Σεισμική διακινδύνευση σχολικών κτιρίων

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Outline

• SERA European Research Project
• Objectives
• Methodology
• Application in 179 schools located in the Municipality of Thessaloniki
• Comparison with the rapid visual screening (RVS) procedure proposed in 2014 by the Ministry of Environment (FEK 405/B’/20-2-2014, §40).
• Concluding remarks
SERA Integrated Risk Model for Europe

http://www.sera-eu.org/
Objectives:

• Local (e.g. city), national and continental scale integrated seismic risk assessment framework.

• Build upon research efforts and data collected in previous European projects (SHARE, NERA, SYNER-G, LESSLOSS.....RISK-UE)

• Produce an integrated assessment of seismic risk across all countries in Europe and share models and results through the EFEHR web platform and GEM’s OpenQuake platform.
**Seismic Damage Assessment Methodology**

<table>
<thead>
<tr>
<th><strong>Exposure</strong></th>
<th><strong>Hazard</strong></th>
<th><strong>Fragility</strong></th>
<th><strong>Seismic Damage</strong></th>
</tr>
</thead>
</table>
| Building Schools | PGA, Sa (0.3s), Sa (0.6s), Sa (1s) | Fragility Curves per Typology:  
  a) P(=NO)=1-(P>Slight)  
  b) P(=Slight)=(P>Slight)-(P>Mod.)  
  c) P(=Mod.)=(P>Mod.)-(P>Ext.)  
  d) P(=Ext.)=(P>Ext)-(P>Complete)  
  e) P(=Complete)=(P≥ Complete) | Distribution of the expected damages in school buildings in the various building typologies |
Step 1: Mapping and classification of the school buildings (*Exposure*)
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Definition of building classes using selected attributes of GEM Building Taxonomy

- Main construction material
- Lateral load resisting system
- Number of storeys
- Seismic design/ductility level
Step 1: Mapping and classification of the school buildings (*Exposure*)

<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>ELEMENT CODE</th>
<th>LEVEL 1 VALUE</th>
<th>ELEMENT CODE</th>
<th>LEVEL 2 VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATERIAL</td>
<td>CR</td>
<td>Concrete, reinforced</td>
<td>PC</td>
<td>Precast concrete</td>
</tr>
<tr>
<td></td>
<td>MUR</td>
<td>Masonry, unreinforced</td>
<td>CL</td>
<td>Fired clay unit, unknown type</td>
</tr>
<tr>
<td></td>
<td>MR</td>
<td>Masonry, reinforced</td>
<td>ST</td>
<td>Stone, unknown technology</td>
</tr>
<tr>
<td></td>
<td>MCF</td>
<td>Masonry, confined</td>
<td>ADO</td>
<td>Adobe blocks</td>
</tr>
<tr>
<td></td>
<td>MATO</td>
<td>Material, other</td>
<td>CB</td>
<td>Concrete blocks, unknown type</td>
</tr>
<tr>
<td></td>
<td>W</td>
<td>Wood</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>Steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LATERAL</td>
<td>LWAL</td>
<td>Wall</td>
<td>DUL</td>
<td>Ductile, low</td>
</tr>
<tr>
<td>LOAD-</td>
<td>LDUAL</td>
<td>Dual frame-wall</td>
<td>DUM</td>
<td>Ductile, medium</td>
</tr>
<tr>
<td>RESISTING</td>
<td>LFM</td>
<td>Moment frame</td>
<td>DUH</td>
<td>Ductile, high</td>
</tr>
<tr>
<td>SYSTEM</td>
<td>LFINF</td>
<td>Infilled frame</td>
<td>DNO</td>
<td>Non-ductile</td>
</tr>
<tr>
<td>(LLRS)</td>
<td>H</td>
<td>Number of storeys above ground</td>
<td>HBET</td>
<td>Range of number of storeys above ground</td>
</tr>
<tr>
<td>HEIGHT</td>
<td>H</td>
<td></td>
<td>H</td>
<td>Exact number of storeys above ground</td>
</tr>
<tr>
<td>DUCTILITY</td>
<td>SOS</td>
<td>Soft Storey Buildings</td>
<td>DUH</td>
<td>Period of construction: 1996-present</td>
</tr>
<tr>
<td></td>
<td>DUCL</td>
<td>Period of construction: before 1959</td>
<td>DNO</td>
<td>Period of construction: before 1959</td>
</tr>
</tbody>
</table>

*SDGEE* Research Unit of Soil Dynamics and Geotechnical Earthquake Engineering
Step 1: Mapping and classification of the school buildings (Exposure)
Step 2: Seismic hazard model

Measured Vs30 (m/s)
- 203 - 360
- 361 - 549
- 550 - 800
- 801 - 986
Step 2: Seismic hazard model
Fragility Model

(Martins and Silva, 2020)
Assessment of seismic damages

Event Based 475 years: Damage distribution to the 5 DS
- **green**: No damages
- **light green**: Slight damages
- **yellow**: Moderate damages
- **orange**: Extensive damages
- **red**: Complete
Assessment of seismic damages
Concluding Remarks

- We propose a reliable seismic damage assessment methodology for school buildings.
- There is important progress in the treatment of the numerous uncertainties involved in hazard, site effects, exposure, fragility/vulnerability functions, and risk modeling.
- We apply the methodology to 179 school buildings of the Municipality of Thessaloniki (239 structural independent components).
- The seismic hazard model results from a scenario analysis with Openquake-engine which simulates the 1978 Thessaloniki earthquake.
- We use the GEM fragility curves proposed by Martins and Silva (2020).
- The herein proposed methodology proved to give more realistic results in order to make a prioritization strategy for strengthening and retrofitting actions for school buildings.

...There is long way to go, but we are on good track.
Recent publications...(01)


Recent publications...(02)


Rήγα Ε, Καρατζέτζου Α, Παναγόπουλος Γ., Αποστολάκη Σ., Πιτιλάκης Κ. Μεθόδολογία αποτίμησης της σεισμικής διακινδύνευσης πόλεων. Η περίπτωση της Θεσσαλονίκης. 4ο Πανελλήνιο Συνέδριο Αντισεισμικής Μηχανικής και Τεχνικής Σεισμολογίας, Αθήνα, Ελλάδα, 5-7 Σεπτεμβρίου 2019.


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Ευχαριστώ πολύ!
Thank you!

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