

REAL-TIME STRUCTURAL MONITORING AND LOSS ESTIMATION

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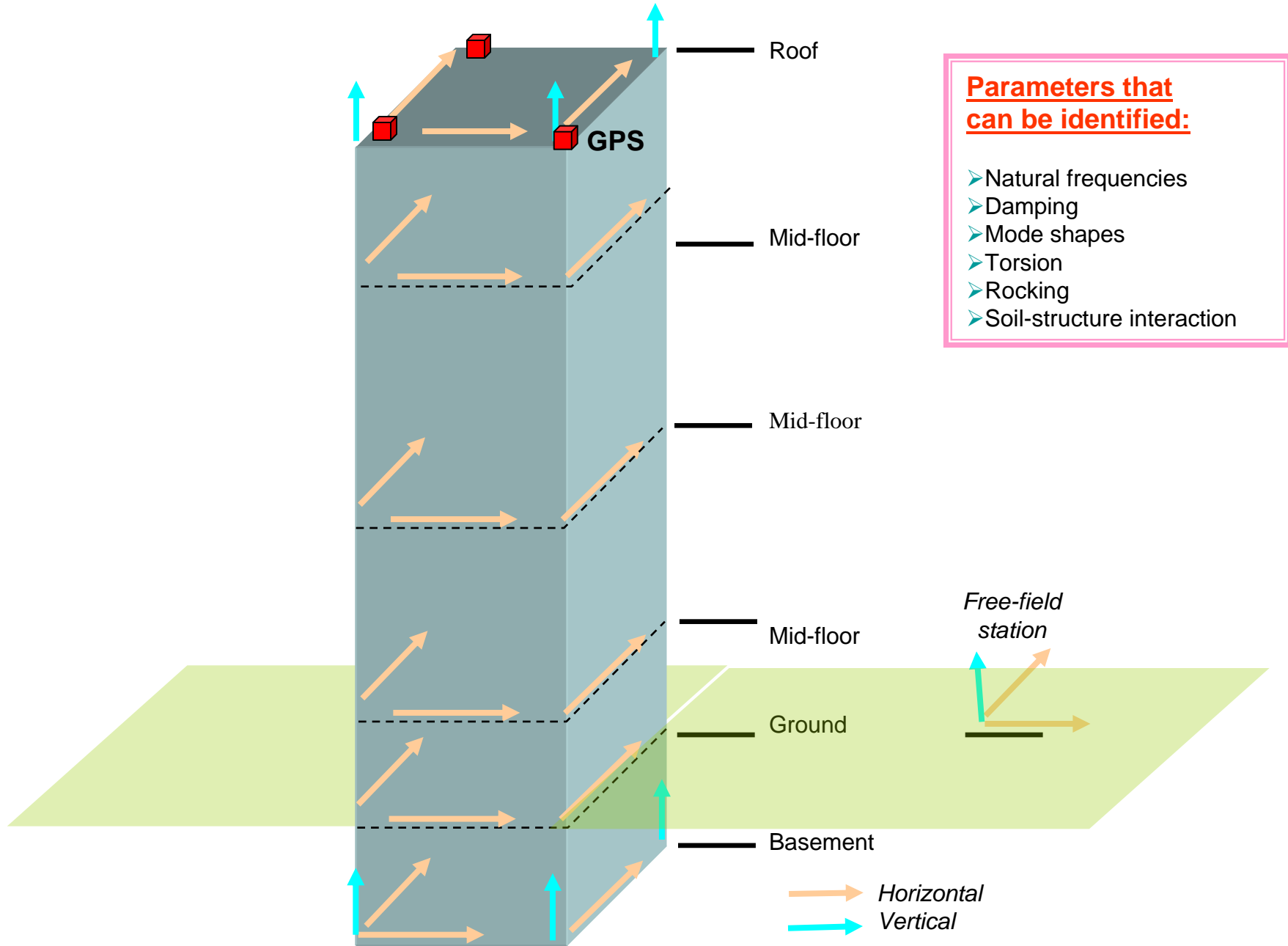
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WHY DO WE MONITOR STRUCTURES?

- To determine the in-situ dynamic characteristics of the structure .
- To check the design and analysis methods used.
- To improve structural design codes.
- To develop new retrofit and strengthening techniques.
- To predict behavior for future extreme loads.
- To detect and locate damage after an extreme event.
- To develop instantaneous damage distribution and loss maps.

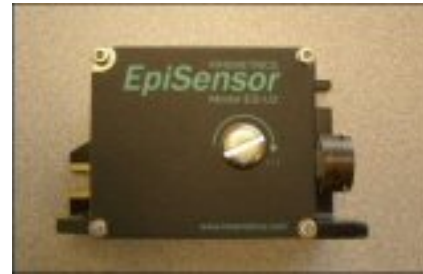
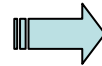
STRUCTURAL HEALTH MONITORING (CONTINUOUS RECORDING)



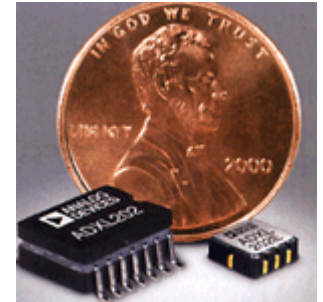
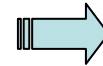
SENSORS



20 cm



10 cm



0.5 cm



RECORDING AND COMMUNICATON BOX

REAL-TIME DISPLAY (Antelope, Scream, Data Streamer, etc.)

Digitexx - Data Streamer V1.0

File Edit Operate Tools Window Help

Amplitude [cm/s/s]

DIGITEXX Data Streamer

Start Time: 12/05/2002 10:02:11
Current Time: 12/05/2002 10:05:55

STOP
Recording
Save Settings

Comm Channels Trigger FFT/TF Advanced

Data type
Acceleration

Mean Sample Size
500

Scheduler Settings

Schedule OFF

Hour: 2 Minutes: 00 PM Duration [sec]: 1

On-demand Recording

Write to disk? OFF

File name: c:\sample1.doc

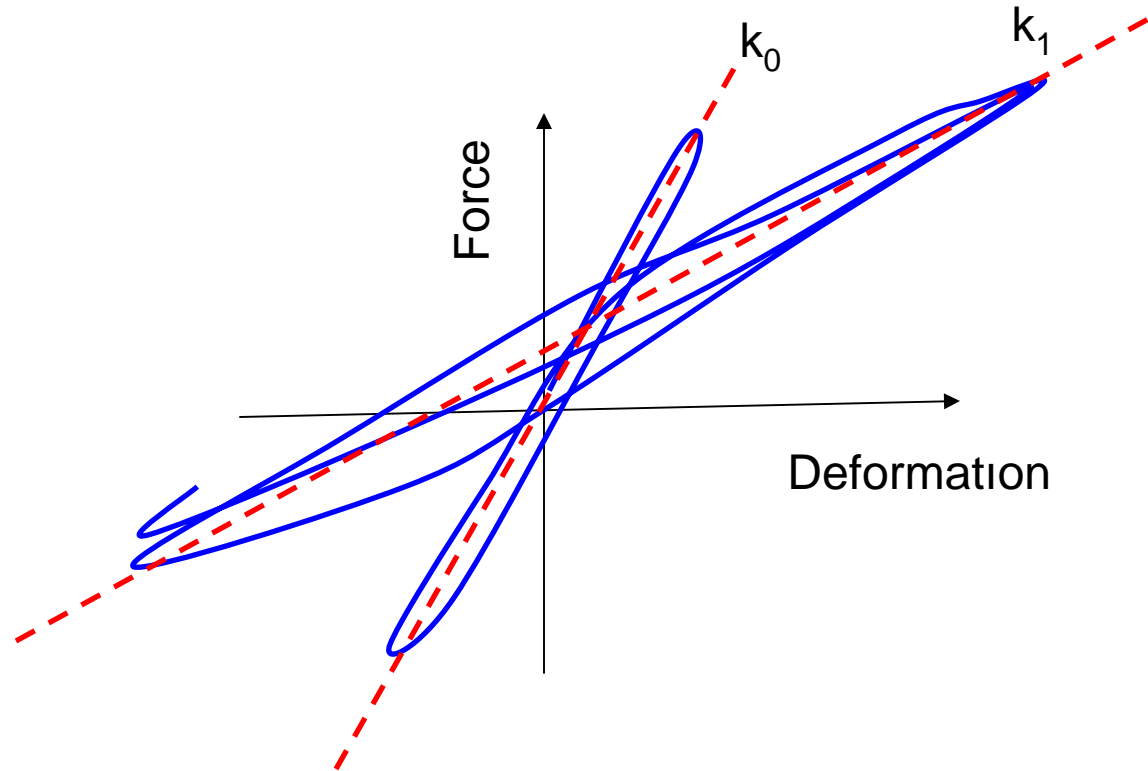
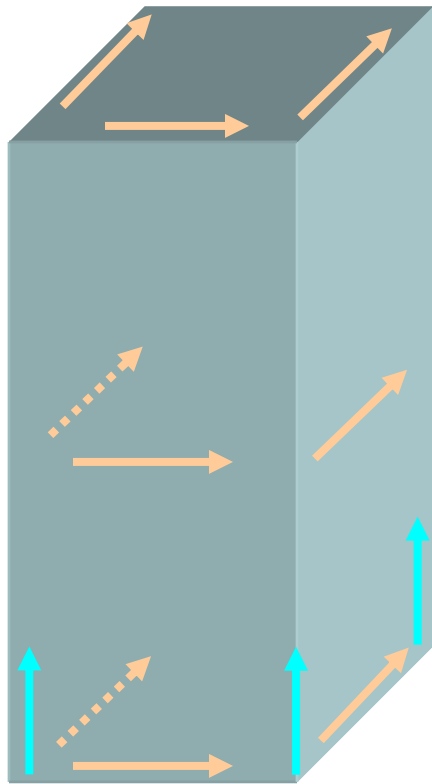
Global Filter Settings

Topology: Butterworth
Type: Lowp Order: 5
Lower Fc: 40.00 Upper Fc: 200.00
PB Ripple: 1.00 SB Attenuation: 60.00

Integration Filter Settings

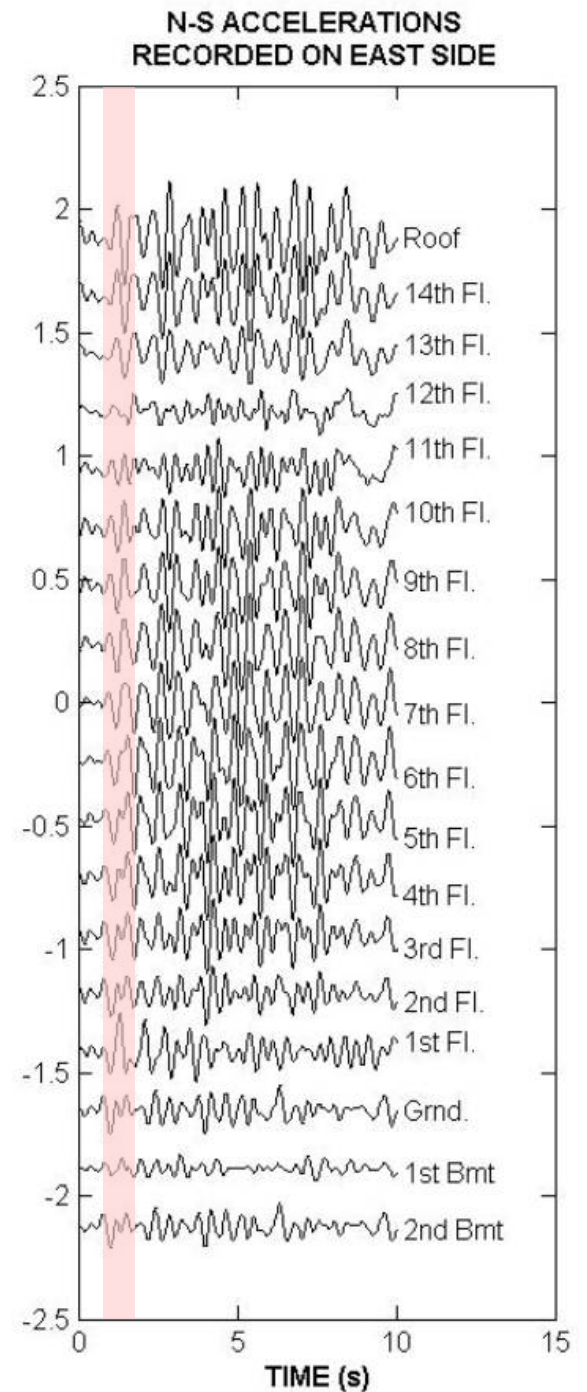
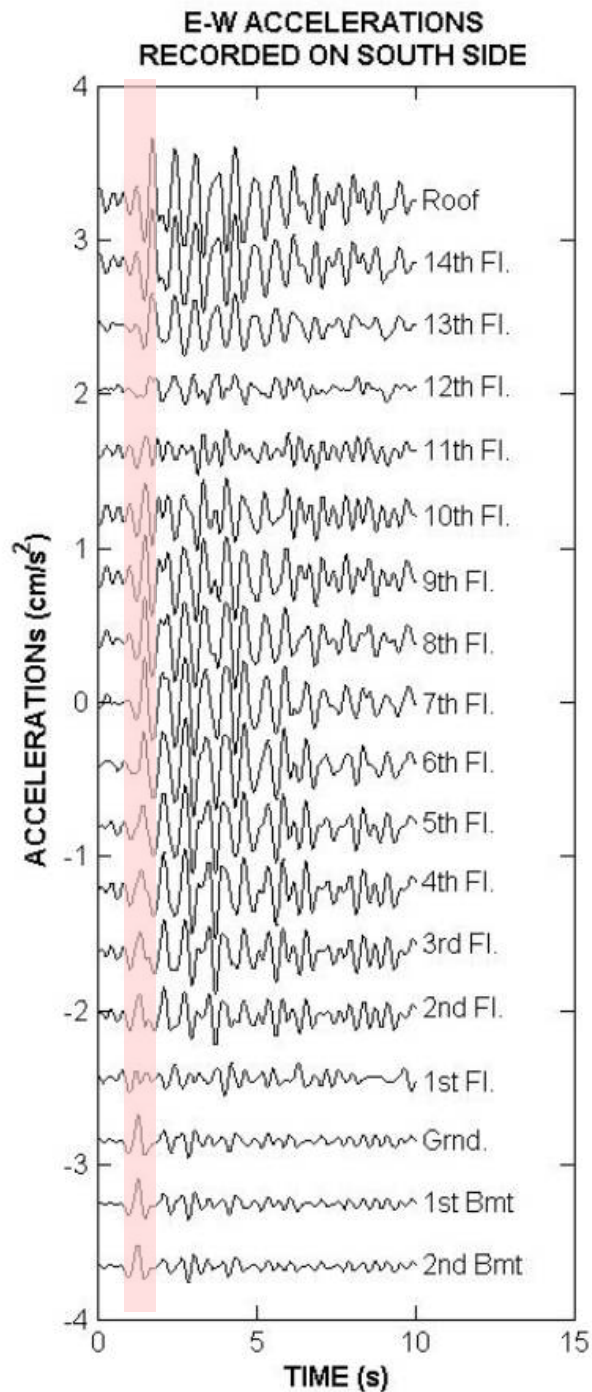
Topology: Butterworth
Type: Highp Order: 2
Lower Fc: 00.00 Upper Fc: 200.00
PB Ripple: 00.00 SB Attenuation: 60.00

CHANGE IN THE NATURAL FREQUENCY vs. DAMAGE

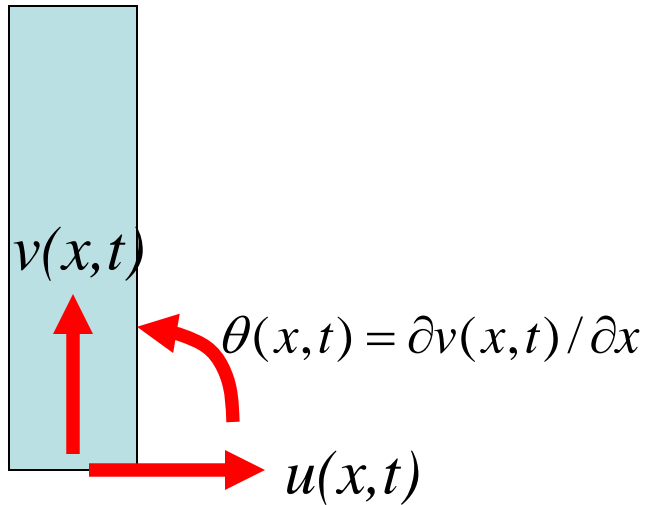
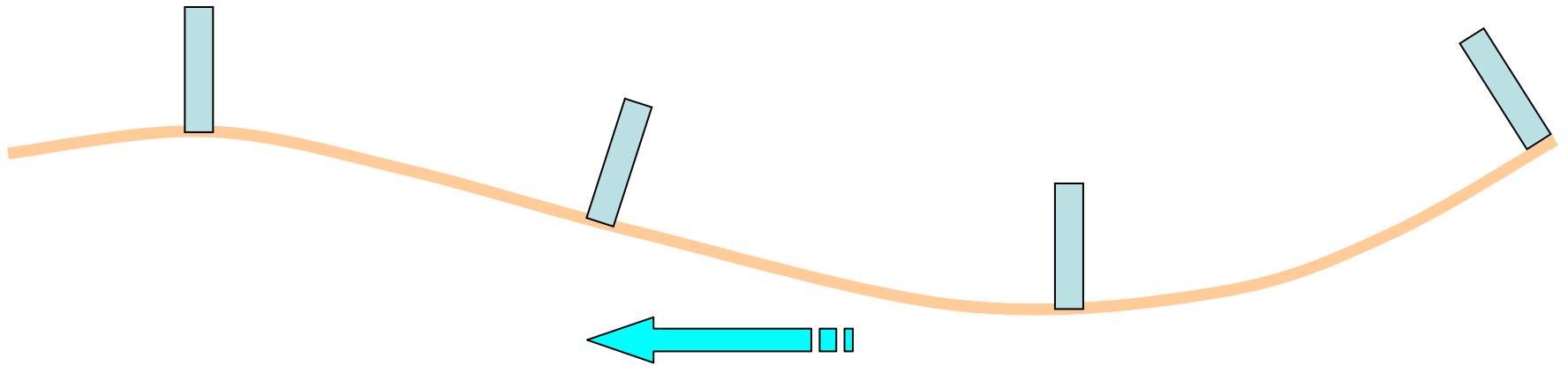


Assumption: Damage reduces the stiffness, and consequently the natural frequency.

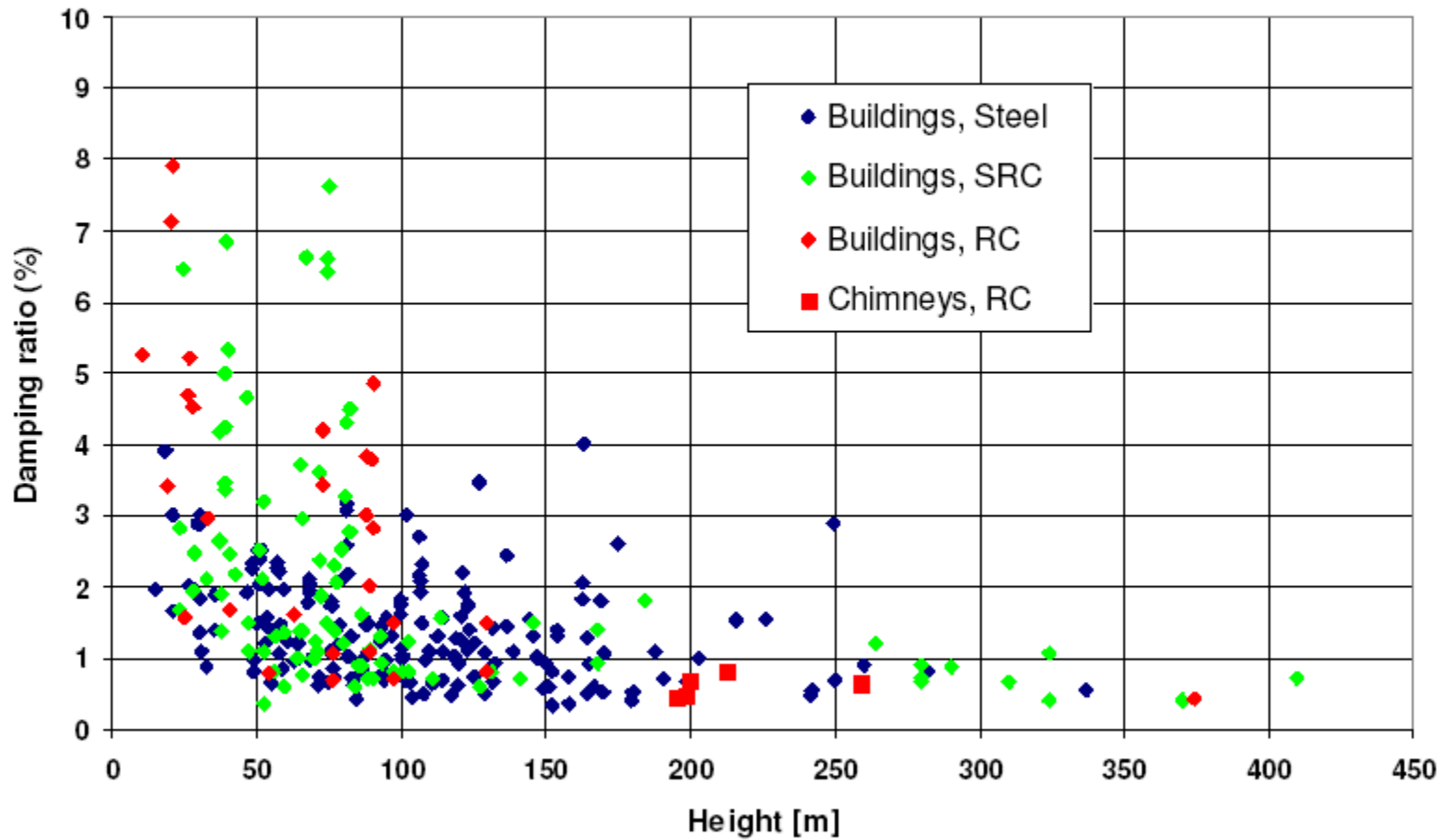
$$k_1 < k_0 \Rightarrow f_1 = \sqrt{k_1/m} < f_0 = \sqrt{k_0/m}$$



SURFACE WAVES FROM DISTANT LARGE EARTHQUAKES

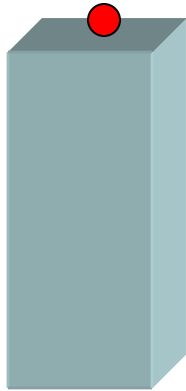


Measured damping ratio vs building height



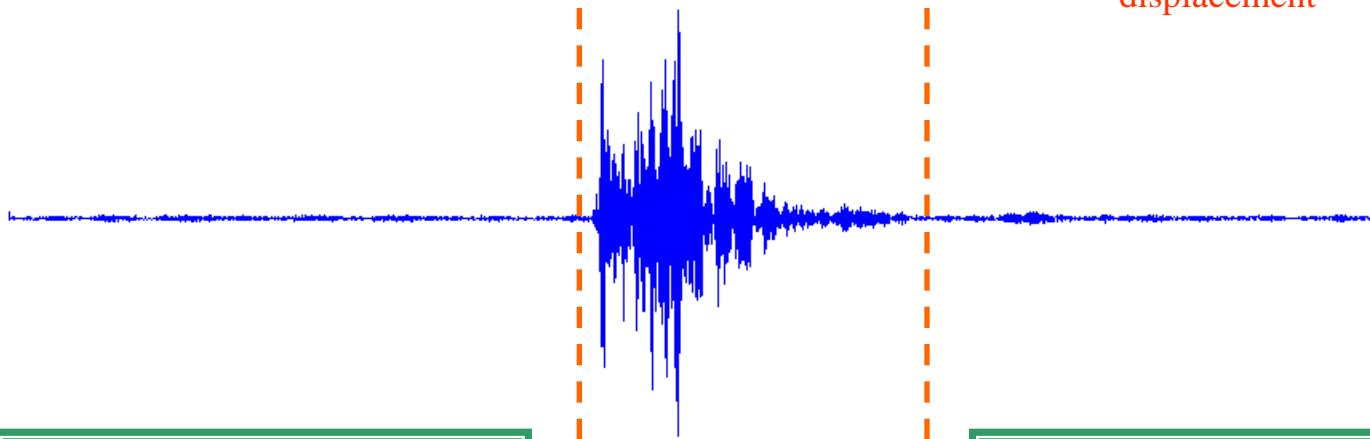
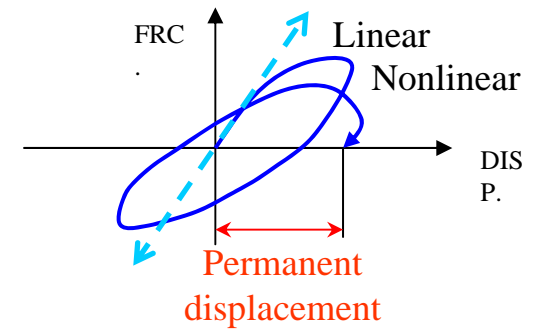
After Satake at.al, 2003

DAMAGE DETECTION BY REAL-TIME MONITORING



Multiple sensor package:

- Acceleration / Velocity
- Displacement (GPS)
- Rotation (tilt-meter)



Pre-earthquake:

GPS & Rot.
sensors

- Reference static displacement
- Reference static rotation
- Mean and variance of dynamic characteristics

During earthquake:

Acceleration
sensors

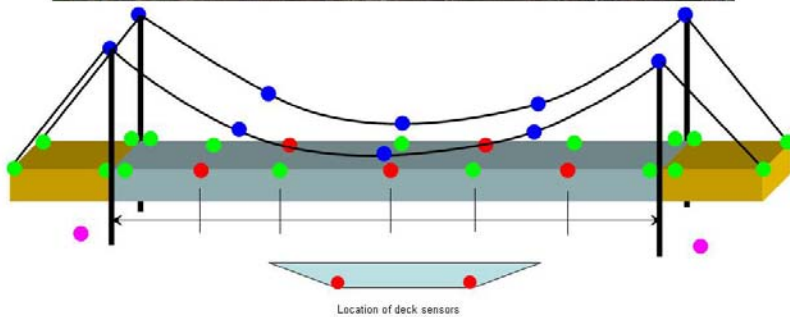
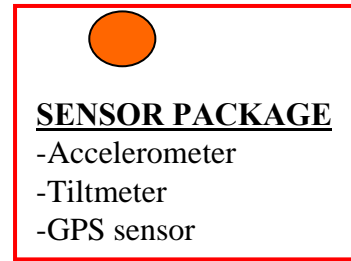
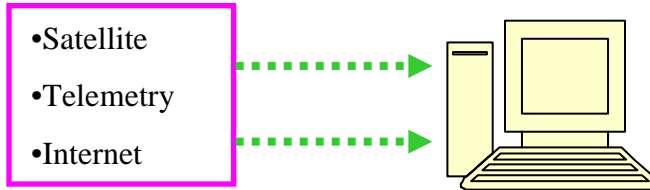
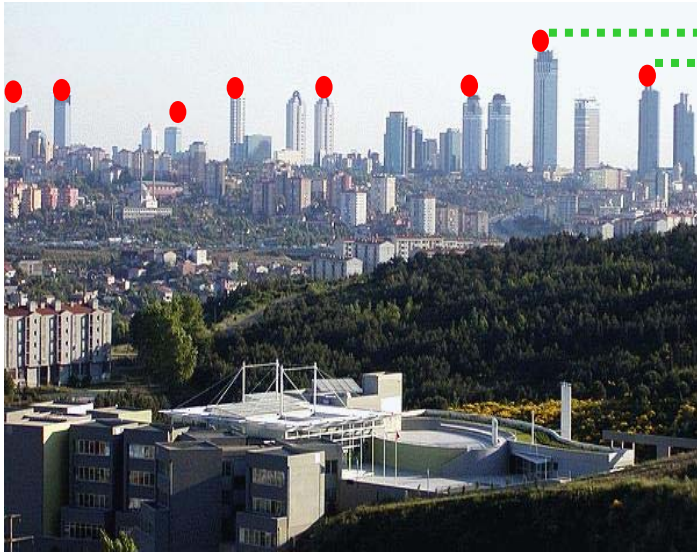
- Changes in dynamic characteristics
- Hysteretic behavior
- Damage initiation

Post-earthquake:

GPS & Rot.
sensors

- Permanent static displacement
- Permanent static rotation
- Mean and variance of dynamic characteristics

REAL-TIME DAMAGE ASSESSMENT



FATIH MOSQUE

