Fire Protection, Services and Maintenance Management of Building
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Lecture - 34
Design of Electrical Systems

So, we continue from where we have stopped or a little bit earlier, as I just talking about electrical supply or electrical services in construction site.

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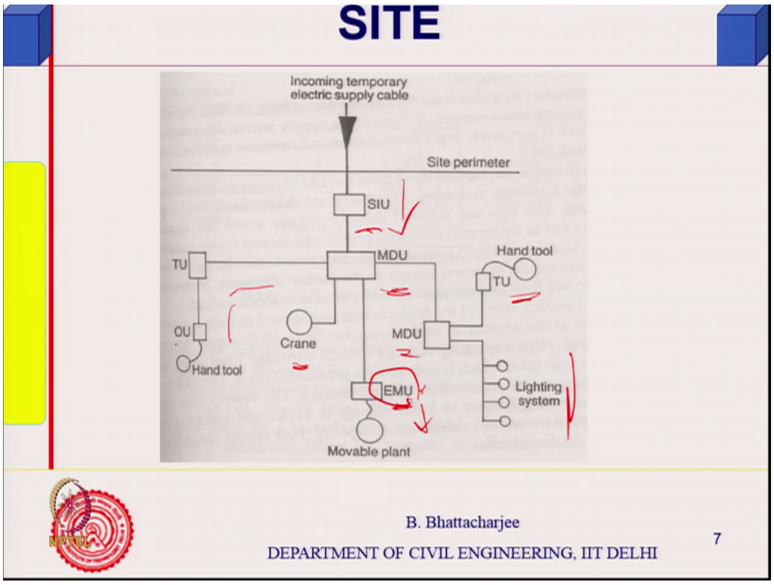

But, I think as just looking before that to earthing we have looked into and site.

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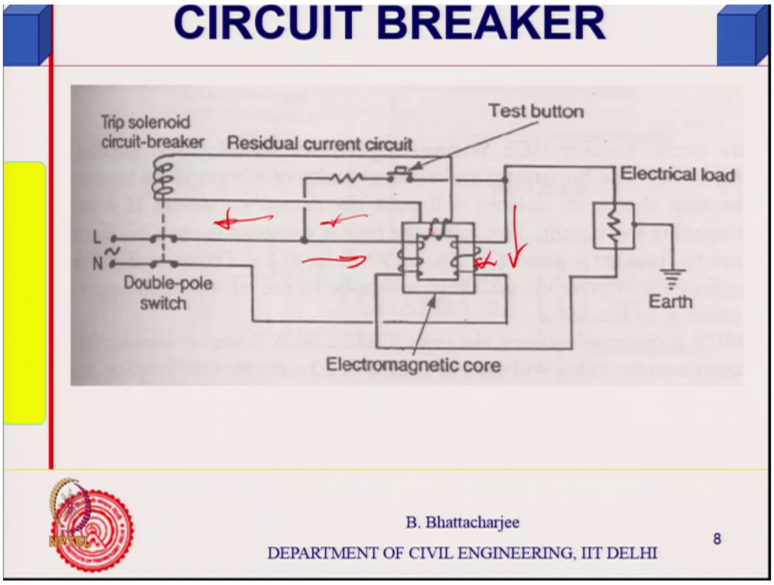

But, I just want to tell you about circuit breaker again and then we will again look into the site. So, as we discussed in the last class, we said this magnetic core. This magnetic core, and live comes like this coils around, and then goes to the load. And, then neutral calls on the secondary site and then goes to the load.

So, when there is same power current is same in the live and the neutral that is there is no you know there is no short circuit or anything of that kind right. In that case this neutral current which is opposing opposes direction, because this a kind of return current and this is the going current going. So, what will happen is this will balance each other. So, there will be no magnetic field generated, because this current direction is like this and if you see the neutral, it goes like this direction, and neutral opposing current right. So, it is direction is like this.

So, neutral I mean neutral current will be some sorry opposing current because neutral current will be returned current. So, returned current direction is something like this opposing direction. So, they are opposing each other as result. So, this is the live current right goes like this and then follows through the load and neutral current comes like this. And they are opposite direction current. And, they are same in that case in the core no magnetic field will be generated there will be no magnetic field, because there is a current in the primary and just exactly opposite same amount of opposing current coming into the press secondary so, the there will be no current generated.

But, in case there is a short circuit or something and excess current passes through this there is the difference between these 2, then this there will be magnetic field generated magnetic in the core, magnetic circuit will be complete and it will actually activate this, you know this solenoid system. Because with no magnetic field here, no current would have passed through these, but with magnetic field the current will pass through this, and it will activate this solenoid circuit breaker which will break the circuit which will break the circuit and this is switch to test the same. So, this is what I repeat and then we go to the scenario of the site, construction site.

In construction site normally you will have; obviously, there will be you know main distribution this is the substation, then from there the main distribution in it. There will be some crane or simulation sort of thing, there will be some movable plant and this you know electromagnetic I mean basically electromechanical units lot of them, and then hand tool service lighting system etcetera then some distribution in it for this and this might be going to the hand tool sections and so on.

So, in the site also similar, but then you will have lot of mobile equipment's mechanical cranes and so on. So, that is, but basic principle is similar.

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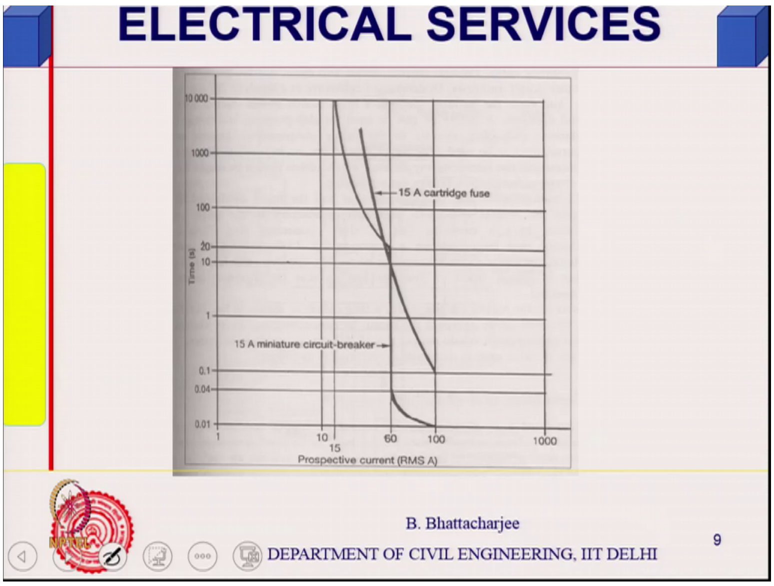

So, coming back to this we just looked into the performance of this one last class we are looking at. And, obviously, the response of this circuit breakers are much better than cartridges or fuses that were used earlier. So, that we explained yesterday.

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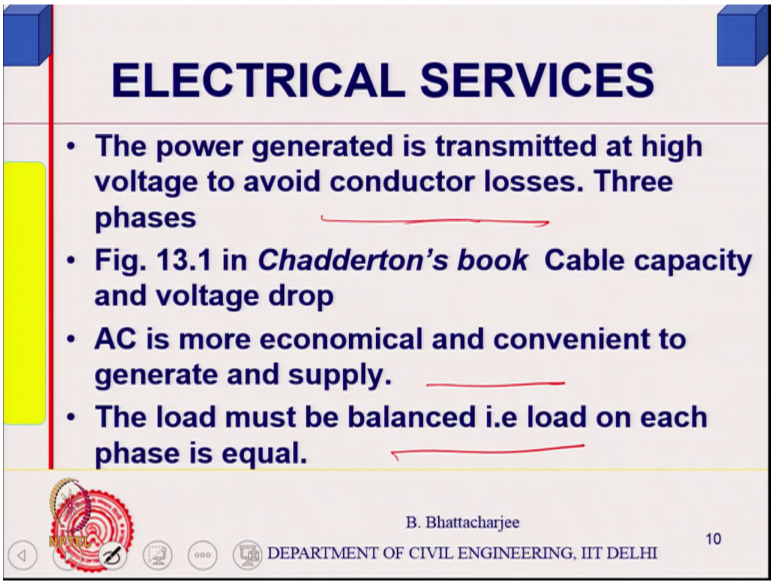

Now, I think then we are talking about transmission through high voltage and then AC is economical etc and load must be balanced this is what I think we have mentioning, that in the 3 phases load must be balanced.

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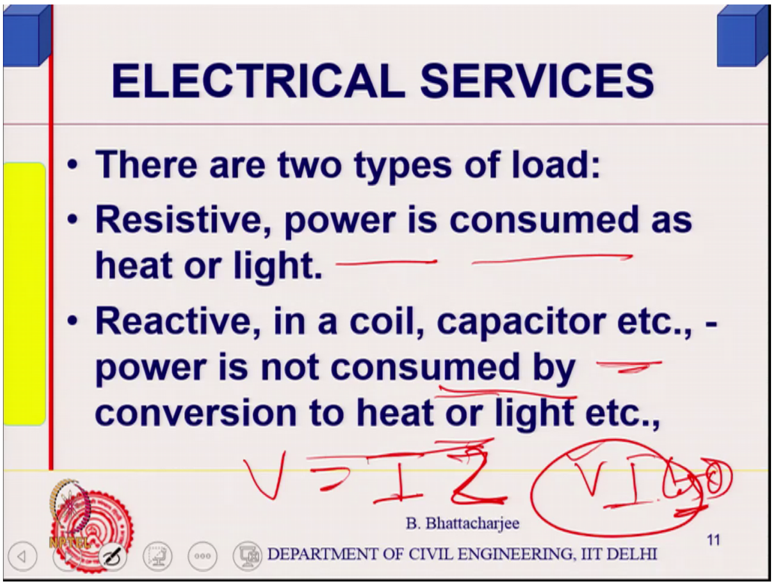

Now, there are 2 types of load as I said resistive where power is consumed as heat or light or work is done. And, there is reactive coil capacitor etcetera I think that is where we stopped yesterday, coil capacitor etcetera were power is not consumed by conversion to heat or light, but it is simply stored and released stored and released in alternating many how alternating current?

So, we would like to you know, but the voltage rms voltage is given as rms current into what you call z impedance right. And V I you know is V I is what is voltage and current this is not the power, but V I cos theta or cos theta represents or some what you call power factor represents the proportion of resistive load, compared to the total load.

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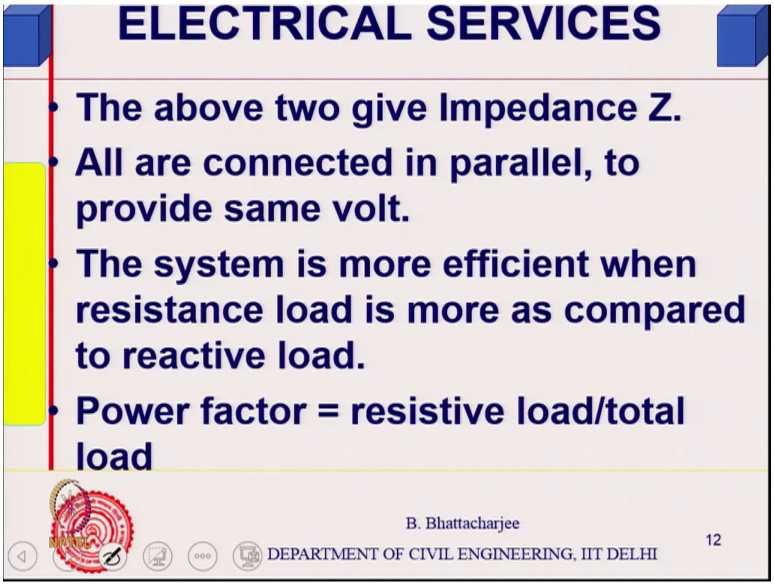

Now, what it is actually let us look at it a little bit more little bit more it is something like this you see.

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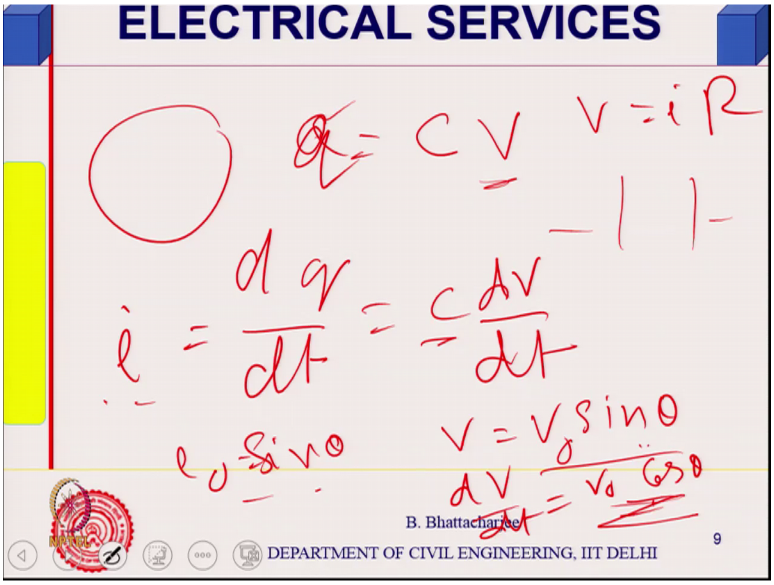

Ah Since there is a phase difference the peak of the current in a resistor, if I apply a an alternating voltage, peak of the current in a resistor and peak of the current in the capacitor, they will not be same type, they will not be same type, you know because 1 can derive this, but I am not interested you must be remembering Q the charge is equals to capacitance into V right. Q the charge is proportional to voltage you applied against the capacitor plate or small q whatever I write it q small q let us say.

And d q d t is equals to the current. So, if you have an 1 alternating current rate of change of charges is equals to c d v d t. Therefore, in case of you know so, this is i. So, i is not proportional to V e rather rate of change of potential rate of change of potential. So, if it is V e is equals to let us say V sine theta you know V 0 sine theta dv dt will be 0 cos theta right dv dt will be v 0 cos theta whatever sine it is right.

So, essentially i is you know if it was proportional to V, if it was proportional to V that is the case of resistance, because V is equals to i R that we know. Here it is the resistance or equivalent resistance you can calculate out based on capacitance value capacitance value and all that, but you can see that it is not in phase with the i, because it was this is V 0 sine theta in case of resistance this will be V 0 sine theta this will be also i 0 sine theta current will be you know so, this sine theta and cos theta is out of phase by ninety degree when sine theta is 0 cos theta is cos theta corresponds to pi by 2.

So, therefore, there is a phase difference of in fact, current leads by pi by 2. Similarly, in a conductor I mean in an inductor actually so, this is this is what it is? So, one can show that they are not in phase and in a complex plane if you draw it, complex you know complex Cartesian plane this is the real axis, this is imaginary axis right.

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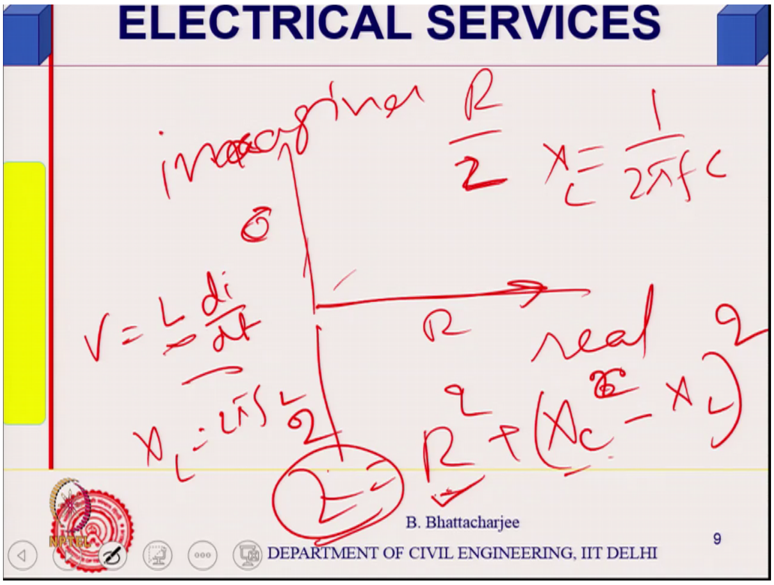

In imaginary axis, imaginary axis this is negative imaginary positive imaginary so, there will be one component here, resistance component capacitance you know equivalent which is equivalent what you call reactance right. So, it is given as 1 by twice pi f c reactance x of the capacitance will be given by twice pi f c.

So, that is they are out of phase by 90 degree. So as a result, if I combine this together I can just like write like R plus x; What we do is we have impedance Z is equals to R plus X square and, in case of inductor in case of inductor V is equals to L di dt. The EMF generated or voltage generated is proportional to rate of change of current in a coil.

So, in case of a coil you know back EMF generated is proportional to rate of change of current. So, this is inductance and therefore, again you can see there will be also output of phase because this time current will be I you know, if it all I sine theta it will be I cos theta where voltage in sine theta. So, it only I now leads by I mean lags by ninety degree I lags by 90 degree.

So, therefore, it is reactance twice pi f L reactance is X L is twice pi f L. So, reactances of inductor and capacitors they oppose each other. Reactance of capacitor and inductors oppose each other, current in the inductor lags by 90 degree, while that in capacitor leads by 90 degree. Let us write so, total you know impedance is given as Z square R square X C or X L square, because they are 90 degree out of phase. So, 100 you know so, I mean 1 is lags there 180 degree out of phase. So, just negative sign would do.

So, R square X C square minus X L square all right. And, Z square is equals to so, this is impedance. So, impedance is square root of resistance square plus the reactance combined reactance of capacitance and inductor. Now, power loss only occurs in this. And, R by Z is what you call power factor, R by Z is what you call power factor, R by Z is what you call power factor right.

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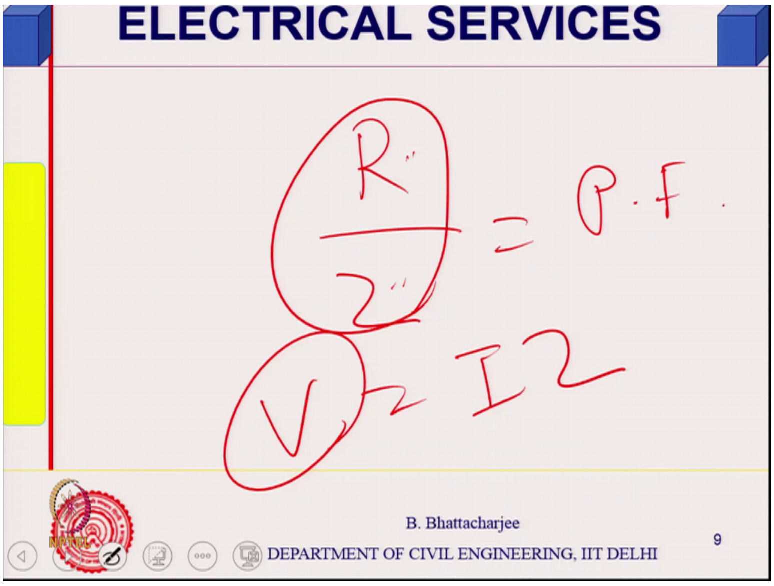

So, R by Z is what you call power factor. Their proportion now higher this value, if it is a purely resistance then pure resistive circuit in that case this will be equals to 1, purely resistive circuit these values will be equals to 1.

Now, the voltage required is I Z actually. Voltage required is I Z. So, you can see that the V is equals to I Z in an alternating current system. So, if my Z value is high my voltage will be high for the same current scenario, but then I will be utilizing only a fraction of it. The fraction is given by this power factor. Therefore, I would like to maximize this power factor or cannot do not like to have lower power factor, if I have lower power factor which means that unnecessary wastage you know unnecessary where my V will be v required will be higher.

So, the one of the principle is that one of the principle is that, you know the power generated is transmitted high voltage that we have said. And then we said that there are 2 types of load resistive, power is consumed as heat or light. Reactive, in a coil right, capacitor etcetera power is not consumed by conversion in to heat or light. And, we would like to the above to gives impedance Z and all are of course, connected parallel.

This system is more efficient when resistance resistive load is more compared to reactive load right. So, power factor is resistive load divided by total load and we would like to keep it at high value, we would like to keep it at high value, we will like to keep it at high value right.

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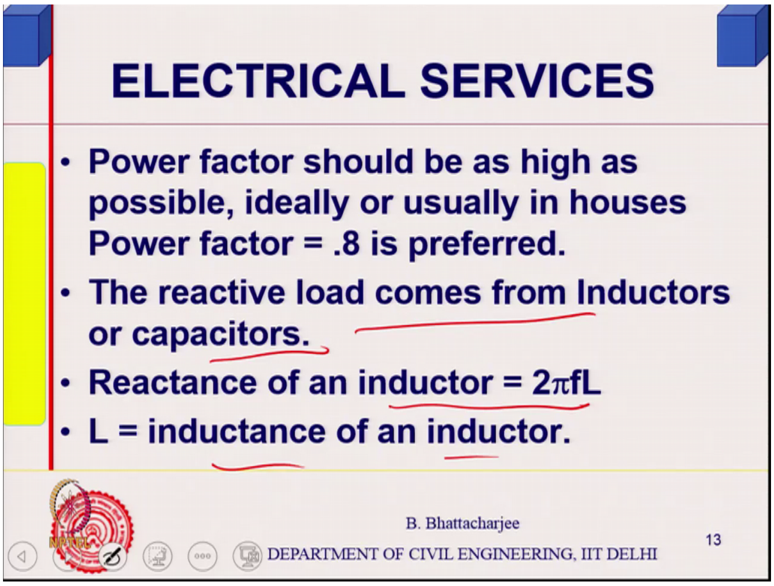

So, power factor should be as high as possible ideally or in houses in or usually in houses it should 0.8 is preferred power factor of 0.8 or above is preferred.

The reactive load come from inductors and capacitors as I said and I have already says the reactance of an inductor is twice pi f L, where f is the frequency L is inductance of an inductor. So, when you have coils like you know you magnetic field like such for example, I have I gave an example of a choke, the motors will have coil winding, and there is a reactive component there as well. So, you might like to have where you have industrial situations you can have or buildings you can have where lifts and similar other devices are working, there you might have a lot of inductive load lot of inductive load.

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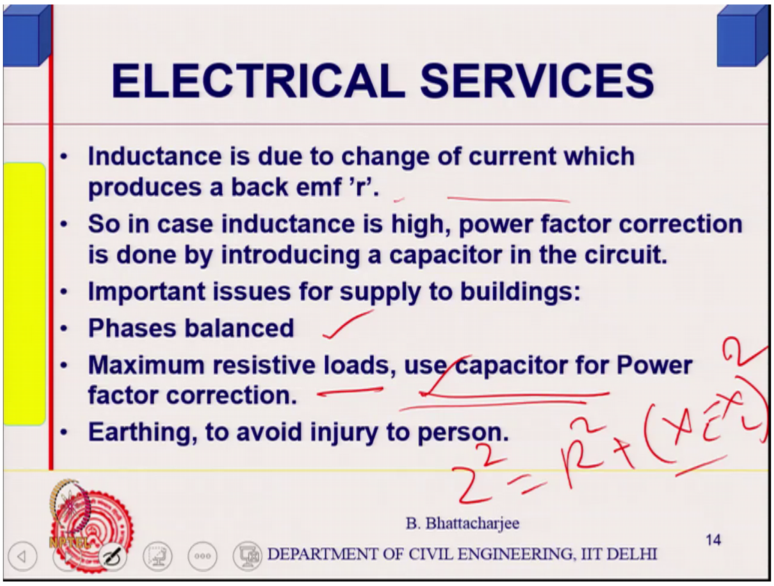

So, we would like to really you know change in current which produces back EMF. So, in case of inductance is high power factor correction is required. So, you would like to have a power factor of 0.8 or above possibly 0.9 or so, where you have lot of motors and similar sort of thing where there are coils you know magnetic field is generated, you were likely to have lot of inductive load you were like to have lot of inductive load. So, we would like to correct this power factor corrections should be desirable power factor corrections would be desirable right.

Usually, in loads the loads that you come across capacitance is less. If the capacitance is also high and inductance is also high inductive load is you know reactance from inductance inductors and capacitors both are high. They would have cancelled each other, but usually capacitive load is less, it is usually from inductive load because of motor etcetera most of them well have inductive load. So, 2 maximize this resistive load you use some time power factor correction right using a capacitor.

So, important issue is first is this issue I will come to that. So, I might actually a power factor connector might be used in a for example, you know the there are lot of laps in the main building. And, let us say I have power factor going somewhere around 0.6 or 0.7 lot of motor motorized equipment and such things. Then, what I do in the main substation I would like to put capacitive load in parallel or I mean you know accordingly appropriately. So, that finally, I get you know the inductive load is reactance is cancelled out by capacitance, because I said that the Z square is equals to r square plus X C minus X L square.

So, you know because there is 180 degree out of phase. So, they oppose each other. So, therefore, I would like to correct power factor corrections are the devices used for power factor corrections are capacitors. So, appropriate design of the capacitor and size etcetera I mean that can capacitance or so, this will be done to correct the power factor correction.

The other issue is other issue is of course, related to other issue is related to, other issue is related to what, other issue is related to, balancing the load, balancing the load right, balancing the load.

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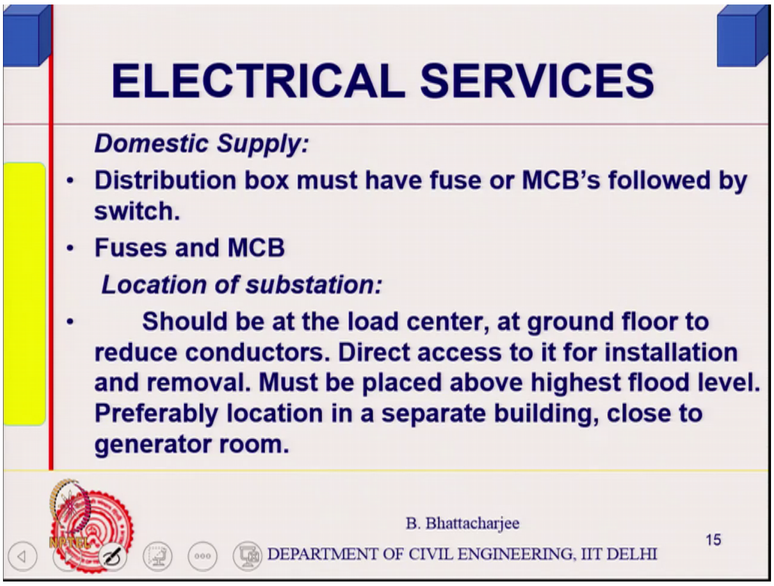

Now, when do we do balancing the load? Because in a multistory building, as I said you might have something like let us say 35 storey building 35 storey.

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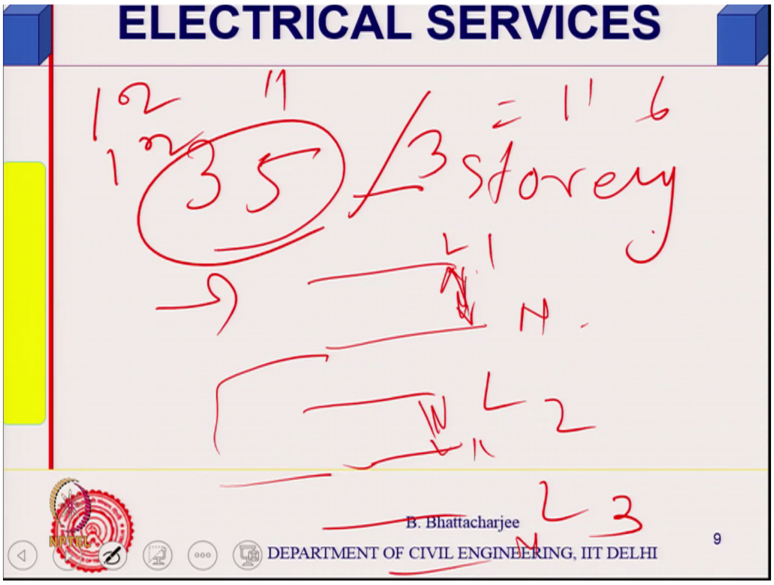

So, what will you do such kind of the electric load is pretty high. So, a single phase supply will not do single phase supply goes to the room because of appliances are mostly single phase live neutral 2 wire and 3 wire with the earth to earth connections, many appliances. So, in a in a building of the kind of 35 storey or something of that kind you will have lifts might have number of pumps for firefighting requirement and so on.

So, there will be some centralized 3 phase motors or 3 phase equipments in addition to that you will have supply to the various rooms which are single phase supply. So, as I said this the 3 phases 3 phases you know the load must in the each phase should be more or less similar load for example, this is L 1 L 2 and L 3 and all the cases you will have a neutral, because single phase is through the neutral, this also to the neutral point must be common in some where here there must be a neutral.

So, live and neutral for the first one, now the load in this one and the load in this one and load in this one must be same. Otherwise it creates dis balances you know back like a back stages, you know where from generations and so on. So, it cases creates problem all the 3 phases might be loaded all most similarly right. So, that is what is the requirement from the electrical energy generation or everything those points of view. So, how do I do it 35 storeys I divide by 3? I get you know 11 point something 6 or something. So, what I do I make it 12 and 11?

So, that is how I distribute. If, it is an area wise one-third of the area will be similar, you know like common motors etcetera that; obviously, you go directly from 3 phase supply, but after stepping down and then you know single phase supply that I am taking that would go that would go actually equal area wise, as an given example supposing you have you know like number of blocks, number of base in the building right.

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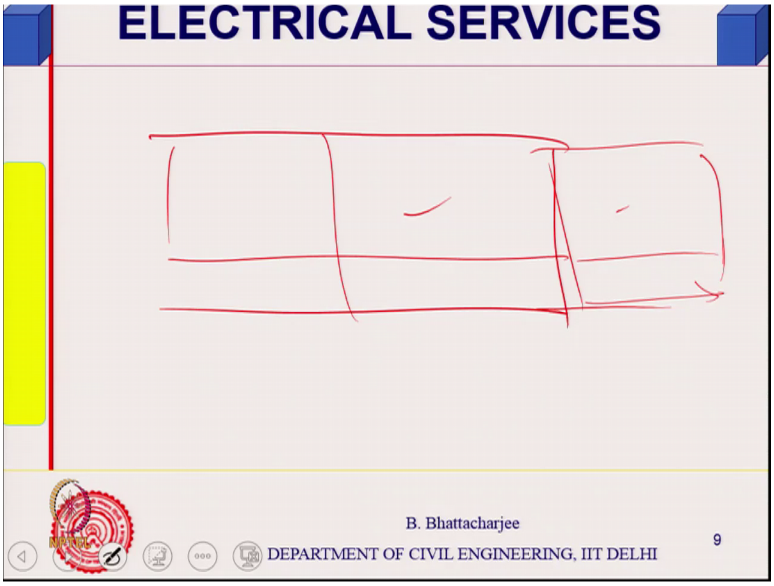

So, long building academic building let us say of the kind of IIT Delhi, very long building there are what you call base sort off.

So, you try to put equal number. If, it is a building of the kind of you know class rooms. So, put similar size class room divide them into 3 similar size 1 and connect it to each phase like that you know. So, try to see that equal area is supplying from each phase each phase is so, area supplied from a phase is same as any other phase.

So, that is the other issue that is the other issue. So, phases must be balanced, power factor corrections is required and earthing is required to avoid the injury to persons. So, these are the 3 things. One is to take care of irrespective of you know irrespective of where you are a civil engineer or electrical engineer this knowledge must be available to you that ok. We should have high power factor collection and I mean power factor if required apply a correction; that means, put a capacitor. And, then load must be balanced so, planning stage itself and load centers substation locations should be usually this is dimensions etcetera given in the national building code.

What is the dimension required? Because, it will depend upon the functional requirement of the substation machine sizes and all that some ideas are given in the national building code gives you some of the guidelines related to this. Where it should be located it should be located at the load center. For example, if you know the load maximum load is and area 1 there is an area a 2 and area 3. Now, the load in a you know it should be weighted average the distance multiplied by the load, distance multiplied by the load, from the load center substation from the substation distance multiplied by the load, that has to be minimized that has to be minimized.

So, your location x y z you can actually it get can be a simple problem, if you divide in your area into coordinate system x and y right. So, distances are x x is a let us say x is the substation location x i is the location I th loads center loads. And, the similarly y yi sum total of this square this should be minimized, because the distance is given by square of x minus x I in Cartesian coordinate system you can you know locate coordinate centroid point of each one of them, of the load in a building and in a room centroid you can you know even take Euclidian distances as we call it and as an approximation, and load multiplied by the distance must be minimized.

So, sum total of load multiplied by the distance must be there. So, this is the distance multiplied by the load a i.

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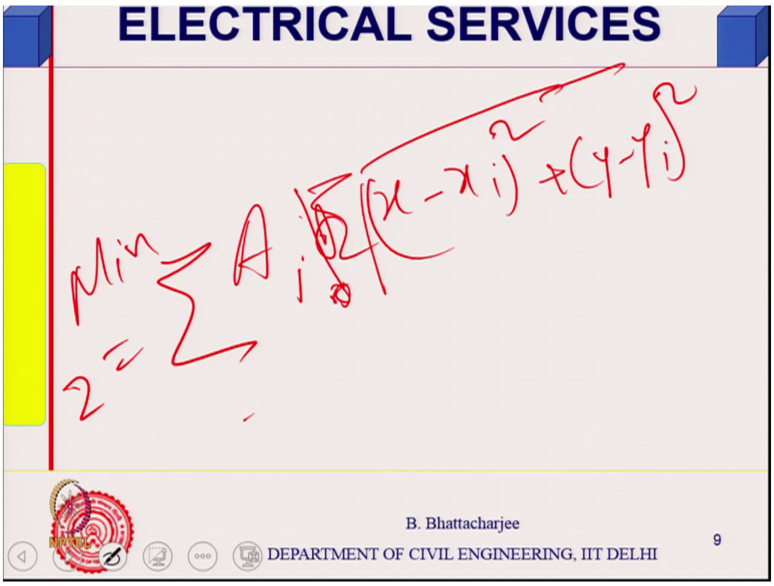

So, if I say so, if I say so, it could be something like this. Let us say for area i A i and it distance from x minus x i square and under root of you know under root of that under root of that plus y minus y i square sum total of all these A i multiplied by this should be minimized. So, minimize let us say minimize sum total of A i you know Cartesian coordinate like Euclidian distance I will call, that will give you the least cable requirement.

Cable cost because the cable size will depend upon the amount of load. So, amount of load so, if you minimize that; that means, cable sizing unless of course, they are all similar then there is no problem, you can just put it at the center. Yes, now what have you what is available at the site? So, substation should be located at the load center of the centroid load centroid of the whole area what you are dealing right?

But, then in multistory building it is usually at has to get the ground floor level above hfl, those requirements are safety requirements are there you do not put it somewhere up. So, above hfl away from you know it will also be a fire separation as to be seen. So, those issues come in and therefore, the location come, but in a spreaded area it should be in the load center load center you know.

So, that is it. That is what I have already set distribution box must have fuse or MCB's followed by switch fuse and that is why, I said should be at the load center substation location of substation at the load center. At ground floor to reduce conductor's direct access to it for installation, because if transformer has to be taken out and placed right. Transformer has to be taken out and placed on maintenance has to be done, you have to lift it put in on a so, transport direct this should be available.

Must be placed above highest flood level, preferably location in a separate building, close to if there is a generator room close to generator room so, this is this what it is allRight? You can see that actually, you can see in the campus in this campus for example, civil engineering substation is accessible from the road straight away, between block 4 and block 5, you know that is accessible it is there is an entry there is an entry available there. I mean they have made some cycle stand, but I suppose although vehicle cannot enter, but and it is just almost isolated in between the 2 blocks in the ground floor level itself.

So, there is some access available not for really truck or something, but changing of transformer that should be actually this should be you know the truck should be able to go and come ok. So, that is what it is?

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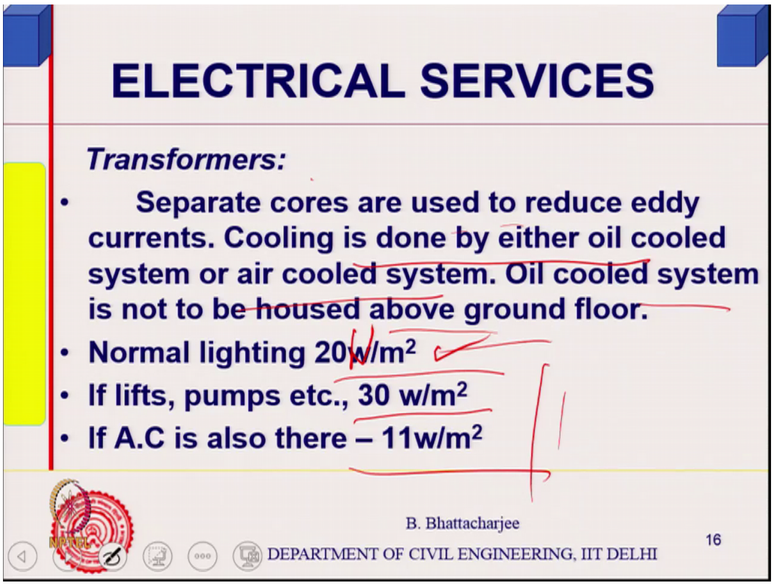

So, transformer usually we might have to take some time decision related to transformer; obviously, vi capacity is one thing that you know.

How much how much kva kilo volt ampere sizing it happens to be that is known to you that would be known, because what you are dealing with? And, generally you know ad current reduction is done because you will have core you can see that, there will be core is separated by sort of insulator to minimize the ad current loses right. And, cooling is done either by oil or air cooled system currently it is air cooled one which are efficient.

So, oil cooled systems are not available you know that not housed above ground floor air cooled system are more efficient and oil cooled there can be fire hazard and all those kind of thing. So, they are not actually preferred. So, that is this kind of guidelines safety guidelines are there. You want to calculate out how much is a load at the planning stage? So, rough guidelines given in national building code. Normal lighting take 20 watt per meter square, 20 watt per meter square normal lighting take 20 watt per meter square.

So, for example, if you know the area of your floor or total building from for lighting only this much how much you need, it will be required. If lift forms are there, then it would be more and if AC is there additionally 11 watt per meter square you got to take. So, these are again the values are given in national building code to start with how much is the capacity you need for a given building roughly you can estimate it out. So, you know like before even giving. So, one has to look into those kind of thing.

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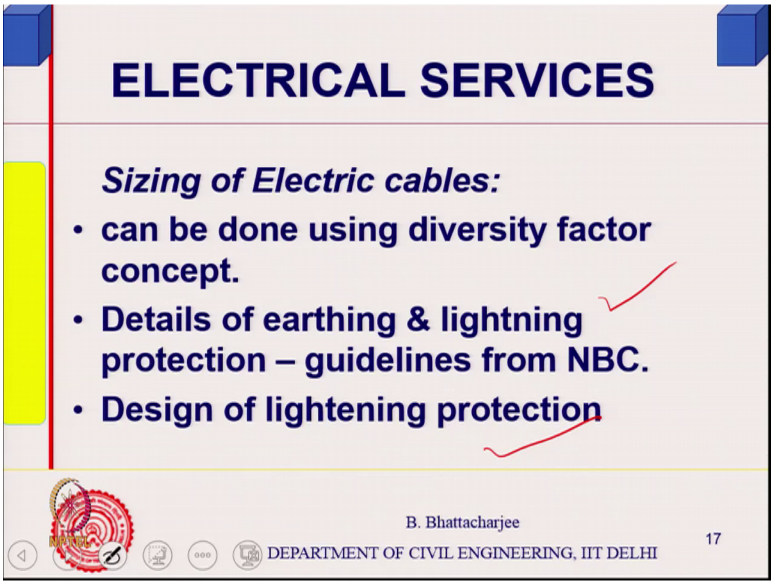

I have already told you sizing of electrical cables, this can be done, this can be done using diversity factor, I mean first you will have you will first like to find out let us say I have I have 10 lamps right, 10 lamps and each 5 ampere rating and then may be some sockets. So, you know another 15 sockets, you know 5 ampere rating and I want to size the cable connecting to all of them. Then I use the diversity factor concept which you have talked about right.

So, sizing of this cables and then size for how many amperes so, factor diversity factor multiplied by 5 into 10 plus you know say 5 into if there are 15 number of sockets something like this. So, multiplied by that would be that many number of that is for that much ampere you know you have to design the cable. And, because I told you other day that you know the current rating related to because R is equals to rho l over a rho l over a. So, for 1 meter length sizing you can just determine right ok.

So, the current rating you can you know based on resistance is this. So, of you know the current for 220 volts for current rating, what is the area or mass or dimension size of the cable that you can find out.

So, this can be found out or you can look from tables as very simple it is not very complex anyway. So, this is what it is right? Then you have to provide details of earthing and lighting protection guidelines are given in lighting protection not lighting lightening protection.

These are given guidelines are given in national building code like how many number of you know, because in case of lightening the high voltage that is generated in the cloud this can heat the building, but it must straight away pass through the ground. So, therefore, you provide conductor at the top of the building and this guidelines are given in national building code.

So, this lightening protection this is given in the national building code. So, this is about all about electrical service system these all about electrical service.