Fire Protection, Services and Maintenance Management of Building
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Lecture - 31
Flow in Pipe Networks (Continued) and Design of Water Supply Distribution System

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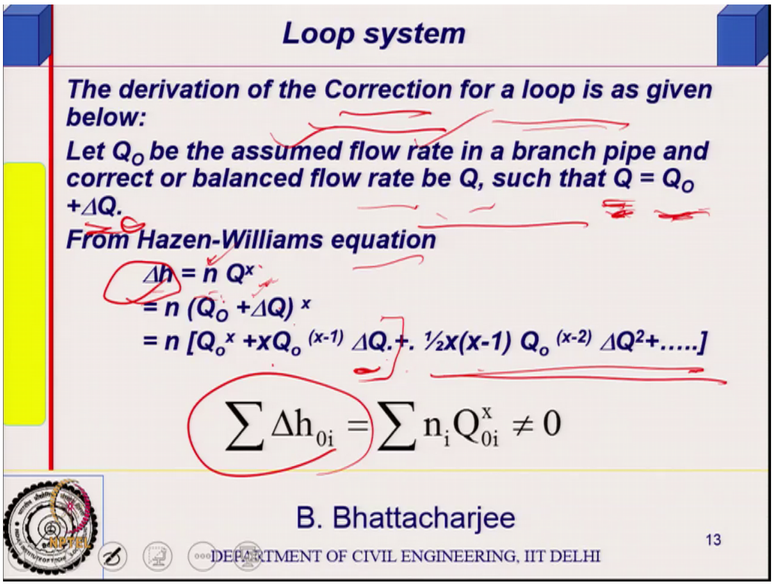

So, we look into pipe network again, just again you know we look into the pipe network. As I said that we have to find out the correction, but one important point is that you know one can Hazen's-William equation is commonly used, but one can use other equations as, because they are empirical like Banning's equation as well. So, let us see how Hazen-William's equation is one can use here for finding out the solving a pipe network problem.

So, what do you want to find out is correction. Now, we have assumed values let us say we are our assumed values Q 0 in a branch right, Q 0 in a branch. So, assumed value is Q 0. Now, since it would not it would not sum up to 0 in a loop. So, you got to change this value and that is the correction. So, the correction is let us say, delta Q. Now, software's might be available today to solve all these. So, therefore, ah, but then we must know the basic principles, because them the software's available.

So, now I apply correction and after that it is Q. So, Q 0 is assumed flow rate in a branch pipe and correct or balanced flow rate is Q, such that Q is equals to Q 0 plus delta Q. From Hezens William's equation finally, what comes is that delta h is something some sort of n multiplied by Q to the power x. Because Q was given as you know h f will come somewhere divided by l h f to the power 0.54 right, h f to the power 0.54. And then you had d which is known, d to the power 2 0.63 d is known, c is known, constant part is also known. So, basically h f you know some total of h f has to be 0. So, h f can be written as h can be written as sum n Q to the power x, because 0.63 is very much there 0.54 is there you know point. So, 1 by 0.54 that will come x will be x is nothing but ah.

Student: 2.85

So, because 1 by 0.54 you know that is what it is I think it is written somewhere I will come back to this I will come back to this.

Student: (Refer Time: 02:41)

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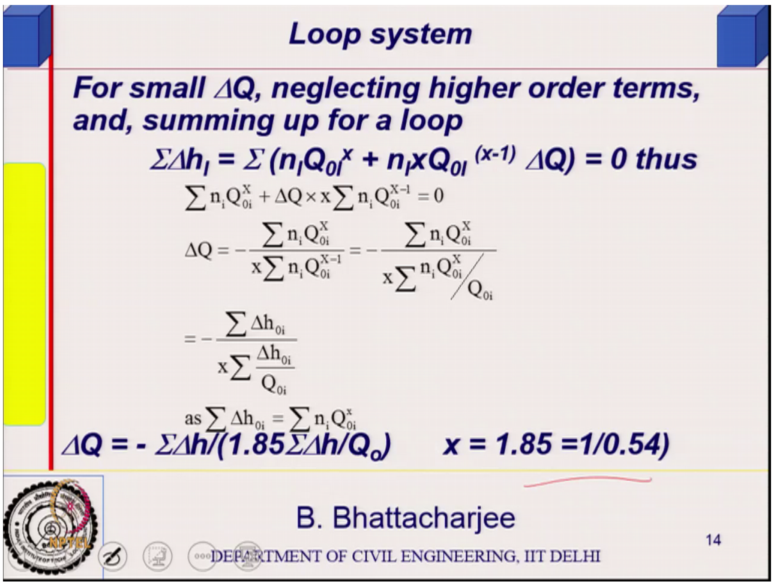

Yeah, this is 1 by 0.54 is 1.85 So, so Q can be it delta h can be expressed in terms of something some constant Q to the power x. So, Q is a final value right correct value is correct value of I want to find out delta h. So, n Q 0 plus delta Q to the power x, delta h means the head loss in that branch head loss in that branch right. Correct value of head loss in the branch that should be equals to Q is the correct flow after correction; so, Q to the power x which is Q 0 plus delta Q to the power x.

Now, this is a binomial you know I can express I can expand it through binomial expression, binomial expansion, so Q 0 to the power x, x Q 0 to the power x minus 1 etcetera, etcetera, etcetera and so on. And every time I will have delta Q and then delta Q square and delta Q cube etcetera, etcetera, so what I can do I can ignore all of these, because delta q will be relatively small relatively small. So, ignoring all of these parts I can find out delta Q I can find out delta Q right. So, I find out delta Q right I can find out delta Q, so delta h 1 0 1 initially was not first trail it was not equals to 0.

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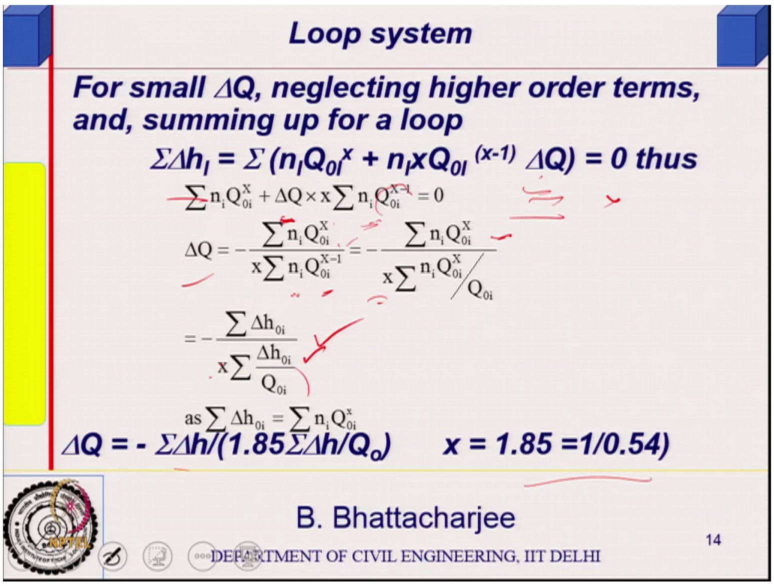

Then I want to find out the correction sum total of all these should be equals to

Student: 0

0. I have neglected the terms beyond the delta Q square and higher terms delta Q square and higher terms I have neglected. Then I have summed them up, sum them up for the whole loop sum them up for the whole loop and that should be equals to 0. So, let me repeat again. So, therefore, I can express and I can neglect all these terms. So, then what I am left with the delta h in a given branch is equals to this much sum total of all these in a given loop must be equals to.

Student: 0

0 it was not earlier not equals to 0, but now must be equals to 0, so that is what I am doing. So, that should be equals to 0. So, therefore, if I expand it out right n i Q i x etcetera, etcetera delta Q i should be able to take out of this. I am assuming the delta Q correction in throughout the branch flow throughout every you know throughout the loop sorry, throughout the loop in all the branches in the loop that is what I have done that is what I have done you know, so I have just expanded. So, delta h in a loop so everyone I assume same correction and that is what I am doing here.

So, I can get an expression for delta Q from this one, because this is equals to 0 delta Q will come outside the sigma. So, this would be nothing but sigma of you know n i assumed values of Q 0 to the power x divided by same, because this is loop specific i th loop for i th loop n i x to the power minus 1. This term this term you know sum total of all this term.

So, delta Q simply comes out to be, because if I expand this, this is outside the expansion rest all are within expansion. So, just I do that and I get relationship like this right. Now if I divide this by Q 0 i then I get same and, in fact the expression comes out to be something like delta. This was the delta h i, which was not equals to 0, because that sum total was not equals to 0. And this is also same value because this is sum total was not equals to 0 divided by Q i of all this one. So, x you know n would be there x or whatever the values that would be there. So, delta you know is delta Q you can obtain delta Q you can obtain. So, delta Q is equals to delta h one point.

Now, x is x to the power, because this is x was coming x is nothing but 1.85 1 by 0.5 4. So, x was coming here. So, x you can find out and that is how you can find out the correction. Repeat this process for you know, and when the error become too small you know, when this is too small, the sum total is very close to 0 you stop. So, you get the corrected values of Q etcetera right so that is how one can obtain I do not know whether I have got an example problem here I might have or may not have I am not sure.

Let me see if I have an example problem for this one, I might have an example problem for the loop tabular form adjusted. This is normally done in a tabular form may be is there somewhere I just check right. But then there are some practical example, let me see if I have some otherwise I might be having I will just check I will just check, but let us take some (Refer Time: 07:51). So, this is the basic principle this is the basic principle right this is the basic principle. I must be having a example problem sometime related to this. So, this is a basic principles right ok. So, thus the basic principle of pipe network ok.

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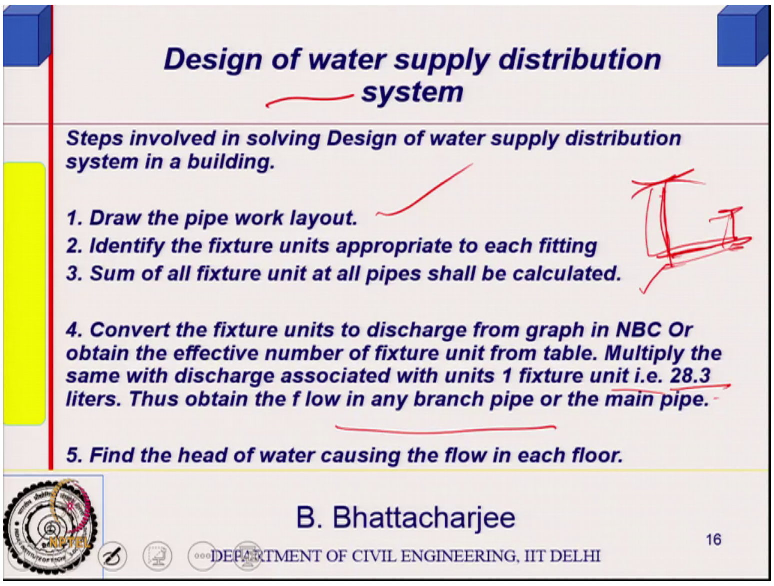

First thing is now let us look into some of those issues related to design. So, first you draw the pipe work layout right like this may be it is there somewhere, somewhere it is there yeah. So, you know the water tank every details of it is known, and the pipe work layout you draw. So, you draw the may be it somewhere there, there are many of them like that. So, this is an example case. So, I just wanted to highlight the pipe layout, it would be there somewhere.

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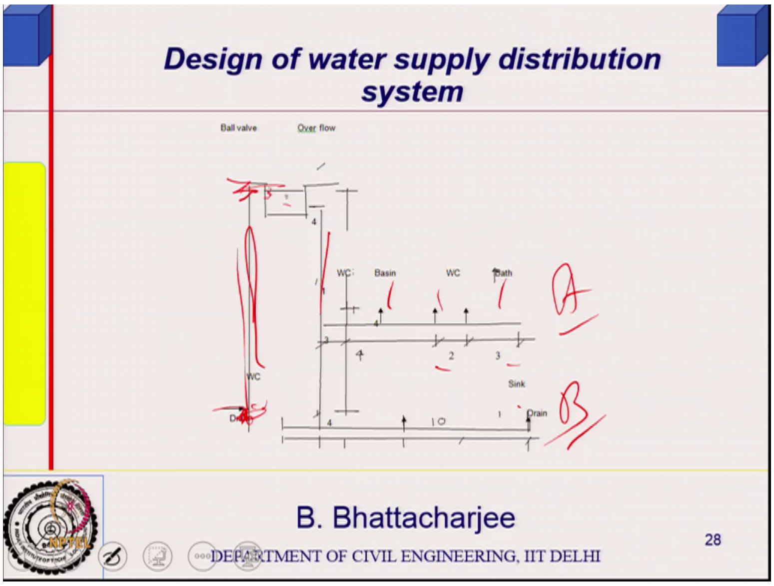

Yeah this is like this something like this; you draw the pipe layout basically. So, this is one floor, this is another floor, and how many you know wash basin, water closer, bath etcetera for each one of them. So, that that you draw it and distance you find out the pipe length. So, you draw the pipe layout right, that is the first thing you do first thing you do is that ok. So, draw the pipe work layout identify the fixture units appropriate to each fixture or each fitting right. Sum of the all fixture units at unit at all pipe you know for all of them and calculate sum total.

Convert this fixture unit to discharge from graph from national building court or obtain the effective number of fixture unit from table there is the table also given graph is also given. So, you can get from the table now one fixture unit corresponds to 28.

Student: 3 liters.

3 liters the discharge from one fixture unit is 28.3 liters. So, if you know the effective number of fixture units, what is the Q that you can find out. Your aim is to determine the d; your aim is to determine the d. And d would generally be same, but if it is different then again series you know network. So, convert this one either or find out effective fixture unit 28.3 liters multiplied by 28.3 is that is the flow for any pipe any branch pipe you can obtain.

Find the head of water causing the flow in each floor, because you know there is a supposing it is a tank supply from the tank what is the head available. And yeah how much is head available at a given floor level because it will be this much. If this is the pipeline here going the tank is somewhere there, this will be the head available head right. Length will be of course, you know, and if there is a loss here, let us say it is a shower. So, another 2 meter reduction or 1 meter whatever the height that reduction will be there, but length of the pipe would be you know total so that you have to see; so, from head of water causing flow in each floor that you can find out.

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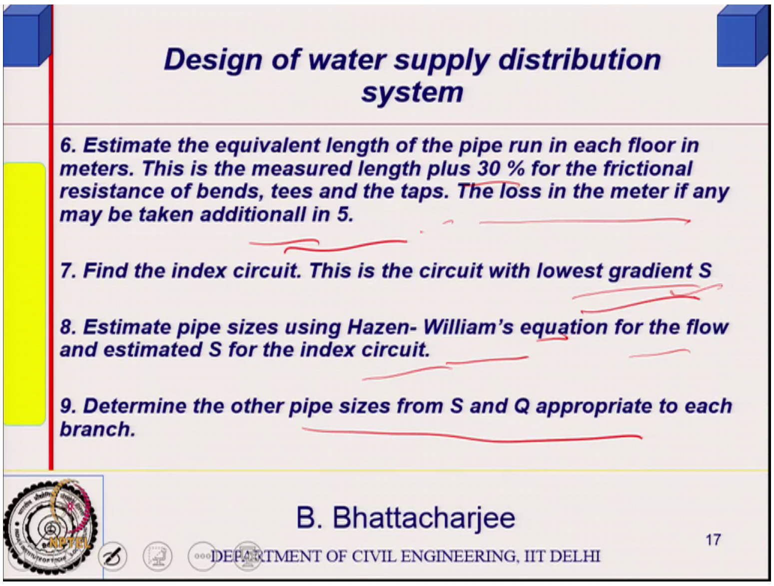

Estimate the equivalent length of the pipe. Now, equivalent length of the pipe takes account of loses. One way is to take increase them by 30 percent, because there will be bends loses in bends. So, you know meter loses of course, directly you can calculate out, but something like 30 percent is frictional loses in resistance of bends tees, taps, etcetera, etcetera. The loss of meter you can you can find out directly. So, it is a water meter is there from the municipal line as soon as you enter into the consumer area that is a water meter right.

Now, this water meter loss in water meter that is given in a table in you know it is given in given in a table, and you can take it from there itself, size of the water meter. Pipe size will dictate the water meter size and that is you know for a given pipe size what is the loss meter loss that is also given. Now, index circuit is that circuit, where the h f by l is you know is lowest S, because that would dictate the size of the pipe lowest S. Diameter will be maximum when S is least. So, you select that index pipe whose gradient is less, because you are not going to change the pipe diameter in every floor you are not going to change the pipe diameter right.

So, in the floor itself pipe diameter would be same. And other floor also it will be same. Mains might be main might be different. For example, if you have a speak less system for firefighting, now there is a main raiser. If you remember we said that there is a main raiser, and there are branches now main size could be different. Because, we will connect to so many branches, but each branch is connecting to the sprinkler head they will be of the same size. Although supposing you know there are one pipe might have a few more sprinkler, but it is not worthwhile changing that is what we do in all engineering design. We have discrete decisions are you know you have discrete values of your design variable when you are dealing with pipe structural sizes and.

So, on you have discrete values say steel built you know already produced one factory produced material. Molded material you can have your choice, but if it is a factory produced material pipes rolled section steel i s you know medium beam or heavy beam i s m b s the sizes are fixed. So what you do you tend to use similar sizes as much as possible, because of other reasons, unless there is a significant economic reason. The similar example analogies columns in rcc columns in a given floor you might group them, and you might have three sizes.

Although some of them load carrying capacity required would be quite different from for each of the column, but you do not change them, because certain cost leave it away there you know the benefit that you will get from a materials reduction. Similarly, here many other costs will in involve and that leave it away. So, therefore, we do not do it you keep it same. So, that is what it is, so this is the circuit lowest gradient ensure pipe sizes might use Hazen William's equation for the flow estimated the S for the S for the index circuit. And using that you find out determine other pipe sizes if required from S and Q for appropriate branch, so that is the procedure.

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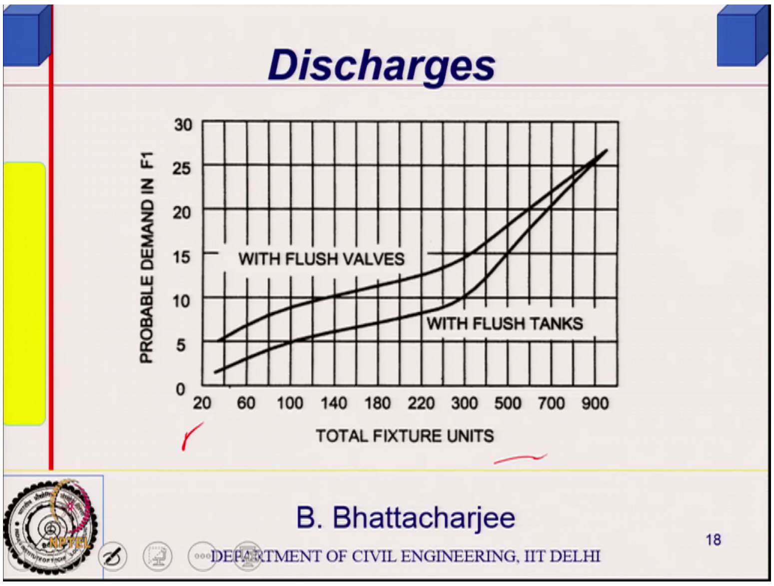

Now, just the graph from the code is you know reproduced. For small values of total fixture units flush tanks with flush bulbs right. This is you know as a dominant flash bulbs or with flush tanks possibly these days more of this, so probable demand is given probable demand is given.

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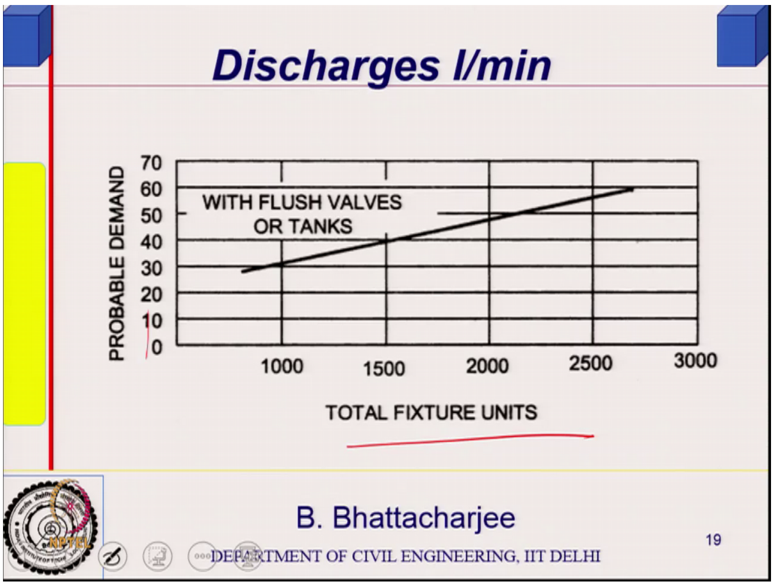

And in fact, total fixture unit when there are large number of them both coincides both situation coincides and probable demand is given in you know probable demands are given.

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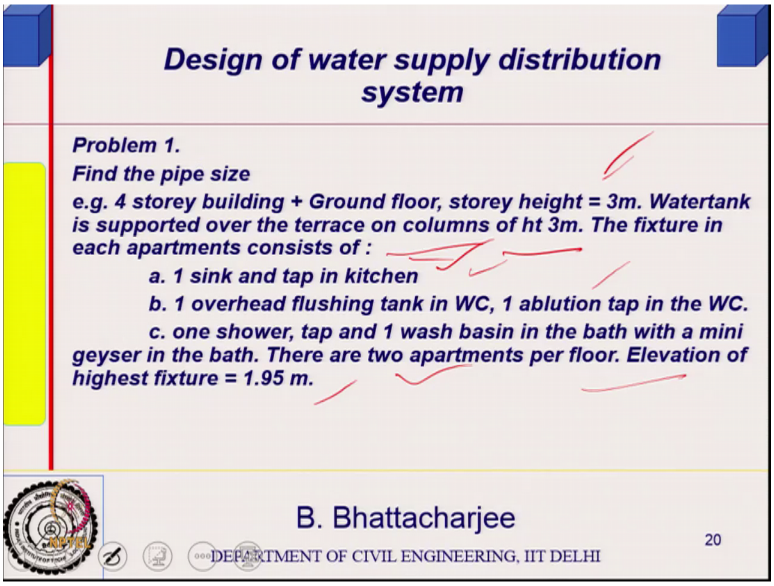

So, I mean I am just showing the curve you can you can refer to them if you like or, you can calculate from a table as well table also. So, example let us take up an example problem, let us say supposing you consider a four storey building, ground floor plus ground floor right. So, four storey plus ground floor and storey height just for the sake of ease we have taken it to 3 meter. Water tank is supported over the terrace on columns at height 3 meter. So, additional 3 meter height has been the fixture in each apartment.

So, it is a residential complex each apartment consists of: a sink and a tap kitchen, let us say a overhead flushing tank in WC one evolution tap, one shower tap, and one wash basin in the bath with mini geyser in the bath. There are two apartments per floor elevation of highest fixture that is your shower is 1.95 meter.

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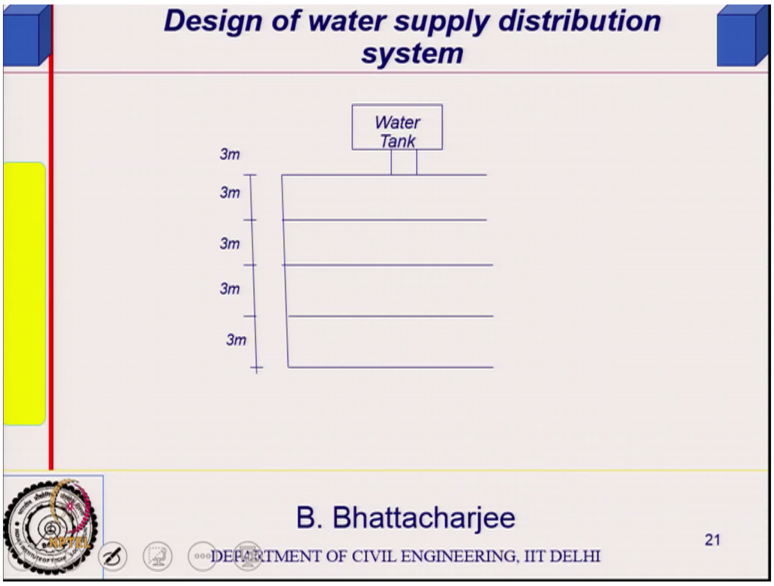

So in fact, in a floor you will have double, because there two apartments there are two apartments. Made it simpler something like this I have a water tank 3 meter, so each floor is 3meter right this is the example ok.

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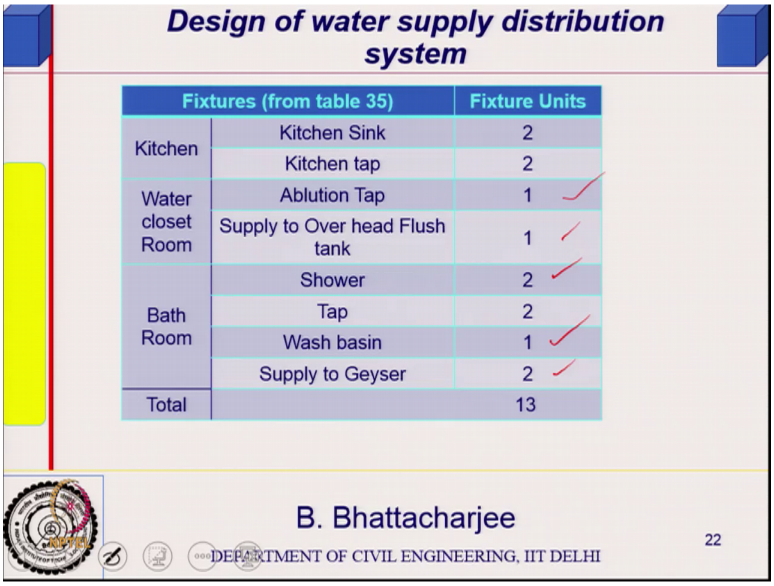

Fixtures (from table 35)		Fixture Units
Kitchen	Kitchen Sink	2
	Kitchen tap	2
Water closet Room	Ablution Tap	1
	Supply to Over head Flush tank	1
Bath Room	Shower	2
	Tap	2
	Wash basin	1
	Supply to Geyser	2
Total		13

And this is what taken from the table you know kitchen sink is given fixture unit equals to 2 to have a field for you. Evolution tap is taken as the least, which is 1 supply of overhead flush tank supply, because that that goes slow. Shower to wash basin it is taken as 1 the minimum geyser is 2 etcetera, etcetera. So, something like that.

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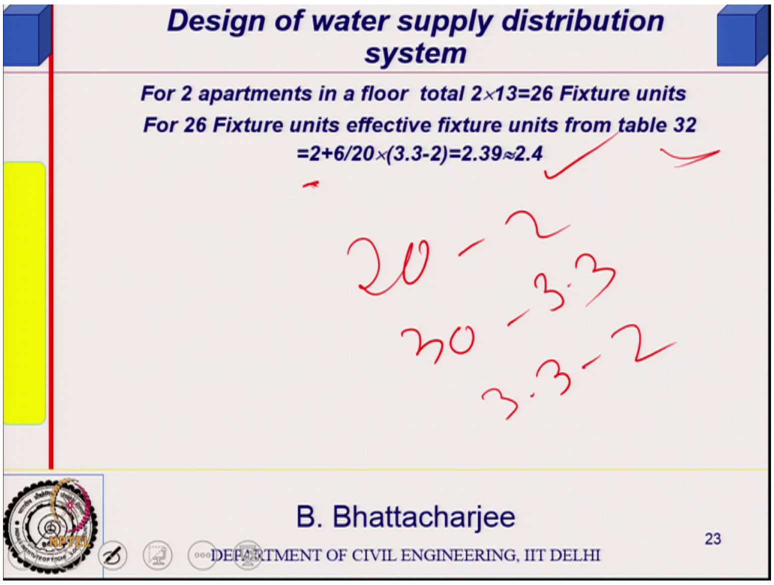

So you know this is the, now how many numbers are there yeah. So, 13 fixture units in an apartment, I have 1 kitchen, kitchen sink 2 fixture unit, kitchen tap 2 fixture unit if I sum them up I get 13. Since, there are 2 apartments, how many there will be 26 fixture units.

Student: 26

For 26 fixture units effective fixture units from table 32 of sp 35 gives you know, it has to be interpolated between, because fixture unit is 26 between 20 and 30 right 20 and 30. For 20 it is 2, 20 it is 2 ok. And 6 is extra 6 by 20 3.3 minus 2. So, for 30 it is 3. 3. For 30 fixture unit, the table gives you effective number of fixture unit to be taken as 3.3. For 30, it is 3.3 right. And for 20, it is 2; so, 20 - 2, 30 - 3.3. The difference is 3.3 minus 2 to be distributed over 10. So, multiplied you know so 6 divided by 20 into 3.3 etcetera. So, you can get actually about 2.4 it comes out to be 2.4 right, 2.4 is a fixture unit by doing out simple interpolation between the2. 2 for 20 additional for 6 right, so that is how we find out ok, so that is the total number of fixture units.

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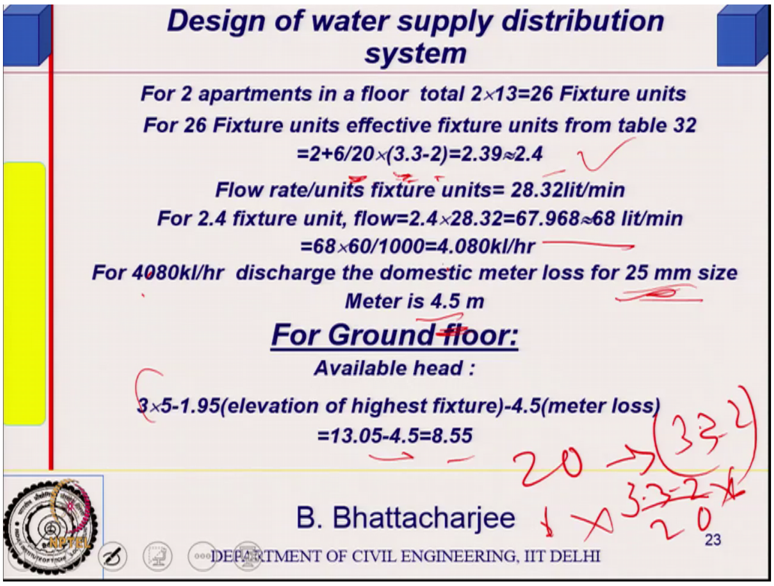

Flow rate is 28.32 liter that is given; so, for 2.4 fixture unit, 68 liters per minute. So, it is given as 2.382 liters per minute. So, it will be 68 liter per minute. And then you can convert this into kiloliter per hour, and per day if you require to use the same formula, right. So, kilo rate discharge meter loss is given for 25 meter millimeter size meter is 4.5 meter this again given from another table you know. So, this is four you know this is 68 into 60, 68 into 60, this was liter per minute I want to convert into hour. So, this will be 4.080 kilo liter per hour right.

And this 4.080, 4.080 kilo liter discharge, meter loss is 25 millimeter right. And this is given in a table 4.5meter; so, now for ground floor available head. So, if I go back to this diagram, if I go back to this diagram for ground floor, 3, 3, 3, 3, 3, 15 right. Minus the meter loss 15 minus meter loss minus 1.95 would be there. So, 15 minus 1.95 minus meter loss 8.55 that is what it is right for ground floor.

Student: (Refer Time: 20:55)

Hm, 3.5 is 15 minus 1.95 minus 4.5.

Student: (Refer Time: 21:06)

This one.

Student: for 26 fixture and effective fixture (Refer Time: 21:08) 32

Is 2.4.

Student: (Refer Time: 21:11) it is coming out to be 2.08 (Refer Time: 21:13)

Ah then it must be you know one has to see I do not know exactly 3.3 3.34 or it might be for 40.

Student: Yes.

It might be for 40. So, whatever the values actually this it might be for 40, this might be for 40 right, this might be for 40 yeah, yeah, yeah, yeah, because I am dividing by 20.

Student: hm

I am dividing by 20. So, it is for 40.

Student: (Refer Time: 21:43) it should be 40

40 yeah 20 dividing by 20. So, for 20 the change is 3.3 minus 2. For one the change is 3.3 minus 2 divided by 20 for 6 the value will be 6.

Student: (Refer Time: 22:00) should be 40

40, so 3.3 correspond to 40 from the table. So, anyway this is the head available head.

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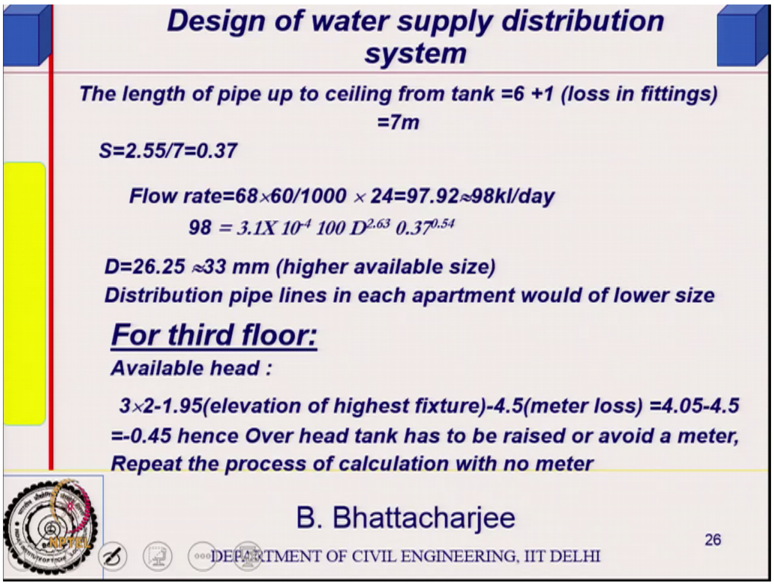

So, what is the maximum length? The length of the pipe from ceiling tank is 12 plus 2 you know loss 2 again another 30 percent you take or whatever two values you know, so its 14 meter. So, if you look at this, how much it will be from tank 3, another 3, another 3, another 3, so make it four 3 s, so it is somewhere here right. So, we are trying to calculate out the length of the pipe up to the ceiling from tank, ceiling 12 plus loss in fitting is 14.

So, up to ceiling level is this at 8.55 divided. So, S comes out to be this flow rate is 97.28 kilo liters that is 68 into 60 divided by 1000. How does it come kilo liter per day, flow rate was 68 right 1000 into 24 hours yeah, so multiplied by 24 hours. So, kilo liter per day we want to calculate out per hour to per day, this comes out to be in 4.0 something multiplied by 24. You know we calculated this out to be 4. How much 4.080 kilo liter per hour multiplies these by 24, how much it will come to 97 or something?

It comes to 97 point something 97 point something 97.92, 98 kilo liter per day. So, putting another formula find out the D, so next highest size is 25 around. So, that is it for first floor available head. You can repeat this process for other floors. And possibly if you repeat this process for other floor, you will get the pipe size nearly same. So, use 25 mm pipe in each floor.

Student: (Refer Time: 24:25)

Hm.

Student: (Refer Time: 24:26)

Yeah, let us see for the other floor somewhere it is coming high

Student: yes, 33.

33 mm distribution pipes lines. So, each apartment will lower size yeah so that is know the pipe main pipe carrying because I am taking from the top, so that has to be highest of this. So, let us see the third floor what does it give third floor the repeat this process in, because the main pipe line bringing that would be of the larger size in each branch pipe I might use the size. Because, this is this I am you know this is for the main pipes I am calculating. So, corresponding to each one of them actually you can calculate out.

Student: Sir, in (Refer Time: 25:06) saying that (Refer Time: 25:08) available head is minus 0.45, so what we are going to do in that case.

Hence overhead tank has to be raised to avoid the meter. So, you have to raise the overhead tank in this you know as we are showing that calculation procedure, but in the third floor that means, you have to raise it otherwise water is not going to come to the third floor itself.

Student: mm.

So, you know overhead tank has to be raised or avoid a meter that 4.5meter loss in the meter. So, if there is no meter you can calculate or raise the head and calculate and so on, so repeat this process this is the procedure this is the procedure. Similar exercise one can do, similar exercise do this is for a 2 storyed one.

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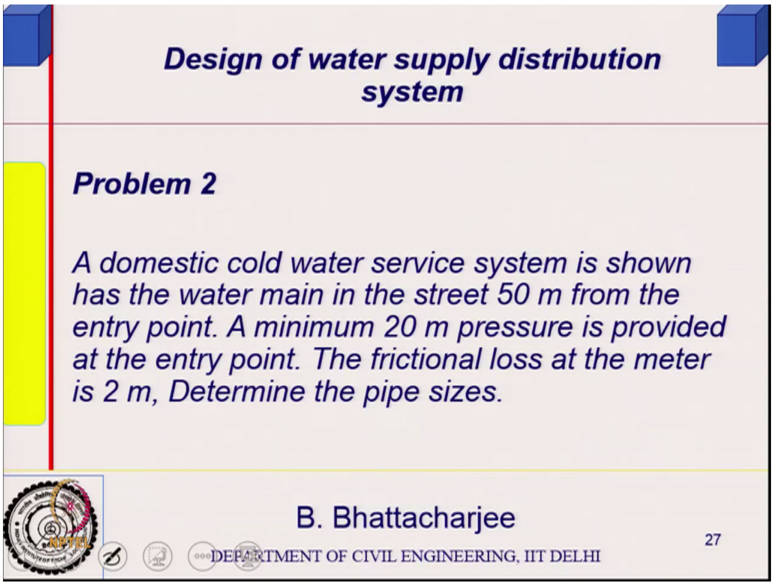

This is for a domestic water supply minimum you know same. Similar, so this is shown there is a water tank there is you know this is what the supply is. This pipe line this dimension should be different than this one, because this should be head available here the length is whatever the length you calculate out. And the head available head may be 1 meter per second or whatever residual head. So, the difference is the head here and the length one has to see. So, the head here is created by the pump you know.

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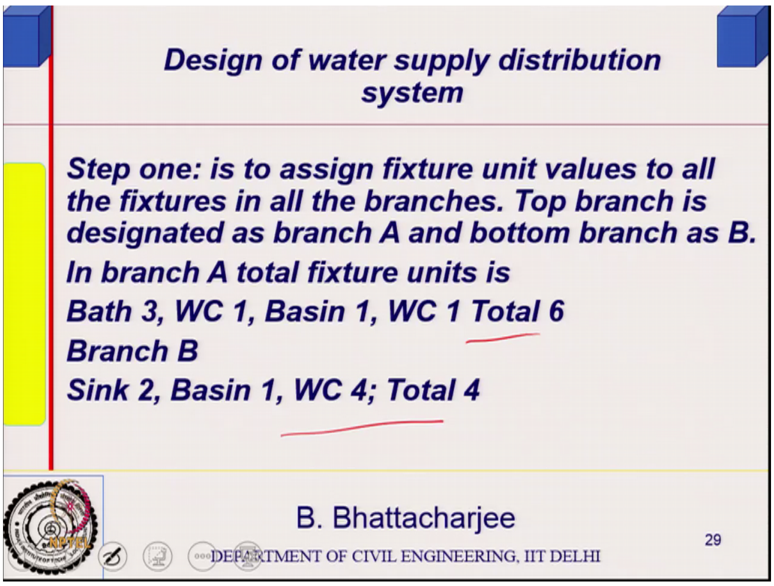

So, again in case of floor assign the unit fixture unit values and same process total 6 branch B total 4 discharge in branch A. So, if there are number of branches there is number of branches actually this is you might call it branch A branch B in the floor itself. And then find out branch A and branch B right.

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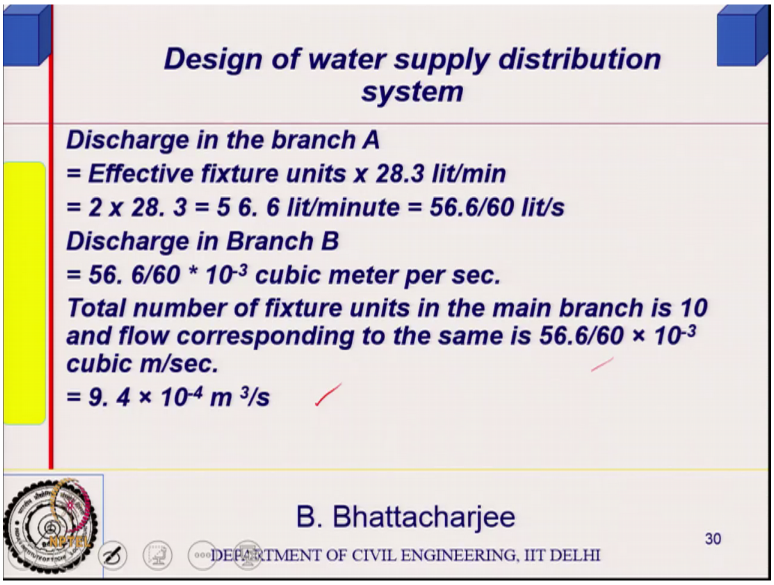

So, required flow is this much this is given in meter cube per second.

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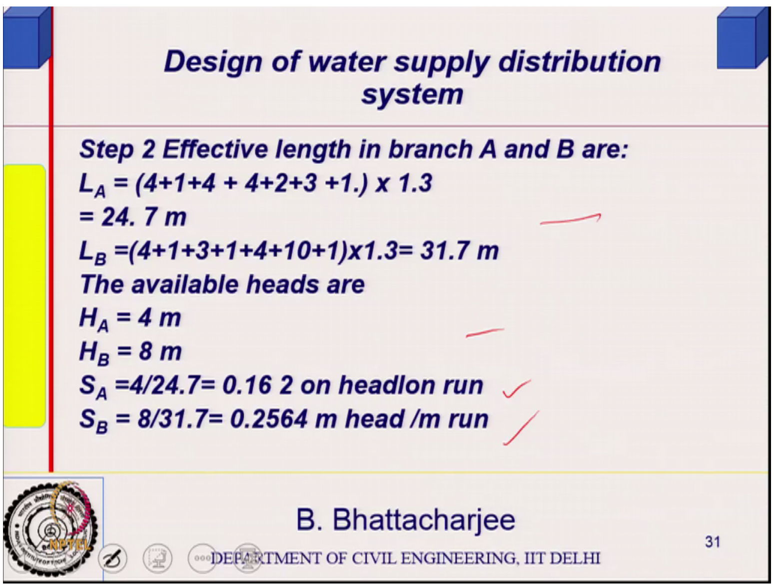

Effective length in branch A and B are calculated S A and S B. Now, the idea here why did I take this example is to show that the one which is lower that will dictate the design, so that is the index.

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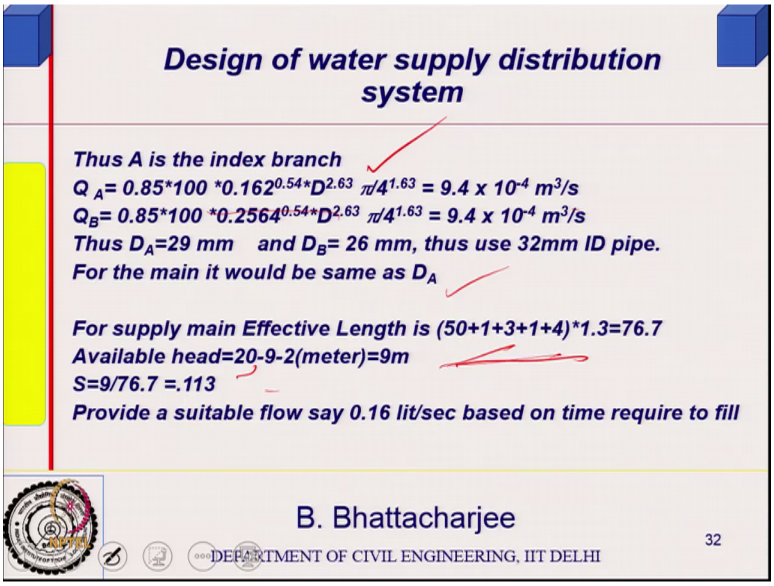

A is the index branch pipe you know A is the index branch pipe is the same procedure and this was all in meter cube, so basic first equation was used. This in meter cube, so everything in basic, but you if you convert everything into kilo liter per day, then the equation just changes, otherwise all same right; to the supply to the main effective length main is this, this the main.

Student: Sir, these 4 2 and 3 are the?

Distances these are the distances here, these are the distances spacing basically between water closers and you know so on so forth. So, this is the spacing actually or distances between them, so that is how you can calculate out. And for the branch you know one of the main supply available [hea/head] head is total given as 9 meters. Because 20 meter was the head from the pump at a distance 9 meter etcetera. And I mean the distance is given. So, for this one, you can you know you do it separately and find out separate pipe size, so that is the supply that is the that is the idea that is the idea right. That is that is that is how you can actually calculate out or design a pipe system in buildings basic principles.

And ah, in fact there are obviously there are software available today to do all these kind of thing, but that is the basic principle all right all right. So, that is related to cold water supply cold water supply.

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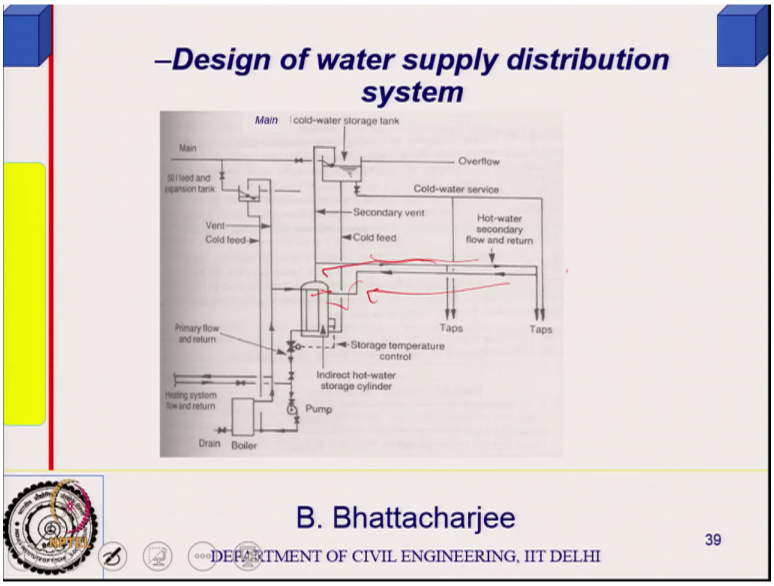

Now, hot water supply system basic principle is I will come to this, but may be first I look into a simpler diagram, yes; this diagram and then we come back to this. Then normally you have you know hot water supply you will have a loop. And wherever you have the hot water storage right or heater or whatever it is, hot water will be at the top and cold water at the.

Student: bottom.

Bottom. So, you supply goes from top and then it comes back right it comes back ok. It you know this is a loop, because otherwise pressure will be generated. Supposing, I keep the tap closed and hot water actually there will be pressure generated. So, I have to have some kind of venting or whatever it is. So, we will see that thus that is that is what it is. So, this is loop of the hot water supply system. Even if you have individuals small domestic water hot water supply system like these are and things like that, so essentially the pressure you know the pressure hot water creates pressure and that has to be released in someone. We will see that again we will come back to this sometime later on.

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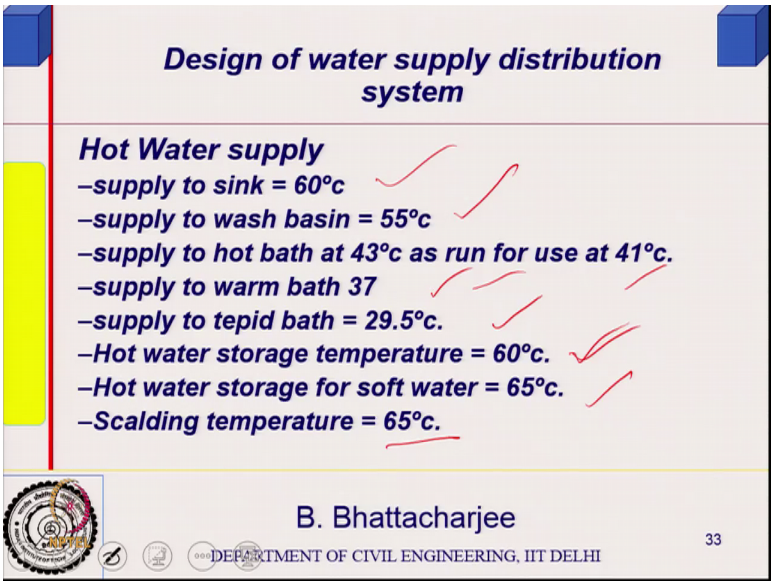

So, basic principle the temperatures desirable temperatures are given in the code, National Building Code gives you. Supply to the sink is 60 degree, wash basin 55 degree hot bath as run or for use at 41 degree, and warm bath is 37, tepid bath is something like this somewhat less, storage temperature preferable is around 60. And if it is soft water, hard water, little bit less soft water 65 degree centigrade, scalding temperature is 65 degree centigrade. So, this basic scheme of hot water you know temperatures of hot water desirable even in the code. So, I think we will look into this just in a minute.