

# **Structural Health Monitoring and Damage Detection Through Non-Contact Optical Monitoring Systems**

**Doç. Dr. Muammer Özbek, İstanbul Bilgi Üniversitesi İnşaat Mühendisliği**

**Doç. Dr. Y. Dağhan Gökdel, İstanbul Bilgi Üniversitesi Elektrik-Elektronik Mühendisliği**

# What is Structural Health Monitoring (SHM)?

- SHM is continuous and/or periodic observations of some structural response characteristics (damage indicators). Sudden changes encountered in these indicators can be related to the presence of damage.
- Depending on the utilized parameters, the type, location, and the degree of the damage can be determined.



## Why do we need these systems? What could go wrong?

If a flaw can be detected at very early stages, it can be repaired on time and with a minimal cost.



However, undetected damage may propagate and cause the total collapse of the structure.



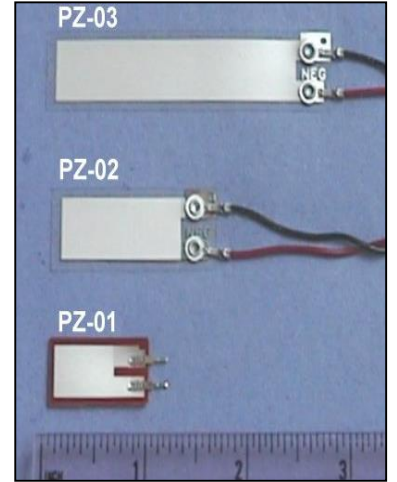
# Damage examples that could have been prevented (if detected at early stages)





# What are the limitations of the other SHM techniques?

- Traditional SHM systems require some sensors to be placed on the structure. These sensors need cable installations and detailed preparations.
- These installations can be very challenging, costly and time-consuming.
- There may even be some locations that are not accessible.
- Resulting spatial resolution will inevitably be low.



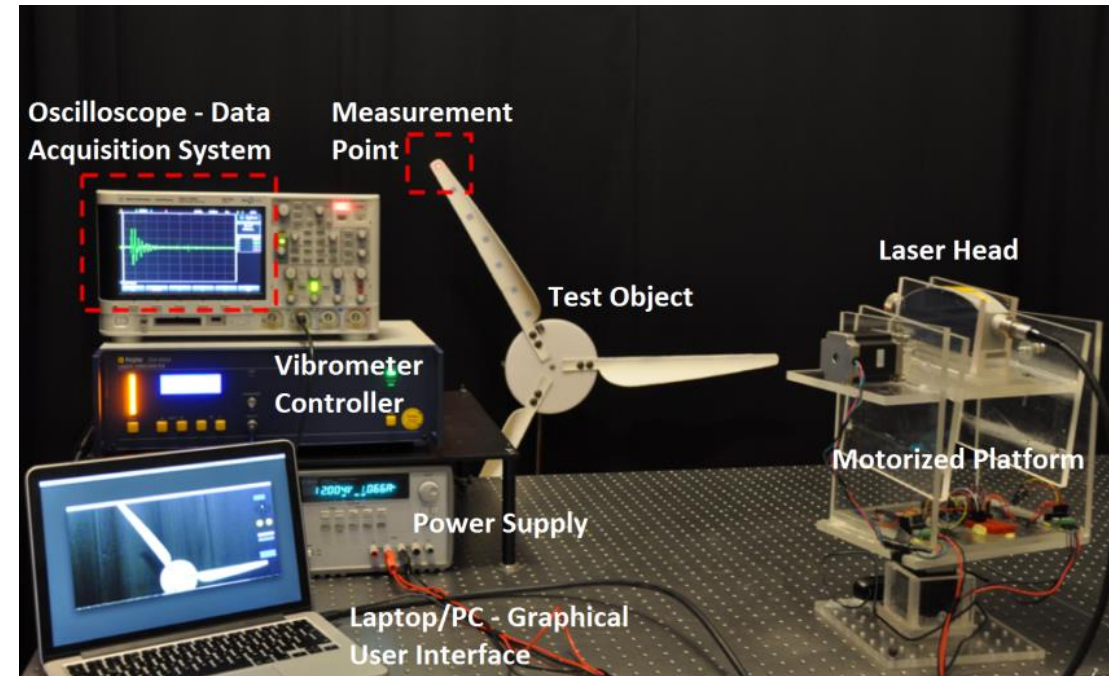
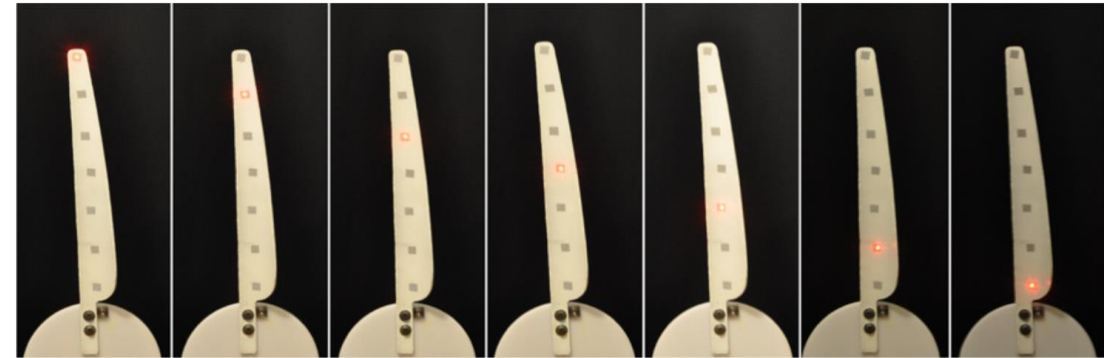
Traditional sensors

# Structalert is a very promising solution to the existing problems.

**High** Accuracy  
Mobility  
Efficiency

**Low** Test Time  
Cost  
Risk

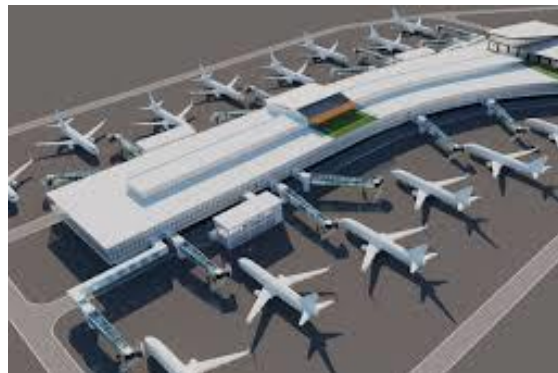
- **Structalert** is a **remote** measurement system. It does not require any sensors to be placed on the structure.
- It can be used for monitoring any existing structure with no cable installation or preparation.
- Tests can be completed in shorter periods. A test, that would take weeks with traditional sensors, can be completed in hours with **Structalert**.
- The number of measurement spots is not limited. Spatial resolution and measurement accuracy are very high.
- A single system can be used to test and monitor several structures.
- The whole measurement setup is located at ground level.





# What are possible applications?

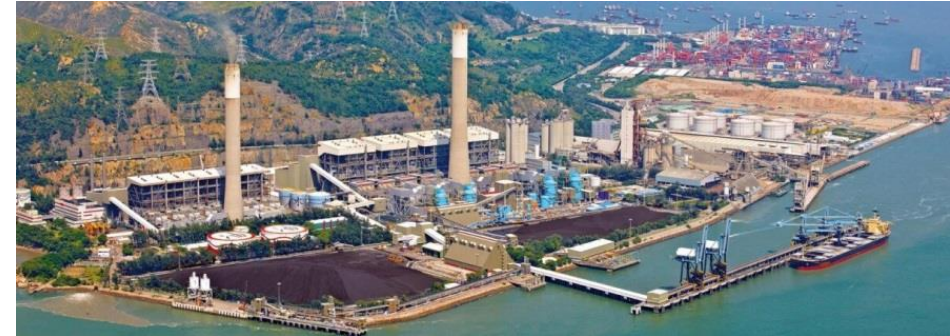
**Structalert** can be up-scaled easily for monitoring and testing all structures and megastructures.





## Structural Control and Health Monitoring of Industrial Chimneys and Towers

- ✚ High-rise chimneys and cooling towers are widely used in industrial facilities, power plants, refineries, and factories
- ✚ Brick masonry, Reinforced Concrete and Steel Towers are typical examples of these structures.
- ✚ The structures may have heights changing between 20-250 m and they are at high risk of damage in an earthquake due to their slender structures.





# Tower Mode Shapes



1<sup>st</sup> Bending  
in X Direction



1<sup>st</sup> Bending  
in Y Direction

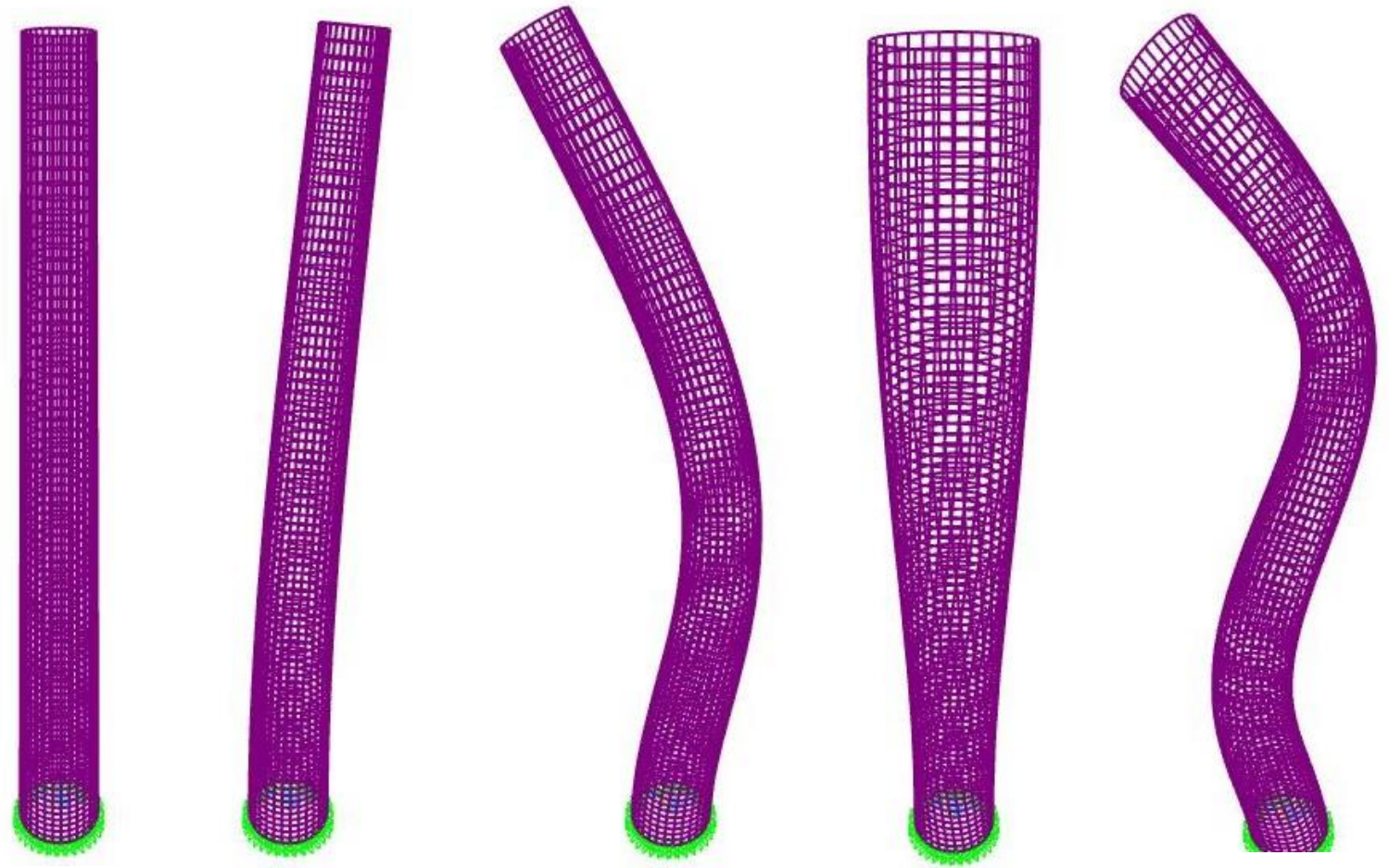


2<sup>nd</sup> Bending  
in X Direction



2<sup>nd</sup> Bending  
in Y Direction

# Tower Mode Shapes



1<sup>st</sup> Bending  
0.44 sec

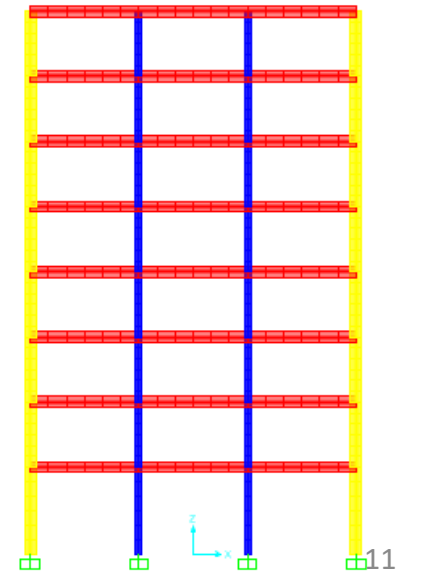
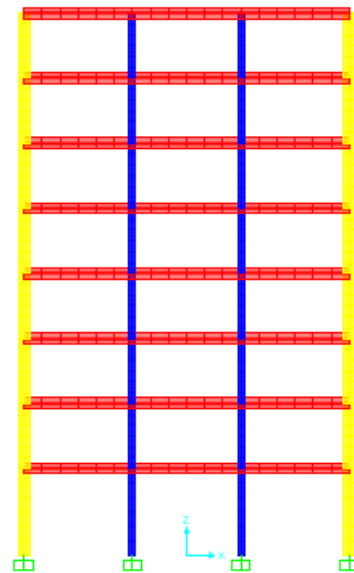
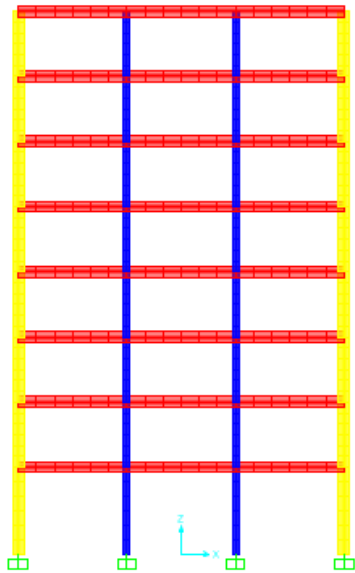
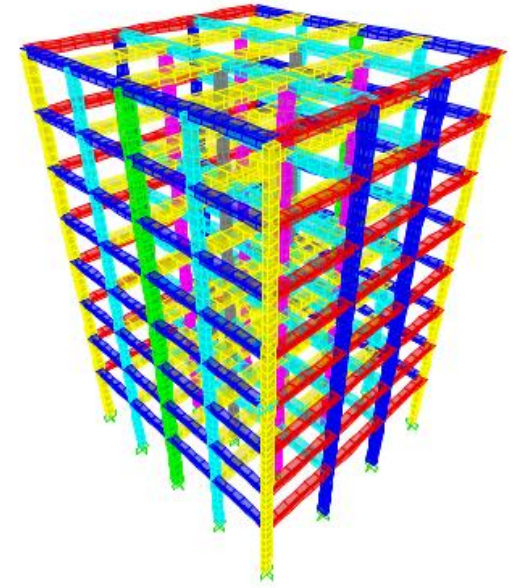
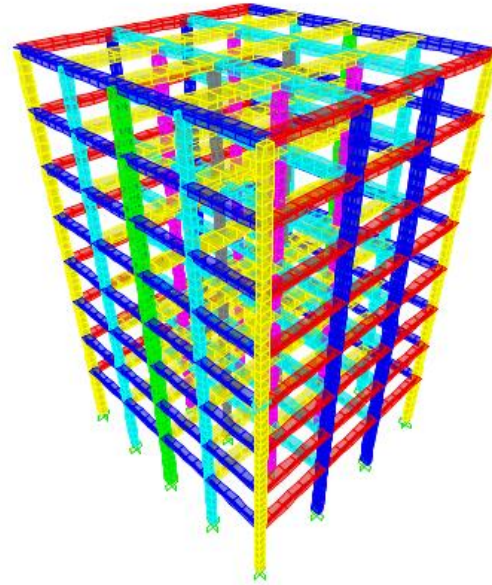
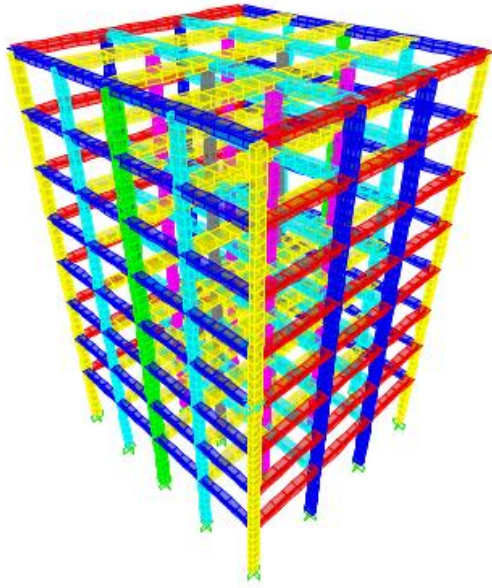
2<sup>nd</sup> Bending  
0.108 sec

1<sup>st</sup> Torsion  
0.05 sec

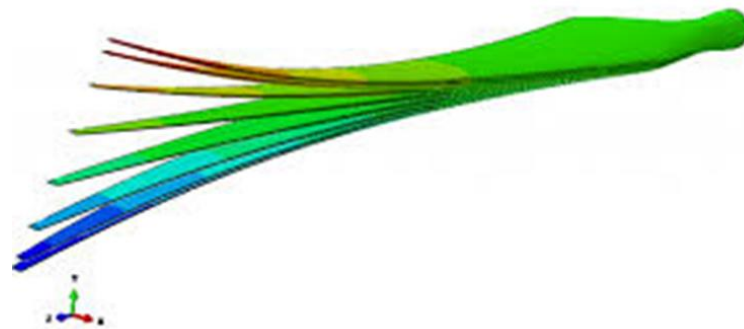
3<sup>rd</sup> Bending  
0.047 sec



# Mode Shapes of an 8 Story Building

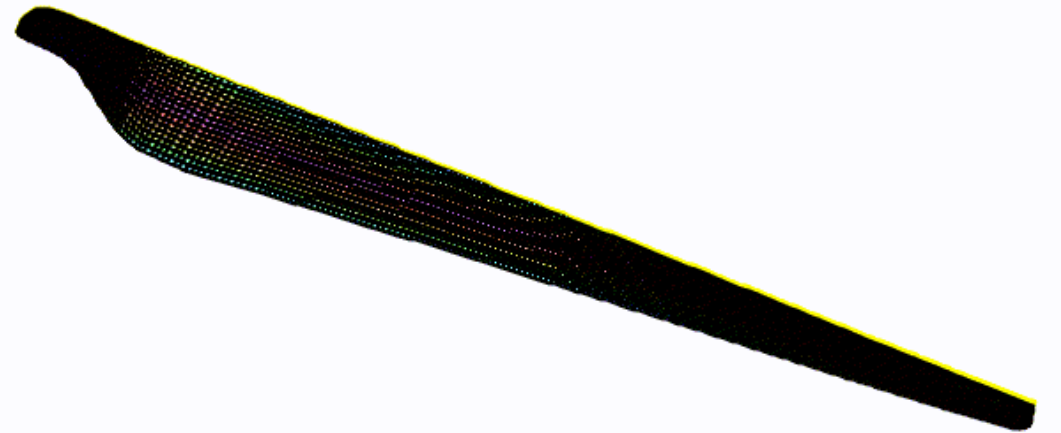
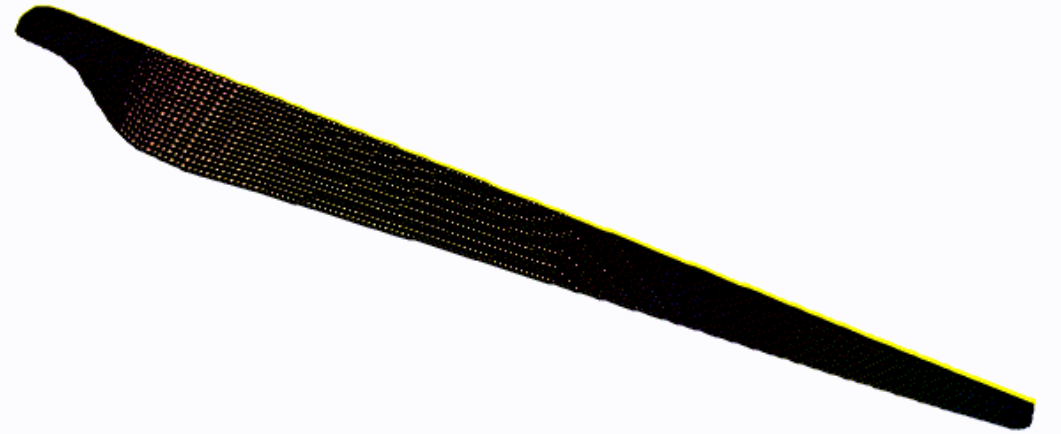
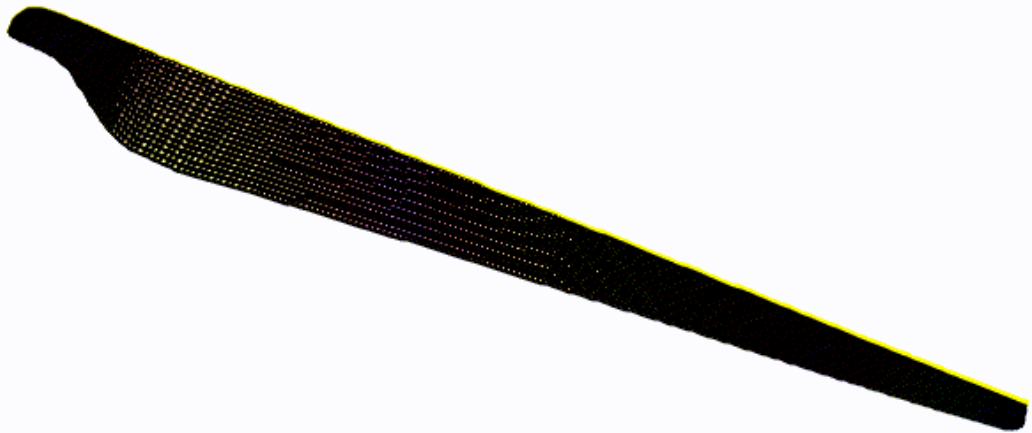
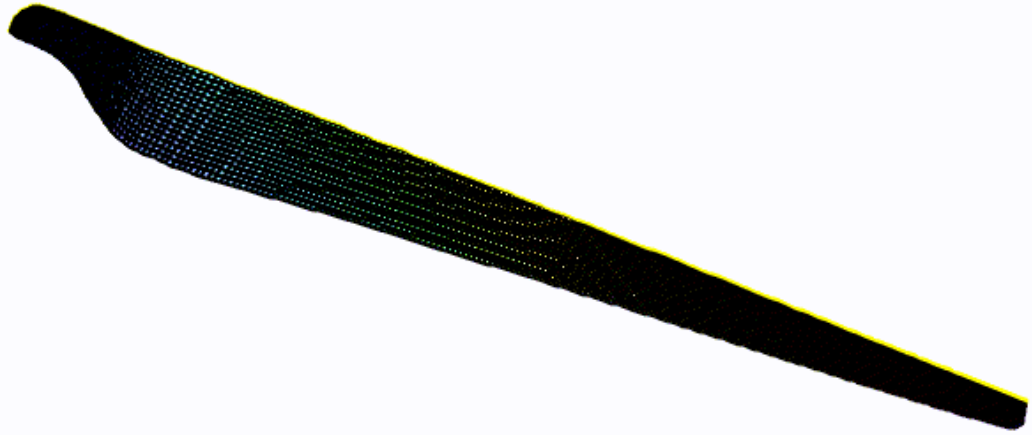


## Field Tests on Wind Turbines

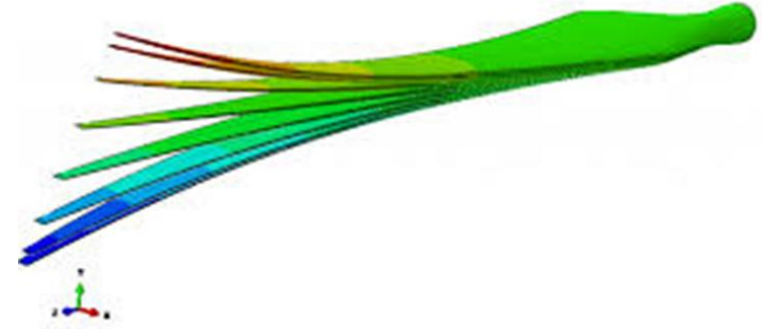
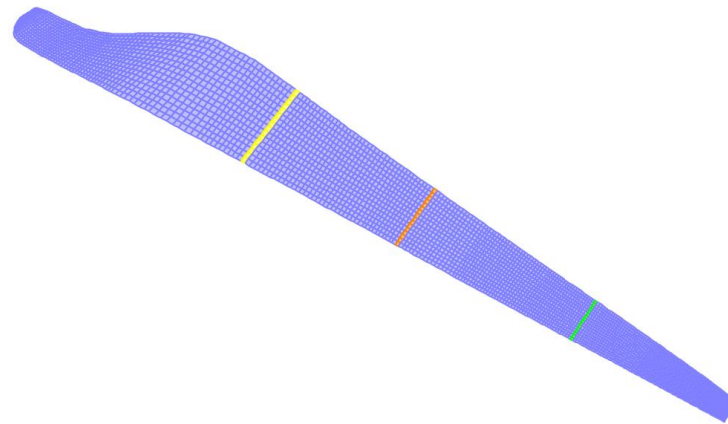
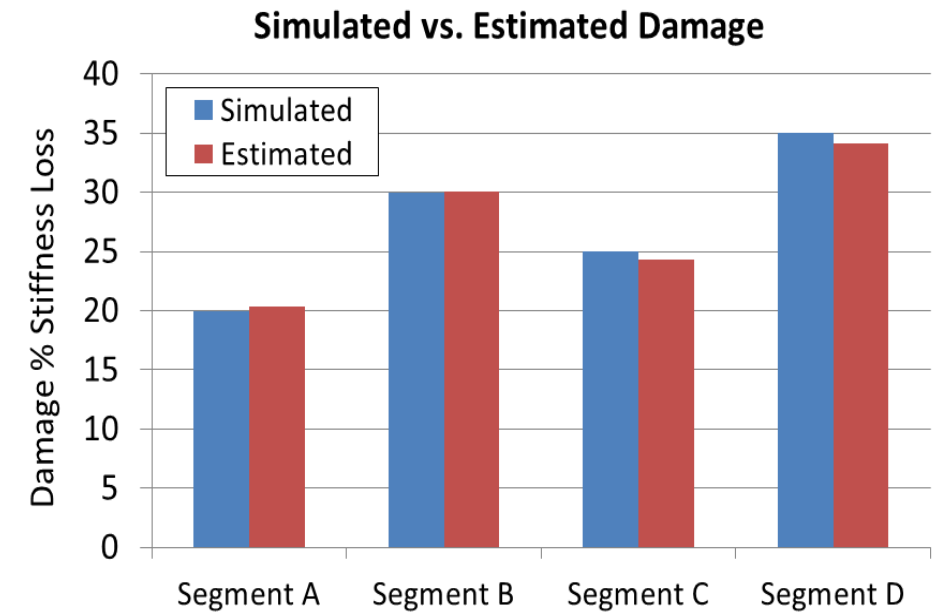
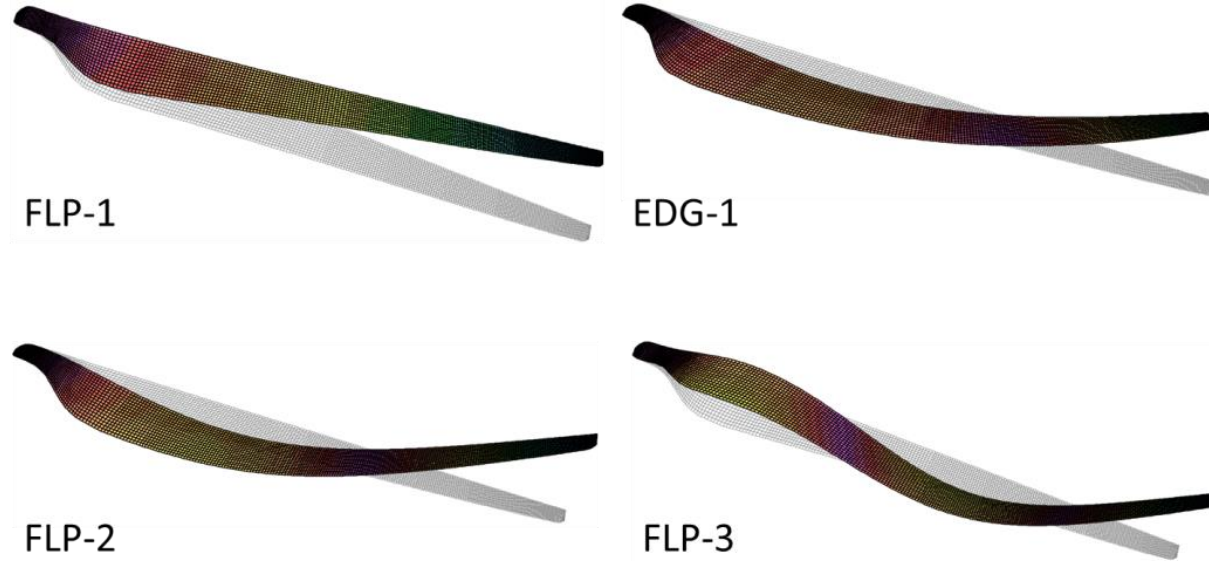




## Wind Turbine Blade Vibration Modes

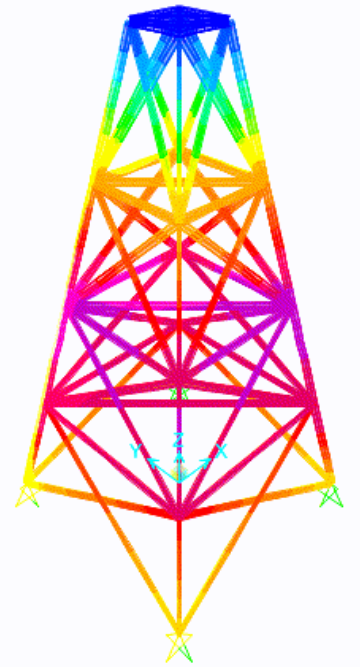
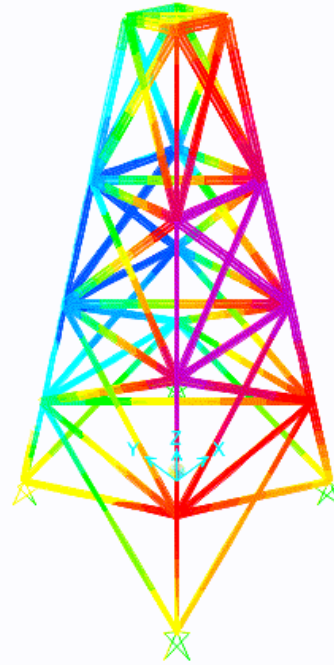
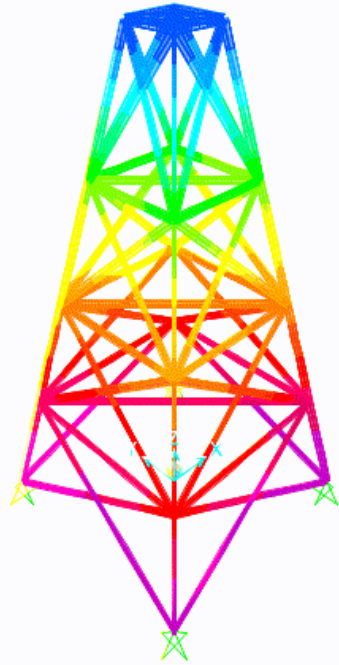
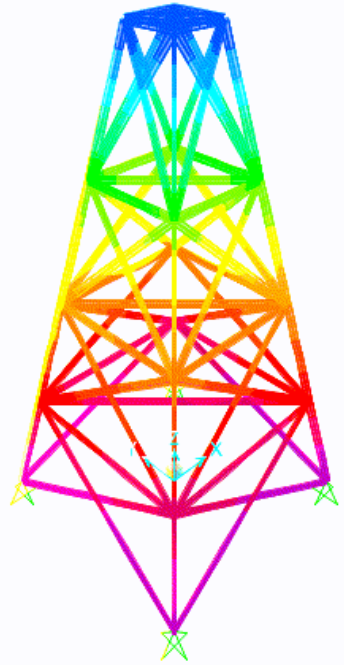


# Damage Detection on Wind Turbine Blades

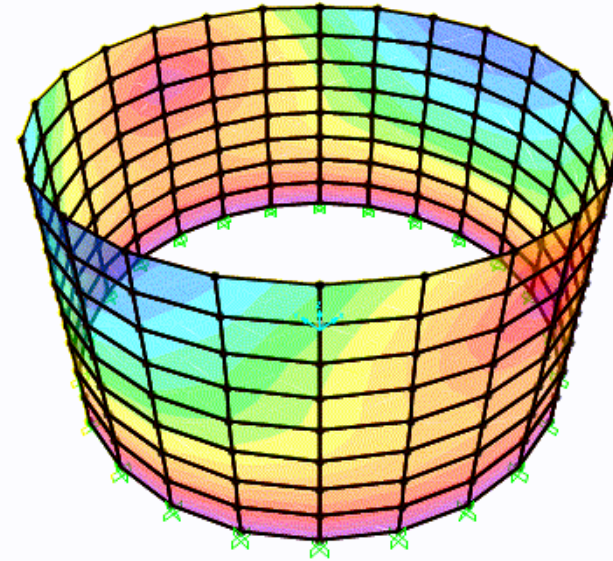
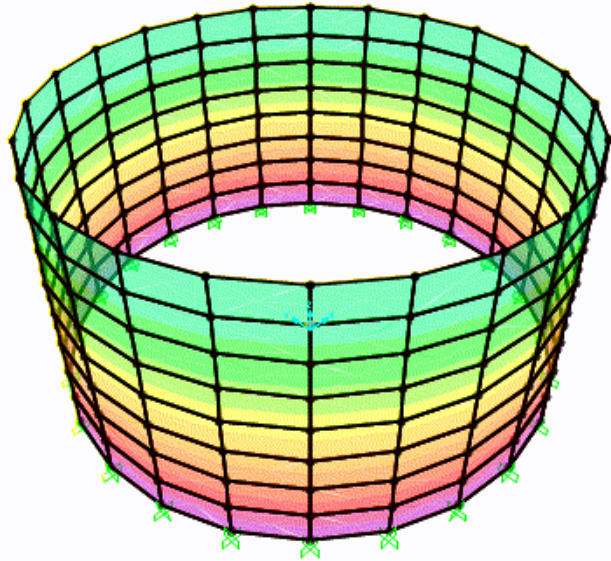
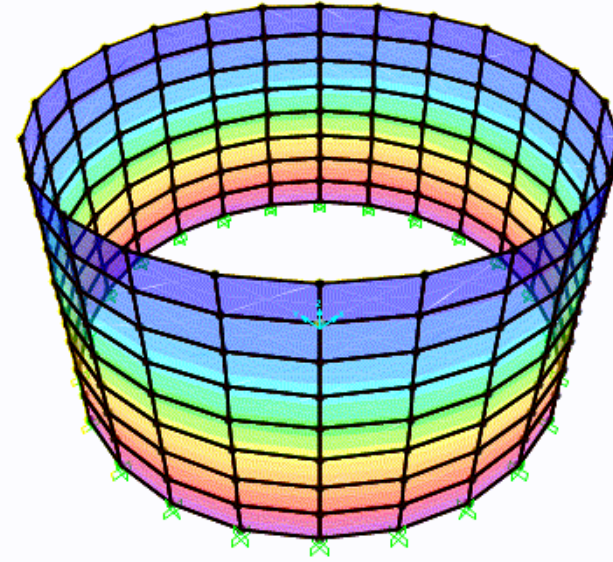
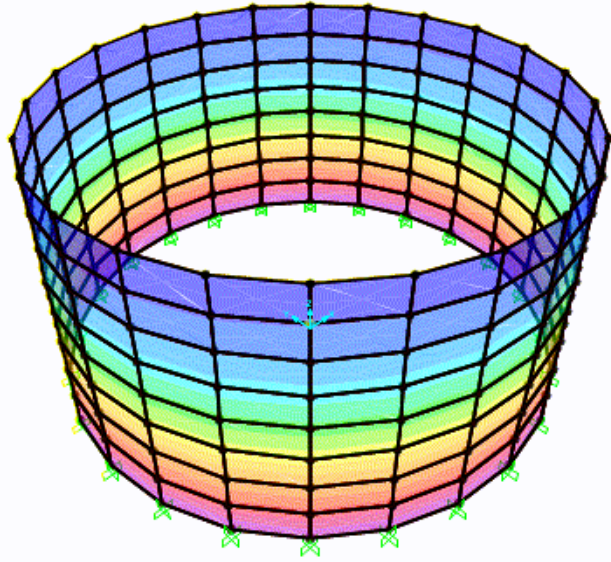




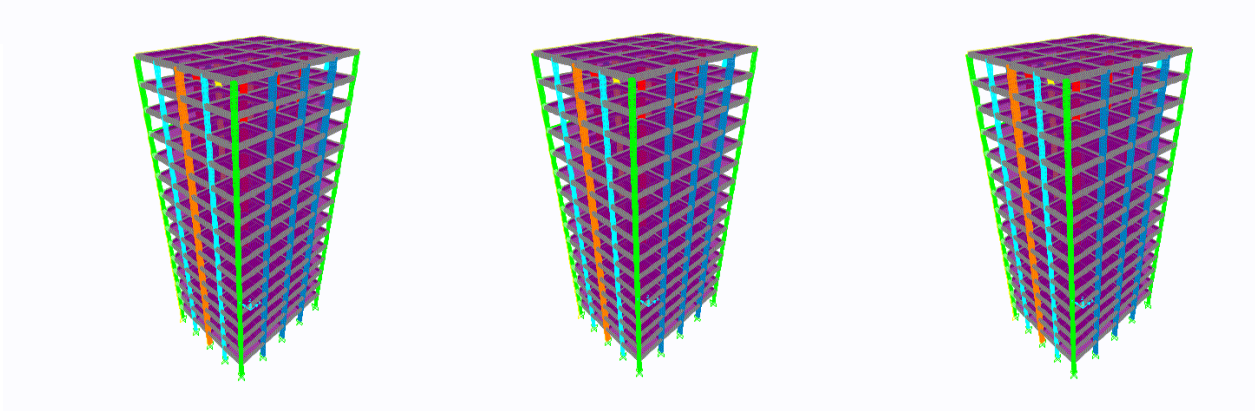
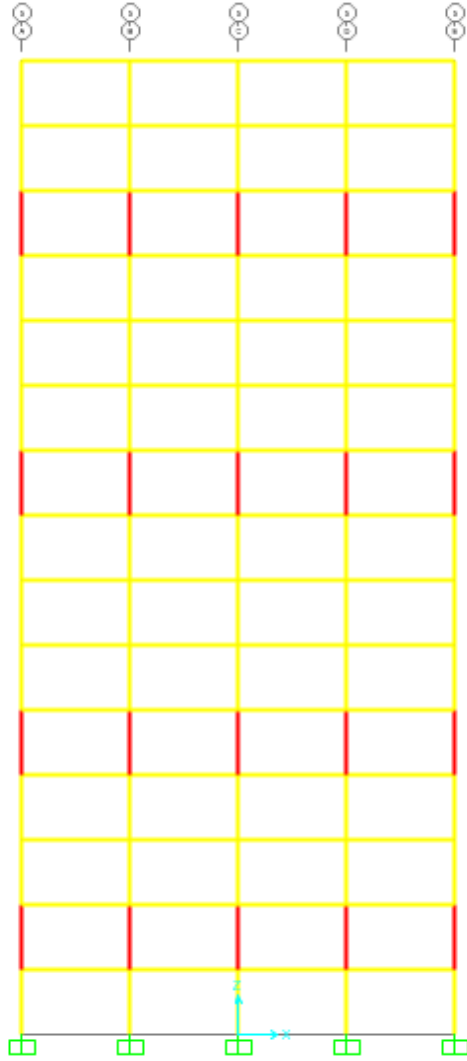
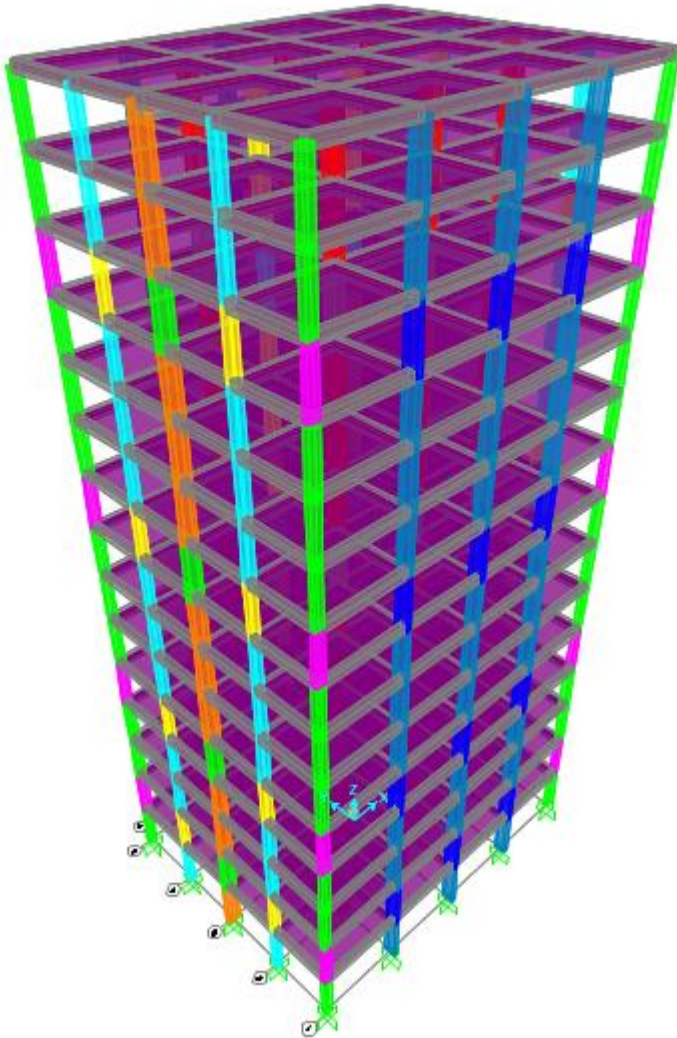
## Mode Shapes of a Transmission Tower



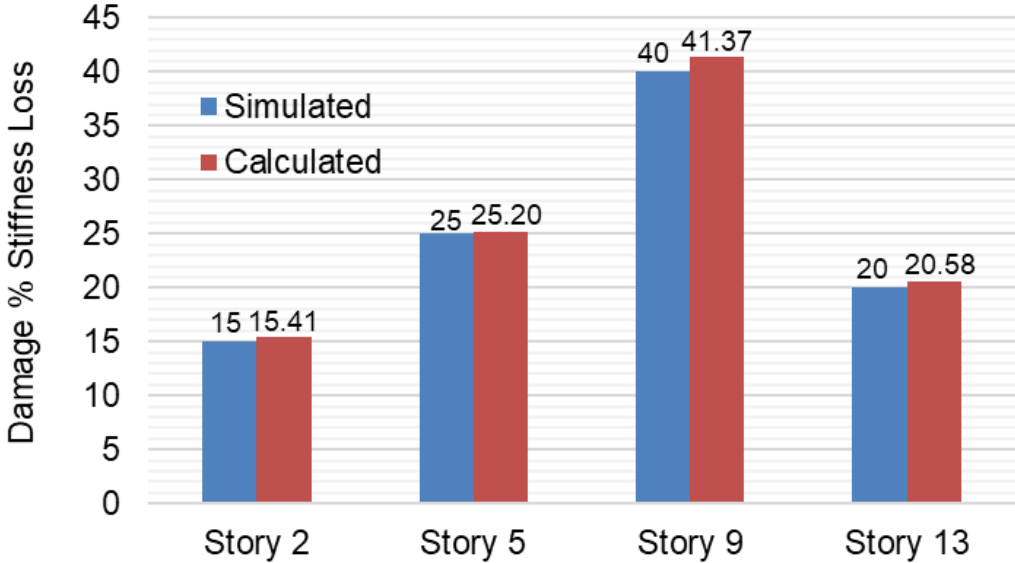
## Vibration Modes of Petroleum Tank – Container



# Damage Detection in Multi-story Buildings

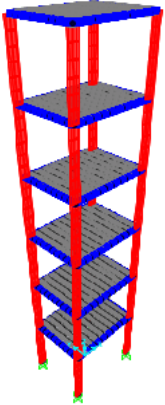


Simulated vs. Calculated Damage

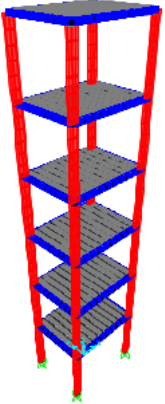




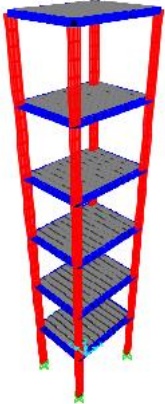
# Damage Detection in Multi-story Buildings



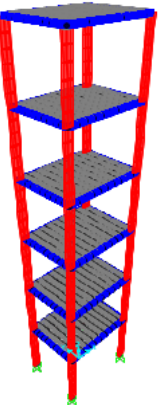
Bending -1 Y



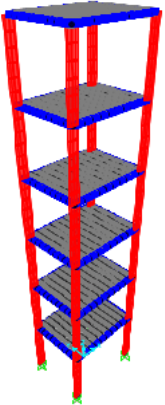
Bending -1 X



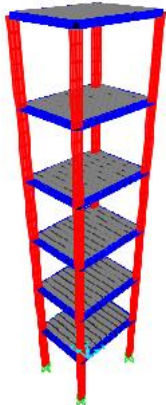
Bending -2 Y



Torsion 1



Bending -3 Y



Bending -2 X

## Related Publications

- Ozbek, M. (2022). Smart Maintenance and Health Monitoring of Buildings and Infrastructure Using High-Resolution Laser Scanners. *Buildings*, 12(4). Doi: 10.3390/buildings12040454.
- Ozbek, M. (2022). An Innovative Structural Damage Detection System for Preventive Maintenance of Wind Turbines. *Arabian Journal for Science and Engineering*, 47(10), 13623-13637. Doi: 10.1007/s13369-022-07171-z
- Dilek Ahmet Uğur, Oğuz Ali Devrim, Satış Furkan, Gökdal Yiğit Dağhan, Ozbek Muammer (2019). Condition monitoring of wind turbine blades and tower via an automated laser scanning system. *Engineering Structures*, 189, 25-34., Doi: 10.1016/j.engstruct.2019.03.065
- Dilek, A.U., Oguz, A.D., Gokdel, Y.D., Ozbek, M. (2017). Development of automated laser scanning system for structural health monitoring of wind turbines. The 25<sup>th</sup> Signal Processing and Communications Applications Conference, SIU 2017.
- Ozbek, M. Development of a Laser Scanning System and Dynamic Analysis Method for Structural Control of Industrial Chimneys and Towers. The 3<sup>rd</sup> International Halich Congress on Multidisciplinary Scientific Research, March 12-13, 2022, Istanbul, Turkey.