Fire Protection, Services and Maintenance Management of Building
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Lecture - 30
Flow in Pipe Networks and Fixture Units

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So, now we can look into; we will be looking into plumbing services that is essentially water supply first and then waste water handling right.

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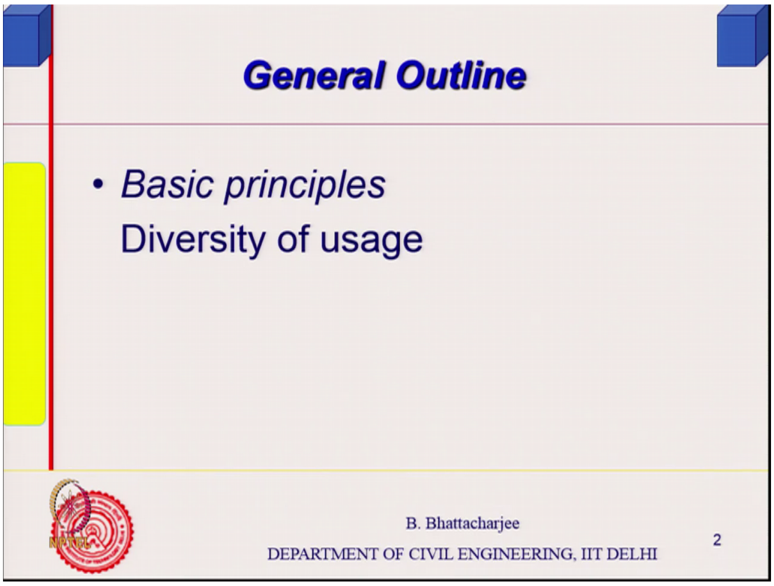

So, we look into some basic principles diversity of usage we have already talked about.

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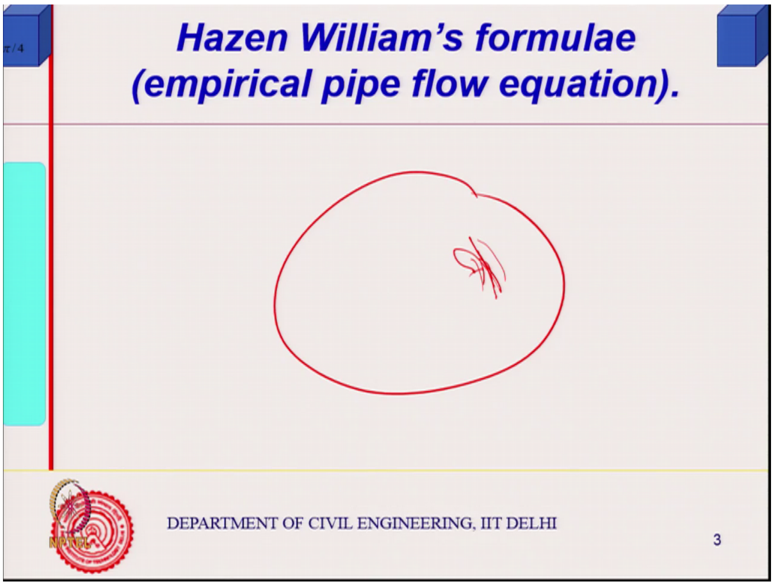

Now, we have already looked into Bernoulli's equation. And we also know about continuity equation, Kirchhoff's law and all we talked about. Now, one can use, one can derive in fact Parsely's equation for stream flow which you might have done somewhere. For example, it is a viscosity you know viscosity is the resistance offered by one layer of the fluid over another when it is flowing.

So, if you take in a let us say you take in a pipe; you take in a pipe or you know the, the flow of a small layer here will be opposed by next layer, it will be opposing it right. And therefore, since it opposes this generates a kind of a shear stress. So, the shear stress is proportional to velocity gradient, more the velocity difference, you know over its distance then resistance will be more, so that is what is viscosity, we know that is what is viscosity.

So, from fundamental principles for stream flow, you can actually derive Poisson's equation which relates flow to area or diameter or such things length and etcetera, etcetera. However, actual flow is not stream flow all the time right, lot of assumptions you make. So, visually in water supply system, we use Hazen William's equation or Manning's equation or similar equations actually.

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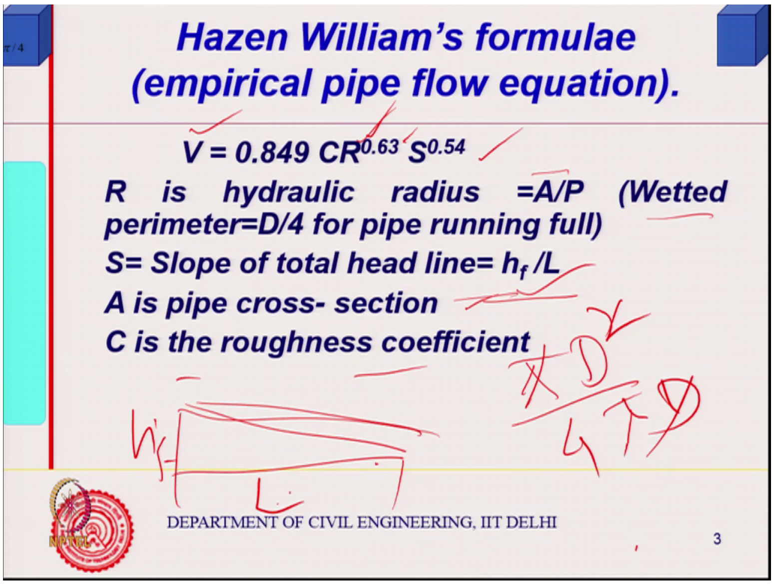

So, generally people use Hazen William's equation for water supply system and that is somewhat, you know it is semi-empirical I mean semi- empirical, because many of the fluid mechanics things are derived also from dimensional analysis, but they are semi empirical, for example, this powers. So, this is in this one V is the flow, V is the flow meter cube per second. And R is what is called hydraulic radius, wetted perimeter divided I mean area divided by wetted perimeter, area divided by wetted perimeter. So, in case, so pipe planning full under pressure, area is pi D square by 4. And what is the perimeter, wetted perimeter the whole pi D is the.

Student: pi D

Is the wetted perimeter so, simply this is D by 4 D by 4 for pi planning full.

So, this is hydraulic radius to the power 0.63 and slope of the head line. So, there will be when pipe there is a flow that the head difference and this is the length. So, this is h f divided by L, h f, so head difference between 2 points in pipe thus, so slope of the head line is this, head line is this two. You know distance between this, but the pressure head would vary. This is not the you know pressure head, because it to would vary depending upon, you can have gravity right, pressure, you know gravity, there are three components of the pressure head, so pressure head, pressure head would vary. So, h f is the slope of total head line right. And A is the cross section, C is something called roughness coefficients, C is something called roughness coefficient.

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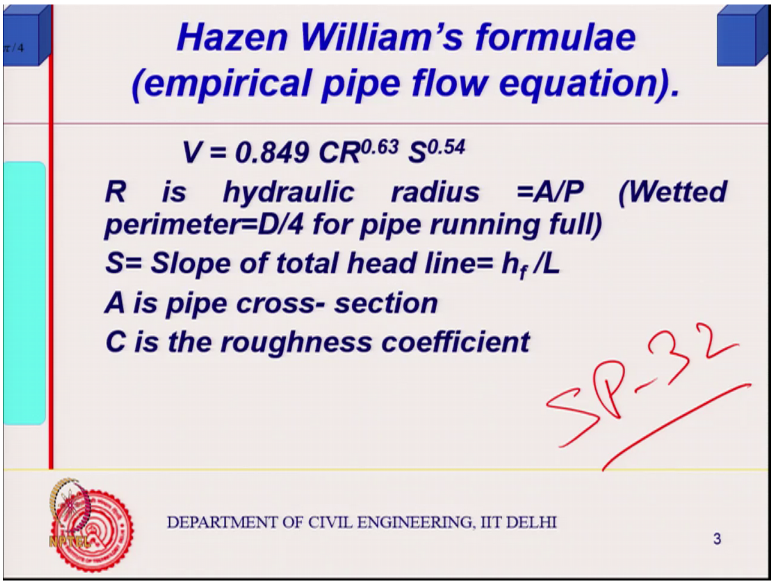

So, thus Hazen William's equation that is what we use in water supply system by enlarge National Building Code or S P 32. S P 32, you will find this, which is available in the net also. So, S P 32 is the one special publication of Board of Indian Standard that gives you. So, they all uses this charts etcetera based on this. So, if this is the case, if I want to convert sorry this was velocity, I made a mistake. This was velocity not flow, velocity as a function of hydraulic radius etcetera, etcetera.

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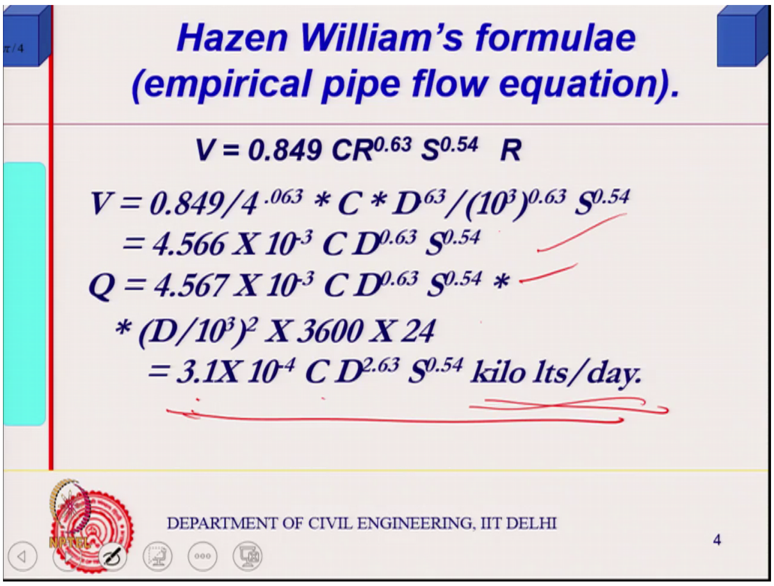

Perimeter you know like equator perimeter and those. And then flow is equals to I must multiply by area right. So, V is equals to and the units are very very much important, units are very much important. So, this was in you know this you have to convert into appropriate unit, so that is why if D is in millimeter, you want to converted into meter right 10 to the power 3 0.63 again comes in. And this is also, because D to the power, you know this, if I look at this R is A by P which is D by 4.

So, D to the power 0.63 will also come into picture. So, D to the power 0.63 will also come into picture and conversion of you know 10 to the power 3 to the power 6 will come into picture. So, all these are all this, actually taking all this; and multiplying by the area, you get an expression for just converting the right units 3.1 10 to the power minus 4 C D to the power 2.63 kilo liters per day. This is in terms of kilo liters per day. So, if it is in kilo liters per day, this is the constant is 3.1 into 10 to power minus 4 right.

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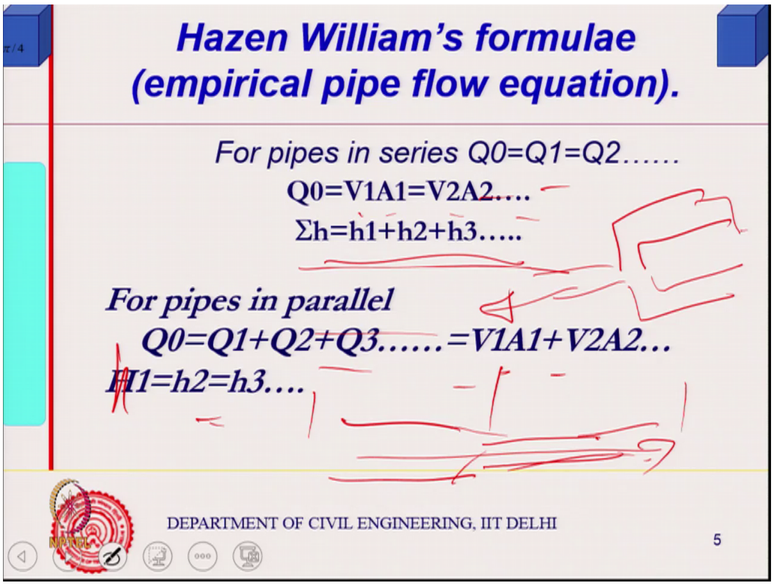

So, a consider now pipes in series. Then flow is constant there are some basic equations actually research will look into some basic equation. Then look into the actual building and things like that. So, V 1 A 1 must be equals to V 2 right. Supposing the 2 pipes there is one pipe and there is in another pipe. And this pipes are in series flow must be constant, if it is a study flow flows you know flows constant.

So, flow through first one and flow through the second one will be same. And head will be sum total of the head difference between these two pipes in series, if pipes are in parallel. So, flow would be sum total of flow thorough all of them for example, if it is something like this all right and something like this, so flow would be, you know like flow would be sum total of the flow through each one of them and there will be under both of them will be under constant head. So, it is like you know as a yes. So, in pipe parallel heads are same 3 pipes in parallel. Let us say I distribute them then the and in the you know. So, head would be this should be small h head would be same flow would be different. So, this the principle this is basic principle when we look into the network principle a little bit later.

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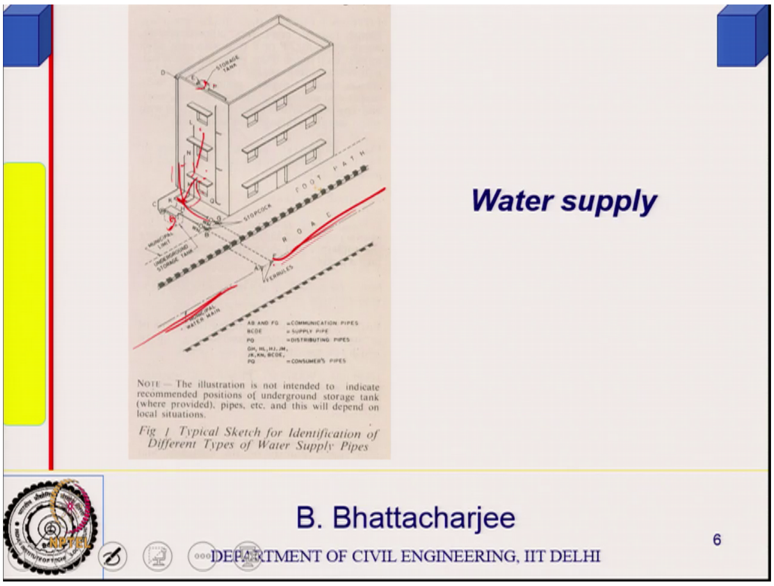

Now, typical water supply in a building, low rise building will have this kind of component; what are these component? See this the you might, because scheme could be something like this, you know low rise building a three storied building, you have the municipal means, you have municipal means. So, from there, there is for rules which will connect it and I might you have two sorts of line, one is for storing them you know say overhead tank, I can store them in overhead tank. And I can have you know direct supply to each floor; direct supply to each floor.

So, you if you see this diagram, we will see this some direct supply lines to each floor. And there could be this is there is a there is a booster pump, which takes it to the overhead tank, where I have storage. So, this is for 24 hourly use all the time use, this is the running water, which is used, if it is intermittent supply, if it is continuous supply, if possibly do not needs storage in a any case, but then continuous supply may not be available. Normally, these are this is connected to the you know the where you use almost every time like bath and also may be something in kitchen, and this might be running water must be for drinking water purposes and so on and so forth.

So, this is the typical line. Now, this is actually this is the municipal line after that is consumers line actually, this will be all consumers point, this is the consumers point from where you know. So, this is the main series of municipal line, then there is a consumer point and there is a branching that is what occurs.

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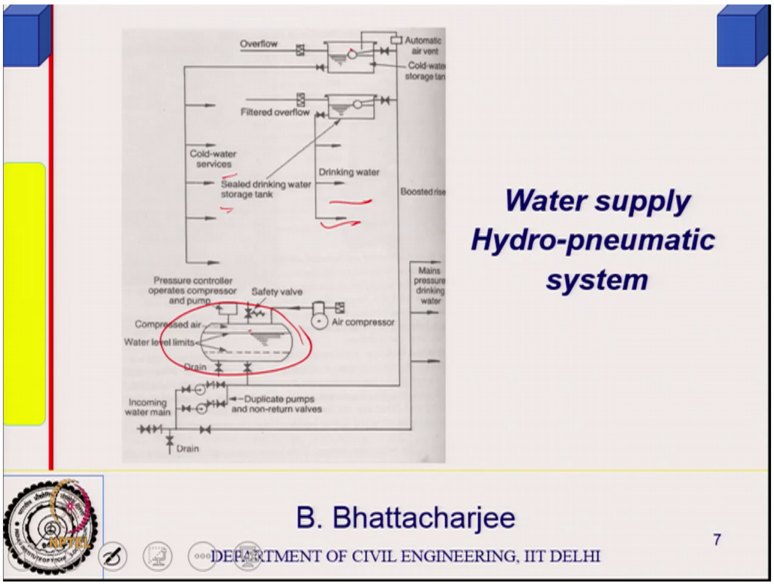

Now, if you will see in relatively, you know relatively taller buildings, you might use what is called a hydro-pneumatic tank. So, essentially what is done here, the water is actually pumped up using compressed air. You know, because I mean you can you can basically the purpose of compressed air is much controlled. So, compressor would be there where you have compressed air here. And water and from this the water is supplied to the overhead tank. You might have some directly supplying from the tank to certain level, if you go to another one it might supply you know so this is to the drinking water (Refer Time: 11:23) running, drinking water this must be cold water supply all the (Refer Time: 11:28) from a tank.

So, this is the also you might have a direct supply going up, direct supply going up, which is you know, which can be connected. So, during the this would be mainly meant for drinking water, this is the storage water line is same, so that is how it is. This is, so this is water right. So, typical water supply system would look something like this. And also a firefighting water right, fire of course, we have shown it earlier, and requirements are given for each type of occupancy what should be the kind of quantity of you know the size of the tank required for firefighting.

And, if you remember we talked of wet wiser system combination and all that. So, this all get coupled together water supply system firefighting as well as for regular use. Now, generally I would like to find out how much is the, you know I would like to find out what is the supply rate or quantity of supply I require. So, usually this is arrived at using something called a fixture unit.

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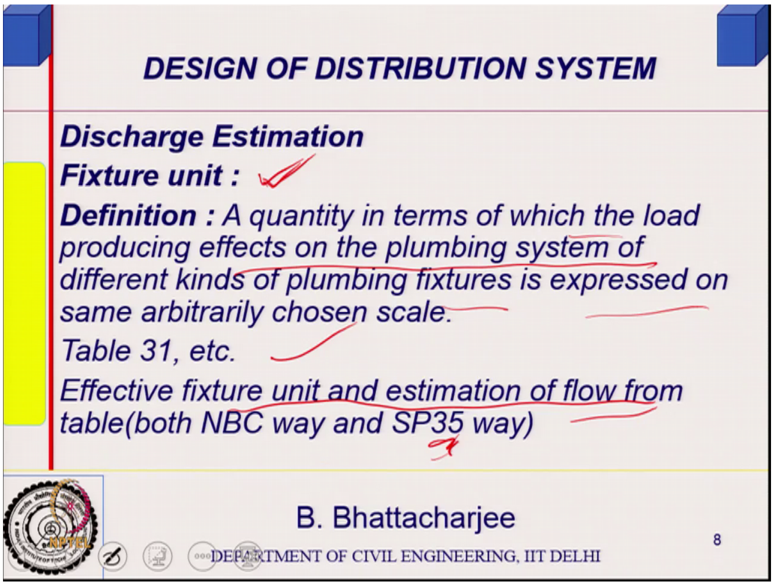

What is fixture unit? You have, you see, if you look at the appliances that use are your you know like for example, a tap, a shower, there they do not you know everywhere you do not require the same flow, tap would require much less flow compare to a shower. So, flows from different discharge units, discharge outlets, they are different that is number one. Second issue is the frequency of use is also different. A kitchen tap might be used more often than a shower right. So, therefore, this is so therefore, what is this one way is to make it, make it all uniform in some manner.

So, we, we actually devised I mean a, a new unit is devised which is called fixture unit new terminology fixture unit is used. Now, this fixture unit actually is a quantity in terms of which the load production effects of the plumbing system of different kinds of plumbing fixtures is expressed on a some arbitrary scale or which is same. For example, you might say the list one a tap, wash basin tap it might be one fixture unit.

Shower might be two fixture unit or something like that. So, you bring in totally your load is expressed in terms of fixture units. So, it is a load producing capacity of different fixture units which are there, so that is expressed in a some kind of a uniform unit throughout. This is given in table 31 of S P 32 for different types of fixtures right.

So, different types of fixtures, supposing now you know in a given floor right how many kitchen taps are there, how many you know bath showers are there, total number of fixtures being known corresponding fixture unit of each one is known to you. You can sum up the fixture unit and that will give you the total number of fixture unit.

Now, each fixture units is flow corresponding to unit fixture unit that has been estimated, because this is the engineering practice people from experience have produced that. So, what is done is you have that many number of fixture units, but you do not take all the fixture units into your design, because of diversity. So, you take something called effective fixture unit to be taken in the design. And these values are also given another table in national building code or S P 35.

Student: Sir sp (Refer Time: 15:38).

30, 32, not 32, it is 35, 32 is functional planning of.

Student: (Refer Time: 15:44).

Building industrial, structures sorry this S P 35. So, in S P 35 it is given in S P 35. So, you can table 31 of S P 35 we can get it. And this is effective number of fixture units are also given right. So, these are based on engineering experience people of experience. So, based on that they have actually produced this kind of table.

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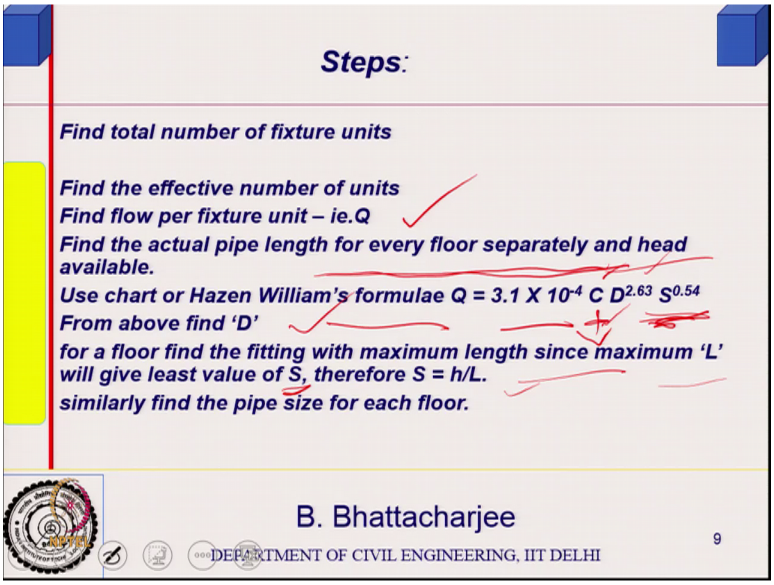

So, if you know that once you know the number of fixture units, once you know the total number of fixture units and effective fixture units, flow of per fixture unit you know is Q then Q multiplied by, you know flow per fixture unit is given Q which I will just tell you in a minute, in a minute I will just tell you. So, then you can find out the total flow, because multiplied by the effective number of fixture unit by Q. In fact, they give you another chart or table also is also available.

Then find out the actual pipe length for every floor, because you want to find out the, if you want to use a Hazen William's equation, you got to know the length right h f by L is equal. So, you find out the actual length right, actual pi length pipe length for every floor separately and head available. Available head would be supposing it is coming from the tank, then you know how much is the head available. Or if it is from a pump at the bottom, the head that the pump is supplying or pump at the bottom is known minus whatever height it has gone. So, you can find out the available head right.

So, use then either chart there are chart available in the court or use this formula that I have given you to find out what is everything. So, this is known this is forecast iron for example is 100 is given. These values are again tabulated. The roughness coefficient or the type of pipe that you were using how much is the value of GI pipes what should be the value that is given in the table. Yes you have found out, because you have found out the length and you have found out the head available, D is the only unknown. So, you can find out the D right.

Now, for a floor find the fitting and maximum length which will give you the least value of S, because the D would be you know; D would be maximum for least value of S. Now, you do not design different pipes, pipe size should be same otherwise, it will be too costly, because additional things will come, there will be loses at the joins. So, use uniform pipe sizes throughout as much as possible.

So, what do you do is you take the least S value and that would corresponds to maximum D value. So, find out the D corresponding to least, least L right. So, find out maximum L and least value of S therefore, S h f by L. So, similarly find for each floor you can find out the pipe sizes. Similarly, for each floor you can find out the pipe sizes all right, each floor you can find out the pipe sizes all right, so that is what it is that is the principle, we will solve a problem or two to, how look into this right.

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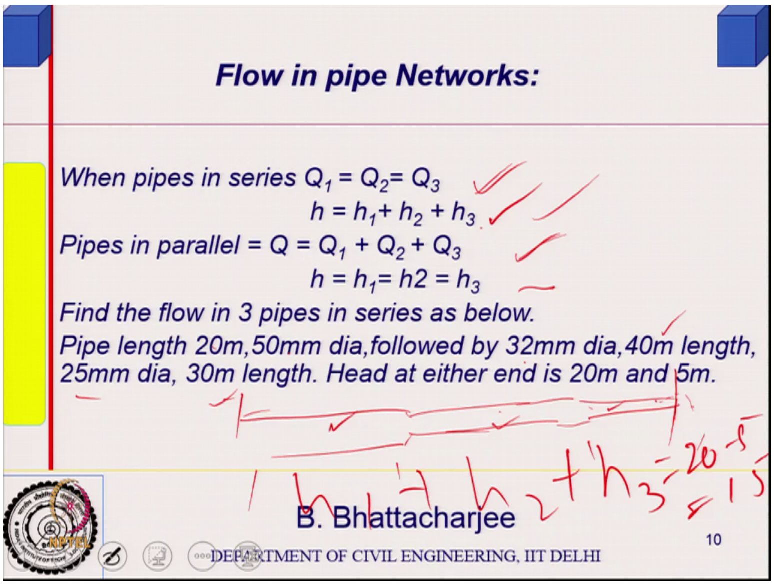

Just as an example let us say first look at the first one simple this you know, if I have pipes are in series I said is Q 1, Q 2 is equals to Q 3, pipes are in parallel Q 1 Q 2 Q 3 is equals to you know is sum total is this, and h is h 1 plus h 2 plus h 3. So, consider this case pipe length 20 mm, pipe length 20 meter, dia 50 mm followed by a 32 mm, 32 millimeter dia and 40 mm length, and 25 millimeter dia 30 30 millimeter length. Head at either end is 20 and 5 meter that means you have got 15 meter head right 15 meter head and there are 3 pipes. Something of this kind larger pipe, then there is a smaller pipe and still there is a smaller pipe right, and lengths are different lengths are different right. So, this is a situation one of them is 20, other is 32 other is the.

Student: (Refer Time: 20:10).

20 meter sorry 50, first one is 50, next one is 32, next one is 25 mm dia and lengths are different. So, you want to find out basically so, h 1, h 2 and h 3 were to find it out you want to find out h 1, h 2 and h 3 right and total Q through them. So, this h 1 plus h 1 plus h 2 plus h 3 is equals to 20 minus 5 that is equals to 15 that is the right.

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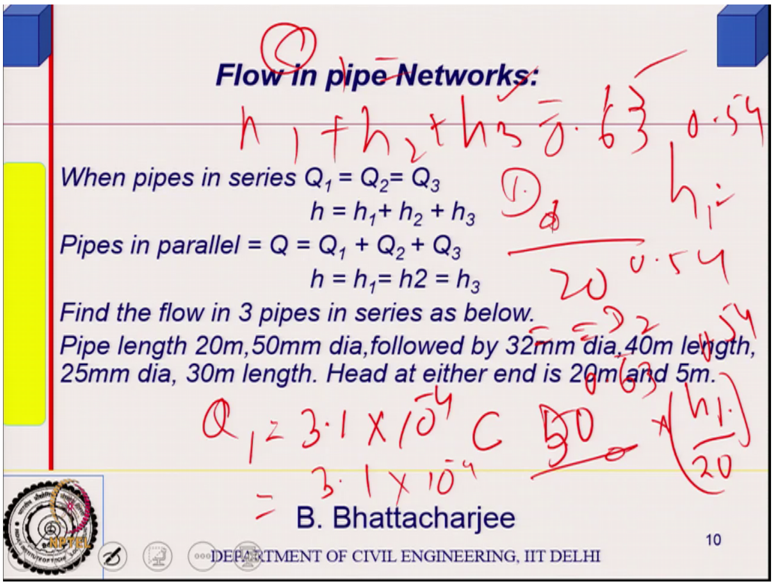

So, if you want to find out; if you want to find that out, if you want to find it out first of all Q 1 is equals to Q 1 will be equals to you know, if it is same, same not you know same kilo liters per the same unit we are using, then 3.1 into.

Student: 10 to the power minus 4.

10 to the power minus 4.

Student: C (Refer Time: 21:14).

C is there and D is known to us. So, Q 1 D is how much and let say 50 mm right, 50 D to the power point; D to the power point.

Student: 63.

63 divided by you know sorry this, this D and then h 1 h 1 by L, L is known to us, how much is L 20 meter.

Student: 20 meter.

This to the power point.

Student: 5 4.

5 4 in the second case, this would be this value will change and this value this is unknown. And this must be equals to 3.1 into 10 to the power 4 minus 4 C etcetera, etcetera what you will you will have know. So, if you put equate this; obviously, everything will cancel out leaving the D and D to the power 0.63 and h 1 to the power 0.54 divided by 20 to the power 0.54, rest all we cancel out. So, you will get I will get one equation, you know this is this must be equals to D 1 D is known to me h 1 is unknown. So, this is also known. So, this values must this must be equals to D 2 by length. So, I will get actually I will get, how many equations, I will get three equations two independent equation actually, because you know like Q 1.

Student: (Refer Time: 22:49).

Q 3 yeah so, two equations I get. Third equation will be h 1 plus h 2 plus

Student: H 3 (Refer Time: 22:57).

15 so, 3 unknowns I can solve. And find out three unknowns I can solve, and find out the 3 unknowns for 3 unknowns, but it is not going to be solved just easily, because to the power 0.53 etcetera, etcetera is there. So, it, it is a transcendental equation, trial and error. And you can solve for this to find out or you know like for example, find out h 1 in terms of h 2; find out h 3 in terms of.

Student: H 1.

H 1. So, you now have one variable and put them.

Student: In the equation.

h 1 plus h 2 plus three equals to 15, but that would be all will be related to you know to the power there is some power should be there. So, from that using transcendental equation, you can actually can use by any one of those methods (Refer Time: 23:50) methods depending upon the situation, you can find out on Newton Raphson or whatever it is to find out the value of h 1. Once you found out h 1 repeat to find h 2 and h 3 can be automatically found out. So, this a one can find out h 1 and h 2 then flow Q 1 flow Q 2.

Student: (Refer Time: 24:05)

Flow Q 3 you can find out, which is the Q flow any flow you find. The problem was to find the Q given this is the scenario when pipe is running full this you can find out right. So, under this head difference, how much will be the flow that you can find out.

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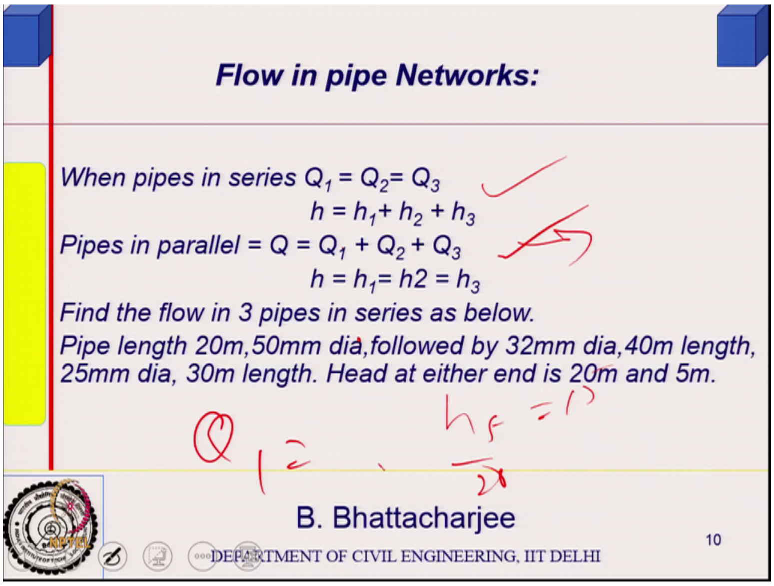

When it is parallel the matter is for somewhat simple because now.

Student: H1, h 2, h 3 and (Refer Time: 24:28).

That is right. So, if we even if it is same and these are in parallel right, and all are subjected to same head. So, Q 1 can be simply found out simply using.

Student: (Refer Time: 24:41).

H f equals to 15 right, because all are the same, length is 20 and D is also known. So, you can find out Q 1 simply putting into the equation, Q 2 you can find out simply putting into the equation back and Q 3 and sum total will give you the total flow total flow. So, when, when there when it is parallel it is easier to find out. It is series then it is little bit slightly more difficult to find out all right, but this is how we can find out, if you know when there is case.

Thus one small problem in S P 35, also and similar line, if you want to look at into a appendix or somewhere, but anyway the same we have I have already explained it is very simple. It is not nothing, nothing complicated except that this will require a little bit of time, if it is in series.

Student: (Refer Time: 25:30).

It will take a little bit if time in calculation right. Let us look into some more issues related to; some more issues related to issues related to some fundamental principle.

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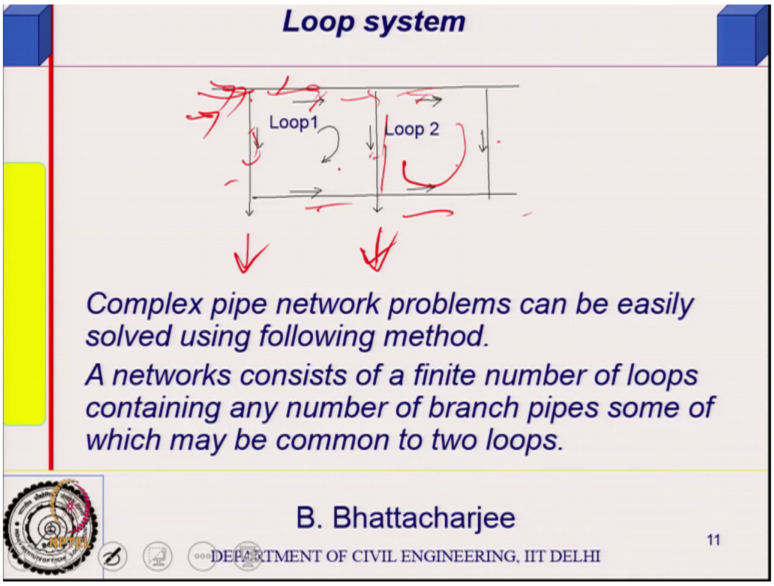

Now, when have complex pipe network suppose something like this have a loop let us say series you know you have loop complex pipe network. So, it will have some finite number of loops. Let us say 2 loops here, containing any number of branch pipes somehow which way be having common loops. So, there were number of branches would be there in this 1 branch 2, 3, 4, in this 1, 1, 2, 3, 4. So, branches are there. And you can solve the problem by applying Kirchhof's law right. So, complex once can be solved.

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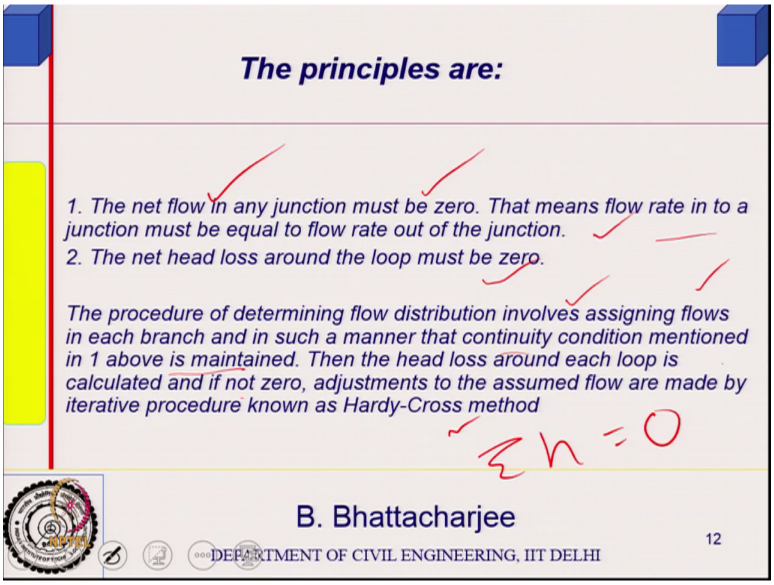

Basic ideas net flow at any junction must be equals to 0. That means the flow rate in a junction must be equals to flow rate out of the junctions. So, you can set equations you know. So, in this junction, this is coming, this is going out. So, whatever is coming in must be equals to whatever is going out. In this junction something is coming from this side. You assumed of the direction of the flow is same must be going out and in this 1, this is what, it is coming, this is when it is coming, this is going out, this is going out. So, again sum total of you know you have to assume the flow in each you might assume or whatever it is that condition is to be maintained.

The net head loss around a loop must be equals to 0. So, you can in a consistent manner, if you calculate out head loss a around a loop that must be equals to 0 right. So, that is what one can do this. The procedure of determining the distribution flow distribution involves assigning flows in each branch ok. Before that you know what information you will have is how much coming in here, how much coming in here. And, so going from here let us say going out from there or going out from there or whatever it is right. So, say you know some water supply system, you have complex networks right.

So, you want to find out the flow in each one of them, then this would be this would be useful, this would be useful right. So, the procedure of determining flow distribution assigning flows for example, you might have a many fold at the top level. So, where your water is coming from the tank, then you have many branches coming out of it right and then been supplied. So, these situations may arise not very regularly, but many places. So, procedure is then to determine the flow distribution first assign flows to each branch. Assume a flow to each branch in ensuring that incoming flow is equals to.

Student: Outgoing flow.

Outgoing flow so, in a manner that continuity condition is maintained, you know in one condition, one is maintained. Then the head loss around each low loop is calculated, you can then calculate out around each loop you can calculate out the head loss right. And sum total find out the sum total, because in a loop you can find out consistent manner what is the head loss right, because you have assumed of Q 1.

So, h f you can find out h 1 h you know h 2 branch each branch, you can find out. Sum total of this sigma h must be equals to 0 for a loop. And if this is not 0, then this is to be adjusted the error as to be adjusted, and that is hardy cross method that is you know that is procedure is called hardy you know using Hardy-Cross method one can do that.

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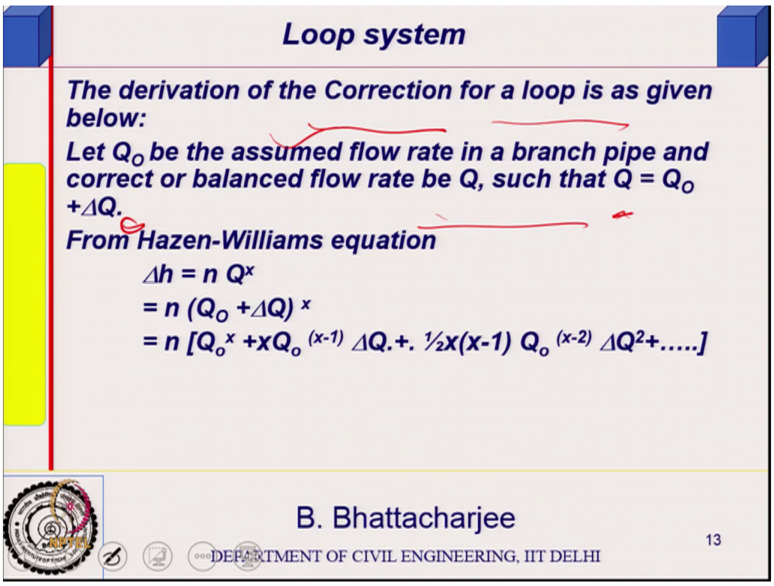

So, what is done basic equation is something like this. You have to first assume find out the sigma h f value in a loop that should be equals to 0 if not 0 that is the error. So, this derivation of the you know correction, you have to do a; you have to do a correction for the same, you have to do a correction for the same right. So, we will just do that. You derive this formula for this one. For example, Q 0 may be assumed flow rate in a branch pipe and correct the balance flow rate. So, correction would be delta Q, and we should get an expression for delta Q. So, we will just look into this.