Structural Health Monitoring (SHM)
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Lecture - 36
Part - 2: Damage Detection Methods

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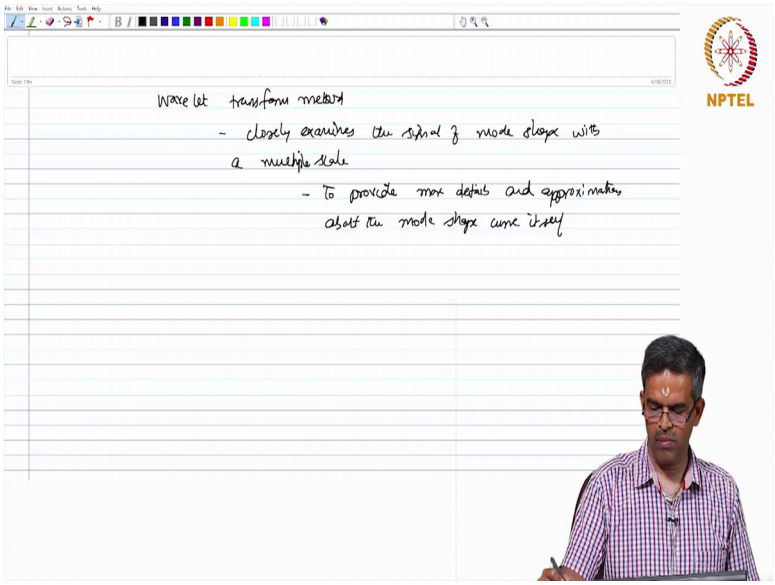

Wavelet transform method for advanced signal processing, wavelet transform method closely examines the signal of mode shape; with the multiple scale the intention is to provide more details and approximations about the mode shape curve itself.

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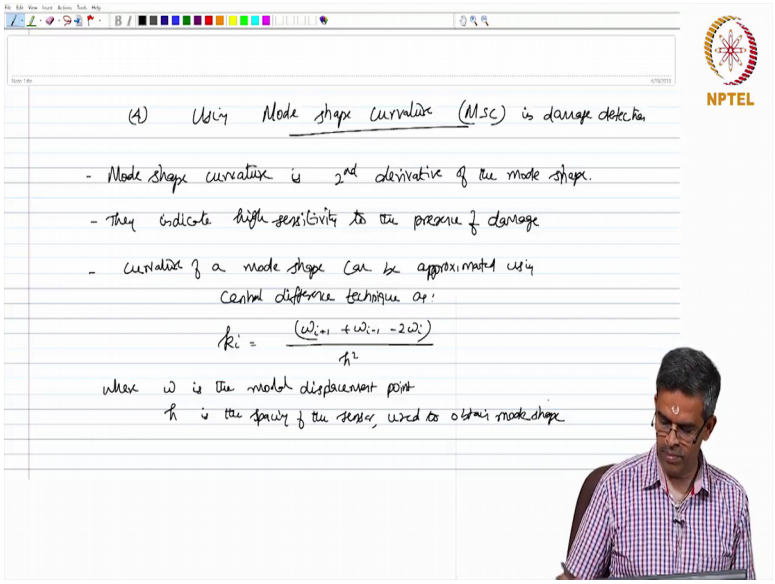

So, we will talk about how to use the mode shape curvature that is MSC in damage detection. We all should agree, that mode shape curvature is second derivative of the mode shape they indicate high sensitivity to the presence of damage. Curvature of a mode shape can be approximated using a central difference technique as k i is omega i plus 1 plus omega i minus 1 minus 2 omega i by h square, where omega is the moral displacement point and h the spacing of the sensor, which is used to obtain the worship.

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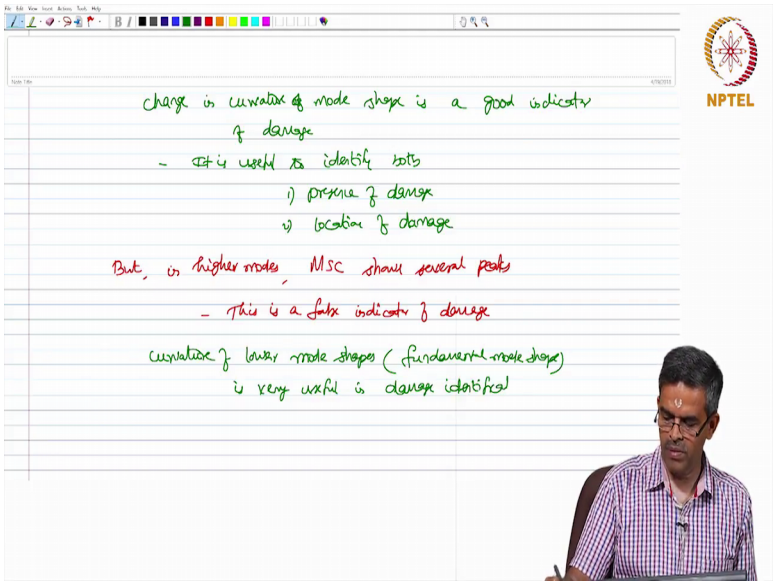

Change in curvature of mode shape is a good indicator of damage. In fact, it is useful to identify both the presence of damage and also the location of damage.

Unfortunately in higher modes, model shape curvature shows several peaks this is a false indicator of damage. So, one has to be careful when you use higher mode shapes for damage detection, when you use the second derivatives of the mode shapes by looking at the change in curvature of this mode shapes. Curvature of lower mode shapes to be very precise essentially fundamental mode shape is very useful in damage identification model strain energy method the MSC.

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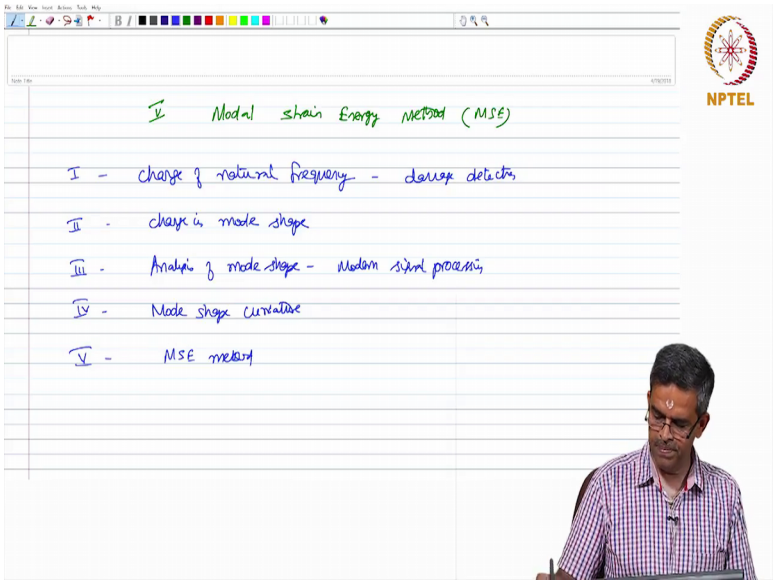

So, far we have seen method using change of frequency to damage detection, that is the first method we have seen, the second method is change in mode shape, the third analysis of mode shape using modern signal processing, the fourth method is mode shape curvature, which are essentially derivatives of the mode shape and the fifth method is what we are now seeing is the model strain energy method.

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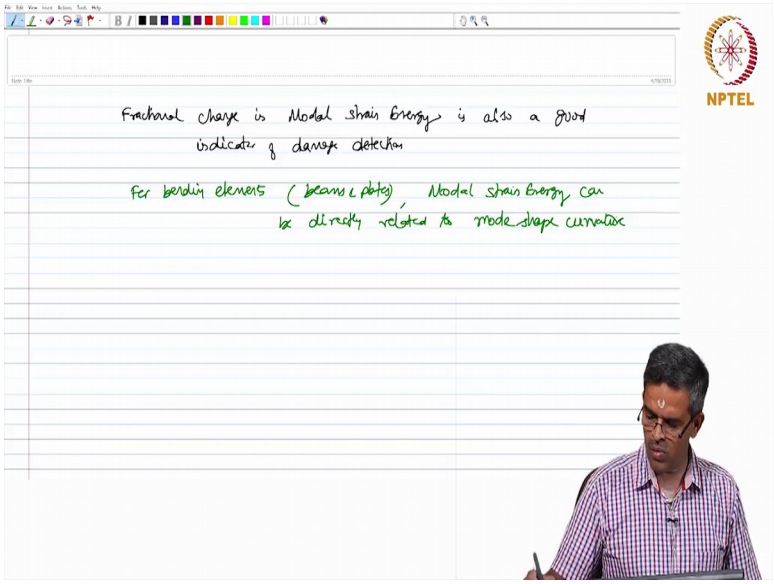

It is important to note that a fractional change in model strain energy is also a good indicator of damage detection. It is an agreed fact that at least for bending elements like beams and plates model strain energy directly related to mode shape curvature.

Let us now compare the different methods with algorithms.

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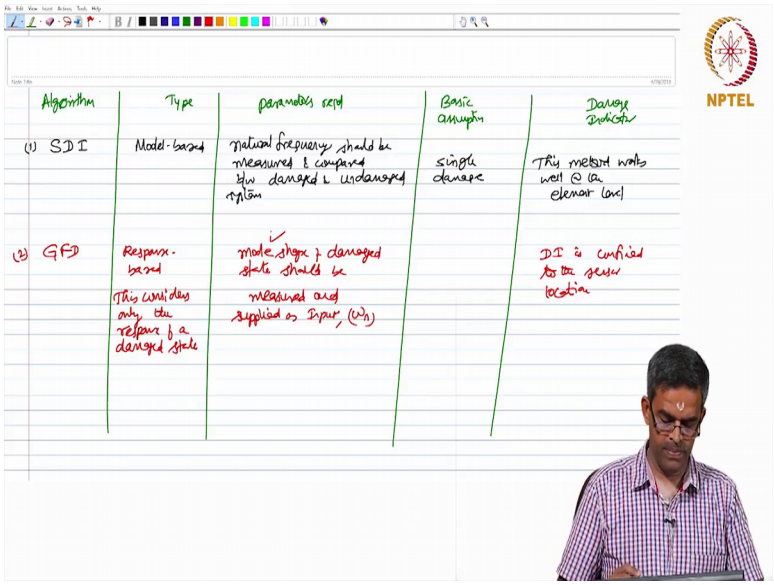

Let us say the algorithm what is generally used with the researcher? And what would be the type of measurement? And what are the parameters required to use this method? And

what would be the basic assumption which uses this algorithm? And what will be the damage indicator? Let us look at the comparison very quickly in a tabular form.

Let us say the first algorithm what we have seen is single damage indicator, which is actually a model based algorithm. In this case natural frequency should be measured and compared between a damaged and undamaged system. And here this method works well at the element level.

Now, the second method which we have seen for comparison is GFD, which is generalized fractal damage method, which is actually response based this considers only the response of damaged state. Here the requirement is mode shape of damaged state should be measured and supplied as input along with the natural frequency of the corresponding mode shape. The damage is defined the damage indicator is confined to the sensor location because you are using sensors to measure the mode shape. So, wherever sensors are located the damage indication will be around the sensor location.

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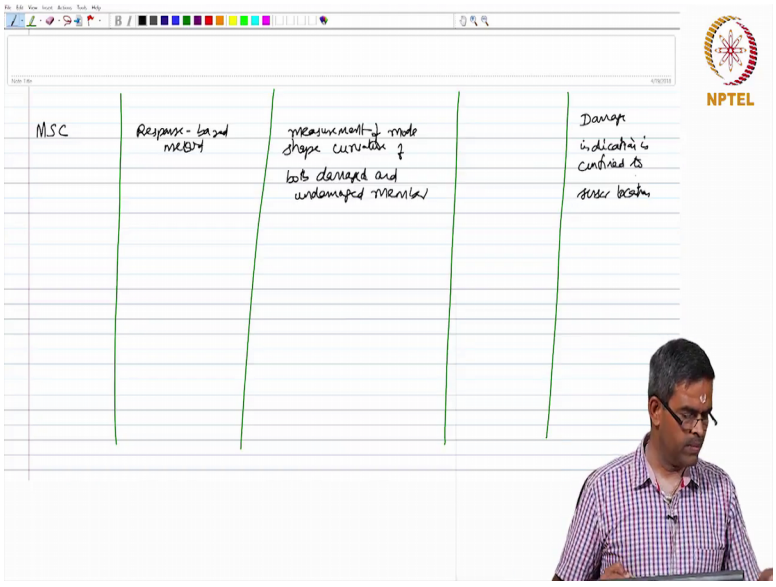

The third one is model strain energy comparison of the curvature. This method is again response based technique, this method also demands measurement of mode shape curvature of both damaged, and undamaged member. This also defines damage indication is confined to sensor location.

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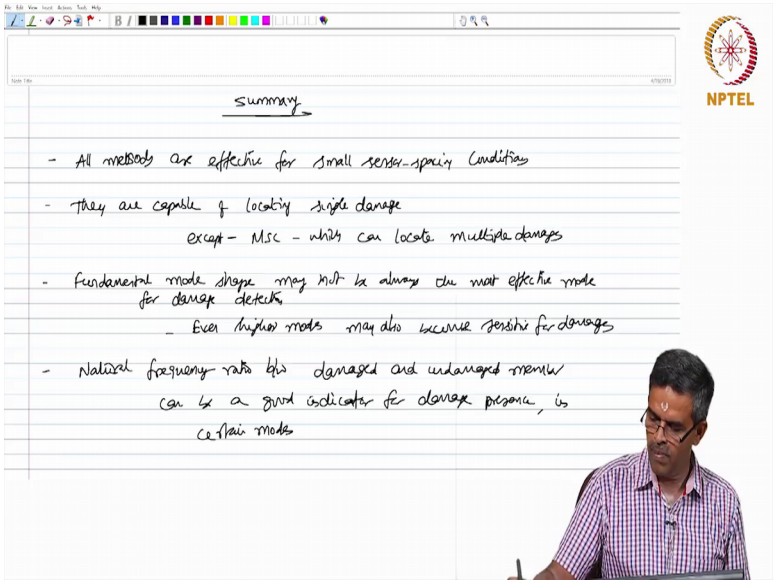

All methods discussed above in this lecture and the previous lecture are effective only for small sensor spacing conditions.

If the sensors are widespread these methods cannot work, because interpolating responses between the sensor data will not suit and will not enhance the accuracy of damage detection by any of these methods, there is the first summary we have. The second summary we have is all these methods are capable of locating single damage except MSC, which can locate multiple damages.

The next summary, what we can see is it is very interesting note that fundamental mode shapes alone may not be always the most effective mode for damage detection. Even higher modes may also be or may also become sensitive for damages. Natural frequency ratio between the damaged and undamaged member, can be a good indicator for presence of damage, but this is true only in certain modes.

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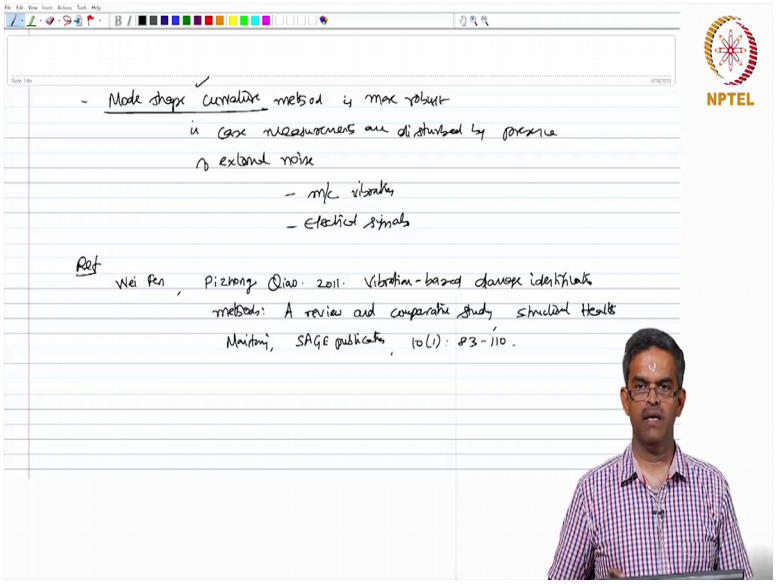

Mode shape curvature method is more robust in case measurements are disturbed by presence of the external noise created by machine vibrations, electrical signals, in such situation one can use mode shape curvature method to obtain.

So, friends in these 2 lectures we discussed about various methods, which are commonly employed by researchers in the recent past to use damage detection techniques we have compared them, we have also exposed their limitations and usage constraints of these methods. In reality more studies can be seen in this paper, vibration based damage identification methods a review and comparative study published by the journal structural health monitoring, sage publications 10 1 83 100 and 10.

So, with this concluding the mass we close this lecture in the next lecture we will talk about statistical pattern recognition and long term structural health monitoring style and methods.

Thank you very much and bye.