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Lecture – 25 Vibration based health monitoring scheme – Part 1

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	Module 2
	Locture 5 : Vibratian-based SHM scheme.
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	to develop party warrings in care of any critical healts state.
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/	- To deal with (triliade) functional compares to avoid malfunction give active and there ensure public safety
	- stim melsed shall be effective and extremel that that functioned lasses to the structural system can be avoided

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.

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- stim metsadu schaldel enable tos Wight-weight schuldars	revisit the dayn	principles towards
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	wayny shutters.	
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- material and fur		
- load pats shifting	ek	
a damaged shutur can be	2-precised is lower	+

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.

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	general, non-linear, trive-varing, spatially discrete as
	a coupled system as belan:
	$M\left(\vartheta_{\mathbf{d}_{j}},\vartheta_{\mathbf{e}_{j}},\overset{\pi}{},\mathtt{t}\right)\overset{\pi}{\times} + \mathcal{J}\left(\varkappa,\overset{\pi}{},\vartheta_{\mathbf{d}_{j}$
	= fapiles + fagiles US
where	MI is the man matrix
	g is the force vector which is a function of Elashi damain these deposits on vel, displacement a time.
	Od damage panameter (for example, crack leaves, loss of skiffness
	loss & mass etc)
	De indicates influence & environmental forces and operation
	anditions on the shutard hears

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.

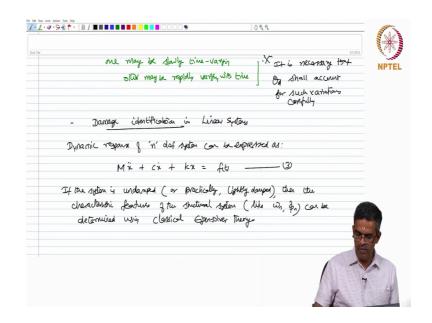
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for example, temperature, humiduity, chape y.	man dishibuliar ek.
for - operational losy	
fect - experimental loads (scaled magnitude;	- operational loads)
- Damage function (Od) is non-wies and can be a	supremed as below:
Od = T (Od, Oz, x, ż, j)	- (L)
While doing such analysi	
Orabuation of damage (damage id	entification)
and dynamic respans of the sortion in	
condition takes place is 2 different	tiusche
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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.

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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.

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	$(k - \omega_n^2 M) \phi_n = 0.$	(4)	N
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	correction parameters to repres		
	the element level of the si		
	This can be appended as	belaw:	
	Ak = 5 k; haj		
	$Ac = \sum_{i} C_{i} ha_{i}$	·	
	7 7 7		
	Am = S My Daj		
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			1
			N/A

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.

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When general damage parameter (Od) is no	
linear matrix correter Da. (corre	chian parameter)
The containing parameter which localizes and	Quantifies the damage,
can be determined by solving the True	erse problem
which is	
Minimizing the weighted sun of compares	ns of obta Gran, E
Minimizing, the following function with E	1
$J = e^{\tau} W_e e + \Delta_a W_a \Delta_a$	6
E = Sha - V	
	1

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.

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When S is the pensitivi	rily mahix which can be computed from the	
	ial derivatives of dynamic Quentities with	
respect to cor	nection parameter, a.	
We Wa W	regular mehrics	
Vector V represes	chargers measurement dola	
		Stel
		A

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.