DESIGNSAFE-CI

A NATURAL HAZARDS ENGINEERING COMMUNITY

Use Case Teams: Advanced Data

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Advanced Data

- To fully exploit data re-use, there is a need to demonstrate how DesignSafe data can be used within various contexts.

- Members of this Use Case team will utilize published data in the Data Depot to develop interactive dataviews, generate advanced data analysis, and demonstrate AI and ML capabilities.

Advanced Data Sources

- Simulation
- Lab Experiments (NHERI Experimental Facilities)
- Field Experiments
- Field Reconnaissance
- Others (e.g. government records; topography; geolocations…)

Advanced Data Tools in the Workspace

Simulation [7] | Visualization [9] | Data Processing [2] | Partner Data Apps [5] | Utilities [2] | My Apps [1]

Jupyter

MATLAB

Simulation [7] | Visualization [9] | Data Processing [2] | Partner Data Apps [5] | Utilities [2] | My Apps [1]

Hurricane Data Analysis

H

NEXT-GENERATION LIQUEFACTION

NGL NEXT GENERATION LIQUEFACTION

SCEC BBP Ground-Motion Portal

S

TPU Wind Databases

T

VORTEX-Winds: DEDM-HR

V

Advanced Data: Machine Learning Classification Problem

- **Data:** Roueche et al. (2018-08-22), "Collection of Perishable Data on Wind- and Surge-Induced Residential Building Damage During Hurricane Harvey (TX)" , DesignSafe-CI Dataset, doi:10.17603/DS2DX22

- **Objective:** Using Conventional ML algorithms classify the performance of a building given its properties.

- **Tools:**
  - DesignSafe JupyterHub is used to implement the classification script.
  - Scikit-Learn module within a Python notebook.

Introduction to ML/DL and its Applications in Natural Hazard s

Dan Stanzione, Mahyar Sharifi, Z hao Zhang, Niall Gaffney

DesignSafe

2/17/2020

Advanced Data: Hurricane Field Data Post-Processing

Field Data Collection

Anemometer and Sensors fixed on roof top

Data collected by Durabook

box

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Data storage and analysis on DesignSafe

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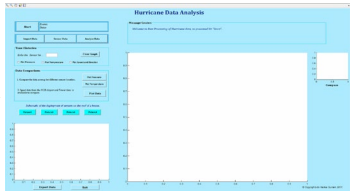
Hurricane Data: PRJ-1928
doi:10.17603/DS2JT3Q

MATLAB
0.1



Data Depot in DesignSafe

Raw data stored on the cloud

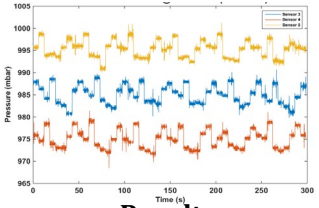
DesignSafe Workspace

MATLAB in the workspace is used to analyze the raw data

Hurricane Data Analysis(HDA)

The Post analysis program to clean and plot the data

The Data can be shared with other users.
The executable HDA GUI is available for users to analyze the data.



Results

Results from the post-processing program

- DS data depot receives raw data during the hurricane.
- Once files are synchronized, the GUI code Hurricane Data Analysis, cleans and post processes raw data on DS.
- Time histories of pressure and wind speed and direction can be computed and shared,.

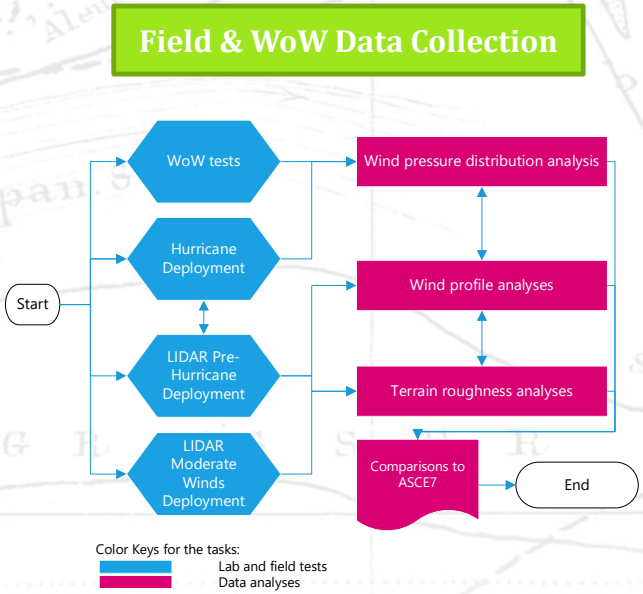
Use Case Projects

- ***Project 1:*** Develop Jupyter notebook to interface with wind data collected in the field and from the Wall of Wind. The notebook will query, process, visualize, analyze, and correlate data from hurricane and laboratory events.(Jean-Paul Pinelli)

- ***Project 2:*** Develop Jupyter notebooks to integrate the workflow environment of Experimental Facilities with DesignSafe, using example applications of shake table and the hybrid simulation experiments. (Gilberto Mosqueda)

- ***Project 3:*** Develop Jupyter notebook that integrates large datasets and the Dakota uncertainty quantification tool to calibrate model parameters for finite element analysis. (Laura Lowes)

PROJECT 1: Jupiter Notebook Interface with Wind Data

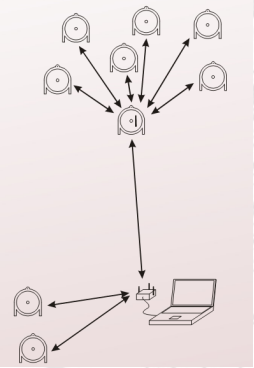


Wireless Sensors Network (WSN)
funded by NIST

- Very large datasets of time histories of wind pressures, wind speeds and directions, temperatures
- Jupyter notebooks, using Python scripts, shall connect to the databases and shall query, process, visualize, analyze, and correlate data from the hurricane and laboratory events databases.
- Data viewing and analysis during event
- Potential users will emulate these published notebooks.

PROJECT 1: Jupiter Notebook Interface with Wind Data

- *Development of Jupyter notebooks for processing and analysis of WSN data* and *of the LIDAR and anemometer data*.
  - Convert raw data into physical units.
  - Check and correct for packet loss.
  - Integrate with picture gallery.
  - GUI plots time histories for different data variables and across different data variables.
  - Compare and correlate time histories between sensor locations as well as w/LIDAR data.
  - Analyze data for dominant motions in hurricane winds that cause severe pressures on building.
  - Characterize wind profile and turbulence intensity
  - Compare different events at the same locations to improve site characterization
- *Jupyter notebooks can serve as templates for re-use by other researchers*.



PROJECT 2: Integration of DesignSafe Tools in Experimental Workflow

- Develop Jupyter notebooks to view and analyze data during experimentation
- Publish notebooks w/data for community use to view and analyze data in the cloud

Potential benefits

- Data viewing and analysis during experiments
- Data viewing and re-use of published data in DataDepot
- Adaptable to others laboratories data acquisition system and metadata requirements, including but not limited to NHERI EF's

PROJECT 2: Integration of DesignSafe Tools in Experimental Workflow

- Develop template notebooks and apply to shake table test and hybrid simulation at UC San Diego Equipment Facility
- Apply workflow for first test to be conducted on upgraded shake table with 6 degrees of freedom – Reconfigurable Testbed structure

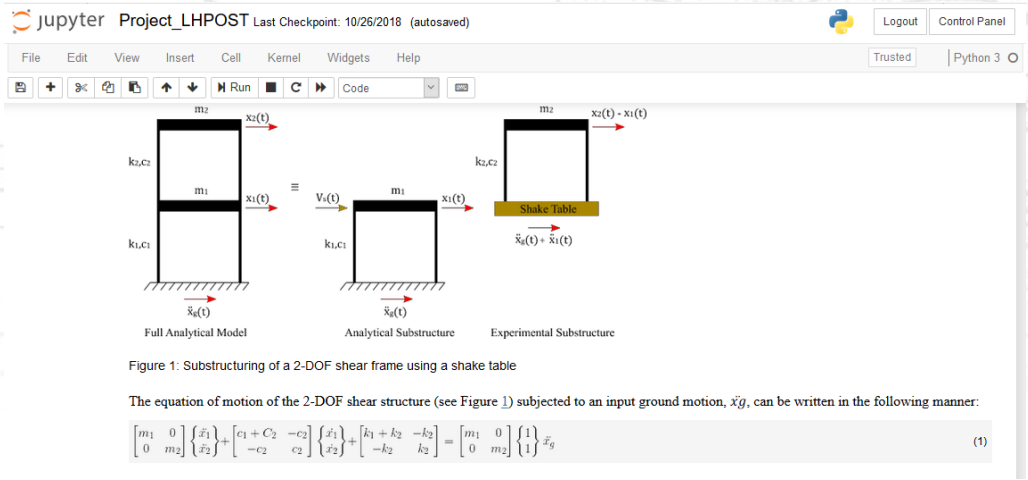
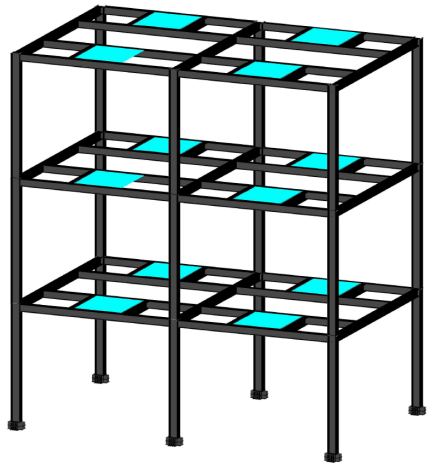


Figure 1: Substructuring of a 2-DOF shear frame using a shake table

The equation of motion of the 2-DOF shear structure (see Figure 1) subjected to an input ground motion, $\ddot{xg}$, can be written in the following manner:

$$\begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix} \begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{Bmatrix} + \begin{bmatrix} c_1 + C_2 & -c_2 \\ -c_2 & c_2 \end{bmatrix} \begin{Bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{Bmatrix} + \begin{bmatrix} k_1 + k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix} = \begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix} \begin{Bmatrix} 1 \\ 1 \end{Bmatrix} \ddot{x}_g \quad (1)$$



PROJECT 3: Reducing Risk via Improved Response Prediction Models

Goals

- i) improved design of new structures and retrofit of existing structures
- ii) improved assessment of regional risk to support decision making.

Using DesignSafe Resources and Laboratory Data

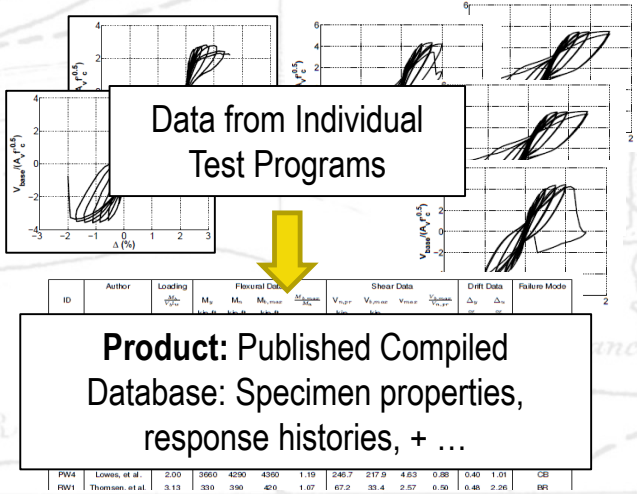
- **Data Depot Experimental Databases:** collections of experimental data sets, from different research groups, that characterize the response of specific structural components.
- **DesignSafe Computing Resources:** Employ Dakota and AI to calibrate cyclic response parameter for use by professional engineers and inclusion in future versions of ASCE 41, *Seismic Rehabilitation of Existing Buildings*.

Products

- Advance DesignSafe support for experimental *databases* to enable model development.
- Database characterizing the earthquake response of slender walls.
- Jupyter notebooks for model calibration using data and software available via DesignSafe.
- Modeling parameters for slender concrete walls.

PROJECT 3: Use Case Study Activities, Questions and Products

Experimental Database



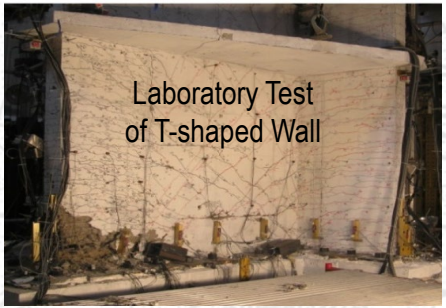
Product: Published Compiled Database: Specimen properties, response histories, + …

Determine "best practices" for:

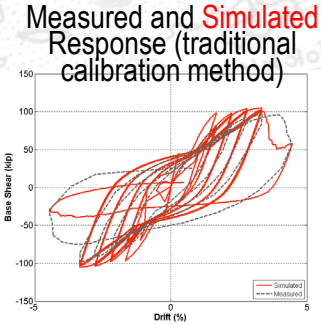
- Storing the database
- Ingesting new data
- Managing the database

Model Calibration

Product: Jupyter notebooks to support model calibration using Dakota and AI for slender concrete wall database.



(Image from Brueggen 2009)



Determine

- Data requirements
- How results of the methods compare
- How much engineering judgement is required
- Best practices for model calibration using these tools

Use Case Projects

- Note that many other examples presented earlier also have key advanced data components
  - Use several resources
  - For wind, earthquake, storm surge/wave applications
  - To analyze simulation, experimental and field data

- Use cases offer apps and Jupyter notebooks templates that can be adapted by the NHE community to leverage and expand CI advanced data capabilities