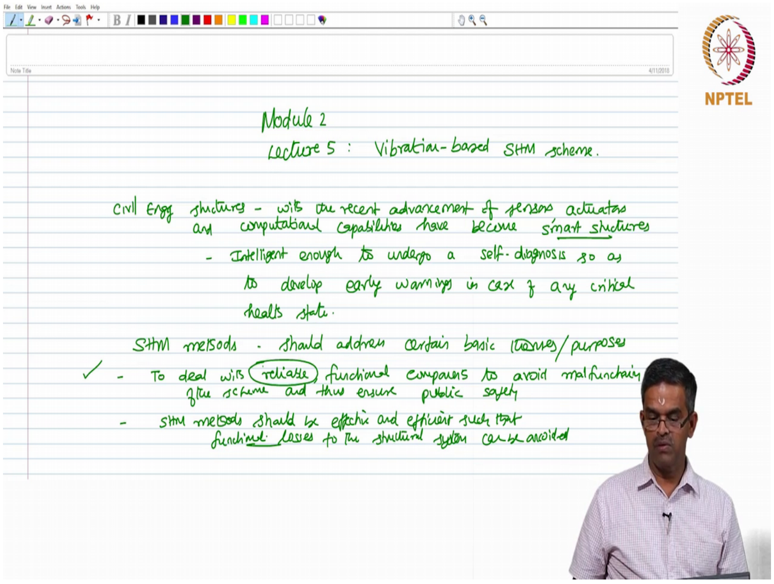
Structural Health Monitoring (SHM)
Prof. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Lecture – 25
Vibration based health monitoring scheme – Part 1

(Refer Slide Time: 00:19)

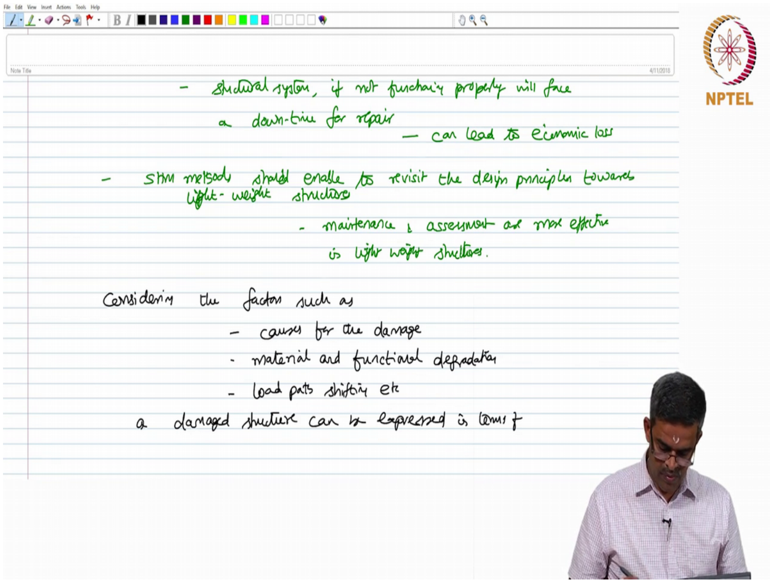


Friends, welcome to the module – 2, lecture – 5 where we are going to discuss vibration based structural health monitoring scheme we all agree that civil engineering structures with the recent advancements of sensors actuators and computational capabilities have become smart structures. They are intelligent enough to undergo a self diagnosis so as to develop early warnings in case of any critical health state.

So, under this objective let us see the structural health monitoring methods. Should address certain basic themes or let us say a purposes should fulfill certain basic purposes. It should deal with reliable, functional components to avoid malfunctioning of the system or the scheme and thus ensure public safety.

So, reliability of the system is the first objective. The second could be the SHM methods should be effective and efficient such that functional losses to the structural system can be avoided when we ask a question how do we get functional loss to a structural system.

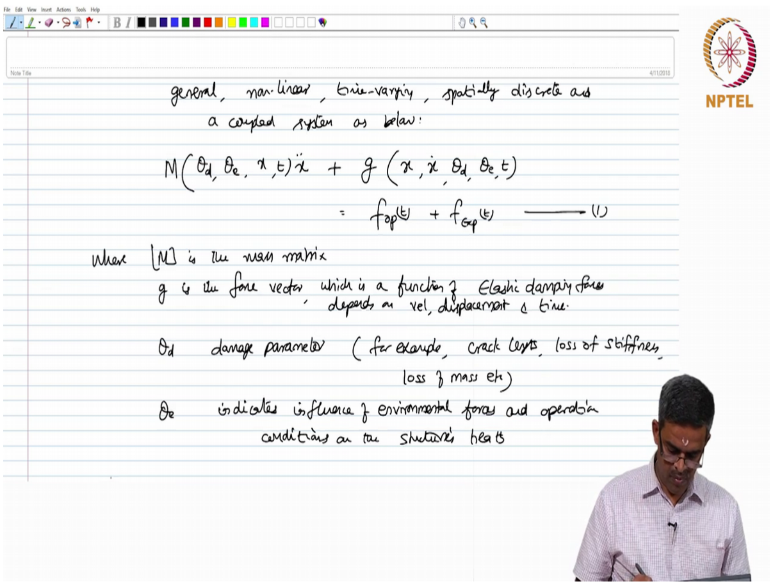
(Refer Slide Time: 04:26)



If the structural system is not functioning properly we will face a downtime for repair and that downtime can lead to economic loss. SHM methods should enable to revisit the design principles towards lightweight structures because maintenance and assessment are more effective in lightweight structures.

Now, considering the factors such as; causes for the damage, material and functional degradation, load path shifting etcetera.

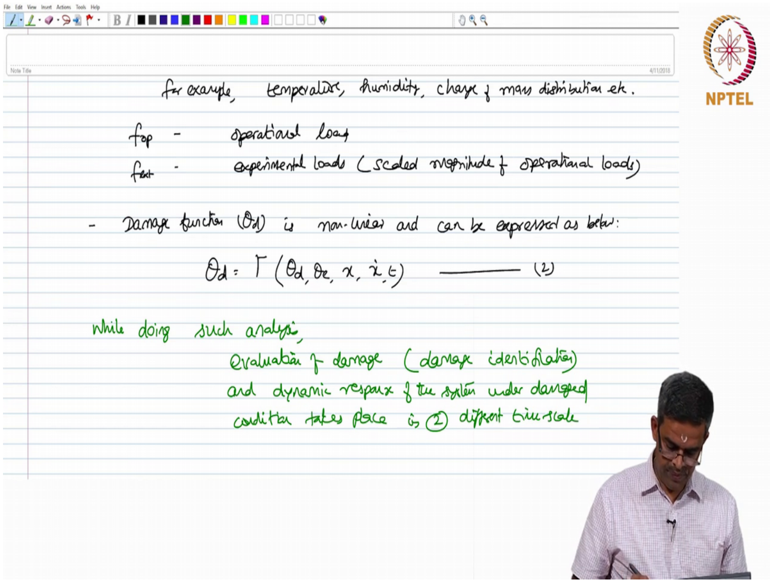
(Refer Slide Time: 07:09)



A damaged structure can be expressed in terms of general non-linear, time varying, spatially discrete and a coupled system as below; theta d, theta e, x, t the x double dot plus g which is a function of displacement velocity theta d, theta e and time will be equal to f operational plus f experiment, where m is the mass matrix g is the force vector which is a function of elastic damping force depends on velocity displacement and time.

Theta d is damaged parameter, it can be any issues for example, crack length, loss of stiffness, loss of mass can be a damage parameter. Theta e indicates influence of environmental forces and operational conditions on the structure as health.

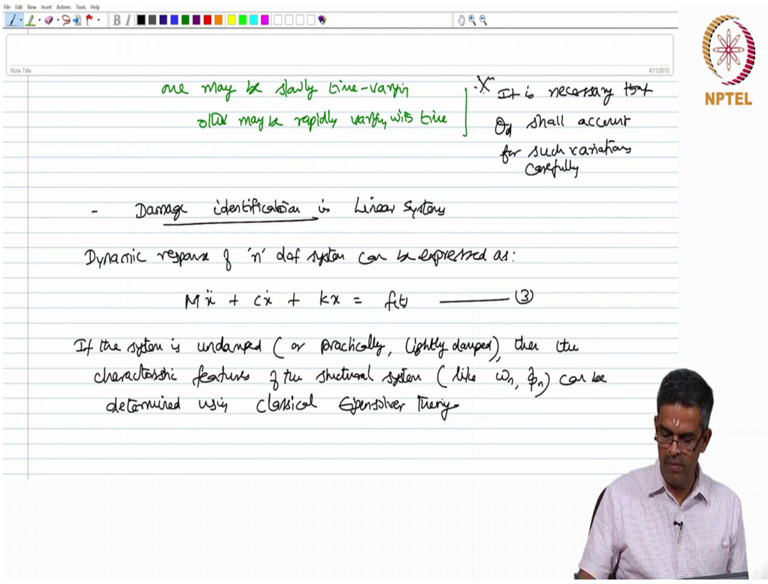
(Refer Slide Time: 10:12)



For example, it can be temperature, humidity, change of mass distribution etcetera f o p refers to operational low enough experimental refers to experimental loads which are essentially scaled magnitude of operational loads.

Further the damage function theta d is again non-linear and can be expressed as below theta d is a function of theta d, theta e, x, x dot and time. While doing such analysis evaluation of damage that is damage identification and dynamic response of the system under damage condition takes place in two different time scale.

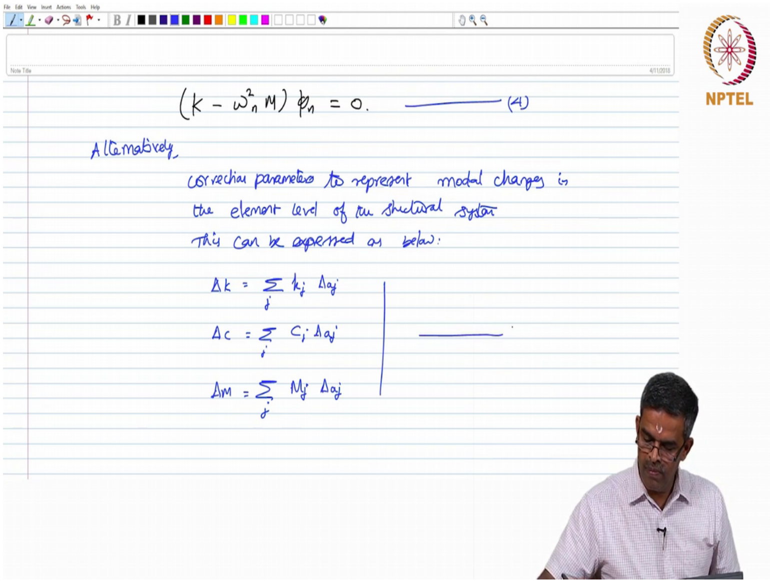
(Refer Slide Time: 12:44)



One may be slowly time varying, the other may be rapidly varying with time. Therefore, it is important, that is necessary that theta d shall account for such variations carefully, that is a word of caution, ok. Let us extend this logic to study damage identification in linear systems dynamic response of n degree of freedom system can be expressed as M x double dot cx dot plus kx, if f of t.

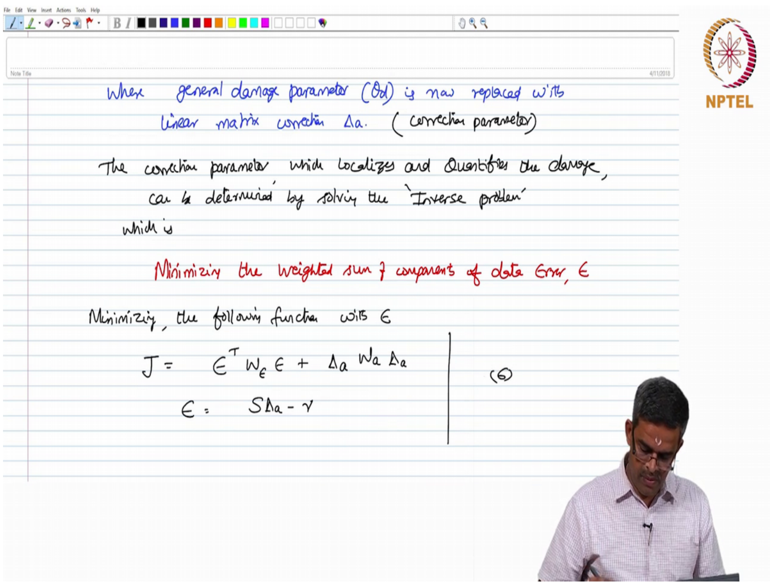
If the system is undamped or practically to say so, lightly damped then the characteristic features of the system like natural frequency more shape can be determined using classical Eigen solver theory.

(Refer Slide Time: 15:20)



This says K minus omega square m phi n is 0. Alternatively, one can use correction parameters to represent the model changes in the element level of the structural system. This can be expressed as below delta k, delta c and delta m.

(Refer Slide Time: 16:56)

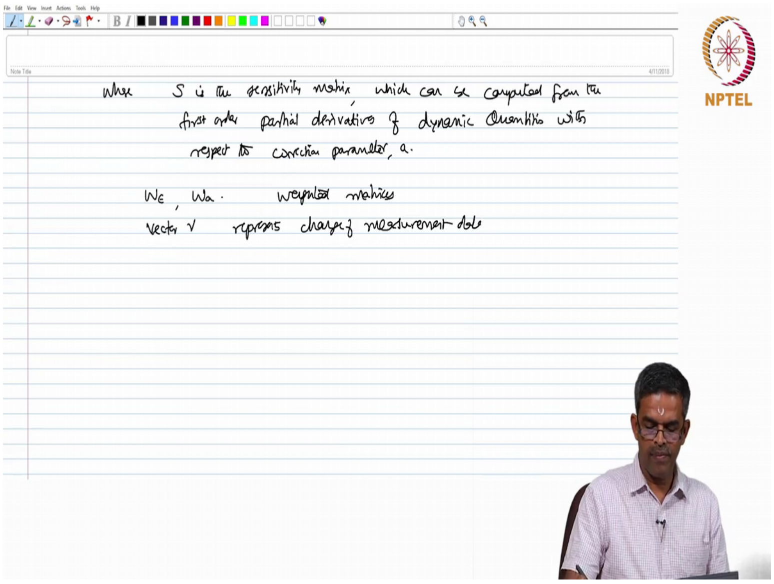


Where, general damage parameter x plus theta d is now replaced with a linear matrix correction delta a. So, delta a is called the correction parameter.

Now, the correction parameter which localizes and quantifies the damage because you can see from equation delta aj is the parameter which quantifies damage on mass, damping and stiffness, ok. So, this essentially localizes and quantifies the damage can be determined by solving the inverse problem which is minimizing the weighted sum of components of the data error epsilon.

So, now, the problem is now reduced to a minimization function, minimizing the following function with epsilon. The function is epsilon transpose weighted function plus delta a weightage of a plus delta a and epsilon is S delta a minus r.

(Refer Slide Time: 19:56)



Where, S is the sensitivity matrix which can be computed from the first order partial derivative of the dynamic quantities with respect to the connection parameter a. W epsilon and W a are called weighted matrices. The vector r represents change of measurement data.