Design of Reinforced Concrete Structures
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Lecture - 02
Materials

Well, so welcome to the second lecture of Design of Reinforced Concrete Structures. We shall consider in this particular class that materials, because that is the part we have to consider – materials, the properties of materials, particularly concrete and steel as reinforcing material - that we have to consider, and then only, we can go for design. So, we should know the limits of the materials which we are going to use. That is why it is very important to study materials.

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As I had told in the last class, that concrete is made by mixing cement, fine aggregates, coarse aggregates, and water, and the proportion also I have shown, it is just as a schematic one, that coarse aggregates, sand cement, and water. I have already told in the last class, just to repeat this one, just one or two slides.

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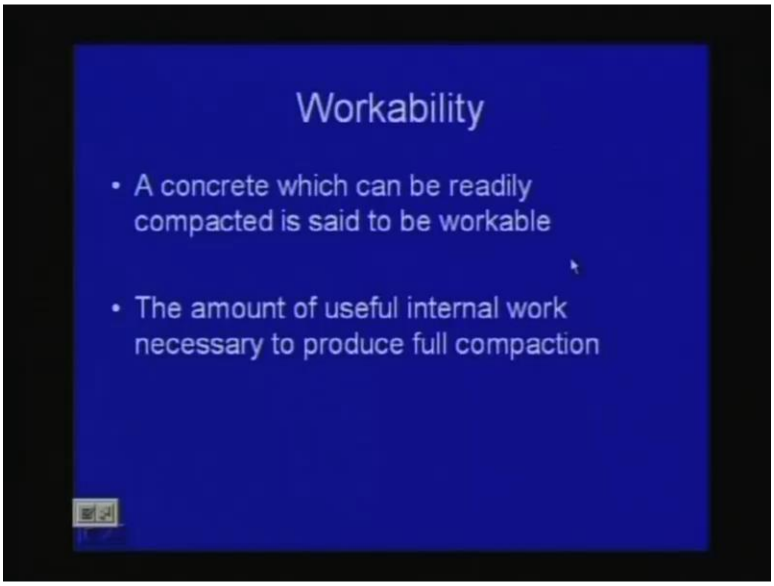

We shall come to the one that is called the workability. Workability that means the concrete, the fresh concrete or we call it say green concrete, that one, that it can flow. You can mix it and you can put it in any way you can put it, and you can get any shape, that concrete. So the thing is that we can say that it should be workable. If you add less water, then it will be almost, say, dry. So, then, what will happen? That you cannot get the required shape, it may just simply, rigidly it can break. If you have more water, then it can flow like fluid; then also it is difficult to get the proper shape. So workability is very, very important, so for the concrete that casting consent. So what we say, workability, a concrete, which can be readily compacted is said to be workable. The amount of useful internal work necessary to produce full compaction.

The other way we can say that, amount of useful internal work, we mean to say the between that aggregates, whenever you are compacting that one - that concrete, so between the aggregates there is some, say friction, say internal friction, between the aggregates as well as the frame work that where you are placing the concrete, for that also you need that internal friction, that you have to work in. So for that, how was that internal work you have to do and on the basis of that also you can say that workability.

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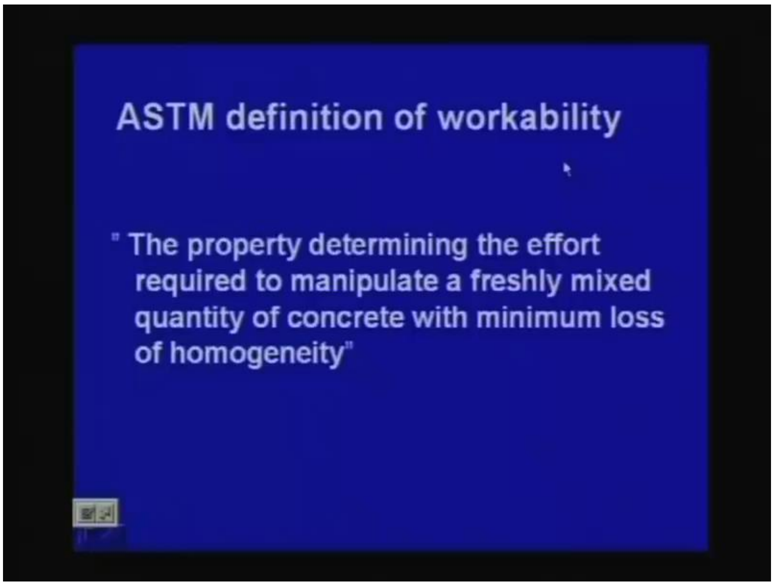

Now according to ASTM definition, this is a very, very standard that code; definition of workability - the property determining the effort required to manipulate a freshly mixed quantity of concrete with minimum loss of homogeneity. So that means, this particular one, whenever we are talking this one, I think we can put it here… So this one, what we can do actually, that for concrete, the coarse aggregates… for coarse aggregates, that you can make it, so that it will be, it will still be homogenous. That means the one portion, that your concrete will not be there, that coarse aggregates. The other portion, sand, all those things, so it should be, that it should be homogeneous, that whole concrete; that should be there and that is according to ASTM definition.

We can go to that is another one that American Concrete Institute; they are also having their another definition, that we can find out.

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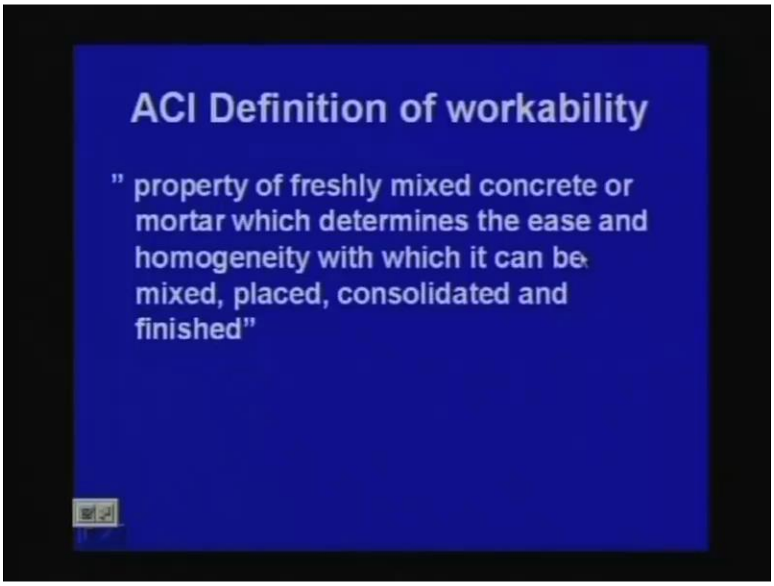

So this one that ACI definition of workability, property of freshly mixed concrete or mortar, which determines the ease and homogeneity with which it can be mixed, placed, consolidated, and finished. So this one is the definition of that workability according to ACI.

So this is, these are the two important bodies in our, say, so far that materials is concerned for any standard. Actually, ACI as well as your, say, other one we can say. So you please… I repeat once more, so that it will help you to note down.

So property of freshly mixed concrete or mortar, it can be concrete as well as it can be mortar. Concrete means you are having say cement, sand, and coarse aggregates. And mortar means cement and sand; that is only fine aggregates. So these are the two things that mortar; mortar we use for, say, placing, say, bricks. So that is one that where we use a plastering - there also, we use mortar which determines the ace and the homogeneity with which it can be mixed, placed, consolidated, and finished.

So, finally, you will get the finished product. So that one you can consider; that one workability; so it is very, very important one that. So far that concrete concerned, that workability is an important property. So that and also it is required, say, there are, say, so many bars. In the last class, I have told you that bars, there are so many, say, your steel bars are there, and that you have place your concrete, that coarse material, it will go in between those bars. Otherwise, if there is a void, then concrete will become weak, and the whole structure will become weak. So, that is why that is very, very important one, that you have to consider, by which you can consider that workability.

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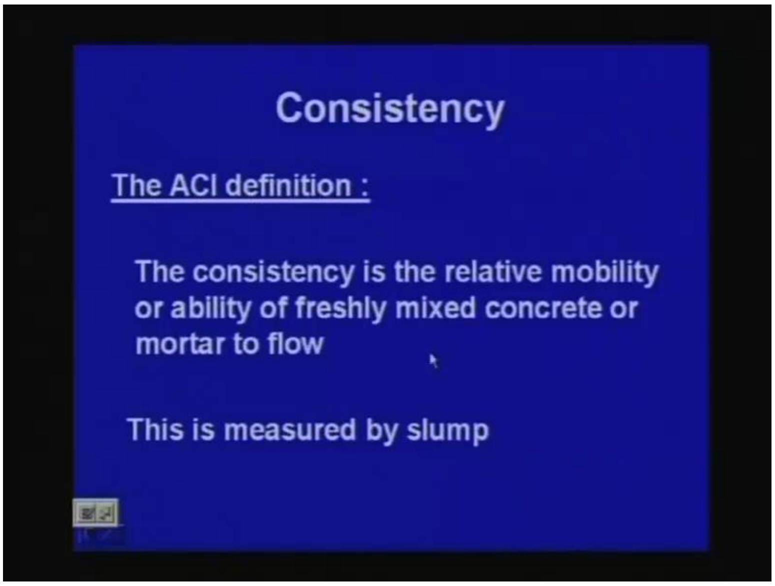

Now another part is called as consistency. That ACI definition is that consistency is the relative mobility or ability of freshly mixed concrete. Just a minute. Consistency is the relative mobility or ability of freshly mixed concrete or mortar to flow. This is measured by slump. So, other way also you can consider that we can find out the consistency of concrete we can find out, and that, how we can measure the consistency of concrete that we can find out by slump.

Now what is slump that we have to find out. So what is slump, that we have to find out. So I repeat once more - the consistency is the relative mobility or ability of fresh mixed concrete or mortar to flow. So you can find out just getting the consistency, we can find out that how we can make it workable.

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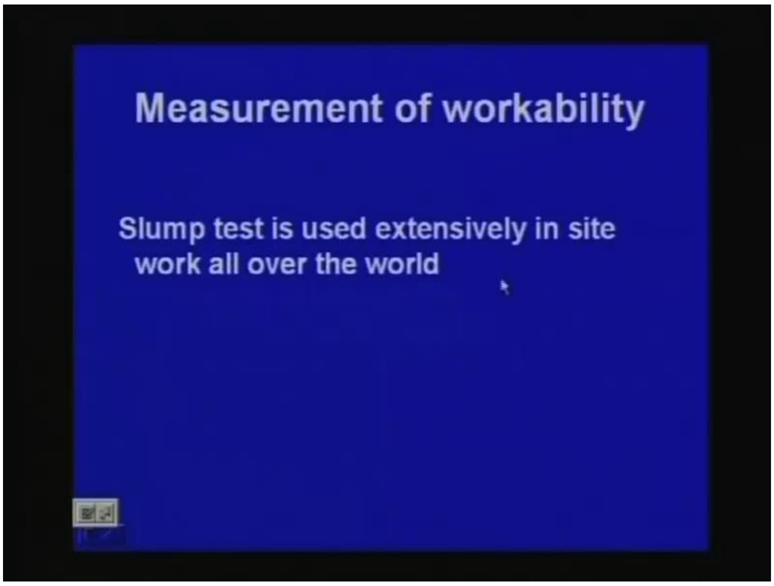

The other way indirect way of… indirect way of measuring that workability. So we can measure by slump. So measurement of workability that is by slump test.

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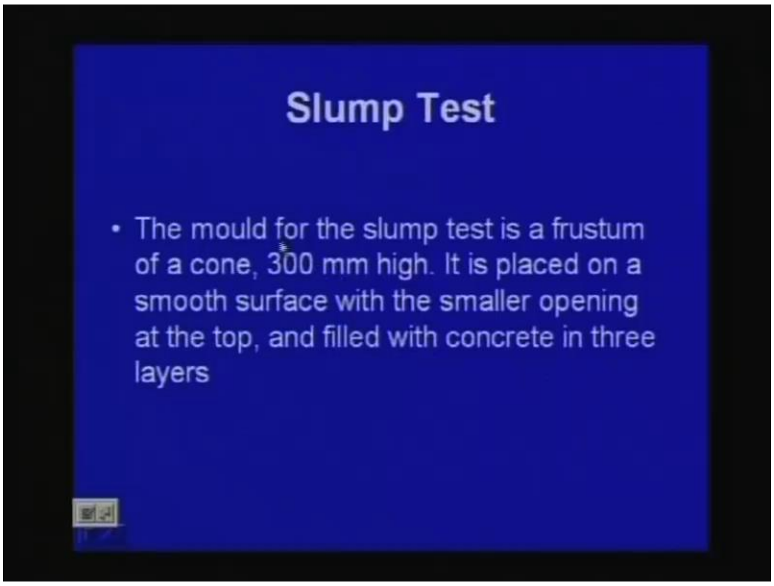

It is used extensively in site; we are talking in site; after all, the concrete is cast in the site itself. So we have find out the workability, that you have to find out from that, your say, slump. And this is the one - that slump test - is used extensively in site work all over the world. So we use it extensively, this particular one, that test - we use it.

So, what is the slump test? There is mould for the slump test is a frustum of a cone 300 millimeter high. It is placed on a smooth surface with a smaller opening at the top and filled with concrete in three layers. I repeat - it is a mould for the slump test; the mould for slump test is a frustum of a cone 300 millimeter high. It is placed on a smooth surface with a smaller opening at the top and filled with concrete in three layers. So you can go that. Let us see that what it exactly it means, because I think one photography is sufficient to tell lot many things.

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So this the one that cone - the frustum of a cone - which is extensively used in our structural engineering laboratory. So you can find out that, your say cement paste, all those things are still it is there. But what is this one? You can find out this cone, which is having say 300 millimeter height and there is an opening. And at the bottom also, we are opening and we can use these two handles. What we do actually, we pour concrete here in three layers. We pour concrete in three layers, and then, we just place it here, and then, we just simply lift it. We lift that one, and then, concrete will come out, and from there, we can find out. So let me tell you this way.

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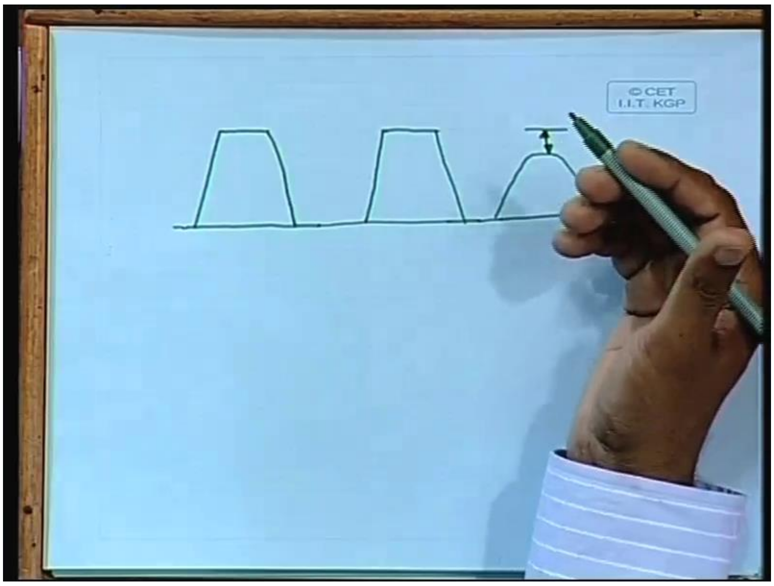

So, this is your slump cone; this is a smooth surface - a slump cone. You are putting concrete through this in three layers you have to put. And we have to make 25 strokes; that we have to make. Each layer is stumped 25 times with a standard 16 millimeter diameter steel rod, because we have to make, we have to do some kind of standardization. Why we are doing that? We are using 16-millimeter diameter steel rod and we have to just hit it like this. We have to hit it like this; like this we have to hit it that bar, that 16-millimeter dia bar. So you place concrete and then you hit it 25 times. That is one layer. Then, again, you put concrete, again another 25 times; and again, you put the third layer; and then you finish it off; that over this particular one you finish it off; over this, you just finish it of this particular one.

Now, when it is done, you just take out with this two handles. You take out this cone with those two handles, then what will happen? You will find out if that concrete, that one, say the proportion is such that almost say solid, then what will happen? You may get the same type of cone - frustum of the cone. If the concrete, that water that one would mixed properly, so that means you can get the shape even if you take out that one. So, then, we can say that we are having this particular one, that means, we are having zero slump. There is no slump. It is not coming down. We can say there is no slump, but it may happen like this also. It will go out that means it will try to flow. Then, we can say, the remaining one - this particular one - that is the slump, it may be 5 millimeter, 10 millimeter, 20 millimeter; that means more slump, more workable. That is more slump means, more workable; that means that you can work with easily, but you do not know whether you can achieve the strength or not; that is a different issue; we are talking the regarding workability of concrete. That means if we get the more slump, then we can say that we are having more slump, means more workable.

Now these particular one, whenever we are talking, this particular one, so that is why for design mix, when we have to mix the design, then you have to specify the slump also; that how much slump do you need. That is one important criteria, because of that what you have to do actually, we generally consider that one is called nominal mix. I have told, say now, it is M 15; now it is M 15 is actually not allowed as per IS 456-2000. The minimum grade permitted that is M 20. M 20 means 1 is to one and a half is to 3. Similarly, M 25 means 1 is to 1 is to 2.

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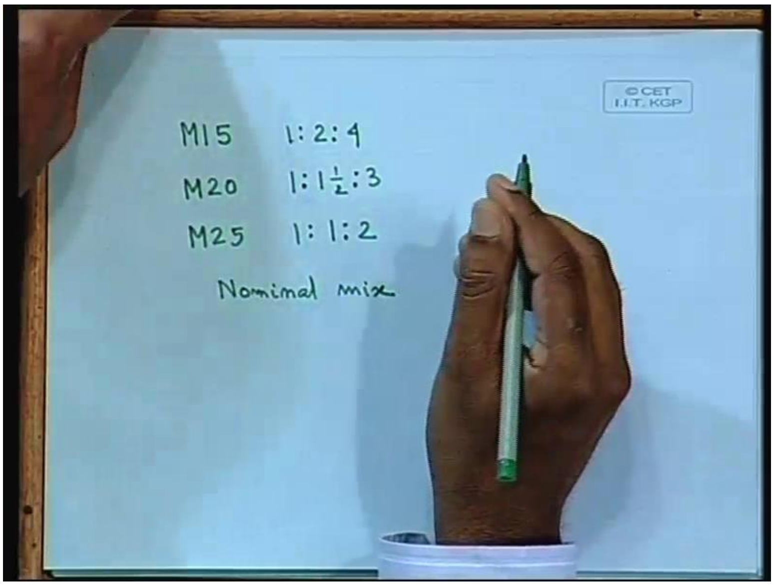

So if I say, just let me repeat - so, initially, that M 15 was there; that is 1 is to 2 is to 4; 1 cement, 2 sand or fine aggregates, 4 coarse aggregates. M 20 1 is to one and a half is to 3. M 25 1 is to 1 is to 2. These are called that nominal mix.

What we shall do actually, this one irrespective of that, say grade, of say your coarse aggregate, fine aggregates, all those things, we can just simply use this one, cast it and we can do our design.

But other alternative is called that mix design. You can design the mix that what proportion it will come closer to this one for a particular case, but we can exactly, we can design that what type of coarse aggregates you are using; what platforms which - from which - you are using the sand; the sample you take it; the coarse aggregate you can take it. Because you do not know the proportion of coarse aggregates. It may be different. It is not according to say IS. It may be something different. So those proportion whatever available… it is not possible that whenever you are doing the bulk casting, it is not possible to go that, make it according to say your IS specification. So whatever is available, that coarse aggregates, on the basis of that you have to cast it.

So, that means, you take the sample of coarse aggregates; you do the civil analysis; you find out the proportion. Similarly, for sand also; similarly, for cement also you find out the cement test; and also you have to specify the slump, that how much you need that workability. So on the basis of that, one can design, and one can achieve the target strength, and that could be used for your that, actual, say your design, and actuals at site; that we will do it at site. This one not required for design, because design means we ourselves say ok M 20, but before that, we should know where we really stand; that is why I am keeping this particular class for materials.

So, coming to the particular point. So we have got this particular one that we can do the slump test, and so what I have already told these things, I have already told, so I shall not repeat it. And you can see that the description of workability.

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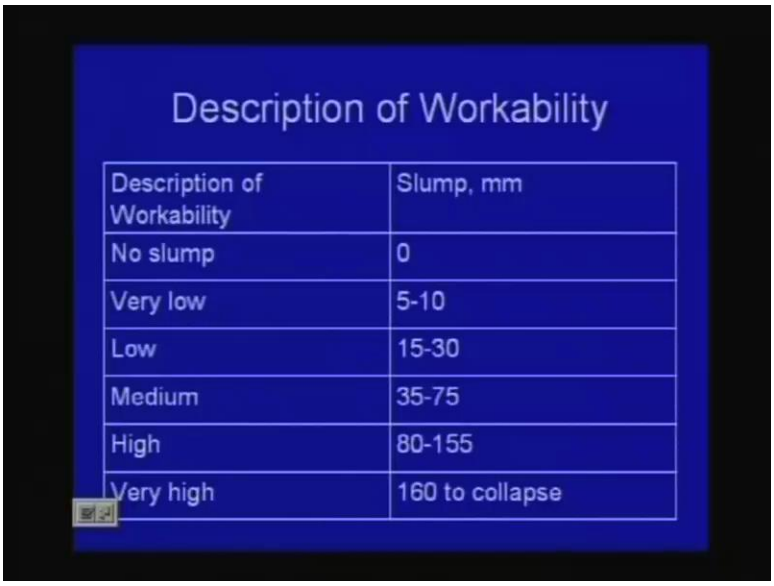

So this particular, no slump that zero; very low - let us say 5 to 10; workability is low - 15 to 20. Medium - 35 to 75 millimeter. When high workability, high workability whenever you are considering that 80 to 155 millimeter, very high workability; that means, it will just, simply it can flow; that means 162 - that almost it will collapse; that means, say, 300 millimeter is the height of the cone. So that means it will almost, say, you will find out as if it is flowing; so that means, it is very high; obviously it is easier to work with water. So for the particular one you can consider. So similarly, that it can flow; so it is very high workability. So this is the one that you can say, qualitatively we specify, not exactly. It is not possible to get the exact value of the workability, but we get the range. Within this if we get it, then we shall consider one particular case; that means, in other way you can consider as if we are having the a little bit fudgy, in that particular way, that graded sand we can consider that particular one.

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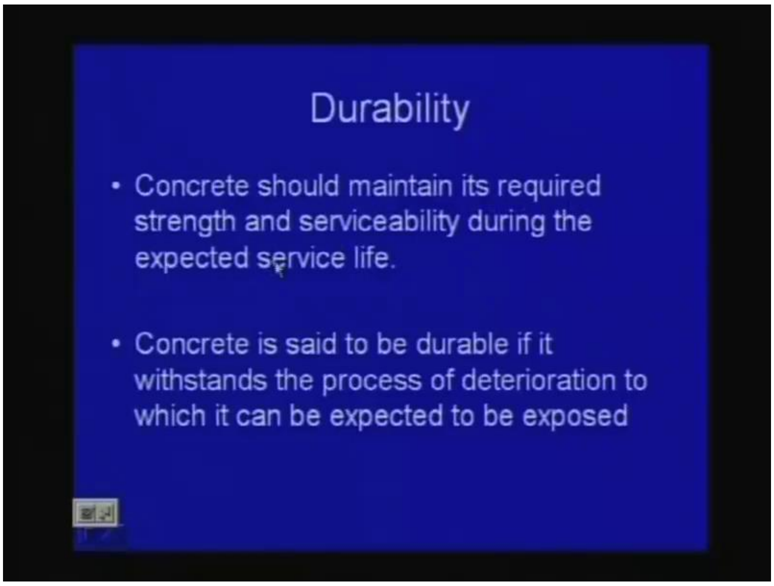

The other aspect is the durability. Because workability is the one aspect, the other aspect is durability. So what is durability? Concrete should maintain its required strength and serviceability. You please note. I am repeating the particular one - that one is the strength I am talking; the other one is talking say serviceability. So these are the two different criteria, which will go hand-by-hand. That holding hand-by-hand - that say strength and serviceability. So concrete should maintain its required strength and serviceability during the expected service life. So a structure is designed for a certain life, for a certain, say, few years, say 50 years or 100 years. So we expect that it should be durable; at least it should withstand the particular load for which it is designed; it should take care that particular load.

Concrete is said to be durable. Concrete is said to be durable, if it withstands the process of deterioration to which it can be expected to be exposed. So, obviously, the concrete, which is cast today, obliviously, it will deteriorate over time. We cannot help it; that we have to accept it. But even then, even then, this particular one, it should withstand that particular one even if it is exposed to different environment; that means, that what we can say actually, in this particular case for concrete, if the concrete is say porous, then water will enter through the particular one. If that other way, I can say permeability of the particular concrete.

So water can enter through that, and then, what will happen? Then you will get that, say, corrosion in steel; that is the dangerous part; and then it will be oxidized; and then it will be bulged; and then it may crack; lot of other things will appear. So, whenever, the concrete is exposed, that concrete, so that particular so thing, even if it deteriorates still it will sustain that, it will withstand the particular load, for the expected life, that whatever that for which it is designed. So workability is one aspect, whenever you are casting that one; the other aspect is the durability.

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Now, coming to these particular one, that is compressive strength. So compressive strength that we consider, I have told cubes, we also use cylinders. And after that they are hardened for 28 days. So we test cubes or cylinders in that American Code - that ACI - they specified, they go for cylinder, but in Indian code we go for cubes. But we use cubes and cylinders - both. In our laboratory also, we find out, we cast, special cast cubes as well as cylinders, but our code goes as per the cubes strength.

During the 28 days before testing, the cubes and cylinders are stored under water or placed in constant temperature, that room - constant room temperature - maintained at 100 percent relative humidity. Generally, we do that particular on cubes, we just simply put it in the water we have, say storage, say reservoir. And thus, simply we dump the cubes, and we before testing, we just simply take those cubes. This is the one - the standard one - we do it, and that we shall do it for the compressive strength, we shall find out on the basis of cubes and your cylinders, we shall find out, and we shall do it after 28 days. Generally, we shall do it under the 28 days itself we test it.

So coming to this particular one, I think, I can show you one graph that is very, very important, because this is important that we have to find out. So, we have say strain, we have strain, and we have stress. Now we have different type of concrete. What we can…

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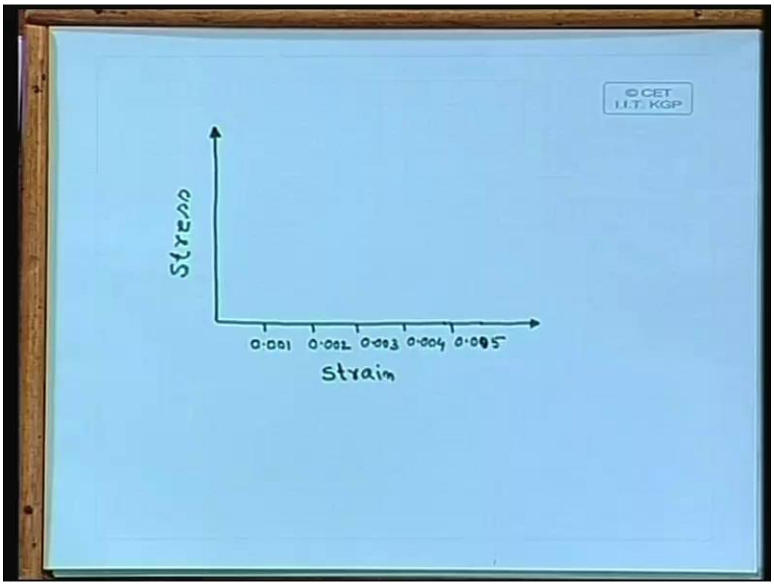

If we test it, that concrete cubes, what we shall find out actually concrete width. So we can measure the strength stress and strain. In other way, we can find out, say your deflection, and the applied load; the load applied and the deflection; because say it is 150 millimeter cubes, so we can find out the deflection of those two, that how much it is compressed, and from there we can find out the corresponding strength.

And we can find out the applied load, and since, we know the contact area 150 by 150 approximately, because after casting it may happen 151 by 152. So, that, we exactly measure for a particular cubes. So, generally, it is 150 by 150 by 150. But the surface - the top surface and bottom surface - it may be 151 by 151, 151 by 152. So that we measure; on the basis of that, we can find out the corresponding stress. So applied load divided by the corresponding stress. And on the basis of that we can find out the stress-strain curve. This is the important part for any material that we have to find out stress-strain curve.

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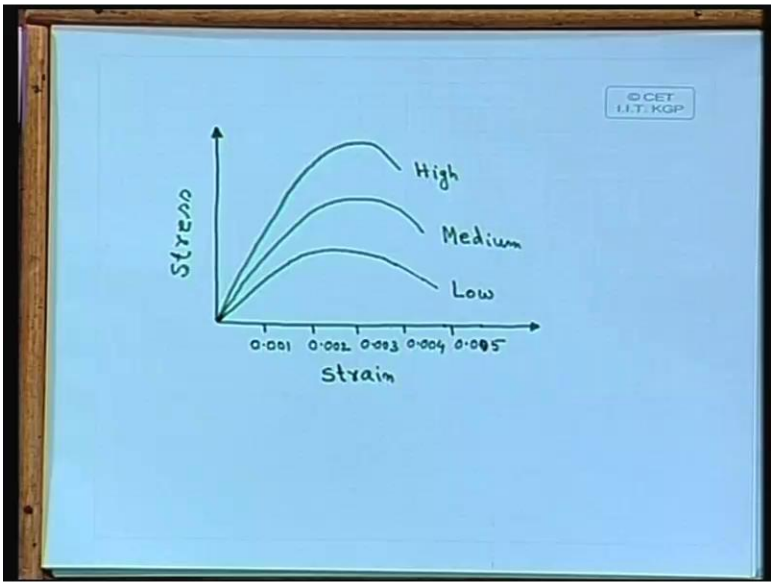

So we can find out like this. Say something it can go like this; the other one, it can go, if the concrete, that one, say higher strength, then we can go little more also, say, like this. This one we consider say low strength. Let us say this one say medium strength, and let us say this one high strength concrete. So just it is worth mentioning.

Generally, it happens, say M 20, up to say M 25, we use it for reinforced concrete, say, generally. Say for the pre-stressed concrete, we take it say M 35, M 30, for your pavement - the concrete pavements - we use it say M 40 grade. So for different application, we use different kinds of, your say strength, we use.

Now, these are the… this one is the stress-strain curve, because this one will give us, when we shall go for actual design, but in actual practice, that if you test it, then you may get this type of say stress-strain curve; that you will get it. And that, only you can get from the experiment, because there is no other way that you can find out theoretically.

For steel also, you have to do the similar way. You have to find out the stress-strain curve. And you can find out another thing, that is called, say, let us say, for this particular one, I can find out that, let us say EC - that modulus of elasticity of concrete. So that is also another part we have to find out. So EC, let us say that modulus of elasticity. So the stress-strain curve, from there we can find out what is the modulus of elasticity, and what is the behavior of stress strain-curve, because at a particular strain, we are interested to find out the corresponding stress; that is very, very important.

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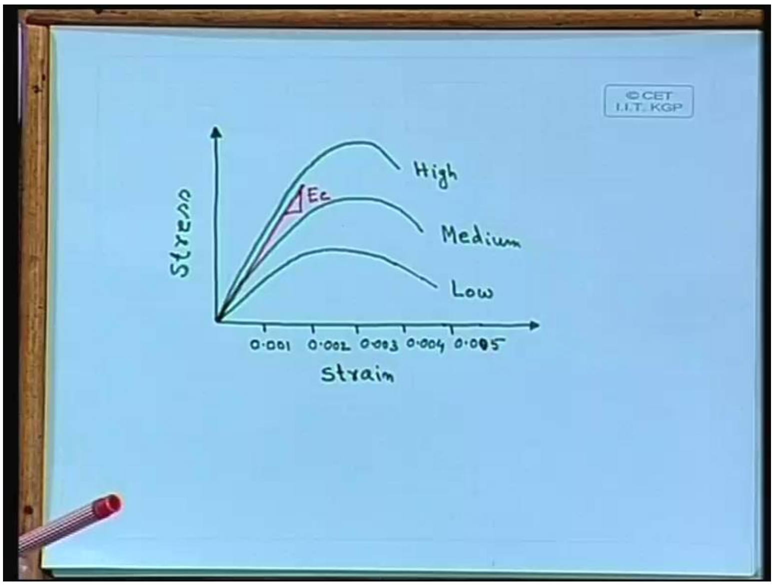

That we have to find out when we shall do our design calculation. And that is why this stress-strain curve is so important.

[Conversation between student and Professor - not audible]

Yes, we are taking the initial one? Isn’t it? That is the one we take it everywhere. If we consider this particular one, say second modulus, and lot of other modulus, we will get it. At different points, you can find out the, let us say, different modulus of elasticity that you can find out. But here, we are taking that one - the initial one we are considering - and that we shall use it. And we shall find out from concrete, from concrete we shall find out what should be the corresponding modulus of elasticity, how much you have to take, that we shall get from IS 456.

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Regarding steel, the tensile strength. Generally, it is 8 to 10 percent of the compressive strength, it comes. For our case, actually for the concrete, we shall ignore the tensile strength. We shall assume the concrete we will not take any tension, for our case, for our design, that will be taken care by your steel only. In other way, I can say, in other way, one interesting thing that when we are talking the particular one, then what is the…what we are going to assume, if we say that, then we are assuming let us say this your section.

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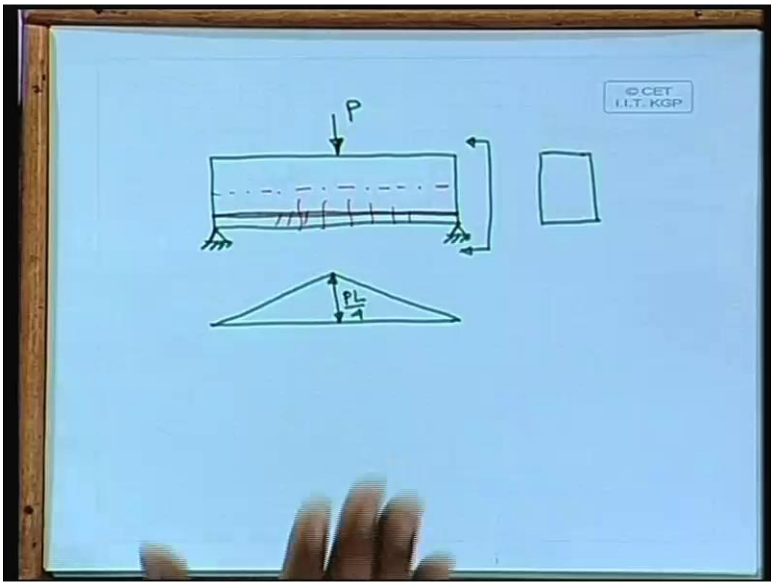

This is a section we are talking. If you look from this side, then we may get, say, member like this. Let us say there is a bar here. Let us put, say, a proper boundary, though the detailing is not like that, but let us consider for the time being, since we have not gone to that level, let us consider that this is the section - the longitudinal section - and we are having this bar - I could put it some other color of course.

Let us say this is your say steel bar, and though the support is not like that, but let us provide the support with which we are familiar. We are familiar with this support. Let us say. And let us apply a load; we can apply load; and then what will happen here? We can find out, we have to find out the bending moment. If this is P, then this one PL by 4. So what happen here? That means, if we apply this one, the top one will be compressive, and bottom one will be tensile. So we are assuming… when we are assuming that concrete will not take any tension, and only the steel will be… steel is sharing that part, it means that there are cracks here; there are some many cracks here. That means there is no connection between that concrete.

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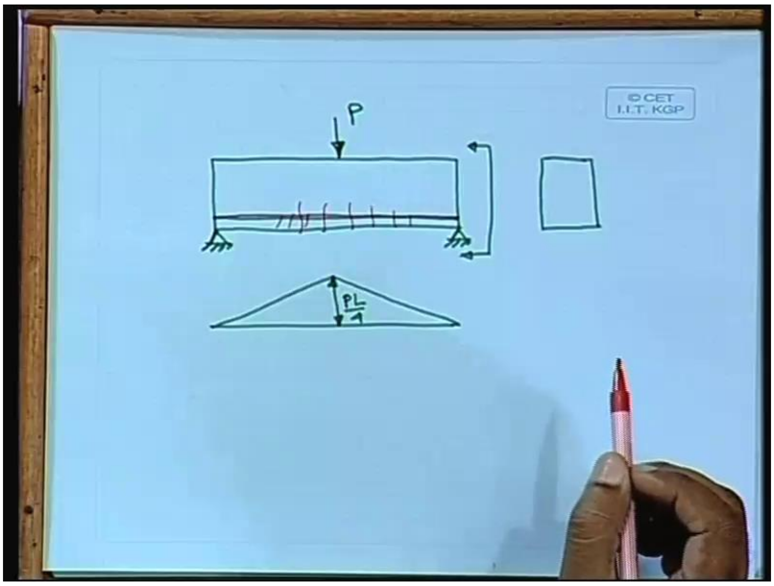

Then only I can say that steel is only taking, because if there is a… there is no crack, if let us say, you are getting, say that you continue, that means the concrete is also taking the load. Since, I have already assumed that only steel will take, that means, I assuming that we are considering cracked section, and the section having… there is a neutral axis here some where, not the central line, neutral axis here; above the neutral axis, it will take the compression, and the bottom, whatever the concrete is there, it will not take any tension; the steel will only take that particular one. That is the assumption we are doing for that particular case.

But anyway, even then, coming to this particular one, just for your reference, here we consider that…. this only we get it from experimental observation, that 8 to 10 percent of the compressive strength that we can achieve, so for that, your say, tensile strength concept.

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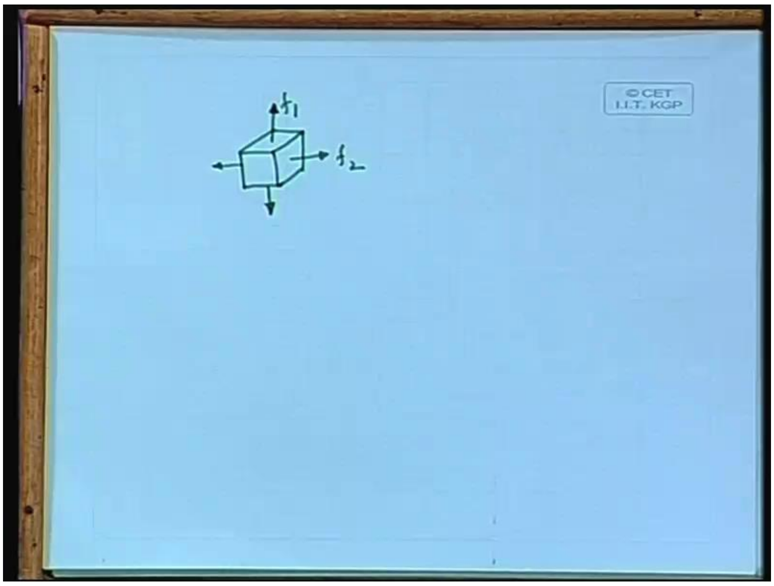

Another part is called that biaxial strength. Another part is called that biaxial strength. What is that? That one is called… if we get one element, if we take one element, and then, this is the corresponding stress. So we are taking in the whole body, we are taking a particular point, and there we are finding the particular corresponding stress, in two directions. So f 1 and f 2 - these are two straight stresses and how it interacts. So that one also we can find out and that is called actually that biaxial strength we can find out.

To get it, generally we get like this. We shall come again in detail in the later stage. Just to give you one schematic description. This one is called, say this is your say tension, and this one also tension. We are plotting that one, say, tension, and here, this one say compression. What we shall get it here, because since concrete is very weak in tension, so we shall get very less component here.

The other side, so you can go like this, and this particular one, because this side it will be more; that compression side it will be more. This is one that zone, the limiting zone that we are talking, that whenever we are having one element, if you remember your, say the solid mechanics that failure theories, if you remember that failure theories, there you will find out that, you say, let us say principle stresses - sigma 1 and sigma 2. Let us say here f 1 and f 2.

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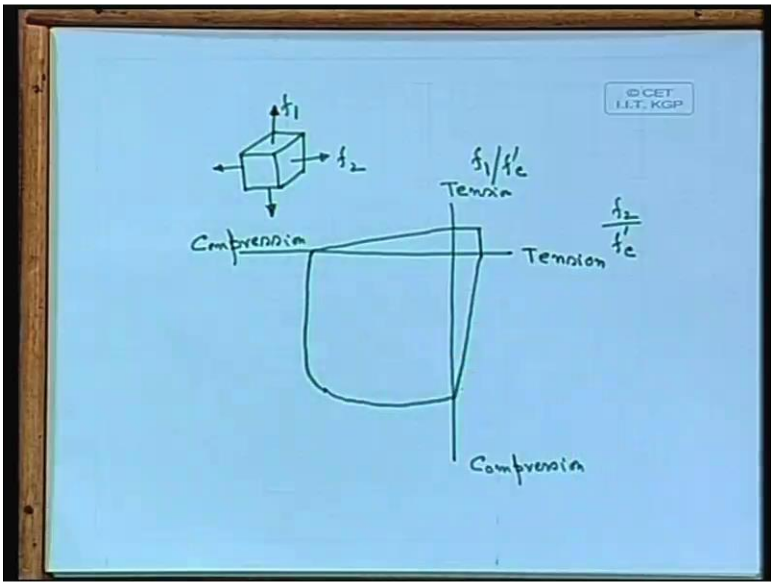

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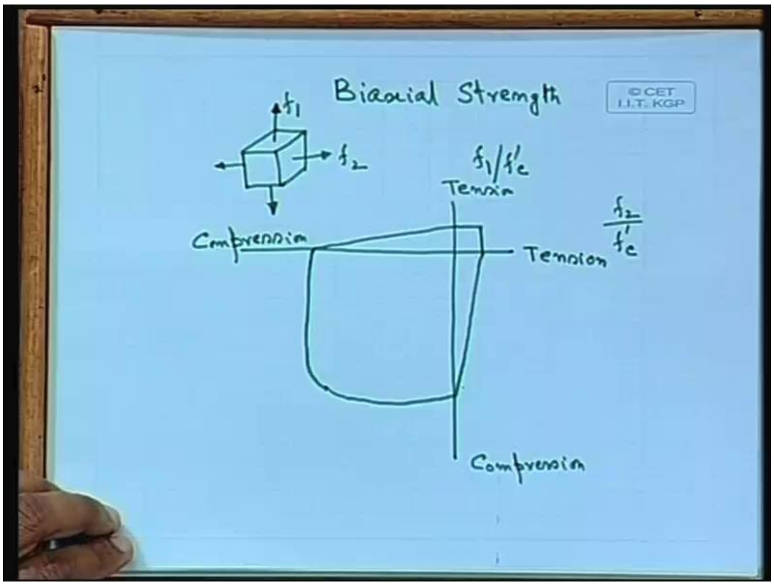

What happen here, this particular one, we can make it say f 1. Let us say this one, since I have already done just f dash, say, f 2. f dash c is the failure load - that maximum that compressive strength that particular one it take, which we can get it from that cube strength. So that is your f dash c, and this is your f 2 in one direction, and this side we are getting say f 1 by f dash c. What we can do it here, this particular one here, so we can find out the zone, that how far it will go in tension and in compression. If it is, say, whenever we are talking biaxial, that means, both axis could be tensile, both axis could be compressive, one axis tensile, other axis compressive, and vice versa. So that, it means these are the four possible cases can occur, whenever we are talking say biaxial strength. Let me write down that one - that biaxial strength.

So far, I have told for cube, that is uniaxial strength, because we are just simply applying load, and we could find out that what is the corresponding that failure load - maximum load - it can take. Now, if it happens, that also a biaxial, so then, it can have compression-tension, compression-compression, tension-compression, and tension-tension - all four possible cases. Then since concrete is very weak, that is why you are getting smaller zone; if it goes beyond this, it means that it will fail. So this is the zone within which that concrete is safe.

If we have this particular one here, this particular zone, we can say that your tension compression, similarly, here also considering symmetry, say tension-compression; and this side having maximum, because the concrete is very strong in compression. That is why we obviously we are getting more. So this one is useful to find out whether we are having the biaxial stresses, that loading applied in two directions, and then it is very useful, from there we can find out the failure load.

The other important part, that is called creep, because I have started telling that one say compressive strength, tensile strength, then biaxial, now we are talking creep, because this is important, because it is time dependent creep that is time dependent. So, both axial and bending deformations of reinforced concrete members increase with time.

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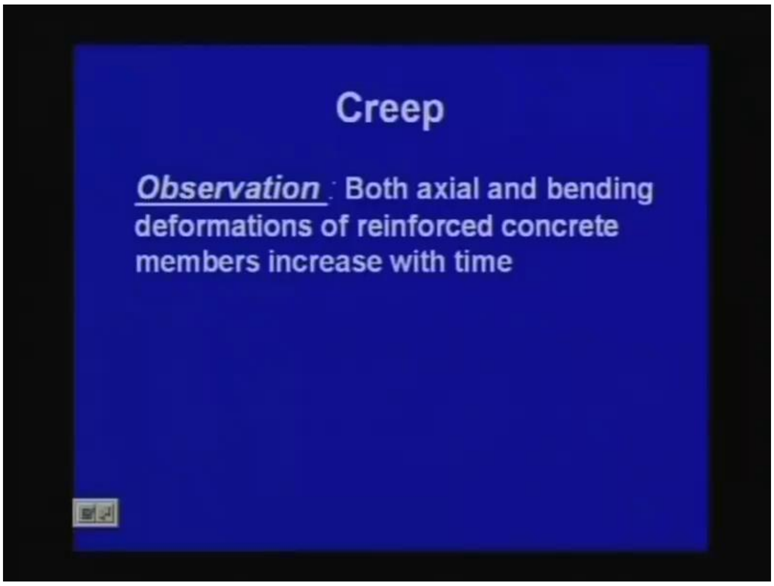

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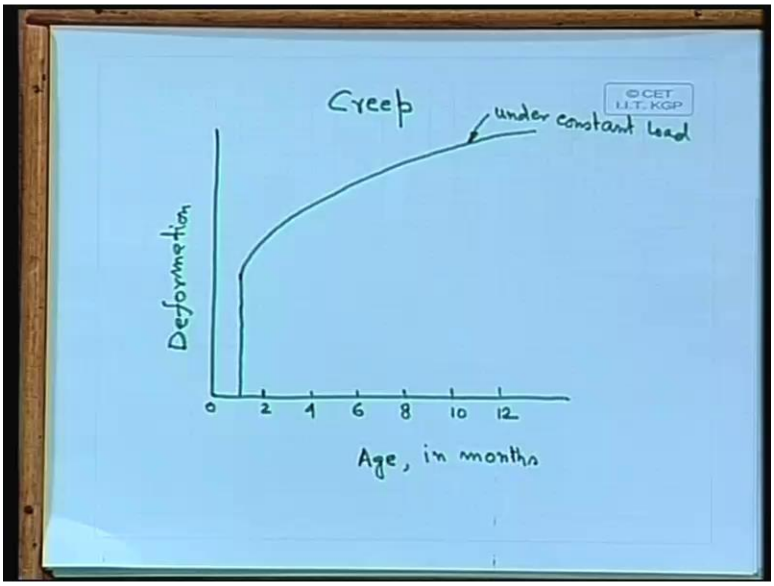

So deformation increases with time. So it may happen that particular one, what we can do… just I can show that one with another curve. So we can say and maybe we can consider that age, that is say age in months. Let us give heading say creep. So what happens here, we have cast the let us say deformation. So, if we start with say, let us say this is 2 months, 4 months, 6 months, 8, 10, say 12, like that we are going. Now what happens here, that if we cast it today, you can apply load after 28 days; that means almost after one month.

So we have applied the load. So immediately, there will be say elastic deformation. We applied load. We immediately we shall get say the elastic deformation. And then, it will start, what the months, you may find out a curve, say something like this. We are having a constant load and the curve may go in that particular fashion. It will keep on that deforming, and it will go like that; this one say under constant load. So it may happen that we are considering one reinforced concrete beam, say 3 meter or 5 meter reinforced concrete beam, and they are at the middle, say we have applied certain loads say 5 ton. Immediately we shall get certain deformation deflection. We can measure the central deflection, and that one, say, we are getting this much; that deflection we are getting this much. When we are getting this particular deflection, now if we keep that load, even then it will start deforming, and that one due to creep, but load is applied, the same load say constant load, say 5 ton, for example

Now, after few months, if we take out that load - 5 ton, then what will happen? We shall get the elastic recovery, but it will not come down to zero. It will not come down to zero, even if we take say after few months, if we just take out that load, it will not come down to zero, because immediately if you take it out, then it will come, but we are taking it after, say, few months. So this is your non-recoverable, non-recoverable that deformation.

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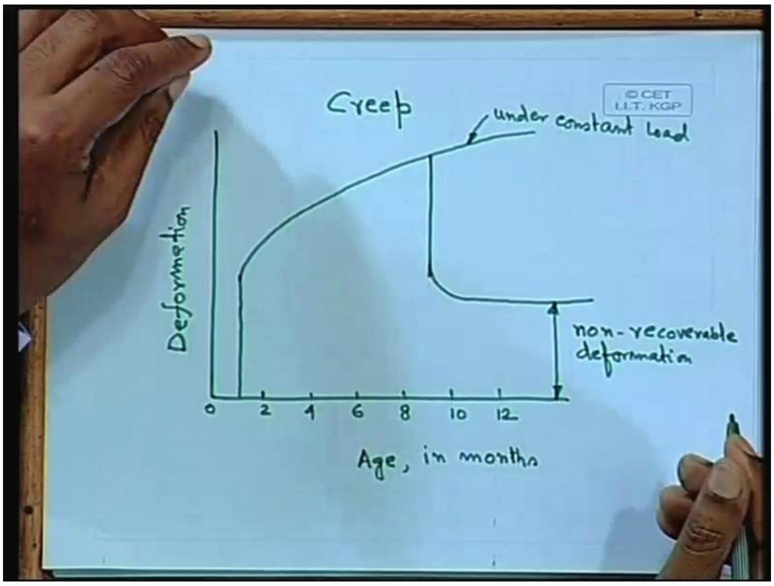

And that we are getting due to creep. That is the time dependent phenomenon that we are getting that is due to creep. So it comes almost same; whenever we shall come to that particular design one, you should find out it will come almost same, almost equal you will find out, in that range. And that one you can say empirical, based on experiment observation; that we shall find out with that particular aspect later on. We have come back to so much.

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So the total deformation is divided into two parts: an initial instantaneous deformation that occurs with the application of load; a time dependent deformation termed creep that continues at a decreasing rate for a period of years. So that means we have to consider at least one year you have to consider, that particular one, at least I should start here, in this particular case, say 12, I should make it. Here I should make the particular curve, say here, at least I should make it 12 months, so that you can say that. Please note that particular one the curve, which I have told earlier; here we should make it at the 12 months. So this is the one that creep we are considering.

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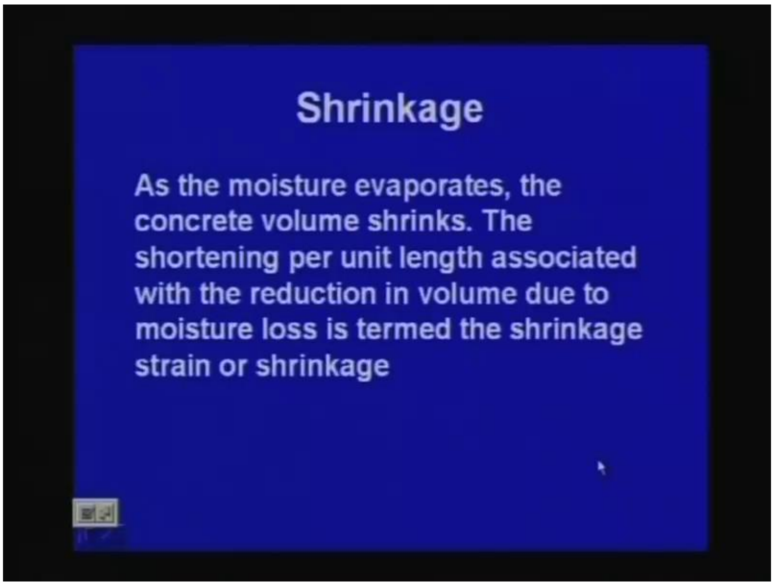

The other one is called shrinkage. So this your another aspect that concrete, that as the moisture evaporates, the concrete volume shrinks. The shortening per unit length associated with the reduction in volume due to moisture loss is termed as shrinkage strain or just simply we consider shrinkage. I repeat, as the moisture evaporates, the concrete volume shrinks. The shortening part per unit length associated with the reduction in volume due to moisture loss is termed the shrinkage strain or simply shrinkage.

So creep, and the other one we consider shrinkage, these are the two things that you have to consider in our, say your, calculation.

[Conversation between student and Professor – Not Audible]

So one is that you say an initial or instantaneous deformation, and the other one, is the time dependent deformation termed creep. So, generally, we consider for at least for one year we consider, this particular one we will consider.

So I shall continue. Now, almost we have finished that, say the materials part - that we are finished, because now we know, and also for steel also, we shall consider also for steel, that we shall also consider that, we shall go the one that our IS code says.

Now the thing is that, now we are coming, we know the limitation that by which we have to work. The concrete is not so simple, but it is really is sometimes really nuisance also. But even then, that almost say 90 percentage of the work we do with the concrete only. And concrete also, another aspect that, your say, another part say maintenance also - that is also another important part. So workmanship of concrete, if it is done properly, you can see that the work is good.

Say, for example, say the our, that say, now it is a new building, but anyway, that our main building if you consider, our institute main building, if you consider that, you will not find any crack is severely; that means, you can say that workmanship of that one was really, really good; whereas, say, sometimes you will find out many new buildings, anywhere, you may find out say that cracks all those things there. That means, there is some kind of, say, you can find out the difference in the workmanship. So if the… it is done properly, it will really stand withstand the load, and it will be there for ever; for so many years, even the expected life, whatever way it is designed.

So coming to the point here, even then, there seems 90 percent of the, say our say, that civilization, that one constructed by concrete, and there is no such other material also, and the concrete is really good other way also. And it is really, you can work lot many things, it will be economic compared to steel also you can say. If you go for steel building, obviously it will be costly compared to the concrete. So this is one aspect that we have do, but even then we can find out that, that what is the method we have to find out.

Now, we have come to materials; now we are coming to the method; that what method we shall apply to come to the definite size of the section. Finally, our objective, if you consider that analysis is very much required, but our objective, finally, you have to produce one drawing; the drawing you have to produce, and that drawing, you will find out that, having the all the detailing according to the size of the section, what is the reinforcement detailing, that what type of bars you are providing, what will be the spacing of bars. So that is why the detailing in concrete is very, very important; because of that your detailing that one wrong, detailing can mislead to that you say catastrophic failure. It can go to a disastrous end.

We shall find out, for say, your cantilever beam. If we consider say cantilever beam; say this your say cantilever beam. In other way, you are familiar just simply like this.

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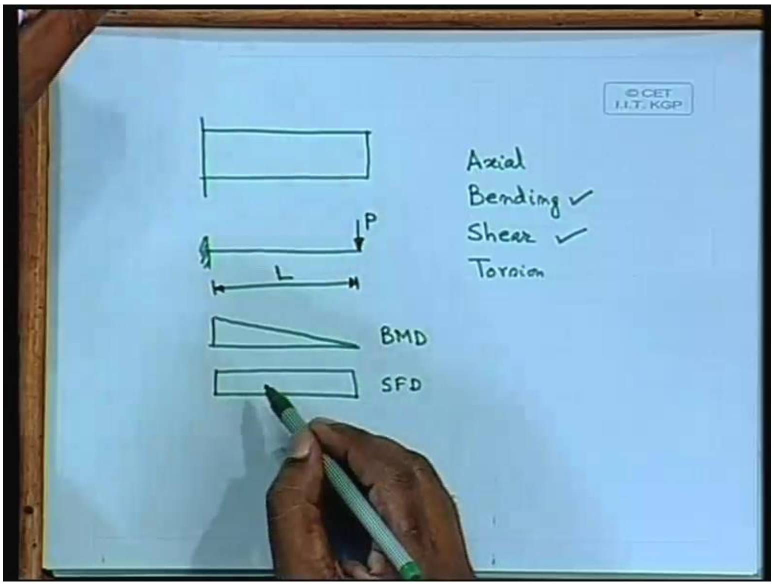

This is your cantilever beam. So far, you have done this type of problem, and we can apply the load - say certain load say p. And let us say… When we are talking this particular problem, then we have to find out here… first thing that we have to provide a suitable section. This beam, whenever we talks beam, beam if we find out there is say, you can have say, axial load; I am not talking for beam. It can have, say axial load – axial, bending, shear, and torsion. Now different elements, the weight is oriented or configured, not necessary it will take all the loads. So, for example, this particular beam consent, it can only that governing one, dominating one - the bending and shear.

So, you can find out the bending moment - bending moment diagram, and you can find out the shear force. So what we shall do, that means, how we can take care the bending? We have to provide a suitable section and we have to provide the longitudinal reinforcement.

In this particular case, the top one will be in tension; top one will be in tension; that means, that you have to provide the reinforcement at the top. Now, by mistake, somebody gives the reinforcement at the bottom only, the topped reinforcement, that one which is supposed to be, but if he has given at the bottom, that means, if you take out the form, that certainly if you take out, the cantilever beam, it will just simple collapse. And it happens also. That particular one, it happens also. So this is called the detailing; the detailing of reinforcement. Even if you calculate steel, due to just say detailing that one at the construction site, that it will mislead to say, your say, disastrous end. So that is why the reinforced concrete the detailing is also important.

So we shall come to the different methods, and we shall start the design of beam, and we shall start with the flexure; that means for bending. We shall consider, we consider bending separately, shear separately, torsion, all of them, we consider design separately. So for bending, we shall start with bending.

So next class we shall start with bending and different methods.