EUROCODE 8, PART 3 AND THE ROMANIAN SEISMIC CODE FOR THE ASSESSMENT OF EXISTING BUILDINGS, P100-3: SIMILARITIES AND DIFFERENCES

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EUROCODE 8, PART 3 AND THE ROMANIAN SEISMIC CODE FOR THE ASSESSMENT OF EXISTING BUILDINGS, P100-3: SIMILARITIES AND DIFFERENCES

- About ECBR

- Background
  - Seismicity and seismic hazard in Romania
  - Vulnerability of existing buildings
  - Seismic assessment and rehabilitation programs: legal framework and application

- Regulatory framework
  - Past and present of Romanian regulatory framework concerning seismic rehabilitation of existing buildings
  - Implementation of EN 1998-3:2005
EUROCODE 8, PART 3 AND THE ROMANIAN SEISMIC CODE FOR THE ASSESSMENT OF EXISTING BUILDINGS, P100-3/2008
SIMILARITIES AND DIFFERENCES

  - Romanian National Annex to EN 1998-3:2005
  - Comparisons with U.S. standards
  - Benchmarking study

- Conclusions
ECBR - European Center for Building Rehabilitation

- The establishment of the Center was decided at the 10th Ministerial Session of EUR-OPA Major Hazard Agreement (2003)
  - Technical activities devoted to:
    - Preparation of regulatory framework for building rehabilitation and risk mitigation
    - Strengthening of building structures damaged by earthquakes
    - Mitigation of effects of natural disasters, including earthquake education
    - Rehabilitation of building envelope and building equipment
    - Other activities related to hazard, vulnerability and risk management

- ECBR benefits from the facilities of INCERC Bucharest Branch laboratories
- Promotes partnership with specialized institutions, agencies and authorities related to building design and building rehabilitation from Romania, UE and world-wide
Background: Seismicity and seismic hazard in Romania

**Vrancea zone** – located at the Carpathian arc bend

- Strong earthquakes that affect Romania, Moldova, a large part of Bulgaria and south-western Ukraine

- Total area influenced by Vrancea earthquakes: 300,000 km²

- 25 million people in affected areas; 2 capitals, 2 NPPs

- Other important seismogenic zones: Banat, Fagaras
Background: Seismicity and seismic hazard in Romania

Other strong Vrancea earthquakes that caused severe damage and live losses, in Romania and in neighboring countries:

- **November 10, 1940 (M=7.4)**
- **August 30, 1986 (M=7.0)**
Background: Vulnerability of existing buildings
Background: Seismic assessment and rehabilitation programs

- In the early 90s, the Romanian government initiated a program of seismic assessment of buildings at risk, entirely financed from public funds (i.e. totally free for owners).

- In case structural intervention would have been necessary, owners would have had to pay one-third of the cost of seismic rehabilitation, the rest being supported by the government and the municipality.
Background: Vulnerability of existing buildings

- However, even though a very large number of buildings were seismically assessed, only few were also retrofitted.

- Among the main causes there were:
  - Intervention could be performed only with the agreement of all owners, which was very difficult to obtain in case of multi-apartment buildings.
  - The reluctance of most occupants to leave the building during rehabilitation works, even if temporary housing was provided by the government.
  - The concerns about mortgages associated with loans on a 20-year term, which were needed to cover the amount of rehabilitation cost paid by the owners.
# Background: Vulnerability of existing buildings

The Ministry of Public Works and the municipalities regularly publish the updated lists of seismically assessed buildings in Bucharest and in all counties, with the corresponding risk classes.

<table>
<thead>
<tr>
<th>Nr</th>
<th>Adresa Imobiliara</th>
<th>Nr.</th>
<th>Sector</th>
<th>An construit</th>
<th>Regim statal</th>
<th>Nr. apart.</th>
<th>Aria dezestimsata</th>
<th>An expertizat</th>
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<th>Ob.</th>
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<tbody>
<tr>
<td>2</td>
<td>Strada C. A. ROSETTI</td>
<td>28</td>
<td>2</td>
<td>1933</td>
<td>S+P+8E</td>
<td>38</td>
<td>4.013</td>
<td>1993</td>
<td>PRE. BUC. D. CARANCI D. BADEA</td>
<td>PJRTL 43/02/05.2007</td>
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<tr>
<td>3</td>
<td>Strada C. A. ROSETTI</td>
<td>44</td>
<td>2</td>
<td>1933</td>
<td>S+P+28M+Ma</td>
<td>10</td>
<td>1.003</td>
<td>1995</td>
<td>PROBEJ BUC. - A. SIMION</td>
<td>PJRTL 78/05/05.2004</td>
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<tr>
<td>5</td>
<td>Strada COVACI</td>
<td>1</td>
<td>3</td>
<td>1880</td>
<td>S+P+17E+Ma</td>
<td>5</td>
<td>911</td>
<td>1993</td>
<td>GEROM - I. VARGA</td>
<td>PJRTL 20/05.2007</td>
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<tr>
<td>6</td>
<td>Strada GHEORGHE MANEA</td>
<td>10</td>
<td>3</td>
<td>1900</td>
<td>S+P+2E</td>
<td>0</td>
<td>672</td>
<td>1993</td>
<td>PROGRAMEANU AL. ALEXANDRU</td>
<td>PJRTL 23/09/05.2007</td>
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<tr>
<td>7</td>
<td>Bulv.ul CHERNOSHE MIRINESCU</td>
<td>3</td>
<td>4</td>
<td>1946</td>
<td>S+P+1E</td>
<td>3</td>
<td>1.752</td>
<td>1997</td>
<td>A. CIOCOLA</td>
<td>PJRTL nr. 1/05.01.2004</td>
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<tr>
<td>8</td>
<td>Strada ION VADARESCU</td>
<td>36</td>
<td>5</td>
<td>1985</td>
<td>S+P+1E</td>
<td>3</td>
<td>580</td>
<td>1995</td>
<td>BALAN M. CRISTIAN</td>
<td>PJRTL 11/05/05.2012, AC 47/01.09.2011, AC 55/24.98</td>
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<tr>
<td>15</td>
<td>Strada IULIU PASTEUR</td>
<td>26</td>
<td>5</td>
<td>1936</td>
<td>S+P+13E+Ma</td>
<td>8</td>
<td>1.263</td>
<td>1990</td>
<td>MIRA - M. MIRA</td>
<td>PJRTL 19/09.2002</td>
</tr>
<tr>
<td>16</td>
<td>Strada MIHAI EMINESCU</td>
<td>17</td>
<td>1</td>
<td>1937</td>
<td>S+P+7E+M</td>
<td>40</td>
<td>6.005</td>
<td>1995</td>
<td>PROCESMA</td>
<td>PJRTL 20/10.09.1995</td>
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<td>19</td>
<td>Strada IFANTUL LEETERIE</td>
<td>11</td>
<td>5</td>
<td>1938</td>
<td>P+DeM</td>
<td>10</td>
<td>1.262</td>
<td>1997</td>
<td>D. ARSEN</td>
<td>PJRTL 19/09.2002</td>
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</tbody>
</table>
Background: Vulnerability of existing buildings

Source: http://www.riscseismic.ro/
Romanian regulatory framework for seismic design, assessment & rehabilitation of buildings

Romania: Seismic regulation timeline

- **1941** – First provisional instructions for the seismic design of buildings
- **1945, 1958** – Instructions and tentative standard for seismic design
- **1963** – First seismic design code; revised in **1970** (*P13-63, P13-70*)
- **1978** – Major revision of seismic design code and macrozonation map after the $M_w=7.4$ Vrancea earthquake (*P100-78*)
- **1992** – Major revision of seismic code and macrozonation map, incorporating conclusions after the **1986** ($M_w=7.1$) and **1990** ($M_w=6.9$ and $M_w=6.4$) Vrancea earthquakes (*P100-92*); additions in **1996**
  - 2 chapters dedicated to seismic assessment and rehabilitation
  - quantitative assessment based on the seismic safety factor “R”
  - decision of structural intervention – depending on R value
Romanian regulatory framework for seismic design, assessment & rehabilitation of buildings

Romania: Seismic regulation timeline (continued)

- **2006** – First Romanian seismic code harmonized with EN 1998-1:2004 (P100-1/2006)
- **~ 2004...2010** – Translation and adoption of Eurocodes as National Standards (SR EN); enforcement of National Annexes
- **2009** – Enforcement of the Romanian code for the seismic assessment of existing buildings (P100-3/2008)
- **2013** – Commentary and examples for P100-3/2008
- **January 2014** – Estimated date for the enforcement of the new edition of the Romanian seismic design code (P100-1/2012)
Comparative analysis of Romanian, EU and US codes for the seismic assessment of existing buildings

### Synthetic Table

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<tbody>
<tr>
<td><strong>Performance-based assessment</strong></td>
<td>YES</td>
<td>≡ EN 1998:3-2005</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>- State of damage in the structure - defined based on limit states</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>- Seismic hazard levels - defined based on the mean recurrence interval (MRI) and on the corresponding probabilities of exceedance</td>
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</tr>
<tr>
<td><strong>Limit states</strong></td>
<td></td>
<td>NA: choice of limit states to be checked: 1. Life Safety (≡SD renamed) 2. Damage Limitation (DL) Chosen for similar significance with LS for new buildings</td>
<td>1. Ultimate limit state, ULS (Life safety requirement) 2. Serviceability limit state, SLS (Damage limitation requirement) Note: For ordinary buildings, check for SLS is not compulsory</td>
<td>1. Life Safety, 3-C 2. Immediate Occupancy, 1-B</td>
<td></td>
</tr>
<tr>
<td>1. Near Collapse (NC) 2. Significant Damage (SD) 3. Damage Limitation (DL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Distinction between ductile and fragile structural elements</strong></td>
<td>YES + Primary seismic and secondary seismic elements, according to EN 1998-1:2004 EC8-3 clause 2.2.1.6(P)</td>
<td>≡ EN 1998:3-2005</td>
<td>YES</td>
<td>YES</td>
<td>≡ ASCE/SEI 31-03 &amp; 41-06</td>
</tr>
</tbody>
</table>
Comparative and benchmarking studies for the evaluation of the Romanian code for seismic assessment of existing buildings

- Analysis on two R/C medium-rise multistory buildings
  1. frames
  2. shear walls
- Comparative assessment of seismic safety degrees or of equivalent criteria, according to the considered codes
- Objective: evaluation of code performance, suggestions for potential future improvement of the Romanian code
Comparative and benchmarking studies for the evaluation of the Romanian code for seismic assessment of existing buildings

- Buildings chosen for poor seismic performance: post-elastic incursions in most structural elements, damage in 1st floor columns, story mechanisms in upper levels

P100-3:2008

- The assessment by the 1st, 2nd and 3rd level methods resulted in a degree of seismic structural safety of min. 0.52...0.58 (RsII)
Comparative and benchmarking studies for the evaluation of the Romanian code for seismic assessment of existing buildings

**EN 1998-3:2005 & NA**

- Overall verification in terms of displacement, based on nonlinear static analysis: results close to those obtained acc. to P100-3/2008

- Overall verification in terms of displacement, based on nonlinear static analysis: slightly more severe results, without modifying general conclusions on building state

- Verification based on nonlinear dynamic analysis: due to the different formulas used to evaluate plastic rotation, results less severe than P100-3 were obtained; however, differences were small
Comparative and benchmarking studies for the evaluation of the Romanian code for seismic assessment of existing buildings

**ASCE/SEI 31-03**

- Less severe or qualitatively similar results as compared to EN & P100
- Inelastic displacements smaller than for EN & P100
- Significant differences concerning verification criteria – qualitative comparisons
Comparative and benchmarking studies for the evaluation of the Romanian code for seismic assessment of existing buildings

**ASCE/SEI 41-06**

- Strength demands for linear analysis are greater than those corresponding to EN & P100

- Displacement demands for nonlinear analysis are smaller, as compared to EN & P100 – different calibration of displacement amplification factors in the US standard, for the analysed case
Comparative and benchmarking studies for the evaluation of the Romanian code for seismic assessment of existing buildings

Conclusions of the study

• Quantitative differences between evaluations performed according to considered codes

• General conclusions concerning building state – quite similar

• Largest differences – those among Romanian & European codes, on one part, and U.S. codes, on the other part
Thank you for your attention!