Computational Hydraulics
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Lecture 48
Steady Flow in Pipe Network (Contd.)

So let us start with this steady 1D pipe network HC which is Hardy Cross discharge configuration 1.

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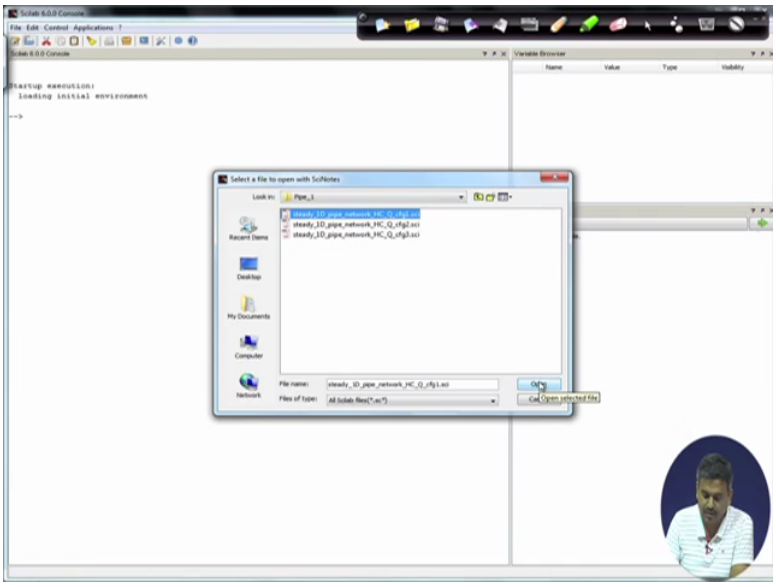

So we will try to utilise the same structure as we have used in case of gradually varied flow. But fundamental difference is that we do not require that much computational effort like our gradually varied flow. Let us start with this clc clear. This was there for gvf but we will not utilise it. This given data g is 9 point 81, global, eps max this is required for convergence, 1 into 10 to the power minus 6.

Beta value, beta it is 2, pipe n is pipe number so we have 8 pipes. Number of maximum, number of pipes connected to a particular loop we have 4. This is required for loop connectivity Matrix that I have discussed already. Now junction number, this junction number is 5. And ploop, ploop is for pseudo loop and iloop is for interior loop. Now loop number which is the total number of loops we have ploop plus iloop. That means number of pseudo loops plus number of interior or internal loops.

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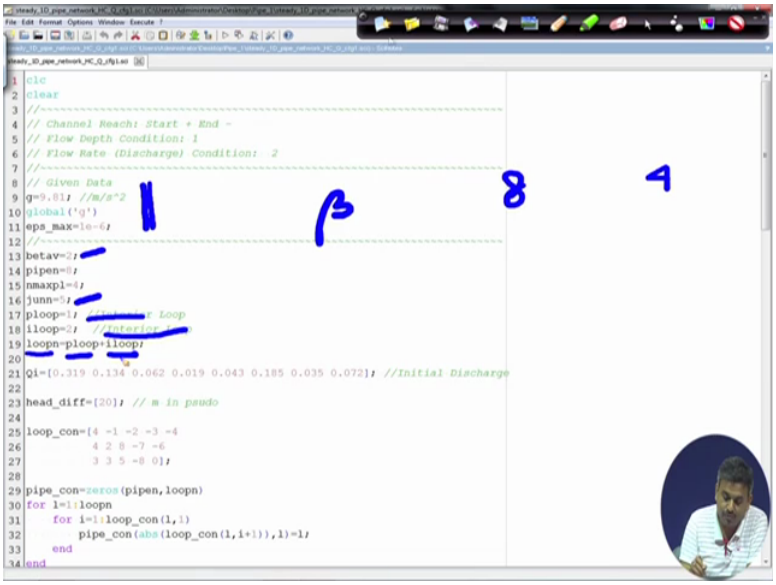

Now we have specified the discharge values directly without sign. Please check this thing, I have not used any signs here and we head difference 20 between two this tanks or reservoirs. In this case this is the loop connectivity matrix.

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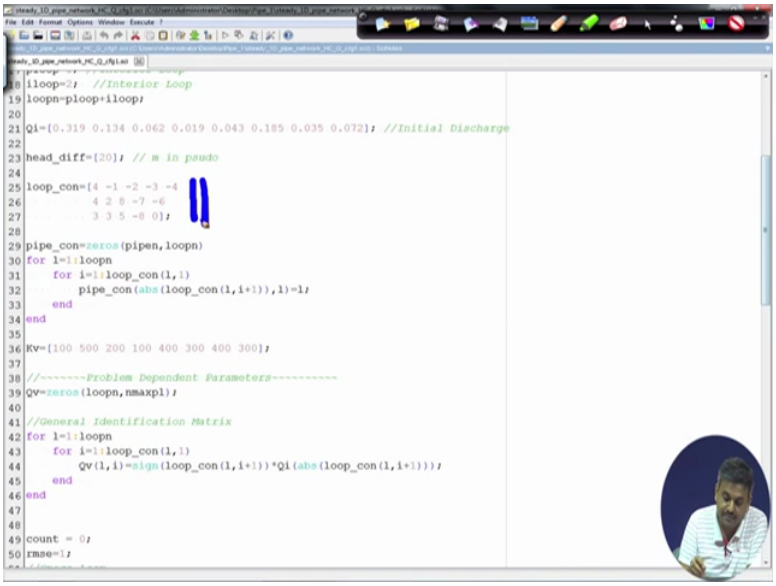

Now we need to construct one pipe connectivity matrix. So what is that? That means in starting from pipe 1, 2 up to 8 we need to provide certain information. What is information? Information is that in that matrix we will have first column which is for first loop, second column is second loop, third column is for third loop. Why this is required? This is required

during our delta QL update. So this one it is connected to first loop only. So we will write it as 1.

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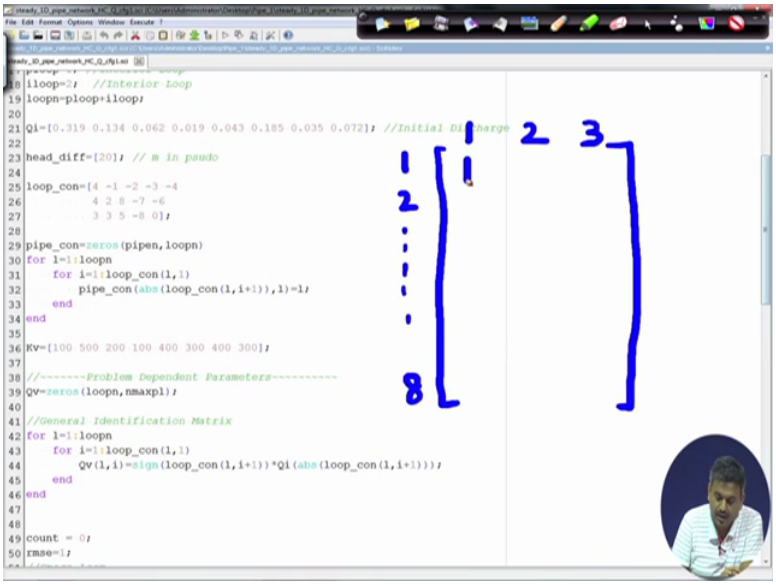

Second one it is connected to second one and first one. So I will write it as 1 and 2 both. So like that we can enter the pipe connectivity in a particular loop and we can provide this information during calculation.

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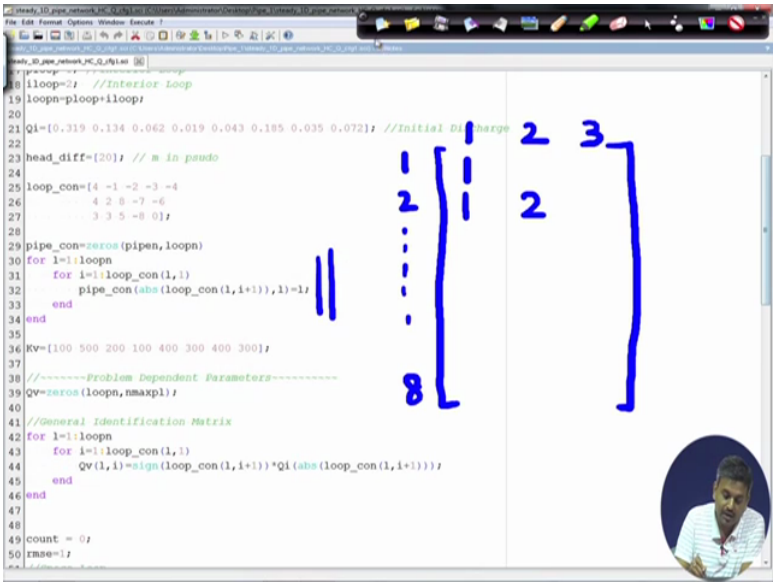

Now we have straightway these Kv values. Kv is nothing but Ki cap.

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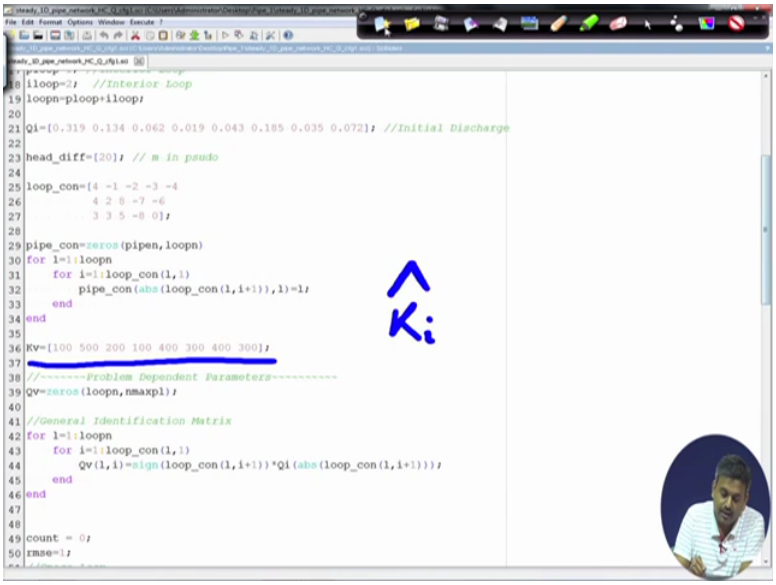

Now again we need to specify this Qv. What is Qv? Zeros loop number. So Lth loop and up to maximum number of pipes connected in a particular loop we need to create this Qv matrix because this is a main matrix that is required for our calculation. Because we need to preserve the sign convention in this matrix itself.

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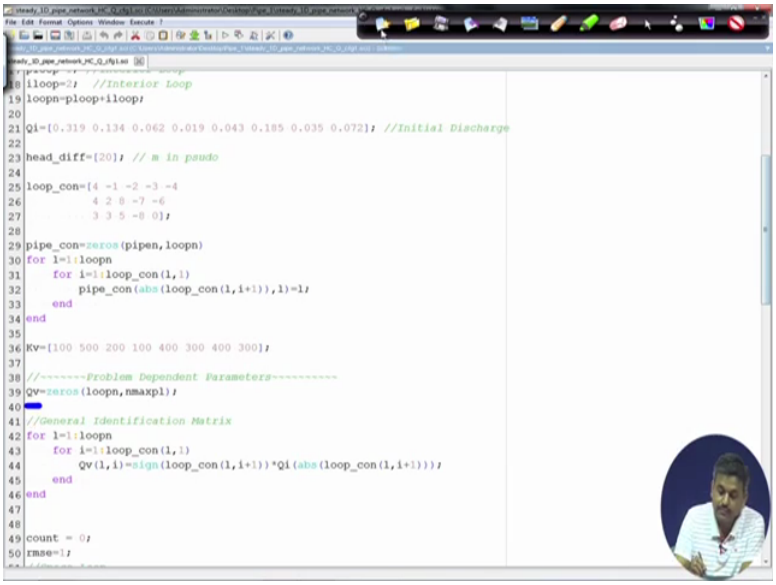

Now for general identification we have this Qv. We need to transfer our initial values. If loop connectivity L i plus 1 which is starting from second column of the loop connectivity matrix, if it is positive then Q should be positive for that loop.

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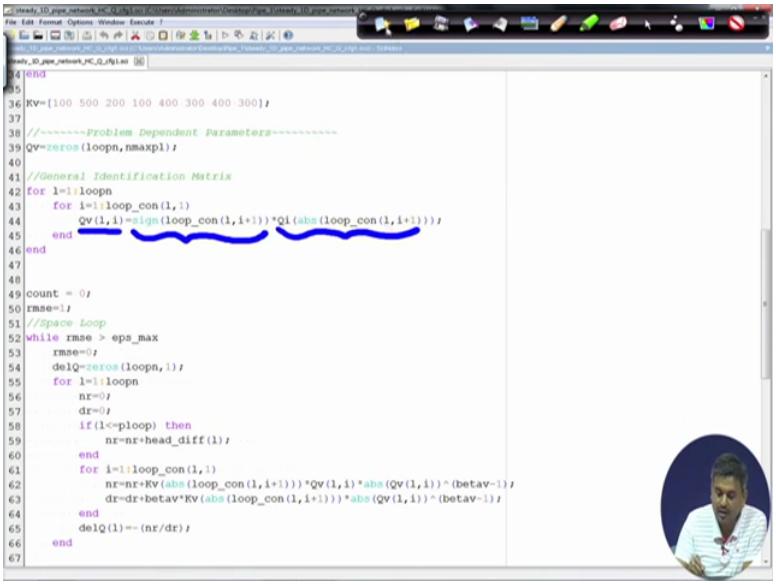

Otherwise what it means? Let us see our loop connectivity matrix. If loop connectivity for first entry this is negative this sign gives us negative for negative value or minus 1 for negative value, plus one for positive value. So sign multiplied by Qi. Qi value I have specified without any sign so I should input these values within this Qv L i with this sign. So sign should be coming from this loop connectivity matrix directly.

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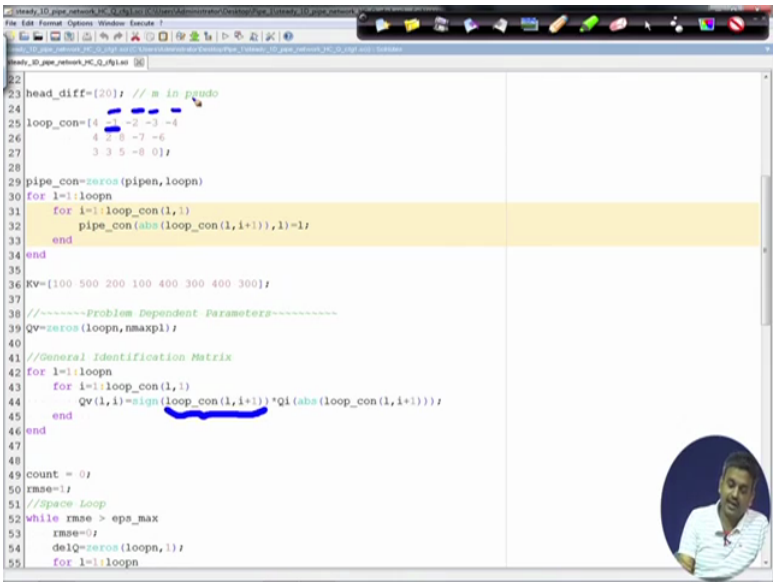

Now with this information or initial information I can start this iteration. Obviously in this case we have only space loop or this loop for iteration. Counter equals to zero, rmse equals to

1 so that I can enter into this while loop. This rmse equals to zero, del QL zeros loopn 1. That means for each loop I have specified one del Q.

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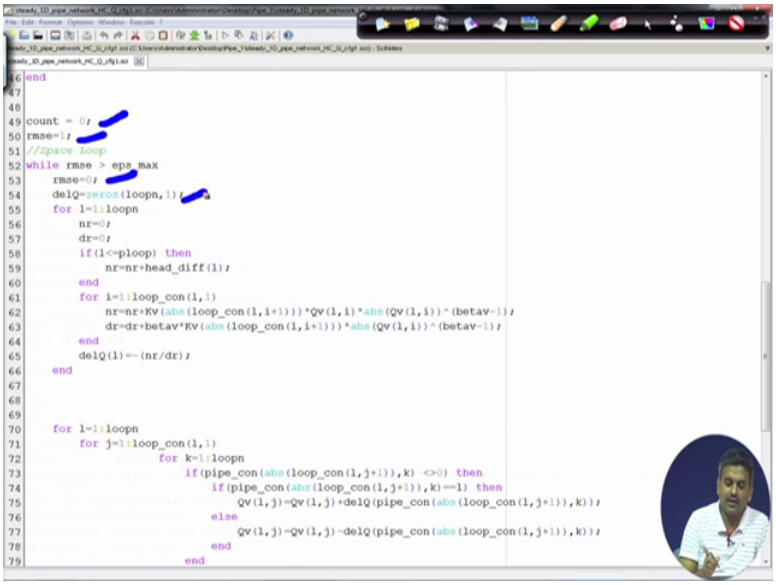

Now this part is important for our calculation. For L equals to 1 to loop numbers, nr dr numerator and denominator, if L less than equals to plop. That means less than equal to number of ploops then we need to add this nr value equals to nr plus head difference. The head difference we need to add here directly in the numerator because for our problem only this head difference is there.

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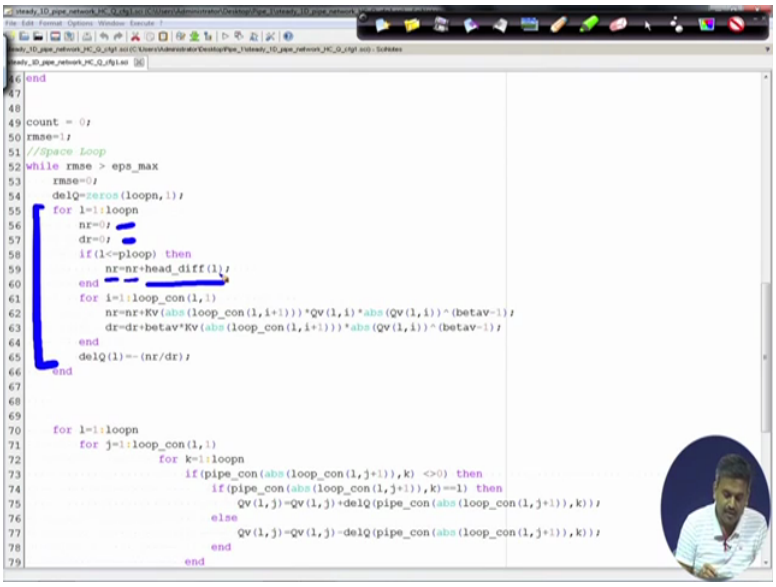

So i equals to 1 to loop connectivity L 1. L 1 means it gives the entry in the first column. So for the first loop we have four connected pipes. For four connected pipes I can calculate this nr equals to Kv which is K value into Qv into absolute Qv into the power beta v minus 1. Again denominator this is dr equals to dr into beta v into Kv abs Qv L i to the power beta minus 1. After taking abs I am taking this power.

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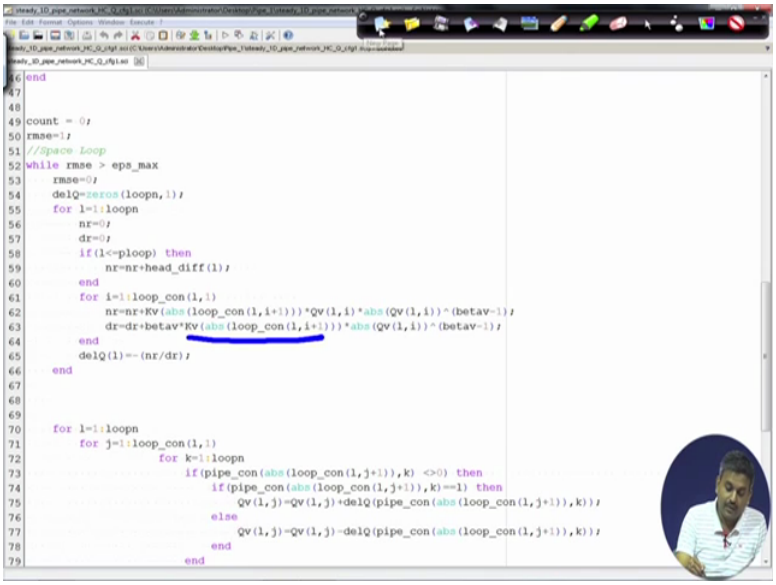

So if I divide this to numerator by denominator this with a negative sign I will get this QL value or del QL value. Now this del QL value is okay but we need to add this to our different discharge values. So how to add this? So let us start with information with a loop connectivity. So three rows. So L equals to 1 to loop number. So 1, 2, 3.

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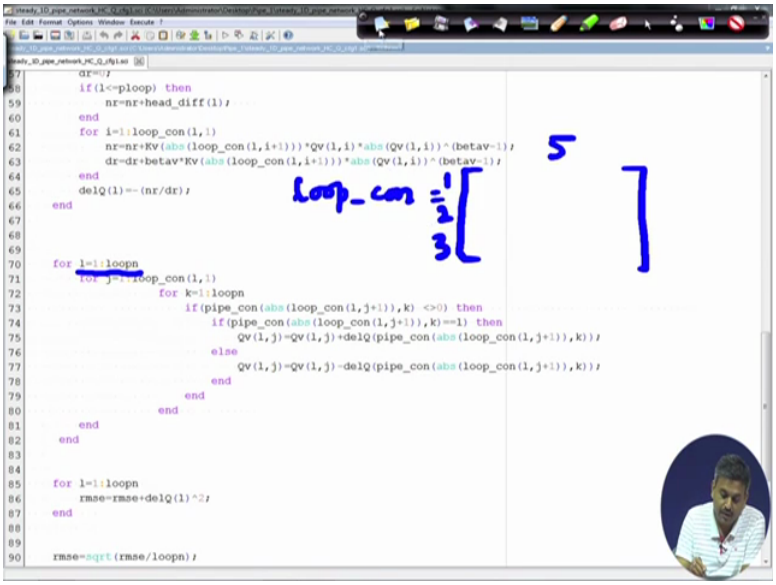

For each loop you can start and I can go or I can iterate from j equals to 1 to loop connectivity L 1. That means for first loop I should use j equals to 1 to 4, for second loop j equals to 1 to 4, but third loop it is j equals to 1 to 3. So I am checking different entries there. 1234, 1234, 123 and this is zero.

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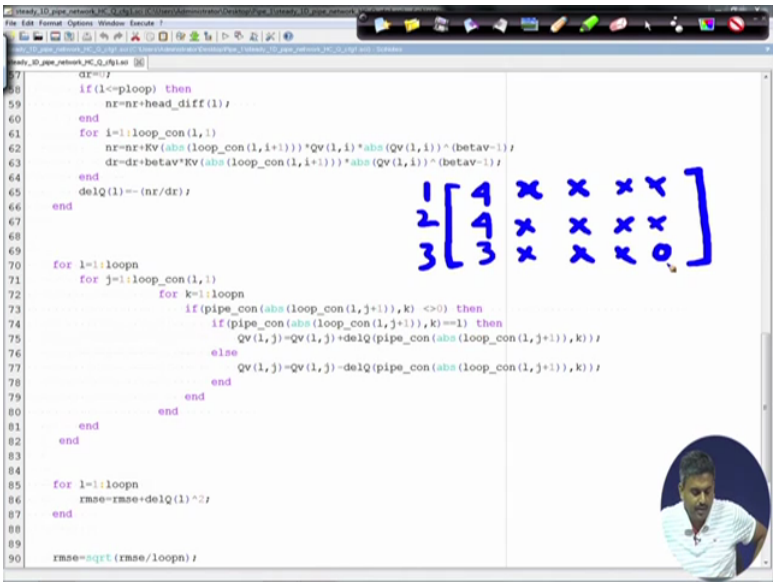

Now in this case next level is K equals to loop number. Now we need to add this del Q value. For del Q I am adding this K index. If K is the index for del Q and it directly matches with 1, let us say we are talking about Q1 and we are in L equals to 1. So I should add that value here.

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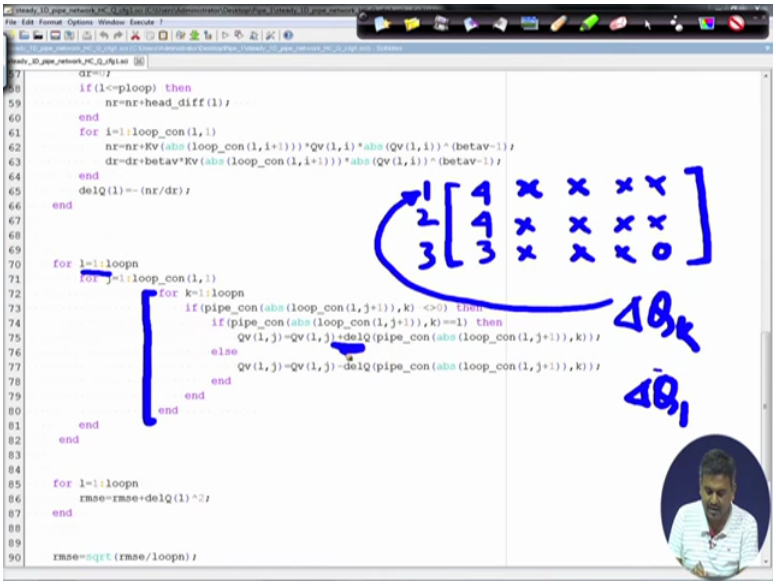

Otherwise if there is no match between K and L here I should subtract this del Q value because I need to consider or I need to update my discharge in different loops. So after performing this operation I will get the updated Qv values. Obviously in this case we need to calculate the rmse value. What is this rmse? Rmse is equal to already I have used rmse equals to zero. So rmse equals to rmse plus del QL to the power 2.

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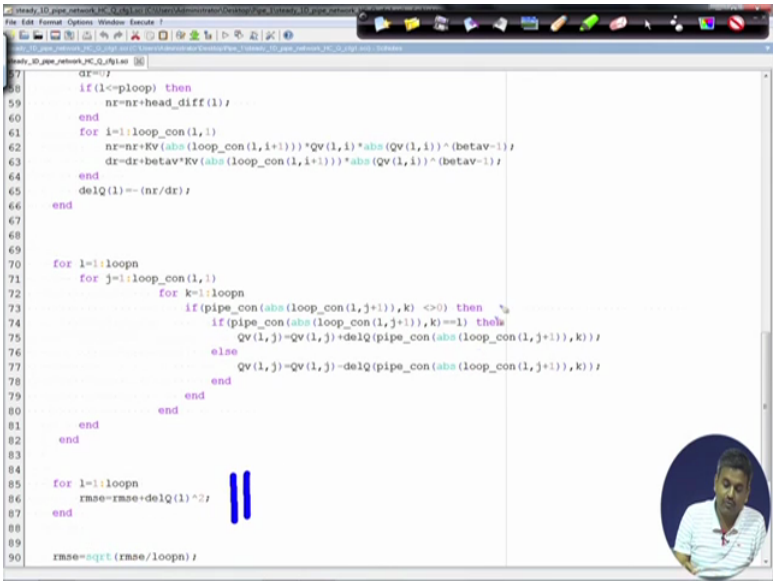

So I am taking square of all discharge or increment value there. So with this I can calculate rmse. Rmse equals to square root of rmse divided by loop number because for each loop we will have one del Q. So I can display this count and rmse value.

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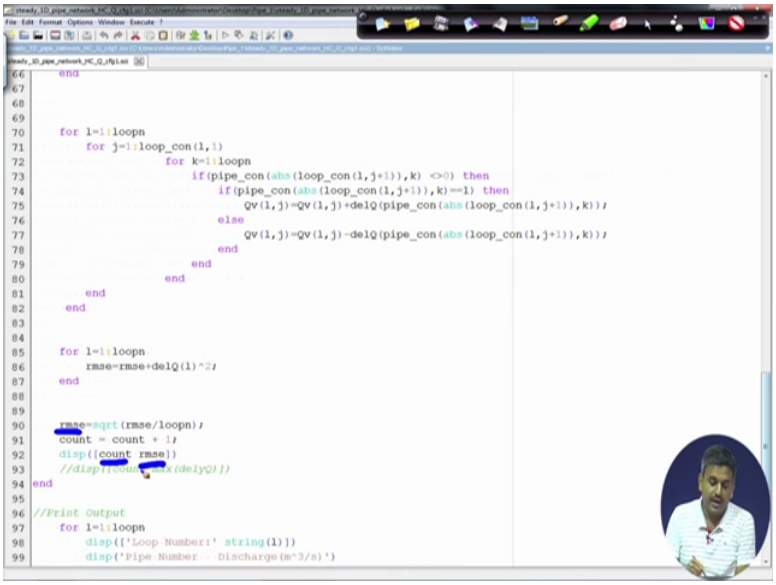

If there is convergence obviously this loop this is for while loop this will terminated and I will get the discharge values for different loops, okay. For loops and these are different connected pipes.

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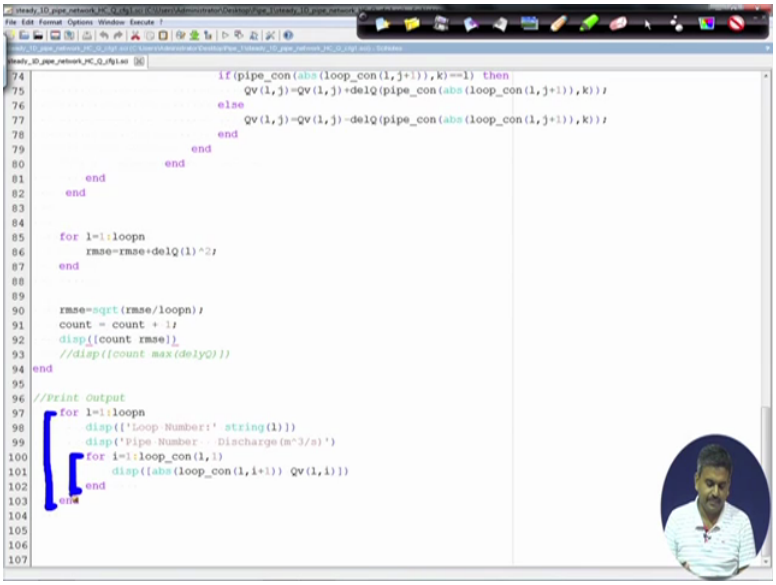

Obviously this abs value means the actual global pipe number and Qv is the discharge value with proper sign for that Lth loop.

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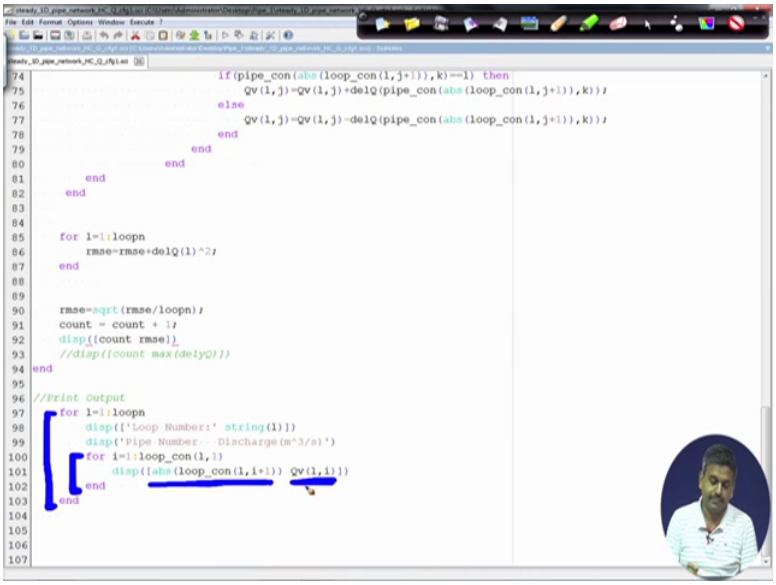

Now if I run this I am getting negative discharge value which is consistent with my first loop, loop 1 all negative discharge values. Loop 2 I have second pipe which is having positive, eight pipe which is having positive.

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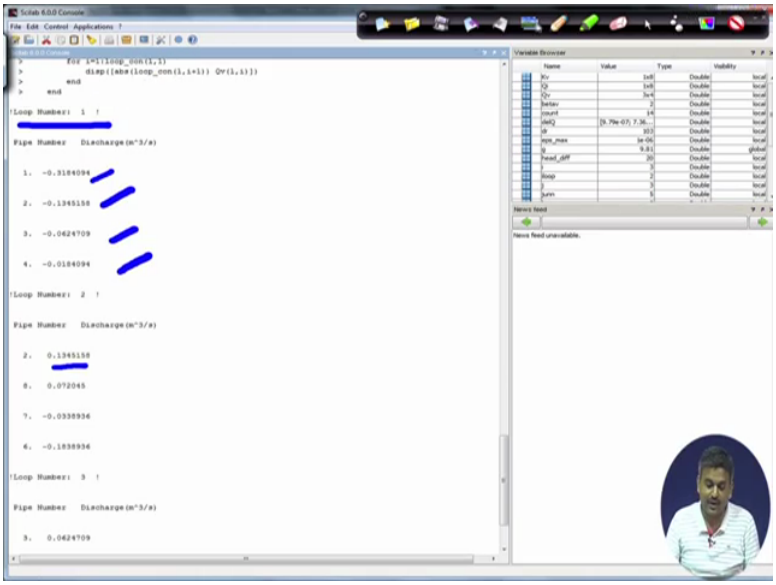

So if I see physically what is the meaning of this one? So here in this case we have loop 1 which is initially loop 1. For loop 1 this is loop 1, for loop 1 we are getting this negative values.

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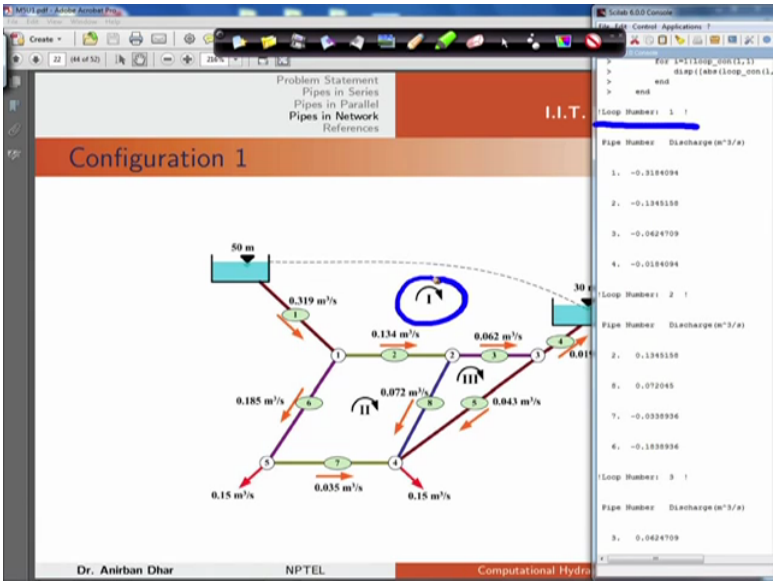

This 3184 we have assumed close values that is why there is no change in values, almost nil. But only change is there for last one. This is point 019, I am getting here as point 0184 which is very close to this one.

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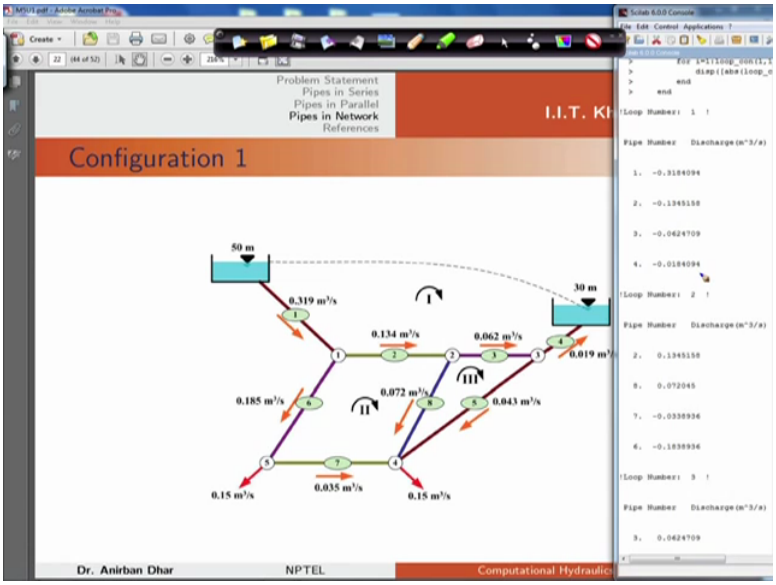

For loop 2 this pipe number 2, pipe number 2 is positive, this is consistent, pipe number 8 again this is positive, this is consistent, pipe number 7 this is negative, pipe number 6 this is negative. Again we are getting the same value here.

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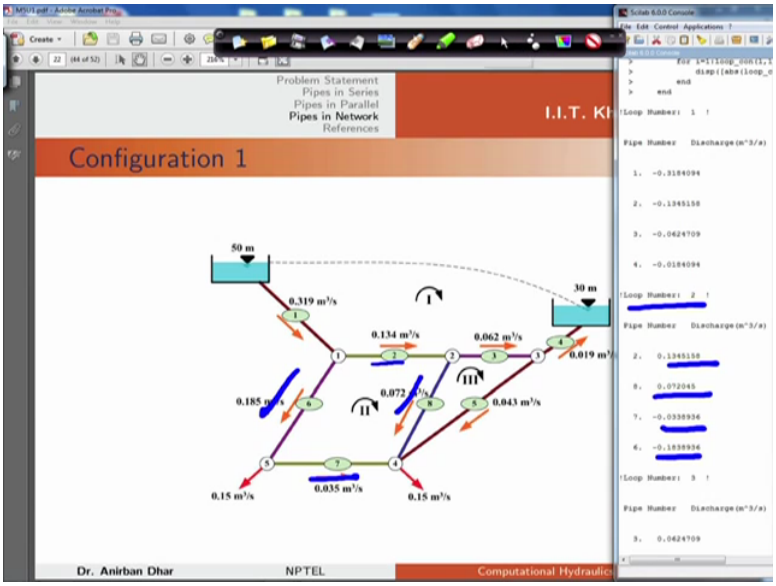

Now we can change the initial distribution of discharge. If I change this initial distribution of discharge then I should get the same value starting from specified initial discharge values. So let us say that this is my configuration.

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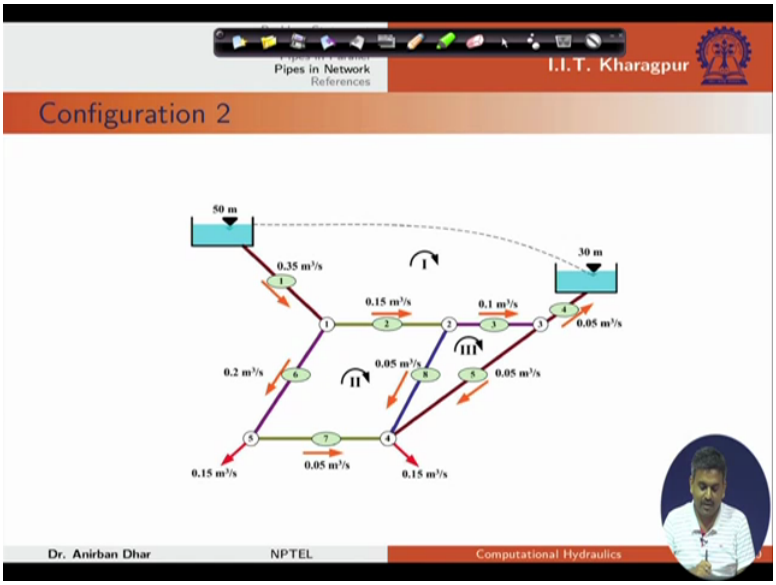

So what is the value here? In this case I have changed these values. This is point 35, this is point 2, point 05, point 05, point 05, point 1, point 15, point 05. But one thing is that I have not changed the direction of the flow. Whatever direction I have assumed initially I have calculated my values based on that only.

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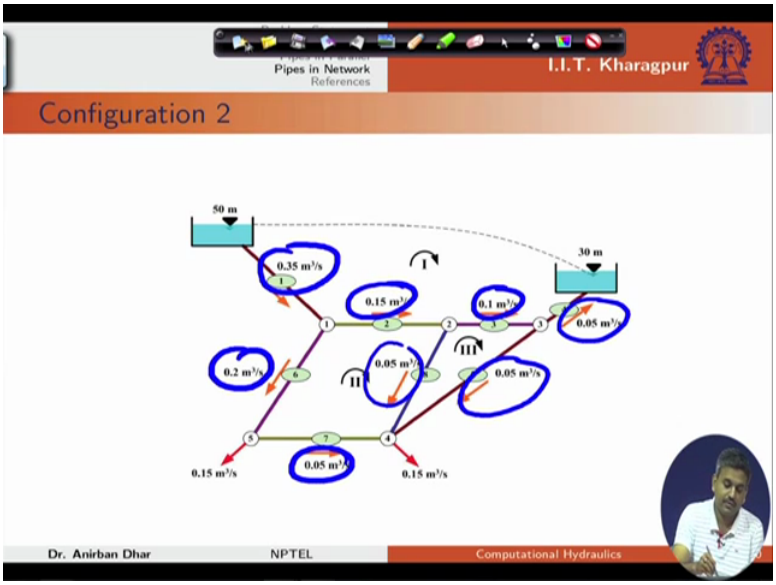

Now if I run the same thing with configuration because in this case the configuration part changes. Minus 2, minus 3, minus 4, there is no change. 2, 8 there are no change in that one. Only change is there in terms of magnitude or values of Q. There is no change in this connectivity matrix.

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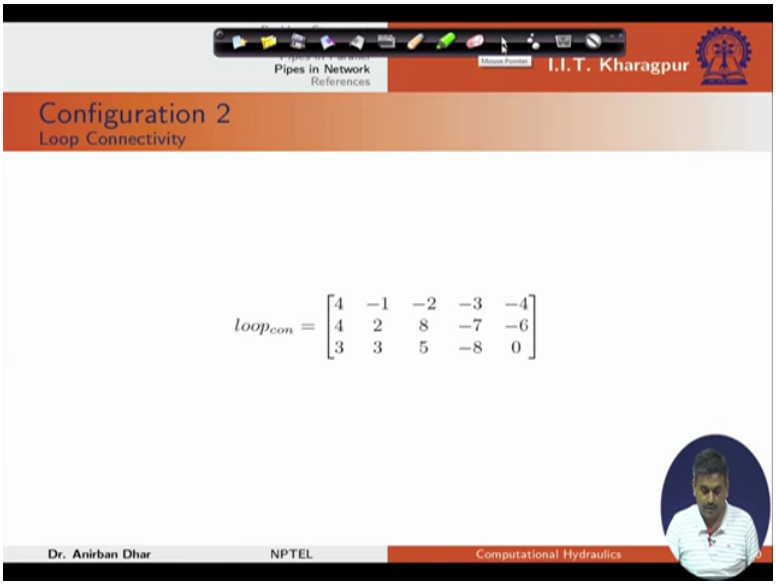

So for this connectivity matrix or loop connectivity if I open this configuration 2 which is this one, these are the specified discharge values. This point 35, point 15, point 1, point 05 these are initial discharge values and there is no change in the program otherwise.

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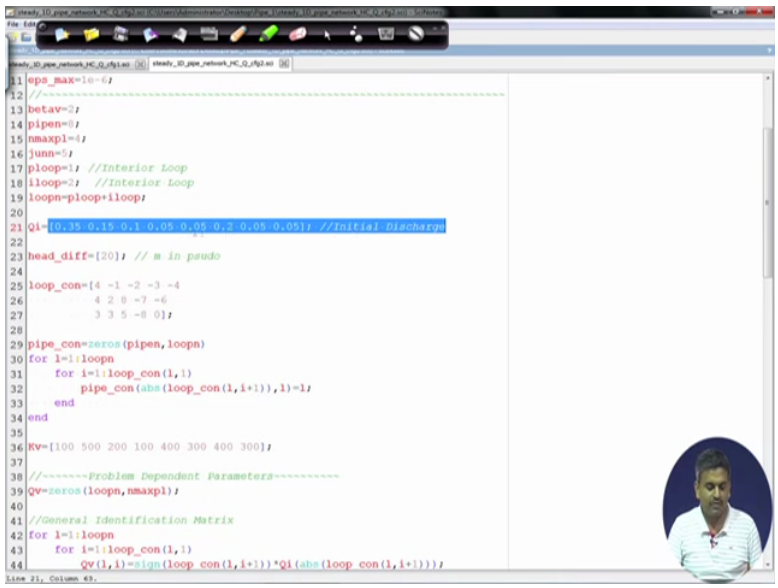

So I can again iterate using this method and interestingly I am getting convergence again and discharge values these are again same values are coming. Minus point 318, point 134, point 062. These values are same as we have got from our configuration 1.

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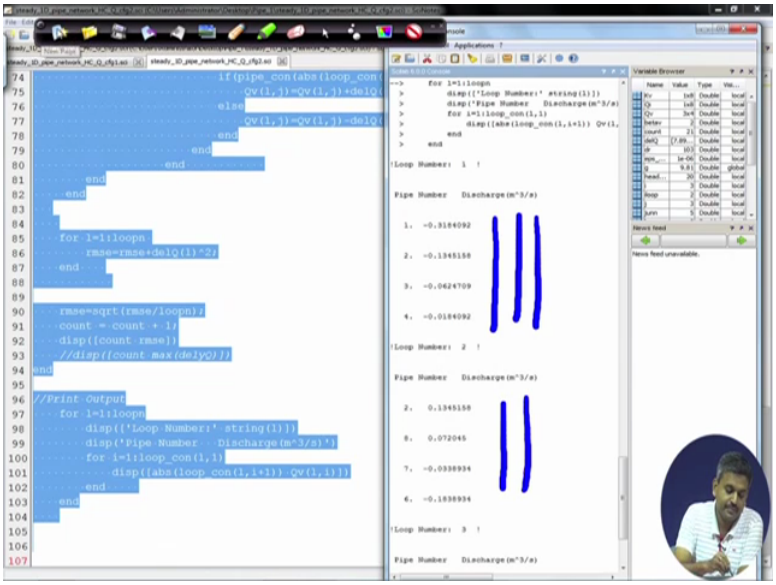

Now let us change this configuration or direction of flow. So let us change this direction. Now in this case let us consider that flow is from right to left. So flow is towards this tank which is having higher elevation.

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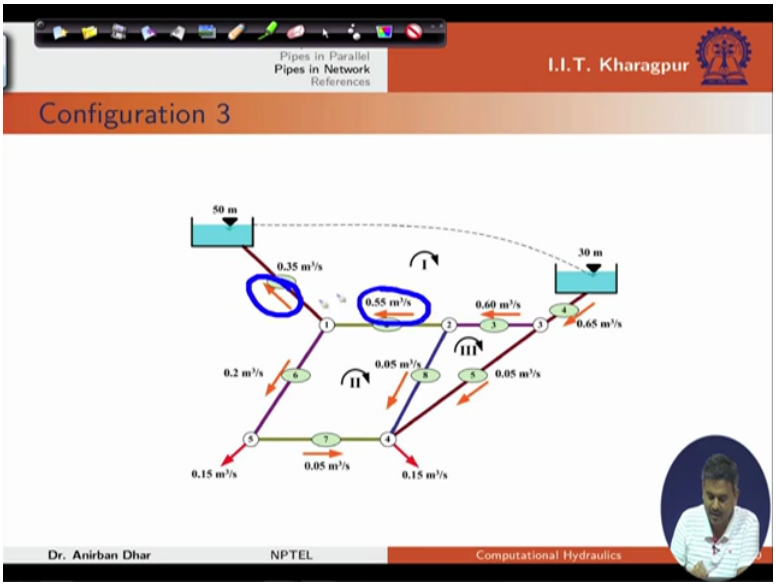

These are the values which I have got by specifying the discharge by maintaining discharge continuity at the junctions. So these are assumed values to maintain the discharge continuity at the junction itself.

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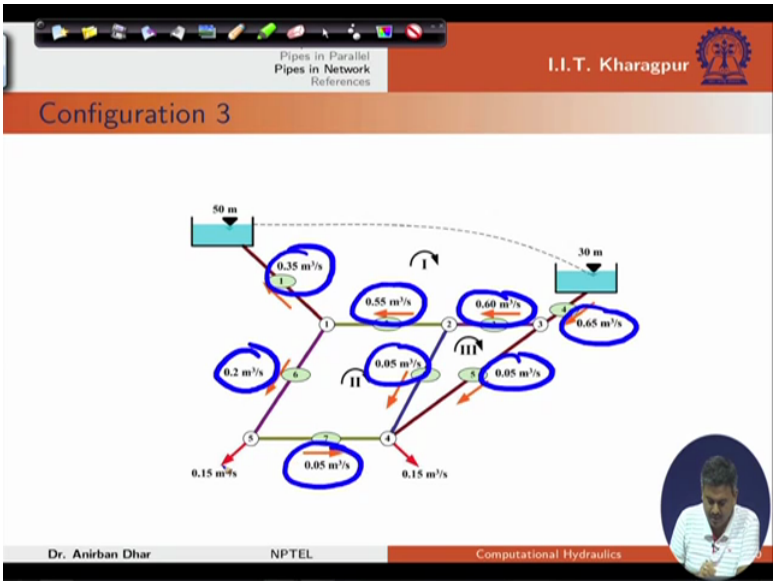

So in this case if I see the connectivity matrix, connectivity matrix I can see that 1234. So these four entries are actually positive entries. That means the flow is clockwise and loop connectivity if I see this is minus 2 and minus 3. These are only two changes here.

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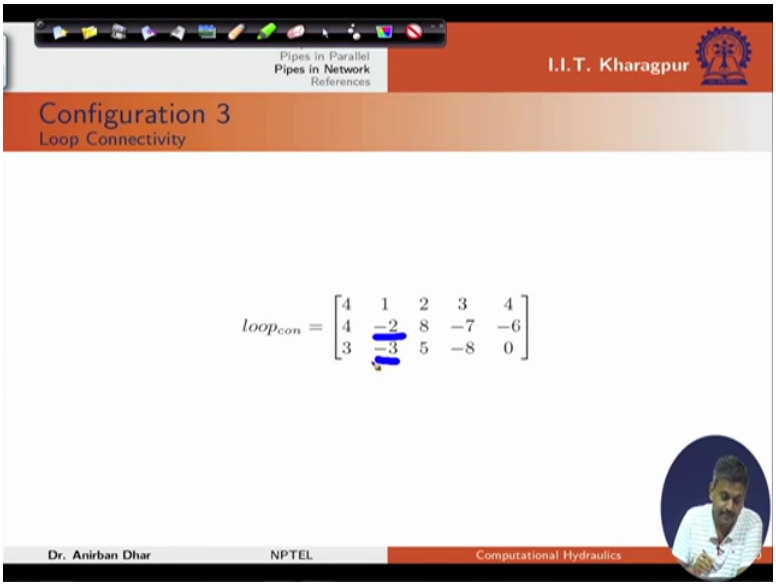

So with this configuration if I try to run my problem using Hardy Cross method I can see in this case we have got convergence with 21 iterations. The convergence parameter was 1 into 10 to the power minus 6 up to that level we have set the accuracy.

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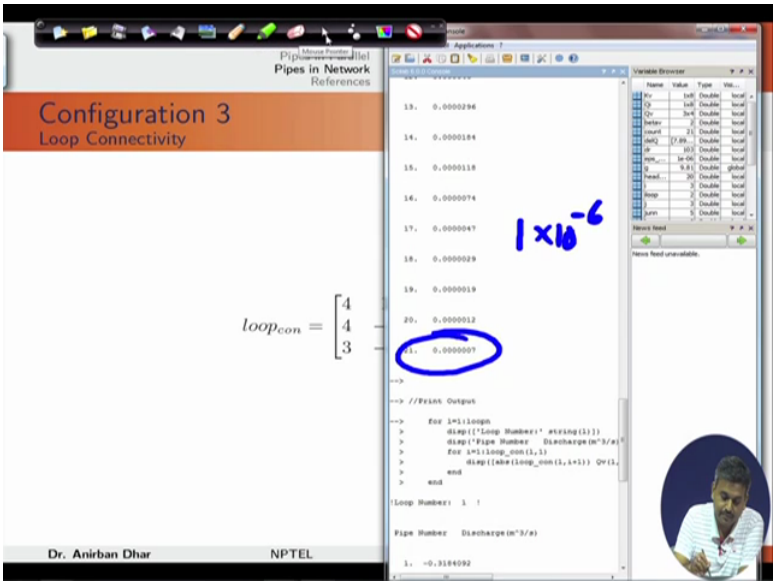

So if I open this third configuration or cfg 3, now only change is there for this one, connectivity matrix, this is 1234. These values are there.

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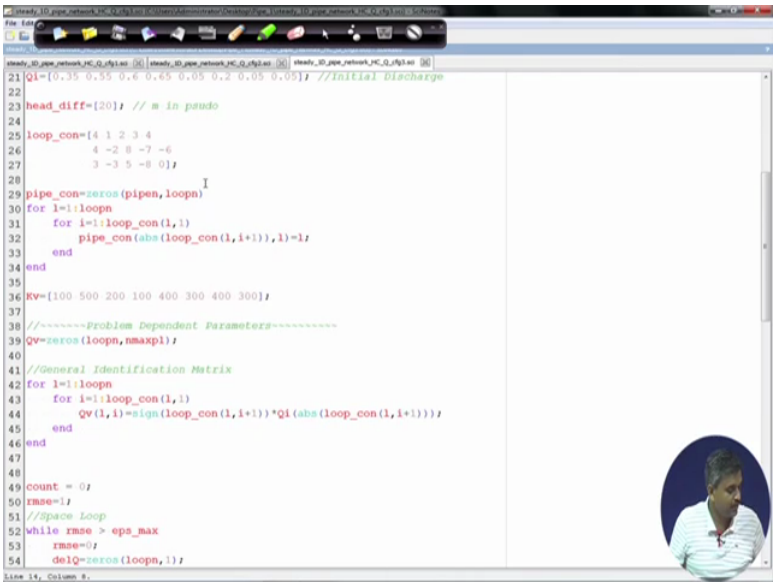

So now if I run it I am getting negative value in that here. Again this is 27, 27 is the number of iterations that is required for this one.

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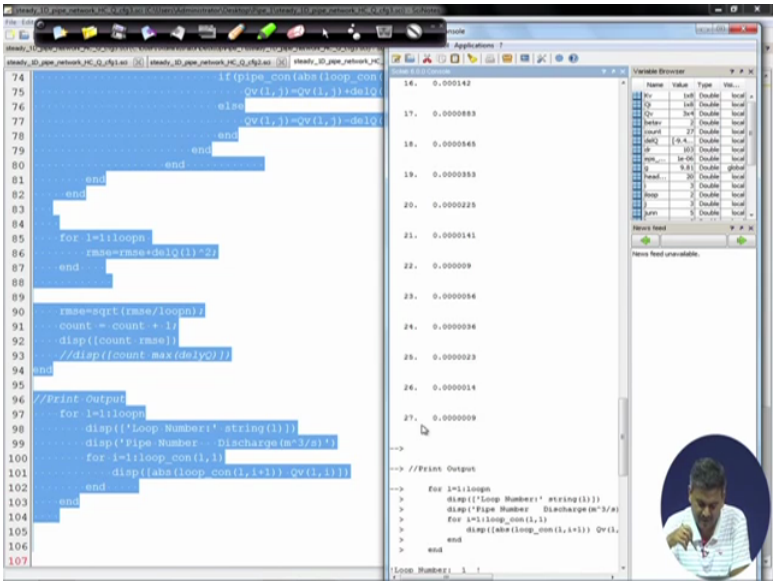

So what it means this negative? Negative means this flow is counter clockwise. We have considered the flow as in clockwise direction but it is showing that whatever value you assume by maintaining the junction continuity you will get the exact direction of the flow.

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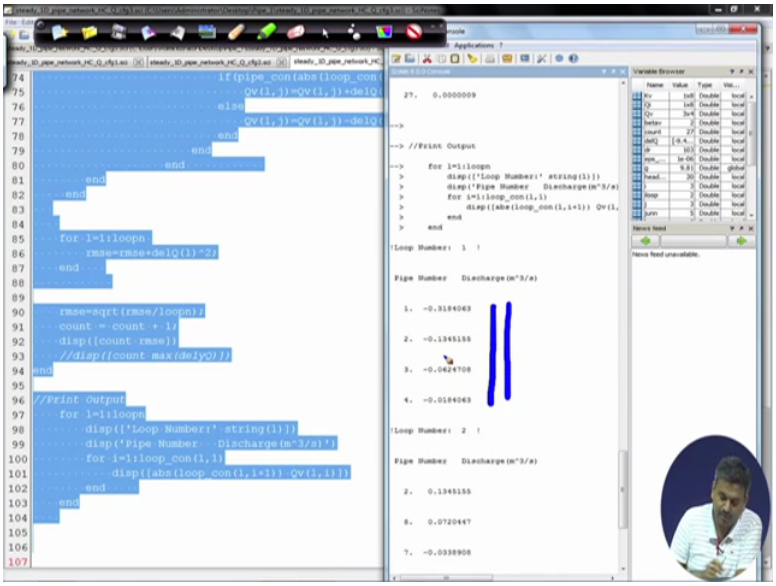

So obviously with the configuration 3 we are getting convergence here and at the same time we can visualize the actual direction of flow from the final results. So this was having a positive value because positive Q for these four.

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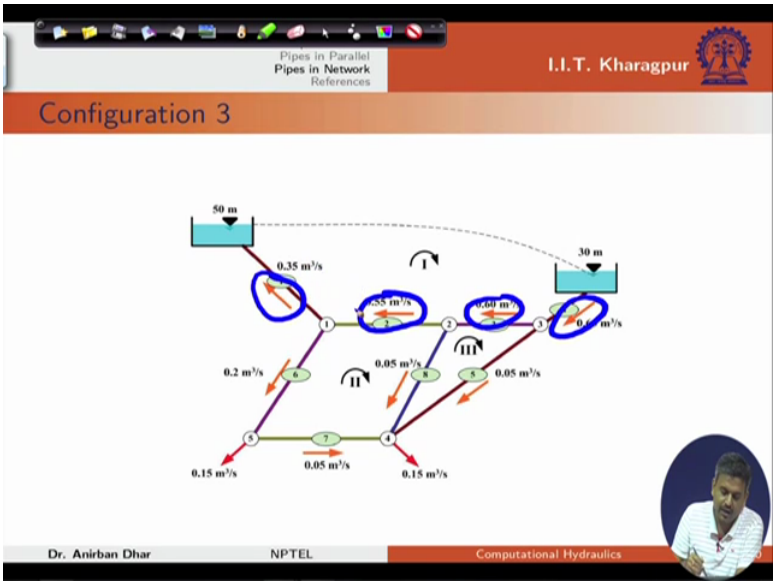

But finally when I have got the result, results are showing negative values. That means the flow is just opposite to the assumed direction. So with these three you can change different values and get the desired value for a specific network. You can also change the network configuration for maybe you can change K values or difference in elevation del h or you can add pump to this problem to see what are the changes occurring during the solution process.

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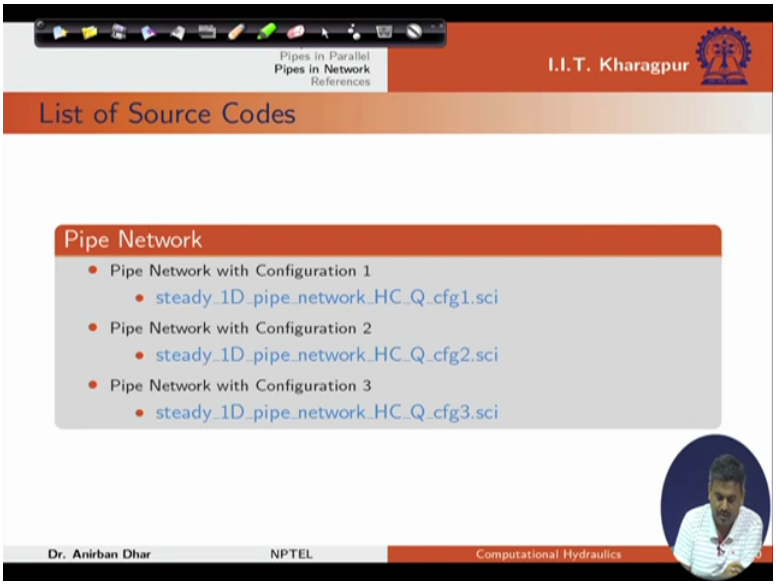

Obviously I have not included the pump system within this source code. You can suitably modify these codes to add the pump consideration in pseudo loop calculation. Thank you.