Fire Protection, Services and Maintenance Management of Building
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Lecture – 23
Diversity factor (Continued)

So, we are talking of Diversity of Usage. You know we said supposing I have got 100 hotel rooms, it is unlikely that all of them will be occupied all the time. So, only a part of it is occupied. Similarly, if you have let us say a even in any space, any activity space, you have a number of outlet let us say electrical sockets.

So, all of them will be plugged in or all of them will be in use simultaneously the chances are relatively low. So, there is a diversity of usage. Sometimes they may be all running full I mean all might be you know used by everybody, while many other times there will be only 1 out of some and numbers that would be nice.

So, this diversity of use is taken into account when we are trying to size, the supply line right. So, for example, as we saw earlier we discussed earlier. So, this called diversity in usage we call it diversity or in usage.

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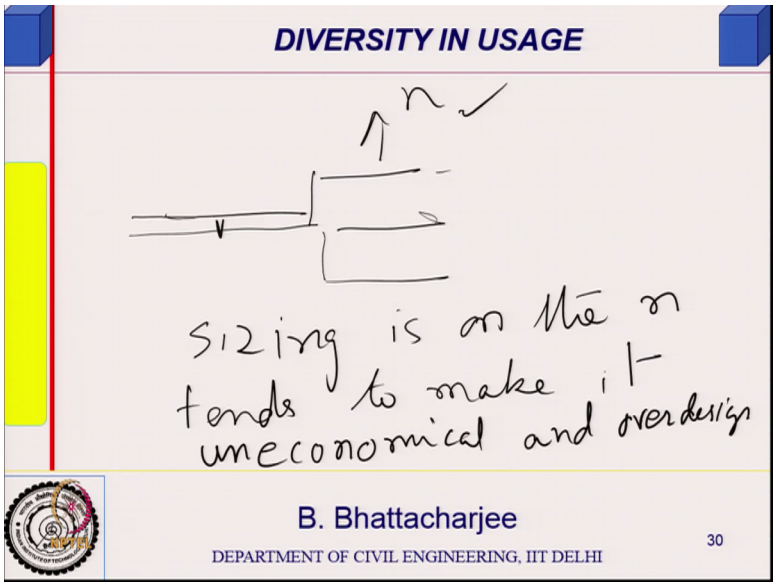

So, supposing I have a electrical cable, supplying to several you know several points. Now, if there are n number of them, sizing of this one would not be on the basis of n. So,

sizing is on the not on the on the on the basis of n it tends to make it uneconomical because of over design. So, you can because all n will not be in use simultaneously.

So, you take only a factor out of this and this is what we call as diversity. Because, all the time all n will not be used simultaneously, so, 100 hotel rooms all rooms will not be occupied, sometime it may be sometime much less. So, this diversity of usage we take into account. So, similarly supposing and supplying water. Now, what are supplied to all the rooms if I take care off in the inlet pipe sizing leading to all the set of room in a given floor, that would be surely over design and uneconomical. So, this is called diversity in usage.

And in order to find out I mean we multiply by a factor, n is multiplied by a factor right and that factor of course, we determined statistically.

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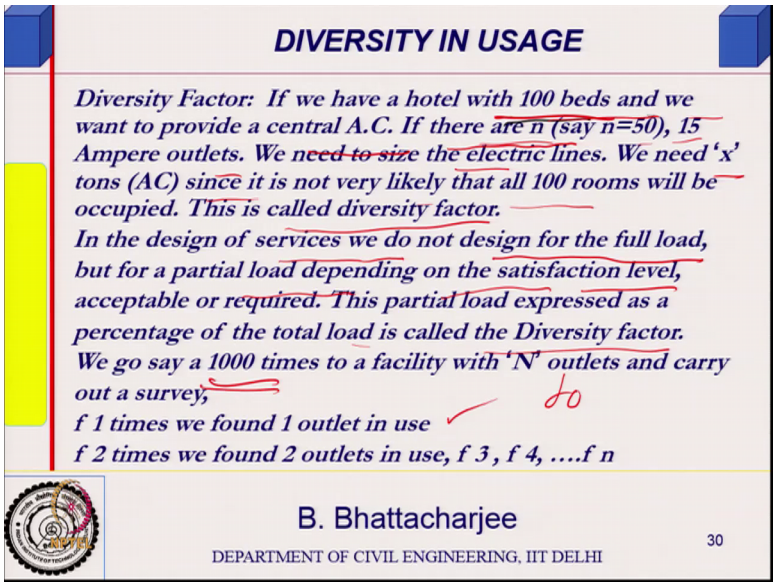

So, that is what we are saying diversity factor if you have a hotel example wise with 100 beds. And, you have hotel with 100 beds let us say and we want to provide centralized A.C. If there are n equals to 50 some value right or similar cases supposing there are 15 n n number of 15 Ampere outlets. We need to size the electric line supplying to that. We need in this case we need 'x' ton of AC since it is not very likely that all the 100 rooms will be occupied.

So, we multiply by a factor and that is we call as diversity factors. So, this is diversity factor deals with this issue. If the design in the design of services, we do not design for full load, but for a partial load depending on the satisfaction level. If you design for all 100 any time anything happens you are satisfying this. So, this is called satisfying 100 percent simultaneous demand right, satisfying 100 percent simultaneously demand.

But, then we need not satisfy a 100 percent simultaneous demand, we may satisfy some partial or a fraction of it some percentage of it. And, this percentage you know or fraction we expressed we will call it diversity factor. So, how do you determine this, how do you determine this? To do that I got to know the probability of 1 you know, 1 outlet or 1 room being in use right.

Now, if I know 1 room in use I can consider to be a again a binomial situation, probability of finding either a room are in use or it is not in use. So, my success is it is in use failure is it is not in use right so, there only 2 possibilities there. So, probability of a room on an average a room is in use is important like for example, you know this is a similar case of a die scenery of a die right. So, in case of a die I had 6 outcomes possible right.

So, what is the probability in 10 trials right? 10 trials I get success that is let us say success is the die outcome is 4, outcome of the die is 4 that I call it success failure is anything else right. So, in 10 trials or in n trials, how many times? I get exactly, how many times probability of finding let us say exactly out of 10 trials or n trials or whatever it is exactly 4 or 5, 6 number of times 4 will come or 1 number of time 4 will come. So, that is basically case of binomial distribution right ok.

So, similarly, but then for that probability of finding 4 in case of die we know it is 1 by 6 because 4 is 1 of those 6 outcomes, but in case of services outlet, we do not know. So, we have to determinate the probability of success which is probability of finding any room in use probability of finding any room in use. So, in order to do that one can actually a pass data you know if you are trying to find it out you should have passed data.

So, pass data for example, you went and you found out f 1 time let us say 1 only 1 of those outlets is in use. We went and found that f 2 time 2 outlet us are in use and f 0 is no outlet in use, f 0 is a number of times you know you have actually done large number of

experiment let us say you know some 1000 times of something of that order, or if you have passed data from that you can generate.

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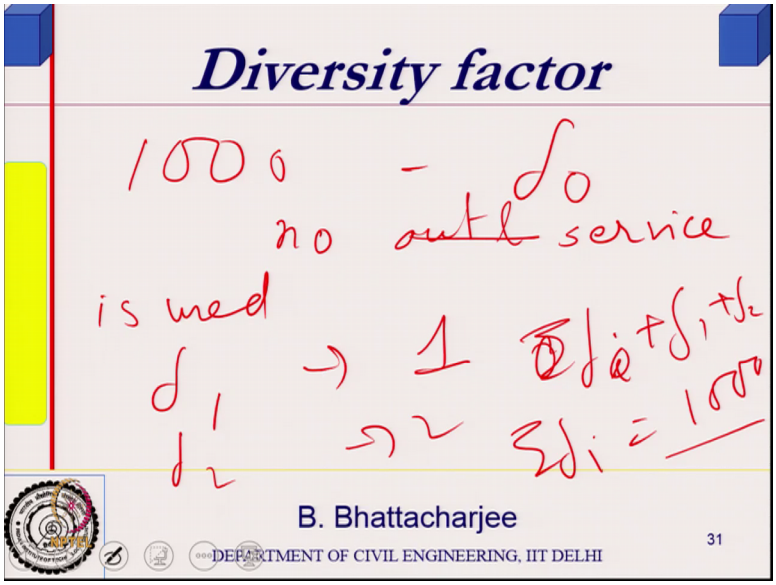

So, out of those 1000 you know, you found f 0 there is a number of times no outlet in use, no hotel room has been occupied, no outlet or no services is being used you know. I would rather call it no services is being used no service is used f 1 only 1 in use. So, even and found that f 1 times only 1 in use, f 2 times only 2 in use.

So, if you some up f 0 plus f 1 or so, you know sigma fi if I call it f 0 I mean f 0 f I f 1 plus f 2 which is sigma fi that is equals to which is thousand or whatever the value is whatever the value is. So, this I can plot it in form of a histogram; this I can plot it in form of a histogram right.

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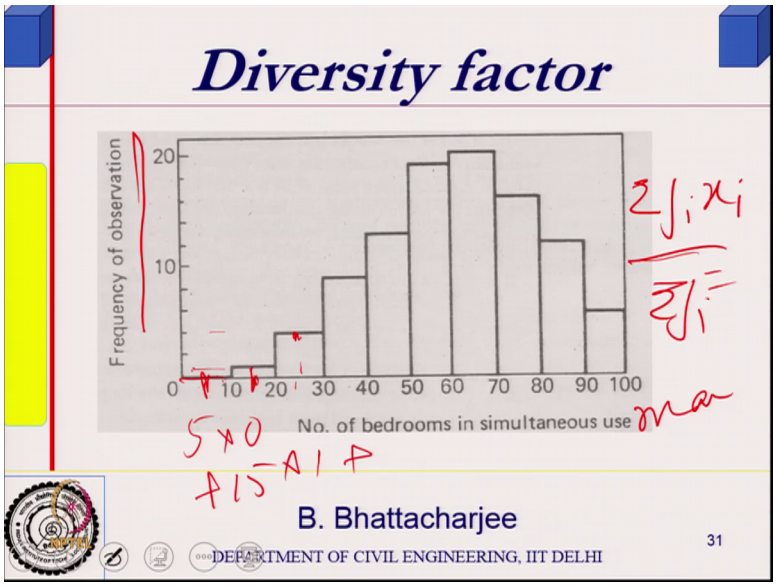

So, you can plot it in a form of a histogram. Say in case of 100 hotel rooms possibility looks something like this. Some 0 to 10 number of room being in use well I never found that case. So, f 0 you know f this value for 5. So, 5 into 0 15 into let us say a 1.

So, 10 to 20 number of rooms in use. I can even make them because there are a 100 of them I can divided it into class intervals that is what in statistics we do? So, we divide them into class interval; take the class representative value which is the midpoint 10 to 20. So, 10 to 20 is 15. So, 15 into 1 plus you know 25 into 2 or so, on so forth. So, therefore, I can find out sigma fi into x i value, where x is a class value class representative value, class the present value.

If it is not 100 it is much less I need not use the class, if it is not you know if it is not 100 let us say it is 15 outlet us or something like this. So, 10 outlet us in that case 10 outlet, in that case I need not take that class value will be 1 2 3 itself. So, this divided by sigma fi. So, this is frequencies frequency of observation, this divided by sigma fi will give me the mean value.

Mean value is class value multiplied by the corresponding frequency sum it up divided by total number of observations right, or it is first moment actually as you call it right this you know you find out that. So, this is what it is. So, mean number of mean number of bedrooms or hotel rooms in use I can find out in this manner.

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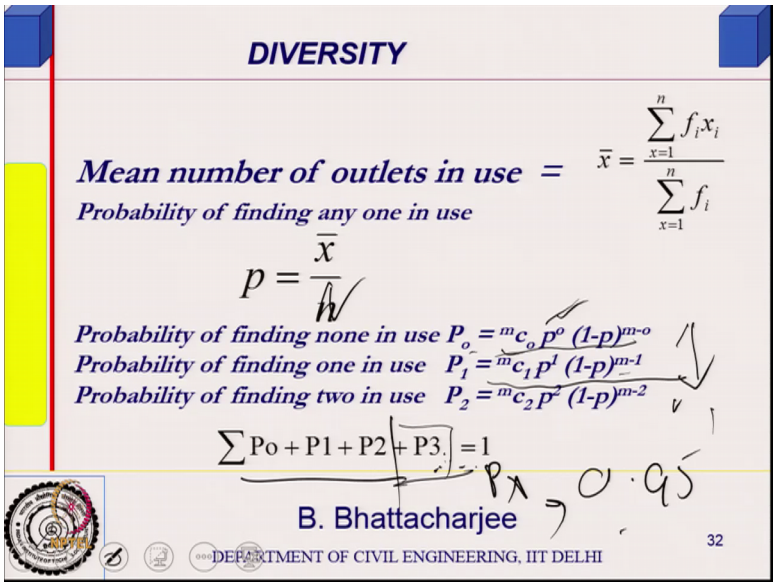

So, this is the simple algebra part of it mean number of outlet in use would be given by x bar and let me call it would be a phi x I divided by sigma fi, if I have got done n trials if I have done entrance right. So, that is what it is? So, that is x 1.

Now, I had actually 100 rooms out of this I find out that x bar number of rooms are on an average i find x bar number of rooms are in use. So, probability of finding a room or probability of finding a success is simply x bar divided by 100 or in you know not 100, I mean x bar yeah x bar divided by 100 in this case, I think I am calling it capital N it should be capital N not this small n it should be capital N and 1 of them should be.

So, it should be x bar should be x bar should be or x bar I have found out probability is x bar divided by capital N, where capital N in this case was 100 right. Because, I had hundred rooms out of this I find x bar number of room is in use on an average mean x bar number of room in use right. So, that is what I can write algebraically this is not correct this should be capital N, where capital N in this case is equals to capital N, in this case was equals to 100 capital (Refer Time: 11:50) in this particular case.

So, that is mean number of room is use n is a small you know number of observations. So, I would have taken 1000 observations out of which I found out from that I found out the mean, number of human is sometimes I went and I found 0 to 10 there are no not never it was less than 10 to 20 the some number like, in my observation I found certain

number of times, which I call as f 1 if it is discrete 12 outlet us. So, and you are doing the experiment.

So, maybe you found 0 time no one use you found 0 time maybe one in use also you found that it is not. So, it will be 1 multiply it by 0, 2 multiply it by let us say you have found 2 rooms, 2 outlet us are in use maybe sometime you found out so, correspondingly that the frequency. So, relative frequency multiplies it by the random variable value of the value, when you divide it by some of the frequencies that will give you the mean value.

And, probability of probability of probability of you know problem probability of probability of finding 1 outlet in use is given by, this mean obtained divided by number of outlet us used in experiment, number of outlet us used in experiment, number of outlet us used in experiment right. So, that is what you do now this is a situation. This is the probability of success then; that means, probability of finding 1 room in use any 1 room in use right.

So, if you have hundred rooms any 1 room in use is probability is this it is equal for all of them it is equal and probability of finding that room in is not in use this 1 minus this big 1 minus this (Refer Time: 13:36). So, I now want to find out probability of 0 being used out of some another you know so, my data I might have used from past data where I might have had an might have been you know 100.

But now I have a hotel in which I have 80 rooms let us say not 100 and I want to find out how many rooms I should consider to find out the diversity factor. For it could be different for air conditioning ducts, it could be different for water supply, it could be different for you know cold water supply, hot water supply, and so on. So, it could be different for different things. So, this probability has to be known to us right. So, now, this n might be equals to let us say n dash or some m let us say let us say it is m.

So, now I have instead of you know I want to design for a new hotel which you have 100 instead of 100 rooms, it would have 80 rooms which is m right. So, out of m I want to find out the probability of out of m, what is the probability of only 0 room in use, 0 room in use probability of finding 1 or less rooms are in use, probability of finding 2 or less number of rooms are in use and 3 or now this probability will increase.

So, if I want to the probability of finding m or less number of rooms are uses this 100 percent, because m is the total number of rooms. So, if I supply for all m rooms I will satisfy all the time come what it may be, but I will be over sizing I will be doing over sizing. So, what I do? Instead of m I possibly use lesser number some factor multiplied by m in my design right now, this probability I have already found out from past data the way they have given the example. So, now, I want to find out for m cases now for this should be you know capital N.

Student: Capital N (Refer Time: 15:39)

No they are not saying they are different.

Student: (Refer Time: 15:42)

No this is number of observations.

Student: Capital N.

Small n, capital N is 100 number of rooms that I said you can use.

Student: (Refer Time: 15:52)

Interactive notation whatever you want to use so, I use this you know, I used here I have used I am saying n outlet us where the experiments was done, what data is available to me. So, this n is 100 outlet us 100 bedrooms if it was. So, small n is the number of observations in my state 22 was 1000. So, m is you know N is a number of room in my experimentation total number of room in use.

Now, I am interested in finding out of m rooms or m outlet us, how many I should be catering? Such that it is because if I provide for all m the supply line for all m as I said you know like I have got something like this is the supply line let us say water supply line or air conditioning duct and now this will be supplying to 1 0 I mean 1 2 3 also trap to m right. Now, I this sizing will not be on the basis of all n, it would be m multiply it by some factor which I am calling a diversity factor, which I am calling as diversity factor right multiply it by some m.

Now, I want to find out no information that is available to me is p right. So, if I supply for all of them I says for 100 percent 100 percent demand out of if I supply for m minus,

if I cater this sizing is done on the basis of m minus 1 then my diversity factor is m minus 1 divided by m. Similarly, m minus 2 divided by m, diversity factor is the 2 which means that if it is more than m minus 2; I will fail, you know I will not be able to supply.

So, either I say that we do not get a see in this room, the next thing you know already m minus 2 as people have occupied it the next one comes you get a non AC room, which is actually has got implications on cost, because you know it will have implication in cost and also your reputation etcetera. So, you have to management has to decide, what should be the value of diversity factor? But, on the basis of what is the probability of failure, overall failure?

Because, if you provide m you will satisfy 100 percent simultaneous demand, if you provide m minus 1, it will satisfy possibly you know this much percentage of simultaneous demand, some percentage is not this much, some percentage of simultaneously. We want to find out how much is this percentage? Now, this is a situation of same binomial distribution, I find you know probability of finding a room in use 1 room in any room in use and not in use right.

So, 1 minus that will be there now, I want to find out the probability out of a m room, what is the probability of exactly 2 room in use, 1 room in use, 0 room in use and if I sum all of them up. Then, it will be the probability of 2 or less number of room in the use right is it all right. I can find out the probability of out of m some x number of room in use, x minus 1 number of rooms in use up to 0 or I will do that mathematical exercise algebraic exercise for all of them.

Then go on summing up the probability of finding 0 room in use, probability of 1 room in use, probability of 2 room in use, probability of 3 etcetera room in use, and if I sum up all this probability that will give me the probability of x room or less number of room in use. That means, that much of simultaneous demand and if I sum it up go up to m, then it will be 100, because the possibilities are either 0 room in use or 1 room in use 2 room is in use if and all m are in use.

So, sum total of all those probabilities will be 100. So, I just got to decide that, what is a simultaneous demand? I would like to satisfy. If I say I want to satisfy 95 percent of the simultaneous demand, then sum of this probability and it will be up to let us say some y number of outlet us which will be corresponds to 95 percent. Then, I provide decides this

for y number of them or in other words I find out my diversity factor which would be y divided by m y divided by m.

Let us look at this further. So, probability of m room in use will be given by, probability of m you know exactly 0 room in use will be p to the power 0, because probability of finding 0 room in use, then all m room and not in use. So, it is a joint probability of 0 room being in use and m room being not in use. So, 1 minus p to the power m minus 0 and this 0 room can be any one of this m rooms. So, I can select them in m c 0 ways. So, that is why this is a binomial distribution case which earlier also we discussed.

So, this is the probability of finding 0 room in use probability of finding 1 room in use is similarly m c 1, because I can choose that room maybe the first room or the last room, if they are all equal rooms p to the power 1 probability of finding 1 room in use. And exactly 1 room in use and m minus 1 room in not in use and this I can choose in this manner now if I sum these 2 up then I will find probability of finding 1 or less number of room in use.

Similarly, I can do for 2 and 3 and 4 etcetera and I sum them up and if I sum all of them up to the last room then I will get equals to 1 I will get. So, dot dot dot dot dot etcetera I get equals to 1 if I sum all of them up I will get equals to 1 right. So, what I do is I find out sum it up to this, then sum it up to this progressively I go on finding yourself, when the sun becomes 0.95 for some value of x P 3 P 4 up for P x let us say it is 0.95.

Then, if I provide you know sizing I do for x number of them, then I will satisfy my simultaneous demand 95 percent of the time. And depending upon this p value which is usually small, then you know you would find that in case of 100 rooms, you satisfy thirty rooms possibly will satisfy 90 percent of the demand, or if you satisfy 70 percent of them 95 percent of the demand. So, your diversity factor is 0.7 or 70 percent

So, similar it is the case of electrical, there you sometimes they use thumb rule, but the idea is behind this. So, if you have data then it is very easy to actually you know use it for a given occupancy given society also, given locations maybe hotel rooms. It will depend upon you know like it is a seasonal and those kind of things. So, if you have data, then you can find out maybe you take the fixtures of the data and do the sizing.

So, in fixtures and also you are all rooms, you will rare rarely all rooms in before only sometimes all rooms are likely to be put. So, this is called diversity news edge right this is called diversity in usage.

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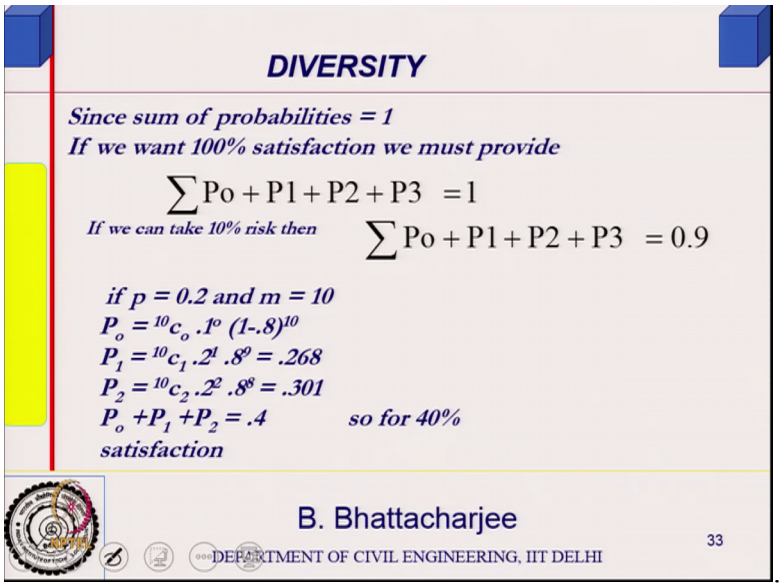

So, if we want 100s percent satisfaction, we must provide all sum total equals to 1 you know up to m equals to 1. So, P 0 of sum of P 0 plus P 1 plus P 2 P 3 P 4 P m, that is equals to 1 the sum of all these equals to 1.

But, if we can if we can take 10 percent risk, because the cost increases enormous, because 10 percent risk if you take you will find that it becomes possibly 80 percent of that or 70 percent of the say it is simultaneous demand you satisfy you risk you are taking is only 10 percent. So, that is the idea. So, you take you know sum total of all these equals to 0.9 you take. So, value values dot dot up to x P x is equals to 0.9.

So, then x is the number of them. So, for example, if you take P equals to 0.3 2 and I have m equals to 10. So, P 0 P 0 will be 10 c 0 1 to the power 0 1 minus 0.8, because 0.2 is the P, which you have found out from past data probability of finding 1 room in use.

Student: (Refer Time: 24:36)

No one to the powers this is.

Student :(Refer Time: 24:42).

Yeah it should be this is correct this is this is 0.2 to the power 0 and 1.2 0.2 to the power 10 that is what it should be like at 10 c 1 is 0.2 to the power 1.

So, if you calculate this out 10 c 1 into point 2 to the power 1 in to 0.8 to the power 9, and this value comes out to be 0.268. Next, value comes out to a 0.301. So, if you take you know and take just up to this if you sum up to P 0 P 1 P 240 percent of the demand gets satisfied. Because this is 0.268 this value whatever you can calculate out C 1 is 0.268 and P 2 also I am adding. So, it is no more much more than that 0.3 0.2 etcetera.

Student: (Refer Time: 25:42)

Yeah 0.5 plus something more, this value is now this will show up to point. I think this is not correct I mean you can just calculate the point that I am trying to show is that even 2 out of 10, if you see that you might satisfy more than 50 percent of the demand, 50, 60 percent. So, you need not use all of them and that is the idea right you can take this calculation correct it, there is no problem.

So, so, for 40 percent satisfaction, then I need to just take one of them 1 know 1 may not satisfy 2 might satisfy, because 1 will be less than 0.42 will be more than 0.4. So, you are if I decide then I will satisfy just show you through an example small calculation I have taken. So, P 1 plus P 2 is greater than 0.4. Actually it is greater than 0.4 therefore, I have to satisfy for 2 it is more than 4, 3.3 0.2 etcetera something whatever is you can calculate out.

So, this is what we use in sizing? Once we have seen earlier we have seen that how do you find out capacity storage? And, this is the network sizing first thing we do is I should do the sizing for how many that I should try to then, of course, then the mechanics, physics, whatever it is it comes into picture right. So, that is how that is why I using you know diversity in usage.

Now, once I have done that actually once I have done that. Now next is; obviously, the basic laws will apply now right, because we have seen that supposing I want to do sizing for water pipelines right water network water pipeline network I want to show it is size.

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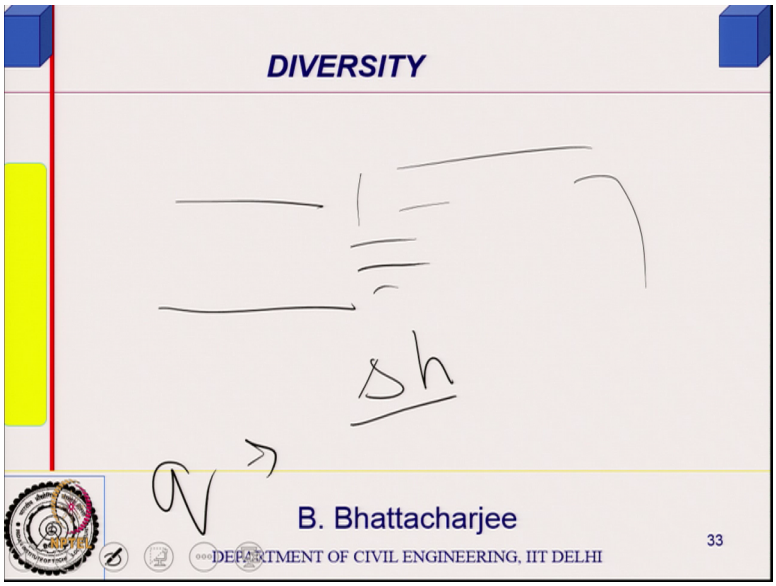

So, then the loss of water supply will be applied. And there we have seen that it is somewhat different in fact, it is not linear. The driving forces basically had difference delta h in case of water right, delta is your pressure difference whatever you call it. And q is related to delta h not in a linear manner or p delta p is not a linear manner linear manner right. So, here there will be it is a non-linear where it is electricity of course, voltage and current they are related linearly because v equals to higher.

So, respective law will now apply, but then we have 2 types of variables which you have already discussed, then 1we call as a cross variable which is the potential driving force and another is the flow variable. And we said that at any junction sum total of inflow must be equals to sum total of outflow. And, also we have said that in case of any loop, total across variables sum total of all across variable will be equals to 0 equals to 0. So, that is that is how we do it? So, we will you know this is how we look at the diversity and then diversity is used to find out the sizing basically and that is what it is.