i. And subsequently we need to transfer these values or update these values for next iteration. So yv should be gv in to gid minus 1 and this is yv is gv 2 gid.

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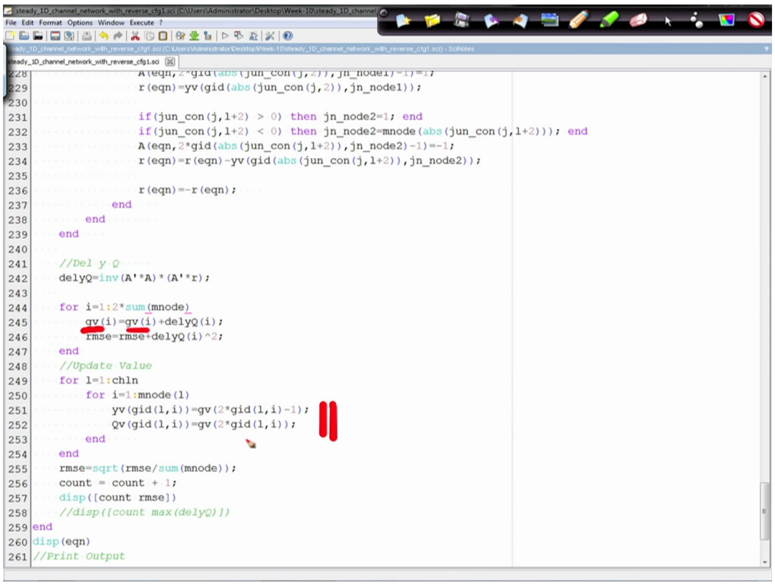

Now let us run this one because last thing is rmse calculation count rmse values and final thing is print L 1 to channel number. This is channel number then section, distance, depth, discharge values.

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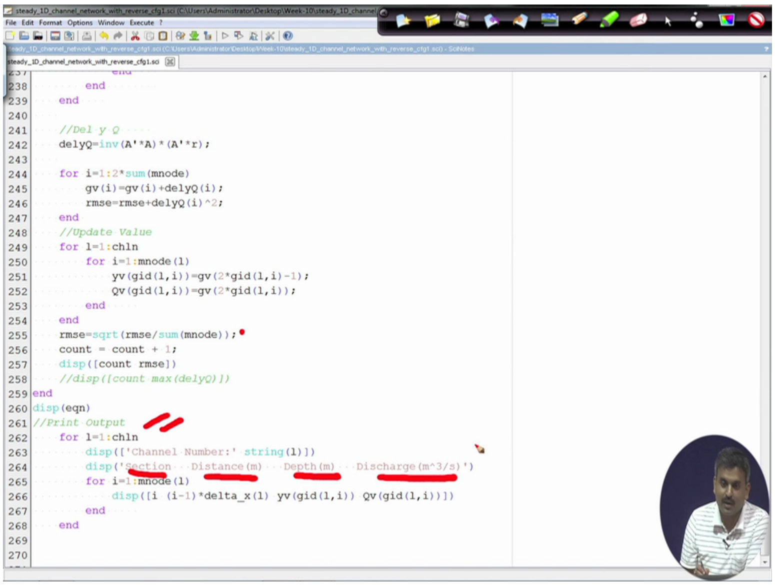

So if we consider these discharge values. Now if I run this what I am getting? For all sections that means whether it is depth or discharge all values are positive. So obviously y should be positive but if our direction for flow under consideration is incorrect then I should get a negative value.

In this case I can see that for first channel I am getting 97 point 74, second channel 154 point 25, third channel I am getting 55 point 09, fourth channel 40 point 65, fifth channel 52 point

66, sixth channel 12 point 01, seventh channel 107 point 76, eight channel 142 point 23. Now if I change the direction of flow, direction of flow means if I conceptualize the problem by changing the direction of flow let us see this configuration. Now in this configuration natural gradient is in this direction.

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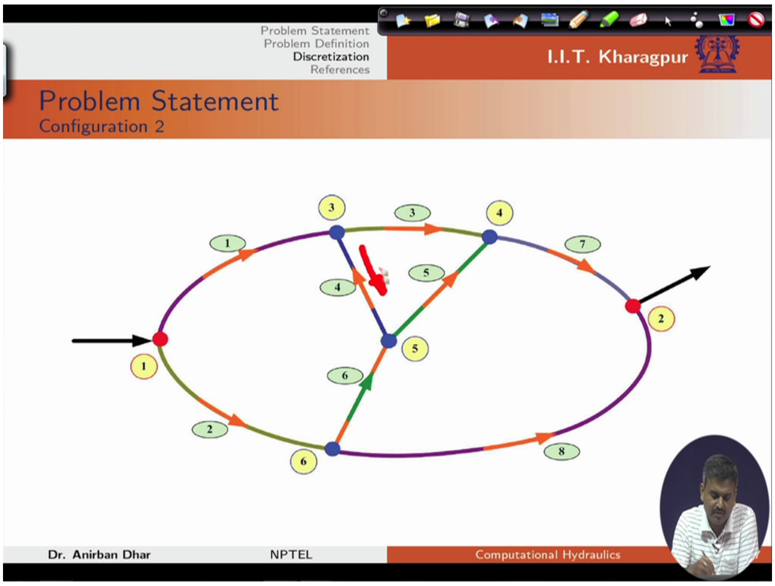

So I have kept the flow direction for all other channels that means channel 1, 2, 3, 5, 6, 7, 8 same but I have changed the direction of flow for this channel 4. That means I am considering channel is flowing from 5 to 3. Obviously 3 is higher elevation 5 is having the lower elevation in this case.

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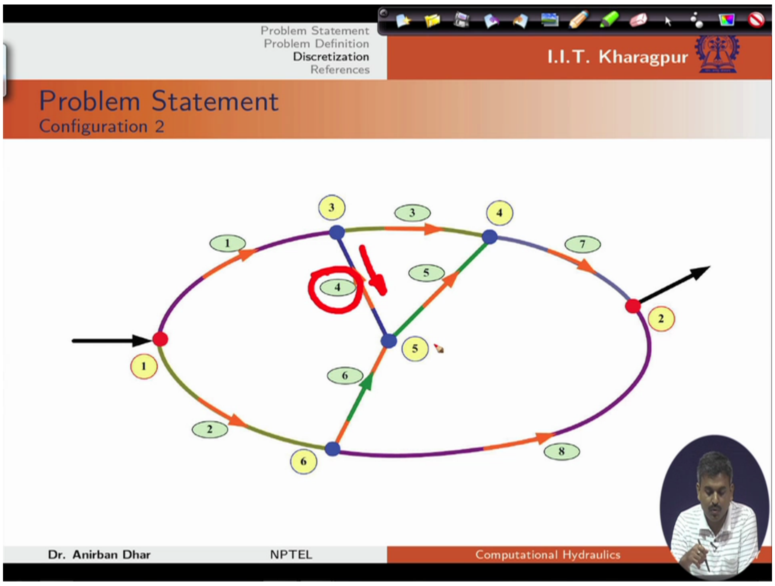

Now if the connectivity is from 5 to 3 obviously I should change my numbering or section numbering scheme. So for all other channel reaches the section numbering scheme is same. But now from 5 to 3 this is flowing so I should start channel section 1 at section or channel junction 5 and it should end at 3 with N4 plus 1.

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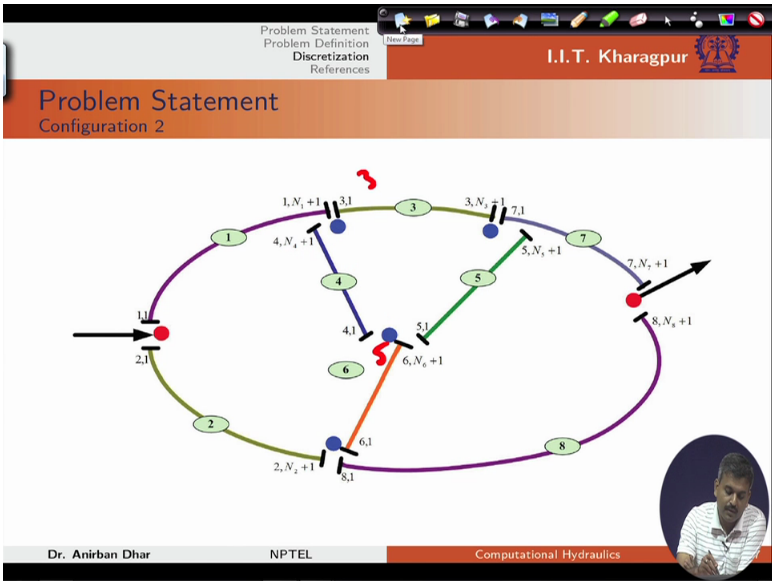

Now this is a numbering scheme that means now I am considering the flow is from 1 to N4 plus 1. So that is my convention that from 1 to N4 plus 1 it should be positive. Now I have to change this channel information. In this case I have changed it to 5 3 next level. There is no change in this particular matrix but now for section or channel junction 3 this end section of channel 4 is connected. So this is minus 4, this is plus 4.

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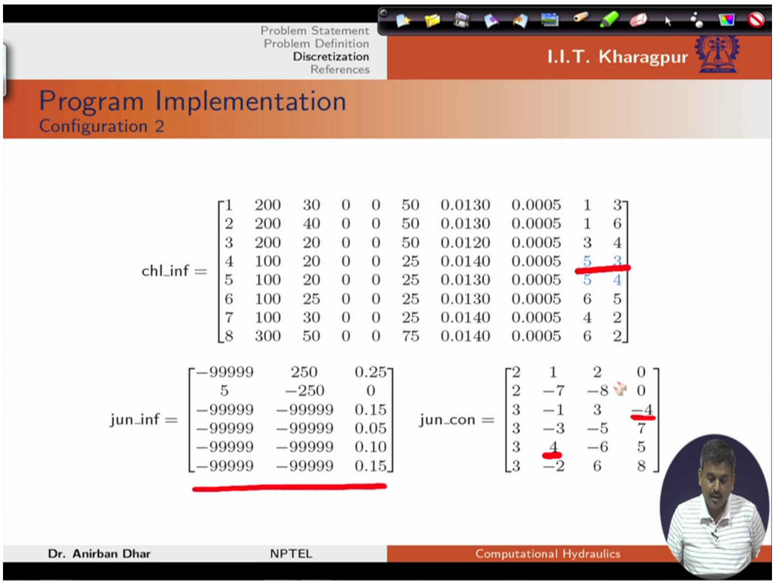

Now if I implement this same thing here so let us see what will be the problem or what will be this case? In this case obviously everything is same. Gv again I am considering 1, this is same. Only change is there this is 5 3.

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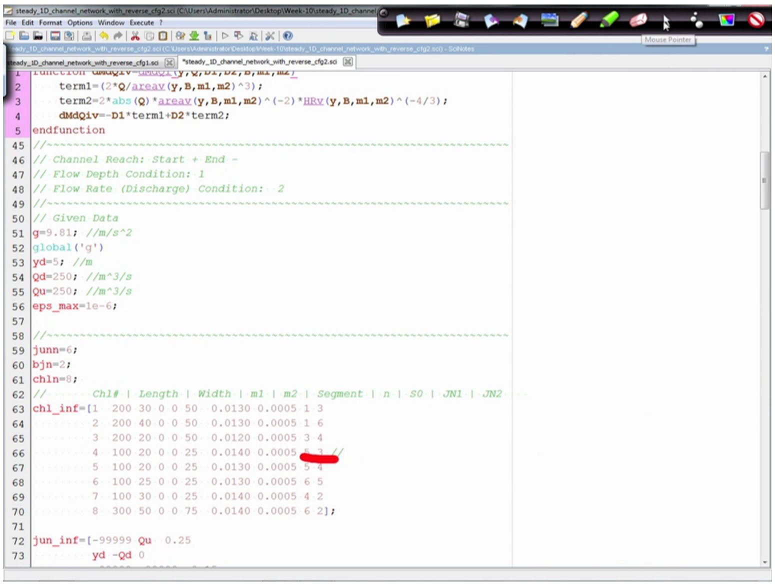

And this part this is minus 4 and 4.

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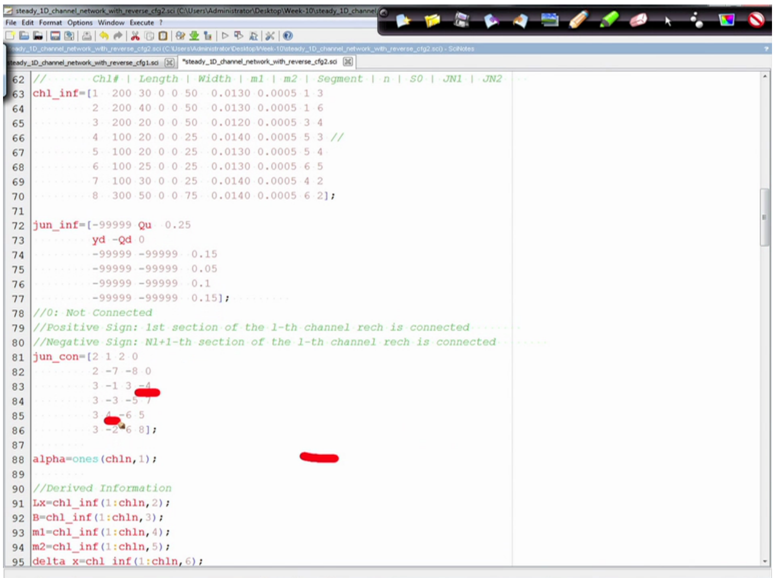

Other values are same. Now if I run it I can see that at channel 8 I am getting 142 which is the same as previous configuration. Channel 7 which is 107 this is same as previous configuration because we have considered the same direction for flow for 7 and 8.

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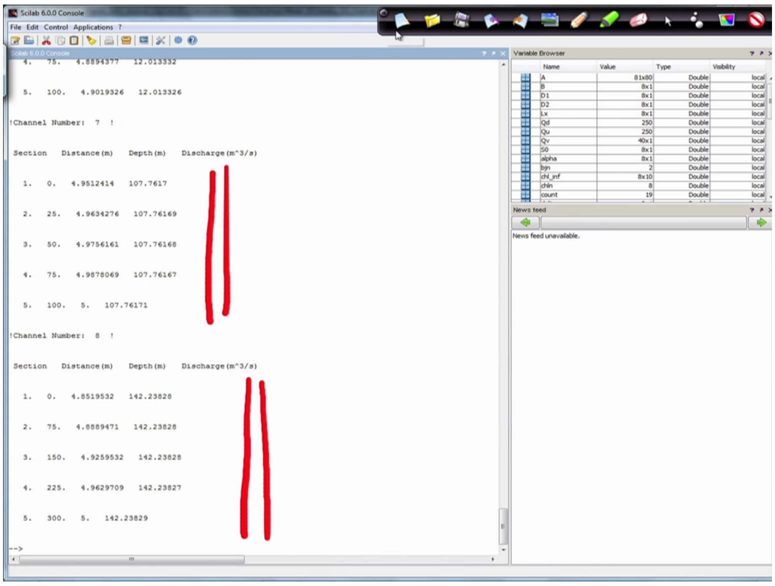

If we consider 6 this is 12 again, this is same. For channel number 5 this is 52. But interesting thing is visible for this channel number four. Here we are getting the value of minus 40 655. That means whatever flow direction I have considered for my problem that is incorrect and flow should be from 3 to 5 as I have assumed it from 5 to 3 that is not correct.

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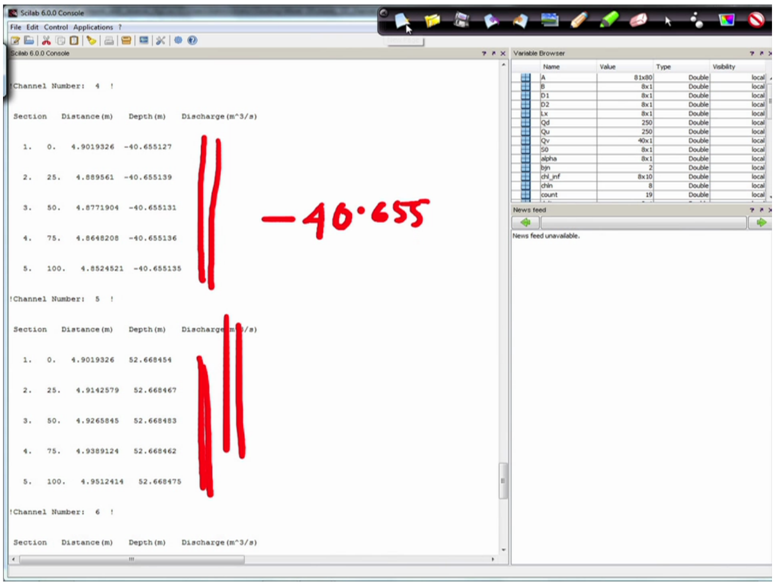

Similar thing I can extend for other channel reaches. Now let us consider or let us disturb this flow system for this channel reach 4 and 5. If I change the flow directions. Now in this case I am considering the flow is from 5 to 3 and in this case I am considering for channel reach 5 it is 4 to 5.

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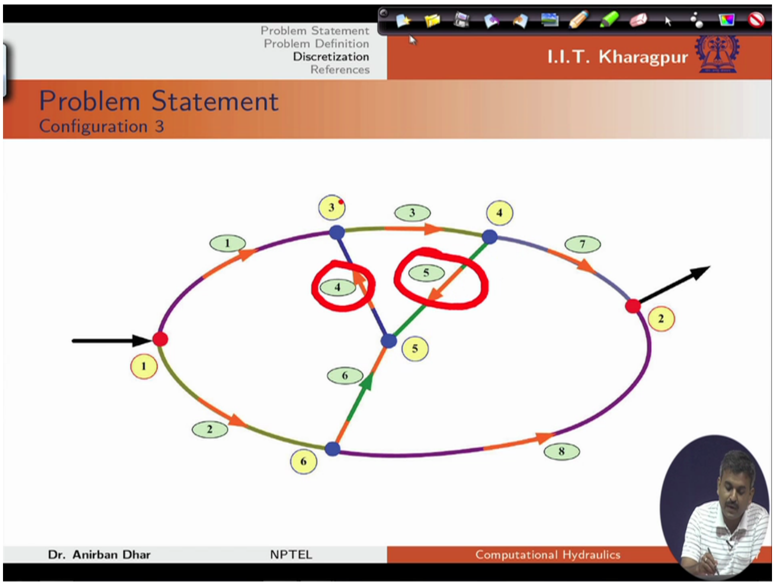

Now what will happen with this configuration? Again I need to change this section numbering scheme. So this is my direction of flow as per assumption.

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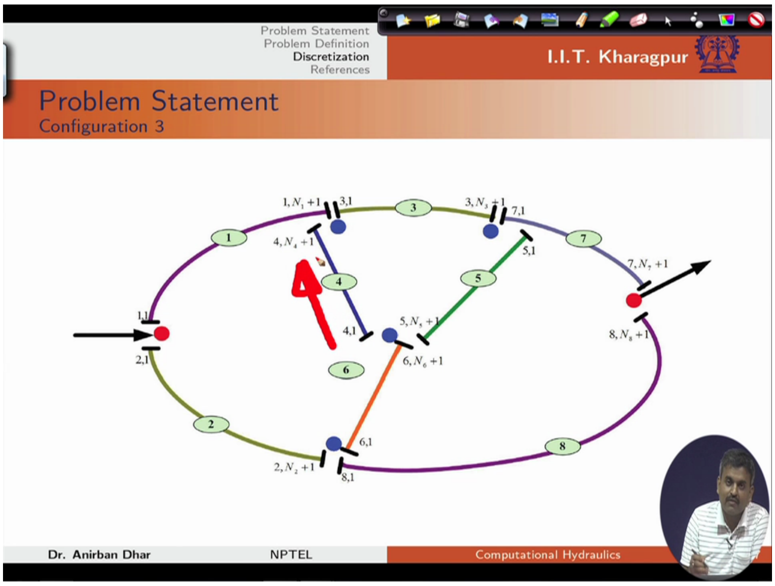

In this case this is my direction of flow for channel reach number 5. So obviously in this case I have to change this channel information matrix.

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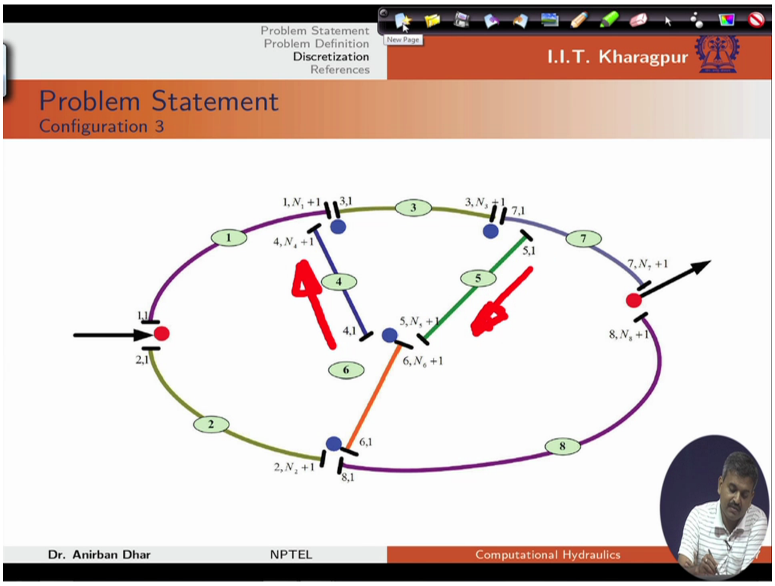

In channel information matrix I have to change these two entries. This is 5 to 3 and 4 to 5. Now flow is from 4 to 5.

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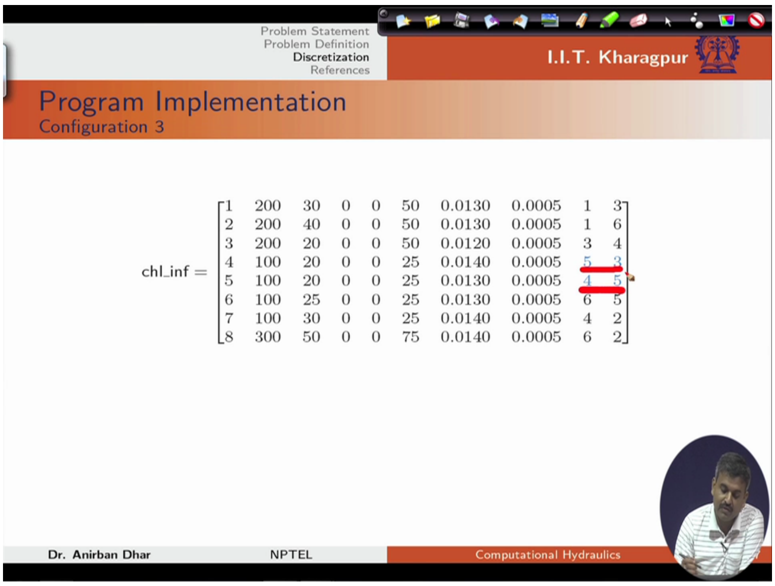

And again I need to consider this that at channel junction 3 this end section of 4 is connected, at channel section 5 starting section of 4 is connected. Channel section 4 starting section of 5 is connected and channel junction 5 ending section of channel reach 5 is connected.

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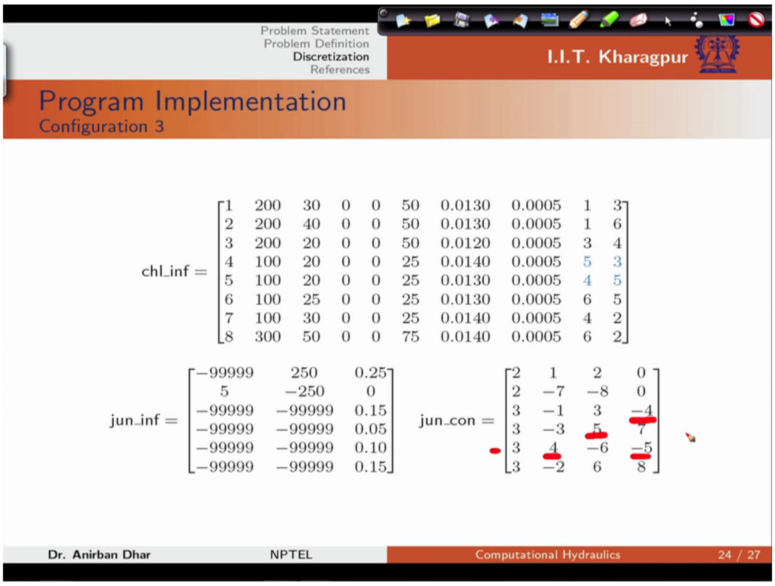

Now with this configuration let us again utilise our program for this calculation. This is configuration cfg 3. Now let us see what is the situation there? Now only change is here this is from 5 to 3 and 4 to 5. In this case minus 4, 4, this is 5, minus 5.

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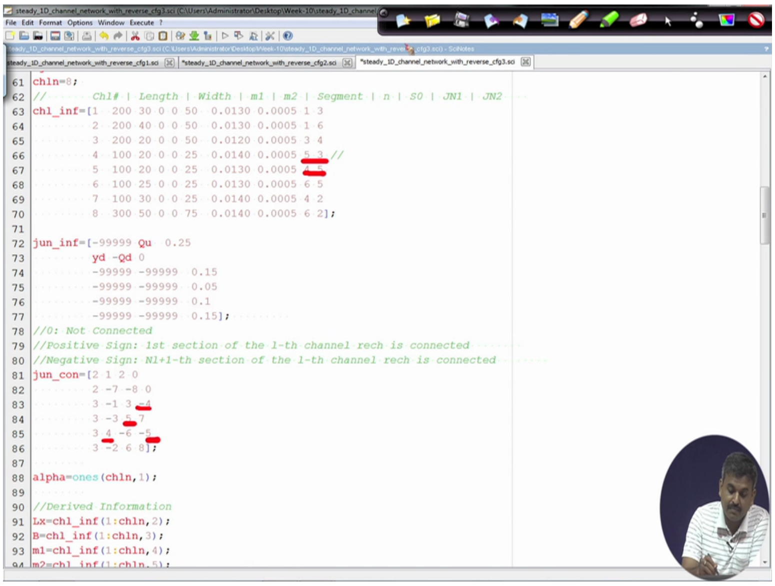

We can run this with these two changes. Interestingly I am getting the same result for 8, 7, then 6 I am getting same result and for 4 and 5 where I have change the direction of flow I am getting negative values. In this case this is 40 point 655 and this is minus 52 point 668.

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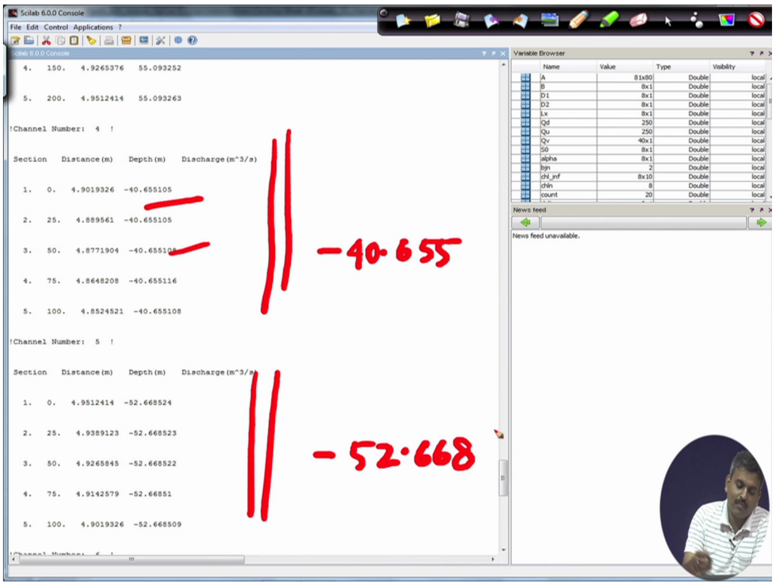

So we are starting from arbitrary values without satisfying the continuity at the junction but we are getting the desired discharge and depth values. So for other channel reaches channel reach channel reach number 1, channel reach number 2 we are getting positive values because we have not changed the direction of flow in this cases.

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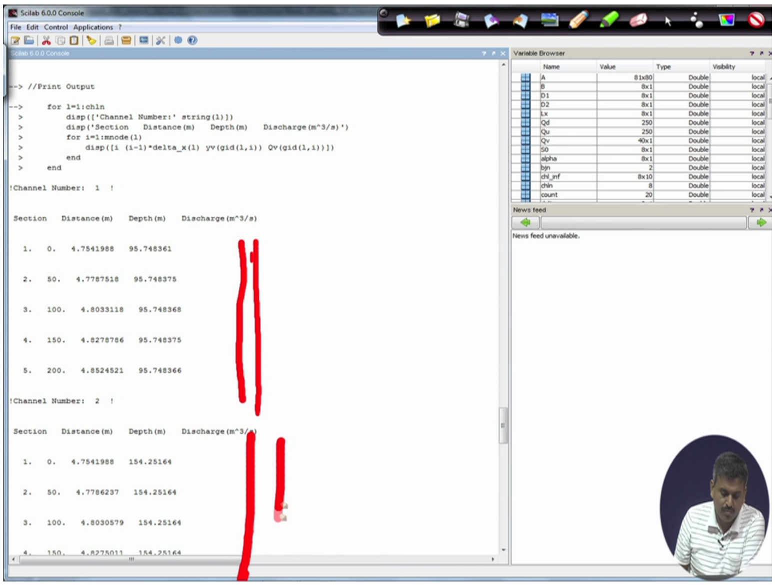

We have changed only the direction of flow for 4 and 5. Now we can say that our code can consider the reverse flow situation in steady channel flow conditions. Now this is the last configuration that we have considered. So we have considered three different configurations and we are getting our desired value because starting point was that we have allowed the subcritical flow condition in the channel as per the slope or bed slope.

And in case of configuration 2 and 3 we have changed the flow direction and we are getting negative values because that is expected from the program for reverse flow situation. Now these are the three source codes that you can utilise to check the solutions of our channel configuration. Configuration 1, configuration 2 and configuration 3 for this loop channel network.

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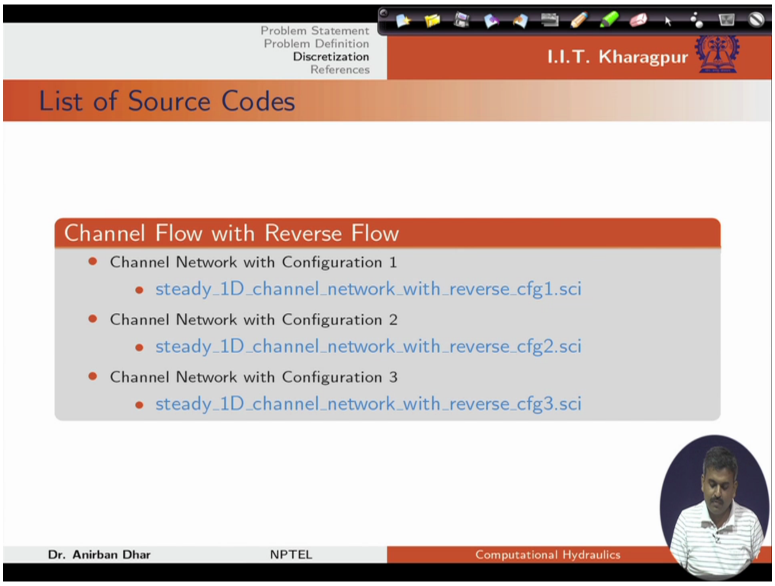

In the next lecture I will be discussing about unsteady channel flow condition. Thank you.