

## Module 2, Lecture 8:

### Damage identification - Visual Inspection methods

Damage identification - Visual inspection methods. (VI)

one of the serious limitations of VI method - it affects the decision-making process & resource utilization, significantly.

### (1) Timing

- Inspection frequency of VI method can be selected as per the requirements of structure, environmental conditions and operational loads
- Static assessment of the structure may not be sufficient enough to identify damages, which are critical
- A continuous monitoring is preferred
  - Crack propagation - which cannot be captured by VI tools

## (2) Interpretation of results VI method

- VI method - depends on visual input, user expertise and domain knowledge, user experience & training etc
- results by VI - a subjective assessment
  - may be inadequate to compare with him assessment
- this is due to the fact that
  - VI teams may not be experienced
  - VI guidelines, used by different agencies may differ
  - there are no set/standard guidelines for VI.

### (3) Accessibility

- It is very important to know ~~that~~ effective results of VI depend on physical accessibility of the VI team to the surface of prospective damage.
- If not sufficient accessibility is provided, internal impediments can be interpreted from results/reports of VI members
  - serious limitations

## Sensors used for measuring parameters

### Sensor type ✓

### Functionality ✓

### Purpose ✓

1) Accelerometer	Vibrations	Modal Analysis
2) Strain gauge	Surface strain	Stress-strain response
3) Anemometer	wind velocity/direction	wind load estimation
4) Inclometer	inclination	pier settlement is OK to bridges
5) GPS receiver	displacement/amplitude	model validation
6) Sonar	pile-top elevation to a bridge	scour detection
7) Reference electrodes	voltage potential level	Corrosion monitoring

## SHM - challenges (in comparison to alternate methods)

- (1) System complexity
  - not the complexity of structural system
    - It is complexity of SHM system
    - This is dependent on size & complexity of the structure, being monitored
    - It also depends on functional characteristics of the structural system for example, an automated, multi-functional SHM system
      - which is integrated with Alarm Monitoring System (AMS)
      - such systems require a complex and robust network software - which is highly complicated
  - SHM system complexity also depends on experts remaining service of the structure

## (2) STM system maintenance

- STM system required complicated network & testers, which are guided and controlled by complex hardware/software
- There is a major problem of break-down of the system itself
- It requires a regular maintenance to sustain long-term operation
- STM system need a rigorous & continuous maintenance

— which can be of high expense

Tips to reduce STM system maintenance cost

- reduce the system redundancy of the structure
- To avoid break-down, provide renewable power source to the hardware of STM system. This eliminates the need to check battery in case of wireless sensors

(iii) one need to employ adequate IT professionals to ensure ongoing functional condition of STM system

### (3) Automated Data Analysis

- Let us consider a situation, equipped with automated control engineering and automated communication, is termed Alert Monitoring.
- All data, collected by the system, may not be relevant to identify the potential damage.
- It is important that data analysis capability should be enhanced, is called Automated Data Analysis
- Some system should be well-trained for the test data to which it need to respond automatically.
- Sometimes it may cause false alarming also ✓

## (4) Reliability/Responsibility

It can be confusing, mainly, data is acquired from the student system as a continuous seqs.

- All data collected need not be processed.
- Automatically processing the "valid data" is a challenge
  - data should be reliable
  - data should be taken from the required source and not been interpreted
- If any data, related to failure (e.g. collapse of the system is entered, then who holds the responsibility?



Certain important issues to compare visual properties methods & STM methods

### (1) Functionality

overall functionality of the full-scale STM and VI are not exclusively different and important difference is the frequency / interval <sup>out</sup> which VI is carried

- VI has discrete & infrequent time intervals where as STM methods have greater time intervals (as continuously monitored)
- STM methods have potential to generate information even on a daily basis (VI methods cannot do this)

one major functional advantage of VI method is that

the scope of VI method is not only limited to damage detection, but leads to broad evaluation of the complete structure (preliminary assessment of the AD is possible with VI)

Even completely unaffected structures cannot execute or extend the damage detection scenario to the complete structure

(2)

cost

In both the cases, i.e. VI method and STM method, | cost

depends on characteristics of the structured methodology  
(or) answer

- Cost implementation of STM system - will be very high if it is not required for the structured system
- STM methods - the structures of high importance
- VI methods can be applied to all types of structures
- cost of VI is subjected to the extent of details required from VI

- It also depends on inspection frequency

There are ③ factors, based on which cost can be compared

(1) Upfront cost

(2) Maintenance/operational cost

(3) Return on Investment (ROI)

## Cost comparison

## STM methods

- (1) Negativity of the upfront cost is STM method is towards hardware/software compares
- 2) Maintenance cost depends on the longevity and health of the student
  - cost towards data acquisition & data management
- (3) ROI is slow
  - effectiveness of STM will be realized only when the maintenance cost is comparable to reliability cost

## VI methods

- i) Negir cost is towards labour (technical expertise) and advanced equipments to conduct VI
- ii) As such, there is no special operational cost involved
  - except, is care of inaccessible location, labour need to be insured.
- (3) ROI is quick, & visual
  - Immediate perception of the VI results based on which maintenance/repair is initiated

### (3) User resistance

- STM method depicts advanced features of I-T industry
  - advanced techs, acquisition system, communication system, data management et becomes inherent part of STM methods
  - A significant shift towards IT-based system maintenance from a conventional civil maintenance
    - This involves resistance from the user, in terms of using updated software, employing more IT preferences
- aka

## VI method

- IT is done periodically (as scheduled updates)
- These inspection updates are well planned and become a part of maintenance of the system
- VI are contractual
  - It does not demand any additional training/knowledge towards citizens for the user
- VI methods are done by expert third party

But in general, user resistance is vital to successfully implement a exercise stn on the structure

It is also important to note that

- both VI & SVM are to be combined for effective results
- depending solely on either one of them is not a good practice
- combined approach will be more successful for early detection of structural problems & reduces human error



## Summary

Even though, initial investment towards wireless tends to  
still meet or may be superior in comparison to  
VI method, but still  
added functionality  
timeliness of operation support  
adds more value towards buyer initial investment



