Regional Workflow

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Outline

SimCenter Regional Workflow
Running the Anchorage Testbed
SimCenter Software

The SimCenter is providing a framework that will enable workflow applications to be built that will enable research in Natural Hazards engineering. The framework will allowing researchers with different applications to work together to build more powerful applications. Applications to scale from individual buildings to regional scale.
Resiliency Decision Tool

- **describe the region**: specify characteristics of buildings and infrastructure in the region
- **describe the hazard**: specify the regional distribution of ground shaking, wind, or water
  - for each random region-hazard sample:
    - propagate uncertain characteristics of the regional assets and the hazard
  - for each asset in the region:
    - **describe the asset**: create stochastic models for response, damage, and loss estimation
    - **describe the event at the site**: specify hazard-consistent loads for response estimation
      - for each random asset-event sample:
        - propagate uncertainties in asset models and event description
        - **estimate asset response to the event**: describe the response with engineering demand parameters
        - **estimate asset damage and its consequences**: prepare a stochastic description of damage and loss for the asset
  - **describe regional damage and direct losses**: aggregate damages and losses in the region considering dependencies
  - **estimate indirect regional consequences**: describe regional consequences of infrastructure- and social disruption
  - **simulate regional recovery**: estimate the temporal and spatial variation in the recovery of communities
Backend Application:
Regional Workflow for Hazard And Loss Estimation
rWHALE

Deierlein, Kareem, Conte, Deelman, Deodatis, Kijewski-Correa, Taflanidis & Tien
Frank McKenna & Wael Elhaddad

Current Release V1.1 (Feb 2019)
- Regional earthquake workflow
- Various hazard representations

Future Release V2.0 (Sept 2019)
- Regional storm workflow
- Initial version to consider ASCE7 wind loading and HAZUS type damage and loss
Input File for Regional Earthquake Simulation
"Events": [
  {
    "EventClassification": "Earthquake",
    "EventApplication": "LLNL-SW4",
    "ApplicationData": {
      "pathSW4results": "/Users/fmckenna/NHERI/Hayward7.0/",
      "filenameHFmeta": "/Users/fmckenna/NHERI/Workflow1.1/createEVENT/HFmeta"
    }
  }
],
"Modeling": {

},
"Events": [
  {
    "EventClassification": "Earthquake",
    "EventApplication": "SHA-GM",
    "ApplicationData": {
      "scenarioConfig": ".//HayWired7.25.json"
    }
  }
],
"Modeling": {

}
Regional Workflow Testbeds to Verify rWhale

San Francisco Bay Area Testbed
- 3D ground motion simulation (M7.0)
- 141,400 red-tagged buildings
- 5.6% net buildings loss ratio

Atlantic City, NJ Storm Testbed

Anchorage, Alaska Testbed
- Parcel level damage
- 3,828 red-tagged buildings
- 14.5% net buildings loss ratio

Memphis, TN Lifelines Testbed
Real Importance of Testbed Workflows?

- They Test the Interfaces of Framework for the Different hazards
- They Provide Seed Data & Example Applications
- Demonstrate Flexibility & Extensibility of Framework
- Foster Collaboration
- Provide Code For Research Applications
Workflow 1: Hayward 7.0 on Bay Area

Objective: develop and exercise a workflow to connect software models and systems on a challenging computational model that engages a broad cross-section of NEHRI community

Ground Motions: 3D simulation, GM’s at 2km grid (Rodgers, Pitarka & Petersson)
Building Inventory: UrbanSim and DataSF Portal; geometry, age, occupancy
Building Analyses: OpenSees, simplified NL MDOF, FEMA P58 (w/Cheng & Lu, Tsinghua)
Visualization: UrbanSim and 3d Urban Polygon Modeling (Xiong et al., 2015)
Interpretation: UrbanSim; urban growth, damage/loss, displaced occupants/population

Policy/Planning decision support: building losses & downtime in 2010 and 2040
Sample Input Data

Building Inventory – by Age

Ground Shaking Intensity (PGA)
High Resolution Results

- Parcel-level Data of Building Damage

San Francisco

Opportunities to evaluate planning and policy decisions (land use, retrofit, etc.)

Oakland - Alameda
Sample Output Data

Building Demand Parameters

Building Loss Ratio

Loss ratio:
- 0.0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
Displaced Population in Residential Construction
(person/parcel; Oakland, Lake Merritt Area)
UrbanSim Output - Sample Results

Quantitative Statistics to Evaluate “What-If” Scenarios
How Accurate Is IT?

SimCenter Workflow

If know area, to east of fault there are hills and no construction! **SimCenter Info at parcel level**
Anchorage M7.0 Nov 1018 Losses

Data for 97,421 tax parcels in the regional simulation

- Red Tags
Buildings

• **Tax data for 97,421 buildings/parcels** was obtained from Municipality of Anchorage public property appraisal records

• **Data was processed to obtain BIM**
  • **84435 buildings** records were processed successfully (78509 Residential and 7926 Commercial)
  • 2000 building records failed processing (2.3%)
  • 10512 Parcels were vacant or not buildings (e.g. parking lots)

• **Buildings locations were mapped to parcels locations**
  • 400 Buildings with missing parcels locations
Buildings

• Buildings included in the regional simulation

~12,000 buildings in Eagle River
Earthquake Records

- **Event:** Anchorage, Alaska Nov 30th 2018 earthquake
  - **7.0MW**, 8:29:28 AKST, 61.340N 149.937W Depth 40.9 km

- Recorded ground motions were obtained from CESMD (12 records) and Alaska Earthquake Center (12 records)
  - Nearest neighbor search was employed to map the ground motion records to buildings
  - One record (PGA = 0.81g) was removed from CESMD website on Dec. 19th
Ground Motion Records

Circles are records of the strong motion center (CESMD) and Diamonds are records from Alaska Earthquake Center (AEC)
Synthetic Ground Motions

PGA values at stations in Anchorage with synthetic records generated using the stochastic loading library
Losses (CESMD Records)

- ~3828 buildings are red tagged (95% subjected to a record with PGA = 0.47g)
- Total repair cost $7.5 Billion
- Average loss ratio is 14.5%

Locations of red tagged buildings

Parcels color-coded by loss ratios
# Losses By Year Built and Stories

<table>
<thead>
<tr>
<th>Year Built (Seismic Design Level)</th>
<th>Total Count</th>
<th>Red Tags (CESMD GM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973 – 2018 (High Code)</td>
<td>63332</td>
<td>3599</td>
</tr>
<tr>
<td>1941-1973 (Low Code)</td>
<td>20795</td>
<td>228</td>
</tr>
<tr>
<td>1899-1941 (Pre Code)</td>
<td>138</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stories</th>
<th>Total Count</th>
<th>Red Tags (CESMD GM)</th>
<th>Average Area (Sqft)</th>
<th>RedTagged Average Area (Sqft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>43845</td>
<td>148</td>
<td>2397</td>
<td>13161</td>
</tr>
<tr>
<td>2</td>
<td>39153</td>
<td>3674</td>
<td>2785</td>
<td>2838</td>
</tr>
<tr>
<td>3</td>
<td>1137</td>
<td>148</td>
<td>9666</td>
<td>14809</td>
</tr>
<tr>
<td>4</td>
<td>62</td>
<td>0</td>
<td>55411</td>
<td></td>
</tr>
<tr>
<td>5+</td>
<td>69</td>
<td>0</td>
<td>99558</td>
<td></td>
</tr>
</tbody>
</table>
## Losses By Occupancy

<table>
<thead>
<tr>
<th>Building Types</th>
<th>Total Count</th>
<th>Red Tags (CESMD GM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential - Single Family</td>
<td>56440</td>
<td>2076</td>
</tr>
<tr>
<td>Residential - Town house</td>
<td>4645</td>
<td>133</td>
</tr>
<tr>
<td>Residential - Multi-Family</td>
<td>19096</td>
<td>1380</td>
</tr>
<tr>
<td>Office</td>
<td>1384</td>
<td>107</td>
</tr>
<tr>
<td>Hotel</td>
<td>117</td>
<td>21</td>
</tr>
<tr>
<td>Industrial</td>
<td>107</td>
<td>4</td>
</tr>
<tr>
<td>Retail</td>
<td>2350</td>
<td>91</td>
</tr>
<tr>
<td>Mixed-use Residential</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Mixed-use Office</td>
<td>40</td>
<td>2</td>
</tr>
</tbody>
</table>
Losses

- Losses

<table>
<thead>
<tr>
<th>Ground Motions</th>
<th>Median Repair</th>
<th>Red Tags</th>
<th>Average Loss Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>CESMD</td>
<td>7.5 Billions</td>
<td>3828</td>
<td>14.5</td>
</tr>
<tr>
<td>AEC</td>
<td>6.9 Billions</td>
<td>6858</td>
<td>11.8</td>
</tr>
<tr>
<td>Synthetic</td>
<td>4.2 Billions</td>
<td>9330</td>
<td>10.4</td>
</tr>
</tbody>
</table>

- Red Tags

![CESMD Map](image1)

![AEC Map](image2)

![Synthetic Map](image3)
Actual Losses

• Losses reports
  • With reports of damage growing after the quake and aftershocks, inspectors with the city of Anchorage have identified more than 750 homes and buildings that suffered substantial damage, said Don Hickel, the city of Anchorage’s lead structural inspector, on Friday. Another 900 buildings sustained minor damage. And the list keeps growing. About 740 more homes and buildings await inspection. The state has received more than 6,000 requests for help primarily from people reporting damage to homes.

• USGS Incident Journal (Hazus)
  • 5 Red Tags and 252 Yellow Tags
  • $1.7 Billion Economic Loss


https://fema.maps.arcgis.com/apps/MapJournal/index.html?appid=637ac220386e4e0f8728f0b2ee3d82be
Outline

SimCenter Regional Workflow
Running the Anchorage Testbed
Running An Anchorage Testbed

- Datasets on DesignSafe-ci
- Software on Github
- Agave App rWhale at Designsafe-ci

Not Needed by You Today
Datasets available on DesignSafe
DataDepot/CommunityData

Building Data, Motion Data & rWhale Input File for Regional Earthquake
Software on Github
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Building the source code on Unix-like systems

Before building the workflow, the following dependencies will need to be installed:

1. GNU Compiler Collection (gcc & g++) version 4.8.1 or newer.
2. GNU Make.
3. CMake

This repository uses CMake for the build process. The general instructions for building the workflow application is as follows:

1. Install the dependencies using Conan (note that adding the simcenter remote is only needed once)

   conan remote add simcenter https://api.bintray.com/conan/nheri-simcenter/simcenter
   conan install ..

2. Use CMake to generate the make files

   cmake ..

3. Build the applications using the generated make files

   make
**RUN RWHALE** ver. 1.1.0

rWHALE: Regional Workflow for Hazard and Loss Estimation. This Agave application runs the regional earthquake workflow on TACC Stampede2 using applications and data in DesignSafe Data Depot.

🔗 [rWHALE Documentation](#)

### Inputs

#### Regional Simulation Data

- **Select**
  - Click to select input data

One or more data files used for the regional simulation in compressed form, these files are extracted inside the data folder

#### Workflow Configuration File

- **Select**
  - Click to select input data

This is the configuration file that specifies the applications and the data used for the regional simulation

#### Number of Buildings to include in the Regional Simulation

This is the actual number of buildings to include, it can be less than the total number of buildings in the database

- **Logging**
  - Enable collection of logs

### Job details
Instructions for running on DesignSafe

1. Download files from community data
2. Review the files
3. Create a directory at DesignSafe in Datadepot
4. Start workflow/simulation app rWhale
5. add 2 zip files, set input file & set rest of args
6. Select RUN
7. Wait till finishes and look at csv file