

## Module 2

### Lecture 2: Local and Global monitoring

local monitoring refers to observing local phenomena i.e. for

local effects like

crack initiation

crack propagation

etc

extensive strain

- local monitoring is carried out NDTs
- local monitoring is helpful to determine severity & damage
- nearly it is very useful in lab scale  
when certain parameters need to be controlled

Ex:

modeling a girder of deck, the bridge  
under traffic load (rolling loads)

- need to control speed of load movement etc

## Global Monitoring

- will focus to determine deformations (large displacements)  
under excessive loads, when the structure is vibrating

- Usually, modal parameters like

frequency  
mode shape  
damping estimates } are measured

They are then correlated with the analytical studies to identify/quantify the damages on the structural system.

### Static & Dynamic Monitoring

Variation of parameters like

deflection	}	slow-varying process need to be carefully monitored
inclination		
settlement of foundation		
crack widths		
corrosion of rebar		

Simultaneously, changes can be also be caused due to environmental conditions such as:

- temperature variation
  - humidity
  - wind force/direction
  - current or wave
  - wave force/direction
- or

Do not lose sight of effects, but to get the can sometimes exhibit a quasi-static behavior

- While monitoring these parameters, one should measure and the peak value, which is observed over a long-period of time

- This kind of monitoring as static monitoring

## Dynamic Monitoring

- This kind of monitoring is carried out with a higher sampling rate
- Dynamic monitoring is used to obtain variation in structural characteristics under dynamic load effects

## Phenomena

## Monitoring Strategies

## Sensor Types

(1) foundation  
settlement

local

LVDT

continuous

laser

static monitoring

hydro-static liquid system

long-term monitoring

All types.

(2) Displacement

- Global monitoring

LVDT

- short-term monitoring  
story-frame monitoring

laser

periodic or triggered  
monitoring

GPS

(3) Inclination & rotation

- local
- short-term  
long-term

inclinometer  
(uniaxial/biaxial)

(4) Crack detection

- Global
- dynamic

FOS

(5) Crack widths

- local
- periodical
- static

LVDT

Crack sensors



## (6) Vibration

- Global
- Short-Term
- Periodic
- Dynamic

Accelerometer  
(uniaxial, biaxial  
triaxial)

## (7) Corrosion

- Local
- Continuous
- Spall Integrity
- Seismic Sensors
- Embedded Sensors

## Data Evaluation and Assessment

- Once, data is collected from the users, it needs to be processed to evaluate the validity of the structure
- one of most common methods of evaluation is using probabilistic tools
- performance of the structure, needs to be upgraded - out come of the assessment to STM
  - under economic conditions, if the revised design of the structure shows higher safety
    - Then we should check this arrangement using Reliability tools

✓ Reliability-based classification is also important in such cases

✓ S. Chandrasekaran. Risk & Reliability of offshore structures, NPTCL, ISGMOthers

S. Chandrasekaran. 2016. Risk & reliability of offshore structures, CRC press, USA

For satisfactory performance of the structure, following conditions should be satisfied:

$$R \geq S \quad \checkmark$$

where  $R$  : resistance of the structure

$S$  : load effect on the structure

To obtain load effect on the structure, distribution of loads, intensity

- location
- intensity
- time/space dependence
- direction

Variations that time dependent needs to be known

This can be obtained readily from continuous monitoring data

Target Reliability Index ( $R_T$ ), which is used in assessing the condition of the structure is estimated

A Table is recommended by ISO: 13822, also is the Basis for design structural assessment of existing structures

Limit state

✓  
B

Reference period

a) serviceability

- i) reversible
- ii) irreversible

0  
1.5

}

to calculate remaining service life

b) fatigue

- i) can be inspected
- ii) cannot be inspected

2.3  
3.1

}

- remaining service life from

c) ultimate

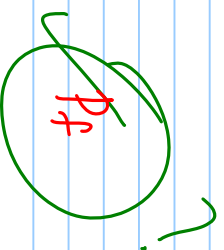
- i) very low consequence of failure
- ii) low consequence of failure
- iii) medium
- iv) high consequence

2.3  
3.2  
3.8  
4.3

To design for service life of the structure (about 50Y)

Relationship b/w  $(\beta)$  &  $P_f$ .

$$\beta = \phi^{-1}(\phi(P_f))$$



$$10^{-1}$$

$$10^{-2}$$

$$10^{-3}$$

$$10^{-4}$$

$$10^{-5}$$

$$10^{-6}$$

$$10^{-7}$$

$$1.3$$

$$2.3$$

$$3.1$$

$$3.7$$

$$4.2$$

$$4.7$$

$$5.2$$

Sayyid down

1

2

3

In general  $P_f$  is given by:

$$P_f = P(R-S \geq 0)$$

where  $(R, S)$  are stochastic variable

But, as the structure with same classification are designed for equal load with different material,

design codes recommend partial safety

Design value ( $F_d$ ) will be based on

partial factor for material

partial factor for load effects

models uncertainty

& load effects error



$$f_d = \frac{f_k}{\gamma_m \gamma_n} \quad \frac{1}{\eta}$$

$f_k$  = shear capacity, which is reduced by the factors ( $\gamma_m$ ) & ( $\gamma_n$ )

$k_e$  = load capacity factor

$\eta$  = model uncertainties,

covers accounting for scaling up the last scale means &

full scale structure.

## Summary

- local & global monitoring
- static & dynamic monitoring
- different types of different phenomena
  - spatial & time
- Data assessment & evaluation
- Reliability tool to assess condition of the structure
- $P_f$  - linked to  $\beta$  - failure factor is clear.

Ref:

Arvid Hagill 2007. civil structural health Monitoring - strategies, methods and applications

Lulea University of Technology, Sweden



