9th NEES/E-Defense Planning Meeting

Break Out Session: Monitoring

Friday, August 26, 2011, 3:45-
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Recorder: Naru Nakata

The objective of structural monitoring is to identify changes in structural material, geometric, and systems properties due to long-term deterioration and from extreme events such as earthquakes, strong winds, floods, and snow storms. These loads typically will push the structure beyond their design limits resulting in permanent deformations or material damage. In addition to identifying damage, monitoring systems should provide information at various levels:

- Before an earthquake leading to repair and strengthening
- During the emergency response period immediately following an extreme event inform about critically damaged or collapsed structures
- During the recovery period after such an event provide information on the type and degree of damage of large number of structures reducing the recovery time.

Damage diagnosis consists of the identification, localization and quantification of the changes that have occurred in the structure. Such diagnosis is still very challenging because of the complexity of civil systems, the lack of appropriate sensors for the different types of damage, and sparse instrumentation schemes. Moreover, algorithms that convert the collected data into diagnostic information are still lacking.

Over the past decade significant advances have been made in the development of new monitoring hardware technologies and in the formulation of algorithms for damage diagnosis. Many of the new instruments and algorithms require extensive testing and verification that can be achieved primarily with large scale testing such that conducted at the E-Defense/NEES facilities.

The breakout session for monitoring during the E-Defense/NEES meeting discussed the research needs and coordinated efforts required to address some of the gaps in structural health monitoring. The following is a summary of the discussion and the recommendations of the members present at the breakout session:

- **Issues Discussed**
  - How to best utilize the test data obtained at E-Defense and NEES
  - How to use the tests as an opportunity for payload tests to install instruments and health monitoring systems (monitoring).
  - What new E-Defense tests are needed for improvement of technologies
- **How to best utilize the test data**
  - *Questions to the E-Defense Test Data Management*
    - Are the E-Defense test data available?
    - →The answer is YES. But, most US participants did not know.

        - When do the E-Defense test data become available?
        - →Two years from the test (FYI, six months in NEES test data)
        - How can we access the E-Defense test data?
        - →**ASEBI** (Archives of Shakingtable Experimentation dataBase and Information)
        - (FYI, NEEShub for NEES test data, see appendix for copy of webpage)
    - *Recommendations*
        - Some Japanese group published papers on damage detection related research using E-Defense data without participating experiments.
        - US researchers are also very interested in the E-Defense test data.
        - Dissemination of the availability of the E-Defense test data is critical for effective use in research community.
        - Use data for algorithm verification
        - Use data for uncertainty quantification
- **How to use the tests as an opportunity for payload tests**
    - *Example of successful monitoring payload projects*
        - Drs. Nagae and Nitta's payload test at E-Defense
            - Deployed their sensor units for strain and gap displacement measurement
            - Detected cracks and damages
        - Prof. Kiremidjian's NEES payload test at Univ. of Nevada, Reno
            - Payload to Multi-Span Bridge Project
            - Deployed their wireless smart sensor
            - Wavelet energy-based algorithm was shown to be promising for detection of global damage
    - *Suggested Ideas:*
        - Damage detection with dense measurement
        - Deployment of new instruments
        - Algorithmic based payload
    - *Questions:*
        - Is information about instrumentation scheme available?
        - Who is in charge of data sharing?
        - To be successful in the NEES proposal, a letter of agreement from the E-Defense director is required. What should the letter be saying?
    - *Comments:*
        - Difficulty in Monitoring Payload: May not possible to put all the sensors we want
        - Importance of Coordination: Payload teams should not interrupt the main project team.
        - It is worthwhile to review information of sensor arrangement in the past experiments.
- **What new E-Defense tests are needed for improvement of technologies**
    - *New Sensor Technologies*:
        - Wireless Sensors and Smart Sensors
        - Rotational Sensors

        - Acoustic Emission Sensors
        - Laser Scanning
        - Crack Sensors and Corrosion Sensors
    - *Ground Motions:*
        - Long period and long duration ground motion tests
        - High amplitude and long duration ground motion tests
    - *Monitoring System Technologies:*
        - Localization of damage
        - Identification of hidden damage
        - Early warning based on the state of structure
        - Targeted failure mechanisms and their detection methods

Desired Collaborations and Benefits of collaboration:

- Monitoring objective in US and Japan are very similar thus working together the two groups can more rapidly advance the state of the art of monitoring
- Payload projects using full-scale experiments at E-Defense and NEES facilities can greatly advance the adaptation of innovative monitoring technologies in both countries.
- Data sharing to help development of monitoring technologies and algorithms
- Results from payload projects can serve as proofs of concepts and proof technologies thus enable faster acceptance in practice