Statics and Dynamics
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Lecture – 07

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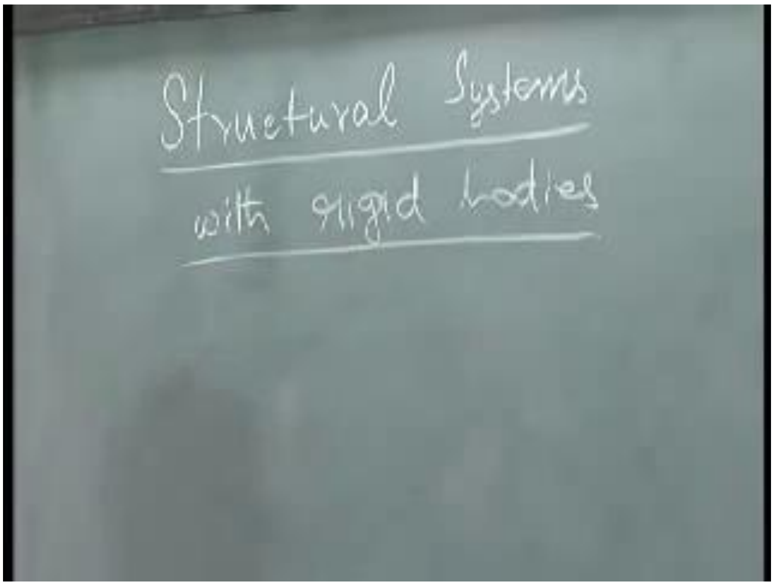

Today we look at structural systems that are made out of rigid bodies. Now to understand it better, we will just assume that the bodies are rigid that make of a particular structural system.

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Usually there are sets of rigid bodies that are connected to each other, either in a rigid way or through a inch or through a slot. There are many ways in which you can connect the rigid bodies and to form a system. And the system is going to take several loads; we call them as structural systems. There are the different kinds of rigid bodies that you can classify them into, by the very nature of these rigid bodies. For example, this particular piece of chalk this has length dimension far exceeding the other two dimensions. So, in the practical sense, this is like a one dimensional body. For example, another example could be this one, where the dimensions of the thickness as well as the breadth are very small compare to the length of this, and we call this as one dimensional member.

This can be called as two dimensional members, because it has finite dimensions of these, and this dimension, the thickness dimension is very small. So, we can call this as two dimensional body. Even if it is curved, you notice that there is one dimension, this direction, one dimension direction and the thickness is small compare to it. Such systems or such rigid bodies we call as two dimensional rigid bodies. A typical three dimensional rigid body is like this; like solid like, the length breadth and height are comparable to each other, so this is the three dimensional. For our understanding, we will first focus mainly, in this particular exercise on bodies that has one dimensional.

This will be very useful for us to build structural systems, and understand before we go in for systems with are two dimensional or three dimensional. So, to start with, let us look at a single dimensional member. Again a single dimensional it can be a straight member like this, it can be curve in any which way you want, either in a plane or out of plane. You can see this is an out of plane member, but still it is a one dimensional rigid body. For now, we will again limit ourselves to just plane or bodies, which means whether it is straight of curved ,it is on the plane; one single plane that we are looking at. So, let say if this is the board. If this board is, the planes are side of it.

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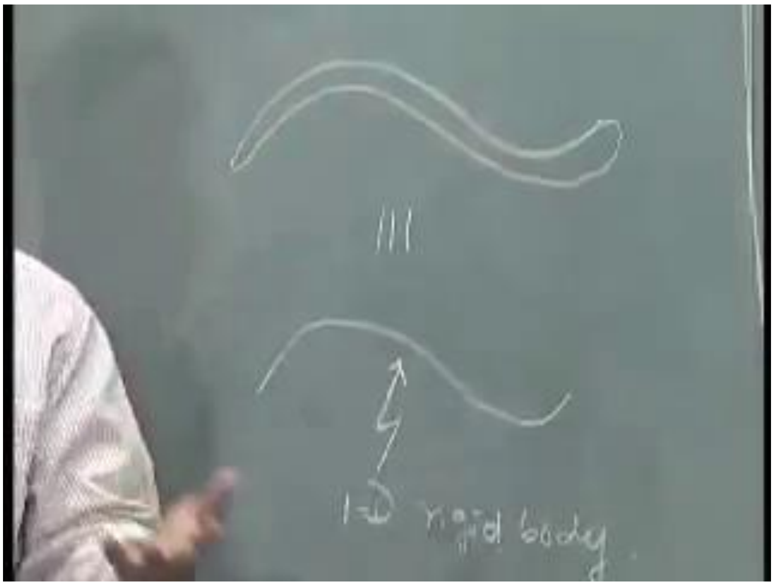

Typical one dimensional rigid body can be something like this, or it could be straight and so on. The very fact that it is one dimensional instead of this we can as well draw the axis of this, and say this is a one dimensional member. So, this is a one dimensional rigid body. And we can build different structures out of this kind of one dimensional member. We will look at some of the examples at a later stage, but let us examine, how do we analyze for forces within this rigid body. The reason why you would want to have an analysis of the forces within the rigid body, is to understand whether the rigid body can take, or the body can take the load or not. For an example if this is a body, and if I am you know pressing it hard on the board, how much hard can I go before this breaks. And that will give me an idea of, if I know the internal forces that will give me an idea of, whether it will break or not for the particular situation that I am talking about. So, such an analysis called analysis of internal forces in a structural system.

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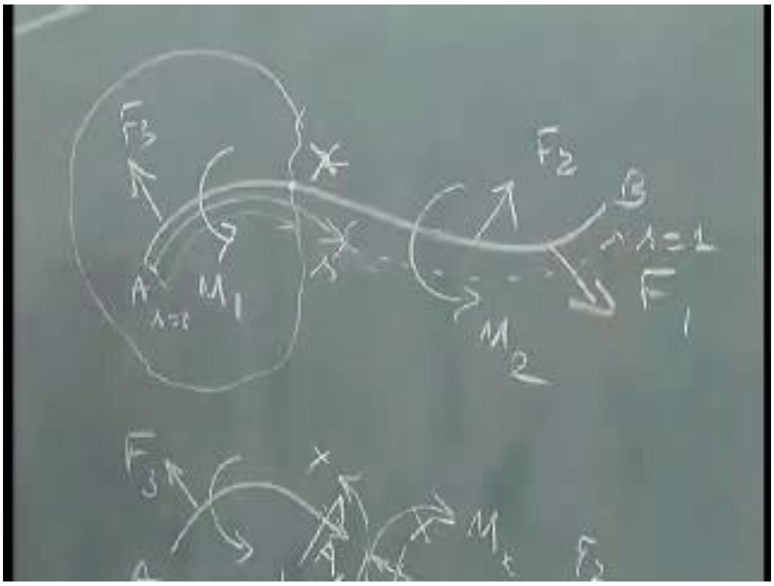

And what are internal forces. Suppose if I take this particular rigid body. From now on I am going to use only line diagrams. And let us say this is subjected to moments or forces in different directions and so on. If have to the examine the internal forces; the first thing that I have to do, is I have to separate this body into two or several bodies, with the point at which I wish to know what are the internal forces in the rigid body. If I have to do this; for example, examine the forces at this particular point x. So, let us say x is like this, and I need to find out the particular internal forces within this particular rigid body. First thing I to do is, separate this rigid body into two pieces, and examine one of the two pieces.

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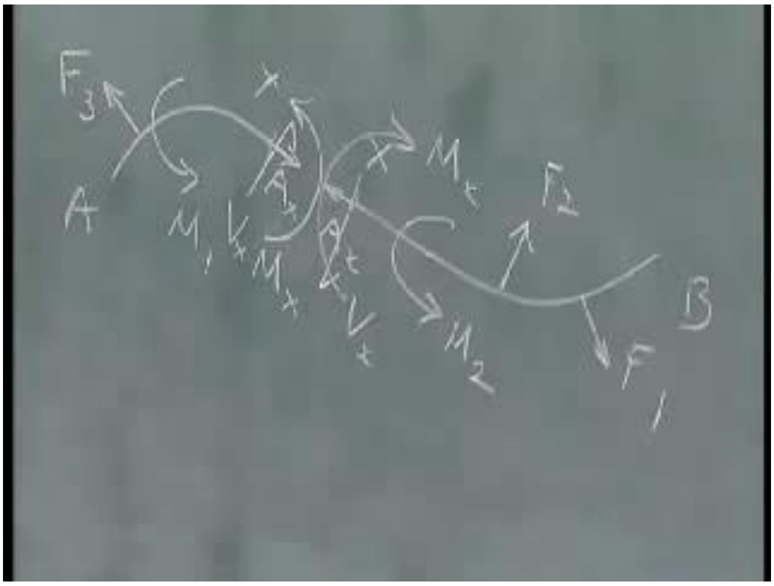

Let us say if we are looking at this particular rigid body, and I separate it. So, I am just showing the separated part. Let us say a, this is x, this is b. So, I have ax here b here this separation occurred at x. We can examine the free body a x or x b. First, I am just drawing all the external forces acting on this particular part of the rigid body a x. If I come to this particular point, this point because of full; that means there will be an axial force, or the force along the curve of this particular rigid body. I am going to call that as an axial force, so we are going to use a a; that could be a force, that is acting perpendicular to it. So, let us just call that force as, what is called shear force, equal and opposite. It could also be resisting; for example this is resisting bending. So, there could be a resistance in bending, and that could form a moment all at x, so I am going to use a suffix x in order to this. Equivalent opposite moments occur, because there are reactions here that will cancel each other. Now I can insert all the other rest of the force is that act on this particular body b. As you can see here, there are three internal force resultants that appear upon sectioning at x. Let me just draw this, little cumbersome.

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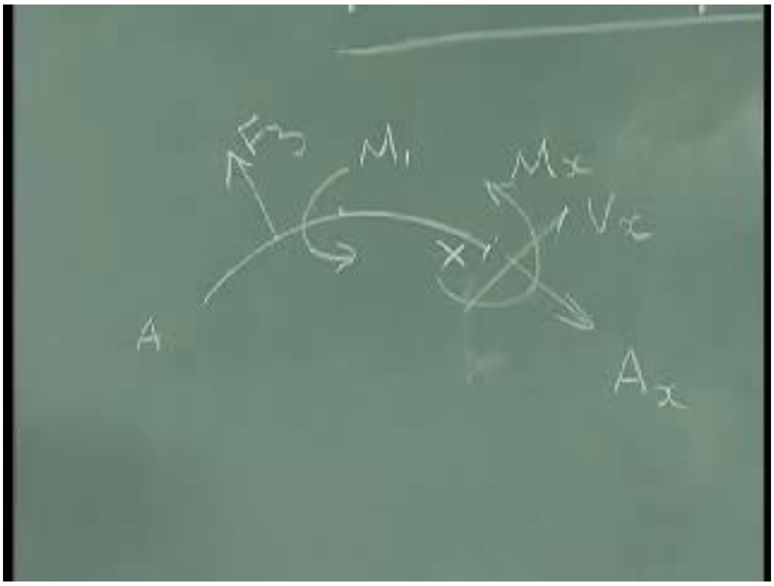

So, I will draw only a x; this is a, this is x. Force F 3 is acting like this, moment is acting. At this particular point where I have section, there is an axial force, there is a shear force v x, and there is a moment, all this appear because of sectioning. So, we are just using a suffix x, where x is the point at which we are looking at it alright. So, this basically essentially shows the free body diagram of a x. Given that F 3 and m 1 are known I have three unknowns a x b x and m x to be found out. Since this is a rigid body, plane or rigid body. There are three equations that we can form,

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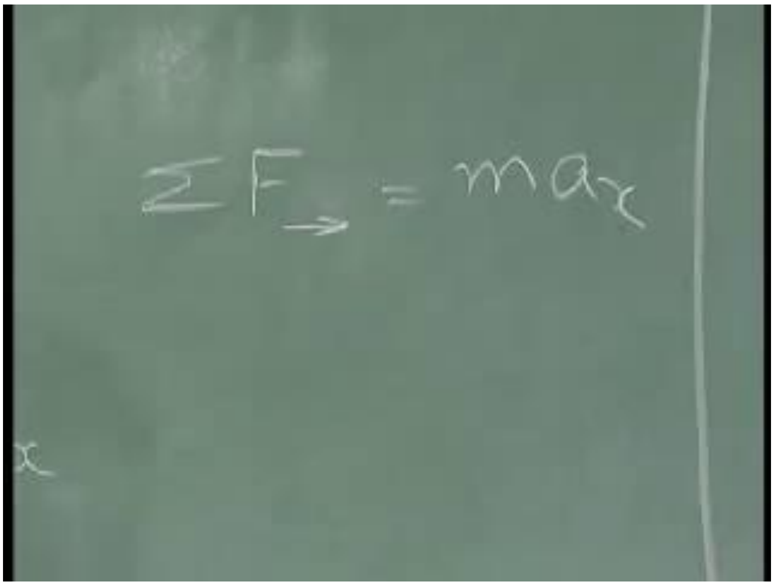

Which are sigma F x is equal to m a x and so on. Let me ask not use F x here sigma a, sigma along x direction along x direction. So, I am just going to put denote direction of here, this is x direction, this is y direction. Let us use a X here just to avoid confusion.

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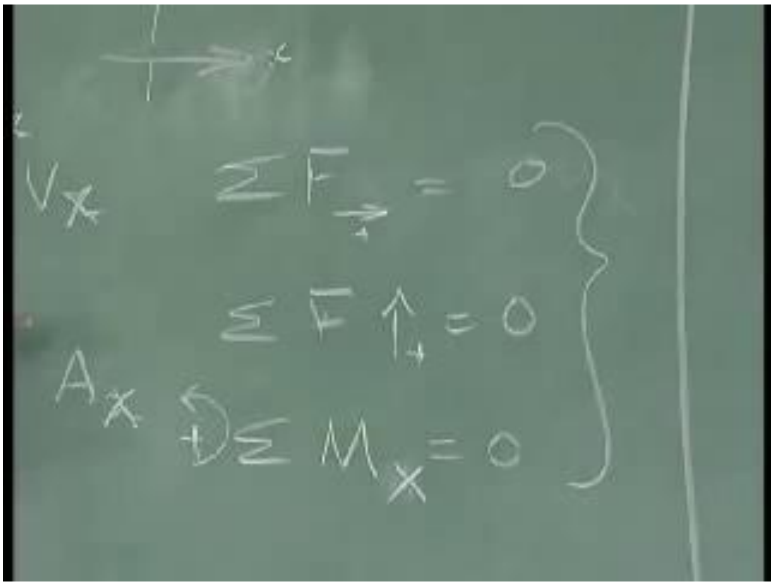

If we are looking at only statics, when we make x equal to zero. Similarly F in the vertical direction is equal to zero and moment; let us take this as positive equal to zero. Three equations can be formed. This can be about any point on this. So, if I take a as the point, or x is the point in question. Then I have three equations three unknowns that I can solve for. So, equilibrium is enough to solve for forces in the member. So, how do we quantify this?

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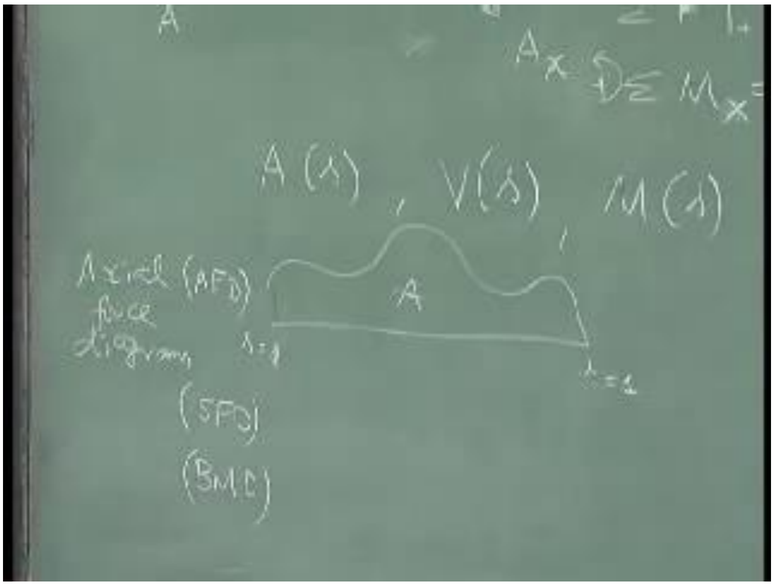

If I have to write, let us say we examine this particular body a b, I can probably run a coordinate s along this. So, any cut here, tells me what this s value. I can start from s equal zero to s equal to either one or something. So, if I take s equal to one I can always find out what will be the value of the axial force in the member. Similarly, at same point s away from a; the shear force, and this. We look at it all the three, vary with respective to the coordinate s. Or in other words I can also do a plotting, starting from s equal to zero to s equal to one .Let us say axial force is changing like this. So, it could be positive or negative. I am just going to talk about one dimensional in the moment. So, I will adopt this to be the axial force.

Similarly I can show the distribution of shear along s equal to zero to one, and similarly n. So, this is an axial force diagram. In short it is called A F D, and you can have shear force diagram S F D, and you can have bending moment diagram, so B M for bending moment diagram. So, these are three diagrams that you can draw. Depending on the nature of these, you can classify the one dimensional structures, or one dimensional rigid body. So far we have just examined the internal forces acting in a one dimensional member. When I say member here, single one dimensional body a structural system consisting of one dimensional body, is basically many of them connected together to form a structural system. Typical structural systems could be; for example, let me just use this same kind of member.

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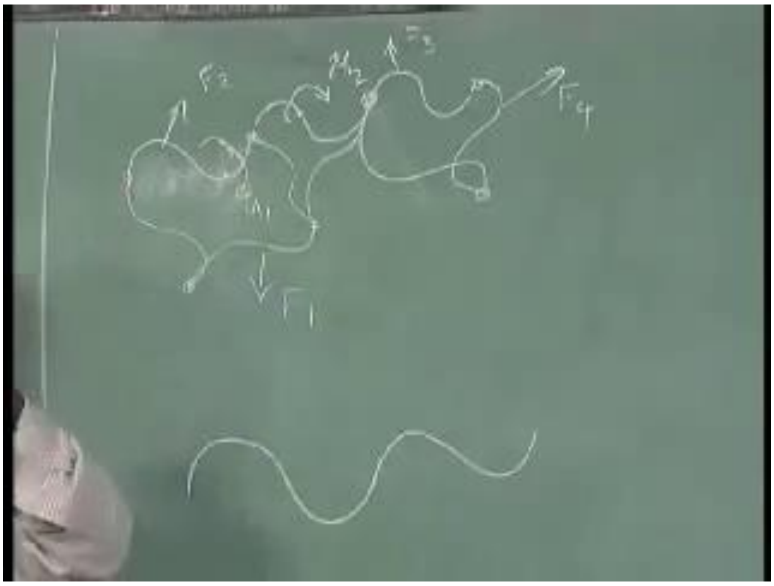

Let me take same s type of member. I could join many s type of members; let us say it will have something like this. This could be a structural system that I have, and there may be forces acting on it everywhere around it and so on. I could have, perhaps, this s integrally joining. There is no integrally joining like this. If you look at this, it is different from this. I will show you in a moment a few of those examples. Here it is integrally joining. Here you have a pin type of joining.

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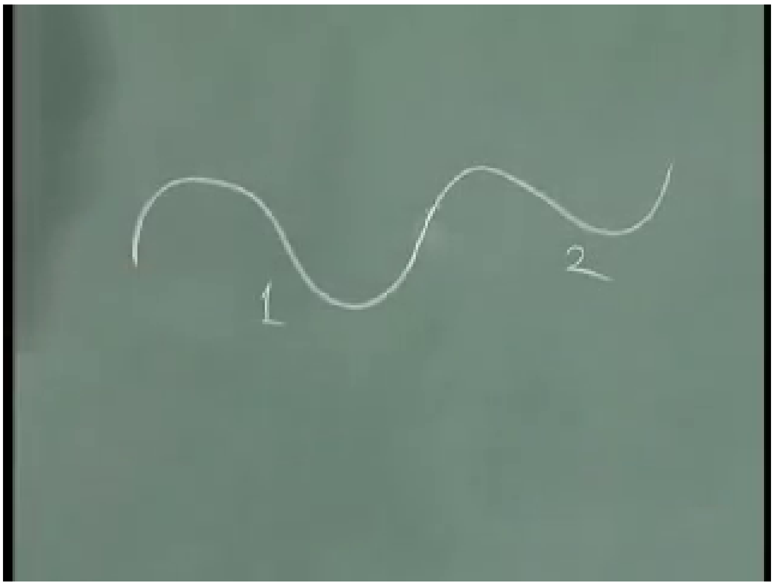

Or in another words, in this particular case, if I have a joining way of having a single pin; that means, this member, and this member can rotate really with respect to each other, at this particular point. But then if I integrally connect them like this, they cannot rotate between each other, and therefore, there will be a moment reaction between them. So, this is another possibility you have. We will look at other possibilities. I could have straight members.

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For example, I could have a straight set of members, connected like this. I could have just a single member, but vertically placed, and forces that are acting are only vertical forces. You look at this, this looks like a column system. There are forces acting only in the vertical direction. Typically, we name them differently, depending on the shape of that particular rigid body, and the internal forces that they carry. The internal force that they carry, could be either all the three of them together, or only one of them or two of them. Any particular combination that we work out in a structural system.

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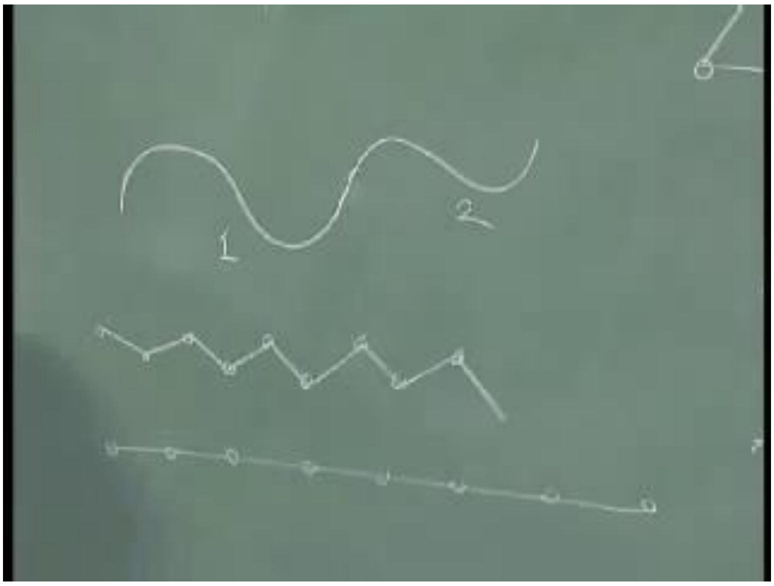

Supposing I take small state elements, and then join them like pins, and then form some structural like this. This is like a chain alright. I can straighten it and I will have something like this, with. What is unique about this is, these particular points where they are pined they are free to rotate, there is no resistance of it. Suppose I think of these elements to be smaller and smaller and smaller, what do you get. You will get so many pins attached to that. Or in other word, it cannot resist any moment at any particular point. Such a member such a structural system is called a cable. So, we name different structural systems that form out of this, as different structure such as trusses, beams, frames, shafts, you have columns, you have cables and so on.

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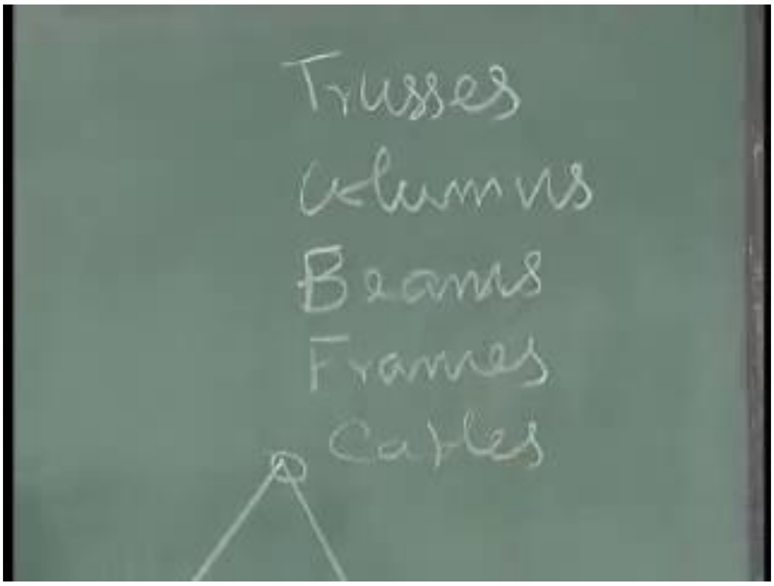

Frames and you can have cables. If you have only torsional action on it, you call them shafts. Depending on the action, we have different names to it. We will see what is unique about each of these systems in the next clipping.

Thank you.