Retrofitting and Rehabilitation of Civil Infrastructure
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Lecture – 06
Load Associated Distress

Hello friends, welcome to the NPTEL online certification course, Retrofitting and Rehabilitation of Civil Infrastructure. Today we will discuss module A. The topic for Module A is deterioration of concrete structures.

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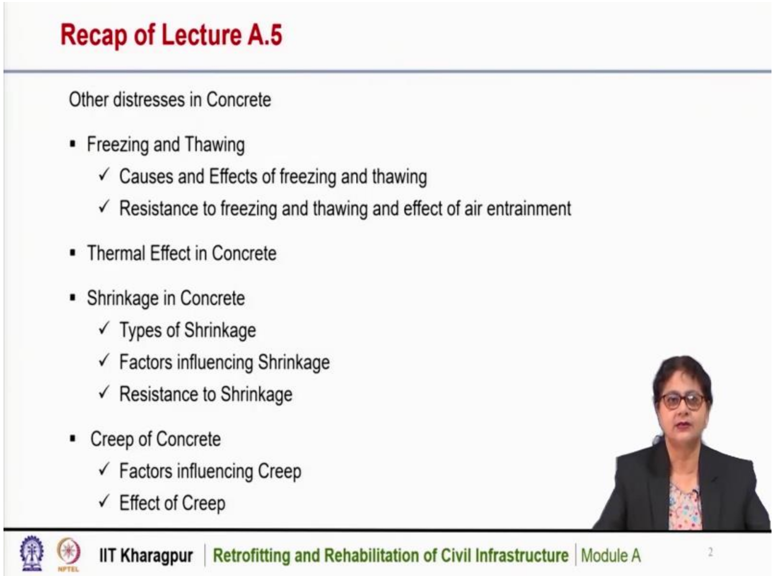

In the previous lecture, we have discussed several distresses in concrete structures. We have discussed, freezing and thawing type of distress, the thermal effect, the shrinkage and creep effect in concrete. In freezing and thawing type of distress, we have discussed, what are the causes and effects of freezing and thawing, how we can resist freezing and thawing and the effect of air entrainment in resisting the freezing and thawing type of distress.

In thermal effect of concrete, we have discussed that there are two different effects of temperature on concrete structures. One is due to the daily variation of temperature and one is due to the seasonal variation of temperature. The shrinkage of concrete has been discussed, what are the types of shrinkage, and what are the factors influencing shrinkage in concrete that has been discussed and how we can resist shrinkage in existing concrete.

In creep effect of concrete, we have discussed what are the factors that may influence the creep effect and what are the different types of effects of creep in existing concrete structures, how the distresses happen due to the effect of creep.

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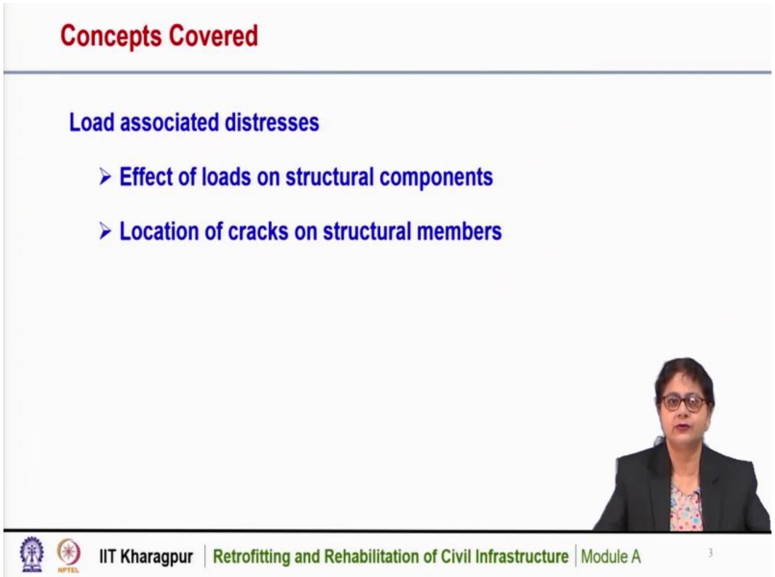

Today, we will discuss load associated distresses. The effect of load on different structural components that we will discuss today and what are the location of cracks or distresses due to the effect of load on different structural members, that will be covered in today's lecture.

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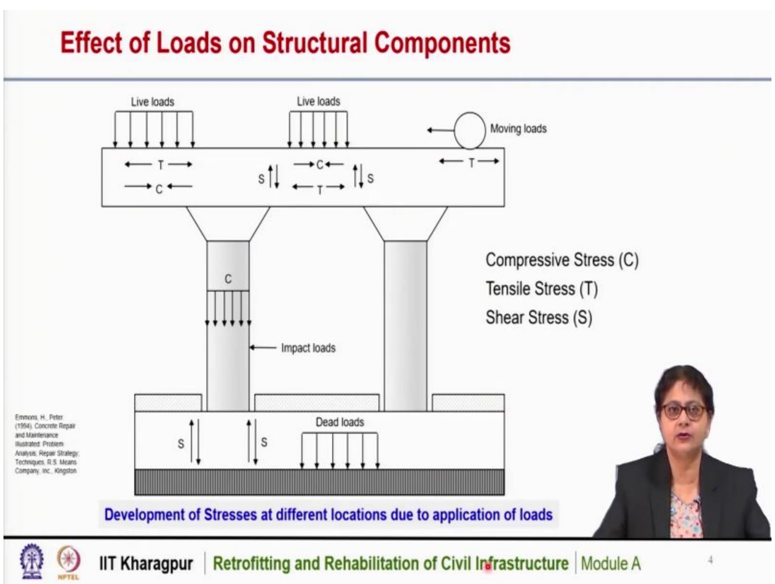

The effect of load on structural components has been shown here schematically, in this diagram. This is a typical frame structure, these are the two columns and this is a beam, supported on these two columns and this is the foundation. The structure may be subjected to different types of loading. One of course, is the dead load, another is life load on the member.

It may also be subjected to several moving loads like due to the moving vehicles it may be also subjected to impact load or earthquake load or wind load which may be horizontal in nature. So, that different types of loads may affect the structural performance. Now, concrete is very strong in compression, but it is weak in tension. And due to the effect of these type of loading, compressive stresses are developed, tensile stresses are developed and also shear stresses are developed.

So, compressive stress is denoted as C here, tensile stress is denoted by T and shear stress is denoted as S. So, due to the effect of these loadings, different types of stresses compressive, tensile and shear stresses are developed on the member. Look at this diagram, this is the live load on this midspan and due to the effect of this load, tensile stresses are developed at the bottom of the span and compressive stresses are developed at the top of the span.

And shear stresses are developed at the side or at near the support. Here this span is continuous, this part is the cantilever portion and here tensile stresses are developed at the top whereas compressive stresses are developed at the bottom. Here also shear stresses are developed at the face of the column.

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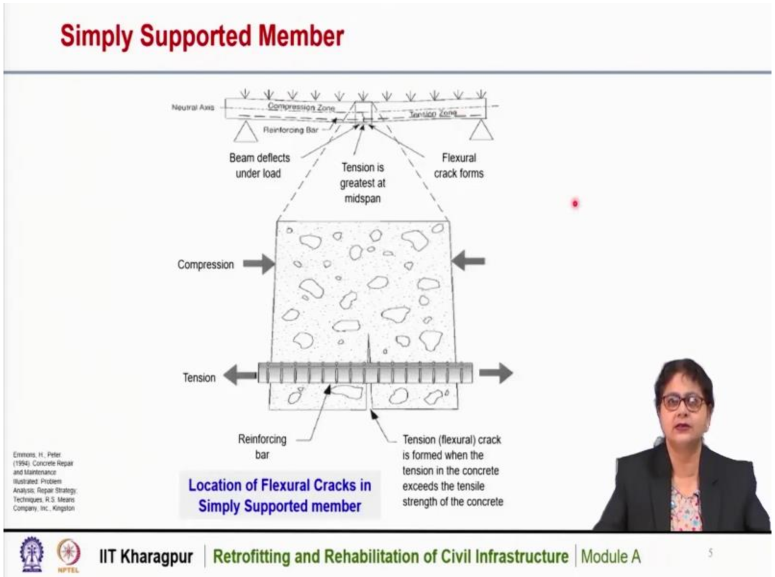

Now, we will discuss the different types of members, simply supported member or continuous or cantilever member and the effect of load on these different types of members. So, look at this picture, this is a typical diagram of a simply supported member. We can see here and it is subjected to live load throughout its span in addition to its dead load. So, because of this loading, the member may deflect as you can see, it may be deflected like this.

And this is the compression zone and this is the tensile zone. So, the tension is there at the bottom of the member, tensile stresses are developed and compressive stresses are developed at the top of the member. Since concrete is weak in tension, so, steel reinforcements are provided to take up the tensile stresses. So, here you can see schematically it is shown, this is the steel reinforcement and this is embedded into this concrete member.

So, concrete is able to take up the compressive stress and the steel is there to take up the tensile stress. However, if the maximum flexural stress developed at the middle point exceeds the tensile strength, there may be a crack at the member. So, you can see here this is a typical tensile crack or flexural crack developed at the bottom of the member. So, this is the typical flexural crack on the simply supported member.

And in most of the cases, we have seen that in case of say simply supported beam in a structure or a simply supported guarder in a flyover or ROB, if it is simply supported, flexural cracks maybe there at the mid span of the member, from the bottom.

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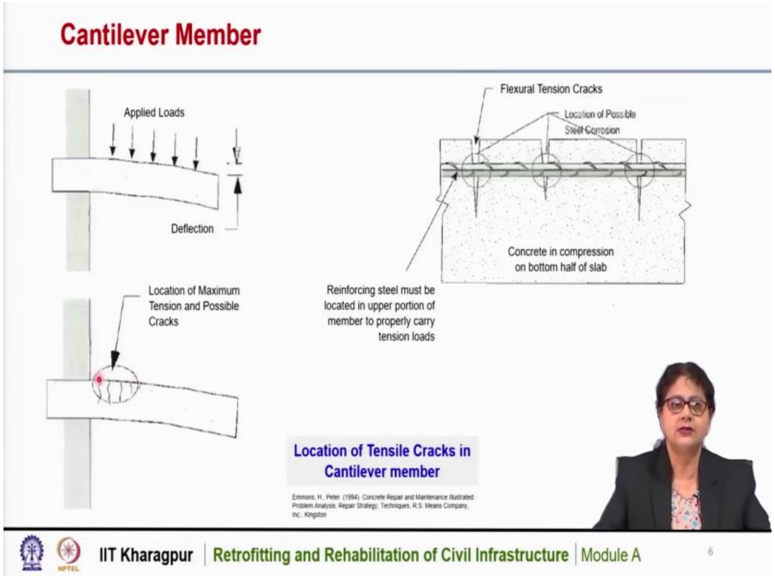

This is a typical diagram of a cantilever member. We can see here cantilever is supported at one end and it is subjected to this type of loading. So, because of this loading, the structure may get deflected and this is the deflection. And maximum moment is developed at the support point. And here also if the stress exceeds the strength, there may be cracks. So, tensile cracks are developed at the top of the cantilever member, if it is not properly reinforced.

So, you can see here that this is a typical cantilever member with tensile reinforcement, and that tensile reinforcement has to be placed at the top. So, this is the tensile reinforcement and if there is crack then the crack appears at the top of the member. So, these are the typical flexural cracks on the cantilever, a member due to the effect of this applied loading.

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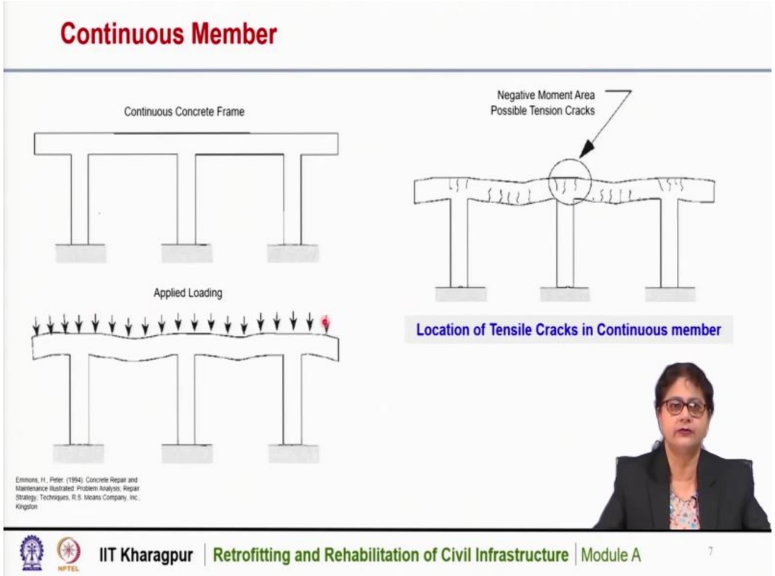

This is a typical diagram of a continuous frame as you can see here, these are the continuous frames supported on three columns and this is the continuous member. And it is subjected to the applied loading. So, the applied loading may be uniform or non-uniform as you can see here, this is uniform loading. And because of this loading, this span is deflected, this span is also deflected as you can see here, this is the deflected shape of the span.

And here also, if the stress exceeds the tensile strength, there may be cracks on the member. So, these are the typical tensile cracks or flexural cracks at the midspan and also at the support, because this is also the location of the negative bending movement. So, this is also the location of cracks on the member.

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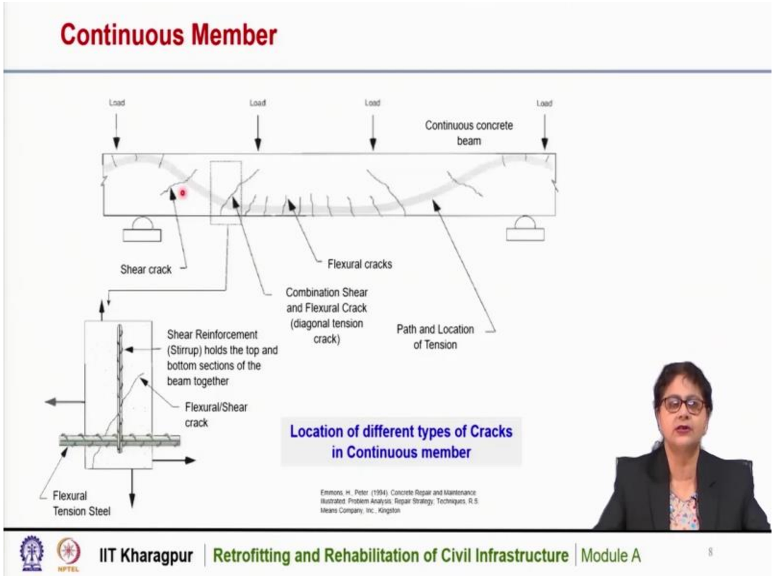

So, this is also another schematic diagram of a continuous member. These are the two supports and the member is continuous beyond the support and also continuous beyond this support. It is subjected to different types of loading. Here, some point loads are there and this is a continuous member. So, because of the applied loading, there may be cracks on the member and as you can see, this is a typical path and location of tension.

So, here is also the location of tension and here also is the location of tension at the supports at the top. So, this is the typical path and location of tension and if the stress exceeds the strength of the member, then flexural cracks may appear. So, flexural cracks may appear at the midspan. As you can see, this is a typical flexural crack. These are typical shear cracks and that shear cracks may develop near the support as you can see, this is the typical shear cracks.

These are combination of shear and flexural cracks on the member, you can see here this is typical flexural and shear cracks. And since this is also the location of tension, so, flexural cracks may also appear at the top of the member near the support. So, these are the flexural cracks also on the member. These are also flexural cracks, these are typical shear cracks and these may be considered as a combination of shear and flexural cracks on the member.

So, if we have reinforcement, this is tensile reinforcement to take up the flexural loading. So, this is the main reinforcement to the member and to take up the shear stress, shear reinforcement or stirrups are provided. So, stirrups are provided to take up the shear stress and main reinforcement is provided to take up the main tensile stress or flexural stress.

And that reinforcement should be placed at the bottom as well as at the top. So, these are the different locations of the different types of cracks on the continuous member.

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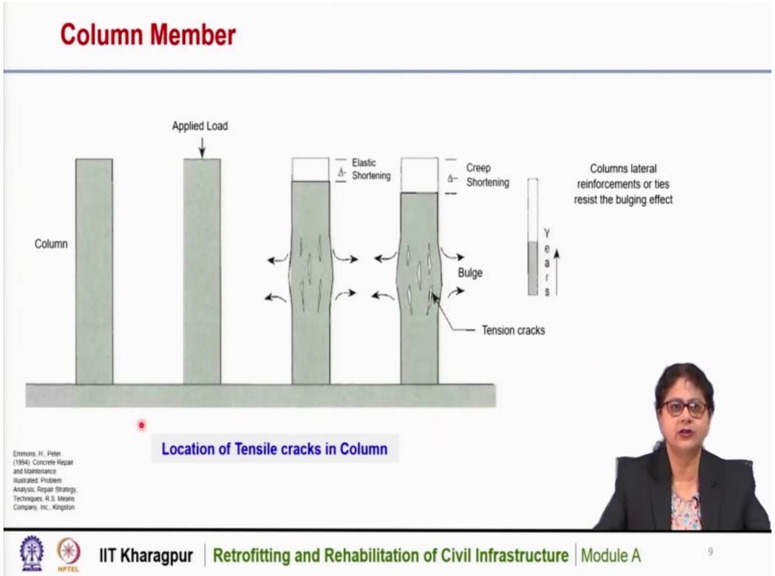

This is a schematic diagram of columns. So, this is a column, columns are mainly compression members. So, the main load that is coming on the member is the compressive load. So, concrete is quite strong in taking up the compressive load. But since it is weak in tension, sometimes we find that tensile cracks are there. So, in case of columns also we find this type of distress, as there is applied loading from the top that is compression loading.

So, due to that applied loading, concrete tends to bulge due to the effect of Poisson’s ratio. So, due to the effect of Poisson's, so there will be the lateral displacement or bulging at the sights, at the lateral direction. So, because of this bulging, the concrete here experiences lateral tensile force on it. And if that tensile stress exceeds the tensile strength, then concrete may crack. So, these are the typical tensile crack on the column, because of this effect.

So, though column is a compression member, but because of the high compressive load if it experiences bulging at the middle of it, then, due to the Poisson’s ratio effect there may be a bulging and it experiences lateral tensile stress at this point. So, when this stress exceeds the tensile strength, then there will be cracks. So, these are the typical tensile cracks that may develop on the column members.

So, here we can see that, this is due to the effect of the applied compressive loading, then this is the elastic shortening and this shortening may be further increased due to the effect of creep. So, you can see here that due to the effect of creep, further shortening is there and there will be more bulging effect and so, more tensile cracks. So, column lateral ties are there to resist this bulging effect. And so, this reduces the lateral ties actually restrict this bulging effect and that helps in reducing the tensile cracks in the column.

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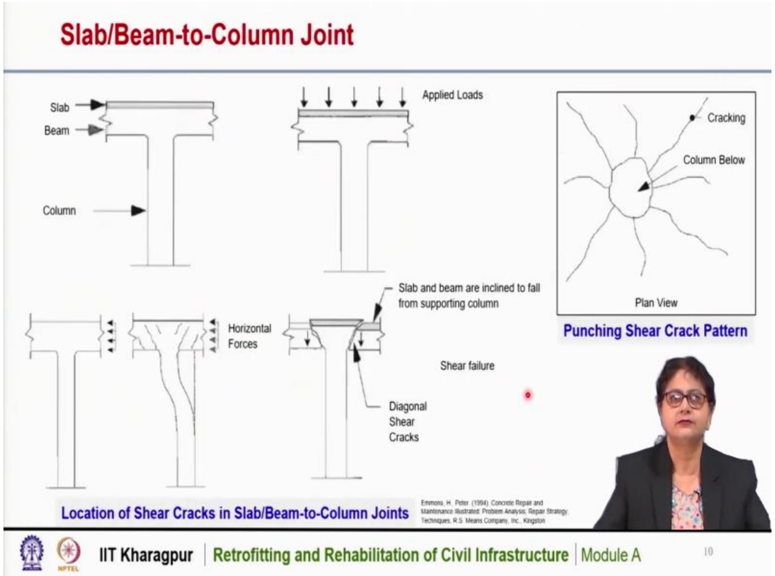

This is the schematic diagram of slab beam to column joint. We can see here; this is the column and this is the slab beam structure and this is the joint. And this portion is also subjected to applied loading. There may be vertical loading or there may be horizontal loading. And because of this loading, there may be shear stresses at the joint.

And if this shear stress is significant and exceeds the shear strength, then there may be cracks. So, these are typical shear cracks on the member. So, there are typical shear cracks and if the stress is significant, then the portion near the joint may be detached. So, slab or beam are inclined to fall from the supporting column.

So, there may be fall of this portion due to the effect of this stress. So, these are typical diagonal shear cracks at the joint, as we can see here schematically in this diagram. There may be also punching shear stress on the member particularly in case of footing or it may be also seen in case of flat slabs, where we can see punching type of shear cracks. And this is due to localized loading on the member.

And because of this punching shear stress, there may be cracks developed on the member. It is typically like this; a number of cracks are developed along the member as you can see here in this diagram. So, this is a column below it and maybe it is a part of a flat slab or it may be a part of a footing. So, punching type of shear stress may develop and that may cause punching shear cracks like this.

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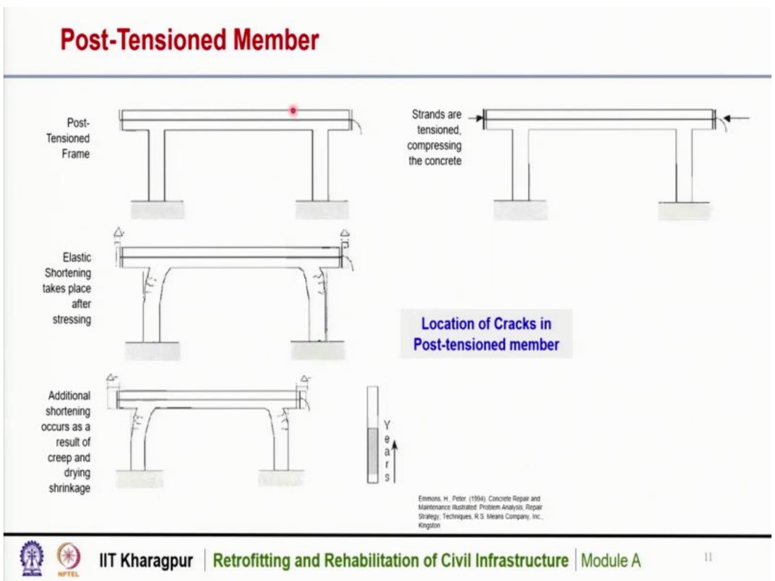

In case of post tension members, strands are tensioned. As you can see here, this is a typical post tension frame and the strands are tensioned and anchored at its end. And this results into the compressing of the concrete member. So, this concrete member is compressed due to the post tensioning and that resulted into the elastic shortening of the member. So, elastic shortening can take place into this member.

So, these members are stressed because of the elastic shortening of this member and there may be cracks developed at these locations. If there is an effect of creep or drying shrinkage, that may result into additional shortening of the member, which further increase the cracking of these members here. So, these are the location of cracks in post tension members.

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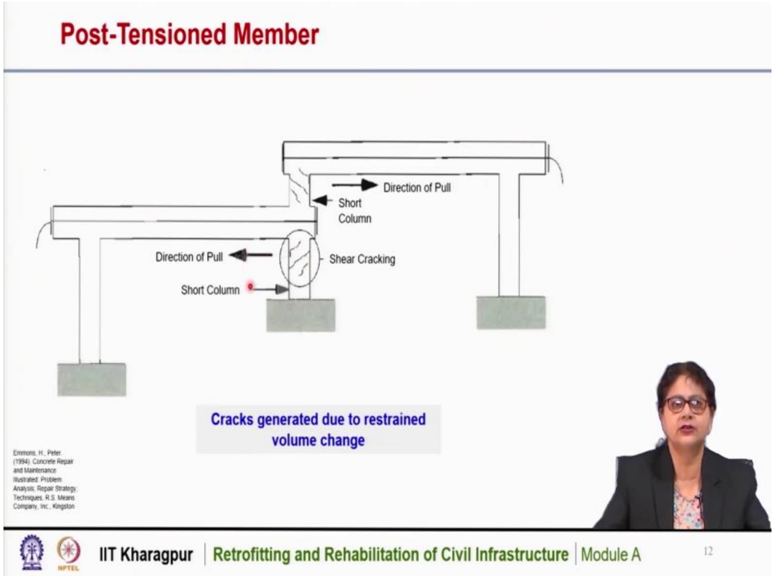

This is also a diagram of a post tension member with short columns here. And because of this post tensioning there is stress in this direction. So, it experiences shear stress at this location. So, shear cracks may appear at this location. And similarly, shear cracks may appear at these locations. So, these are typical diagonal shear cracks that may appear in the portion, in this location of the member.

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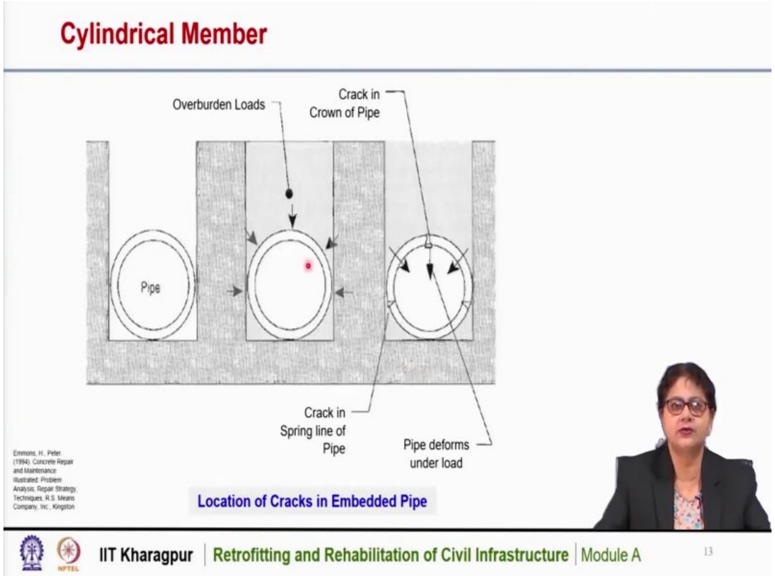

In case of cylindrical members like embedded pipes, which may be embedded inside member and over it there may be some loading due to some overburdened soil or so, and this type of embedded members, cylindrical embedded pipes may also experience stresses due to this overburden loading. And the most stressed portion is the top of this member and also at the sides.

So, cracks may appear at these locations as you can see here, cracks may appear here at the top and also add these two points. So, these are the typical locations of cracks that may appear due to the overburden load on the embedded pipe.

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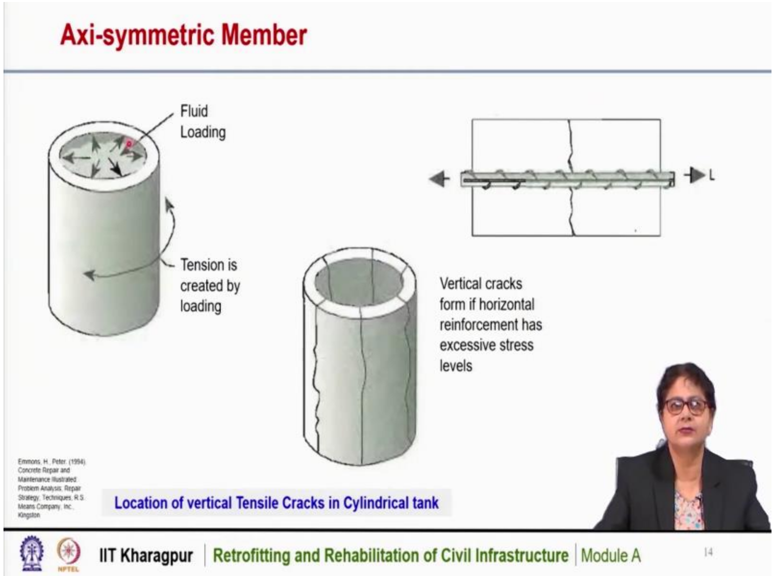

In case of axisymmetric members, this is an axisymmetric cylindrical tank. The structure is filled up with some fluid. So, you can see here, this may be a concrete tank for the purpose of storage of any fluid. And because of this loading due to the fluid, the cylindrical member may experience outward force at its lateral direction. So, the lateral ties are there to resist this bulging effect and tension is created by this loading.

So, to resist this type of bulging we are providing the horizontal reinforcement. And if the stresses are high, so, then there may be tensile cracks on the member. So, these are typical tensile cracks that may form, if the horizontal reinforcement has excessive stress. So, these are typical vertical cracks that may appear due to excessive loading, as you can see here, this is also excessive loading.

And if the reinforcement, this lateral reinforcement is not sufficient to take up this loading, then vertical cracks may appear on the member. So, this is particularly for the axisymmetric member, this type of cracks may appear.

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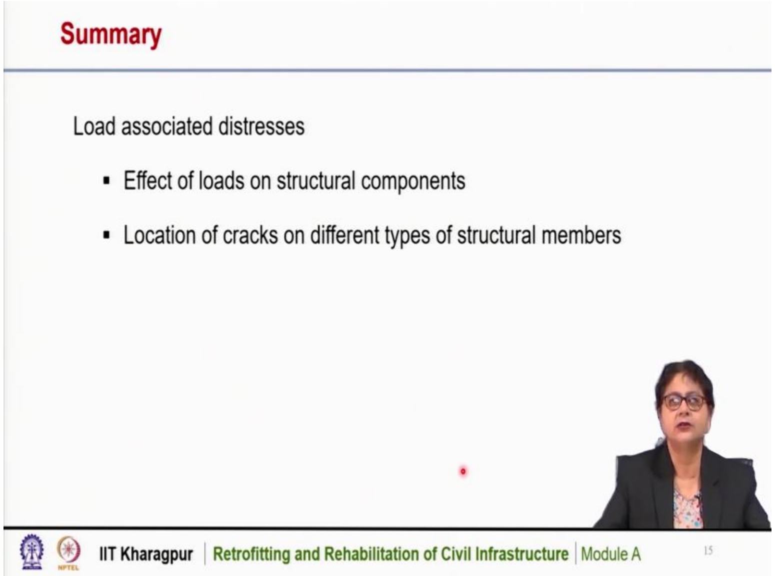

So, to summarize, we have discussed different load associated distresses, that may appear on concrete structures, due to the effect of load on different types of structural components. We have discussed simply supported member, cantilever member and continuous member. And if there are vertical loads on it or horizontal loads, where are the possible location of cracks on the member, that we have discussed in today's lecture.

So, the effect of load is significant on structural members and because of that load cracks, the structure may crack and what are the possible location of cracks on different types of structural members that we have discussed in today's lecture.

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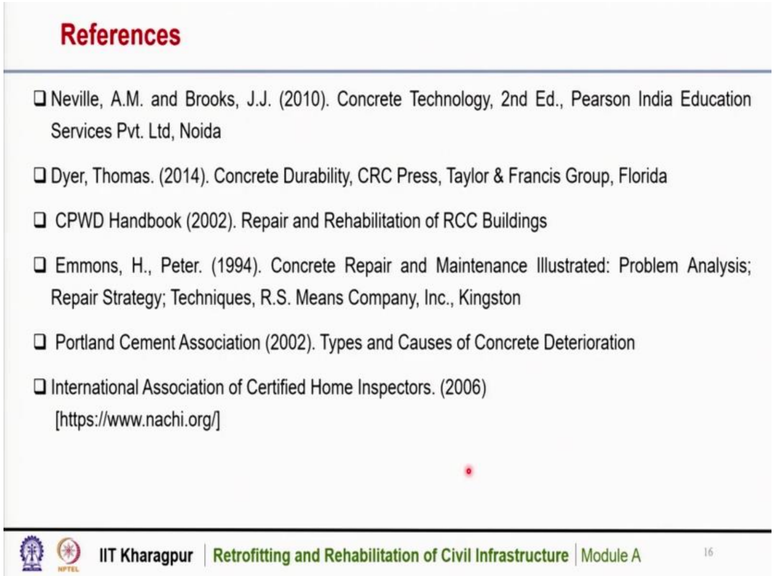

These are the reference for Module A. Thank you.