Computer Methods of Analysis of Offshore Structures
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Module - 01
Lecture – 02
System of Linear Equations (Part - 1)

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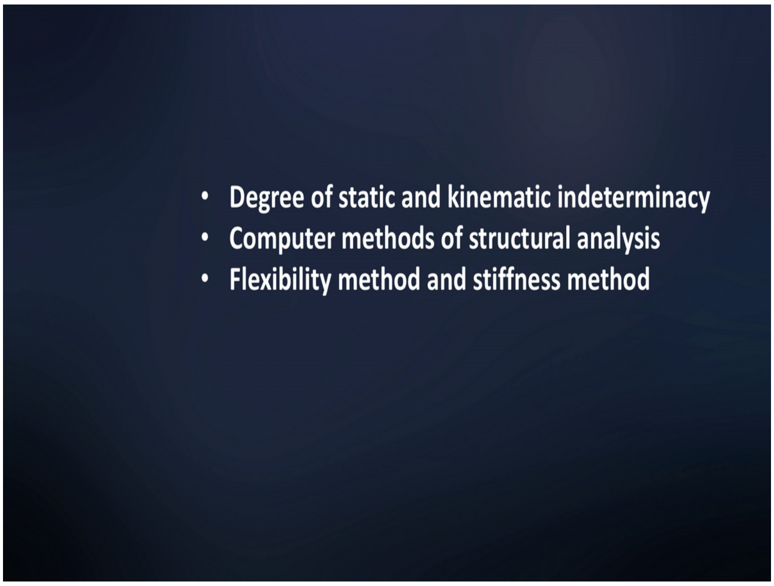

Friends, let us continue with the lecture 2 and module 1. In this lecture we will discuss some basics about System of Linear Equations and introduce you to the matrix methods.

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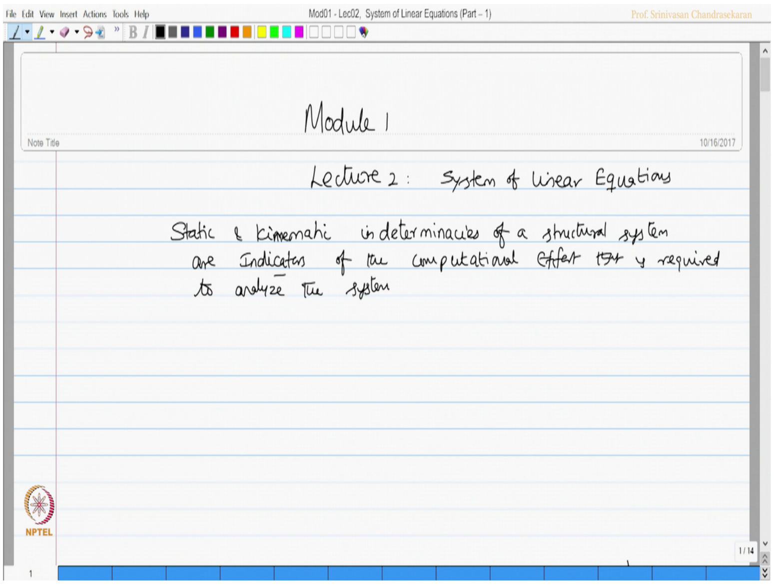

Let us slightly rewind and discuss what we had summarize in the last lecture. We set static and kinematic indeterminacies of a structural system are indicators of the computational effort that is required to analyze the system.

Let us quickly see how this can cause variation in terms of unknowns for solving a problem. Because we all agree that whenever I want to solve a system of equations I should be concerned about the number of unknowns involved in the solution procedure. If the problem formulation is made simple which reduces the number of unknowns, I think that is one of the best formulation a mathematician or an engineer can attempt to do. And here we re-insist the fact that the number of unknowns which are going to be there in the system of equations purely depend on the choice of the method what to demand. If it is a flexibility method the actions are to be unknowns; if it is stiffness method the displacements or to be unknown.

Let us see how can we control this in terms of the type of problem. On the other hand when we recommend a computer method for structural analysis we should also keep it in mind the method recommended should be more or less generic and it should not be problem specific. So given this word as a caution, let us quickly take some examples and see; what are the static and kinematic indeterminacies of the problem. And therefore, how many unknowns do you really have by formulating equations either by using flexibility approach or stiffness approach.

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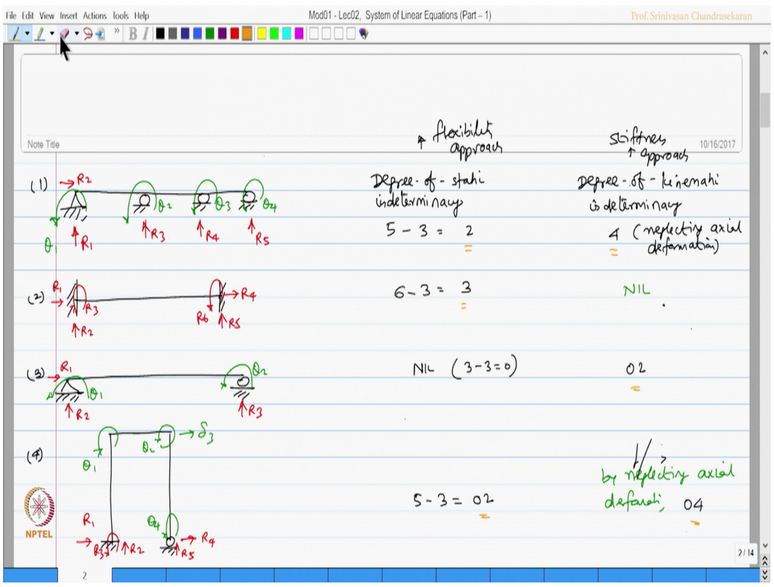

Let us take a continuous beam of 3 span, this indicates a hinged joint and this indicates roller joint. Now, I want mark the reactions. Reactions could be: R 1, R 2, R 3, R 4, and R 5. I also want to mark the displacement unknowns' theta 1, theta 2, theta 3, and theta 4. Having said this, let us try to find: what is the degree of static indeterminacy and what is the degree of kinematic indeterminacy.

We all agree that there are three systems of standard equations are available to solve the problem. So, there are 5 unknowns which are marketed in red in color these are the reactions or actions. So 5 minus 3, I will have two static degree of indeterminacy which will be unknown from a flexibility method, whereas the one which are marked in green color are the displacements in this case there all rotations. So, there are four displacements neglecting axial deformation.

So, friends if I use stiffness approach I will have 4 unknowns, if I use flexibility approach I will have 2 unknowns for solving this problem. Let us take another example which will be fixed beam. Let us mark the reactions as R 1, R 2, and R 3 which are the moments and horizontal vertical reactions that support a and similarly R 4, R 5, and R 6.

Let us also mark the rotational displacements which are free to move, you know for a fixed beam there will be no rotation displacement available or translation available at both the supports. Therefore, kinematic degree of indeterminacy for this problem would be nil, whereas static degree of indeterminacy will be 6 minus 3 which will be 3.

Let us take an example of a simply supported beam. Let us mark the reaction components which will be R 1, R 2, and R 3; let us also mark the degrees of displacement which is theta 1 and theta 2. Therefore the static degree of indeterminacy for this problem will be nil, which is actually three minus 3, whereas kinematic indeterminacy will be 2, because they are two independent rotational displacements available at joint A and at joint B respectively.

Let us take up another example of a frame, single story single bay with one end fixed and other end on rollers. Let us mark the unknowns as R 1, R 2, and R 3, R 4, R 5. So, this enables me to fill up this value as 5 minus 3: 02 that is my degree of static indeterminacy. Let us try to mark the degree of independent displacements at joints θ_1, θ_2, θ_3, θ_4. By neglecting axial deformation kinematic degree of indeterminacy for this problem will be 4.

So, friends look at these examples depending upon the choice of the method, because this method will be closely associated to flexibility approach and this method will be closely associated to stiffness approach. Looking at this you know depending upon the choice of a method I can always have different set of unknowns. So, the equation size can vary depending upon the method of choice what I am trying to do.

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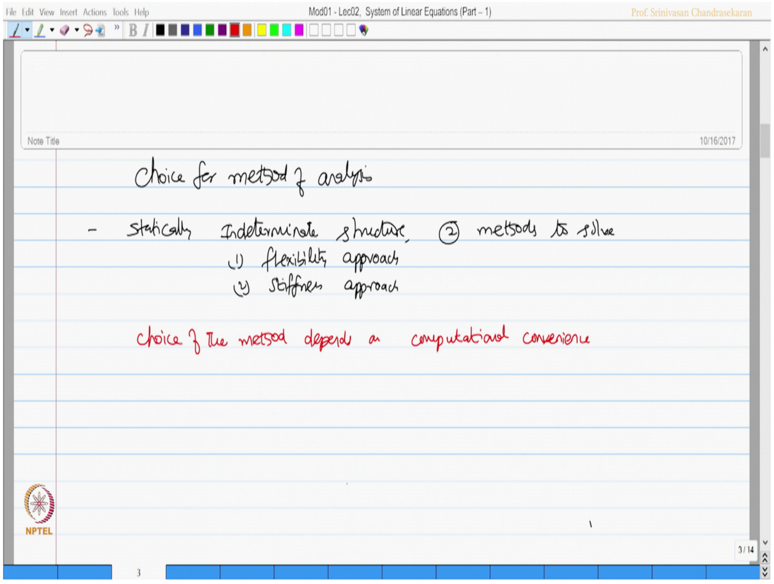

Having said this, let us quickly write the summary and saying what could be a best choice for the method of analysis; because this will govern the system of equations. You know for statically indeterminate structure essentially there are two methods to solve namely: flexibility method and stiffness method. So, the choice of the method depends on computational convenience. Let us quickly argue by both the methods.

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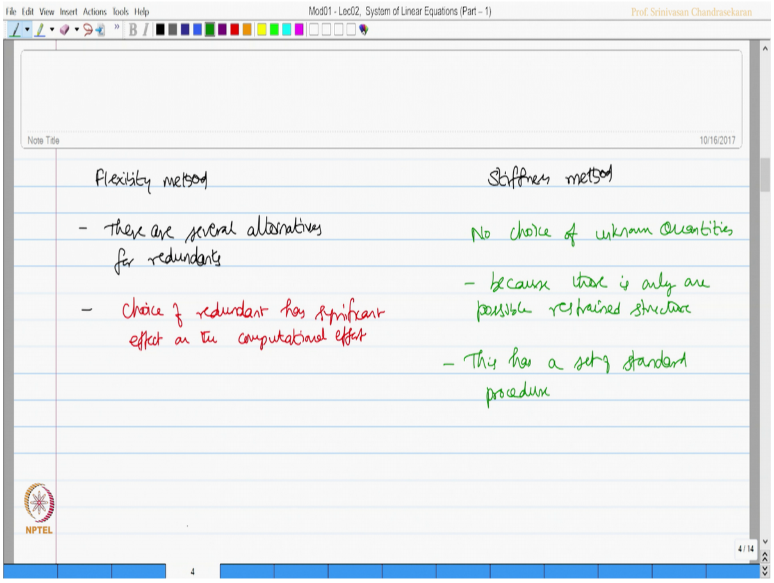

Let us say for flexibility method, we already know that there are several alternatives for redundants; that is unknowns. Therefore, I should say choice of redundant have has significant effect on the computational effort.

On the other hand, if you look at stiffness method you have no choice of unknown quantities, because joints will either have rotation or translational displacements. Because, there is actually only one possible restrain structure, and therefore this has a set of standard procedure.

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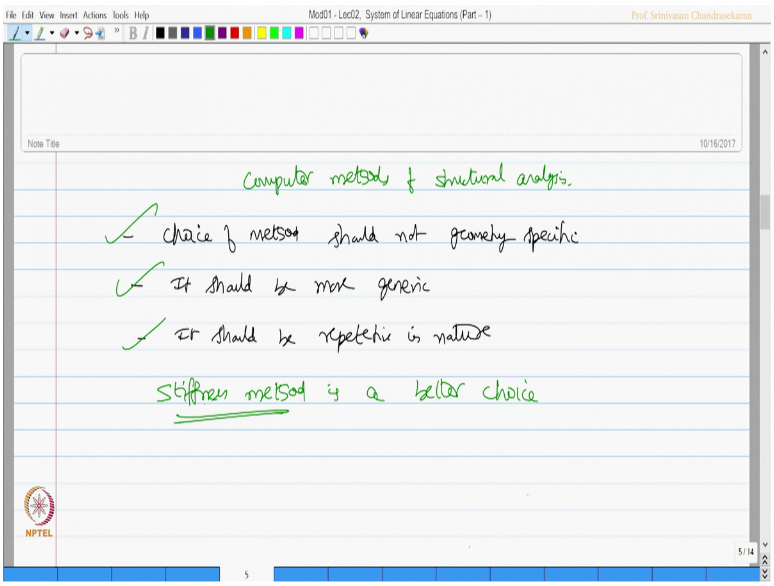

So, if you discuss this argument based on computer methods of structural analysis, in this context we can say that choice of the method should not be geometry specific; it should be more generic, further it should be repetitive in nature. So finally, people have recommended that stiffness method is a better choice.

Fulfilling all the three requirements stiffness method is a better choice. Therefore, in this course in this module we will elaborate application procedures based on purely stiffness method only. Having said this let us say after identifying the variables in a given system which is now going to be displacements either translational or rotational for every joint.

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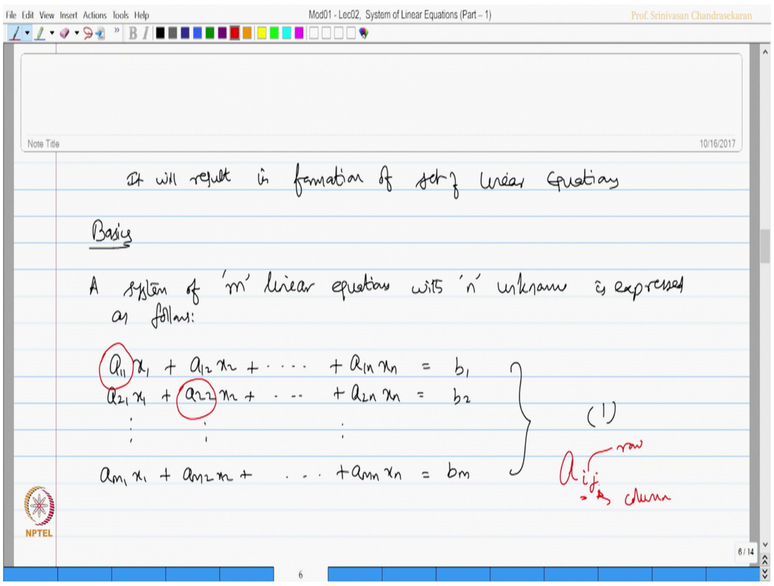

It will result information of set of linear equations. Let us look into some basics of this. We know that a system of 'm' linear equations with 'n' unknowns is expressed as below.

$$a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n = b_1$$

$$a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n = b_2$$

……..

$$a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n = b_m$$

If you look at these coefficients in this equation I will call this is equation number 1. If you look at these coefficients for example, a 11 a 22 what are may be. So, a ij we all agree, and we know that i stands for row and j stands for the column. That is the first subscript is the row the second subscript is the column.

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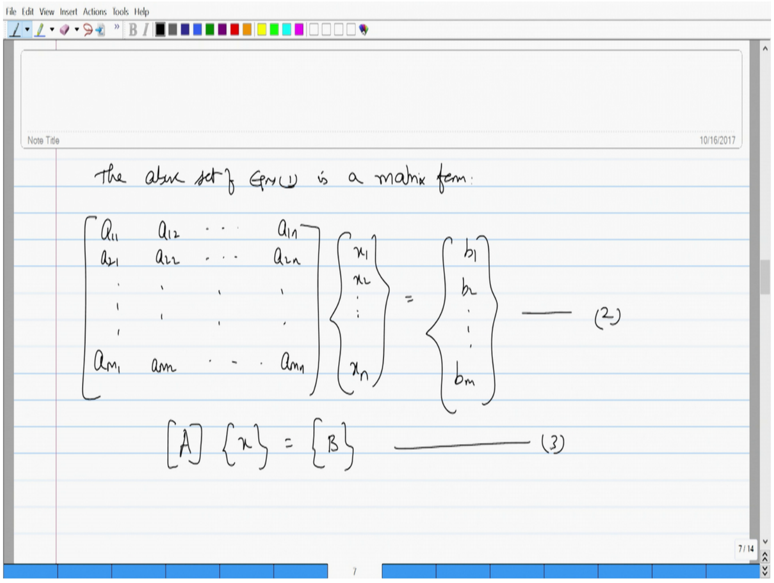

Having said this let us express the above set of equations in the matrix form. So, a 11 a 12 a 1n, a 21 a 22 a 2n, similarly by this logic a m 1 a m 2 a mn multiplied by the variables x 1 x 2 x m can be expressed as this is x n expressed as b 1 b 2 b n- call equation number 2 . Now, this can be written in a matrix form a nutshell as A x is equal to B.