COST Action no. TU1402 Quantifying the value of Structural Health Monitoring
1st Workshop, 4-5 May 2015, DTU Copenhagen Denmark

STRUCTURAL HEALTH MONITORING
&
STRUCTURAL RELIABILITY ASSESSMENT

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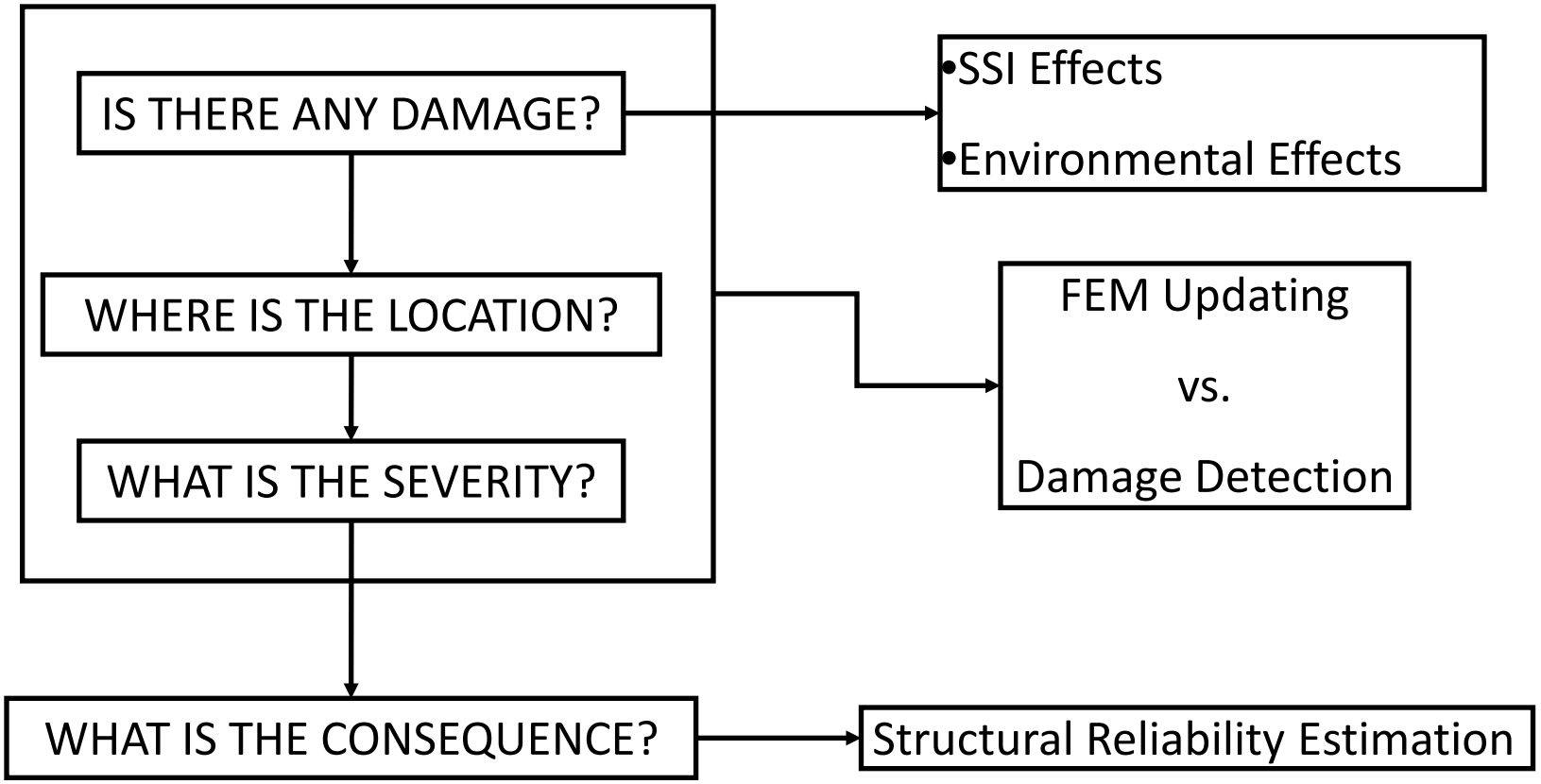
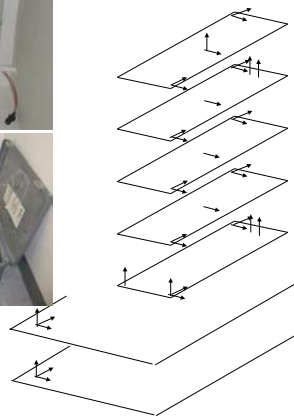
SHM Flowchart



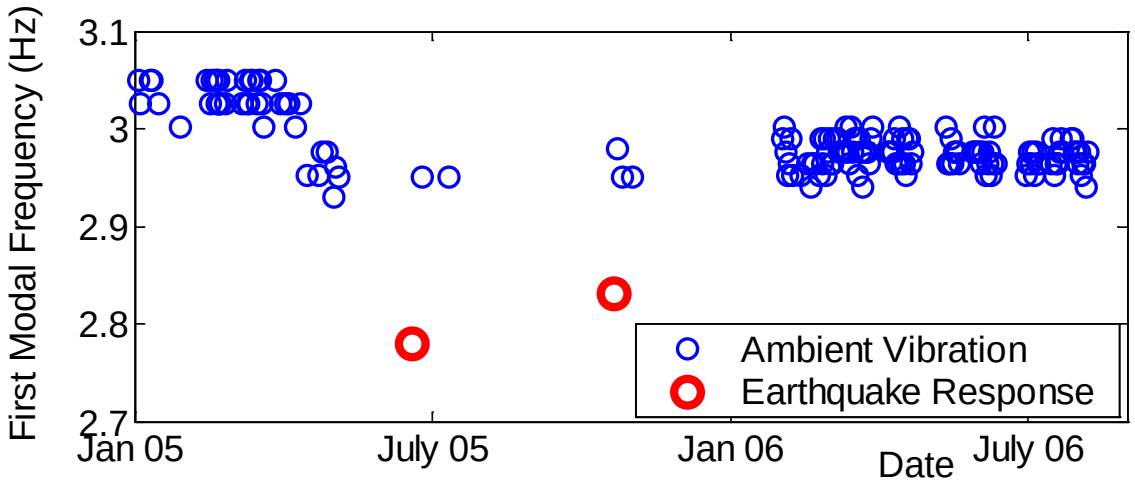
SSI Effects-1: Cal-IT2 Building



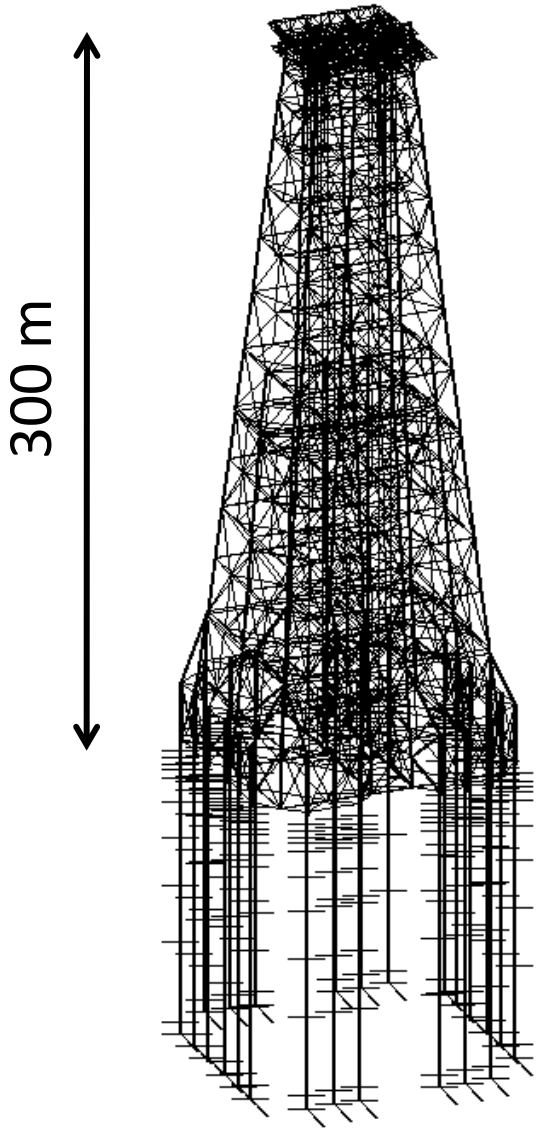
31 sensors on superstructure

12 sensors on soil

Totally 43 sensors

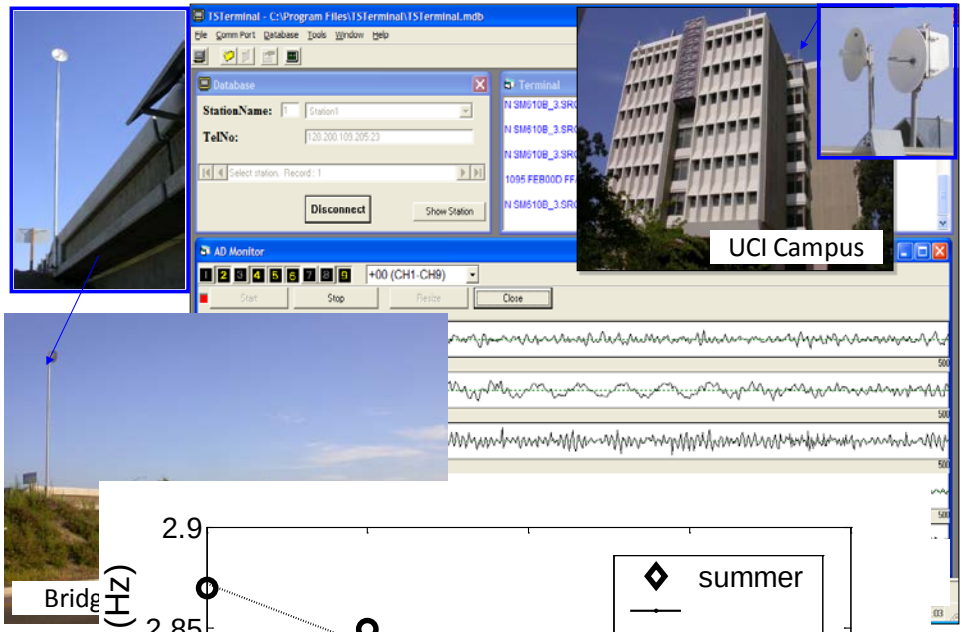


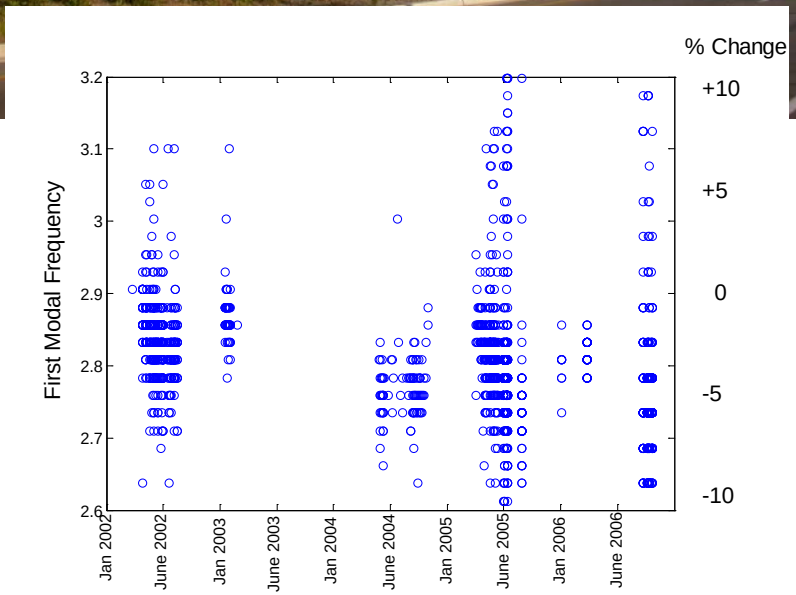
SSI Effects-2: Platform Cognac

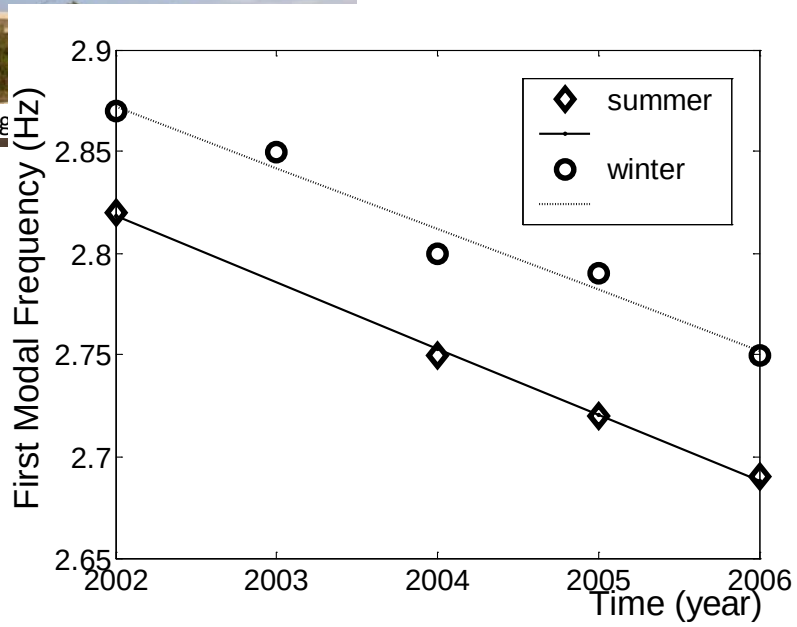


	T1 (X-dir) (Sec)	T2 (Y-dir) (Sec)	T3 (Tor) (Sec)
Measured Periods	4.13	3.86	2.07
Original Model	6.10	5.95	3.03
Mass Reduction (10%)	5.92	5.77	2.99
Jacket Stiffening (10%)	5.68	5.55	2.87
Soil Stiffness (~twice)	4.19	4.05	1.88

Long-Term Monitoring of Jamboree Bridge

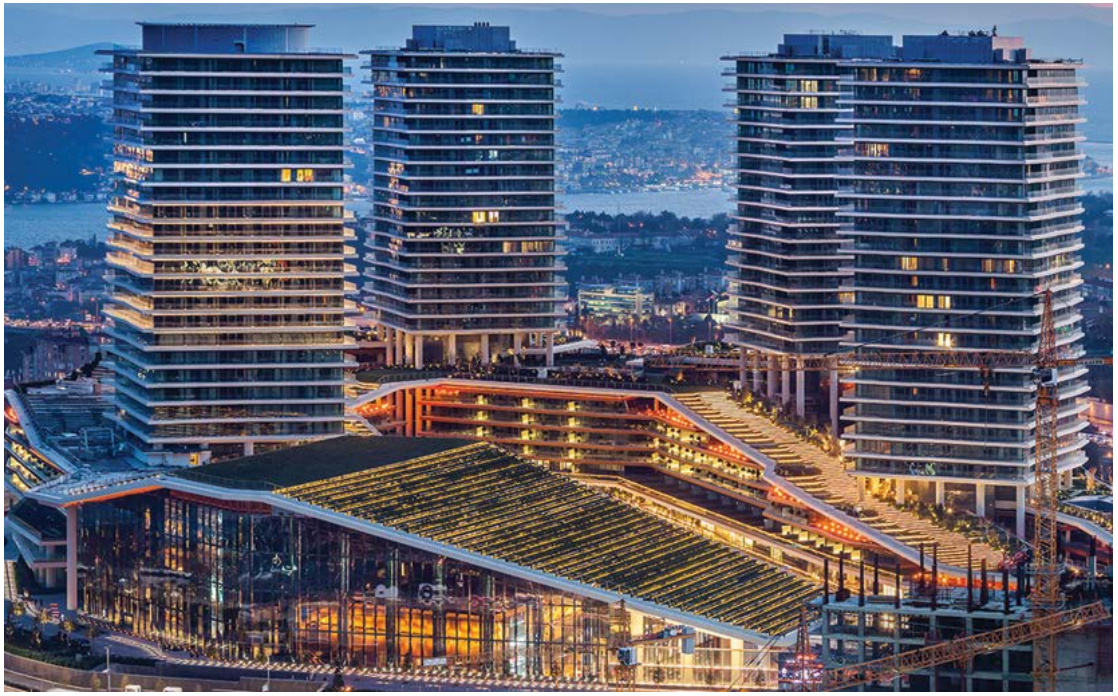






Soyoz S., Feng M.Q. (2009) "Long-term Monitoring and Identification of Bridge Structural Parameters" *Computer-Aided Civil and Infrastructure Engineering*, 24(2): 82-92.

SHM of a Tall Building



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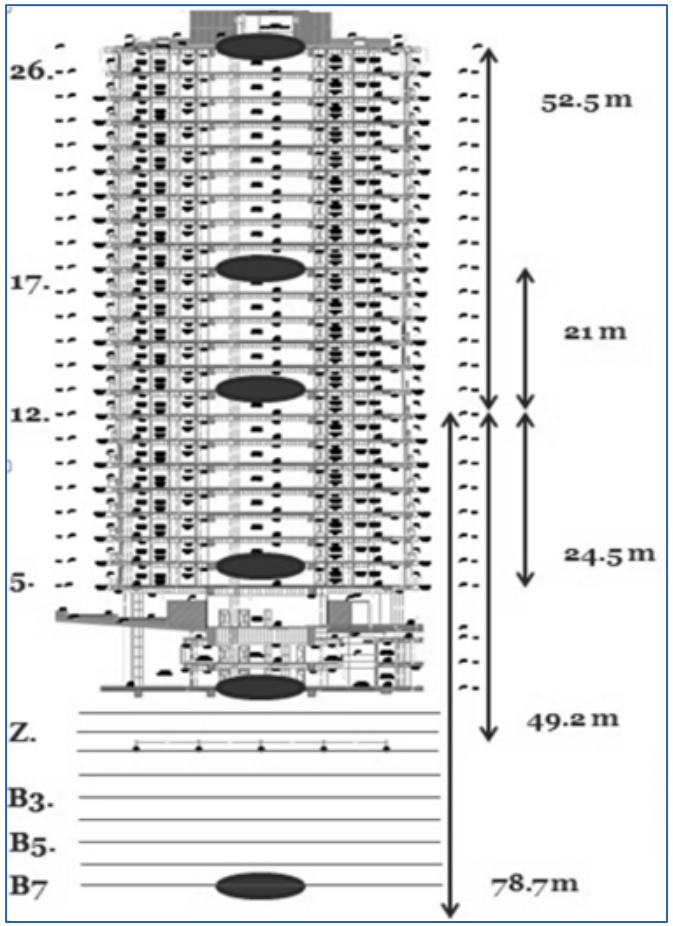
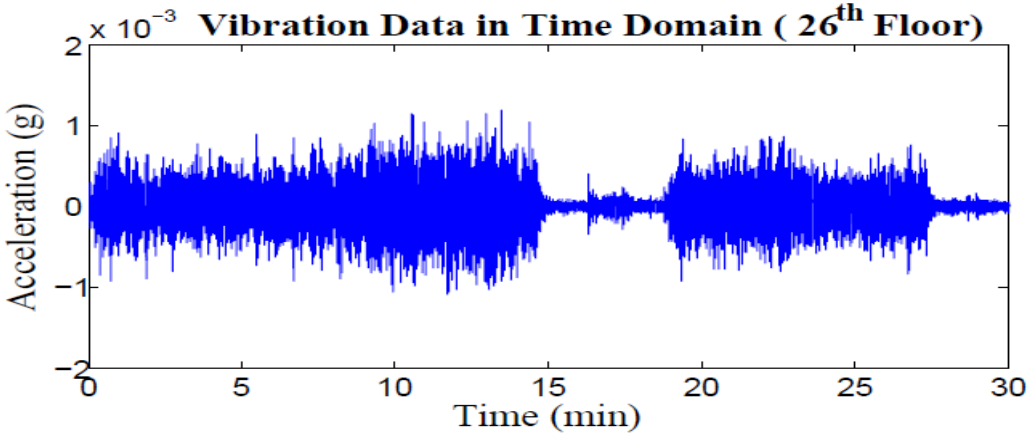
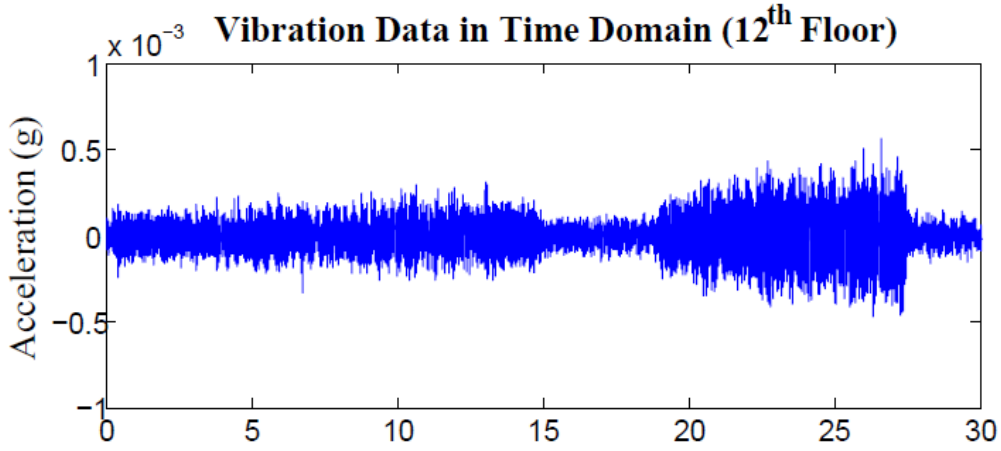
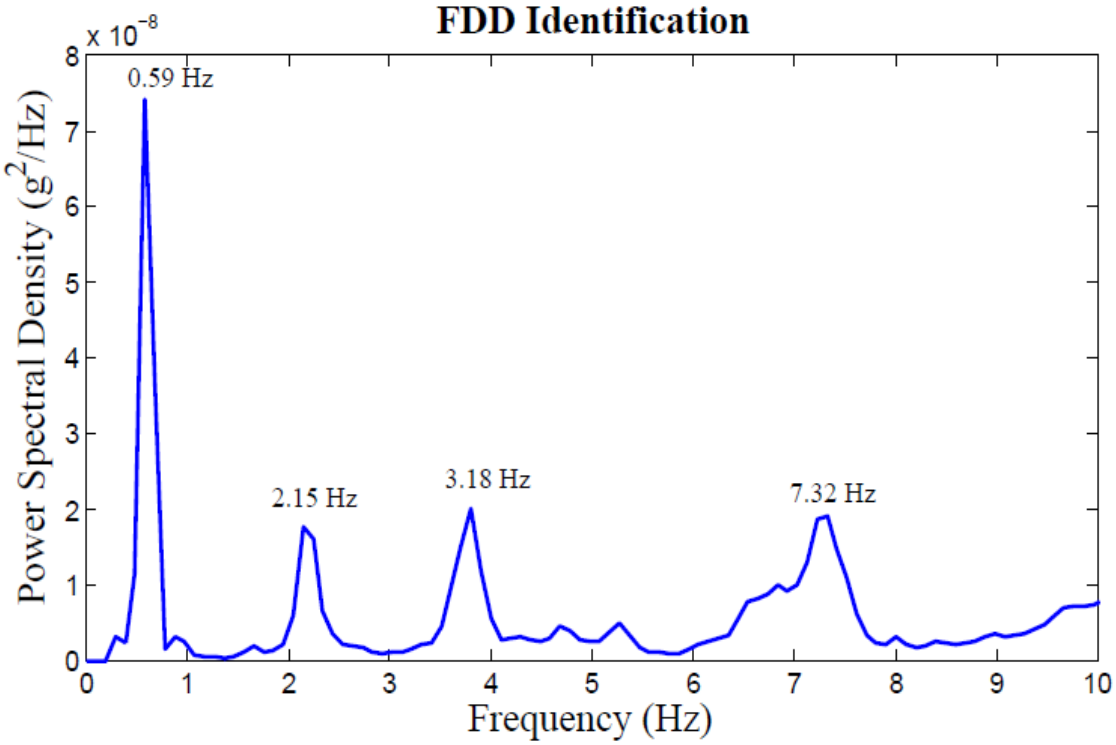
Instrumentation



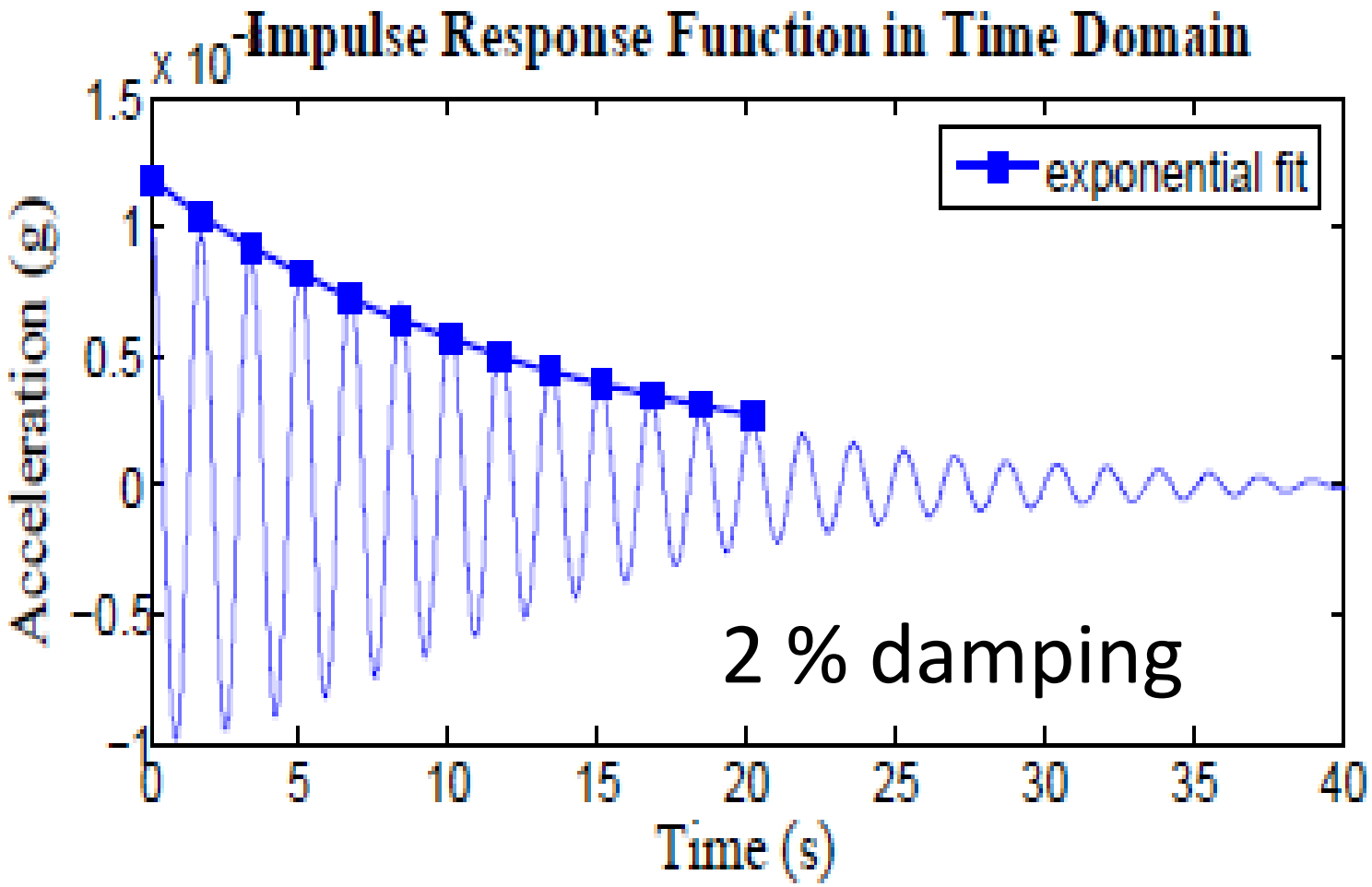




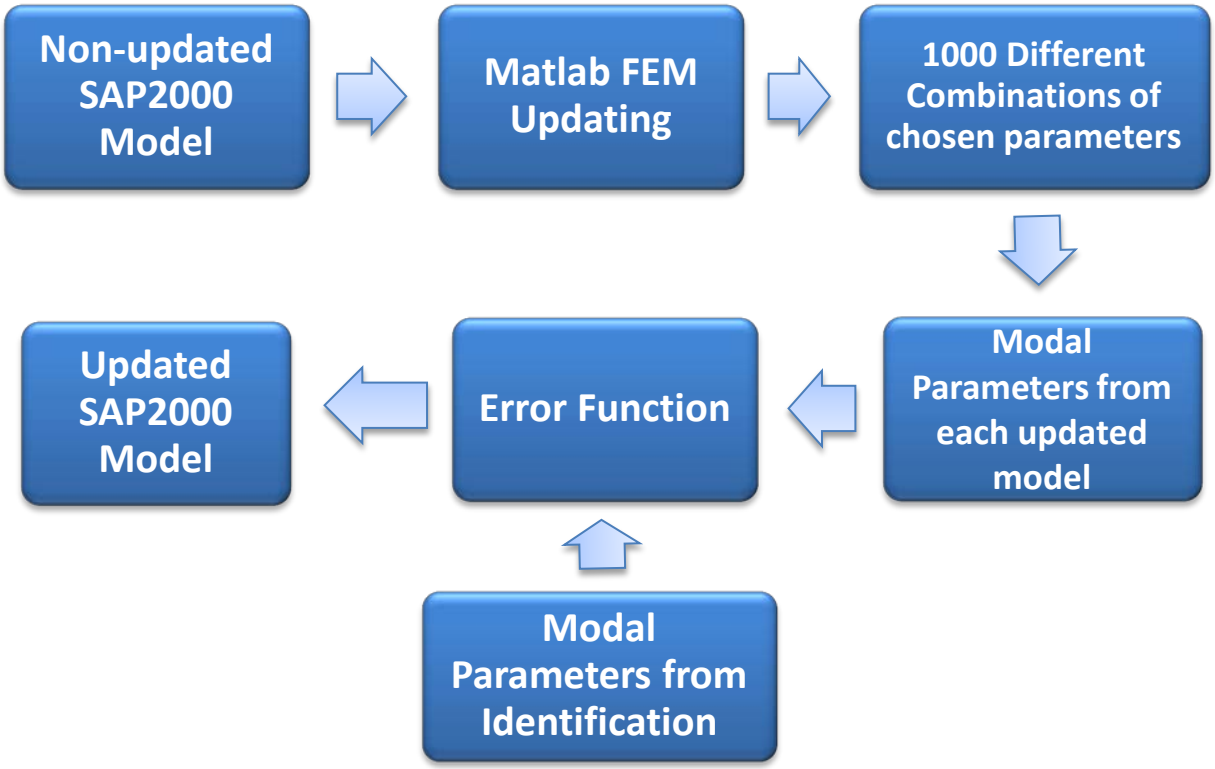
System ID- Frequencies



System ID- Damping



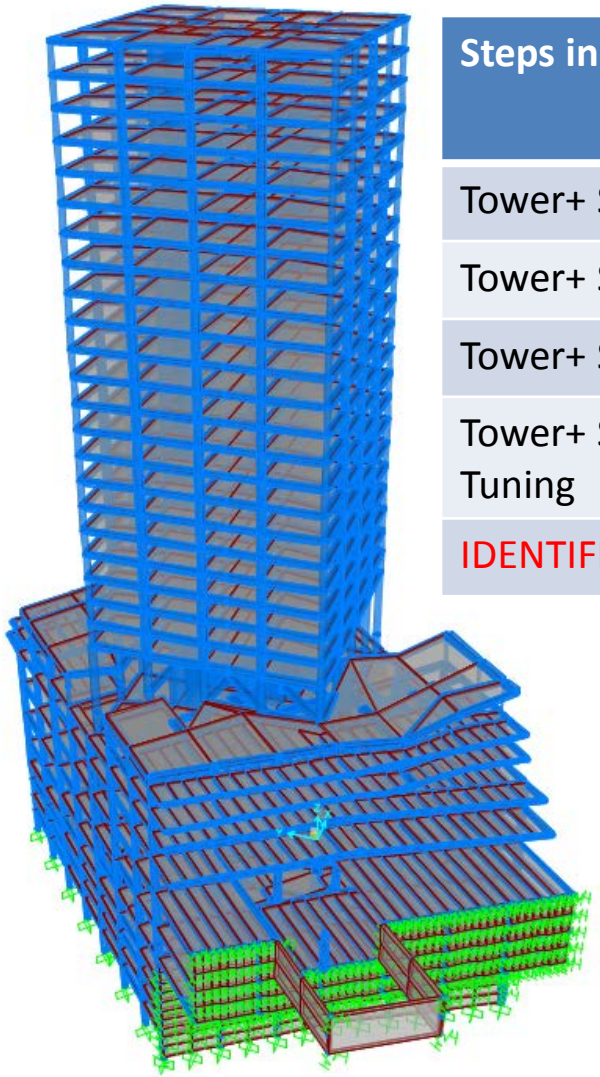
FEM Updating



Error function $$E = \sum_{i=1}^{4} \left(k_i \cdot \left[\left(f_i^* - f_i \right) / f_i^* \right]^2 + h_i \cdot \left[1 - MAC_i \right]^2 \right)$$

(Modal assurance criteria) $$MAC = \frac{\left| \psi_*^T \cdot \psi \right|^2}{\left(\psi_*^T \cdot \psi_* \right) \cdot \left(\psi^T \cdot \psi \right)}$$

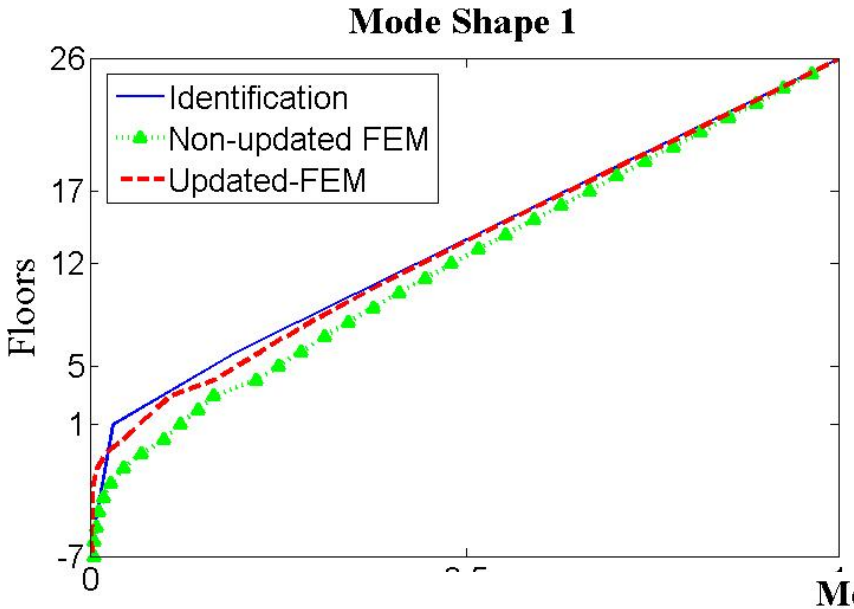
FEM Updating

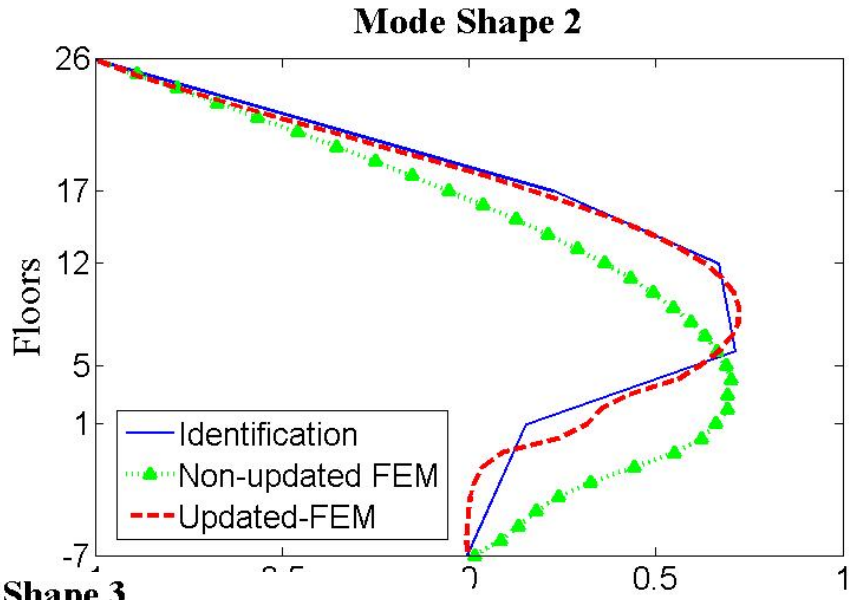


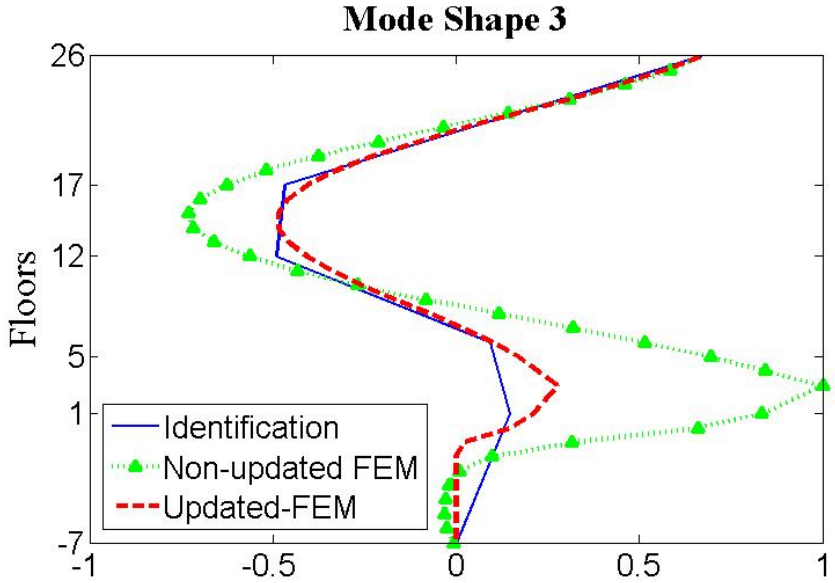
Steps in the FEM	Frequency of 1st Mode
Tower+ Surrounding Structure	0.47 Hz
Tower+ S.S. + Soil Springs	0.50 Hz
Tower+ S.S. + Soil Springs + Seismic Gaps	0.57 Hz
Tower+ S.S. + Soil Springs + Seismic Gaps + Parameter Tuning	0.59 Hz
IDENTIFICATION	0.59 Hz

Mode Number	System ID	Updated FEM	NonUpdated FEM
1	0.59	0.59	0.50
2	2.15	2.03	1.77
3	3.81	3.18	2.62

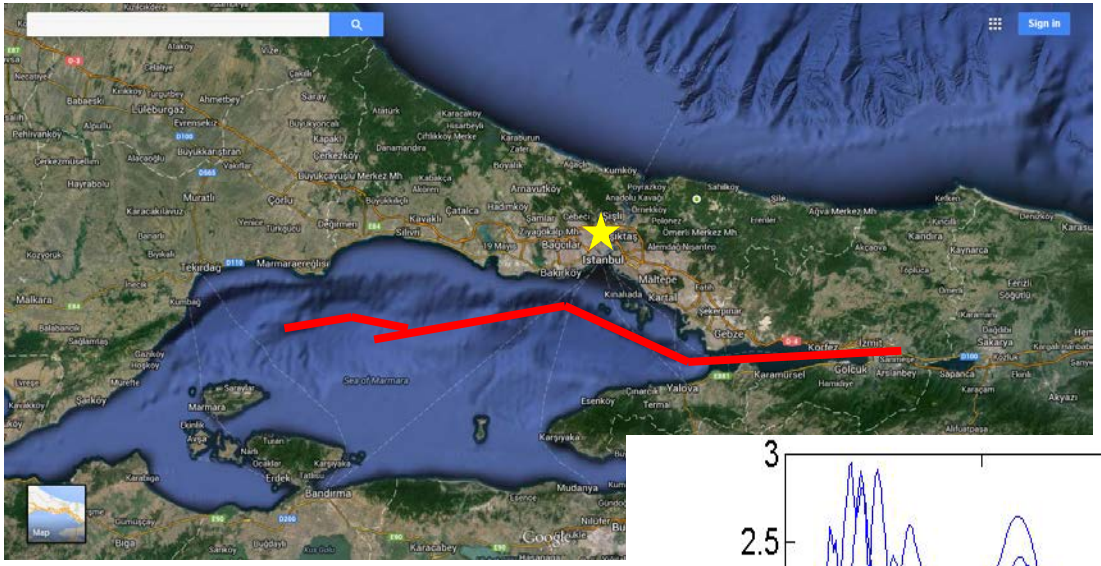
FEM Updating

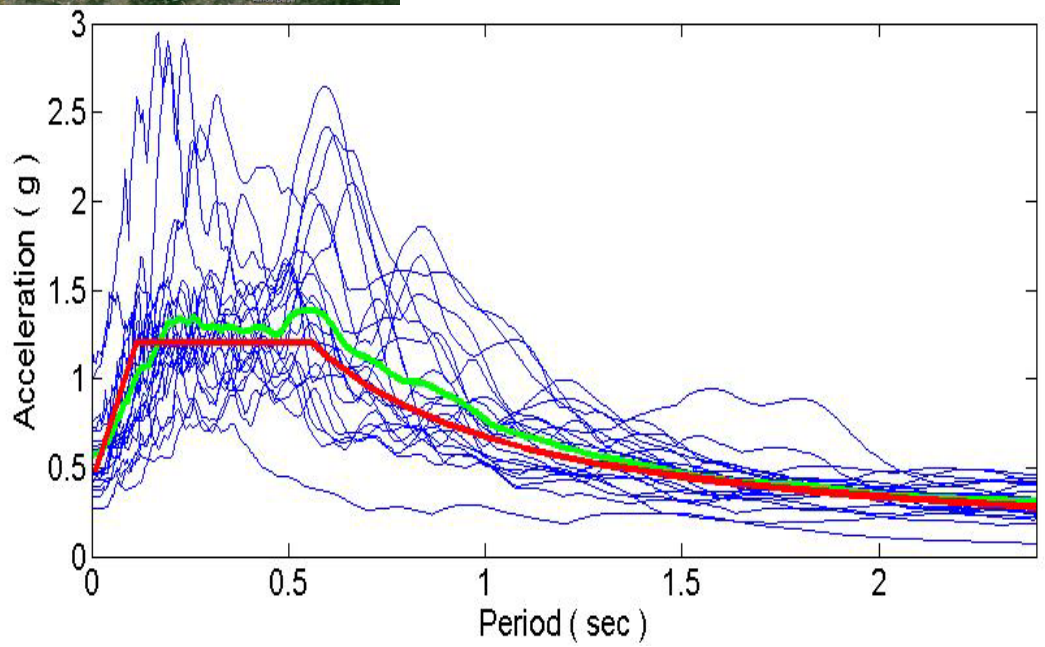




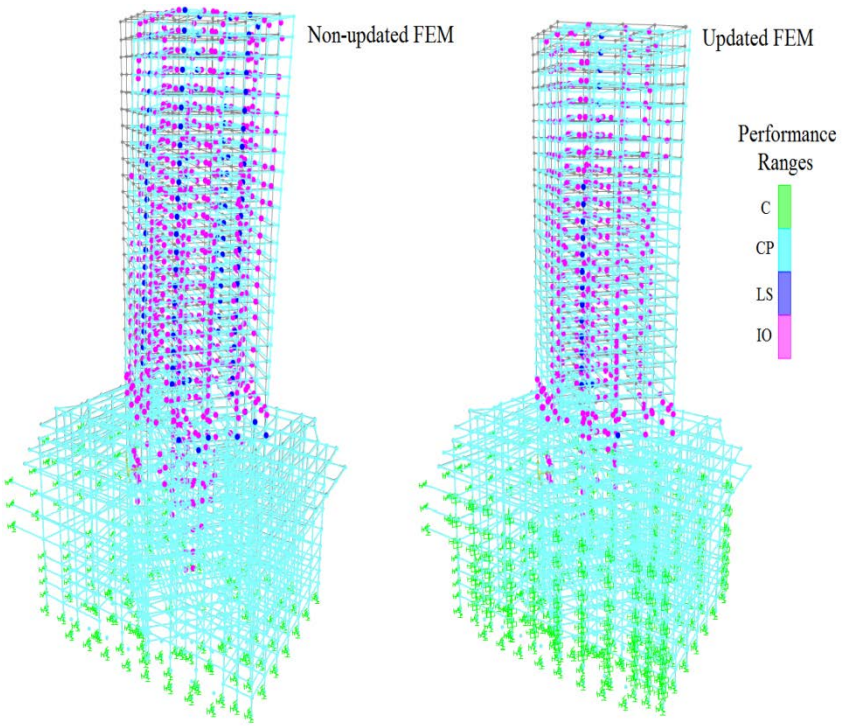


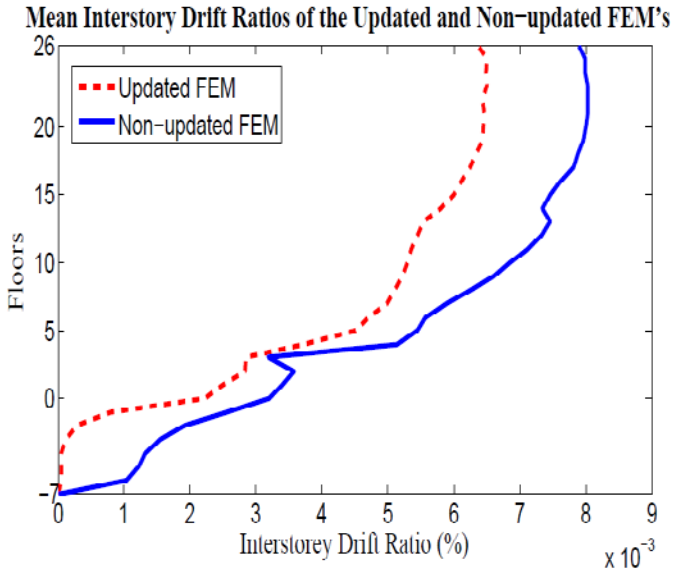
Seismic Reliability Analysis

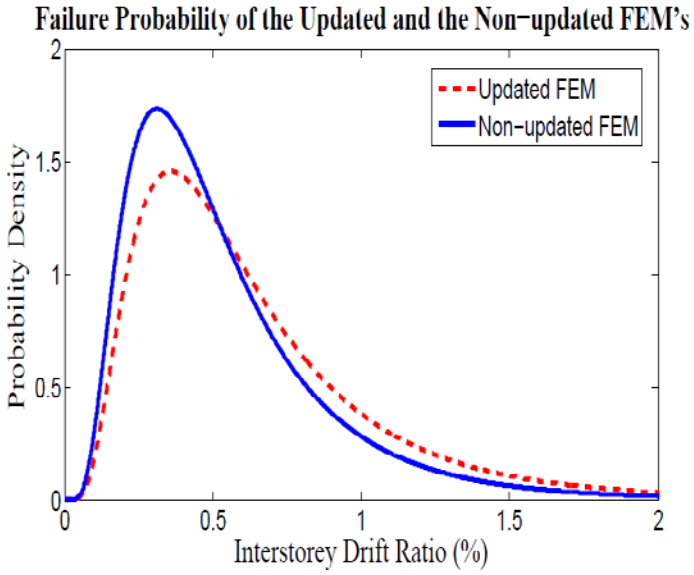




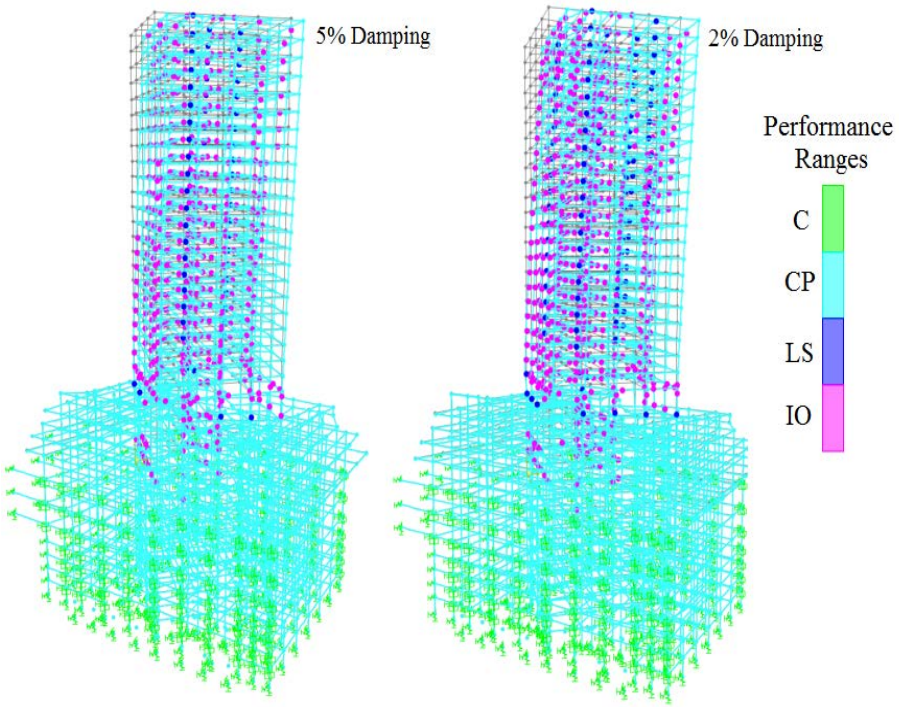
Effect of Modal Updating

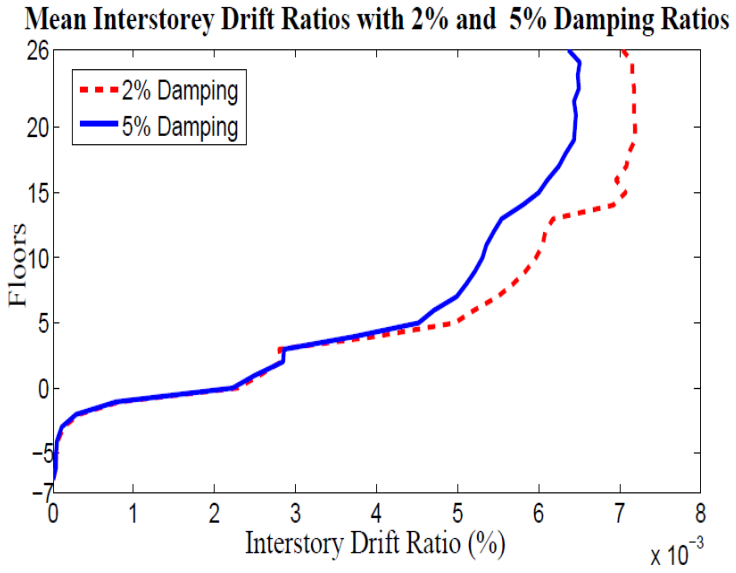


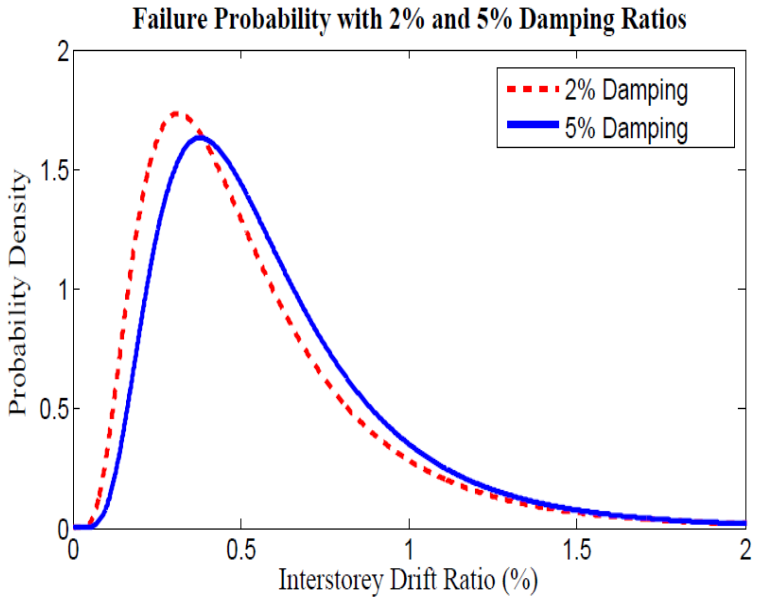




Effect of the Identified Viscous Damping Ratio





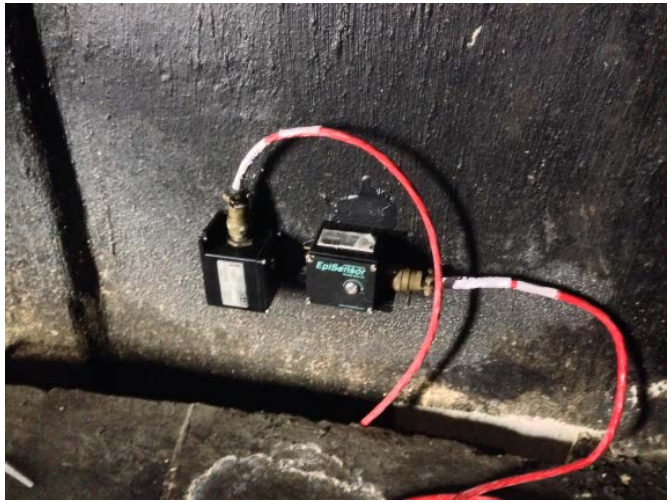


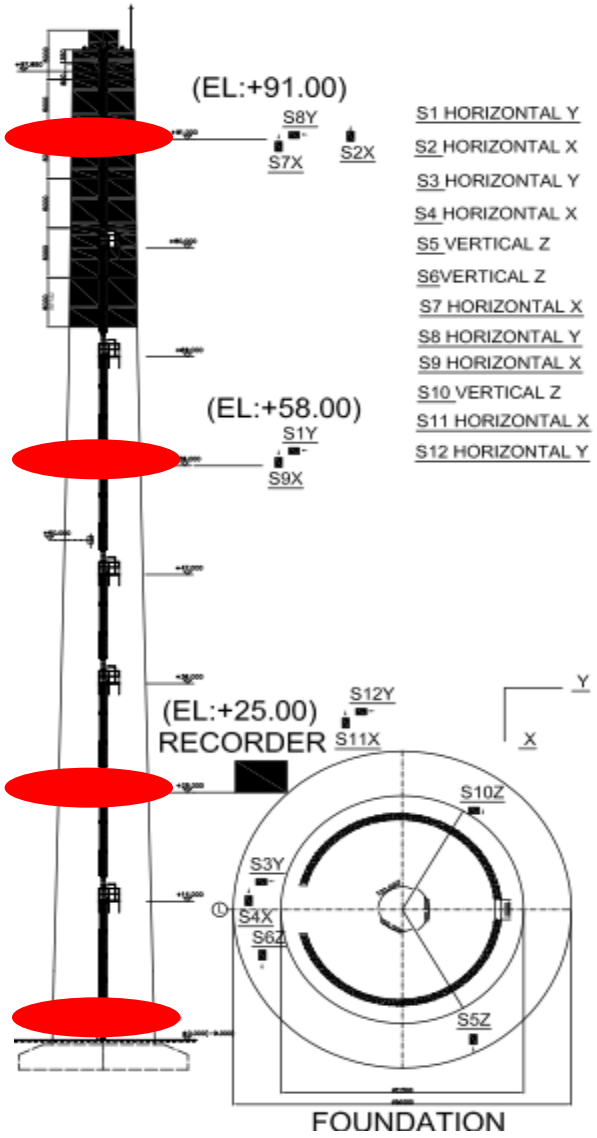
SID and Reliability Estimation of a Chimney

L=100.5 m height
Diameter=9700 mm at base
5750 mm at top
Concrete Class=fc=30MPa

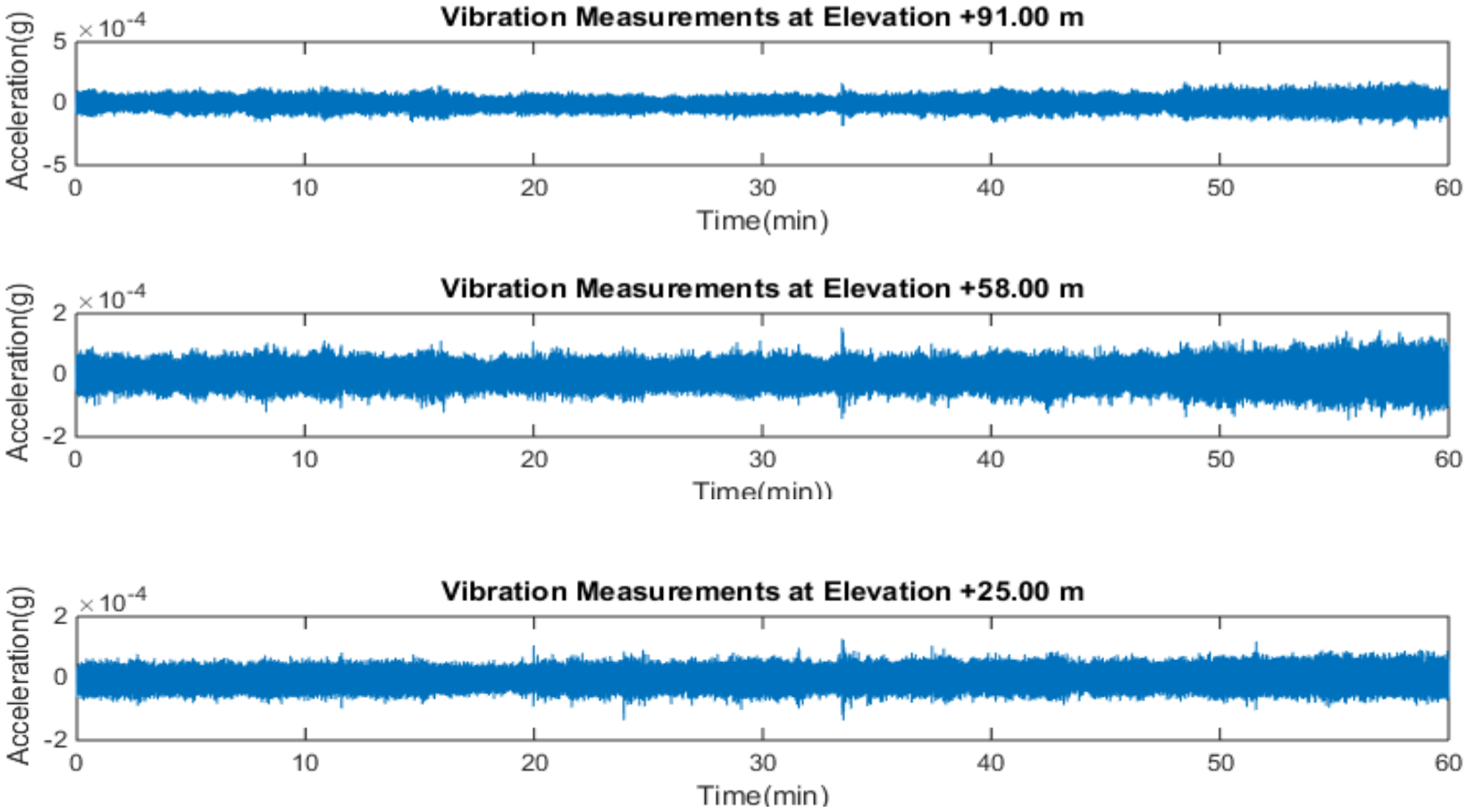
Part of seismic and wind analysis of an industrial chimney at Bilecik

Data Acquisition



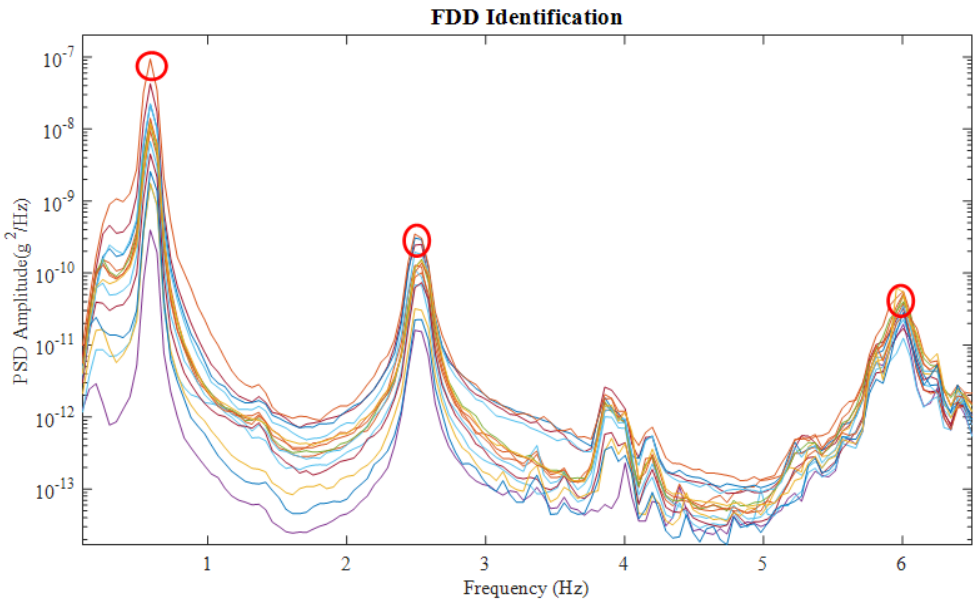


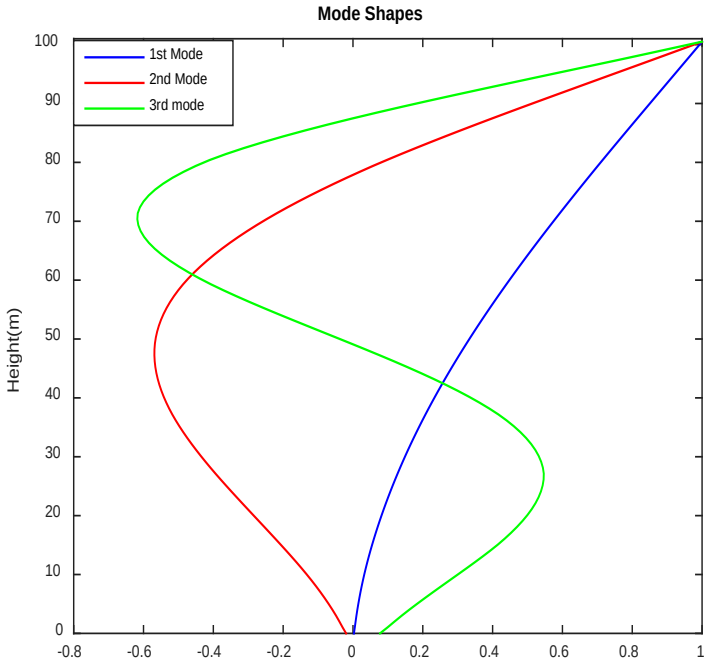
Sample Records



System Identification

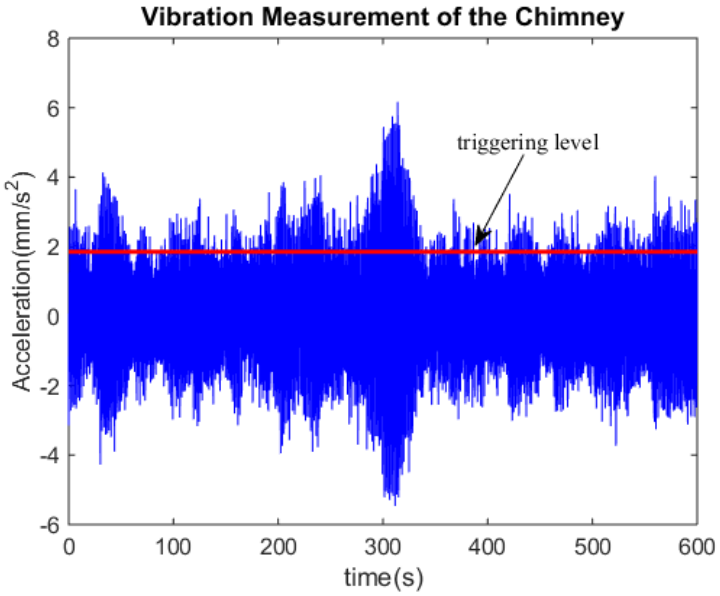
Frequency Domain Decomposition

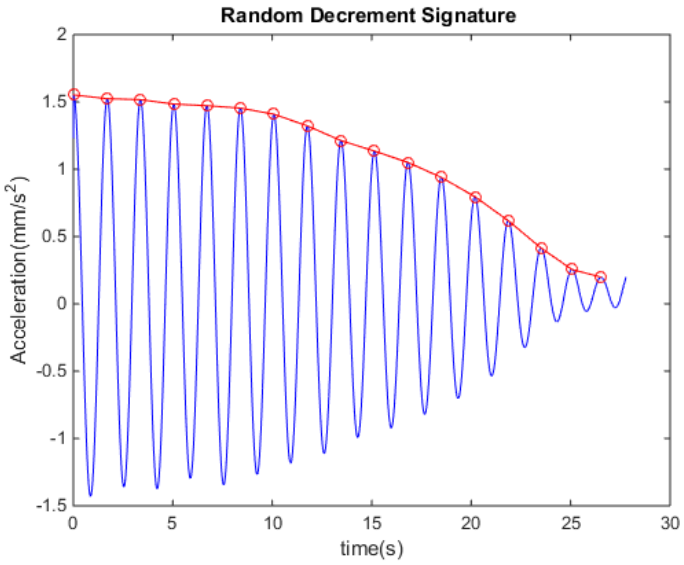


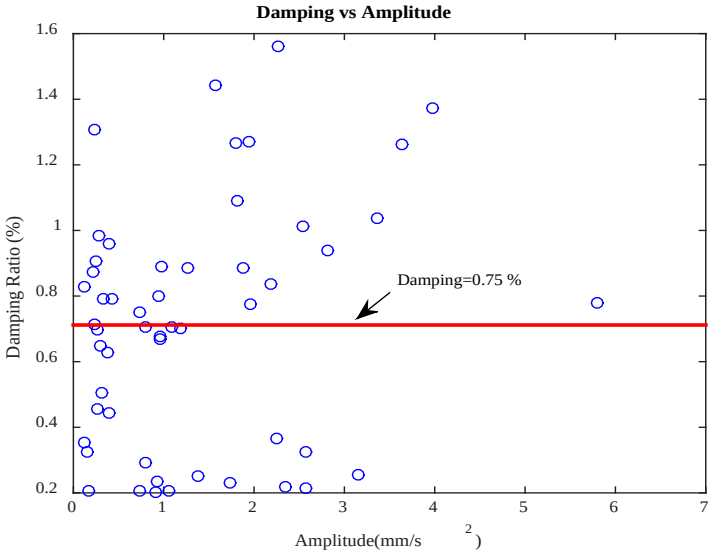


System Identification

Random Decrement

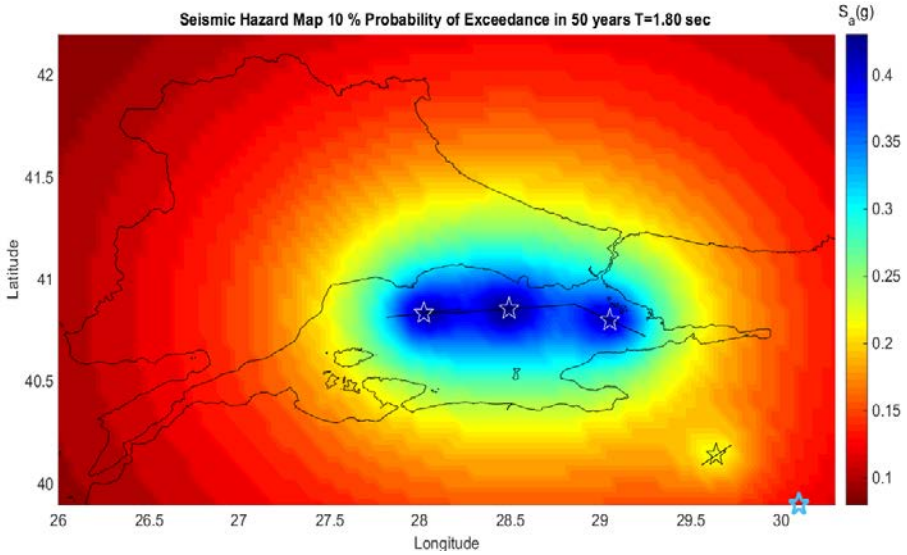


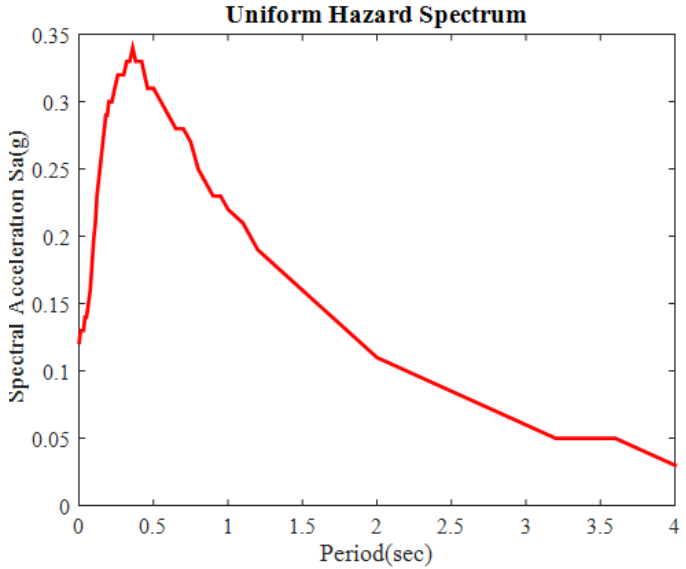


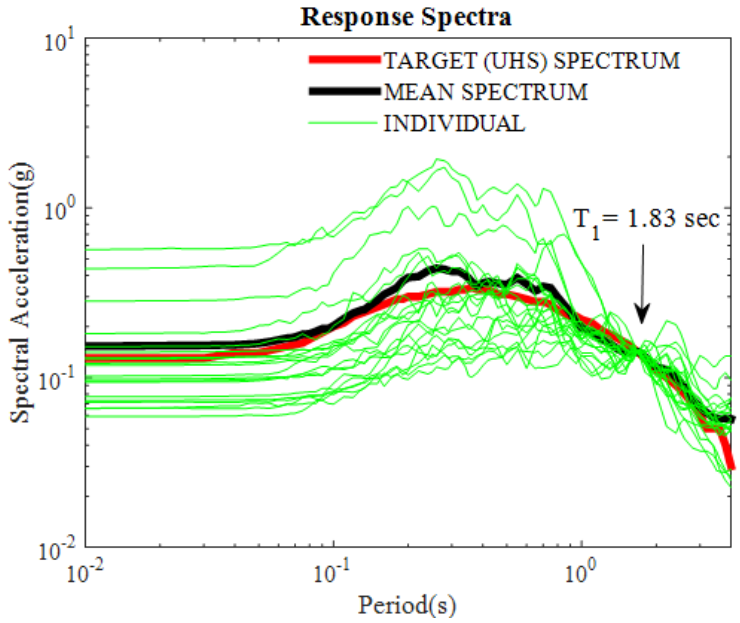


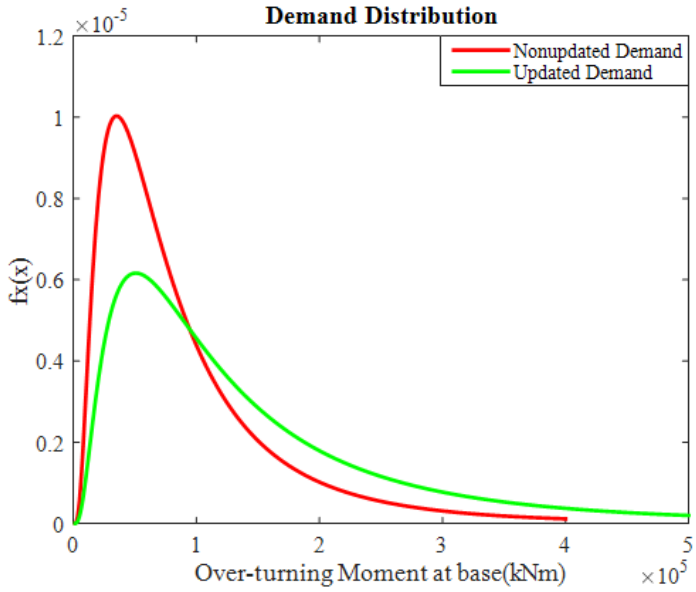
DAMPING RATIOS (Concrete,Lined,Foundation on Gravel)		
CICIND	**EUROCODE**	**Identification**
1.51	1.11	0.75

Probabilistic Seismic Hazard Analysis

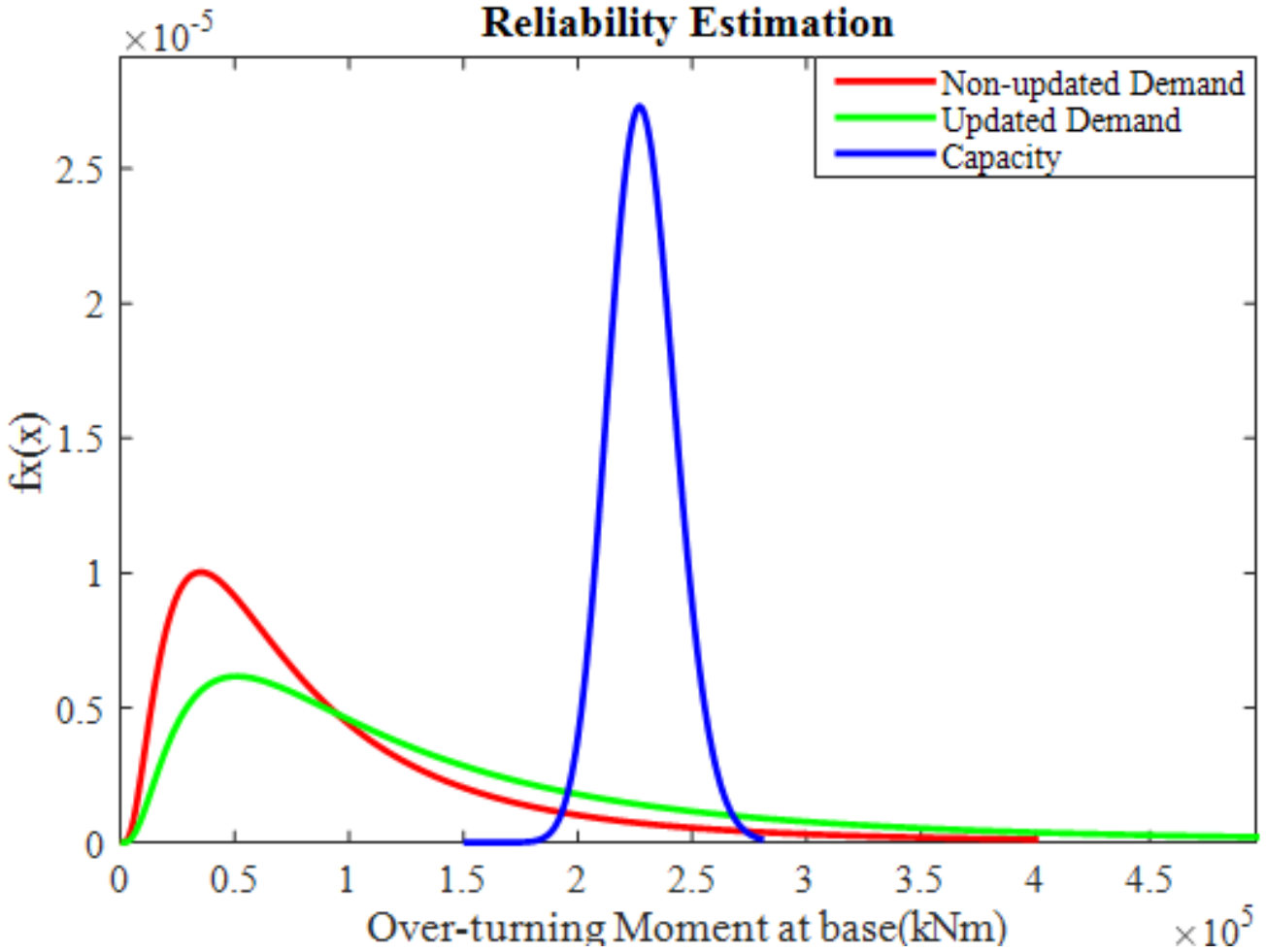




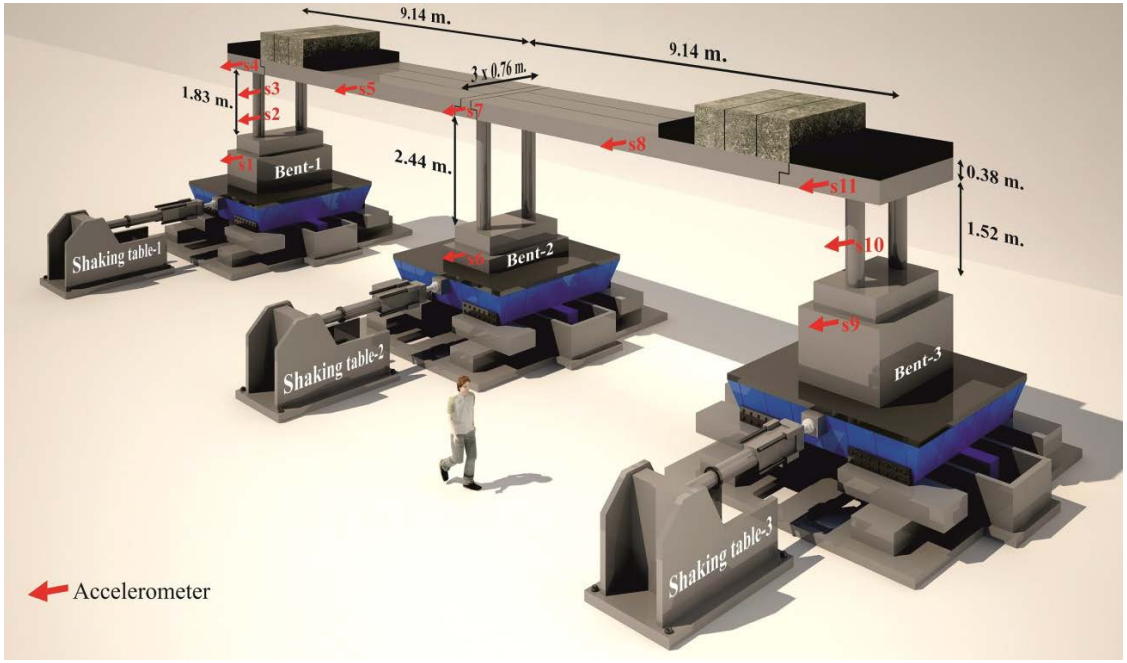




Reliability Estimation



Vibration-based Seismic Reliability Estimation of a Bridge



The shaking table test were conducted at University of Nevada, Reno in conjunction with Prof. Saidii's and Prof. Sander's NSF-NEES project.

•**Soyoz S.,** Feng M.Q. (2008) "Instantaneous Damage Detection of Bridge Structures and Experimental Verification" *Structural Control and Health Monitoring*, 15(7): 958-973.

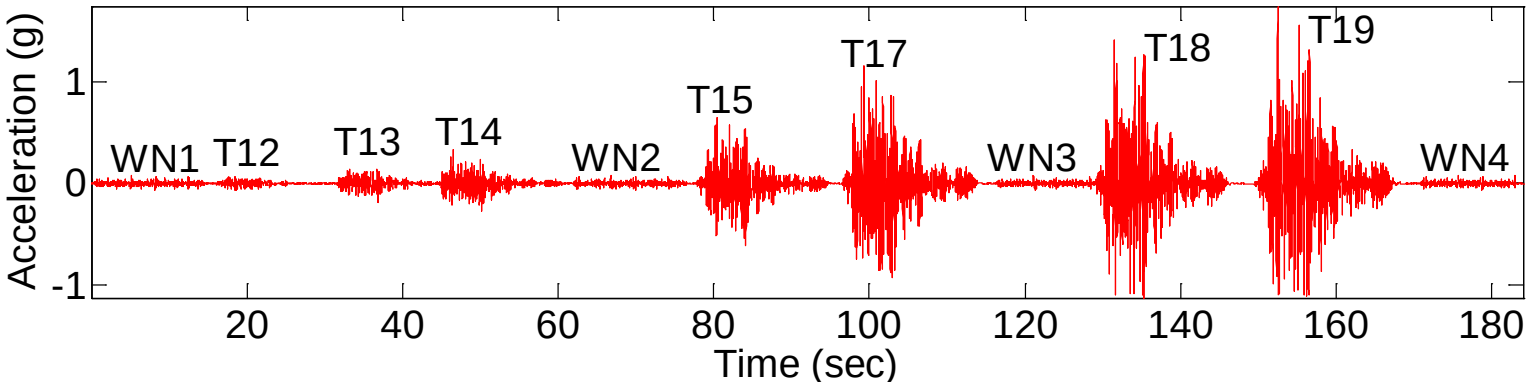
•Chen Y., Feng M. Q., **Soyoz S.** (2008) "Large-Scale Shake Table Test Verification of Bridge Condition Assessment Methods" *Journal of Structural Engineering, ASCE*, 134(7):1235-1245.

•**Soyoz S.,** Feng M.Q., Shinozuka M. (2010) "Remaining Capacity Estimation Based on Structural Identification Results" *Journal of Engineering Mechanics, ASCE,136(1), 100-106*.

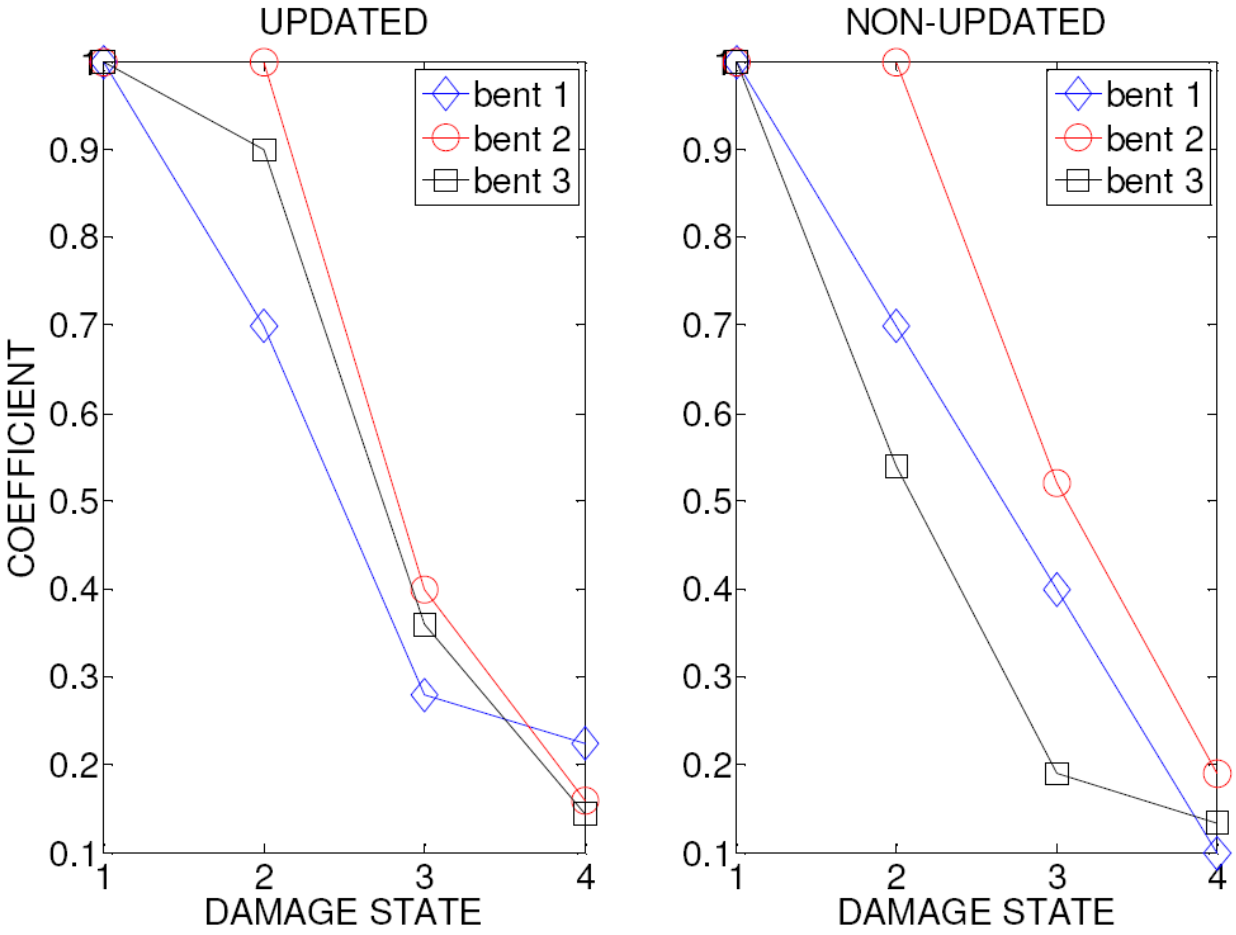
•Ozer E., **Soyoz S.** (2015) "Vibration-based Damage Detection and Seismic Performance Assessment of Bridges", Earthquake Spectra, 31(1): 137-159.

Test Procedure

Test	Ground Motion Description	PGA (g)	Damage Description
WN-1	White Noise in Transverse		
T-13	Low Earthquake in Transverse	0.17	Bent-1 yields
T-14	Moderate Earthquake in Transverse	0.32	Bent-3 yields
WN-2	White Noise in Transverse		
T-15	High Earthquake in Transverse	0.63	Bent-2 yields
WN-3	White Noise in Transverse		
T-19	Extreme Earthquake in Transverse	1.70	Bent-3 steel buckles
WN-4	White Noise in Transverse		

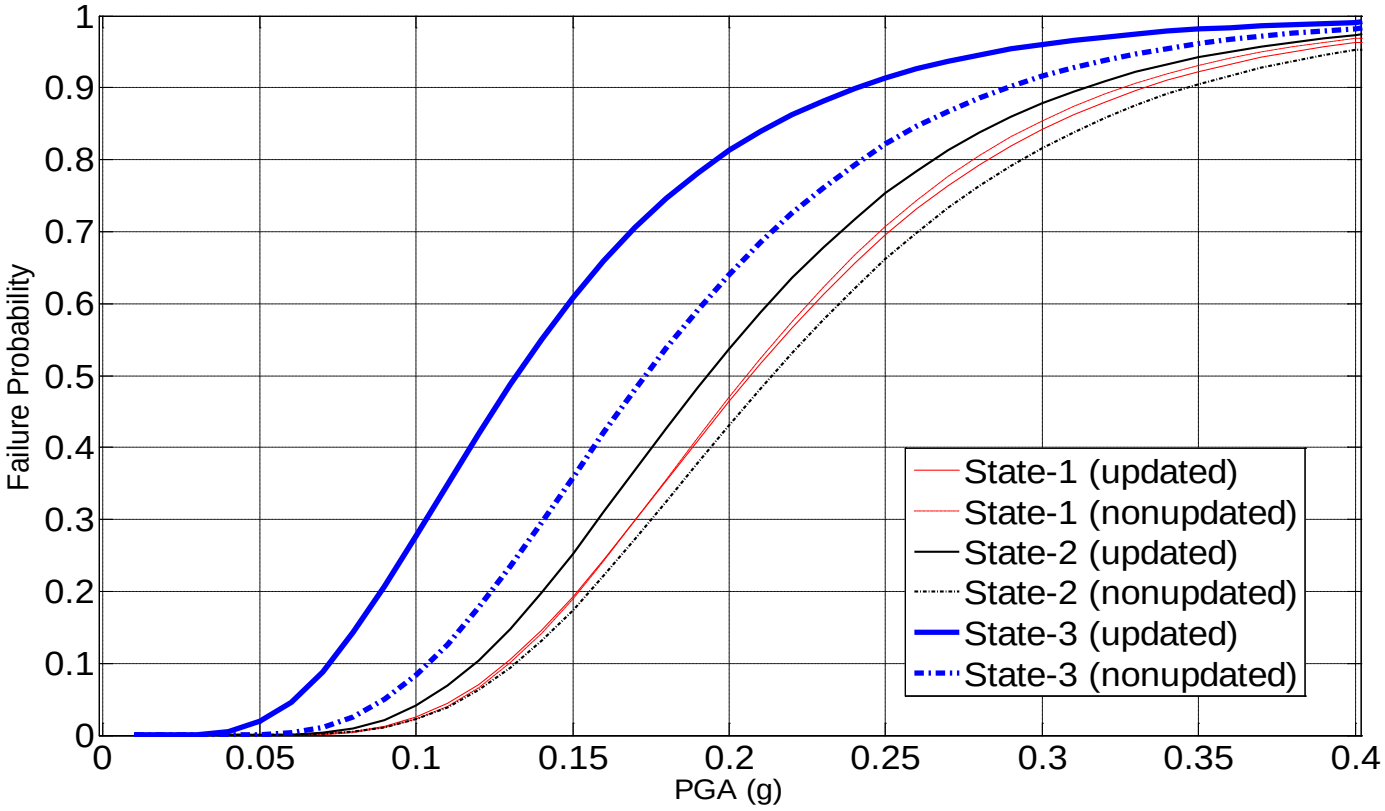


Damage Progress



Stiffness values according to different damage states

Effect of System Identification on Reliability Estimation



Forced Vibration Test of ET-B Building

Soyoz S., et al. (2013) "Ambient and Forced Vibration Testing of a Reinforced Concrete Building Before and After its Seismic Retrofitting" *Journal of Structural Engineering, ASCE,* 139 (1741-1752).

AVS of a Masonry/ Historical Structure

AVS of Cold Formed Structure

SHM of a Wind Turbine




1MW Turbine
Hub Height: 55 m
Blade: 20m
Bottom Diameter: 3 m

Sensors
Tower Acceleration
Tower Dynamic Strain
Pile Strain

AVS of Bogazici Suspension Bridge

SHM of Bogazici Suspension Bridge is carried out by General Directorate of Highways

Thank You