Building evaluation using two components of acceleration time histories causes by shallow crustal fault earthquakes with maximum magnitude 7 Mw

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Fault is one of the dangerous earthquake sources that can cause building failure. A lot of buildings were collapsed caused by Yogyakarta fault (2006) and Pidie fault (2016) source earthquakes with maximum magnitude 6.4 Mw.

Based on the research conducted by Team for Revision of Seismic Hazard Maps of Indonesia 2010 and National Center for Earthquake Studies (PUSGEN) 2017, Lasem fault and Semarang fault are two earthquake sources crosses Semarang.
Introduction
Stability analysis of a structure can be evaluated by conducting seismic loads. The objective of the analysis is to get the information of maximum loads that can be applied to a structure.

The stability analysis in this study were implemented for 3 buildings (minimum 40 m height) at Semarang by conducting dynamic structural analysis and applying modified acceleration time histories.

The modified acceleration time histories were developed from earthquake scenarios caused by Semarang fault earthquakes with magnitude 6 - 7 Mw.
Research Methodology

1. Collecting information and data related with
   – structural details
   – geological and geotechnical data
   – positions of each building against seismic source
   – acceleration time histories due to shallow crustal fault sources with magnitude 6–7 Mw and maximum distance 30 km.

2. Developing modified acceleration time histories by conducting response spectral matching analysis.

3. Conducting shear wave propagation analysis using modified time histories for developing surface acceleration time histories

4. Performing dynamic structural analysis to get the deformation and drift ratio of buildings due to acceleration time histories and surface spectra developed from SNI:1726-2012.
<table>
<thead>
<tr>
<th>Building Number</th>
<th>Dimension Plans (m)</th>
<th>Height of Building (m)</th>
<th>Site Class</th>
<th>Depth of Bedrock (m)</th>
<th>Distance to Seismic Source (Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 (Hospital)</td>
<td>22x78</td>
<td>48.73</td>
<td>SE</td>
<td>165</td>
<td>3.13</td>
</tr>
<tr>
<td>B3 (Hotel)</td>
<td>28.8x19.75</td>
<td>41.2</td>
<td>SC</td>
<td>40</td>
<td>0.65</td>
</tr>
<tr>
<td>B8 (University Building)</td>
<td>40.75x16.2</td>
<td>43.2</td>
<td>SD</td>
<td>60</td>
<td>4.98</td>
</tr>
</tbody>
</table>
Data Requirements (building position)
Data Requirements (structural details)

Plan, elevation, materials and detail of element structure

Building B3
Data Requirements (geotechnical data)

**Bore Log**

**VS30 data**

**Site Class data**

**Boring investigation**
Data Requirements (Bedrock Measurement)

- Data Logger and Computer
- Hammer
- Seismometer
- GPS
Data Requirements (Bedrock Measurement)

Bedrock Elevation

Bedrock elevation map
### Data Requirements (acceleration time histories)

<table>
<thead>
<tr>
<th>Earthquake Events</th>
<th>Station and Epicentre Distance</th>
<th>Magnitude (Mw)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chuetsu-oki Japan</td>
<td>Nagaoka (3.98) and Joetsu Kakizakiku Kakizaki (9.43)</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td>IWTH24 (3.1), Mizusawaku Interior O Ganecho (7.82) and IWTH24 (11.68)</td>
<td>6.9</td>
</tr>
<tr>
<td>Iwate Japan</td>
<td>Cambria - Hwy 1 Caltrans Bridge (5.07) and Templeton - 1-story Hospital (6.97)</td>
<td>6.52</td>
</tr>
<tr>
<td>San Simeon-CA</td>
<td>Newhall - Fire Sta (7.36) and Pacoima Kagel Canyon (6.61)</td>
<td>6.05</td>
</tr>
</tbody>
</table>

All acceleration time histories (reverse mechanism earthquake) were collected from PEER NGA-West 2 Databases.
Data Requirements (acceleration time histories)

Original Acceleration Time Histories of San Simeon earthquake 6.52 Mw with epicentre distance 6.97 Km collected from PEER NGA-West 2 Databases

San Simeon 6.52 Mw 6.97 Km

- NS Direction
- EW direction
Surface spectra and design spectra from SNI-2012 at building B3 location (SD site class)
Data Analysis (Response Spectral Matching)

Response Spectra Target (Deterministic Seismic Hazard Analysis)

Spectral Target for building B3 (SD site class)
Three attenuation functions for deterministic seismic hazard analysis (Boore and Atkinson, 2008, Campbell and Bozorgnia, 2008 and Chiou, and Youngs, 2008)

Spectral Target Horizontal (N-S and E-W Directions)

- Chi-Chi 5.72 Km
- Chi-Chi 8.34 Km
- San Simeon 5.07 Km
- San Simeon 6.97 Km
- Iwate 7.82 Km
- Iwate 11.68 Km
- Iwate 13.07 Km
Data Analysis (Response Spectral Matching)

Select Ground Motion in Terms of Acceleration Time Histories For Scenario M and R

Calculate Target Spectral for specific earthquake M1 and R1

Modified Ground motion due to Lasem Fault
Response Spectral Matching San Simeon 6.52 Mw, 6.97 Km

Original acceleration time histories

San Simeon 6.52 Mw 6.97 Km

- NS Direction
- EW direction

Time (sec)

Acceleration (g)
Data Analysis (Response Spectral Matching)

Response Spectral Matching San Simeon 6.52 Mw, 6.97 Km

Matched Acceleration Time Histories San Simeon 6.52 Mw 6.97 Km

Matched / modified acceleration time histories

- N-S Direction
- E-W Direction
Data Analysis (Site Response/Propagation Analysis)

Acceleration time histories at the bedrock elevation)

Acceleration time histories at building

Propagation Analysis

Ground Surface

Soil Deposits

Bedrock

Modified from Irsyam 2015
Response Spectral Matching San Simeon 6.52 Mw, 6.97 Km

Surface Acceleration Time Histories San Simeon 6.52 Mw 6.97 Km

Propagating of modified acceleration time histories for producing surface acceleration time histories
Comparison of spectral acceleration calculated from SNI-03-1726-2012 and two components acceleration time histories of four earthquake events (a) and drift ratio of building B1 when subjected to SNI-03-1726-2012 spectral acceleration and acceleration time histories of four earthquake events.
Comparison of spectral acceleration calculated from SNI-03-1726-2012 and two components acceleration time histories of four earthquake events (a) and drift ratio of building B1 when subjected to SNI-03-1726-2012 spectral acceleration and acceleration time histories of four earthquake events.
Structural Analysis Results

Drift ratio of building B1

- Chuetsu-Oki 9.43 Km
- Iwate 11.68 Km
- Northridge-02 6.61 km
- San Simeon 6.97 km
- SNI 2012 (Y Direction)
- SNI 2012 (X Direction)
Structural Analysis Results

Drift ratio for building B2
Drift ratio for building B3
1. Stability performance of buildings can be predicted by evaluating surface response spectra calculated using seismic code and surface response spectra calculated from acceleration time histories from a specific earthquake event. If the surface response spectra calculated using seismic code is greater than the surface response spectra calculated from acceleration time histories the structure will strong enough to resist the earthquake force.
2. Based on the deformation and drift ratio results, all buildings were predicted are strong enough to resist earthquake force produced by earthquake with maximum magnitude 6.5 Mw and minimum 5 Km distance to earthquake source. However if the earthquake magnitude is greater than 6.5 Mw, all structures are predicted strong enough to resist an earthquake with minimum epicenter distance 10 km.
Thank you