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Module 1

Lecture 4

- Challenges in STM

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(1) Foremost challenge

is to develop and demonstrate the SHM technology

- which can be useful to maintain the structural integrity with improved reliability and durability

(2) Unlike conventional Non-destructive techniques (NDT)

a single technology of SHM cannot be suitable for all applications

- depends on various factors
  - material
  - component geometry
  - damage scenarios

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(3) Outcome of SHM - should be reliable
- sometimes, it may trigger unwanted maintenance, which may become expensive
- It may also sometimes create spurious warnings
- degrades confidence level on the strength of existing structure

(4) optimization of structural design on the basis of acquired (monitored) data through SHM
- Data, acquired through SHM should be fairly accurate & robust

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(5) major concern is the cost of STM scheme

(6) Owners of structural system, even if it is Govt undertaking, should be convinced with the use of STM
- public funding – on a major investment
- it should produce, reasonably advantageous outcome
- Economic perspective as
- Safety perspective
- it should be producing results, that are debatable and comparable to regular maintenance approaches

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(7) major challenge is SHM

- damage detection
  - locating damage (units)
  - its scalability
  - its prospective fronts
  - its consequences

(8) major challenge is SHM

- reliability & robustness of the sensors
  - lifespan
  - adaptability to work environment
  - successful sustainability to the power network

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Additional challenges in STM scheme

(1) Damage identification in civil structures & mechanical structure is one of the major challenges

Damage is defined as

- change in material properties
- change in geometric characteristics of the system

- This also includes change in boundary conditions and system connections
  - which can lead adverse effect due to flaw degradation

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The above complexities can be handled using NDT tools

- helpful in identifying damages @ Global level

- damages on the structure as a whole can be identified
- but cannot be precisely located @ the local level on each member

for RCC structures this problem is more serious

- increased complexity arising from embedment of steel in concrete

- One of the recent approaches - SPR - statistical pattern recognition

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Damages

are generally initiated @ material level
- defects or flaw

- under certain loading conditions, these damages tend to propagate
  - they can result in system-level damage

- Main concern is not the system-level damage
  - it is the component-level damage

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Damages do not refer to loss of system functionality

If the system functionality is lost, it called as failure

prevent the system to perform is its optimal manner

Damage	failure
- degrades the performance of the system	- total loss of functionality
- It doesn't affect system functionality completely.	- need to mitigated
- Damages can be addressed	- reconstruct the system
	~~Stm~~ is to avoid failure

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Damage to the system (civil structural systems)
can occur in (2) scales

- (1) long-term time scale
  - corrosion
  - fatigue
- (2) short-term time scale
  (i) due to Impact load / shock load
  (ii) aircraft landing.

SHM - as a process of implementing damage identification strategy

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This process involves the following:

(1) Observation (Monitoring on a continuous scale)

(2) Assessment

To determine the current state of the structural system

- based on the extracted data of damage sensitive features
- sensitive features identified to quantify damage
- statistical analysis tools which are used to quantify damage

Non-destructive Evaluations (NDE)

- primarily used to characterize the damage and check for severity — more is prior knowledge of the damage

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(2) SHM challenges in oil & gas industries

oil platforms - generally inaccessible for damage inspection

- vibration-based damage identification has been tried (early 80's) in oil platforms

major challenge is

- damage location is not known
  - because majority of the area of platform is not accessible for measurement

common solution is to simulate the damage scenario using numerical model in software & examine the severity to interpret the damage

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Major concerns of using vibration-based damage detection in oil platforms

(1) machine noise - created by the platform - interfers with the measured vibrations

(2) Instrument deployment in hostile environment - challenge

(3) faulty-mass representation - which arises due to marine growth

(ω_n) - is the major parameter damage is characterized

$$\omega_n = \sqrt{k/m}$$

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(4) Varying hydro-dynamic mass — arise from the fluid storage variation

(5) variations in foundation conditions

(6) absence of wave force or exciting force in higher modes

The above factors (concerns) have limited (restricted) use of SPM in oil industries (oil production platforms)

One of the major concern is that physical size of the structure

- bridges, longer span, less
- sensor network
  - reliability
  - data loss
  - functional robustness

Summary

challenges in SHM process for various industry

- optimal positions of sensors to decide their layout
- networks of sensors — to interconnect them for onward transmission of data
- identification of features, sensitive to even small damages (damage levels)
- Algorithm / acquisition filters to differentiate changes caused by damages & those caused by the environmental loads

- development of statistical methods to discriminate features of a damaged & undamaged system

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