Mechanics of Material
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Introduction and Mathematical Preliminaries

Lecture – 01
Part 3
Introduction to the course
Objectives and prerequisite

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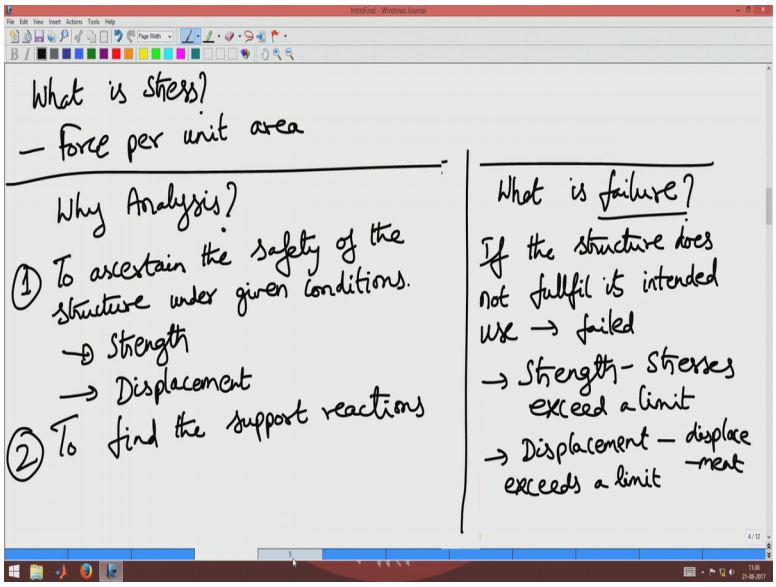

Let us see, why do you want to do analysis.

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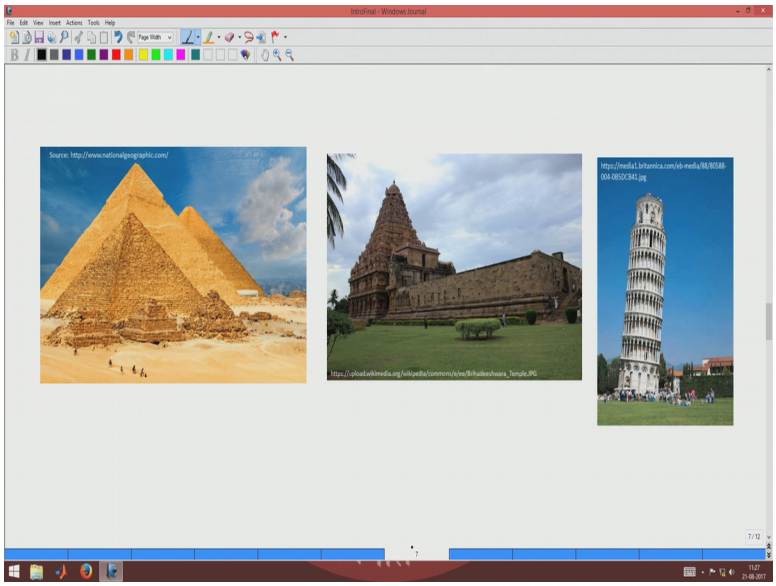

Now, if you see these structures are built without much knowledge of what stress is, what stain is or what constitutive relationship is. The pyramids state back to 100 BC or something like that. The Brihadisvara temple or the big temple in Thanjavur is around 1000 years old, the Leaning Tower of Pisa is also around 1000 years old. In contrast with this what is the difference that you see in this structure.

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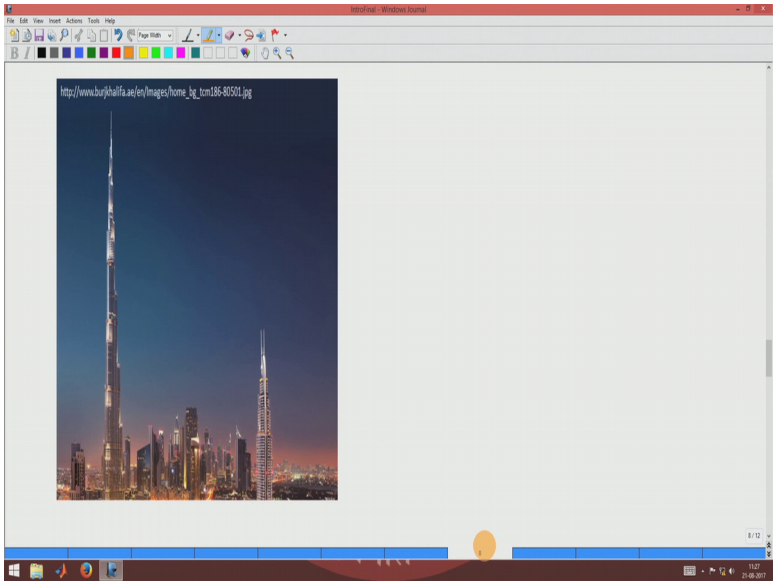

The difference is the sleekness of the structure compared to the massiveness of these structures.

Now, this where the current science (Refer Time: 01:00). Basically the resources you have is limited and you want use this resources effectively, meaning you do not want to waste resources, you do not want to build a structure to last for 10,000 years when the intended design life is just 50 years or 100 years. Similarly you do not want the structure to fail in 20 years when you intended to last for 1000s of years. So, that is a intent you want to use resources economically.

When you say you want to use resource economically should have an understanding of how the structure response to a given scenario or when the structural will fail. Now, when I say failure what do I mean by failure, is concrete crushing a failure is steel yielding a failure is a garbage bag just deforming too much under the weight of the garbage load is it a failure, that is a question I am asking.

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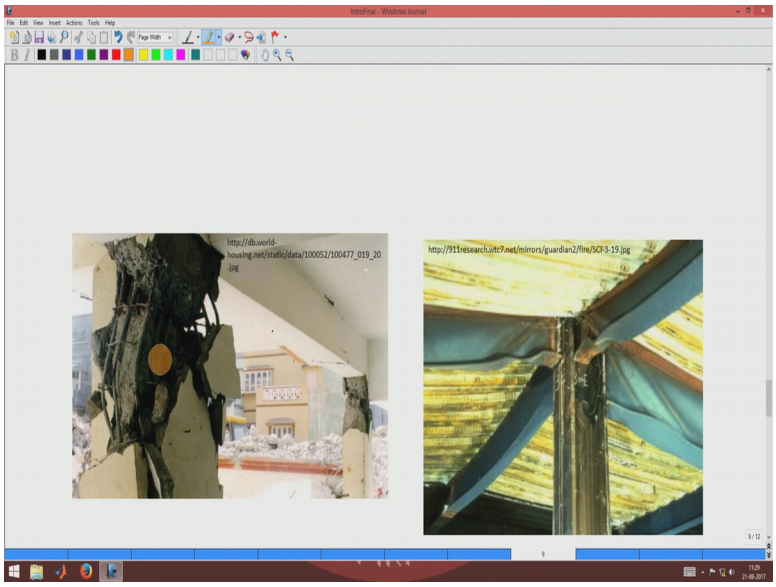

In other words is this the failure of the body or is this yielding which has occurred and buckling that has occurred the failure of the body, what is failure. We have to understand this before we proceed.

Failure by definition is if the structure does not fulfill its intended use then it is said to have been failed, I will give some examples. In the buildings you have a reinforced concrete beam which would have failed which would have cracked due to the dead load. That is not a failure of the beam. The same reinforced concrete beam if would have to be part of a water tank, the cracking of the beam is determined till because water will the

seeping through the cracks deteriorate the concrete and it might also cause leakage of water stored in the tank.

So, what is not a failure in one case can mean failure in a different scenario. So, the reinforced concrete beam which has cracked because of tension and the bottom is not considered as failed in regular residential buildings. The same reinforced concrete beam in the same residential building part of a water tank is considered to have failed if it cracks because water might seep in through the cracks.

Similarly, the yielding of a structure and the adequate scenarios is admissible provided the structure does not collapse due to this yielding of the steel members or yielding of its components. On the other hand if the steel (Refer Time: 04:07) to yield under normal live low situation normal loading situation then it is considered to have being failed. In both these examples it is a load that causes cracking are the failure of the body. The other instances wherein you it need not crack it need not yield, but still such would have been deemed as failed because it has not served its intended use.

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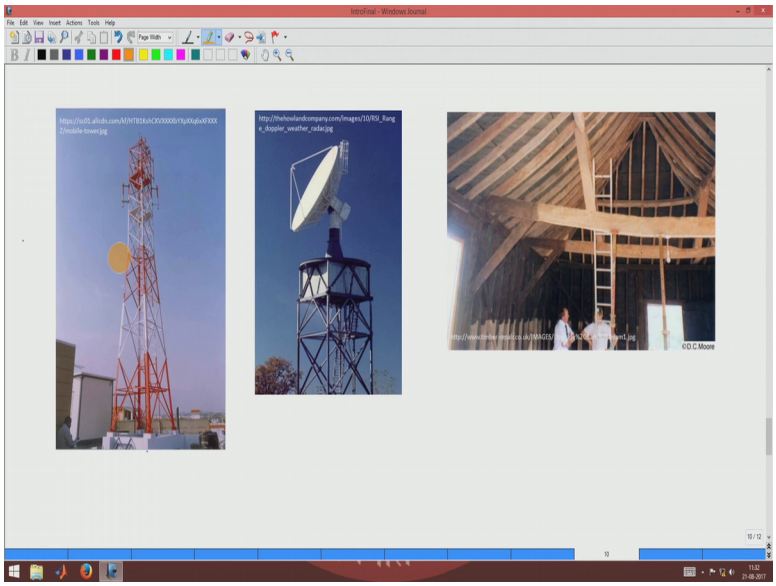

Examples of these are this mobile antenna towers, this weather antenna towers and so on wherein it is essential to maintain the deform shape or it is essential to maintain the shape of the structures accurately because the mobile tower will not be able to receive signals if it deforms more under a wind load or under heavy rains and so on.

Similarly, this weather antenna would asked to maintain its parabolic shape and extreme wind loads if it does not it is deemed to have been failed because it is used to track the cyclones and things like that and you do not track cyclones when and that is quite certain conditions. So, basically failure means different things and different scenarios. There can be failure because the strength or the stresses exceed a limit or it can be displacement caused failure when displacement exceeds a limit.

Another example of displacement induced failure is say you are working on this floor and if the flow sinks by a meter and your feel comfortable walking on the floor no right. So, that is an example of displacement criteria governing the design. So, in a sense there are two reasons why you want to do unless is the first reason is to ascertain the safety of the structure under given conditions when I say safety of this structure, it remains I do not want the structure to fail what I mean safety of the structure I do not want the structure to fail.

So, there are two criterias here one is strength and the other one is displacement that is I want to find and ensure that the stresses in the body does not exceed a particular limit for the given loading conditions. Similarly in displacement I want to compute the displacement on the boundary of the body or an interior of the body where it is not specified and I want to ensure that the displacement is within limits. So, strength means I want to compute the stresses in the body and ensure that these stresses are within the limits, similarly displacement means I want to ensure that the displacements of the body is within the permissible limits. So, that is what I want to ascertain first for a given structure, that is why I do analysis.

The second reason why I want to do analysis is to find the support reactions. I want to find the support reactions and hence I want to do analysis. Now let us understand why this is important ok.

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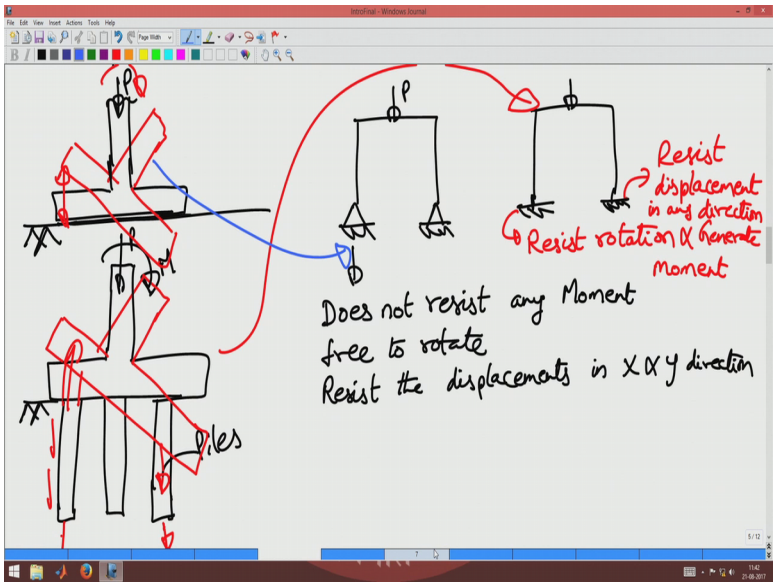

Now, say I have column, this is the column it has some load P coming on it, this is the resting on some foundation which is the resting on some ground, this is the ground on which it rests.

Now, how do I assume, this column is say part of a portal frame there is some load acting here P now the question is what is the end conditions I have to assume for this column. The end conditions can be inch inch condition or it can be for same portal frame it can be a fix fix condition, I am sure you would now what this inch end fixed means. Inch means it will not resist any moment this does not resist the symbol, means it does not resist any moment it is free to rotate free to rotate. On the other hand this symbol means it is a fixed beam which means it will resist rotation and generate moment at the support. Of course this being also this will resist both will resist the displacement in X and Y direction or in any direction that the displacement is resting. Similarly this support this fixed support also will resist, this will also resist displacement in any direction. So, that is the meaning of these supports.

Now what is that I have to assume, that depends upon how I do, how I have define design the foundation. There are two options on is the foundation on rest on the earth like this or the same foundation can be resisted by piles like this. These are called as piles which go down beneath the ground and there is these two possibility of foundations.

Now, what is which one it should be idealized as a inch inch foundation and which one will be idealized as the fix fix foundation there is a question. That depends upon how are the foundation has been designed. Now when I say how the foundation has been designed I would say what are the supporting forces moments that the foundation as to resist. In this case I give only an axial load, in this case I can have an axial force and the moment coming in on the column. So, because this piles will resist this pile can take tension or compression and it can resist basically when a tries to rotate like this when this tries to rotate like this, this has to go up and this has to be compressed which will be resisted by the frictional force here the fictional force will offer the resistance and here the bearing force will offer the resistance.

So, basically now there is a mechanism for this kind of a foundation this kind of a foundation to resist the applied forces and the hence for this the appropriate idealization would be this one. And on the other hand they are if I have a moment this one is free to rotate and it will rotate like this. There is nothing that prevents this from lifting up. There is something preventing it from going down, but there will cost failure of the foundation rather than preventing it from uplift. So, when there is a momentum that is coming in here this is what will happen here it does not resist the moment, so the appropriate idealization for this scenario is inched boundary condition.

So, now, what you understand from this is how you view the boundary condition is important, what is the boundary condition to give assume for the structure depends upon what you are designed the support for, and real life example of for this foundation went wrong is the Leaning Tower of Pisa, the Leaning Tower of Pisa. What happened here was the foundation was not design properly and hence it sunk on one side more than the other said causing it to have a tilt. So, that is why it is essential to understand what you are designing the supporting structure for and suitable idealization in your analysis. So, it is for these two reasons that you do analysis - one is to ascertain the safety of the structure and to find the support reaction so that the supporting structure can be suitably designed.

Now, we saw till now what deformable body is, why do you want to analyze a body as a deformable body, we saw what are the concepts in mechanics and the four equation that connect those concepts. Now why do you want to do all this analysis people have been building, buildings, structures, from time immemorial, but the reason why you want do it is to have a rational basis for utilization of resources.

Now, next let us me conclude this part of the lecture with what are the objective of this courses and what is the knowledge that I expect you to have coming in to this course. I told what is that in other words you will understand what is that you have gaining from this course now what is that you have to come as with an input in this course.

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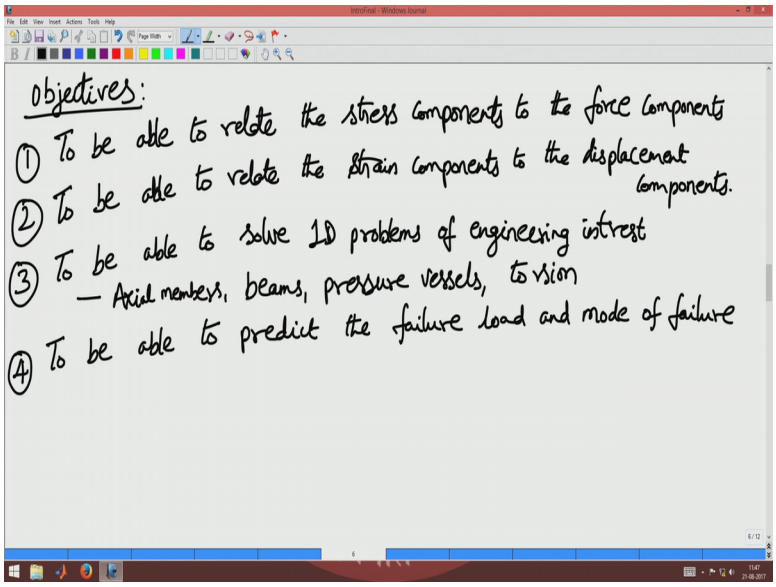

So, the objectives first, objectives of this courses 4: One is to be an end of this course you have to be able to relate the stress components to the force components, you know that is force is a vector it has three components similarly if stress as 6 components it will be able to relate which component of force starting in which area corresponds to which component of the stress. So, we will see more of those in the coming lectures.

Second objective is, to be able to relate the strain components to the displacement components. The third objective of this course is to be able to solve one dimensional problems of engineering interest like axial members, beams, pressure, vessels, torsion, torsion members. The forth objective is to be able to predict the failure load and mode of failure, that is whether the concrete is going to fail by crushing or is the geometry of the body causing it to deform more which is resulting in the failure that is material failure versus the stability induced failures is what you are going to see.

Even material failures I going to be yielding, there can be crushing, there can be cracking. So, which of these failure modes the body is going to fail is what you are have to be able to predict and what is a load at with this will fail, a given body will fail that is

beam at what transverse loading the beam would fail or at what torsion moment the member would crack. These are the thing that we have to be able to predict at the end of this course. So, these are the objectives of this courses.

Now, let us understand what you, what knowledge or what is the skill say that you have to have to do well in this course.

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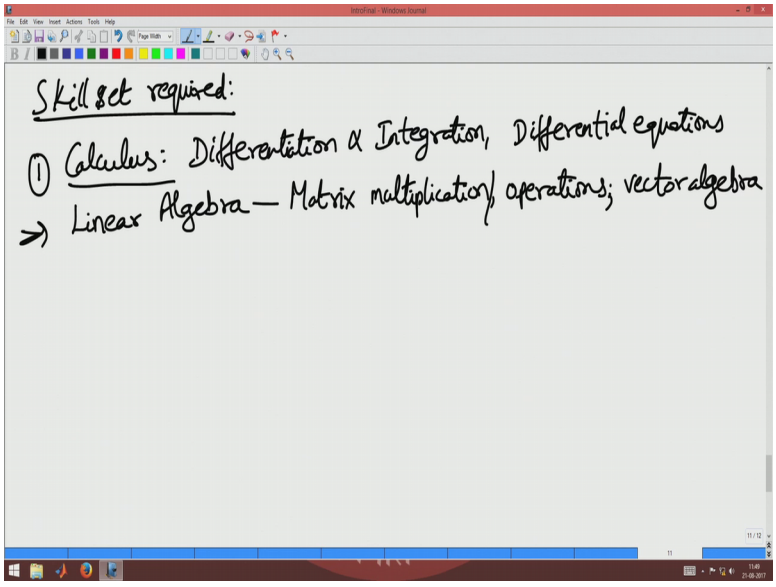

Skill set required - one is should be knowledgeable in calculus, differentiation and integration, then differential equations. This is an absolute prerequisite for this course having knowledge on calculus is an absolute prerequisite of this course. If you have knowledge on linear algebra that would be a plus basically here you should know how to matrix multiplication or in general matrix operations you should know matrix operations and then some amount of vector algebra that is how do you add to vectors or what is the scalar product, what is the cross product, what is the scalar triple product if you have knowledge on those is a plus, but I will be covering most of the linear algebra is required for this course it will be a self contained lectures on linear algebra.

But calculus is something that you should know, I am not going to teach how to integrate differentiate and how to formulate, differential equations or how do you solved differential equation something I am not going to teach you. But having knowledge of calculus and linear algebra would help you do well in this course. So, we have seen the

objectives the skill set that is required and then some basic concepts that we will be learning in this course and why do you want to do analysis.

So, with this I conclude this part of the lecture in the coming lecture we will start off with the first concept in mechanics this force.

Thank you.