Design of Reinforced Concrete Structures
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Lecture - 01
Introduction

Welcome to the course on Design of Reinforced Concrete Structures. So what do you mean by design? Design means to plan or to make drawings for appearance or to show the structure which is not yet constructed. So, the structure which is not built for that, we have to plan, we have to make drawings, and that is called design.

And now, the next question is that - what is reinforced concrete? Reinforce means actually as per the Oxford dictionary, it calls that make it stronger; reinforce means make it stronger. And reinforced concrete, we make it with that steel bar, steel bar. So, we make concrete stronger with the steel bars; that is called actually the reinforced concrete. So coming to the point - the design of reinforced concrete structures. So, we have to design reinforced concrete structures. So, that particular one, we shall do it in this particular course.

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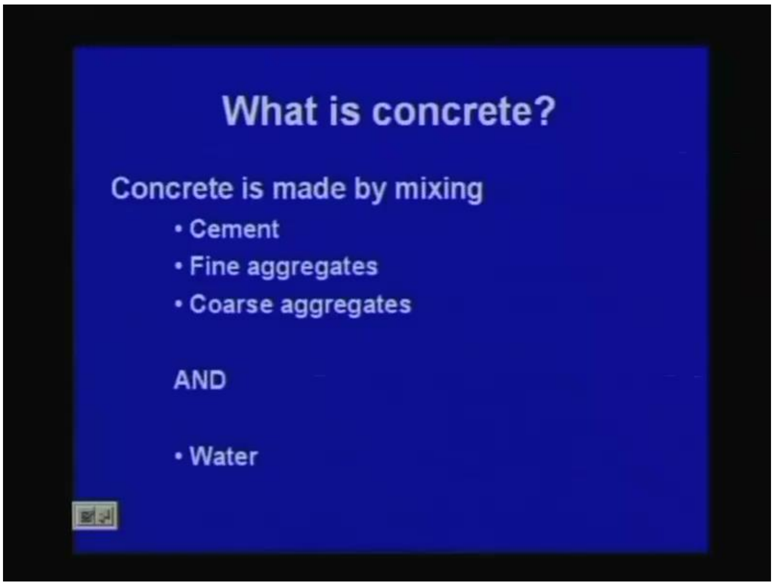

So what is concrete? Concrete is made by mixing cement, fine aggregates, coarse aggregates, and I have kept that - and water - because water I have kept it; cement, fine aggregates, coarse aggregates - these are the three materials which we shall consider, but water also is another governing element. If we add water less, then also that will vary the strength of the concrete. If you add water more, then also the strength of the concrete will vary. So water plays an important role in this particular that concrete making. So that is why we kept it - water. And how to describe that water? We describe this one as water-cement ratio. So water-cement ratio will tell us that whether that particular concrete we shall achieve that target strength.

You can find out the steel. Steel it is made; steel it is made in the workshop and it is in a controlled environment; whereas, we are talking concrete; concrete is made in the field itself. And you can find out that particular one, there are so many factors play while making concrete. We just simply cannot put a particular proportion and we cannot say that concrete is made. There are lot of other things also. Even the concrete is made, there is one more important part - that is called curing. That means even if we make concrete, then you have to cure it; generally, we do it that with water; and if the curing is done properly, then also we can say that significantly that changes will be there in the strength.

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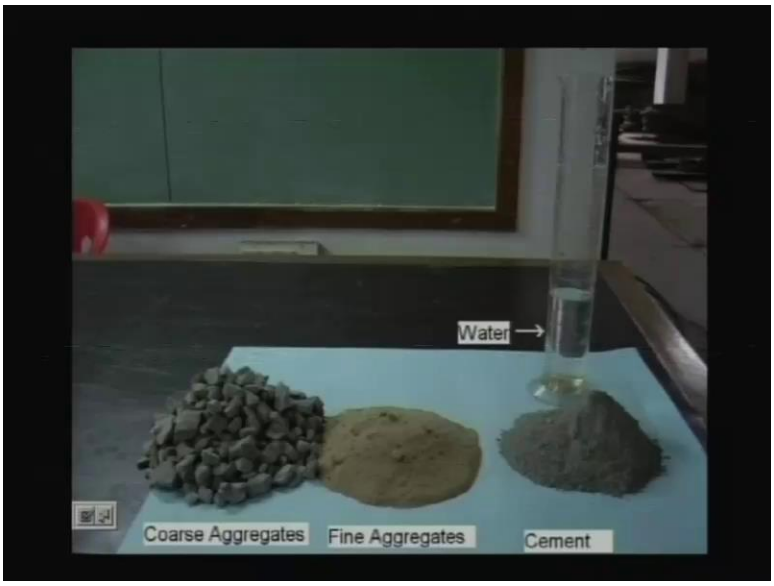

So if we come to this point, just to give this particular one. Generally, this coarse aggregates is made of that stone chips, and this one, obviously, in that bulk amount - that is the major amount, you can say; this one that fine aggregates; and that one we can say this is generally as sand, and which we can get it from the riverbeds. And the binding materials here - that is cement. And here we are keeping that one, that we have to measure that water also; and this one - that water-cement ratio - for a particular case, if you have say, 1 kg of, say, for this case say, cement, then we require, say, 400 milliliter; so we are considering water-cement ratio 0.4. Generally, it comes in that range, 0.5, 0.4 in that range, depending on the target strength.

So coarse aggregates, fine aggregates, cement, and water. Please note this particular one, because whenever we are talking reinforced concrete, we should remember this in particular - what are three different parts? Generally, it comes say, 1 is to 2 is to 4. If we consider 1 is to 2 is to 4, that is the ratio of concrete, then we mean to say that, 1 means cement; 2 means sand; and 4 means coarse aggregates. We generally do not specify that water; we generally specify that 1 is to 2 is to 4; 1 is to one and a half is to 3. So these called different, generally the guiding one - we call it nominal mix.

So, here, we designate M 15. If we consider M 15, we mean to say that we have to achieve the strength of the concrete after 28 days; that is 15 Newton per square millimeter. Similarly, we specify, say, M 20. M 20 means the design mix; M for mix, and 20 means, 20 Newton per square millimeter. So that means we shall achieve that one after 28 days. So, if we test that on the 28th day we should achieve that particular target strength.

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Just let me give an example of that, your, say, slab - this is actually slab - and whenever we specify this concrete - reinforced concrete, then we have these bars; these bars, because this one we are considering slabs, that where you are setting over the roof or the top, that is called the slab.

Generally, we have four components: one is called that slab; another one is called beam; other one is called column; and the column footing. So these are the four components we have to design and that we shall learn in this particular class. So slab - horizontal one just like a plate; beam - horizontal one, so like this we can say beam; and then we have that one column; and column footing, which will transfer the load on the ground - that soil - and that also depends that soil that bearing capacity - that means how much load it can take. If we take, say here, just only, say, a single one, very, very thin one, then a sharp one, then what will happen is that it will simply pierce the ground, so that we have to make a square type of thing or circular type of thing, so that the load could be transferred to the ground, and that depends on the bearing capacity of the soil. That is another aspect; that means, that one will be told by geotechnical engineers who are looking after that soil. So that is another aspect. So we will get the pictures of the soil, of that particular soil, where we going to construct that particular building, and then, on the basis of that we can find out the footing size.

So, I repeat, the number one that we have to know - how to design the slab. Number two - we have to know how to design the beam. Then column which will transfer the load on the ground, and since the column dimension that is not sufficient, that is less, which could pierce the ground, that is why we are making that column size on the bottom little bigger, which are we are considering that footing.

Considering this particular reinforced concrete element, this is nothing but the slab element. Here, we can have the concrete, then we are having bars in two directions, we have bars, and you can see at the top also and at the bottom also. The bars at the top and also at the bottom. And these bars you have to specify the dimension. What should be the dimension of the bars? What is the spacing of these bars? What should be the depth of this concrete? We cannot simply provide the bar at the bottom of the slab; we should give a little bit of cover; that means, we cannot give that one. So if you see the slab from the bottom, you cannot see the bars, here because it will be little bit up, may be, say, 25 millimeter, 30 millimeter, depending on the situation.

If the environment, say, for the normal case, generally, we keep say 15 millimeter for slab. If it is a beam, then we have to keep 25 millimeter. If it is a column, then we keep 40 millimeter; that means, from the outside dimension of the column, we have to give it inside 40 millimeter. So that we have to give that particular dimension.

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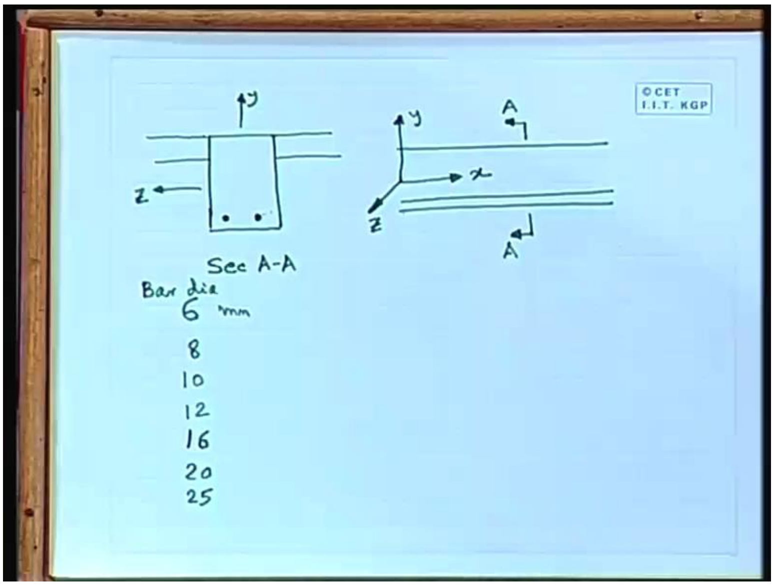

Just I can say, if we have, say, a beam. So, this is your, say, dimension. And let us say we are having the slab; it will start from here. So we have to provide the reinforcement, because concrete is very weak in tension; concrete can take compression; that means, if you press it, it can take enormous load, but if you just pull it or bend it such way, so that the tensile one, it is very, very less; we ignore it; we neglect it; that means that the concrete does not take tension. And that part, we just supplement with this reinforcing bars.

So we are having the reinforced concrete, though we are talking, say one single element, but it has two different parts: one part is taking compression and another part is taking tension. Tensile one will be taken care by steel, which is manufactured in the workshop; and compression one, will be taken care of by the concrete, which we do cast in the field itself.

So, here also, we will find out little bit difference; that is, one is the controlled environment and another one is that environment that is not controlled, because there could be so many spurious thing can enter into that particular one; but anyway, we shall not take here that particular one; we shall assume that we shall achieve that particular target strength.

Now, when we talking about cover regarding this particular one, so this is called actually, this whenever we are talking this particular one, the bar; that means the beam is like this; this is your beam, let us say, the longitudinal direction. Let us specify something, say, your axis; that will be…then it will be more clear. So, if I say this is your, say, x, and then, we can move this particular one, say, your y, and the other one, say, your z.

So, whenever we are taking this particular one, x means another longitudinal direction; so this particular cross section, it means, it means we are considering this one as y, and this one we are taking, say, z. So it is clear? That means, we mean to say this portion, that is one cross section, and there if we see, the bars is actually along this direction, and if you take a section, if you look this particular like this… So we have to specify, say, AA; that means, I am taking as section along this particular line, and if you look that one, then I shall see, and this is nothing but say section AA.

Let us stay there are two bars; we are specifying two bars. So we shall get this two round - this circular thing - may be it could be, say, what is the bar diameter? Generally, the bar diameters, we are having 6 millimeter; it starts from 6 millimeter; then 8 millimeter; then 10 millimeter; 12 millimeter. So we can have bar diameter 6 millimeter, 8, 10, 12; and 14 also available, but generally we do not use it, because, you know, generally it is not manufactured very much, 16; whatever we specify say in our drawing, in our construction that only I am telling; 16 then 20, 25. So we go in that particular order; there are so many others also; but generally for our residential buildings, school buildings, or the common type of structures, we are happy with this type of bars.

Why we need it that, if we do the construction, say, the planning, design, all those things done in the, say, your design office. So now what you have to do, when you will give the drawing, immediately they cannot start, so what you have to do, the site, the stores they will ask for - that what type of steel you are using in your design, that you have to specify; because if I give the drawing now, they cannot start immediately. So, this would have some, say, some tender for say, procurement of different materials, for concrete, say stone chips, sand, then your cement, then as well as steel also. So first thing the steel, because steel you have to give order, then it will come, it may take some time. So that is why they ask for that - what type of bars you are going to use?

Generally, we use for slabs, say 8, millimeter; 8 and 10 generally we use it for slabs. Then we start, say, your beams we generally start from, say, 12, 16, 20; that we generally use. And for columns, we again use 12, 16, 20, 25. It all depends on the designer also, because every design, because analysis is something you are doing, you are following a method, and it is straightforward. And it is, you can say that particular one analysis, that one you can say that almost everybody of us will use the same formula for everything.

Here also, in design also, we shall use the same formula, but everybody has his own design philosophy. So you can find out that there are different school of thoughts, that ok say he prefers this way, the other one prefers that way, but we are using the same formula; but, whenever you are providing, say for example, for slab one can say ok I shall use only 8 millimeter. A designer may have some kind of allergy of using say 10 millimeter dia bar also; he is always interested, fond of using 8 millimeter; this is one kind of say philosophy, but there is nothing wrong on it. So the thing is that 8 millimeter, 10 millimeter like that, but somebody is interested, ok whenever I feel let us use 10 millimeter.

Similarly, for, say, beams, say somebody is interested using say 12 millimeter and 16 millimeter only. Similarly, say, your for columns we shall start, we can start with 12 millimeter, then we can start 16, 20, whatever it is that we can start; we can use it also.

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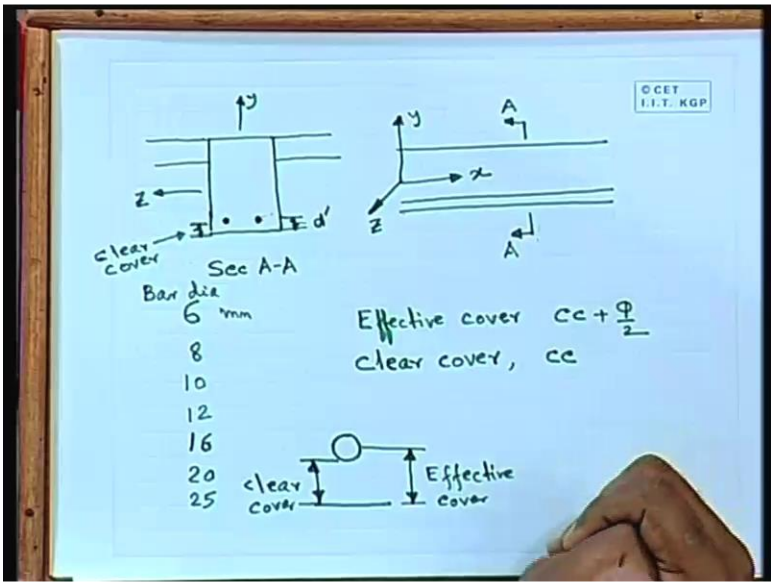

So, now coming to the point I started with that cover. when I told the cover, we mean to say the central line; the central line of the bar, from there to the end of this one we shall say, this is called effective cover. So effective cover, it means this one, let us say that is d dash. We can have other one; that is called clear cover. So we have effective cover and clear cover.

Clear cover means from the end of the bar to the end of that section; that is called actually clear cover. So, we have one clear cover, and another one is called effective cover. Now clear cover, let us say, let us make it little bigger then; this is bar diameter, bar; this is the end of the section; clear cover means… and effective cover it means… this is called effective cover.

So what we can do actually here? If we say clear cover, say CC, then effective cover will be CC plus diameter of the bar - half of the diameter of the bar - so phi by 2. So whenever we calculate that one, effective cover and clear cover, we shall make it like this. We will cover it in detail that at the time of design.

Now coming to this particular point - why do we need clear cover? One important aspect is that is your say corrosion of steel. So that the steel is not corroded; so that is one aspect. And there are so many others also you can find out; from the environment aspect

- that is the major one we can consider that. We have to give cover; we just simply cannot give immediately at the bottom. So that part we have to consider here.

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There is one aspect that is your say, this is your junction, that what we consider here, that this part is called that slab, and the other one is called… this , this one is called say your beams - the beam detailing, and this is your column, and this portion you are having the slab.

[Conversation between student and Professor – Not Audible]

So this portion…(I am not still habituated, right.) this portion is called as your slab; this one is called as your slab; and the other one slab; and there is a junction here say. If can consider that particular junction, what we can do here, that if we consider, let us say this is a plan, and we are considering that four different parts.

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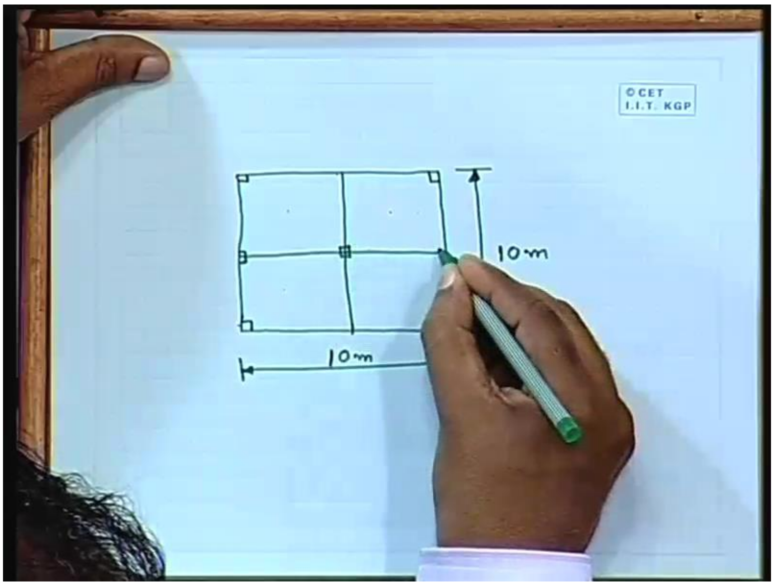

We can see… let us give certain dimension. This one say 10 meter. And let us take this one also say 10 meter. What we can do here, if we use 10 meter, you can find out that 10 meter of one plate if you consider, then what will happen? You will get deflection in the middle too much. 10 meter by 10 meter - that particular one - if have to make say, maybe you can consider a paper, may be even if you can say, you can consider a cloth itself, a big one if you just hold it with say four corners, then you will find out the deflection at the middle too much.

So what we can do? We can keep two horizontal bars like this in the middle, so that your middle point deflection is less, and but, you will get deflection here also, in this four points you will get the deflection, but we can reduce the deflection. So, that means, if we can make, say here beams, the horizontal one, which you call beams; so if we put two beams here in addition to these four beams in the periphery, so you can increase the stiffness and we can reduce the deflection, because deflection is also is an important criteria.

Now, coming to this particular point, let us say that we shall provide four columns, say here, say like this, and also we can provide here also columns. So, one such example here, when we consider that one such example here, this particular one if you consider, that this column, and there are other two beams; this is one beam; this is another beam; and the one column, that one also intersecting. Now this one what happened that we have to provide the reinforcement for this beams, we have to provide reinforcement for these beams, and also you have to provide reinforcement for slabs, and also you have to provide reinforcement for the columns.

So we can find out that it is really a chaotic situation, because there are so many bars you have to provide, and each of them has their own bar diameter. So when you have to consider that part and that is called detailing; detailing is very, very important in reinforcement concrete design. Even if you design that one, that also how to provide that reinforcement, that is very, very important aspect.

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So this one such example that you can see, that how the bars are provided, and through these, through these, all the bars, and there are so many also, there are some kind of say lapping also your can find out. That means it is not possible that we shall get one single bar coming from the bottom to top; may be we shall get say 5 meter or say 8 meter or 10 meter, that length - whatever we can get from the workshop.

Now when we are considering that particular bar, that bar you have to provide, so you have, there should be a lapping. So that thing is that, obviously, we can understand that if we, if we have say two things, like this; this is one bar; this is one bar; and let us consider just with the cord we would like to tie it up. If we make this one small, obviously, one

can simply pull it and take it out, but so that means we should have some kind of overlapping, and obviously, it depends on the diameter of the bar.
If we consider say two wires, the wires have very, very small diameter, then we can have the whatever overlapping required; if the wire having the larger diameter, then we need overlapping more, that means with the cord itself we have to tie it out, and if we pull it so that it will not go out. So this is called lapping and we have to provide the lap length also. So that it will not tear it out. So these are the different aspect we have to consider in the reinforced concrete design.

There is another aspect; this is your column; another aspect that bars whatever we are having, we have to provide for the bars, we call it tie. The tie that means it is tied; these are… these bars are called longitudinal; these bars are called longitudinal; and these bars they are called tie.

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The tie you provide… we provide ties. So this is your longitudinal bars which are going up, and we have to provide tie say like this.

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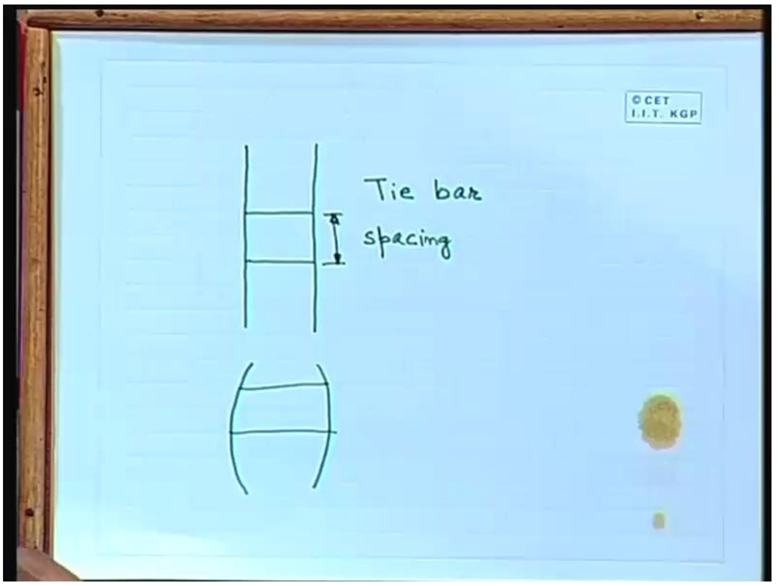

So we have to provide the diameter of the tie bar. And the spacing - this is called spacing; that means… So we have to provide the tie bar and spacing. So this one we have to provide so that, if we do not provide what will happen? If we do not provide, then it may happen, that it will bulge like this.

So that is why you have to tie it out, so that it will not go out; it will not separate out. So this is also you have to provide, and it depends on the, you will say column dimension, lot of other things; when we shall design that column, that time we shall do this particular aspect. So this is another one, we are not going to detail of that particular one.

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This is your at the that construction site, we generally are habituated, we generally see the finished products, but if you see the construction there are so many things in it actually there. If you see this one construction, this is one such block, this is another block, these blocks, and all those things, which are given actually to provide the proper clear cover.

This small, small blocks you will find out at different places, just to provide that one for the proper clear cover. Otherwise, you will… otherwise, it will be at only at the bottom of that particular, say your, surface. So you have it lift it up and your lifting up that is a small blocks, that is made of some mortar; mortar is nothing but sand and cement; so with that we make that.

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This is your say circular column, and here, you can see that this one having, say, spiral; the tie we are making, say, spiral one we are making; so this is another one we generally make. So spiral and this actually one they are going to construct circular column. This is your base at the column that footing; after this they will start the circular section.

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And this one, obviously, we have to use this type of, say, arrangement; otherwise, it is so heavy; you can understand, otherwise that all everything will fall down; you know this is concrete; because fresh concrete, it does not have any strength; green concrete does not have any strength; so it will simply fall down. So we have to use this supports to withstand that particular load, and only after say 28 days or may be after 14 days only we will get the required strength. And then, if you take it out, it will show. Generally, we have to take it out after 28 days, and then you can see that particular structure that is built, and it can take that load for which it is designed.

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There is another aspect here, that is, this is called beam; this one is called column; and this is your, say, beam. This particular beam has a special name, we call it tie beam; we call it tie beam.

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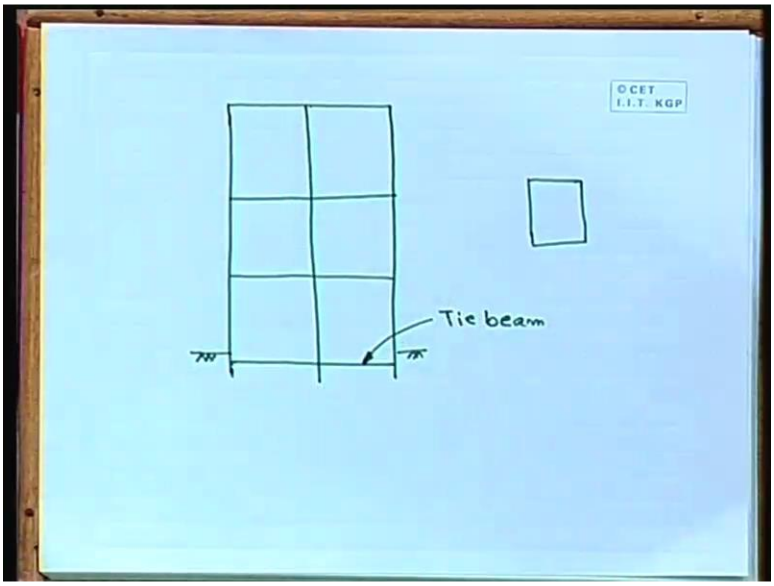

So, whenever we are having, say, this one, we are talking, say, one elevation, and what we do, this is the ground, what do we do, let us say another column is there. So what we do is that maybe we can provide here or we may be we shall provide, say, here one beam. And this is called, at the bottom, this all we can provide one beam say at the first floor level, and another beam at the second floor level, like that we can go.

This beam has a special name; we call it tie beam; and it is rectangular. That means, if you split the cross section, you can see like this. You can see here also, you can see this is the one, we can see that particular one - beam seen here - this particular one here, that one section if you consider, that is rectangular; you can see that particular one, that say rectangular; that you can see.

So, we can come to this particular one. So, tie beam that is the special name that we have to consider. And I have already told that you say curing; curing is generally done like this.

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That is the jute bag, all those things, you just cover it, and we just put water, and that is called actually curing. And that one, we have to do that curing also; that is very, very important. Even if you have cast it properly, all the parts you have taken care off, even then, you cannot achieve the target strength for which it is designed, if it is not done - that curing properly. So that is very, very important

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This is another aspect of that from that site just I have taken from this particular one, and here also, you can also see that construction is going on in our that campus itself; so this particular construction. And you can see the tie beams; there are so many tie beams here; so that one in the bottom. Why we need that one? Because from there we shall… that wall, that week, wall will be started, and that particular one we have to use it.

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Now coming to the point, here one aspect, that is we are doing the cast, we are doing the casting at the field itself. And we know the proportion, let us say, M 20 grade of concrete. That means we would like to achieve the target strength that not target strength, we shall say characteristic strength, we call it the characteristic strength. And that we have to achieve. If I say M 20, why I am telling every time M 20, because that is the one we generally use. M 20, mix 20 that is we generally use for common design - residence and school building like that, college building; so any public building; generally we are happy with that M 20 grade of concrete; that is the common mix we use it.

When do we use that M 20 grade of concrete mix 20, 20 Newton per square millimeter we have to achieve the strength; that is called characteristic strength we have to achieve. And that we shall have to find out - how shall I do know that we have achieved that strength? For that, what we do actually, we take, we at the same we cast 150 millimeter cubes; that 150 millimeter of cubes, that we cast it; this particular one - the three cubes - that we cast it; at least three cubes we have to cast, which having dimension 150 millimeter dimension, and that we have to test, and that we test it with this type of machine.

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This is, your say, we call this say universal testing machine that is commonly available. That this testing machine that we can use it for bending, you can use say for your compression, there are so many other also for tensile strength also, that also you have to use it.

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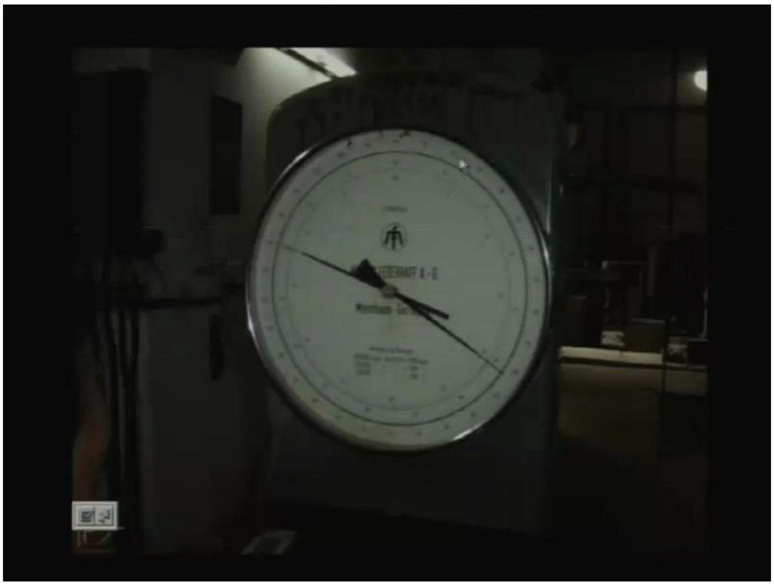

What happens actually if you test it, this particular one, you just keep on loading, and this one will come wherever it will have that crack and failure, only it will go up to that, and then it will go back. So that we can find out what is the… whether we can achieve that; what is the failure load - that casting load that we have to find out.

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So we just do the test like this - that we put the, keep the cube in between this say one, and we do the test. Then we find out the failure, the different cracks it will come, and I have just given, we do not go up to that, but it will cross like this.

So the thing is that, that one hand, which is the you know, you would say just coming to the previous one, let me show you. So this one what will happen, it will, if you add the load it will go move on, move on like this, and it will go only up to failure. So, from there, you can definitely you can find out, and it will not go beyond that; then, it will go back. So from there we can find out the strength, that your say crossing load you can find out, and from there, you can say that what is the failure load, and from there you find out the what is the strength, how much you have achieved that particular load, you can achieve.

This one, say, we are having in our laboratory, say 60 ton; this particular machine can take say maximum 60 ton, 120 ton, and 300 ton; maximum it go up to 300 ton, because these are three different scale. So, we can, depending on the situation, that concrete, we go say 60 ton or whether we shall adjust it or 120 ton or say 300 ton.

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So this is your that another machine where we do the testing for steel. Similarly, we have to do the testing for steel also. So, steel bar, that we put it like this, and we give the tension one; for concrete we do the compression, for the steel we test it for tension. So we put the bar like this for closer view.

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And this one also, the load will be such that it will simply tear it out; this particular one, whenever we shall do the test, it is not that there should be a neck formation, and finally, it will just simply tear it out, and then, we can find out the failure load, and also, we can find out the elongation.

So, that is also equally important, because that one will give us the strength; one is the stress and another one is the strength. So these are the two different aspects that we have to find out.

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This another machine, which is now computer controlled - this is called Instron. This is - this machine - is called Instron. So this one also another universal testing machine, which can do the work say for testing of different parts, say tensile, compression, bending - these are the major three that we can do it that with this machine; and that is why we call it universal testing machine. I am talking this one, whatever available in our department - the structural engineering laboratory. So this is another closer view of that particular one.

Now, this is another important aspect that is called that how, what should be the guidelines, because concrete and steel these are the two different materials, what should be guidelines. We should have certain kind of fixed rules and regulations, which all of us we shall follow, and so that, we shall come to always in a definite result every time. So, for that we have that Indian standard codes. Every country has their own standard codes. So in UK, they are having their own code; then also American Concrete Institute, they are also having their own code; there is one famous that is American Standard Testing of Materials (ASTM), so that particular one we have ASTM, they are also having different codes of how to test the materials. So these codes… so there are so many codes. And Indian codes having that wealth of information, lot of things we can get it from that Indian standard codes.

Just for that one thing and each code having their own name; each code having their one, two, three, four, like that. So can you tell me that, what is that is IS one - Indian standard one? Indian standard one that is made for specific purpose, for a specific thing. That is for National Flag; that is for National Flag.

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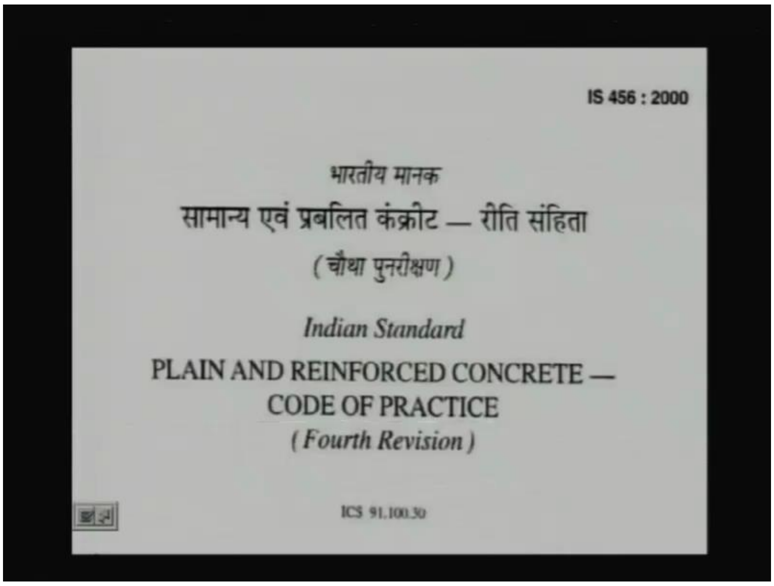

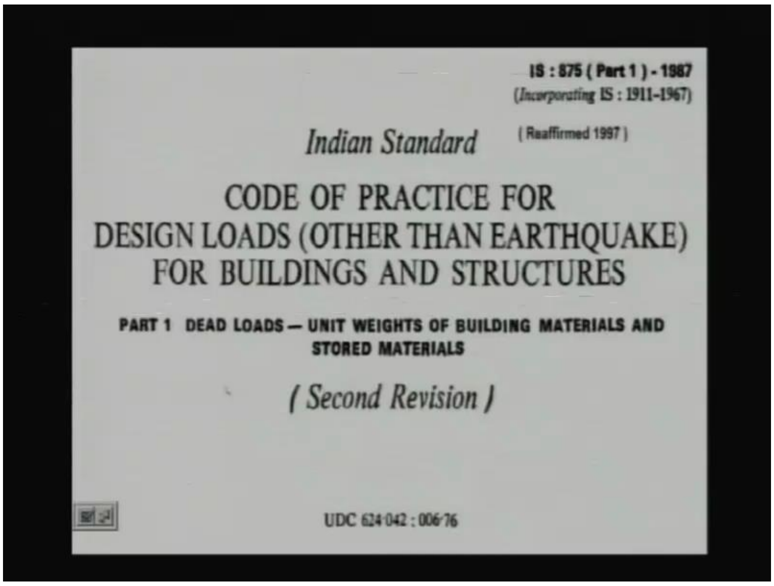

Similarly, here we are having so many codes and we shall follow IS 456 revised in 2000. We shall follow this particular code for our reinforced concrete design. So IS 456 revised 2000, fourth revision; plane and reinforced concrete code of practice. We shall follow this particular code and that is our guideline; we can consider this is our bible for this particular one, because different people can design different way, where we differs, we differ with let us say the diameter of the bar. One can argue why shall we not provide the 8 millimeter bar in the column, but the thing is that… but code says that you have to provide that minimum 12 millimeter. So the thing is that now if one specifies less than, say 8 millimeter, less than 12 millimeter, then obviously there, there must be if nothing goes wrong there is no problem; when something goes wrong, then only lot of debate comes, that why we have used that particular bar, when the code says so. So code is the one that which will give us that consensus, ok we shall follow this particular guideline and everybody will follow that particular one.

So this is way that our code will give for different cases we will find out, for different cases it has given different things, different formulas we have. The formulas also, sometime you can find out empirical; even if we are using empirical based certain experiments also all those things, so there also we have to know and we have to use certain guideline, and which we shall get in this particular code.

But there are few other codes. So that is another aspect that you say design loads. This is another important aspect. Whenever we are talking the particular one say load, that say for this particular building, we would like to design this building, so how much load we shall consider. That we have to consider, because somebody can say it not one that is somewhat experience, ok this is the classroom, it has a capacity of your, say 100 students, so calculate on the basis of that load maximum, say, your weight of each student, on basis of that we can find it out, but that is not the usual way. We should have certain kind of load; say we shall consider may be say 250 kg per square meter load; it will come in one square meter, 250 kg; may be say 300 kg. Depending on the situation, what type building, what for it is made, whether it is a public building, whether it is a residential building, so depending on that, that we can find out how much load will be there.

If we consider, so similarly, here also, the dead load; dead load we mean to say that is self-load of the structure. When a structure is designed, that time when a structure is designed, it should also take care its own self-weight. And it is also enormous; may be sometimes it is say 50 percent. The total load whatever you can consider, that imposed load and its self-weight if you consider 100, so self-weight will comes to 50 percent. That means you have to consider that it has to withstand its own self-weight also. And that, for that, we need unit weights or buildings materials and stored materials, whatever we have, this your say the part one, say that is IS 875 part I, revised in 1987, Indian standard 875, part I, 1987 - so that codes gives code of practice for design loads. And please note other than earthquake, because earthquake is considered separately. For buildings and structures part one that is dead loads, unit weights of building materials and stored materials.

So this one, if we know the unit weights of different materials, from there we can find out the self-weight of the structure, the way that is made. The different constituents if we know, then we can find out the self-weight of the structure and it is revised the second revision in 1987. This particular code we shall follow for the self-weight. Because design load, that load actually, obviously, you can understand that load if you take it different, then your design - your final design - will come different. So that is why load is also another important part that you have to consider.

The other one that is called the imposed loads and we call it live loads also. So self-weight we mean to say dead load, and imposed load we consider live load, because it can… live load we mean to say it can vary, because say orientation of the room, of say different tables, chairs, your furniture, lot of other things whatever we can fix it one day, that we can change the CG, and then, we can find out; that is the way we can do it. So this, that is why we call it live load. So dead load, and your say live load, and that we shall get it in this part II.

The other one is called the wind loads; other one is that wind loads; that you have to consider, because where the structure is being constructed or to be constructed, what is the wind condition over the years. So on the basis of that we have to find out, and obviously, we have the map of India, where that what is the wind speed at different zones, different areas, from that we can find out that how much pressure we shall get it, how much load we shall get it due to wind that is called. So we shall get part III wind load.

We do not need it; so far only we need it in the Himalayan region and all those things, the snow loads, but generally we do not need it. We need it say dead, load live load, and wind load - these are three we get it from this 875; 875 we shall get it. And the other one, since it is a separate one, so we need Indian standard 1893, right now, we are only having part I. We had 1984 revision, that is only one code IS 1893. Now, after the Bhuj earthquake, then we have that particular one, because it has given really an impact, and we are having so many programs on say earthquake engineering in our country, and funded by ministry of Home Affairs, funded by Ministry of Human Resources Development; so that is national program, and that one, it is really is that some kind of awareness is coming, but the code is very old; it is 1984.

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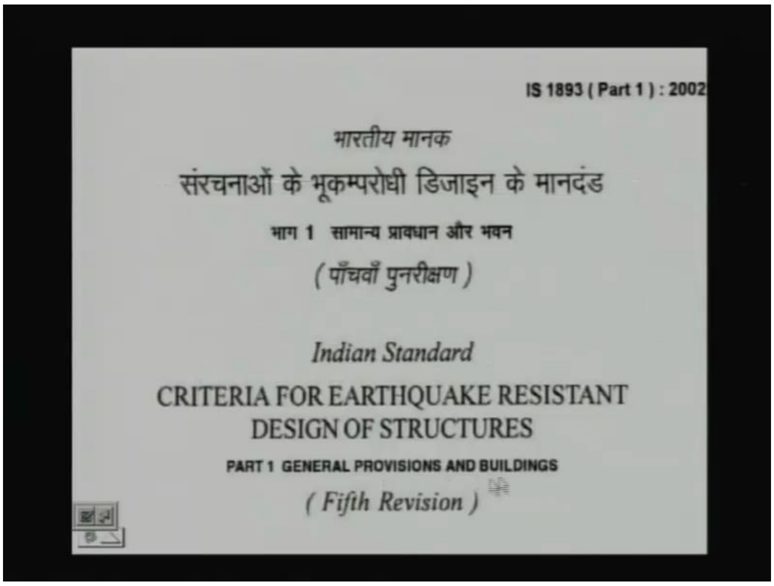

Now it is revised part I, 2002, and that is for criteria for earthquake resistant design of structures, general provisions and buildings; for buildings this particular code will tell that how much load we have to consider, because after all that earthquake load, you can consider, strictly speaking that is probabilistic; that is not the deterministic load; the load is probabilistic. So whatever earthquake will occur today or past earthquake on basis of that whatever load you can calculate, the another earthquake the structure can take which is may be more than the load than whatever way it is designed. So we can say this particular load is probabilistic, but even then we have to consider in a deterministic manner, and that we shall find out in this particular code.

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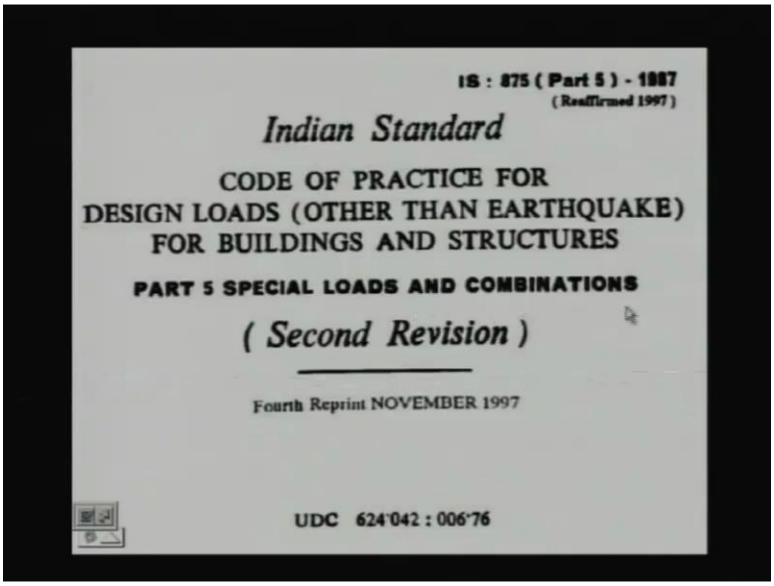

One more important part that is IS 875 part V. This one says the special loads and combinations. This is one of the important aspect we have to consider, because that combination of load, that how shall we consider that particular load, the different loads.

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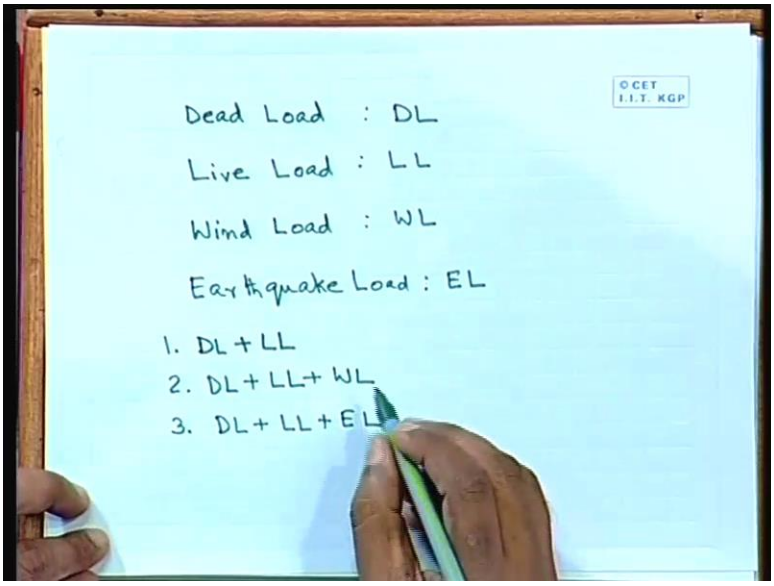

Generally, we consider here the dead load, then live load or imposed load, wind load, and earthquake load. So DL, LL, WL, and El. So we have to find out the different combination. That combination of load we have to consider; live load, that is the one for that which we are going to design; live load is the one for which we are going to design.

That means, we have to care this load; this the load that for which we have to design the structure, but other loads are coming, because for different aspects, because where you are going to construct that building, what type of wind load is there, wind speed is there, what type of earthquake load, whether it is that earthquake prone or not - so all those whenever we are considering, generally, we consider it should be sufficient if we consider say dead load plus live load, because we have to design for this live load only; if we have to design this particular floor, we have to design for this live load only; only live load we cannot design, we have to consider the self-weight.

So this is your one; this is the primary combination; without this we cannot design. Whenever we have to design for this load, we have to design for this we have to include the dead load also, but we do not know where is the structure going to be made; we have to know where we are going to make the structure, construct the structure, what is the wind speed, so for that we have to consider dead load, and live load obviously there, plus wind load. The other aspect we consider here the dead load,plus live load plus earthquake load.

I am giving this one a broad idea, and generally, we do not consider wind load and earthquake load in the same combination. We assume that your cyclone, and your say, earthquake will not occur simultaneously, and that is a reasonable assumption, because if we take care, both of them it is good, but we shall not get an economic design. So that is also another aspect we have to consider, safety is one part definitely, but other aspect also that we have to consider the economy also. So these are the combination. Also I am just telling in general, but there should be some other factor, all those things are there, that also we have to consider. Now, regarding the books - the books which one we shall we follow, what are the books we shall follow.

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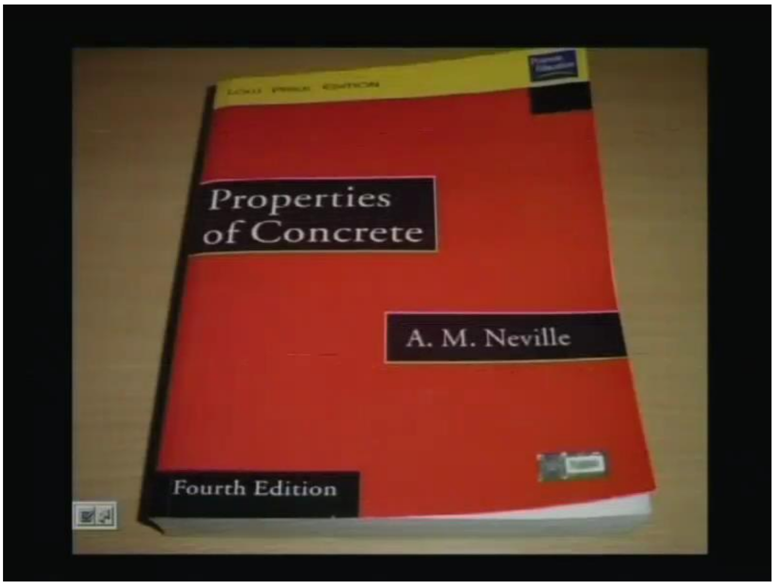

This is one book that Properties of Concrete by Neville. This one here you will get the properties of concrete, because you will get in your structural engineering laboratory also you will find properties of concrete that you will get it.

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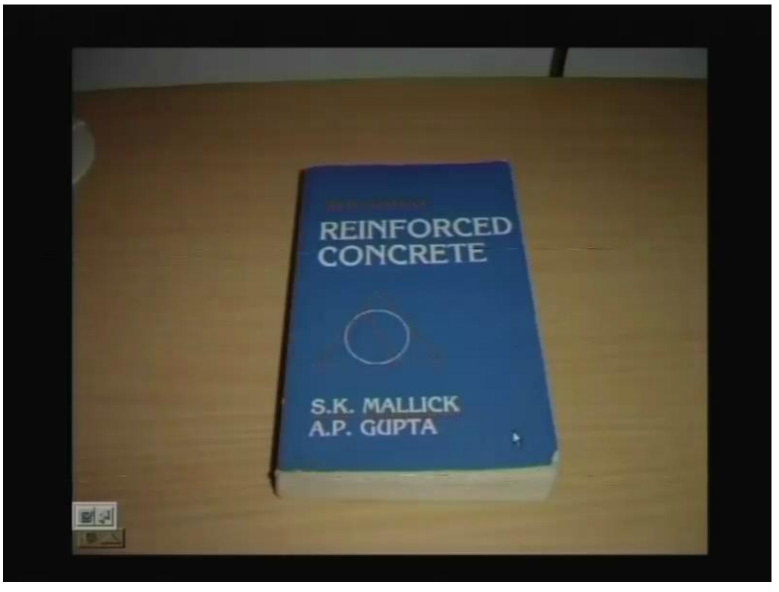

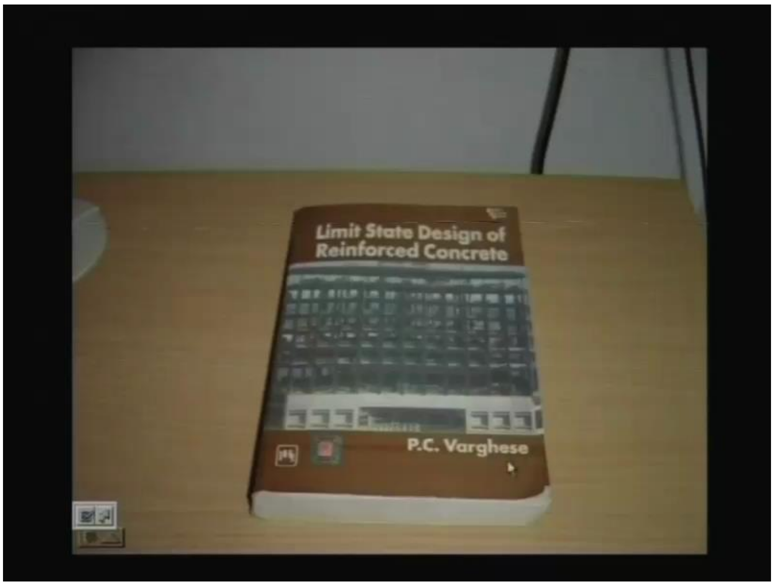

And then, this particular book, because I read this book in my student life also, and in my teaching also I am using this book, both of them actually faculty of our civil engineering department, that Mallick and Gupta, but mainly I shall follow this one; we shall follow this particular book; Varghese also in our departments.

There are so many books available in the market, and all are equally good, but I am familiar with these books. I am familiar with these particular books - three books, but mainly we shall follow this particular book P.C. Varghese - Limit State Design Of Reinforced Concrete; that we shall do it.

So, as a first part we can conclude this particular one after this, and we shall continue that all different aspects, in detail that materials we shall consider; materials we shall consider; and then, we shall go to different aspects of design; and finally, we shall come up with a problem, say design of earthquake resistance structures, that we shall come with one example atleast we shall at least go from analysis to design; that we shall cover up, and so that we can have the full idea of I would say reinforced concrete structures.

Thank you.