Structural Health Monitoring (SHM)
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Lecture – 26
Vibration based health monitoring scheme – Part 2

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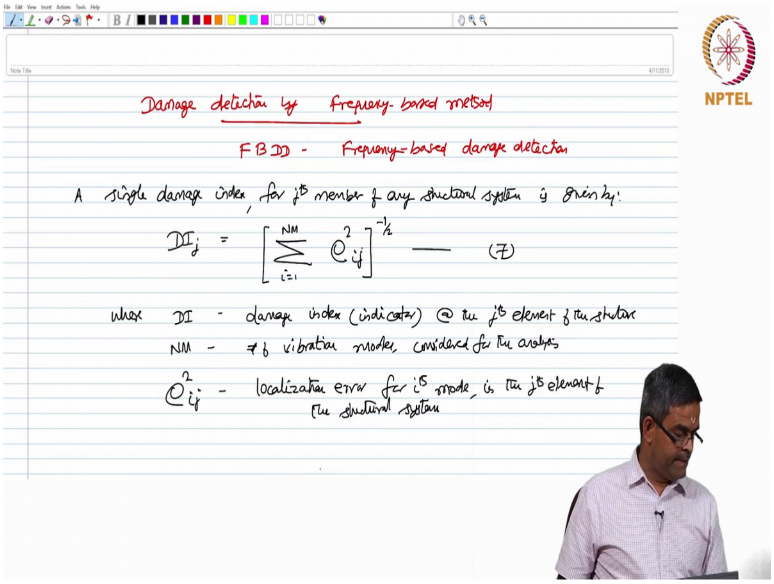

Alternatively, one can also use frequency band method for Damage Detection called FBDD, Frequency based damage detection. A single Damage Index for j th member of any structural system is given by damage index of j th member is summation of i equals 1 to N M, the number of vibration modes square i j minus half.

Where D I is the damage index or indicator at the j th element of the structure; N M indicates number of vibration modes considered for the analysis, e square i j is actually the localization error for i th mode in the j th element of the system.

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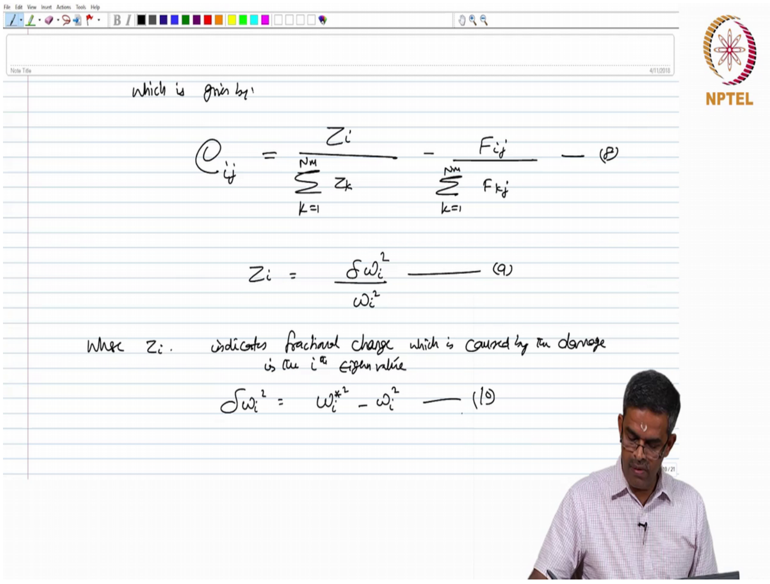

Which can be given by e ij is Z i summation k equals 1 N m Z k minus F i j by summation k equals to 1 N m F k j, Z i is delta omega i square by omega i square. Where Z i indicates the fractional change which is caused by the damage in the i th eigenvalue.

Delta omega i square is omega i square minus omega square, where omega i square is the change in the frequency.

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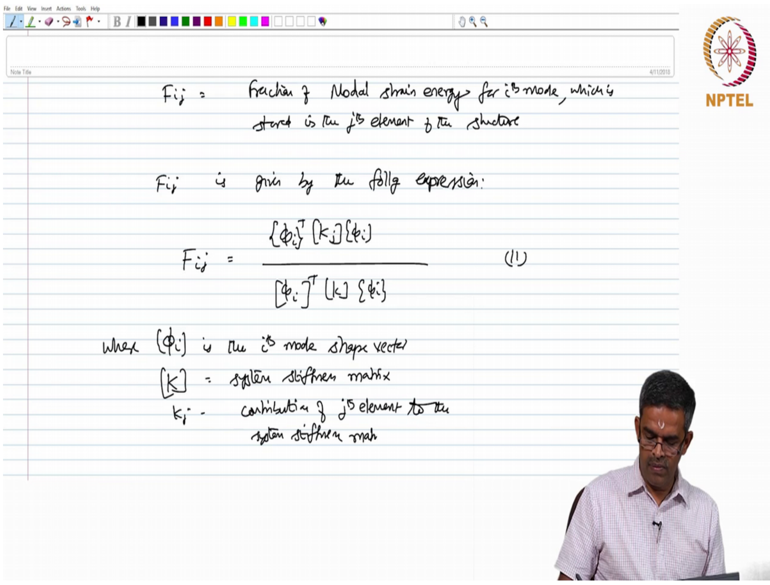

And F i j is the fraction of modal strain energy for i th mode which is true in the j th element of the structure. F i j is given by the following expression; F i j is phi i transpose k j of phi i phi i transpose k of phi i. Where phi i is the i th mode shape vector, k is the system stiffness matrix and k j is the contribution of j th element to the system stiffness matrix.

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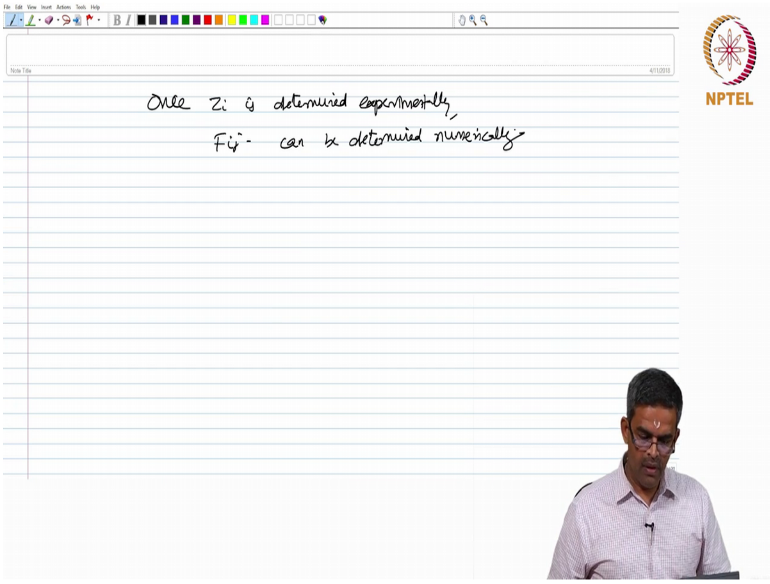

Once Z i is determined experimentally, F i j can be determined numerically. There are some special advantages of using vibration based SHM.

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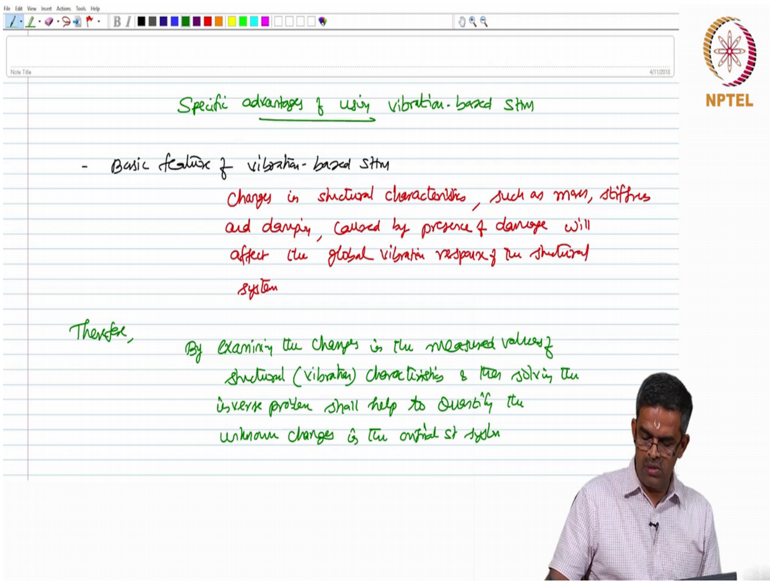

Let us see what are the specific advantages of using vibration based SHM. To understand this let us try to get back slightly back forth and think about what is the basic feature of vibration based SHM. The basic feature is changes in structural characteristics such as mass, stiffness and damping caused by presence of damage will affect the global vibration response of the structural system.

So, that is the basic feature. Therefore, by examining the changes in the measured values of structural characteristics that is vibration characteristics and then solving the inverse problem shall help to quantify the unknown changes in the original structural system.

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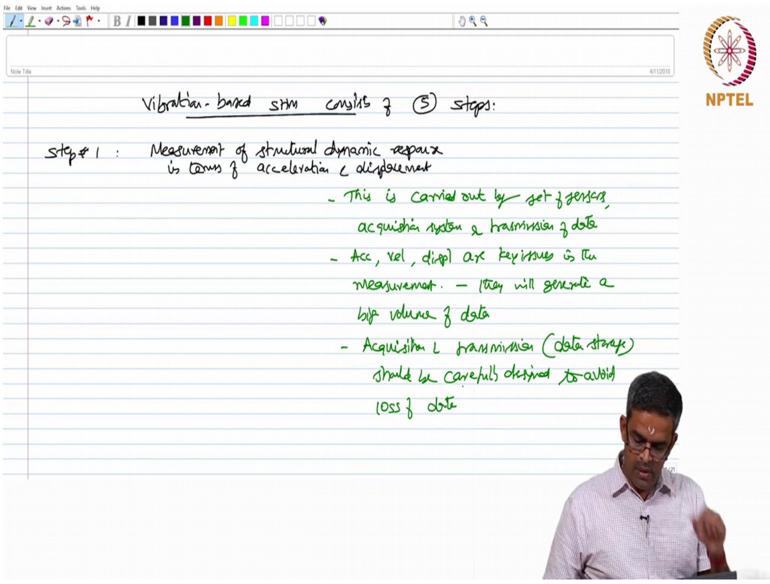

Vibration based SHM consists of therefore, 5 steps. Step number 1 deals with measurement of structural dynamic response in terms of acceleration and displacement. This is essentially done by set of sensors, acquisition system and transmission of data. Acceleration, velocity and displacement are key issues in the measurement. They will generate a big volume of data.

Therefore, acquisition and transmission which includes data storage also should be carefully designed to avoid any loss of data.

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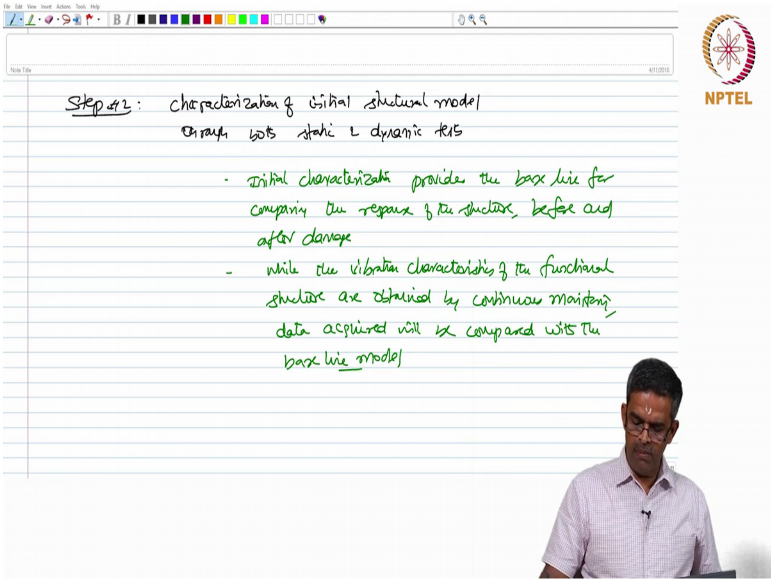

Step number 2, deals with characterization of initial structural model through both static and dynamic test. Initial characterization provides the baseline for comparing the response of the structure before and after damage, while the vibration characteristics of the functional structure are obtained by continuous monitoring.

Data acquired will be compared with the baseline model.

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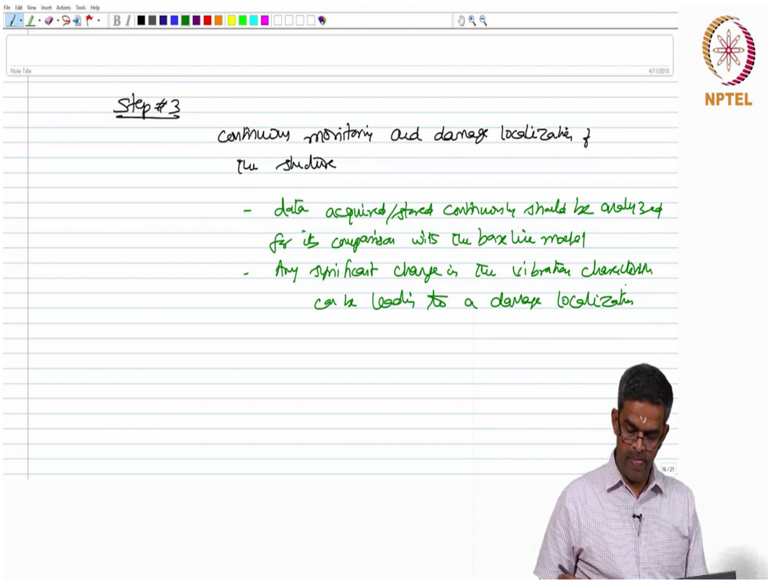

Step number 3, involves a continuous monitoring and damage localization of the structure. During this process, data acquired and stored continuously should be analyzed for it is comparison with the baseline model. Any significant change in the vibration characteristics can be leading to a damage localization.

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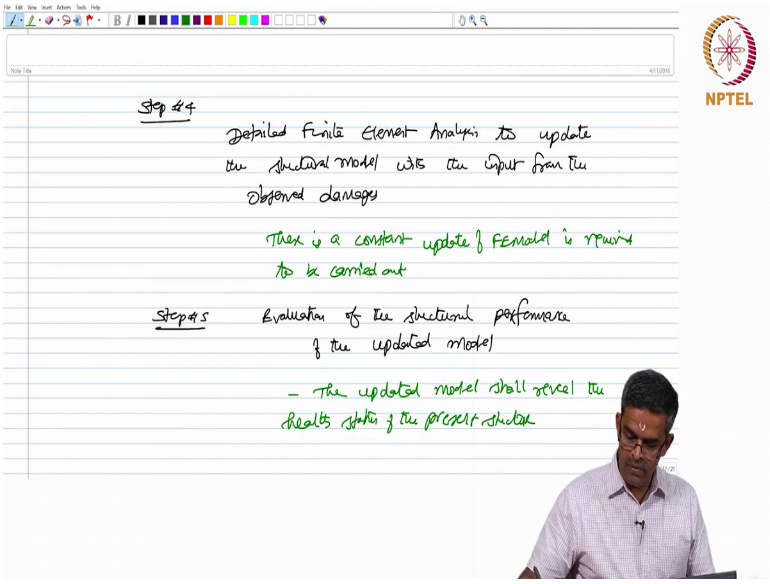

Step number 4, deals with Detailed Finite Element Analysis to update the structural model with the input from the observed damages. So, there is a constant update of the finite element model is required to be carried out. And in the last step is Evaluation of the structural performance of the updated model.

Now, at this stage, the updated model shall reveal the health status of the present structure.

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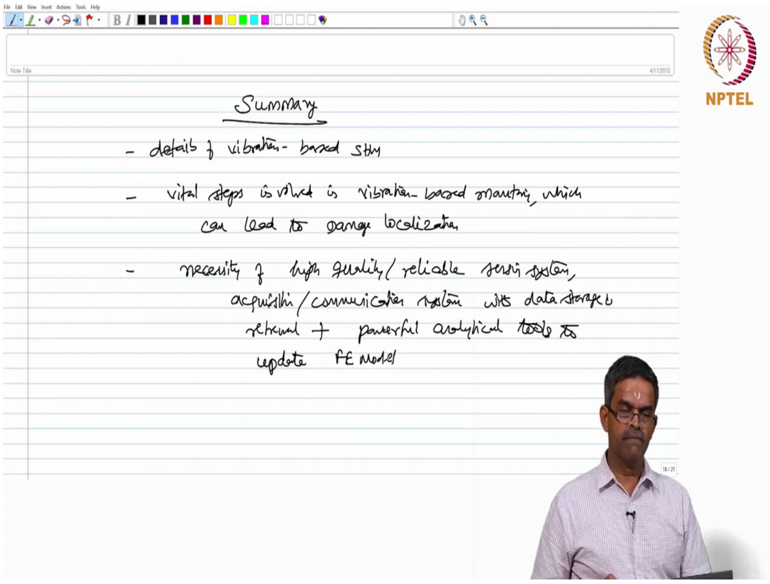

So friends, in this lecture , we focused on to learn details of vibration based Structural Health Monitoring. We understood what are the vital steps involved in vibration based monitoring which can lead to damage localization. We have also seen what would be the necessity of high quality and reliable sensing system, acquisition and communication system with good data storage and retrieval plus powerful analytical tools to update the finite element models.

We will further continue discussions on methods of SHM monitoring in the coming lectures.

Thank you very much.