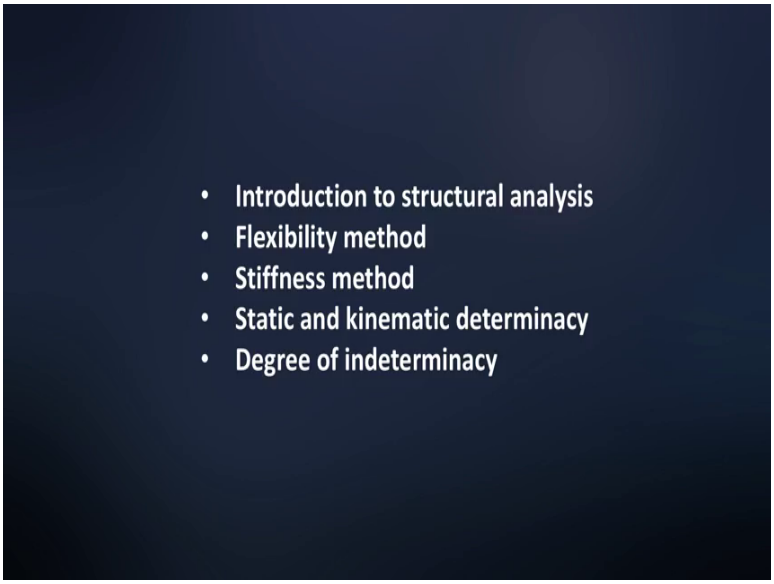
Computer Methods of Analysis of Offshore Structures
Prof. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Module - 01
Lecture - 01
Introduction to Structural Analysis (Part - 1)

(Refer Slide Time: 00:16)



Welcome to the NPTEL course titled- Computer Methods of Structural Analysis Applied to Offshore Structures. This course will be taught in three modules: module 1, module 2 and module 3.

In module one we will talk about computation methods of structural analysis, where we will try to approach generic problems related to structural analysis. And we will solve problems not specifically related to offshore structures, but general structural systems. We will do lot of examples, we will also give you parallely the computer codes which are useful to solve this problems using MATLAB. We will help you to solve problems in a very simple manner using systematic procedure which can be easily programmed using digital computers.

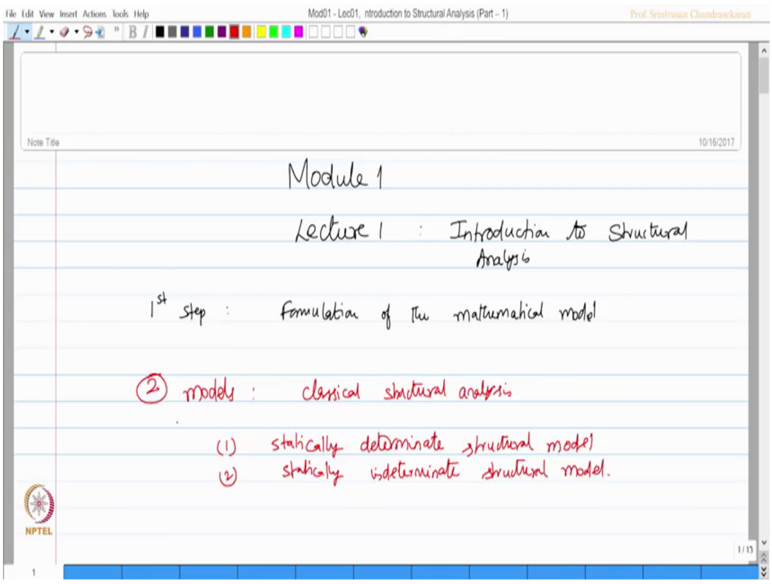
In the second module we will pick up applications of these problems to offshore structures. We will do both static and dynamic analysis. In module three we will talk about advance structural analysis applicable to fatigue and reliability studies.

Through and through in this course we will help you through computer codes which can be used for solving the problems readily on hand. We will also solve the problems by hand using calculators and compare the answers with what we get from the computer codes. We will also give you some screenshots of solving the classical structural problems of offshore structures using standard software.

So welcome to this course, thank you for registering for the course. I think you will enjoy the content of the course. I will be the course coordinator who will be available with you through online and as well as the email contacts. The course will have lot of tutorial supports. You can always exchange your views through announced platforms and discussion forums. We will try to make this course very interactive and very easy and helpful. This course as I said in the beginning is open to all branches of engineering which is having multi-disciplinary in nature. Therefore, the problems will be solved with respect to their features of application. We will go slightly slow and try to understand the applications in a very interesting and useful manner.

So, with this preamble let us start with the lecture of module 1, the first lecture. We will introduce the classical structural analysis in computer methods of purview.

(Refer Slide Time: 02:59)

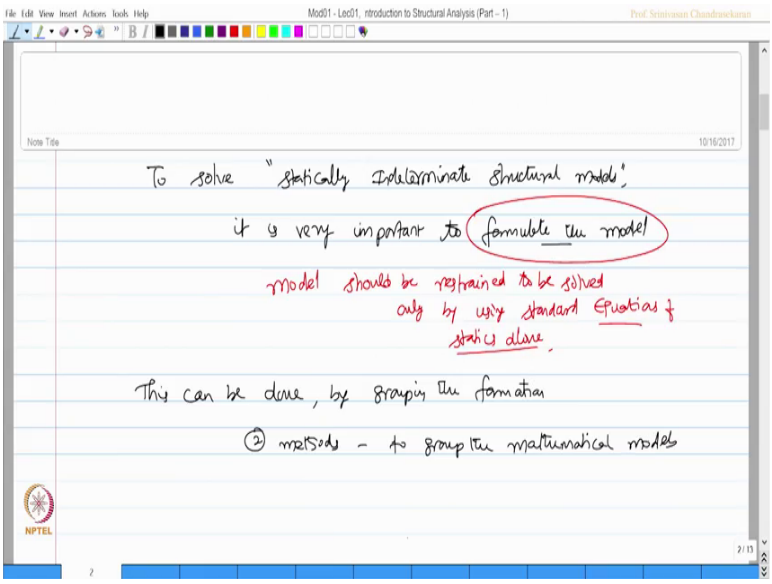


In any structural analysis problem the first step what we generally foresee is formulation of the problem. To formulate the problem we need a mathematical model. The moment I say we require a mathematical model essentially there are two models which are useful to solve problems in classical structural analysis. Namely; statically determinate structural model, the second one is statically indeterminate structural model.

Friends, I am sure you must have studied lot of examples in your first level of engineering courses on statically determinate structural models. You would have found them relatively simple and easy to solve though there are cumbersome equations available to solve them. In comparison to indeterminate models the first type of classical model seems to be slightly and relatively easy and simple.

So, our focus should be mainly on explaining how I can use computer methods and computer programs to solve the problems related to statically indeterminate structural models.

(Refer Slide Time: 04:25)

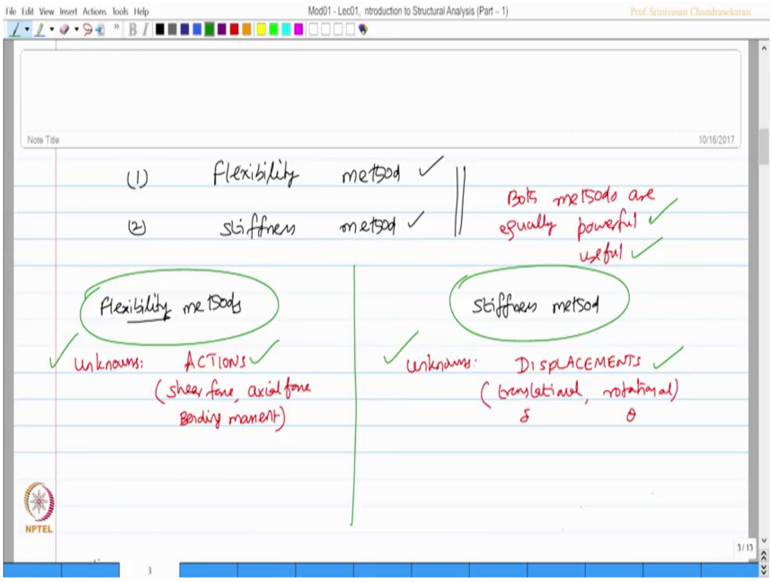


Therefore, I can make a statement now to solve statically indeterminate structural models. It is very important to formulate the model. The moment we say we need to formulate the model we have to follow a standard procedure which should be highly generic in nature, which should not be problem specific, which should be repetitive, so that I can use computer programs to solve the model.

So, it is very important to formulate the model. And the model should be restrained to be solved only by using a standard equations statistics alone; that should be important. When we formulate the model I should make the model in such a manner with the help of standard equations of statics alone I should be able to solve the model. So, it is all depending upon how do you formulate the model.

Now, this can be done, by grouping the formation. There are again two methods available in the literature to group the models.

(Refer Slide Time: 06:28)



Namely: flexibility method, stiffness method. Friends please realize that these two methods are actually done only for simplifying the model so that they should be solvable using standard equations of statics alone. So, it is our convenience to group them. You can either group them in terms of flexibility method to apply the problem or you can solve the problem using stiffness method. But, one commonness is in both the cases I should use only the model to be restrained and solved using standard equations of statics alone. I cannot apply any extra equations of a special form to solve the problem.

With that prerequisite, we say that the literature groups the methods of solution and formulation of the problem itself into two major divisions: one is namely the flexibility method other is the stiffness method. Let us first try to tell you very important statement that both methods are equally powerful; I should say numerically they are equally useful and there is no supremacy of one method over the other.

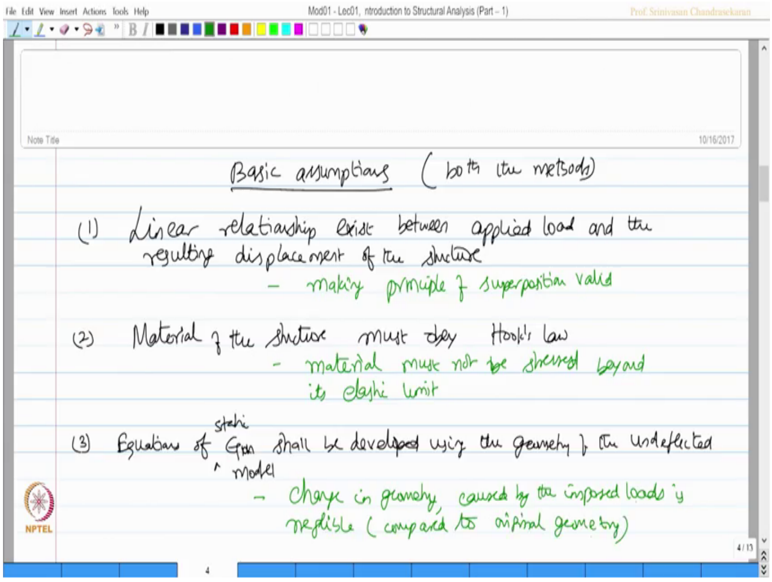
But, as we proceed further in discussion we will try to converge to one of these two methods because of specific reasons, because of those method can be easily programmable using digital computers. So, our main objective here is not to solve the problem, my main objective is to make the problem solvable using computer methods; that is the focus.

Having said this, let us try to now understand the difference between these two methods, because I should know the difference. So, in the flexibility method because any method of solution has unknowns let see what are the unknowns in this case. The unknowns are actions. Say for example: shear force, bending moment or axial force, bending moment. So, these are my unknowns in the problem.

So, these unknowns will remain in the formulation of the problem, whereas when you go to stiffness method on the contrary here the unknowns are displacements. For example: translational displacement and rotational displacement. Translational as delta and rotational as theta all will be unknowns in this method. So, please understand in both the methods there is a significant difference in identifying the unknowns for formulating the problem. One method focuses unknowns as the actions, whereas the other method focus unknowns as displacements.

Now we divert whichever is convenient to us we should use that method and you cannot cross these methods while problem is being formulated. As I said in the beginning again I repeat: both methods are equally powerful and equally useful and I should say relatively simple and easy; you can apply any one of these methods. But amongst these two formulation methods we have one method which has got distinct advantage than the other method which we will try to come out and bring out during this lecture.

(Refer Slide Time: 11:09)

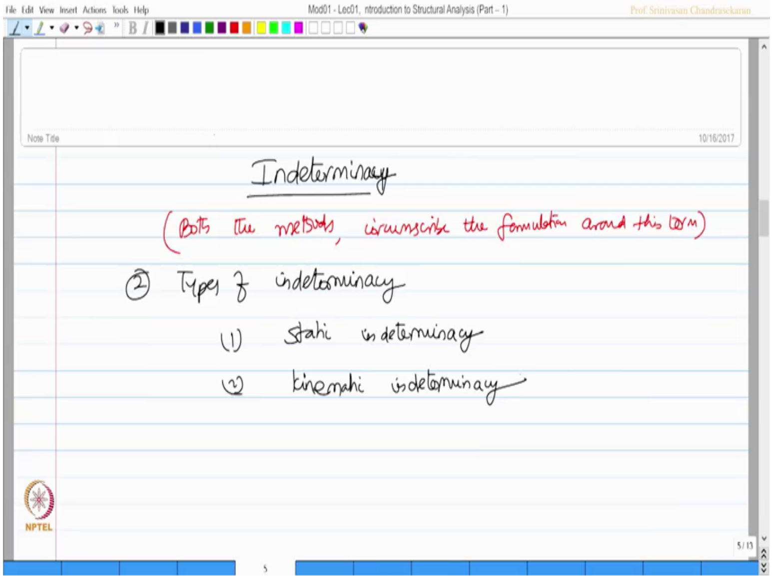


Now, both the methods have certain basic assumptions, because every problem formulation has some idealization. So, what are the basic assumptions which are applicable to both the methods? One, linear relationship exist between applied load and the resulting displacement; displacements can be translational can be rotational, resulting displacement of the structure. This makes a very important secondary statement making that this makes principle of superposition valid through the formulation.

The second assumption what we have for both the methods common is; material of the structure must obey Hooke's law. This has again a secondary statement which says that material must not be stressed beyond its elastic limit. The third assumption which again common to both the methods is that: equations of equilibrium shall be developed. In fact, we can make it very clear, equations of static equilibrium which shall be developed using the geometry of the undeflected model. Now this again has secondary statement saying that change in geometry caused by the imposed loads is negligible when compared to original geometry.

So, these are friends the basic assumptions which are valid and applicable to formulation of the problem by both the methods namely flexibility method and stiffness method. Having said this, let us introduce one more term which is important for problem formulation in both methods.

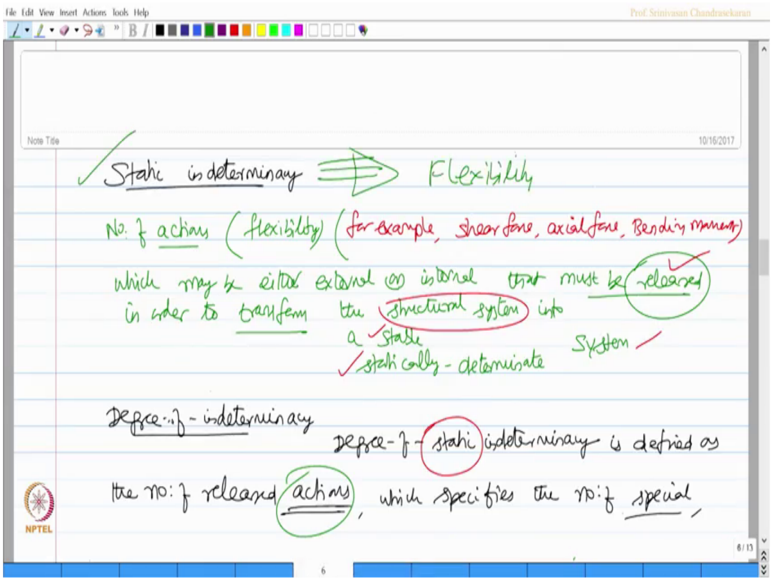
(Refer Slide Time: 14:56)



Let us say indeterminacy. Friends, I should tell you that both the methods circumscribe the problem around this term.

So, we should clearly understand; what is indeterminacy in terms of problem formulation by either flexibility method or by stiffness method. The moment we say indeterminacy again there are two types of indeterminacy, namely: static indeterminacy and two, kinematic indeterminacy.

(Refer Slide Time: 16:07)



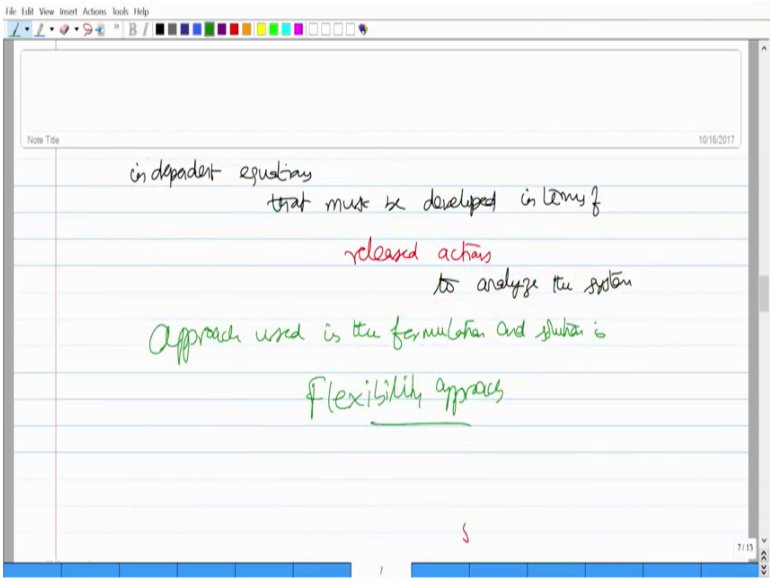
Let us now explain; what is static indeterminacy. This is actually the number of actions; please note the keyword: "actions". We already remember and recollect that actions are resembling flexibility; if you recollect you can see here the unknowns in flexibility method or actions. So, the moment you see word actions I can tag this to flexibility method. So, number of actions which are for example, now you are in a better question to answer this for example, shear force, axial force, bending moment etcetera.

So, these are my unknowns in the flexibility method, but we are now defining; what is static indeterminacy. While defining so we say it is number of actions like shear force, axial force, bending moment which can be either external or internal that must be released; that is another keyword that must be released in order to- why do you release this in order to transform the structural system into a stable statically determinate system.

So, friends what is an objective? The objective is a structural system is known to you convert transform that system into a statically determinate and stable system; that is a objective. While doing that you have to identify the number of actions like shear force, axial force, bending moment, etcetera, which should be released to convert or transform the problem into a simple stable statically determinate systems.

Then comes the question of what is degree of indeterminacy. Now I should say the degree of static indeterminacy. So, I am using a new word here degree of static indeterminacy is defined as- the number of released actions, again the keyboard related to flexibility method which specifies the number of special independent equations.

(Refer Slide Time: 20:09)



That must be developed in terms of; now what will be the unknowns in this equation- in terms of the released actions to analyze the system.

So, the approach used in the formulation and solution is flexibility approach. As you can recollect easily now, in this actions are released; actions are related to flexibility. So, static indeterminacy is a term related to flexibility; having said this.