Design of Reinforced Concrete Structures
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Lecture - 03
Different Methods of Design of Reinforced Concrete Structures

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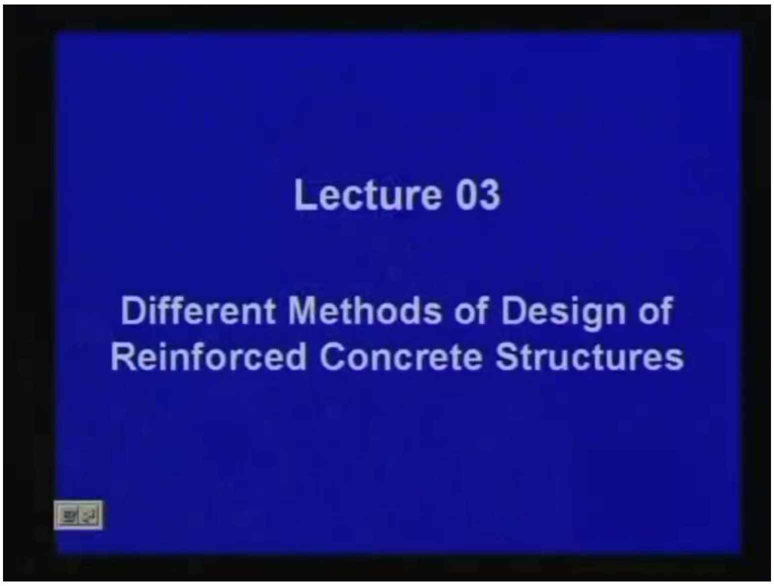

So, welcome to the lecture number 3, that Different Methods of Design of Reinforced Concrete Structures. Today, I shall give you the brief idea of the different methods. So far, we have done the introduction, why you are going for concrete, what is the limitation of the materials, show the permissible stresses, those things, and also stress-strength curve - that we have seen in the last two classes. So, today we shall start with the design.

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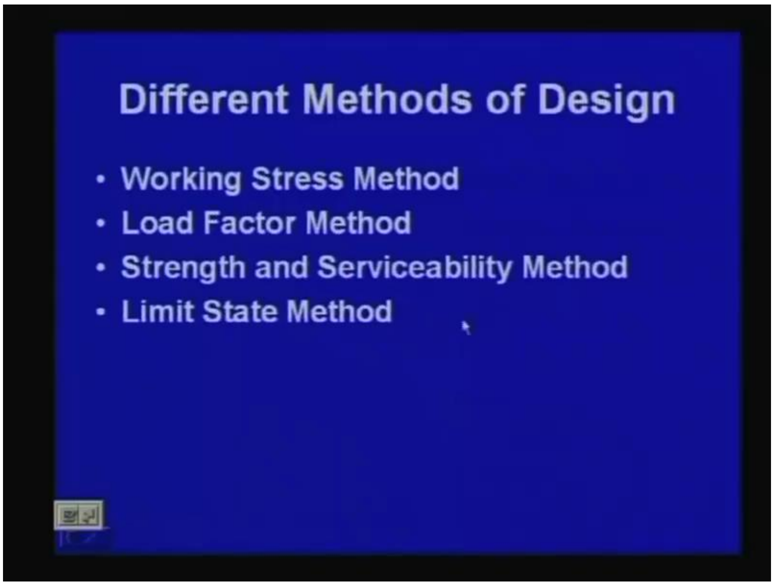

First, let us over view the different design methods. For that, one is called that working stress method. The first one that is the working stress method. Let me first give the list of different methods, then we shall come, and then finally, we shall come to the one, which one we shall study in this particular class. So, first one that is working stress method. There is another one, that is load factor method; we shall come again in brief each of the methods. Third one, the strength and serviceability method. We shall consider strength as well as serviceability. The first two we can say only we are considering strength, but for the third one we shall consider strength and serviceability both.

And finally, we have that limit state method; that is the one, which is the present day practice. We do this particular one, the limit state method, that we use it extensively for our design reinforced concrete design, and that, we shall study in this particular course. So, I repeat, working stress method, load factor method, strength and serviceability method, and finally, the limit state method.

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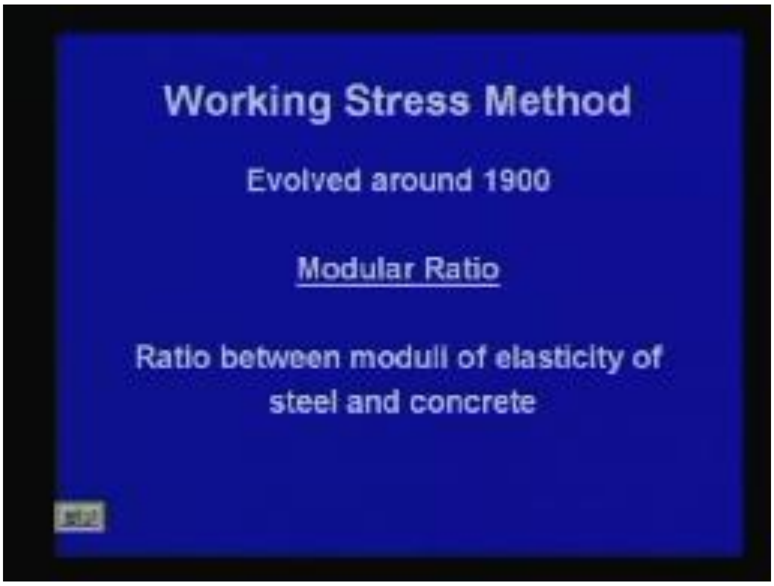

So, what is working stress method? This has evolved say around 1900 or the late nineties of the, or close of the, say, nineteenth century, and this is the basic concept of modular ratio. So, what is modular ratio? Ratio between two modulus, that elasticity of steel and concrete.

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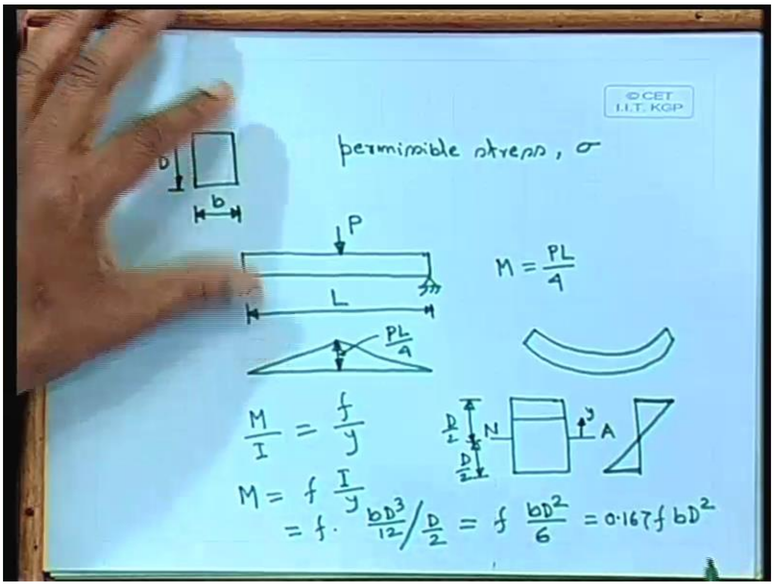

This is one, I can explain, this particular one, that we are considering, say, particularly, we are starting with the beam. We have to find out the dimension of say beam. If we have to find out the dimension of the beam, what we can do, let us forget the reinforced concrete for the time being; let us consider that we would like to provide a section, may be a rectangular, may be a rectangular, which is having the width b and depth D. We would like to provide this particular section for a beam. Since it is homogenous, so, permissible stresses at the top, permissible stresses at the top, and the permissible stresses at the bottom - both are same.

We are considering a beam where the permissible, that means, the section will fail with certain limit; maybe we can consider that one, say, sigma; permissible stress, say, sigma; that means, if it is more than that, then we shall consider the section failed; that is the thing we are considering here. So, what is the… and if we consider this one, this is the section of a beam; this is the section of a beam; we can consider a simply supported beam also. So, a simply supported beam. So, a simply supported beam having certain length, a span, let us consider L. So, we would like to provide this particular one. We can consider different kinds of load; we can consider say concentrated load at the centre; we can consider UDL; whatever the arbitrary load we can consider. So, what we have to find out what is the design philosophy, we have to find out the maximum moment.

The beam has two parts: one is that one that bending moment - that is the governing one - and shear force. So, for the time being, we are considering that only for the bending; that means, we shall check the bending, we shall resist bending only. So, beam will… so, whatever section we shall provide, that section will resist the bending whatever coming due to external load as well as including the self-weight.

So, considering that, if you would like to provide this simple section, say rectangular section, homogenous section, may be, say, made of steel, aluminum, may be made of wood also, we can consider. So, if we consider this particular one, then what we shall find out? For this particular case, we know, let us say that we are applying certain load to be more specific say P. So, bending moment M equal to P L by 4.

So, what we can do it here, we would like to find out… let us go little more specific also, that we will elaborate, the bending moment diagram will be like that. So, this is your P L by 4. So, we have to resist this particular moment, providing this particular section. That means we have to give certain dimension of b and certain dimension of D. b, generally it is governed by the wall thickness; generally not always. If you consider that any building, you will find out that beam or column that is projected from the wall, that means, we cannot provide that one within the wall, we cannot keep it, that is why you will find out that thickness is coming little more. But generally, it comes with the wall thickness or you can consider brick thickness. Generally, it comes say a width of the brick or length of the brick that is 250 millimeter, and wall thickness also we provide that, and we can also keep the beam, we always keep the beam within that particular 250, but sometimes if it is not possible due to other reason, we go a little more, but generally we keep it 250 millimeter.

So, this one we can restrict it; so, that means, we have another one that is D. Now, coming… since I have told this beam that is governed by dominating one that bending, we have to check that one whether we can resist that bending moment. So, what is the equation? Our equation is M by I equal to, say, f by uI or sigma by uI whatever it is. So, M is the moment, that all you know, I think from the your first year or second year class. So, M is the moment; I is the moment of inertia or second moment of area to be more specific; f is the stress; and y that where you are going to find out the stress.

If I would like find out the stress and where from it is let us recapitulate. If this is the section, due to this beam, we have in the top we have compression and at the bottom we have tension. If we consider, because this beam, that one will deflect like this, it will deflect in this way. So, we shall get tension at the bottom and compression at the top. Most of the cases, you will find out this type of nature of that, your say stresses, in beam. Only in cantilever you remember, cantilever it will be different. So, cantilever tension will be at the top and compression will be at the bottom. And that is why we provide main reinforcement; please note, main reinforcement, I am talking; that means, there is some secondary or some will also be there; that one due to other reasons; but let us consider only we are considering the main reinforcement or we say that, call it, longitudinal reinforcement. So, that one we have to provide in the top for cantilever, because tension is being developed at the top.

So, here if we consider this particular equation, let us recapitulate. We should have one neutral axis. And from the neutral axis, we will have that y, we are going up. So, at any point, we can find out the corresponding stress. Generally, the stress diagram comes, in the neutral axis it will be zero and it will be this one. So, we can find out the stress, which will be maximum at the edges on the outer side - at the top at the bottom. We shall find out that stress and on the basis of that we have to find out whether it is coming within permissible limit or not.

If it is say wood, it has a permissible limit; if it is say steel, it has a different value; similarly, for aluminum, it has a different value; for any material, each material has its own permissible limit. And that one, where, how we are getting that one? That one, we are getting from the stress-strain curve of that particular material. If we can find out the stress-strain curve of that material, we shall find out the yield strength; that where that material will yield. That all we shall consider, that one like concept, that is the failure part we can consider, for the time being let us say, and on the basis of that we shall find out the permissible limit, permissible stress, and that stress, obviously, it will be lower than the yield strength, because we have to provide the factor of safety.

So, if we provide say factor of safety, say one, then may be the yield stress we have to consider. If it is, say, 2, then half; if it is 3, then one-third. So, that way we consider in our design. So, now, we shall consider this particular one. This is the equation M by I equal to f by y. So, M will be equal to f times I by y, and we shall get it here. If we consider at the top, if we consider at the top, if we consider at the top, then f b D cubed by 12 and y is D by 2; y is D by 2, because we are considering from the neutral axis, we are going top, this is D by 2; and similarly, here also D by 2.

So, we have to find out the moment that is the one governed by that; that is the maximum limit; and we can find out here f b D squared by 6. So, this is the simple equation, and which, will come in our all the calculations. We shall consider this simple equation, we shall consider. So, we can find out even more clear way. So, I can say 0.16, let us say go up to 7 f b D squared. So, this is the equation we shall get it. Please note, M equal to 0.167 f b D squared; that is the one we shall consider and let me follow in the next page.

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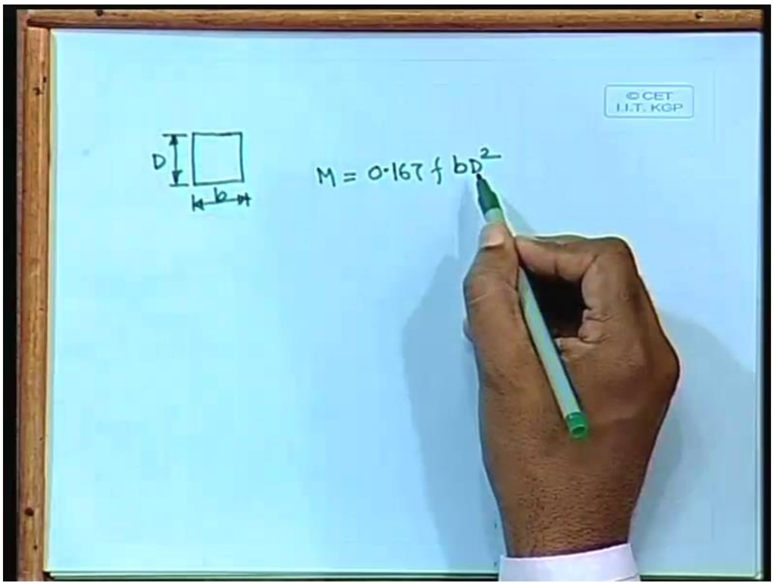

Just to recapitulate once more in this particular diagram. I repeat once more, D and b, and we have found M; M equal to moment of resistance we can consider 0.167 f b D squared. So, we can find out, say, the equation becomes very simple, handy, and we can find out the moment of resistance of that particular section. The section you are going to provide, if you know the moment, so you have to provide the moment of resistance.

What we can do it here, if I know f, permissible limit f, permissible stress f, if I know; b also, I am assuming b depending on your, say, practical difficulty, not difficulty, say from the practical consideration, you are providing b 250, 300, whatever you consider the width of the section you are providing. And so, we know everything, f and b. Only we do not know D, and that D - depth - we can provide on the basis of that moment.

In other way, there are two parts: one is that one, that you can design you are providing; the other way, let us assume b and D, and let us assume b and D, and find out the corresponding moment of resistance. And that moment of resistance should be more than the moment developed due to external load and self-weight. It should be moment of resistance of that particular section you are providing, that should be more than the moment developed due to external load and self-weight. That way also you can do it; that means, you can make a table also, with different sections, b and D different sections, you can make a table, and from that we can already compute those moment of resistance, you can keep it in a tabular form, and whenever you will find out that this is the external moment, so let us provide this section, because we generally do not provide whenever we are considering design, we do not provide, say, 175 or 177.2 millimeters; not like that. We always provide some regular number.

If we consider in the say reinforced concrete design, you will find 250 by 250, 250 by 200; 250 by 300, like that we will provide, in a multiple of may be 25 millimeter. So, since we provide, that means, we have very, very few options; not the huge options we have. So, for all the cases, we can keep ready our calculation, that moment of resistance for that particular section, and immediately we can provide. That way also we can do it.

And that now-a-days through computer, that only we do it; that means, we have computed the moment from any analysis software; let us choose this section; let us find out whether this one having more than that moment of resistance, more than the moment computed. So, that way you can easily provide the section.

So, now what we shall do it here, this one very simple; this one we are considering for the homogenous one, where top and bottom having the same that your, say, permissible stresses, but for concrete we do not have that case.

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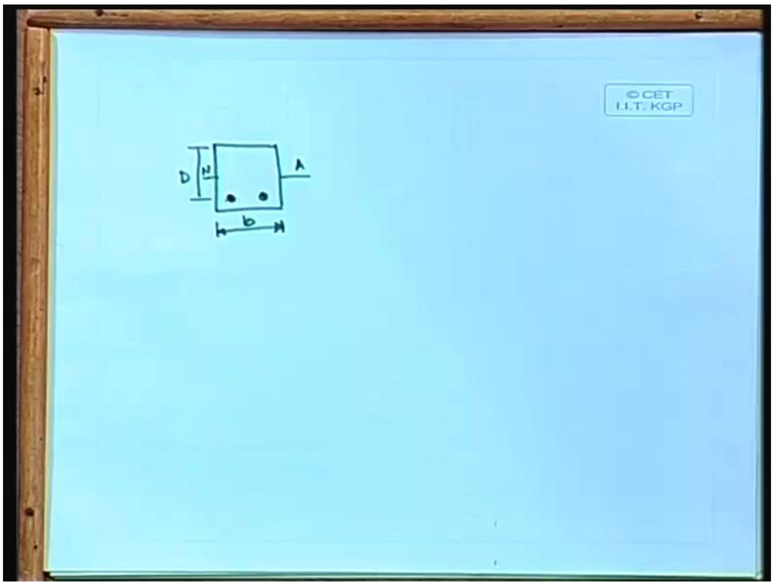

For concrete, we have, when we are considering concrete, we are assuming the tensile 1 at the bottom. So, this is the concrete, say section, and here, we are assuming that the concrete in the tensile part will not take any load, that beyond neutral axis, they feel there should be a neutral axis also, so it will not take any load. So, we have to consider this; it will be resisted by these two bars only, for this particular example. For that what we do? We use this modular ratio concept; that means, we know the modular ratio of the steel, that is modular of elasticity of steel reinforcing bar, and modulus of elasticity of concrete.

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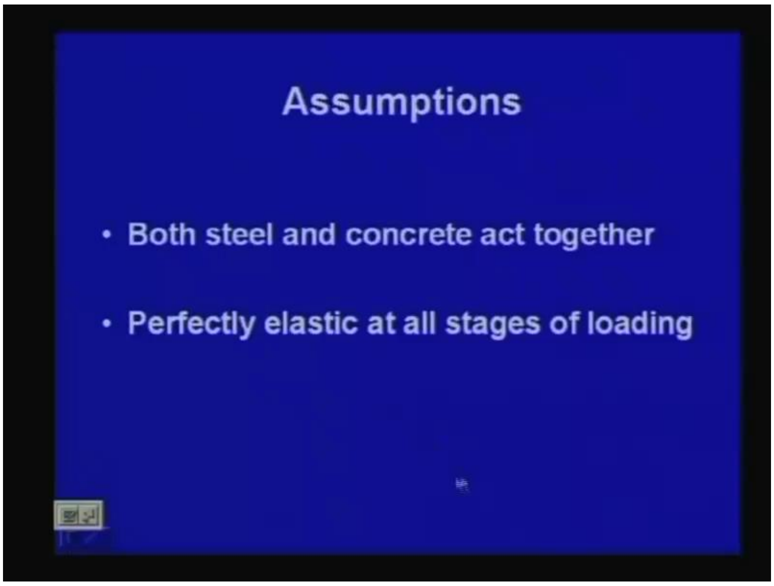

So, what are the assumptions? That both concrete and steel act together; it will work simultaneously; there is no slip; there is no slipping, that means, whatever you are considering that concrete and steel, the steel is embedded on concrete, and there is no slipping. Perfectly elastic at all stages of loading; it is perfectly elastic at all stages of loading - this one we are assuming.

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And we have to consider factor of safety. Factor of safety, we consider for concrete, about 3, with respect to cube strength. The cube strength that we have told, that cube strength, that cubes 150 by 150 by 150 - those cubes. So, from the cube strength, you will get it, that we shall find out, and we shall take factors up to 3.

For steel, we consider about 1.8, with respect to yield strength. So, for steel, the yield strength, so we have to divide by 1.8, and then, we shall get the corresponding, say, permissible stress in steel. So, that is the one, that much, that is the one freedom you are getting in your design. So, based on your experiment of a definite sample, we shall get the yield stress or cube strength; from there, we can find out the corresponding permissible stress.

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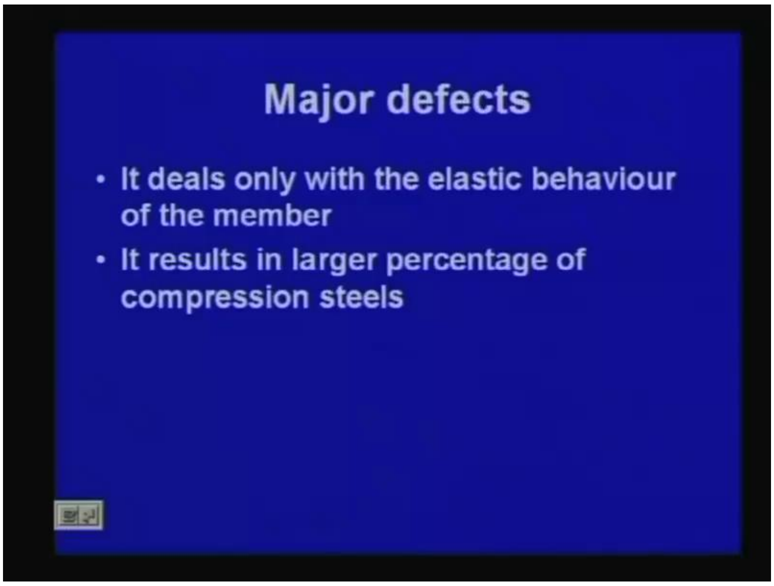

Now, obviously, each method has some defects. It deals only with the elastic behavior of the member; it deals only with the elastic behavior of the member. It results in larger percentage of compression steels. That one, let me elaborate. Sometimes, we know that steel only will takes a tensile part, tensile zone we are reinforcing with steel bars, to take care the tensile stress developed in the concrete section, but what we do it, sometimes we provide reinforcement steel in the compression zone also, that we provide. And this particular method, will result more compression steel, because that whatever the compression will be, because, that means, due to other methods you will get less, when you are telling that more, that means, it will be obviously; so that one we shall find out in limit state; that we can compare that particular method.

So, we are not going to detail of that particular one now, but we shall come back when we shall solve few problems, which has developed that particular theory, that time we shall come in detail.

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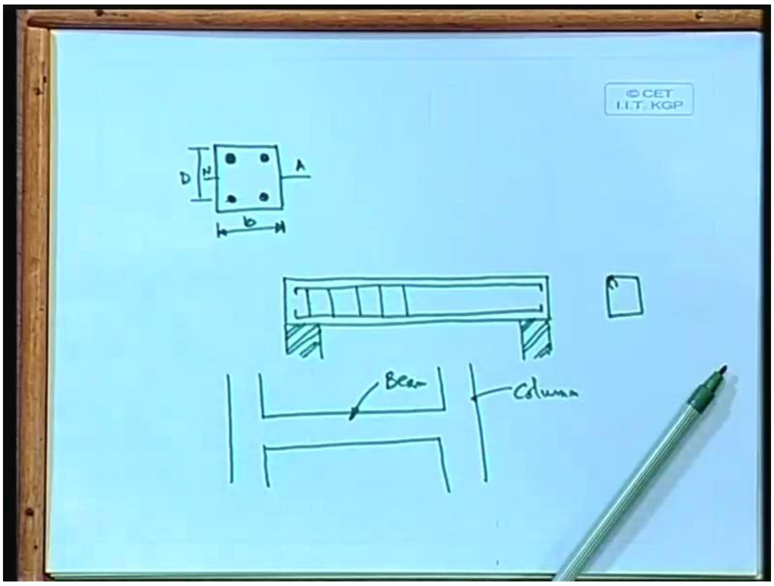

Only thing I would like to tell for this particular section here, we provide reinforcement, say if we reinforcement top also, that is you would get compression one; that means, in the compression side also you are providing reinforcement; in the compression side also you will provide the reinforcement.

Generally, what we do it actually, even if we provide the, even if we provide reinforcement at the bottom, we also provide reinforcement at the top also, though it is not required, but we provide this one to hold stirrups; the stirrups goes like this, that one will resist shear, because stirrup resists shear. It looks like this; this shear it looks like this. That one, when we shall design shear, that time we shall consider this stirrups, but what I mean to say, we also provide the reinforcement at the top, but even if we provide the reinforcement at the top - this longitudinal one I am talking - even if we provide that longitudinal reinforcement at the top, even then we have not, we have not actually considered in our design; we have only considered this one at the bottom.

So, that time, though it is in the compression zone, even then, we have not considered this one in our design; this one we are just simply keeping this one to hold in this stirrups. But compression steel is something different; generally, provide near the support.

See, if this is a support say your wall - brick wall; here is also a brick wall; compression reinforcement, because bending moment, since we can consider this type of support, just this is simply supported. We can consider this support as a simply supported, because the moment will be here zero, but we can consider, this is your say column, and this is your beam, this one beam, and this is column.

What I mean to say here, the support condition in this case, and the support condition in this case - two are different. That fixity of this one, that means, the way it is hold here, the way, and the way it is placed here - they are two different support conditions. Simply for this case, simply you are placing the beam on the top of the wall, but whereas, here you are fixing this one as if it is clamped. I can consider this one as a fixed case. So that means, moment will be developed at the two supports. So, you have to provide reinforcement, in the support; in both supports we have to provide the reinforcement. That means, you have to design for the support moments also.

Where as in this case, we have to design only for the span moment, because that is the only moment developed in this particular case. So, even if we consider the support condition with some arrow, all those things, whatever you have done so far, now you have to find out from your experience that what is the support condition you will consider, if it is say, if it is say the column, both sides column, it may happen like this also.

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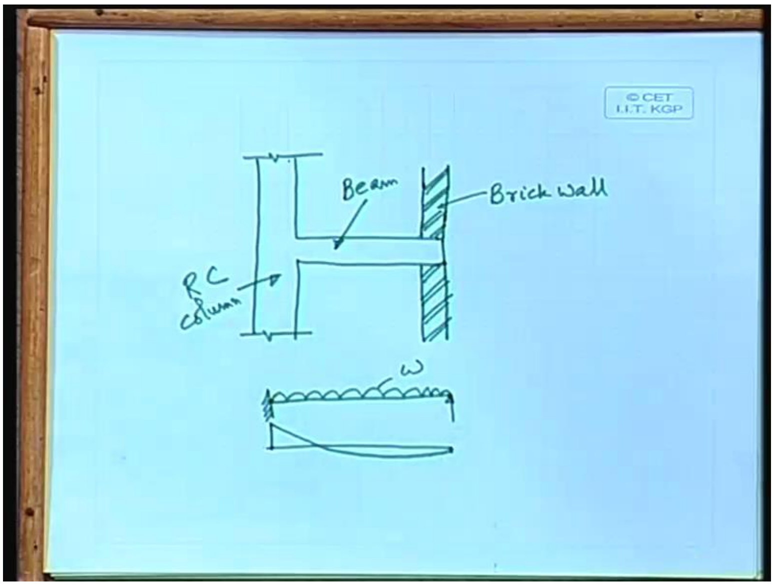

It may happen like this also. I can show you one more example. So, this is your say RC column; this one beam; and this one brick wall. So, what is the support condition, that what support condition should be suitable for this type of problem? Because it is again different. So, we can consider this one as a propped cantilever; that could be the more logical. We can assume this way; fixed and it is propped. So, fixed and propped. So, that could be the solution, and if we have say UDL; let us assume that we have UDL; UDL it may come if there are say live load as well as your no that brick wall, and that one, we can consider that say W shape.

So, we can find out the bending moment diagram. This is the nature of… this should be the nature of the bending moment diagram. Here this is zero, and we shall get support moment, and we shall get span moment also. And we have to find out what is the maximum moment between these two, and then, we have to design, first we have to design with the maximum moment, and then check with the other moment. You provide reinforcement with the other moments whatever found or developed in the beam section at different section; that is the general philosophy we consider.

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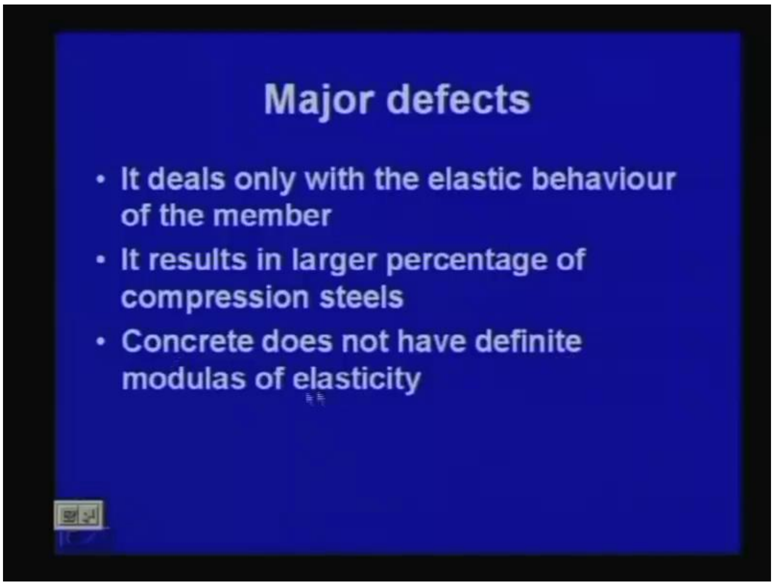

So, that we shall again come back to this percentage steel - on the compression steel - that we will find out what will be the percentage steel, how all those things that we can compare.

The other problem, the other problem, that is concrete, does not have definite modulus of elasticity. This is one big problem. Though we assume that concrete has a, say your, certain modulus of elasticity, roughly we can say, say 25000 Newton per square millimeter.

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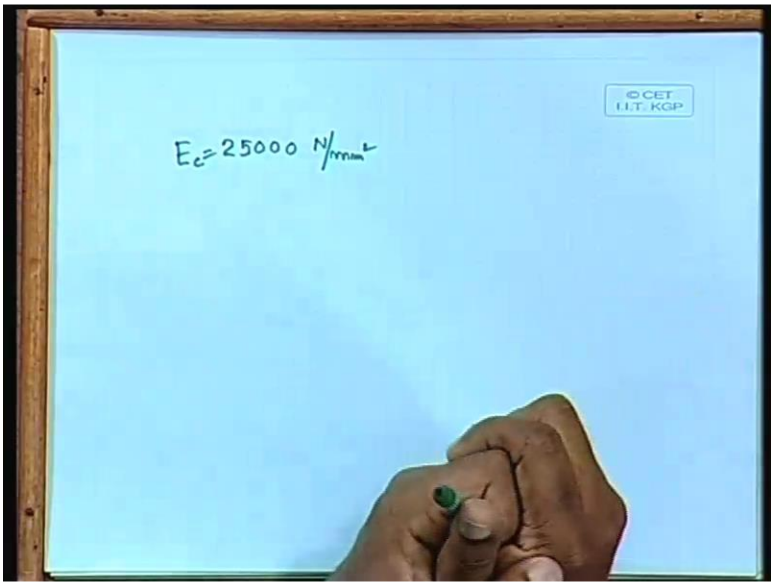

It is dependent on say your cube strength. For different cubes you will have different values, but approximately, I can say 25000, 22000, those values which will come that definite formulas that 5700 root over FCT, that we shall come back. So, that way also we can compute, that our what our code says. For the time being, I am not telling that.

So, this is because of say shrinkage, and creep, because it is a time dependent phenomena that particular one concrete behaves. So, that is why, because of that, the modulus of elasticity changes, because of particularly, because of say creep and shrinkage, that we cannot get the definite value; the one we can get it for is steel.

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We shall come back again with that working stress method, with a small problem, we shall come back, but today just in this particular class, let me tell you the overview of the different methods. So, one is the working stress methods, that one I have told. Now let me teach the load factor method. This was introduced in USA, in 1956; UK in 1957.

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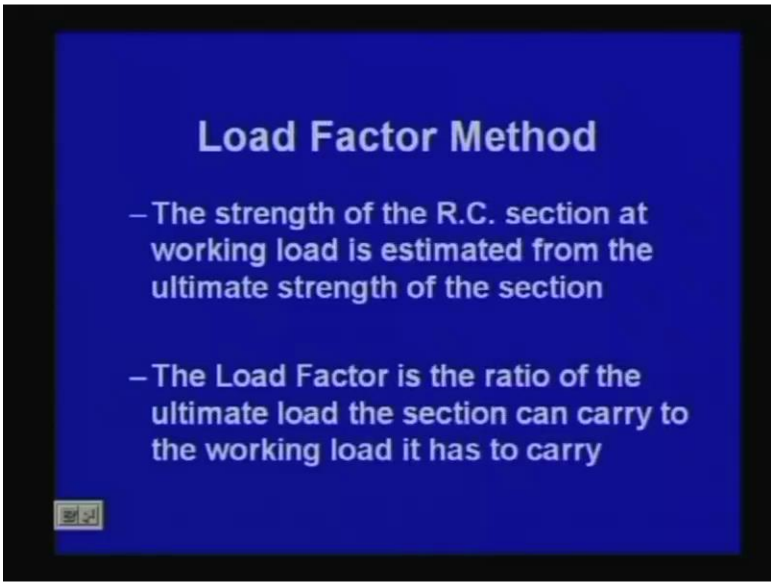

The strength of the RC section at working load is estimated from the ultimate strength of the section. So, we can find out the strength of the RC section, that one due to your working load, whatever load actually given, we can calculate from the ultimate strength of the section; we can find out from the ultimate strength of the section; that means, we are going approaching towards a non-linear part of the concrete; we are not assuming, no longer we are assuming the concrete that stress curve is linear. We are going, we are also taking care of the non-linear part of that concrete stressing curve.

Load factor is the ratio of the ultimate load the section can carry to the working load it has to carry. So, this is the one; that means, we can find out, from this particular load factor we can find out, that how much maximum it can take.

So, whatever that working load given, and whatever the ultimate load that it can take, from the ratio we can find out, and that is why you call it actually load factor. So, one is coming from the resistance of that particular section, considering the ultimate strength, considering the non-linear part of the stress-strain curve of the concrete, and from there, we can find out that load factor method, because concrete behaves in a non-linear one, due to our… that is the one, which governs the behavior of the concrete, and that is why it is worth considering that you would, say, that non-linear part of the stress-strain curve.

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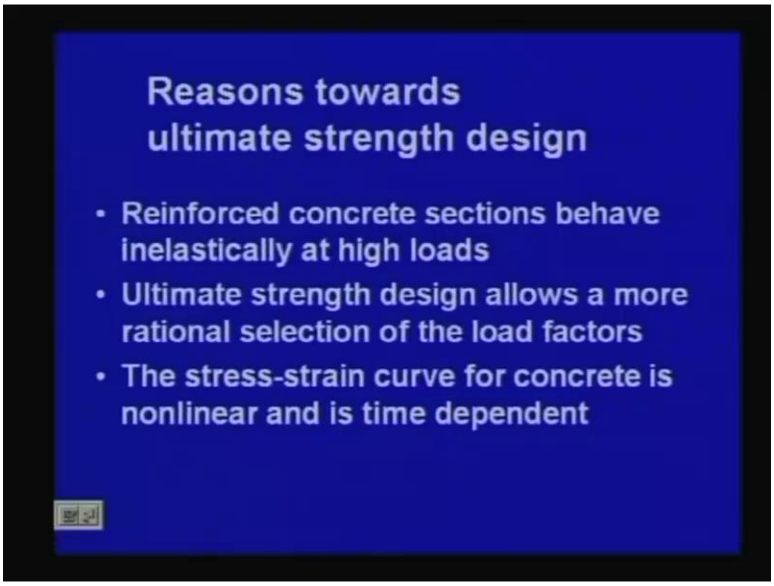

So, I have already told, but anyway let me repeat once more. Reinforced concrete sections behave inelastically at high loads. So, if you apply more load than it will behave in an inelastic manner; no longer it is elastic; and which is logical also in our consideration. And that is why, we find that this is the one, which we should consider. So, reinforced concrete sections behave inelastically at high loads.

Ultimate strength design allows a more rational selection of the load factors. So, what we can do, that means, if we know the ultimate strength of a particular section, so, from there, we can find out that how much maximum load it can take; how much maximum load it can take. And that is why we can say that; otherwise, say, that it allows us to go approaching the more closer one, that one is the maximum strength it can take. And the stress-strain curve for concrete is non-linear and is time dependent - already I have told - and that is because of creep and shrinkage only. And that one, we use second kind of empirical formula; we shall do that, we shall find out deflection, we shall find out due to creep and shrinkage, we shall find out, and that one, we shall do with our code, give some empirical formula, that we shall use it, and we shall find out the deflection.

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Now, because the ultimate load factor, the load factor method is nothing but we shall come back to the limit state; that is why I am just giving you a only a very simple introduction, because that is the one we are going towards the limit states.

Now, what we shall do it here, if sections are designed for by ultimate strength requirements alone, if we just simply consider the strength requirement with the ultimate load, that ultimate strength, the cracking and deflections at the service loads may be excessive. This is another, you can call conflict, you can say; we have just seen the philosophy, that we have started with the elastic method, then we have found, that concrete, if we consider it behaves in a non-linear elastic one with a high load. So, let us go for the ultimate load, because that one will give us more, better estimate of the strength of the section; that is the one we have to consider.

We are providing a section, if we say that this section will take this much of load, if we consider the modular stress-strain curve, then we can get the more that the capacity of the section will be more, and obviously, it is a reasonable and good estimate, but if we go to that level, then we are facing another problem, that it may happen, because we have assumed that concrete will not take any tension; steel will only take tension.

So; that means, here in the bottom, the crack may appear and crack may appear, and if the crack that one width, if we find out the crack opening, then also the user of that particular, say residents of that particular building, he may feel discomfort. If we have say excessive say deformation, I can say that it will not fall, but even then, if you move through the your say floor, and if it is a deforms, then also we shall feel discomfort, and that is the reason that we have to consider the not only strength as well as that it should be serviceable. And that is why your are considering that sales serviceability part. And so, if sections are designed by ultimate strength requirements alone, the cracking and deflections at the service loads, may be excessive, that may be excessive.

It is necessary to keep crack widths and deflections within reasonable limiting values. So, you have to provide, that is obviously based on experiments. If the crack width is this much or the deflection is this much, then we shall not feel any discomfort; the users will not be panicked. So, those thingsm it will not be scary. So, those things also you have to consider in your design; not only the strength as well as the serviceable condition.

So, these are the major two points what we consider, and we are we started with the strength, and also we are considering the other part, that is your serviceable part also.

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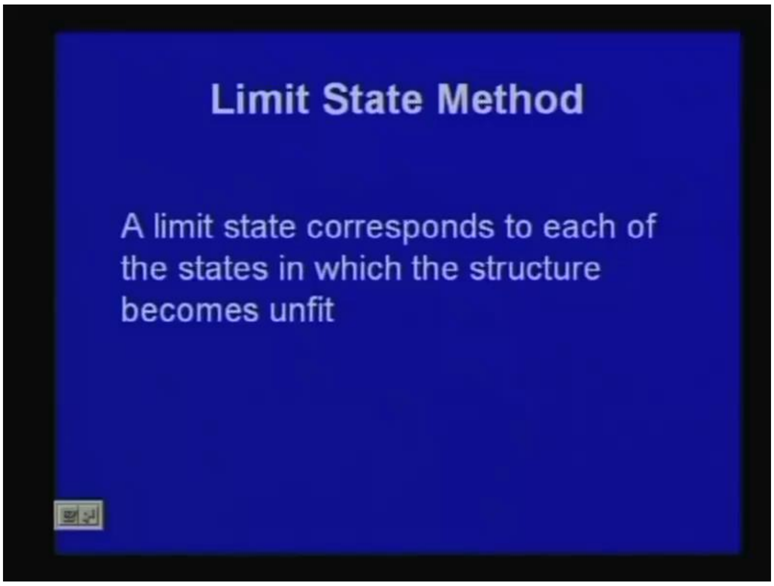

So, coming to the final one, and which we are going to study in this particular course, that is the limit state method. A limit state corresponds to each of the states in which the structure becomes unfit. So, we should have certain kind of… the one we have already told, that whether you are considering work stress or ultimate strength, that is one side; whether you are considering say crack width, deflection - that is another side; but the thing is, that these are two hands you have to consider, and each of them, we can consider that is your say limit state. So, limit state, it may be due to collapse, and limit state due to collapse, means we are talking from the strength point of view, and limit state due to serviceability.

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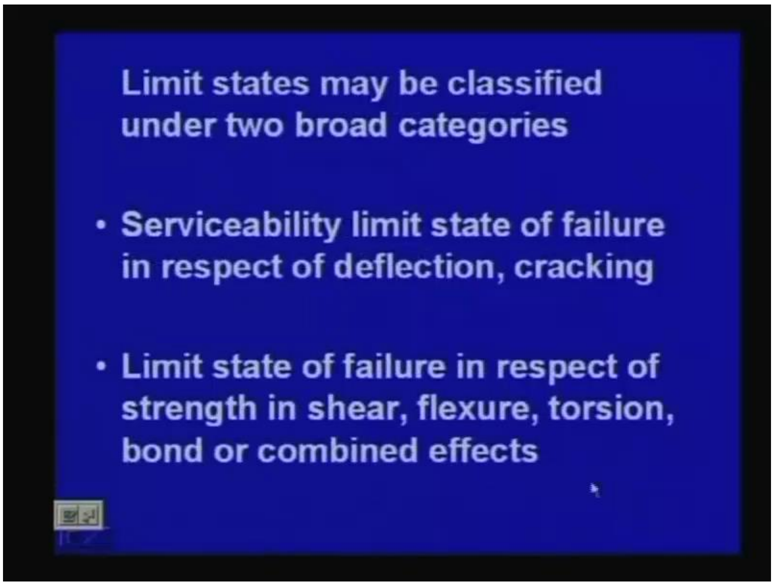

So, limit state may be classified under two broad categories. I have already pointed out. So, serviceability limit state of failure in respect of deflection, cracking. So, this is the one we consider is a serviceability limit state. The other one we consider limit state of failure in respect of strength, in shear, flexure, torsion, bond or combined effects that axial also will come, when we were talking, say your columns.

So, these are the called limit states; one part is from the serviceability point of view; other part is from the failure point of view or we consider that one say collapse - limit state of collapse. And that is those two things we shall consider in our case; those two things we shall consider.

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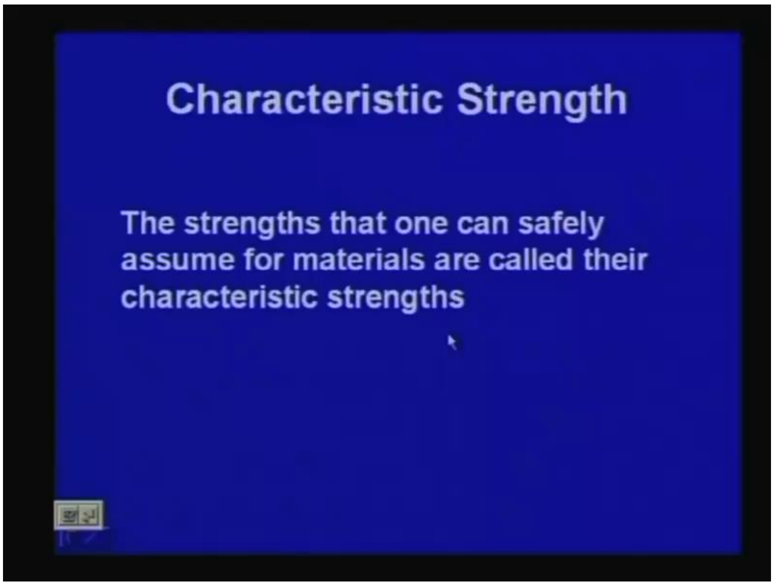

So, now we consider that characteristic strength. I had told already, that it comes from the cube strength, cube strength of concrete. The strengths that one can safely assume for materials are called their characteristic strengths; the strengths that one can safely assume for materials are called their characteristic strengths. So, this is the strength for each material it should have one characteristic strength; that is the maximum limit we can consider for that particular material. We shall not assume that one for our design, but we shall start from that particular, say, strength.

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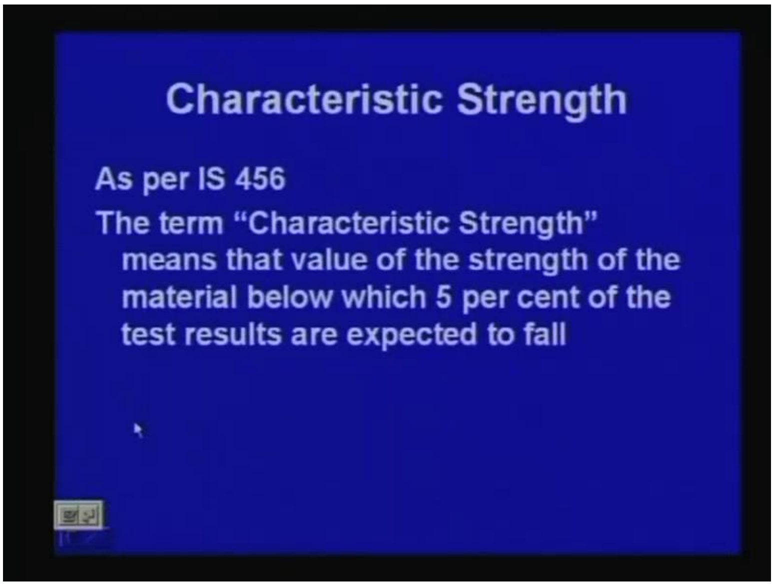

Now, let me find out in our IS 456, that our design code, what, how it is defined. The term characteristic strength means that value of the strength of the material below which 5 percent of the test results are expected to fail. That means, even if you consider a lot of say safety measurement all these things, even then also, that means, about 95 percent on the good faith, that way you can consider, and that is the value we shall consider our characteristic strength; that we shall consider.

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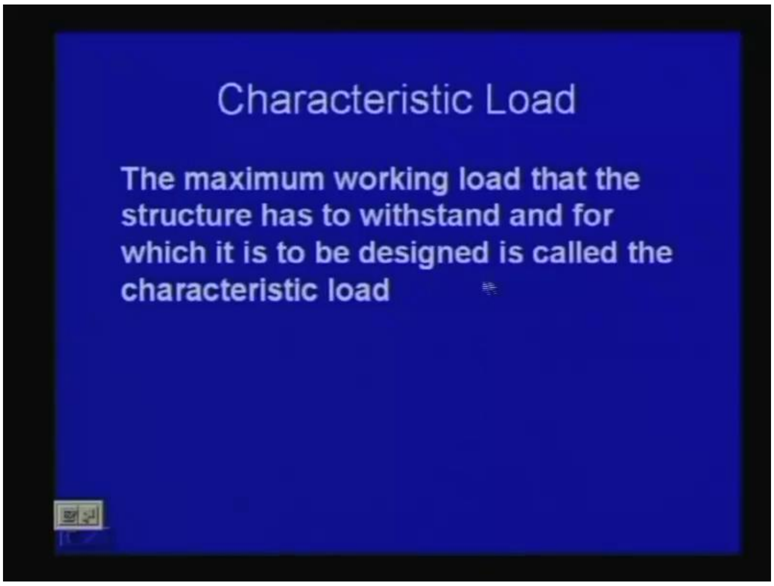

Similarly, we have the characteristic load also. The maximum working load that the structure has to withstand and for which it is to be designed is called the characteristic load. So, we have one part the characteristic strength, the other one the load point of view; that will be maximum safe load, maximum load it can take. So, that one also you have to consider. So, these are the two parts we have to consider in our design.

So, load and your strength - those two things only will give you that one proper design, because if you underestimate the load, that is dangerous; and if you over estimate the load, it is safe, but at the same time it is not economy. So, this is, these are the… and some times in the design of this we face problem also, because if the structure is not a usual regular one, sometimes the structure could be, say little bit say different, that the people used to not used to design it regular manner. So, obviously, there we face a lot of problems - what should be the design load. That particular case we can consider.

Say, for example, I can give you one example, we have done say ISRO, that they are having one that second launching pad, and they are having two arms - they call it cryo arms - which is holding the vehicle - the rocket vehicle - and that is 18 meter. You can imagine the 18 meter. The cantilever having 18 meter. And this one will be just removed, immediately that when the zero position will come, the zero time, and it will go to this limit within 3 seconds. So, and then, the vehicle will start moving up. This is the one that, obviously, it is not a standard design, though it is made of steel, but it is not a standard design. So, what should be the load? What should be the load? And also not only that, it is dynamic. You can imagine that one, that immediately that when that minus 10, minus 9, in this way and when that zero will come, then immediately it will just simply move to this level, and that you have to do it within 3 seconds. We have just last year only we have completed that work, and so you can imagine that even you know the material properties, lot of things, but you do not - what about the loading, because there loading one can argue no loading will be this much the loading will be other one.

So, you have to consider here the dynamic analysis also; the dynamic analysis also you have to do it; and from there you can find out what is the load, you can find out. When we shall come back to your, say earthquake resistance, design of earthquake resistant structures, in the later part of our of this course, that time I shall tell you that, what is that dynamic load, that we shall discuss in detail.

So, the load also, another important factor in your design. So, according to IS 456, what they have mentioned, the characteristic load, means that value of load which has 95 percent probability of not being exceeded during the life of the structure.

So, even then, we are considering one limiting value, even then, we are assuming that few cases it may go up, it may cross that particular limit, that is also possible. So, that way we are assuming that your say load.

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So, what are the different loads? The just to summarize the thing dead load, live load - that I have already told, wind load, earthquake load. So, these are the… there are so many other loads also we will may come, but these are the four loads generally we consider. Even if you consider say the leaves of that the tree - tree leaves actually accumulated on the roof - that one also sometimes you may have to consider; that may be it is unusual, but some time also it creates problem. So, because this is coming that with the water, and it will be thick, that it is under, people they are not going to check it in a regular manner. So, may be 5 years something like that it may go, but it may happen some other problem also.

But anyway, we shall consider in our case, that these are the four loads we shall consider.

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Actually, I am developing one program actually based on that, that one I have given a name also. So, that one, depending on the four loads - dead, wind, earthquake, and live load - the program actually it analyses as well as design also. I shall try to give it in a.. that I shall make it a little bit say good at least. So, that you can also use it.

So, on the basis of that, that program actually I am developing, and this one, we use it that one analysis, and also it will show you the deformed shape, and also you can get the bending moment, shear force, and then, you can design your section.

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The partial safety factors for load. So, factored load, we do not only check the load, whatever load we are getting, that is your that load whatever is coming, in our limit state design particularly what we do, that load multiplied by certain factor, that one will give you the factored load or the design load. So, when you will design the structure, the load which is coming, you multiply with certain factor, that one will give you the design load, and then, on the basis of that, you have to compute moment, shear force, all those things.

Or other way you can analyze the one with the actual load, and later on, at the time of design, you multiply with the factor given for different load, and do your design.

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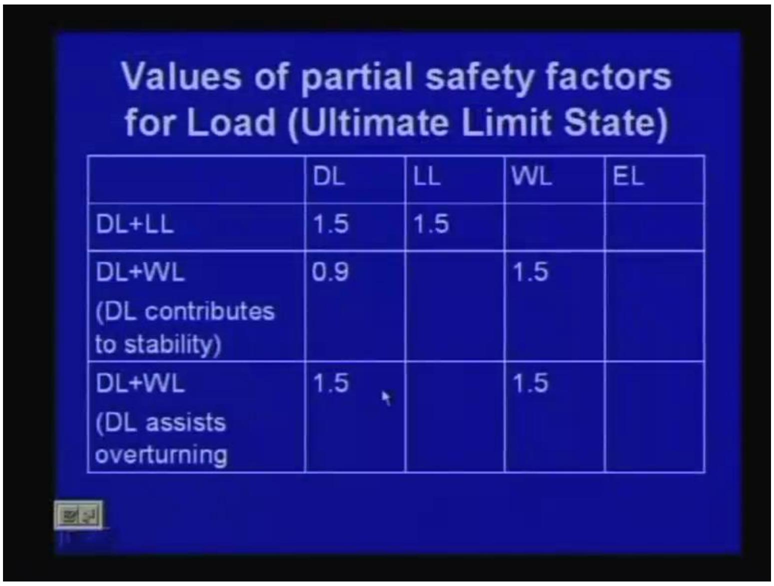

And these are the different values. There are different combination. If we considered say dead load and live load only, then you have to multiply that load with 1.5 onward; dead load means, say your say slab, if you consider slab, the self weight of the slab you have to multiply it with 1.5; and live load also whatever you are getting, that you have to multiply it with again 1.5.

If it is due to say.. if you consider dead load and wind load, then, you consider that one dead load contributes to stability, when you are considering that aspect. So, you are assuming little less, on the stability, because as if that… so, that it will be more you are considering from the safety point of view, you are in the other side. I mean to say, that means, if you take less dead load, so from the stability point of view what will happen, that means, that wind is more, so that means, it becomes say unstable; it may be unstable.

So, that part you are considering, that is why you are reducing that load. And wind load that you are even multiplied with say 1.5.

So, similarly, for dead load and wind load also, we are having this one, which shall come in detail, I think there is no point of discussing, just because we shall again come back in detail at the time of say your design.

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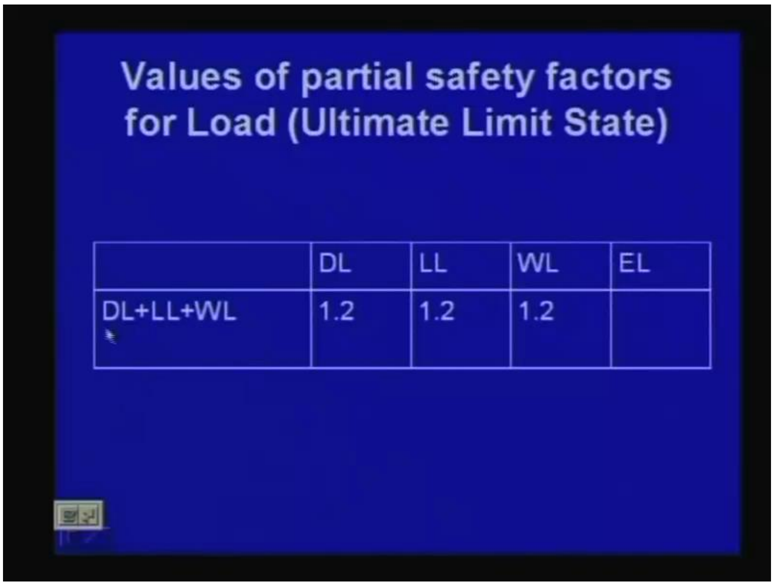

	DL	LL	WL	EL
DL+LL+WL	1.2	1.2	1.2	

Just to give you just an estimate that how that factor comes. Now, we can have dead load, live load, and wind load also, when we consider that, then we reduce the value 1.2, all of them, it comes 1.2

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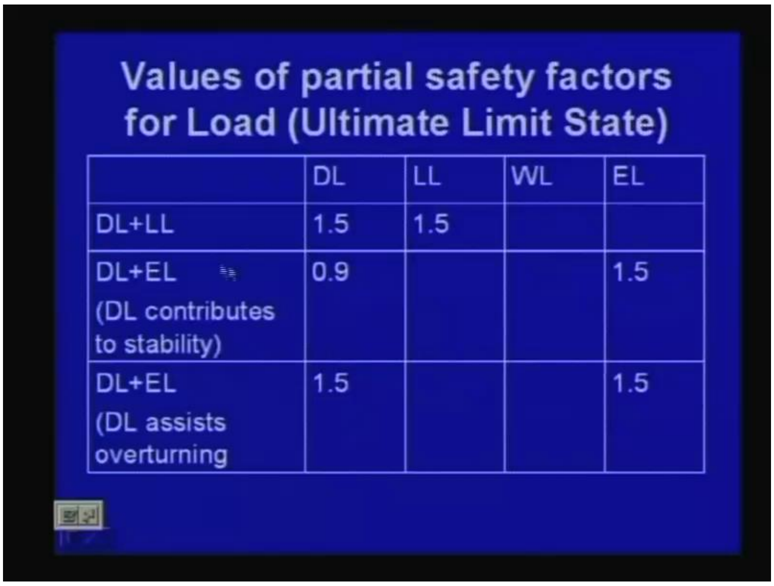

	DL	LL	WL	EL
DL+LL	1.5	1.5		
DL+EL (DL contributes to stability)	0.9			1.5
DL+EL (DL assists overturning	1.5			1.5

We come here for the similarly, for the earthquake load also, the similar fashion it is the almost same thing, similar fashion; that means, we consider wind load and we consider earthquake load separately, but that the combination comes in this manner.

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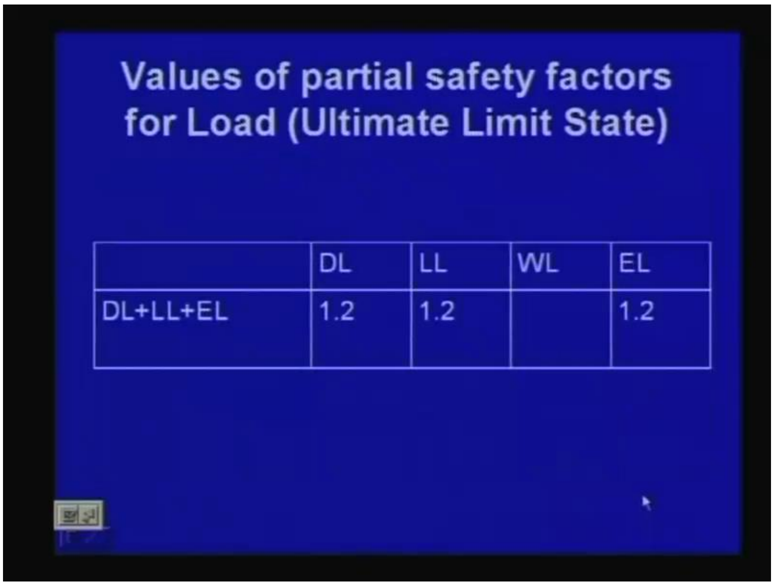

And similarly, dead load, live load, and earthquake load, we consider.

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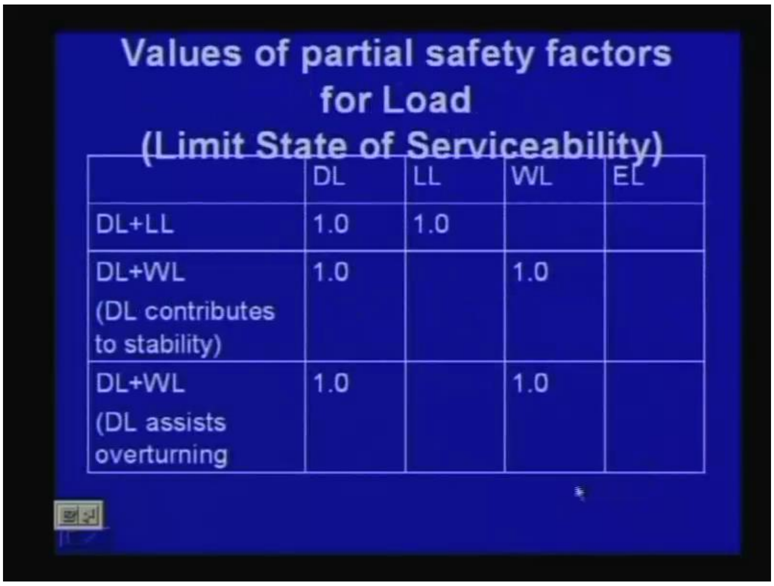

And this is for serviceability. Whenever we consider serviceability, I mean to say that when we consider for, say cracking and deflection, that time we do not multiply with any factor, the we just simply take the same that load.

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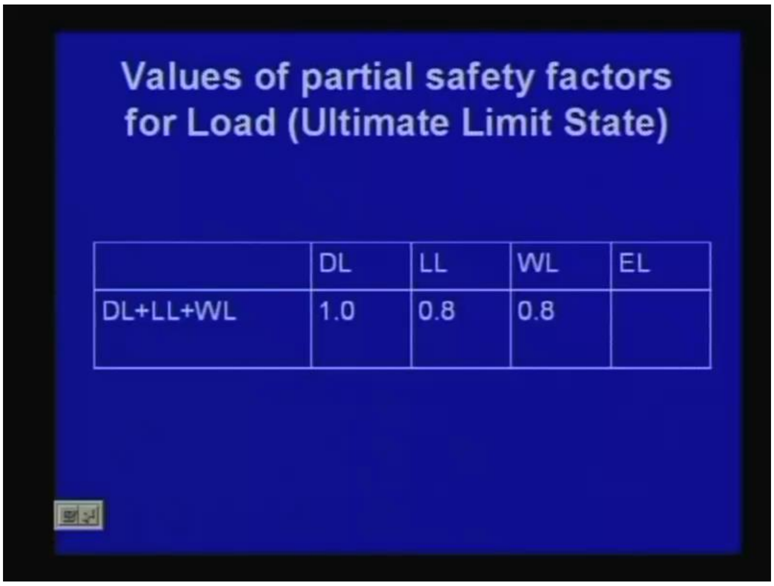

And this is your say for dead load, live load, and wind load, that we consider.

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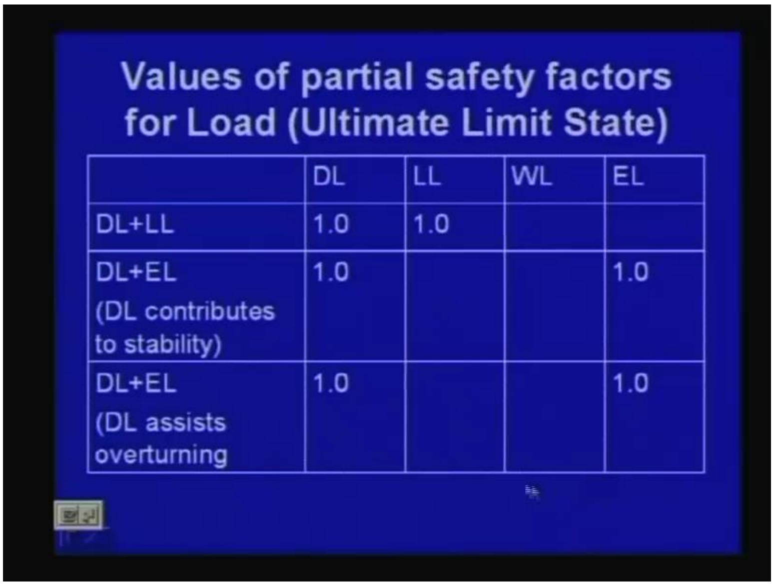

And the other one, when we consider, say earthquake load, we consider. So, there is no point of coming to all those things in detail, because whenever we shall solve the problem, we shall come to this values. Whenever we shall solve problems that we shall come, and that time it will be easier to remember also. So, we shall, the first part of our lecture, let us conclude here now.

Let us take a five minutes break and then we shall come to the next part.