Engineering Mechanics
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Statics – 2.5

For example, in this particular module let's look at whether this particular structural system is stable in the static sense. Whether this is stable is a question that we have to ask. Let's examine it step by step. The first thing I would attempt to do is I would look at this particular free body. Let me just hash it to indicate. I am going to take this particular system, entire structural system and look at its support reactions and ask the question, whether it is rigidly connected to the fixed frame of reference.

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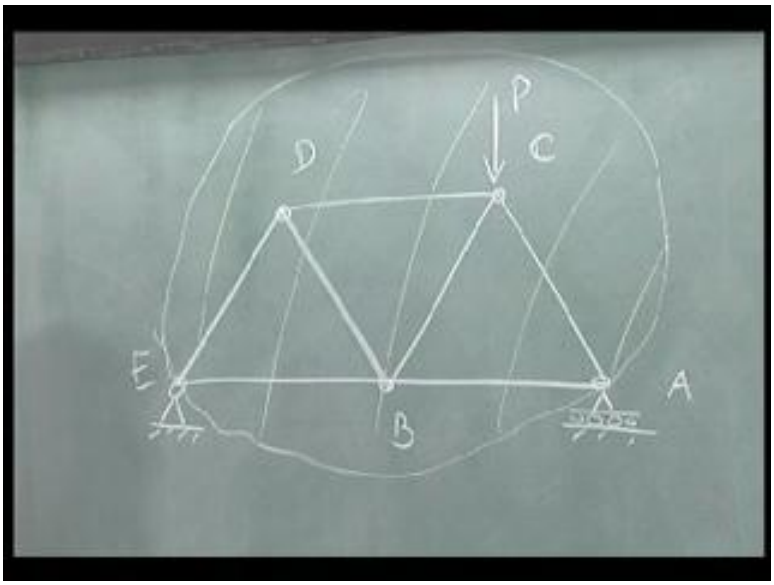

If the answer is yes then we can proceed to find out the nature of the structural system itself as a separate body. Mind you if I do this at this particular point, if I pin this particular body at this point, the only way that the body can rotate is like this. Assume that this body is stationary within itself. If I use a roller support to arrest the vertical moment here at A then I know that this particular body cannot move as an integral body with only these particular supports. In other words these supports at A and E are enough to give a particular rigid body a stable support.

The first question that we answer is the support system to the structure… Here the structure is this which consists of rigid bodies connected together. Is the support system to the structure stably or stable in connection to the fixed frame ? The answer to that question in this particular problem is yes. If I hinge at E and have a roller support at A that is enough to pin this particular rigid body to the fixed frame of reference. Therefore the next question that I have to ask is; is the structure itself a rigid body? If it is a rigid body, then from the earlier concept that we know, it will be a structure that is stable.

So let's examine that. How do I examine that particular concept? It is not difficult, in order to do that first let us make it a body with the supports they moved. Typically this particular body should indicate the characteristics of a single rigid body. So if I start with this particular member, for example, I am going to take this member. I hold this member and ask the question, if I connect these two and don't connect at this particular point, these two members can rotate about B and E.

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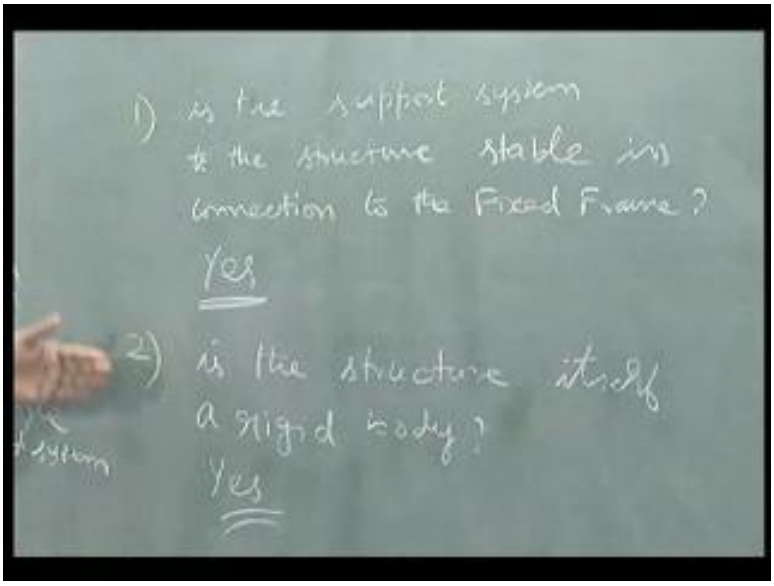

If I take this particular member DE and this particular member BD and ask the question if they are pinned at these two points, what will happen to these? These members BD and DE will rotate about E and B. Now to arrest the rotation I am pinning it at D. The moment I pin at D, there is an arresting of rotation of BD as well as DE with respect to each other and with respect to BE. The net result is that this particular triangle that you see, formed by pinning at these three points itself forms a rigid body. Because BD is rigid, DE is rigid and BE is rigid. This particular construction of DBE is a rigid body and to this rigid body, I will again examine by inserting two BC and CD pinned at D and B.

Again they can rotate about B and D and if I pulled the relative rotation of these two members at C, they become rigid again with respect to this rigid body which means I can include this and say that both together form another rigid body. I can extend this argument and show that I can engulf this region also and therefore this entire body ABEDC is a single rigid system, planar of course provided each of these members that we have AB, BC, CD, DE and BE are rigid. That satisfies this condition and therefore the answer is yes and if these two conditions are met then I will say that this structure is a stable structure. Very simple. This is one of the criteria that has to be met in order to analyze for the forces in the structure for stability and static's. Thank you.

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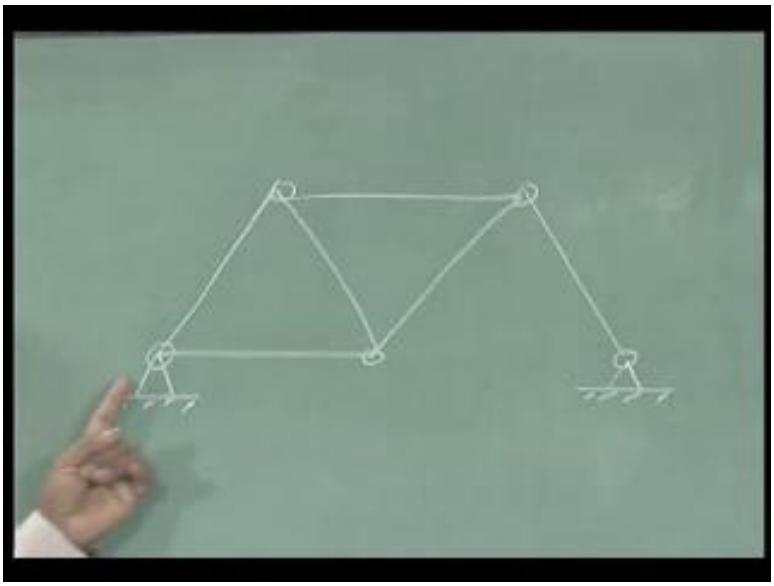

Now let's look at some examples in relation to stability. Let's say I have something like this. I have one like this and another like this and I ask the question is this a stable system. Let's examine it and find out. Unlike the previous system which I have just taken a similar system here. Here I have taken a roller support here and a hinge support here. In contrast both are hinge system, but I have one member lost over here and I want to ask the question is this a rigid stable system. Let's examine. First let's take this, the structure out of the fixed frame of reference. I find that this has a hinge and this is a hinge and if I remove these two, there are two reactions that occur or in another words if I have to draw this as a free body and examine the equilibrium, there are four unknowns that I have to solve for but mind you I can just solve for only three equations.

But one thing is clear. It is rigidly connected to the fixed frame of reference and therefore let me go to the next step. The next step I will examine the free body of this. Like in the earlier case, as long as I have 3 members like this joined as a triangle, it becomes a rigid system. This rigid system is again forming a triangle with these two and therefore they together will be a rigid system but this rigid system along with this is no more a rigid one. There is a degree of freedom that you see here. Therefore this no more remains a free body, rigid body. If it were a rigid body, a rigid body has 3 degrees of freedom but here I have a system of rigid bodies, this is one rigid body that can have 3 degrees of freedom. In addition this can have a rotational degree of freedom and therefore plus 1 so 4 degrees of freedom are possible in this particular system of rigid bodies. Here I have a case where externally it is fixed to the system in a stable way but internally there seems to be a mechanism possible.

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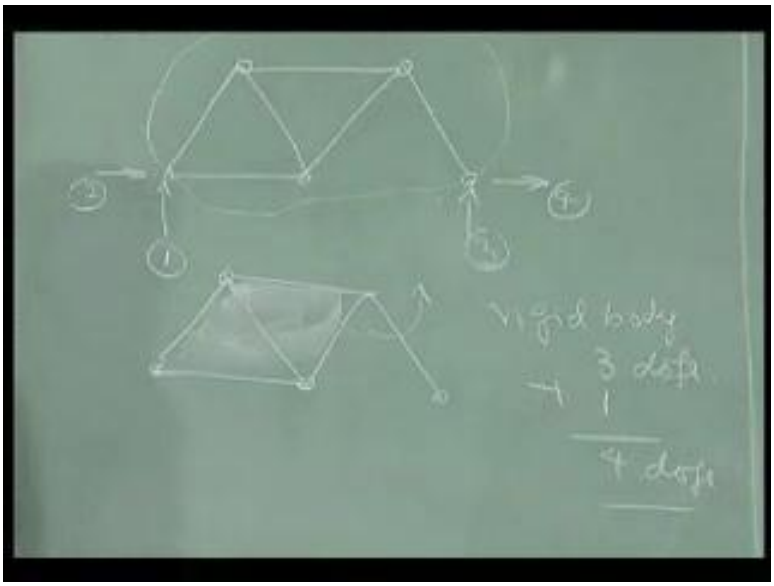

But since I have to find out 4 unknowns from the external support and I have 4 degrees of freedom for this body that I can form, it is possible to solve for the 4 unknowns through 4 degrees of freedom. In that sense if I take the entire thing together, it is a stable system. Even though this particular body that I am looking at is not a stable body. Let's look at a simpler example than this.

Supposing I had this also and I ask the question, is it a stable system. The answer is immediate, yes I have. This also included and this is a single rigid body. Mind you single rigid body means I will have only 3 degrees of freedom, which means I can generate 3 equations. I have to solve for 4 unknowns, only 3 equations which means I have to generate another equation from some other condition. I cannot generate from the equilibrium conditions that I already know. Such a system is called a statically indeterminate system.

A statically indeterminate system, statically meaning there is no movement. Indeterminate means you cannot determine using purely equilibrium equations. Let me just show an example from this. Let me modify a little bit of this. Let me remove this member and ask the question supposing I had something like this and will this be a rigid body or in other words will this be a stable system. Let's examine that. Earlier we did that exercise and asked that question, let's look at the external supports. The external supports are introducing three actions, two from here and one from here, so one, two and three reactions or in other words three unknowns have to be solved from equilibrium of this particular body. This body already we found out that these two can form a rigid body, whereas this body does not integrally form a single rigid body with this rigid body or in another words it has a mechanism of being able to rotate at any moments.

Therefore, this particular system of rigid bodies will not have 3 degrees of freedom but 4 degrees of freedom which means I can write 4 equations but there are 3 unknowns only to

be solved and we have a problem here. Why it's a problem? Because we have assumed this particular body to be stationary whereas it is not. It's not very difficult to understand, think of it like this. Supposing I apply a force like this and look at this. This is hinged, if I apply a force this can move. So what will happen is this will move like this. You will get it to be something like this, it will move like this.

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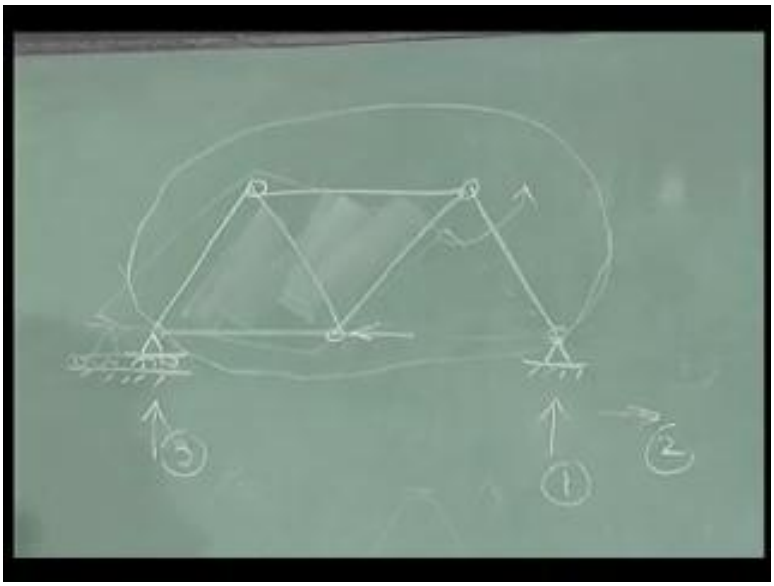

Can you imagine that just moves down rotates like this, it moves down and moves like this which means if I apply a force here, it becomes a non-stationary system. Such a body, such a system is called a mechanism. Other name to that is statically unstable system. Many times people don't put this statically and call it as just unstable system.