Structural Health Monitoring (SHM)
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Lecture – 22
Part- 2: Estimation of Structural Health using Static SHM

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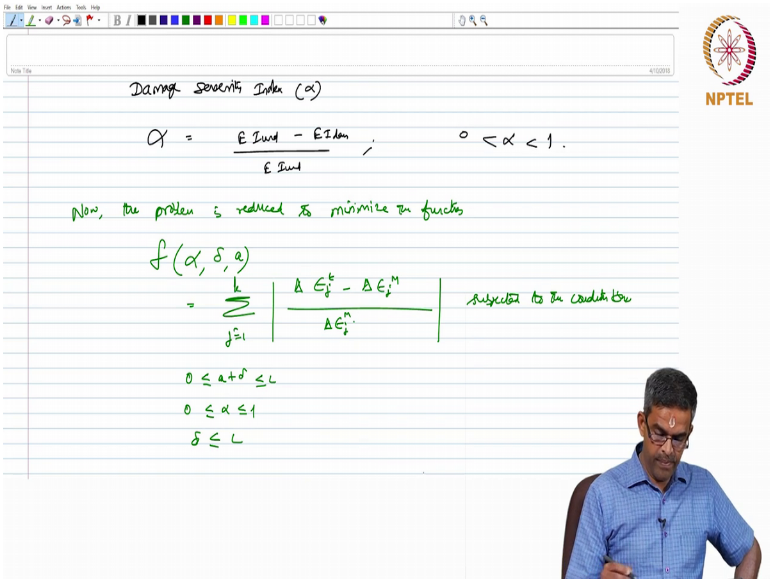

One can establish damage severity index alpha. So, alpha is given by E I undamaged minus E I damaged by E I undamaged, where alpha varies from 0 to 1.

Therefore, now the problem actually is reduced to minimize the function which is function of alpha, delta and a; which can be given by summation of j equals 1 to k mod value of delta epsilon j t minus delta epsilon j m by delta epsilon j m.

Subjected to the condition that 0 less than a plus delta less than l, 0 less than alpha less than 1 and delta is far compared to l lesser.

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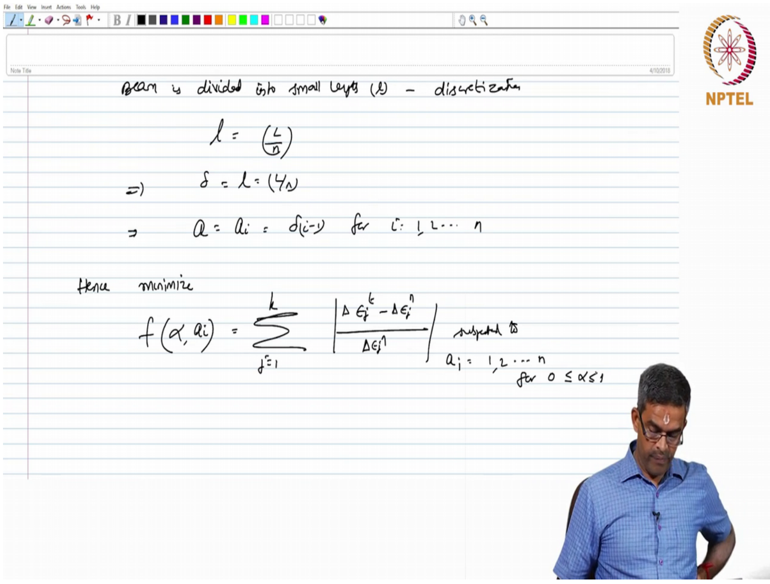

So, to execute this beam is divided into small lengths l this is discretization such that l is L by n and therefore, delta l is L by n and therefore, a equals a i is delta of i minus 1 for i equals 1 to n.

Hence minimize f alpha and a i which is summation of j equals 1 to k, delta epsilon j t minus delta epsilon j n by delta epsilon j n mod value subjected to a i is 1, 2, n for 0 less than alpha less than 1.

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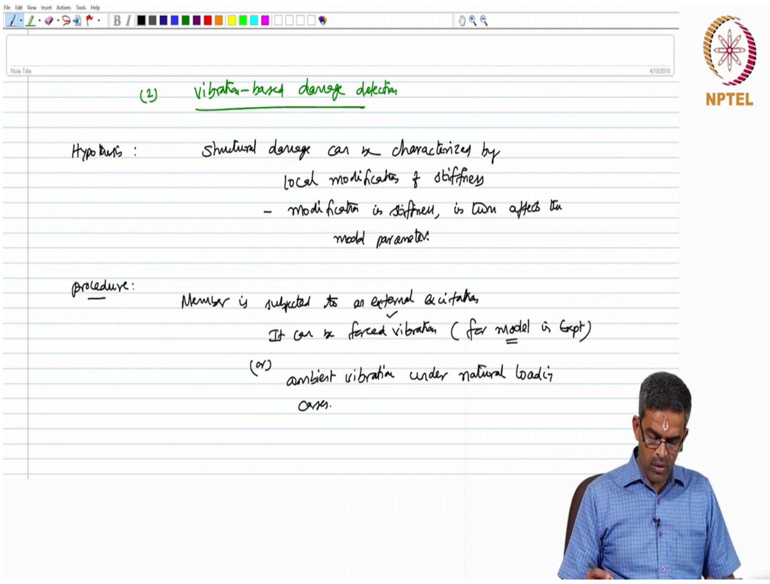

Let us now talk about the second method which is vibration based damage deduction. The hypothesis began this method is that structural damage can be characterized by local modification of stiffness. The change in stiffness or modification in stiffness in turn affects the modal parameter. Let us see how the procedure works. Member will be subjected to an external load excitation. This excitation can be a forced vibration which is possible for a model in experiments.

Because it is not possible to create a forced vibration for a prototype system and the service is automatically created by the external loads, for of course, model scale one can create a forced vibration or alternatively it can be an ambient vibration under the natural loading cases.

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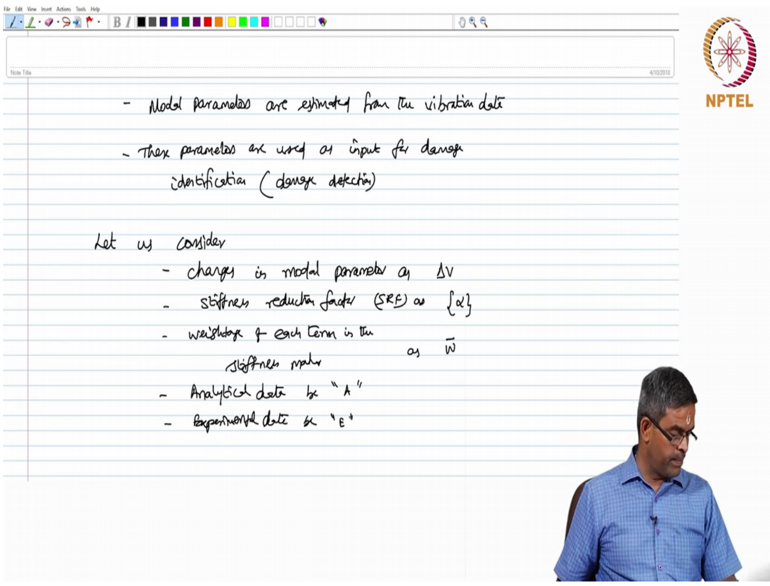

So, for this model parameters are established and estimated from the vibration data which is a standard procedure. Now, these parameters are used as input for damage identification or we can also call this as damaged detection

Let us consider changes in model parameter has delta V. Let us consider stiffness reduction factor that is SRF as alpha vector, let us consider the weightage of each term in the stiffness matrix of the member as W bar and let analytical data be represented by capital A and experimental data be represented by capital E, is not in smallest, is experimental data.

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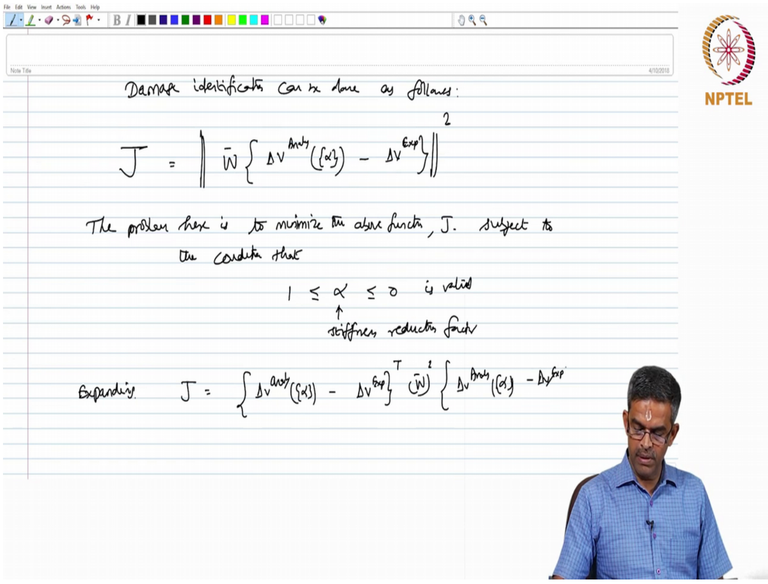

Therefore, damage identification can be done as follows; J will be equal to some function which will be the weighted value of change in model parameter from the analysis of that of alpha minus change in moral parameter of that of the experiments and square. Now, the problem here is to minimize the above function J subject to the condition that 1 less than alpha less than 0 is valid, this is what we call as stiffness reduction factor.

Therefore, expanding J will become delta V analytical of alpha minus delta V experimental the transpose W bar square of delta V analytical of alpha minus delta V experiment.

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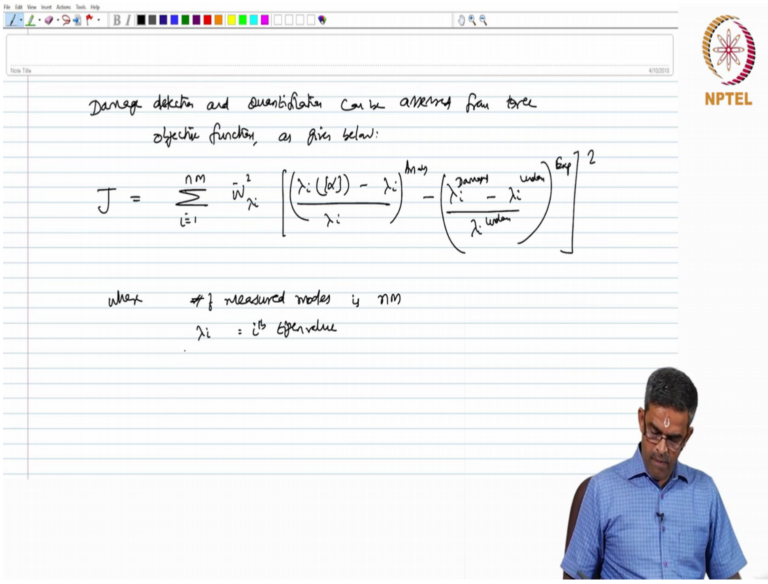

Damage detection and quantification can be assessed from three objective functions as given below. J is equal to algebraic sum of i equals 1 to n m, w square lambda i of alpha minus lambda i by lambda i analytical minus lambda i damaged minus lambda i undamaged by lambda i undamaged which is obtained experimental the whole square where number of measured modes in the analysis is indicated as n m, alpha i is the i-th Eigen value.

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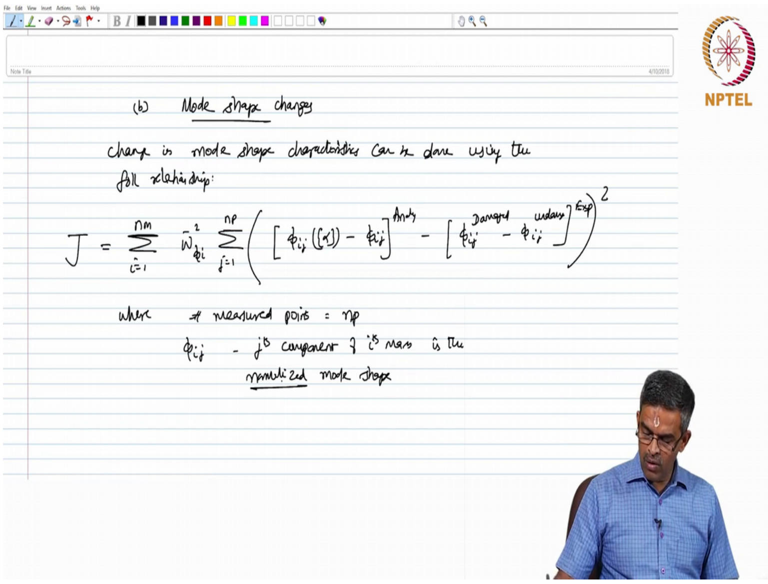

When I want to trace the mode shape changes this can be done using the following relationship. In that case the minimization function will be equal to sum of i equals 1 to nm W bar phi i square summation of j equals 1 to np phi i j of alpha minus phi i j which is analytical minus phi i j of damaged state minus phi i j of undamaged state, which is obtained by experimental the whole square, where number of measured points is np and phi i j is the j-th component of i-th mass in the normalized that is important.

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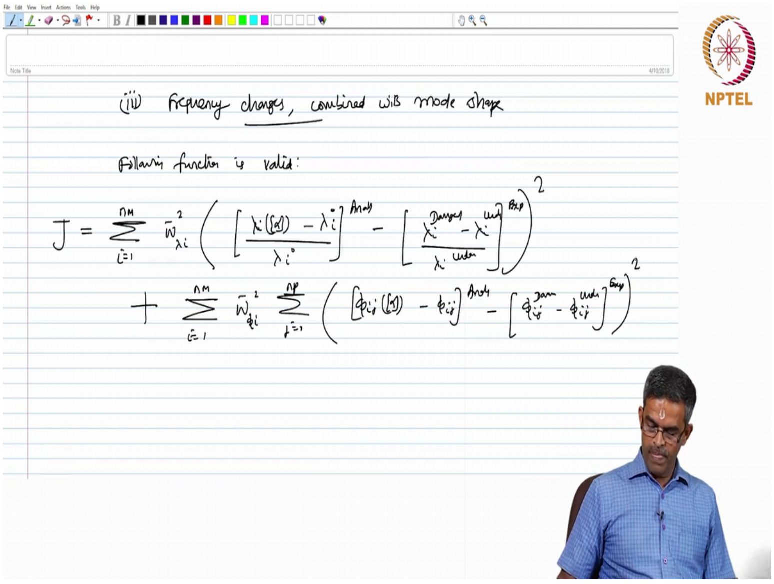

I can also do this by looking at the frequency changes. Frequency changes combined with mode shape can also be done. Following function is valid. J equals algebraic sum of i equals 1 to nm W bar lambda i square of lambda i alpha minus lambda i lambda i 0 analytical lambda i damaged minus lambda i undamaged by lambda undamaged experimental square plus this is arising from one part of the problem. The second is from the change of mode shapes this is the frequency change.

Now, the second part of the equation will give you the change in the mode shape i equals 1 to nm W bar phi i square summation j equals 1 to np phi i j alpha minus phi i j which is analytical minus phi i j damaged minus phi i j undamaged experimental the whole square.

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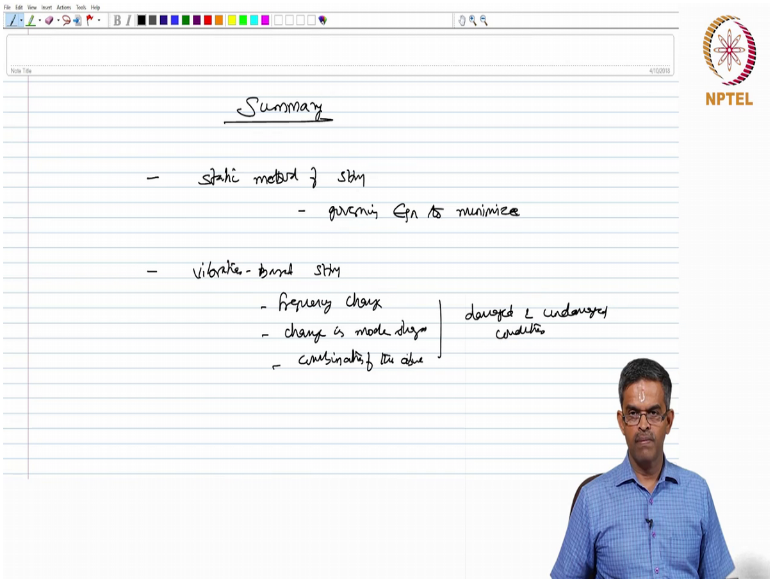

So, friends, in this lecture we learnt about introduction to static method of structural health monitoring, we also learnt about the governing equation to minimize and we also saw how it becomes a minimization problem.

We also learnt about vibration based structural health monitoring, how the frequency change, change in mode shape and combination of these two between the damaged and undamaged case is helpful in estimating the vibration based characteristics or deviations of vibration characteristics in the structure caused because of damage.

Thank you very much.