Design of Steel Structures
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Module - 6
Flexural Members
Lecture - 1
Introduction to flexural members: Beams

Hello today analysis and design of beam members; beam member's means, when the flexural action will come into picture. As we told earlier that a building or a structure is consisting of different type of members 1 is tension member it may undergoes under tension. Another type of members is called compression member, which includes column and other type of compression member. Then another important members, which we use in case of structure is called Beam member.

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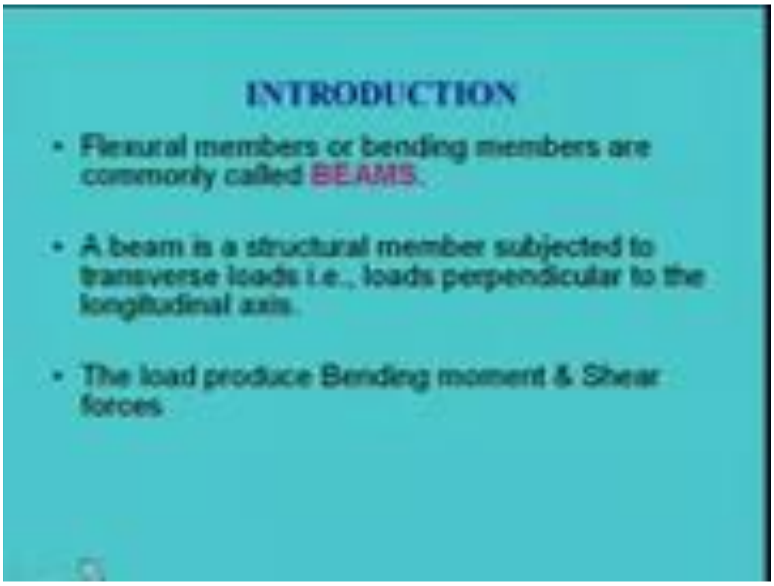

So, here we are going to introduce a beam member. First what is beam? We can say that, flexural members or bending members are commonly called as beam member. Generally, we whatever flexural members we use to say that is the beam in general we use to call. Now, a beam is a structural member subjected to transverse loads; that means, load perpendicular to the longitudinal axis this is the beam.

And the load will produce bending moment and shear force. That means, suppose if we have a beam member like this, and if we have a load like this then what will happen? It will produce bending moment as per the loading condition and as per the support condition.

So, this will bending moment here maximum moment will be developed as per the loading condition and also shear force will develop; shear force it will become say something like this right. I will come later in details, so one is bending moment is coming into picture, another is shear force is coming into picture with these 2 we have to design.

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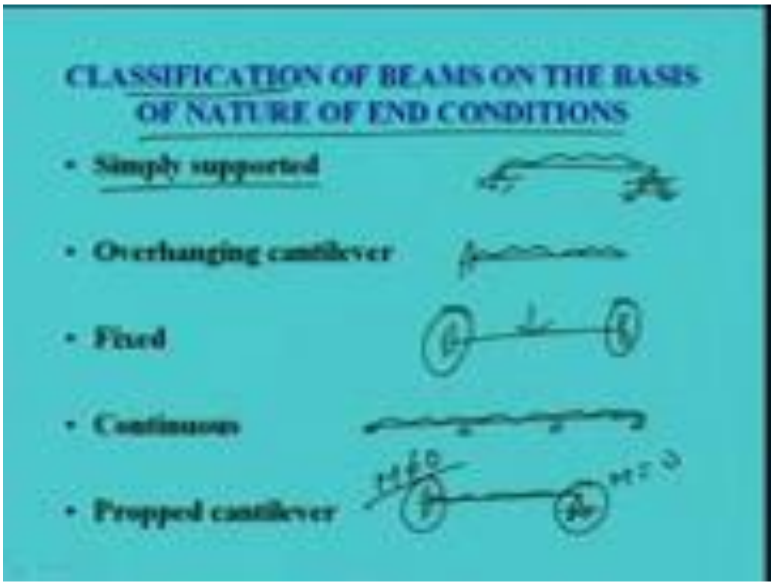

Now, this beam members can be classified into different way as per the nature of end condition right: one is say simply supported we can say simply supported beam; that means, as per the boundary conditions of the beam member we can classify the beams into this categories like simply supported this is called simply supported say, suppose loading is say UDL loading or something is there.

Another is overhanging cantilever say such type of members are all called overhanging cantilever. Now, another type of beam is called fixed beam, this is fixed in the both end they are fix it will be there. So, moment in this end and moment and this end will be developing. So, support moment will be developed as well as the as means, span moment will develop as per the say loading condition, right.

Another is say continuous member which we used to seen in many cases in the industrial building say continuous member; say self weight and imposed load is there right. Another type of member is called say propped cantilever right. So, suppose loading is like this, so here it is fixed and here it is hinged simply supported. So, what will happen here their moment will be 0 and here moment will be some value right.

So, as per the boundary condition or end condition of the members we can classify the beam members. And this is required, because when we are going to design a particular beam members we need know, what type of connections are given and accordingly what will be the moment and shear force will develop at the end.

And accordingly we have to design the members that is why we need to know, what type of boundary conditions have been given in the member. And also we have to know what is the effective length of the member, because that we also require.

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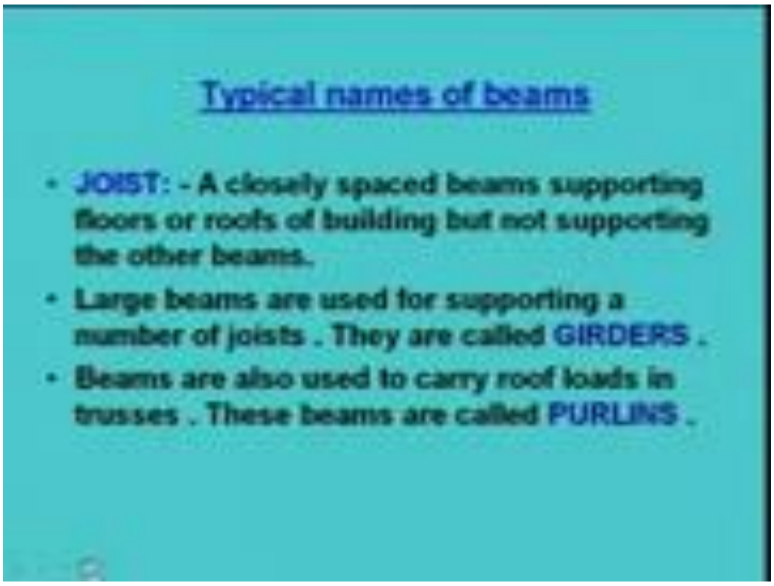

Now, in building or in bridges or in different type of industrial structures the same beam member is named in different way. Somewhere it is told joist, somewhere it is told girders, somewhere it is told lintel. So, those names before going to design the details of the beam we must know, what are the types of names we are using in different cases like joist.

When it is told that a closely spaced beams supporting floors or roofs of building, but not supporting the other beams means, joist still not support the other beams right. So, this type of beam is called JOIST. Another is Girder large beams are used for supporting a number of joist they are called Girder. That means, when say suppose these are joists is supported by the large beams say these are girder. I can say this is a girder and this is a joist; joist is supporting on the girder.

So, we can find out means the girder which one is girder and which 1 is joist. And this term girder is used mostly in case of bridges, in bridge design you will see that the term girder is frequently used not beam we used to tell girder. Another term will come into picture later you will see, the plate girder, gantry girder; gantry girder when industrial cranes etcetera will come into picture that time we will see gantry girder.

We will also design here we will show and plate girder in case of bridge structure we will see plate girder is frequently used right. Another terms is used which is called Purlin. Beams are used to carry roof loads in trusses. These beams are called Purlin. So, when the beams will be carrying the roof loads of the trusses. We can name those beams as a Purlin, right.

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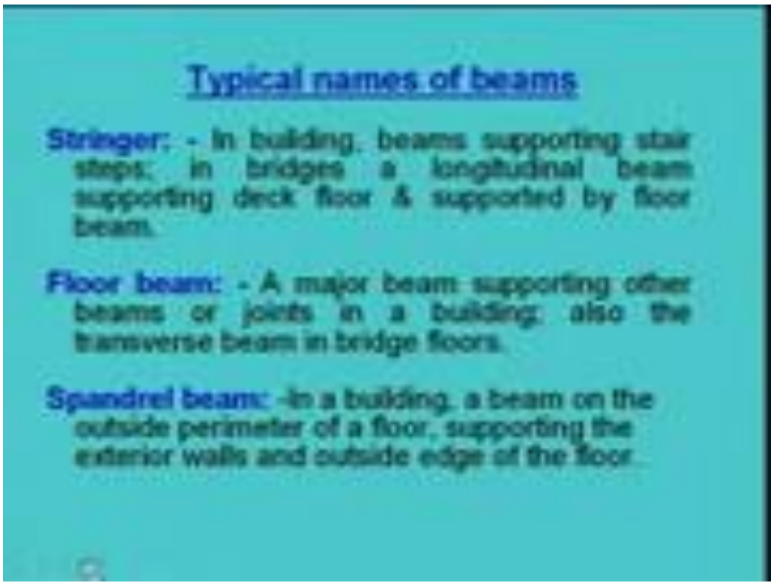

Next is Stringer: in building, beam supporting stair steps, in bridges a longitudinal beam supporting deck floor and supported by floor beam this type of beams are called Stringer. And another name we use is floor beam: a major beam supporting other beams or joints in a building; also the transverse beam in these floors are told as floor beam. Another is spandrel beam: in a building, a beam on the outside perimeter of the floor, supporting the exterior walls and outside edge of the floor when it is supporting the exterior walls or outside the edge of the floor it is called as Spandrel beam right.

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Another is Girt: a horizontal beam spanning the wall columns of industrial buildings used to support wall coverings is called Girt. And a roof beam usually supported by purlins is called Rafter. Another is lintel which in case of RCC building we will see that this is used. Beams are also used to support the loads from the masonry over the openings. Such types of beams are called Lintels.

That means, when some windows are there or doors are there we use to provide some beam which is generally called Lintel or. In fact, when the masonry walls are there which has to be carried by the beam say masonry wall is there, this is masonry wall say something like this and this is also bricks right. So, such type of things when it is coming this is called Lintel right.

So, what we have seen that the beam means into picture, but that member is named differently in different places right. We have to know if we do not know what is girder means, we may design for different reason right. So, unless we know what is girder means, basically a beam member then we can think in that way to start the design.

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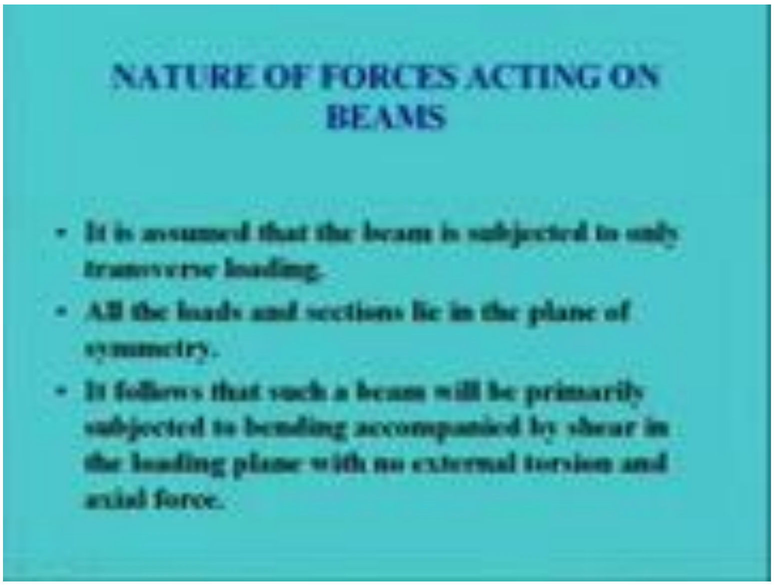

So, nature of forces acting on beams, so as I told the nature of forces will be perpendicular to the axis of the member, then only we will tell this as beam. Now, this forces generally becomes symmetry in the plane of the section; that means, all the loads and sections lie in the plane of symmetry right. And we are assuming that the beam is subjected to only transverse load.

So, with this symmetry it follows that such a beam will be primarily subjected to bending accompanied by shear in the loading plane with no external torsion and axial force. As we are assuming that only transverse load is coming into picture and it is symmetrically acting. So, we are assuming that only the flexural action and shear is coming into picture no torsion will come into picture.

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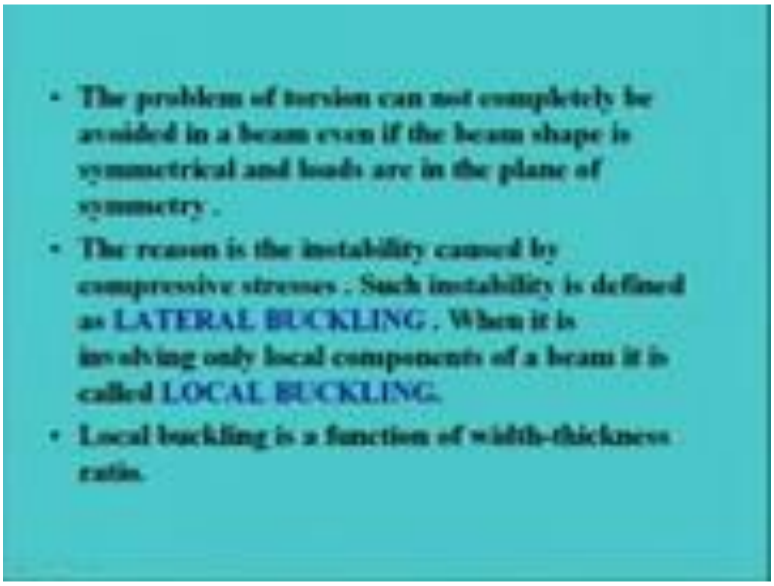

But this torsion means problem of torsion cannot completely be avoided in a beam even, if the beam shape is symmetrical and loads are in the plane of symmetry. That means, even the loads are in plane of symmetry and beam shape are symmetrical. Then, also we cannot avoid the torsion because of the local buckling because of the buckling lateral instability.

The reason is the instability caused by compressive stresses. Such instability is defined as Lateral Buckling. And when it is involving only local components of a beam it is called Local Buckling. So, when the buckling is only effected by the local component then we used to call that Local Buckling right.

So, again we will show later when we will come into details of local buckling and other things that local buckling is a function of width to thickness ratio. That means, beam width and beam thickness we have. So, we can make thus local buckling as a function of beam width thickness ratio, right.

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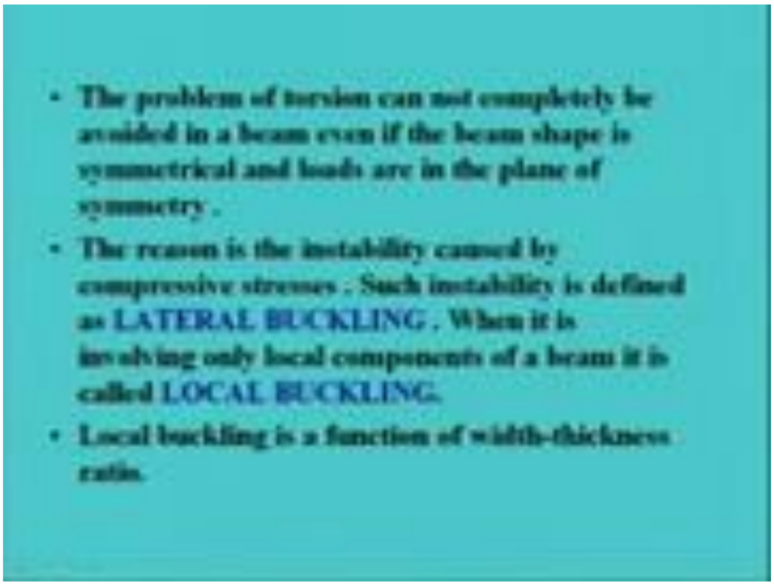

Now, when we are going to design a beam member we must know what are the possible ways of failure? Because, if we know the reason of failure in what way it is going to fail then we can design the beam accordingly. The beam has to design so that, it can withstand the service load without any failure, without any structural failure right. So, before going to start the design process we will discuss little about the failure aspects of the beam how it cause failure.

Basically 3 type of failure we observe: one is bending failure; another is shear failure and then deflection failure. These 3 types of failure is coming into picture. So, bending failure as we know from this name we can understand that, bending failure is because of the stress developed due to bending moment.

In case of beam bending moment will develop and bending moment will cause a stresses; stresses means, the flexural stresses in both the side 1 will be due to compression and another will be tension sigma bc and sigma bt will we can named is. So, because of that it may fail. Another is shear failure because of exceeding the limiting value of the allowable shear stress then it may fail.

So, that is called shear failure and another is deflection failure. Deflection failure means, because of excessive deflection of the member. So, bending failure generally occurs due to crushing of compression flange or fracture of tension flange of the beam. So, if we see the say suppose this is a member say we have the loading pattern like this. So, what will happen?

It will moment will develop like this, so maximum moment is here right. Now, the failure if we see say this is a beam member Now, if we see some cracks are here at the middle then we can understand that this is failing due to the bending. And if we see the cracks are at the support, near the support diagonally then we can assume that the failure is happening because of the shear. Shear stresses exceeding the limiting values right.

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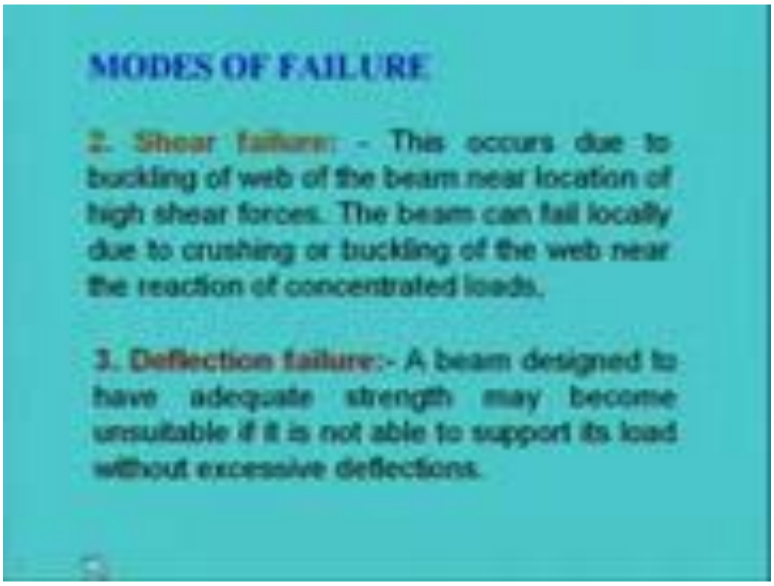

So, shear failure occurs due to buckling of web of the beam near location of high shear forces where, the high shear force will develop there it may fail. The beam can fail locally due to crushing or buckling of the web near the reaction of concentrated loads right. Another failure is termed as Deflection failure: a beam designed to have adequate strength may become unsuitable if it is not able to support its loads without excessive deflection. That means, if excessive deflection occurs then there is no meaning of making adequate strength right, because deflection will cause lot of problem.

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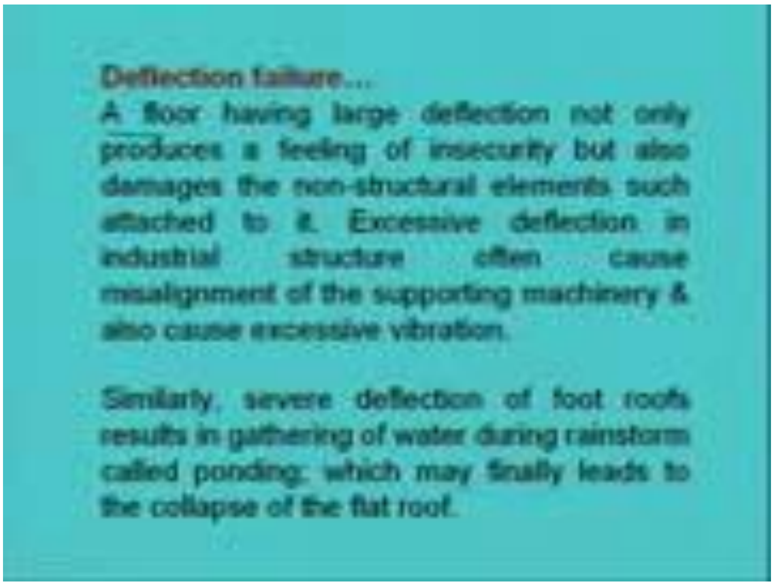

Like a floor having large deflection not only produce a feeling of insecurity, but also damages the non-structural elements such as means non-structural element attached to it. Such as: plaster and other type of architectural beam. Excessive deflection in industrial structure often causes misalignment of the supporting machinery and also causes excessive vibration.

So, these are the possible problem which will occur due to excessive deflection. Severe deflection of foot roofs results in gathering of water during rainstorm which is called Ponding, which may finally, leads to the collapse of the flat roof. So, this is another problem which may occur due to excessive deflection.

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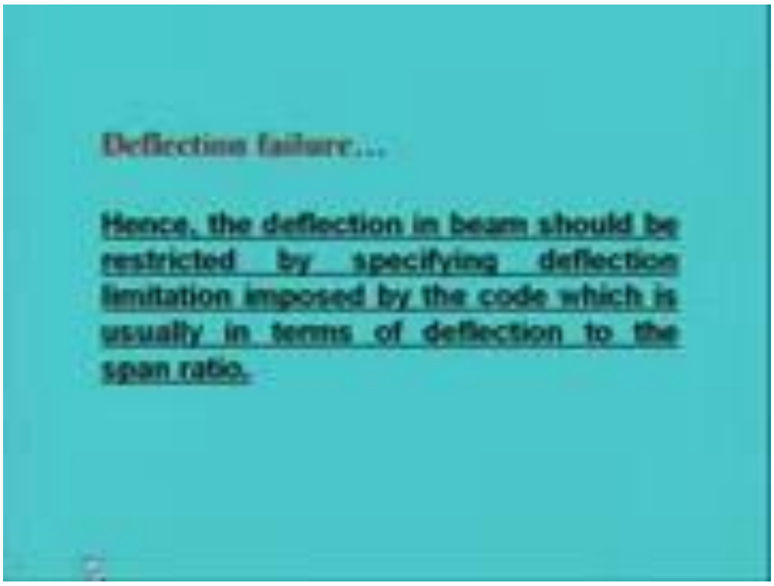

Therefore, the deflection in beam should be a restrained by specifying deflection limitation imposed by the code, which is usually in terms of deflection to the span ratio. If deflection is this, that is this then what should be the limiting value. That means, the code has guided some guidelines through which we can find out what is the limiting deflection. What is the maximum deflection can be allowed, that we can find out from the Codal provisions.

And we can find out what is the deflection calculated from the imposed load means from the load and other means, from the load, dead load, live load, imposed load, other loads. So, we can find out the maximum deflection from the load point of view and we can find out allowable deflection from the Codal provisions. Then, we have to check whether it is exceeding the Codal provisions or not.

If it is exceeding then we have to redesign, we have to increase the depth of the beam or we have to change the dimension so that, it follows the Codal provisions. So, to avoid this deflection failure means to avoid the excessive deflection in the beam code has suggested some formula means, some Codal provisions, some coefficients are given which has to follow to avoid the excessive deflection in the beam right. That I will discuss later in details.

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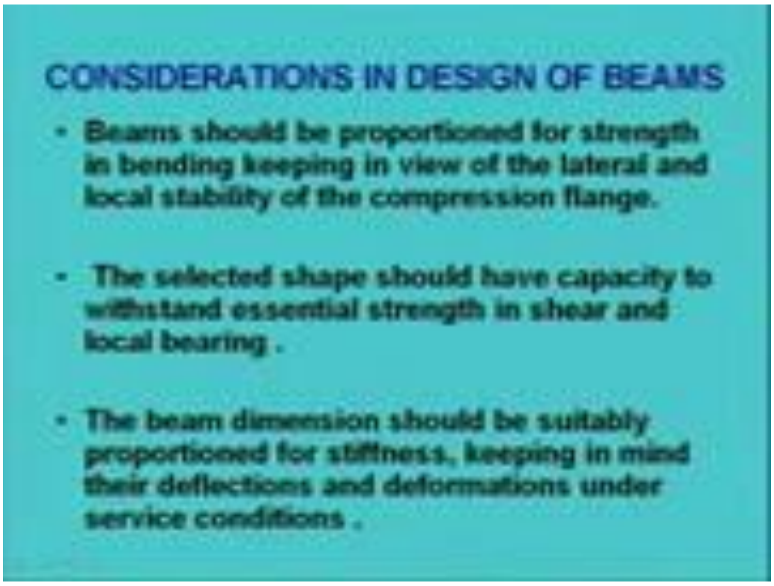

Now, a consideration in design of beams first is: beam should be proportioned for strength in bending keeping in view of the lateral and local stability of the compression flange. The selected shape should have capacity to withstand essential strength in shear and local bearing.

Another part is the beam dimension should be suitably proportioned for stiffness, keeping in mind the deflections and deformations under service conditions. That means, dimension of the beam should be proportioned for stiffness, keeping in mind the deflection and deformation under the service load.

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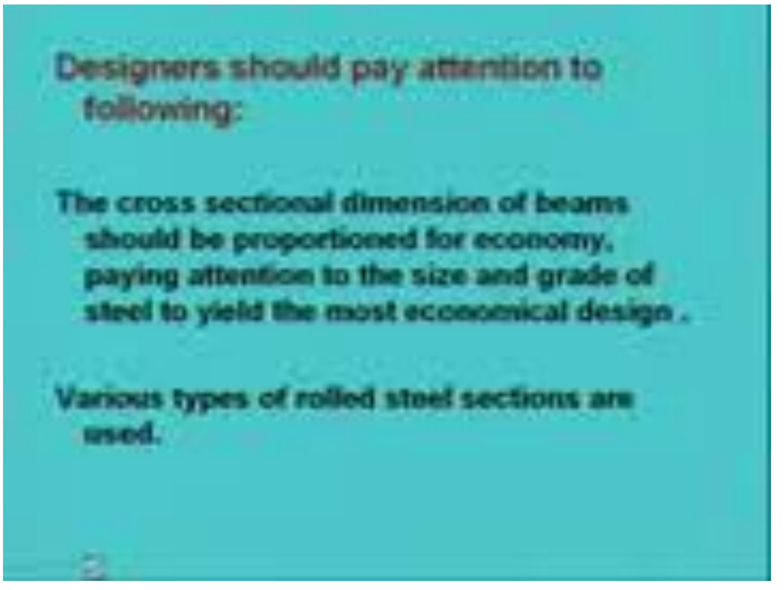

So, designers has to pay attention of the following considering those aspect. That is, the cross sectional dimension of beams should be proportioned for economy, paying attention to the size and grade of steel to yield the most economical design. So, we have to see what will be the most economical design and accordingly we have to find out the suitable shape of the beam. Now, various type of rolled steel sections are used which we will discuss now.

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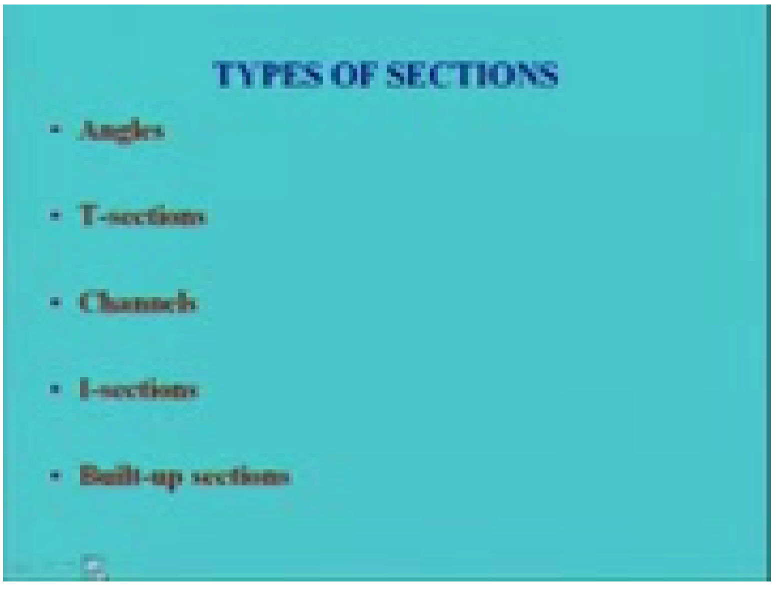

So, what are the sections available for beam member. First thing is we can use means, anybody can use a beam member as rectangular or a trapezoidal, as per the requirement of the side, as per the requirement of the structural analysis the designer has to decide whether he will go for rectangular section or trapezoidal section or circular section or some other sections right.

In RCC building we will see most of the cases we use to make the beam as a rectangular section; sometimes we use to make as a T section, right. But in case of steel building steel structure generally we use some other type of roll section which is available in the market. And these sections are made in such a way that, the economy of the section can be achieved.

Now, these are some of the section which are available in the market for using beam. 1 is angle section as we know earlier also we have seen, that angle section can be used for tension member, compression member also we can use as a beam member also. I will show later that, what are the limitations of this angle section or other sections.

Similarly, we can use the T sections different type of T sections are available in the market based on the requirement 1 can choose T section. Or the channel section also one can use right. Another section which is available is I sections right. So, these are the sections which are there.

But most of means many cases we will see that this available sections, which are in the market is not sufficient to carry that much load or the length of the span is so high that we cannot design the beam with the available section. In that case we have to go for some built up section right.

Now, with the available section we see means from the experience 1 can see that the I section is the most effective section for using as a beam member; that means, for the flexural action right. Now, for built up section when we go for built up section? When the stress is exceeding from the limiting value.

Then, what we used to do? Maybe these I sections can be added with some plate as per the requirement either top or bottom or at the both we can add some plate. Or we can add say I section is there, we can add some what you call some channel as per the requirement right.

So, what is the advantage of this type of section? As we know if we see the I section this moment of inertia that M by I is equal to sigma by y right So, we can find out the moment carrying M is equal to sigma by y into I right. Now, if I is more than M will become more now, how to increase this I for this say suppose for this case what will happen, we can find out I is equal to 1 by 12 bd cube.

If I can find out means, I of area plus Ar square right. Now, this r if it is more than this will become more; that means, r means this is the r value right So, r means the distance from the CG of the extra plate and CG of the I section. So, in this way we can increase the r right. So, in this way we can increase the I value easily we means with the little increase of the material. So, in this way we can increase the moment carrying capacity of the beam. That is why built up section is chosen for a higher load and for higher span. We will show later, how to means economically use the built up sections.

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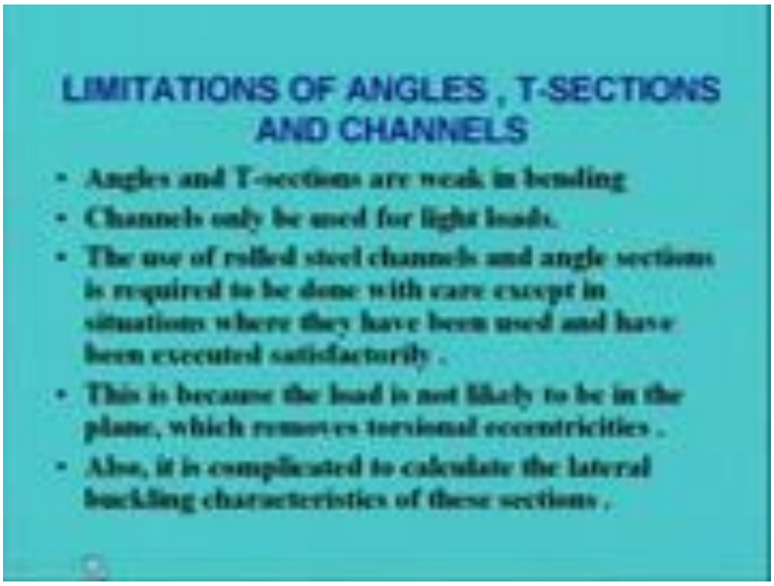

Now, if we loop the limitations of the different section we will see that angle and T sections are weak in bending that we have from the experience we can see. The angle sections and of course, this is not symmetry. So, when the bending moment will occur, so because of unsymmetry we have to see what are the stresses in different cases are happening and accordingly we have to design right.

So, in general angles and T sections are weak in bending this is 1 thing. Another thing we have observed that, channels only be used for light loaded, light loads. The use of rolled steel channels and angle sections is required to be done with care, except situation where they have been used and have been executed satisfactorily.

So, we have to take little extra care for using steel channel angle sections. Why, because the load is not likely to be in the plane, which removes torsional eccentricities. So, torsional eccentricities may come into picture because of load which is not likely to be in the plane. And also, it is complicated to calculate the lateral bucking characteristics of these types of sections. This is also from calculation point of view it is little complicated. So, these are the limitations which we observed in case of angle channel and T sections.

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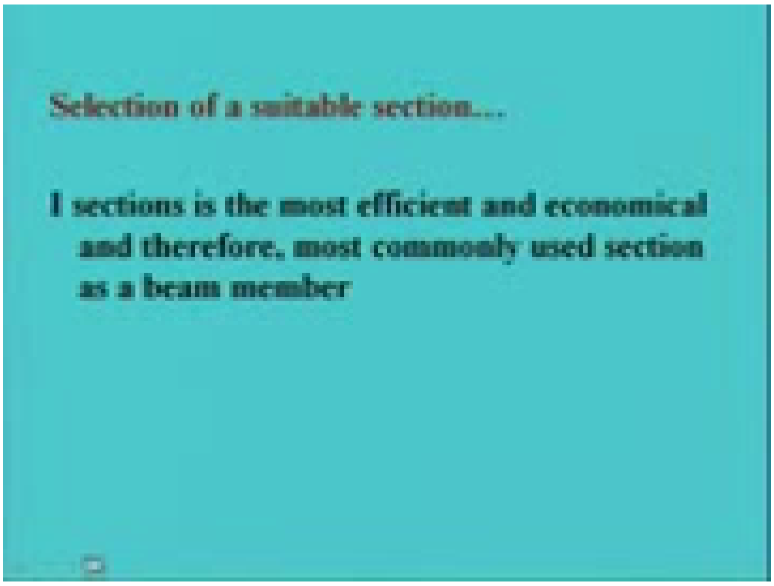

And it is also observed that the section of I section is the most efficient and economical and therefore, most commonly used section as a beam member. So, we will see mostly we are using I section as a beam member, because that will make most economical why. As we told that if a section is like this say rectangular section then what will happen. We know that, this is the stress diagram and we know that sigma is basically M by I into y.

So, I have to become more to reduce the developed stress. So, I here what is I I is 1 by 12 bd cube. But with the same material if I can make something like this then what will happen with the same material, with same weight if I make like this sections what will happen.

Here I can find out if this is d then I can find and if this is b then I can find out I is equal to 1 by 12 bd cube plus this portion means if I consider that A; A into r square where, r is this much distance from the CG of this portion and CG of the total section. So, we can increase this I up to a certain level by making the configuration of the beam member as like this in place of rectangular section.

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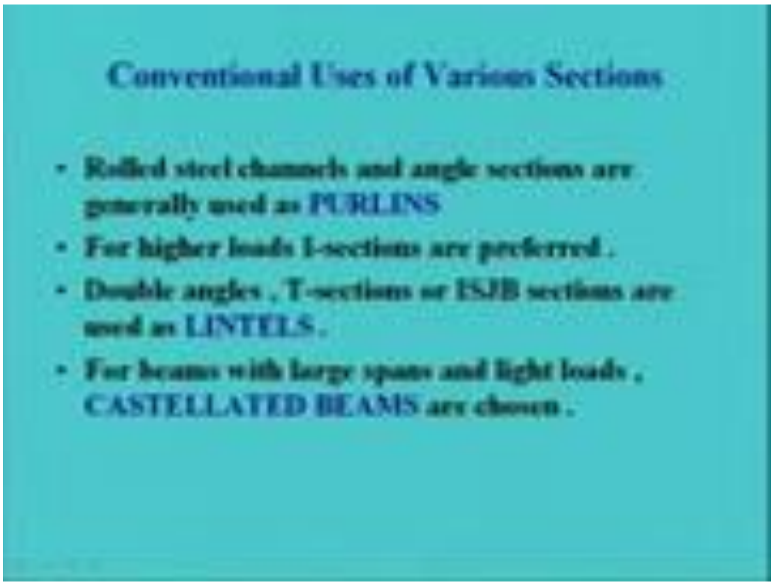

Now, we will see some conventional use of various sections like, generally we see that rolled steel channels and angle sections are generally used as a Purlin. In case of Purlin we generally use rolled channel and angle section. And for higher load generally I sections are preferred right.

And double angle, T sections or ISJB sections are used as Lintel. In case of Lintel we can use T sections or ISJB sections or double angles. And for beam with large span and light load, generally Castellated Beams are chosen. So, these are some conventional use of various sections which you should remember.

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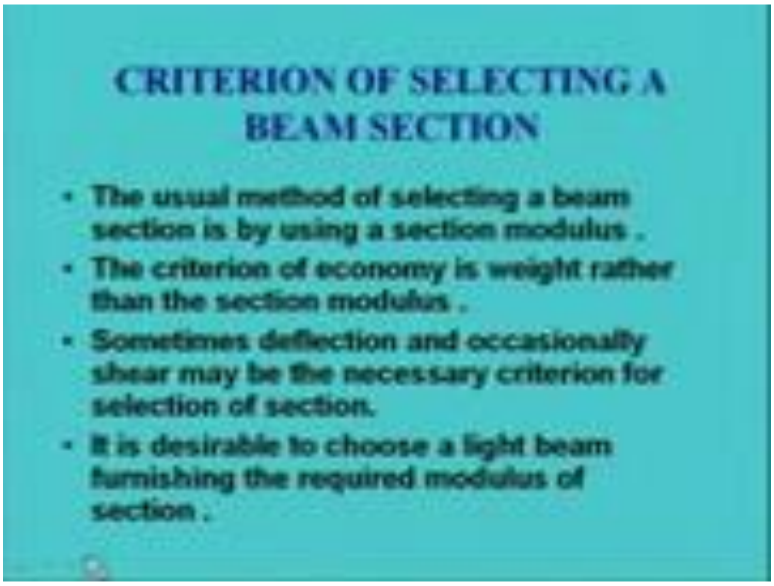

Now, criteria of selecting a beam section what are the criteria. First is the usual method of selecting a beam section is by using a section modulus. That means, as we know sigma is equal to M by I into y; that means M by I by y is Z, so this is called Section Modulus. So, from this we can find out Z is equal to M by sigma; that means, in usual conventional what we use to do, we know what is the possible moment means maximum bending moment developing in the beam.

And we know what is the stress, permissible stress in the section. So, from these we can find out the section modulus; section modulus which is required to carry that much moment. So, first step in general we use to make this. Then, the criterion of economy is weight rather than the section modulus. So, we have to see again weight. So, section modulus we can choose say Z.

Now, whether we will go for say rectangular section or I section or channel section or some built up section that we have to decide through the weight, not only the section modulus. Section modulus we are finding now which 1 with same section modulus which type of section is giving us less weight or least weight, that type of shape we have to decide.

So, it is very easy first to decide what will be the minimum section modulus required to carry that much moment. Then, with that section modulus what are the available shape of the beam. So, from that we can find out the least weight of the section; that means, we are making as well as the same section is capable of carrying that much bending moment.

Now, sometimes deflection and occasionally shear may be the necessary criteria for selection of section. So, sometimes we have to see what is the deflection is coming and that span by depth ratio we have to see and from there also we have to find out right. And also, sometimes shear when shear is coming into factor majorly. It is desirable to choose a light beam furnishing the required modulus of section what I was telling right.

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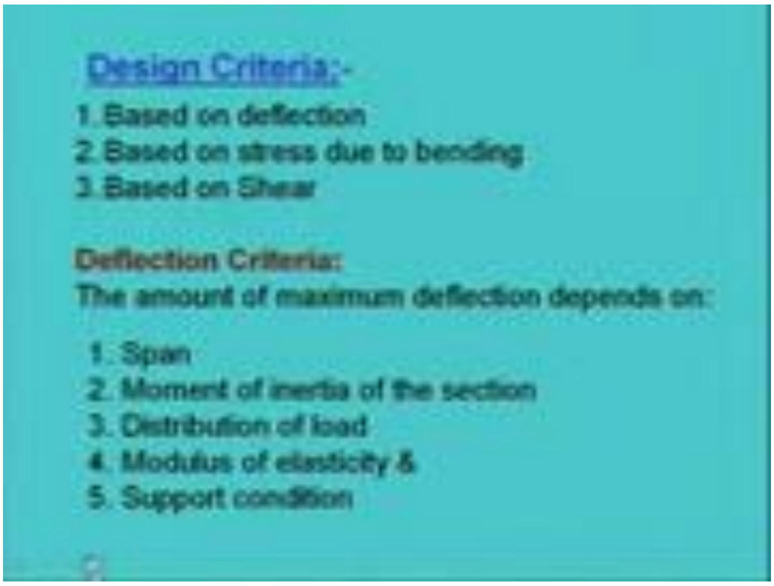

Now, design criteria. So, as I was telling the design criteria will be based on what type of failure we are going to have for the member. As we showed the failure is coming because of bending, because of shear and because of deflection. So, design criteria also will be based on deflection and bending then shear. So, 3 things we have to see that we will design the beam member with basically 3 conditions: one is deflection, another is bending and another is shear.

So, in case of deflection criteria let us see what are the things has been given in the code and how we will proceed. Now, we know the deflection means maximum deflection depends on this few factors: one is span, then moment of inertia of the section, distribution of load, modulus of elasticity and support condition.

Because we know deflection depends on modulus means type of material; that means, the modulus of elasticity then span type of loading, type of boundary conditions. So, all these things is coming into picture to find out the maximum deflection.

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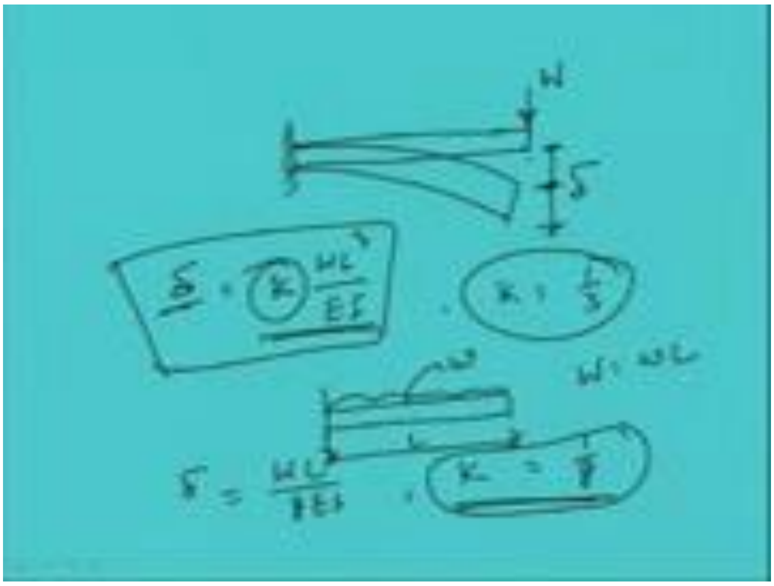

Say let us have a cantilever beam with say concentrated load of w. Now, what will be the maximum deflection; deflection will happen like this right. So, this will be the delta deflection. So, delta we can write say K into WL cube by EI, where K will be basically here 1 third. So, we can find out the maximum deflection from this equation right. Or if we have a say UDL load then also we can find out the maximum deflection will be say WL cube by 8 EI; that means, here K will be 1 by 8.

What does it mean? Say here is w, so W is w into length if length is this 1 right if length is this. So, what we are seeing that we can make a general equation of such type the delta is equal K into WL cube by EI. Now, this K is the deflection coefficient this deflection coefficient depends on the loading pattern as well as the boundary condition right. So, in this way we can find out.

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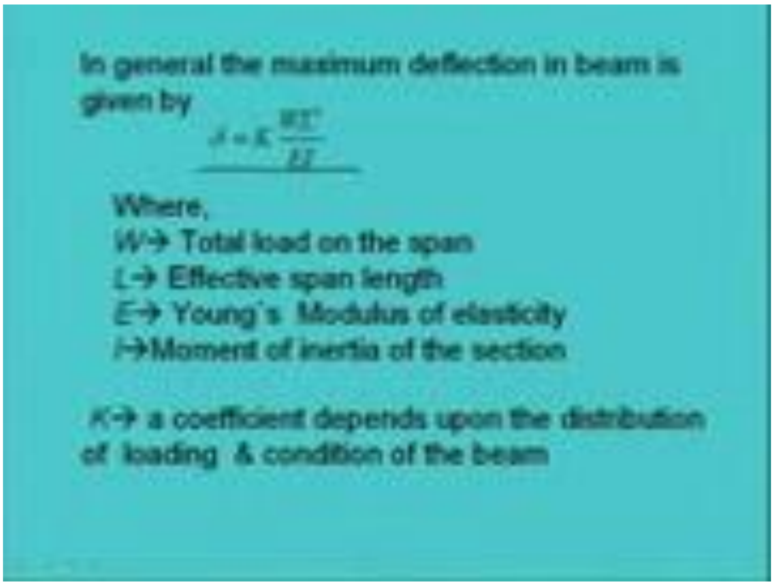

Now, here whatever equations we have written we know that W is basically the total load on the span, not UDL load the total load on the span. And L is the effective length of the beam and E is the Young modulus of elasticity and I is moment inertia of the section. And K is the coefficient depends upon the distribution of the loading and end condition of the beam. So, with this we can find out the maximum deflection right.

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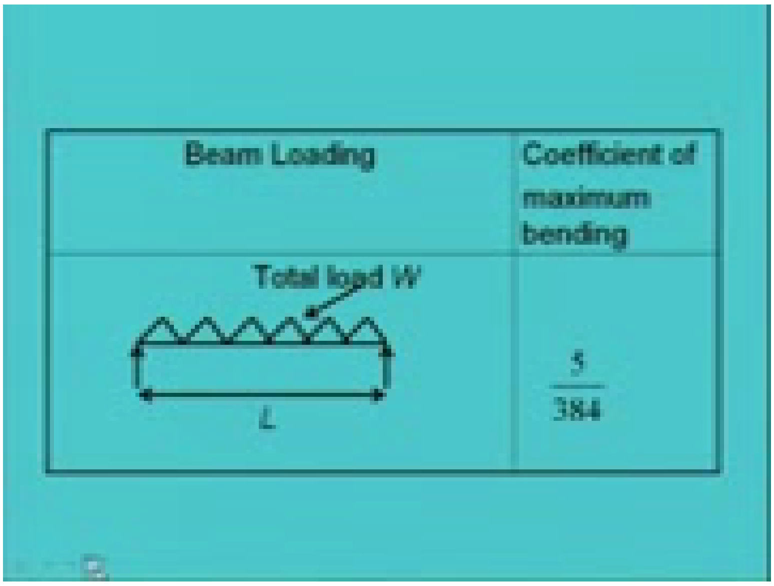

For some standard loading condition and boundary condition we know what are the deflection coefficients right. Like say suppose we have a simply supported beam with

UDL load then the coefficient K will become 5 by 384 that we know right. So, if such type of case happens we simply can find out the deflection; maximum deflection and that also means we have to remember the coefficient of maximum means, maximum coefficient from which we can find out.

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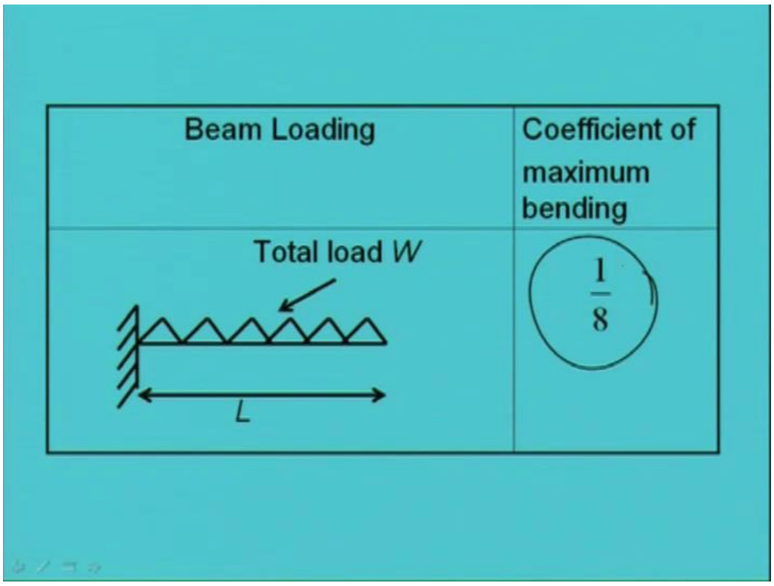

Similarly, say if it is like this UDL then we can find out like this, right.

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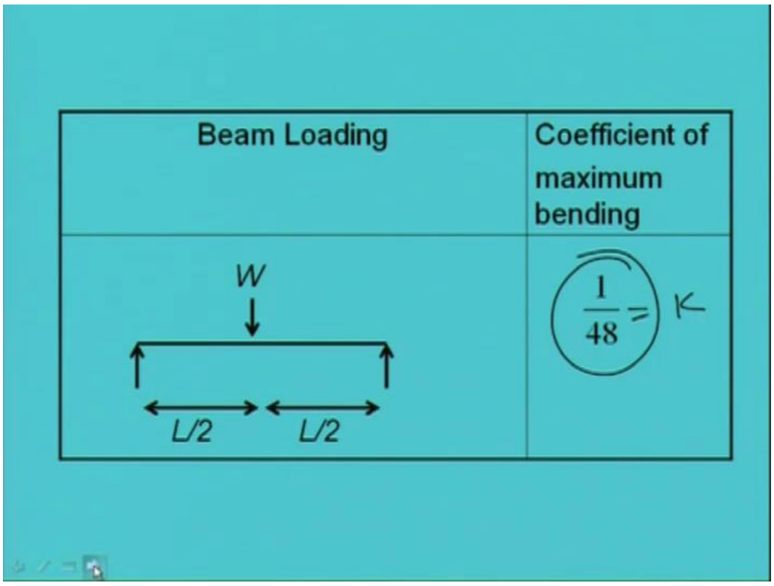

And again, if it is say beam loading is like this say L by means the load is acting at midpoint of the beam section and the beam is under simply supported condition. Then K will become 1 by 48.

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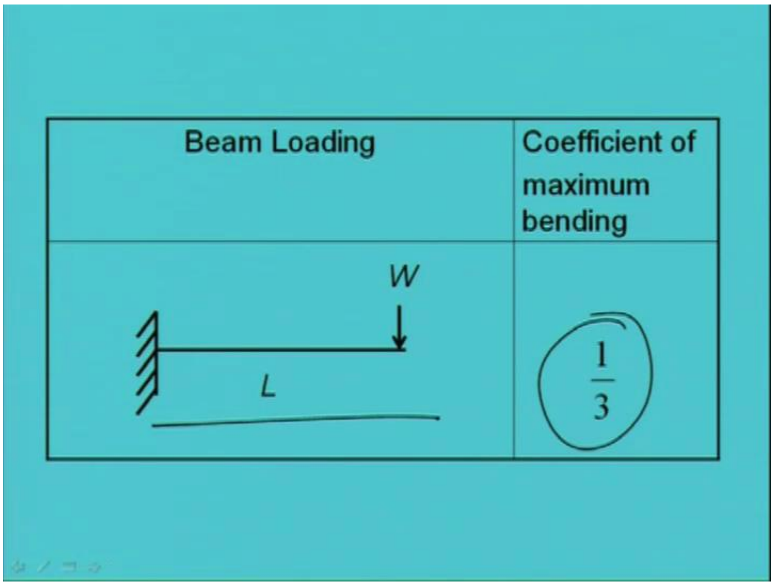

If it is a cantilever type with a concentrated load then this will become 1 third right.

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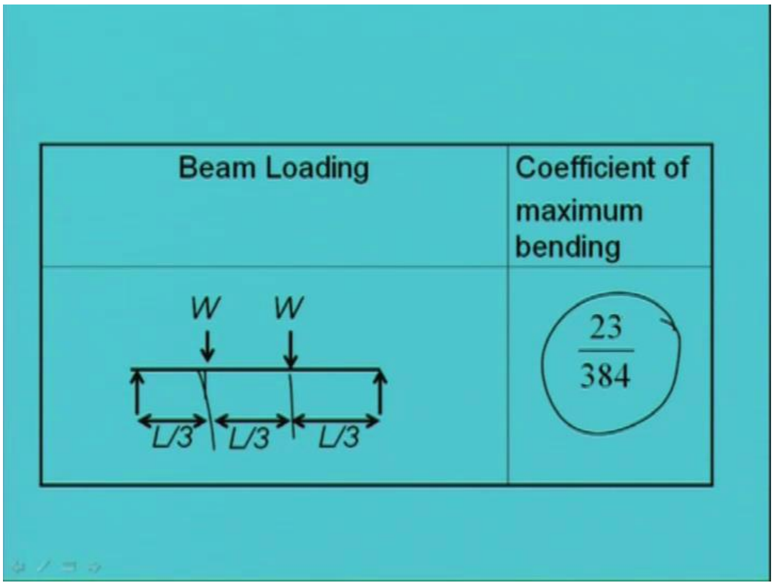

So, these are some standard conditions we are showing which you can remember like, if the load is at 1 third 1 third distance then the coefficient will become 23 by 384, right.

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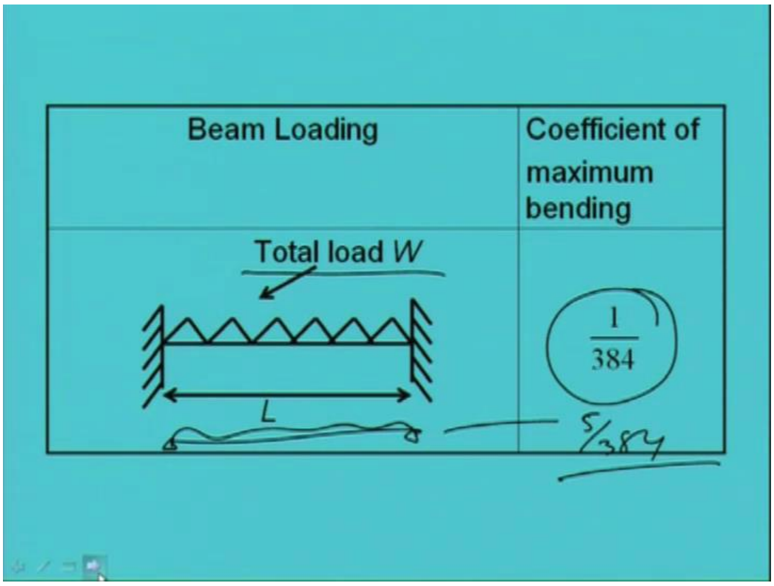

Again if beam is fixed end with fixed end at 2 side and which are UDL load then this will become 1 by 384. If you remember if it is simply supported with UDL load then this is 5 by 384. So, in this way we can find out the maximum deflection.

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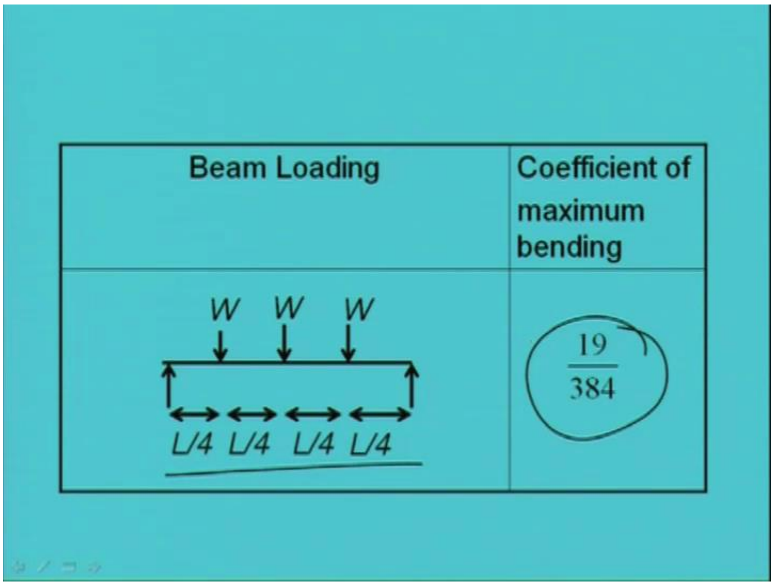

Say if 3 loads is there at L by 4 distance then this will become 19 by 384. These coefficients can be found from any standard structural analysis book.

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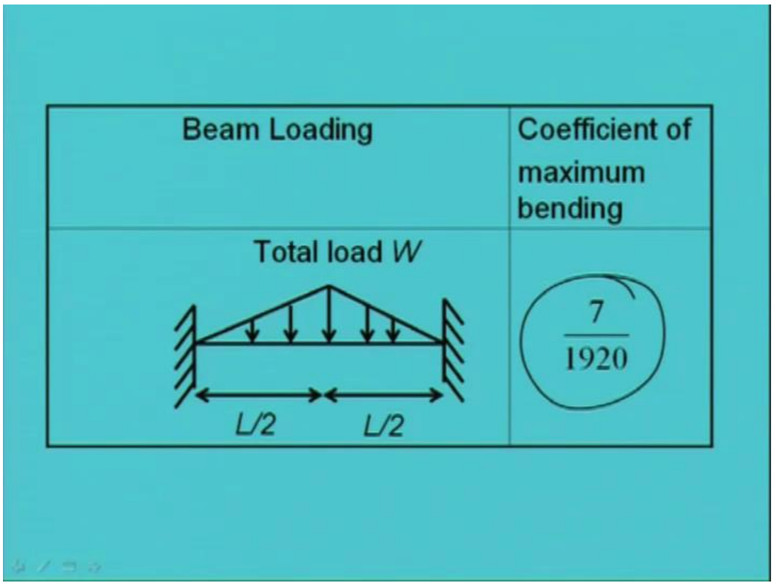

And if beam loading is triangular like things then the deflection coefficient will come say 7 by 1920 right. If the load is at the midpoint with beam end condition as fixed then the coefficient will become 1 by 192.

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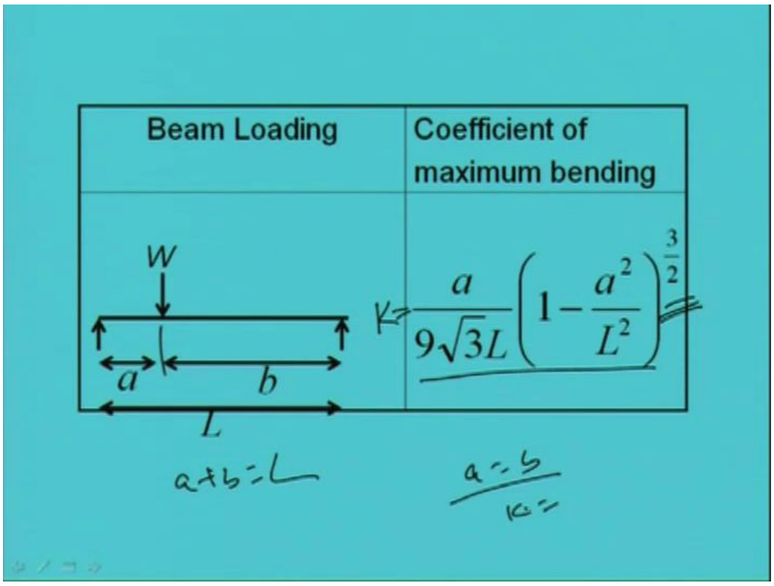

Similarly, if beam means this can be made generalized if beam is loaded at a distance from 1 side and b distance from other side where, a plus b is equal L. Then, we can find out the coefficient as a by 9 root 3L into 1 minus a square by L square to the power 3 by

2. So, in this way we can find out. Now, if a is equal b we can find out K what will be the K similarly we can find out for every cases.

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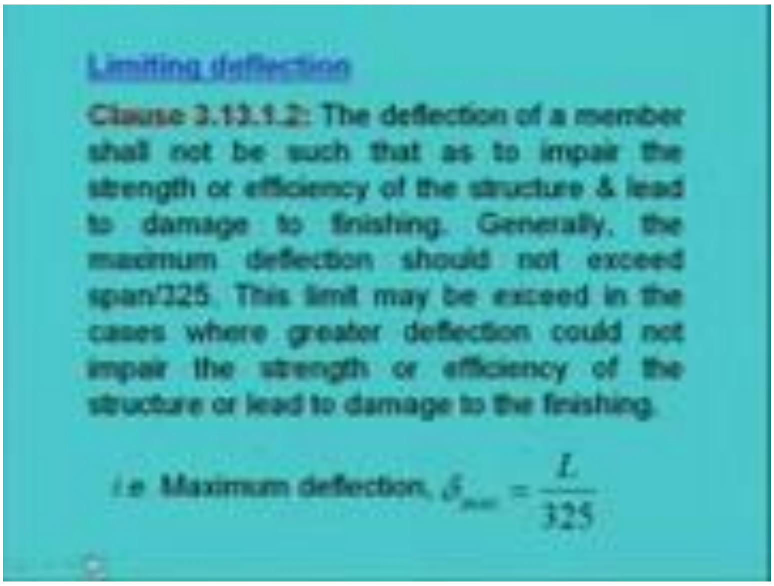

Now, let us see what are the Codal provisions for limiting the deflection. That in clause 3.13.1.2 it is told, the deflection of a member shall not be such that as to impair the strength or efficiency of the structure and lead to damage to finishing right. Generally, the maximum deflection should not exceed span by 325 this is important span by 325.

This limit may be exceed in the cases where, greater deflection could not impair the strength or efficiency of the structure or lead to damage to the finishing in those cases only we can exceed this ratio right. So, maximum deflection as per the Codal provisions it is given as L by 325 where, L is the effective span right. And this is given in clause 3.13.1.2 of IS: 800 1924.

So, from this we can work out some expression through which we can have some idea that how deflection can be controlled right.

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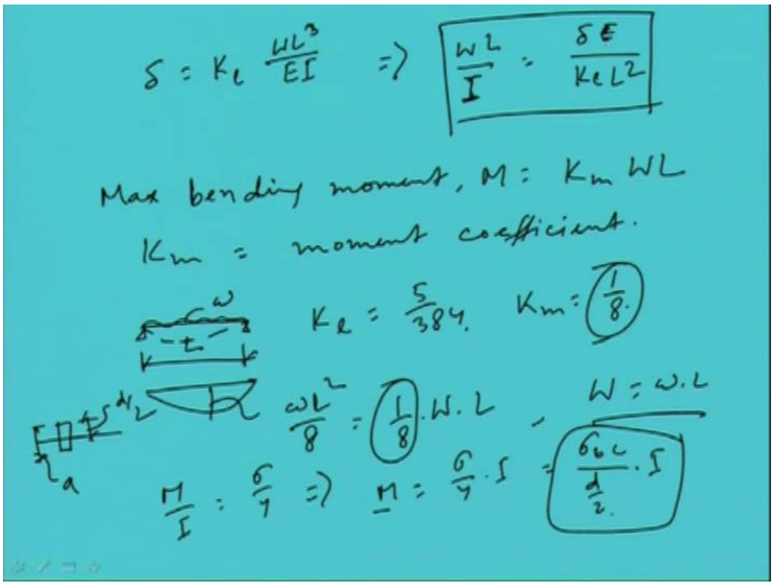

Say we know the maximum deflection of a beam member for single span beam member can be written as like this: WL cube by EI where, KL is the coefficient of due to displacement right. So, from here I can write say WL by I is equal to say delta WL by I is equal delta into E by KL into L square this is 1 equation I am keeping here right.

This is what we got where, KL is the coefficient for different type of boundary conditions and for different type of load the KL value will be changing which we have shown earlier right. And maximum bending moment can be also find out similar way. Maximum bending moment say M will be also can find out Km into WL in this expression where, Km is moment coefficient right.

So, these 2 things we can write. Now, say suppose for UDL load say we have a load and right UDL load with say span L. Then we know what will be KL value? That is as per the tabular form we have shown earlier KL value will become 5 by 384. And Km value will become 1 by 8 maximum moment will develop here WL square by 8. So, right we know maximum moment will be this is WL square by 8; that means, 1 by 8 into W into L, where W is equal w into L right. So, we can find out Km as 1 by 8 right.

So, again we know we can write M by I is equal to sigma by y. So, from this I can find m is equal to say sigma by y into I is equal to I can write say sigma means, say sigma bc means due to bending sigma bt or sigma bc. Sigma bc is compressive stress due to bending and sigma bt is the tensile stress due to bending.

So, sigma bc by y; y will become if such say this is d then y will become d by 2 because the maximum stress will develop at the extreme fiber. So, y will become d by 2 into I right. So, what we are getting m is equal to sigma bc into I by d by 2.

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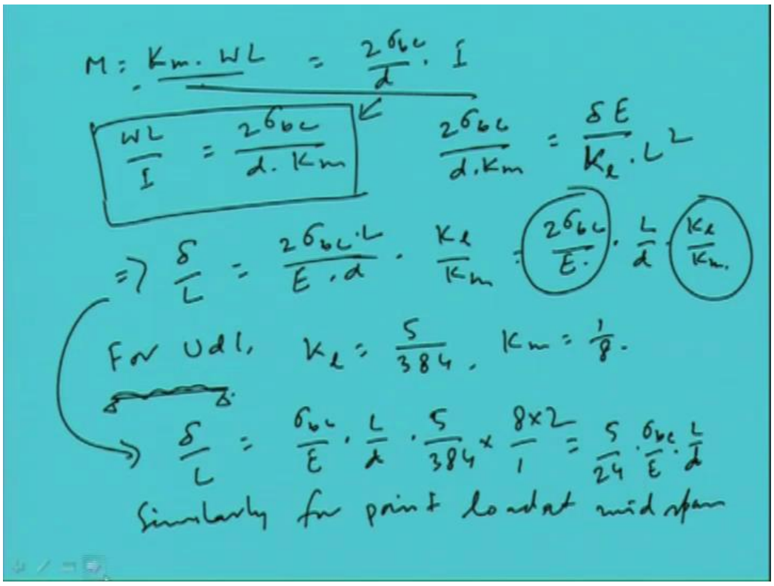

Again we know M is equal to Km into WL, so if we put the value this will become 2 sigma by d into I right. So, M is equal to we can write Km into WL and earlier we found M is equal to this is 2 sigma bc by I right. So, I can write WL by I will become 2 sigma bc by d into Km from these 2 equations I can write like this. So, WI by WL by I is equal to 2 sigma bc by d into Km right.

Again in the earlier equation we have shown that, WL by I is delta E by KL into L square. So, if we make equal of these 2 equation because WL by I is common to both the equations then we can write that 2 sigma bc by d into Km is becoming delta E by KL into L square. So, from here I can find out delta by L delta by L will become 2 sigma bc into L by E into d into KL by Km.

That means, 2 sigma bc by E into L by d into KL by Km. So, for a particular case we have the value of this we know the what is the E value from the material property and the stress. So, we can find out the delta by L ratio right say, for UDL load with simply supported means this case as we are showing we know KL is 5 by 384 and Km is 1 by 8 as we seen earlier.

So, we can find out delta by L from this equation delta by L which will become sigma bc by E into L by d into I can put the value of KL and Km KL will become 5 by 384 by Km; that means, 8 by 1 all right and 2 sigma bc it was so 2 right. So, from this I can find out 5 by 24 into sigma bc by E into L by d. So, similarly for point load I can find out say for point load what I will do we know for point load at mid span of simply supported beam.

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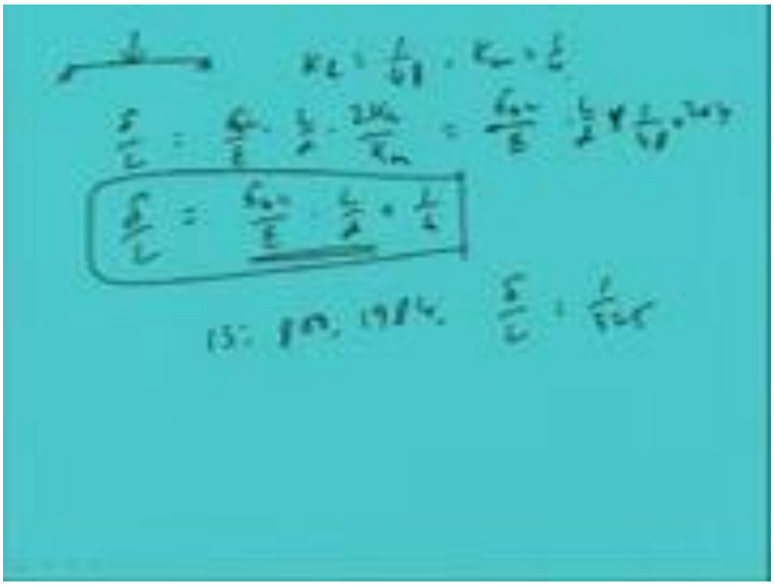

That means, if we have a simply supported beam if we have a point load then we know KL is 1 by 48 and Km is 1 by 4. So, in this case delta by L will become say sigma by E into L by d into 2KL by Km. So, if we put the value the sigma bc sigma bc by E into L by d into this will become 1 by 48 and 2 into 4. So, this is finally it becoming sigma bc by E into L by d into 1 by 6.

So, delta by L can be found out for different cases we can found some expression. And in IS code IS: 800, 1984 this delta by L is given as 1 by 325. Now, if we know what is the values of this? Then we can find out for different type of boundary condition with different type load what will be the limiting value.

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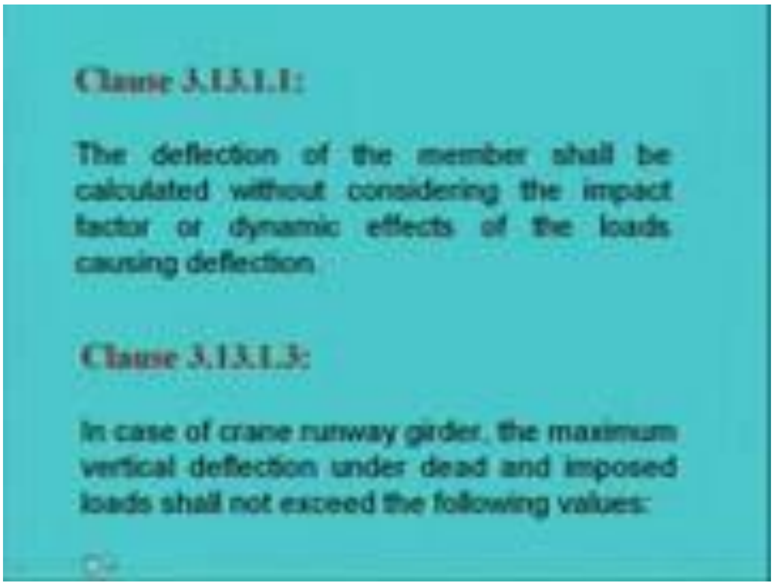

Again in clause 3.13.1.1 it is told that, the deflection of the member shall be calculated without considering the impact factor or dynamic effects of the loads causing deflection right. And in clause 3.13.1.3 is told that, in case of crane runway girder the maximum vertical deflection under dead and imposed loads shall not exceed the following values. So, in case of crane runway girder, the maximum vertical deflection has been specified in clause 3.13.1.3. What is those conditions it is told?

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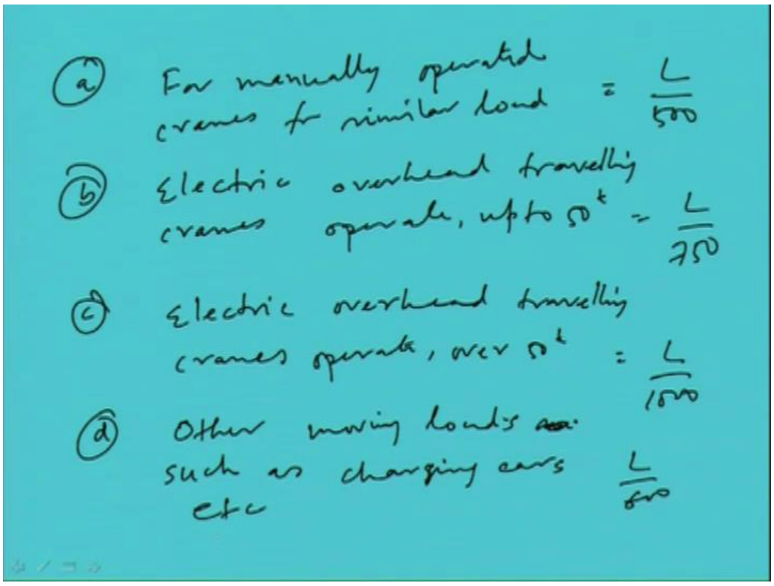

It is told that for manually operated cranes, for similar load means earlier whatever load we have provided this will be the vertical deflection maximum will be L by 500. And for electric overhead travelling cranes operate up to 50 ton this will be L by 750. And electric overhead travelling cranes operate over 50 ton will be L by 1000. So, in this way the Codal provision has been made. Another option has been given in the code that is that other moving loads such as: say charging cars etcetera this will be L by 600.

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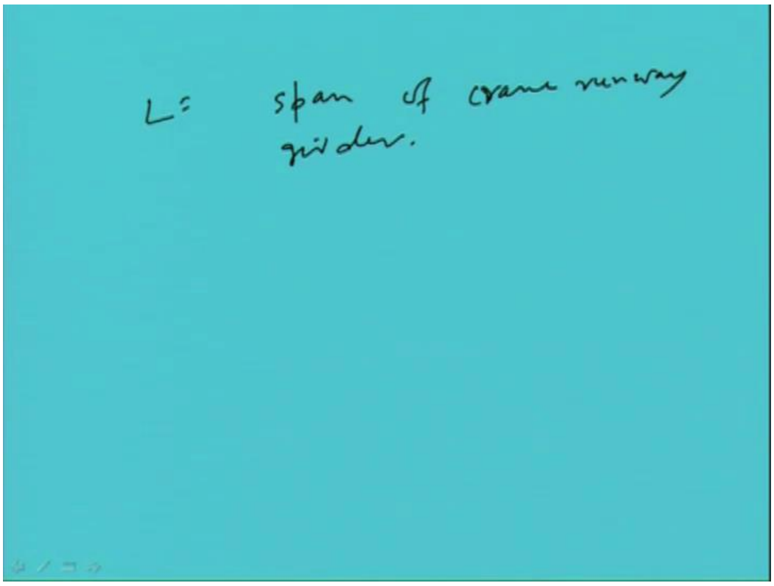

Where L is span of crane runway girder right.

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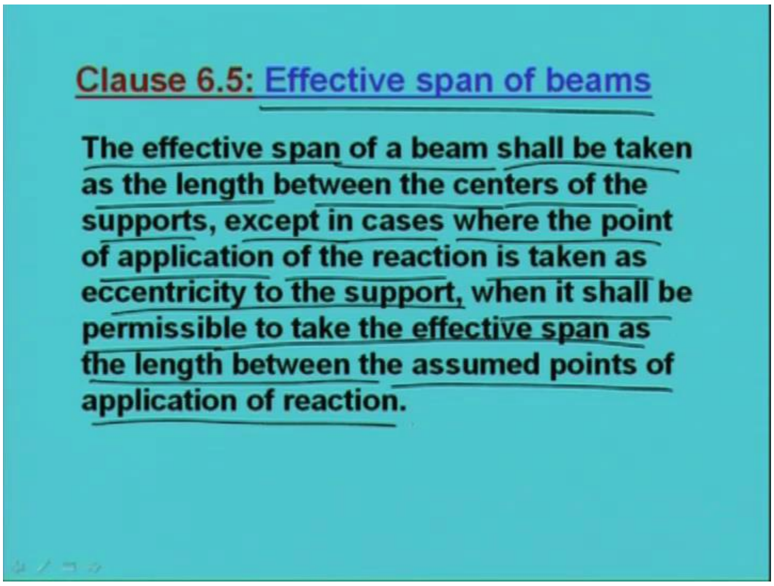

And in clause 6.5 the effective span of beams have been defined. That is the effective span of a beam shall be taken as the length between the centers of the supports, except in cases where the point of application of the reaction is taken as eccentricity to the support, when it shall be permissible to take the effective span as the length between the assumed point of application of reactions. These are told in clause 6.5 regarding effective span of beams 5 minutes more no.

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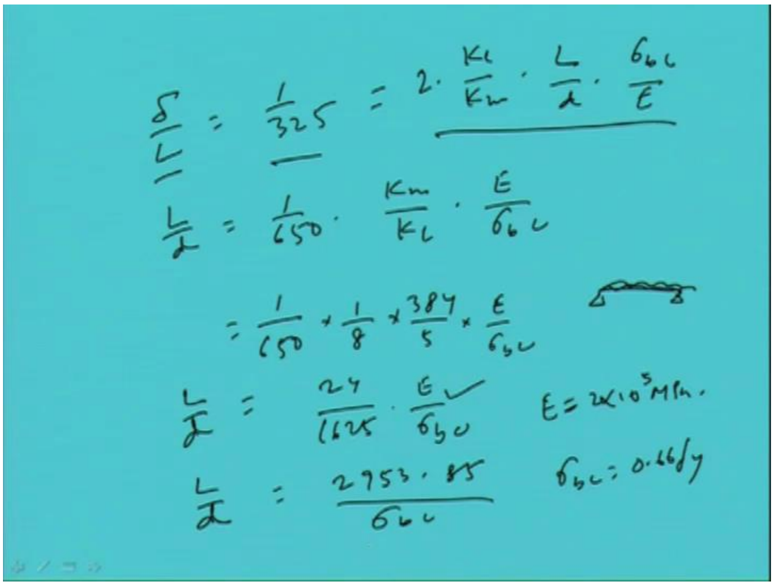

Now, regarding this effective span of beam if we consider that delta by L as 1 by 325 and if we consider the previous expression, then we can write this delta by L is equal to 2 into KL by Km into L by d into sigma bc by E. The earlier we have seen the delta by L can be written in this way which, we have derived earlier right. So, now if we derive further with the values we will see that this is becoming if we put the value.

Now, L by d is becoming say 2 will come this side. So, 1 by 650 into Km by KL into E by sigma bc right. And for UDL load with simply supported we know that value of KL and Km. So, if we put the value of KL and Km, so what we will get we will get Km is 1 by 8 and KL is 5 by 384 right. So, we are putting the values then we will get this as 24 by 1625 into E by sigma bc right.

So, L by d ratio we are getting in this way. Now, we can put the value of E. If we put the value of E generally E is taken as 2 into 10 to the power 5 MPa. So, if we put this value we will get L by d as 2953.85 by sigma bc. Again we know sigma bc is 0.66 fy. So, if we put this value what will happen we will put the value.

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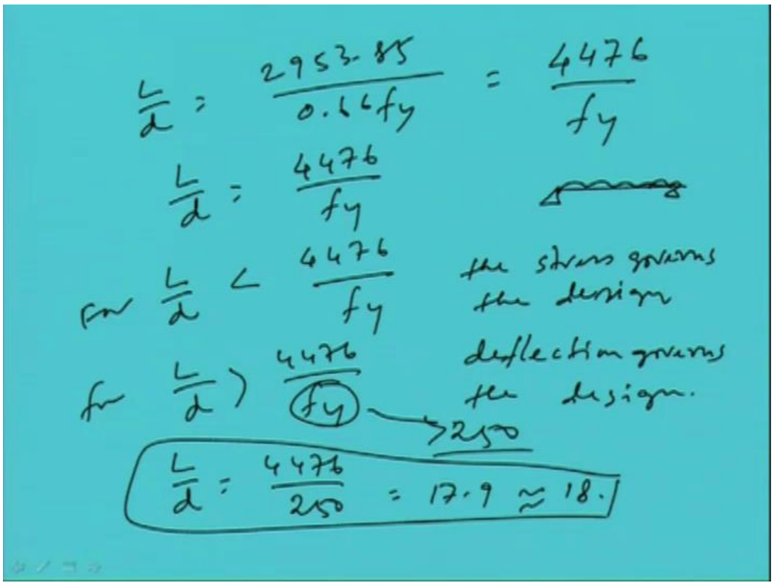

So, L by d will become 2953.85 by sigma bc means 0.66 fy. So, this will lead to this equation the 4476 by fy. So, for this particular case L by d is becoming 4476 by fy. So, we can limit the values in this way right, which case we are going to limit that is the simply supported beam having UDL load, right.

So, now L by d if it is less than this 4476 by fy then what will happen then deflection is not a factor, so the stress governs the design right. And if it is more than this; that means, for L by d is greater than 4476 by fy then what will happen. The deflection will govern the design deflection right. Now, again if I put the value this fy as say for 250 if I use fy as 250 then I can find out L by d is equal to, so 4476 by 250 which is 17.9 which will be equal to 18.

So, in this way we can limit. Now, for a particular case we have shown that how the L by d ratio is going to decide, in this way we can make it. So, in next class we will see how the bending stress is going to occur and how to take care all these things we will show and then we will start the designing of a beam member.