COUNCIL OF EUROPE/EUROPEAN CENTRE ON PREVENTION AND FORECASTING OF EARTHQUAKES (ECPFE)
EARTHQUAKE PLANNING AND PROTECTION ORGANIZATION (EPPO)
WORKSHOP "IMPLEMENTATION OF THE EC 8-p.3:2005 - ASSESSMENT AND INTERVENTIONS ON BUILDINGS IN EARTHQUAKE PRONE AREAS"
ATHENS, APRIL 12, 2013

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

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Bucharest, Romania

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

- **Comparison between EN 1998-3:2005 and the Romanian code for the assessment of existing buildings, P100-3/2008**

  plus:

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

- **Conclusions**

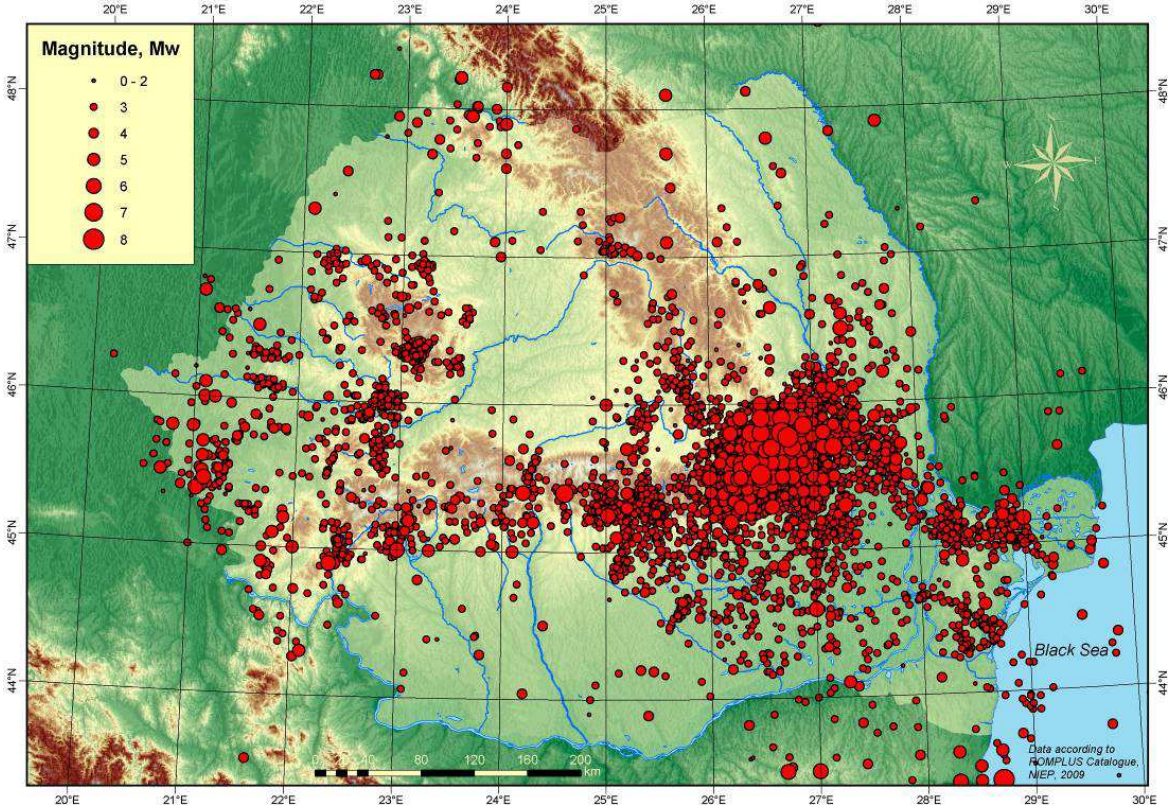
ECBR - European Center for Building Rehabilitation

- 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**

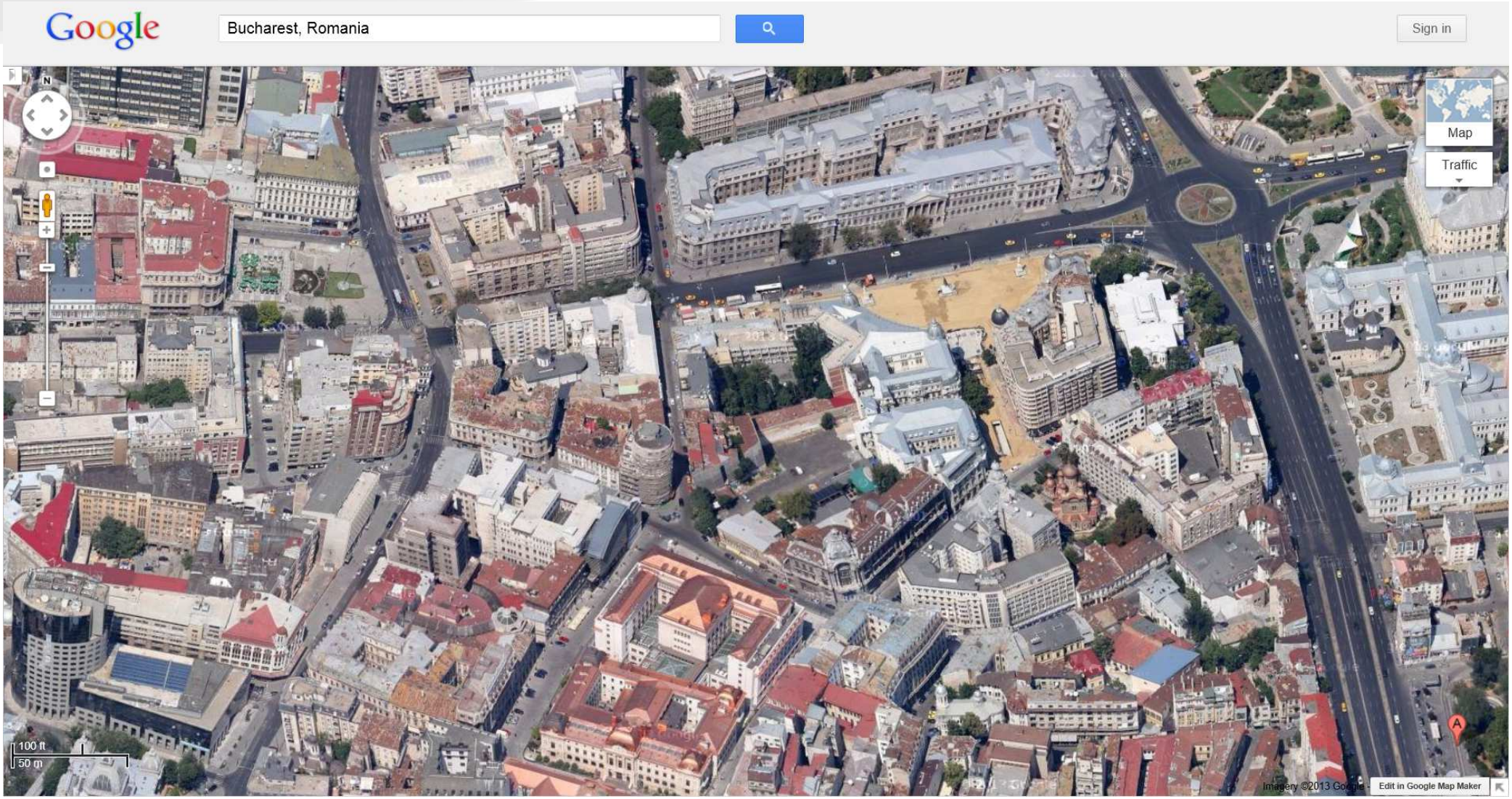
Background: Seismicity and seismic hazard in Romania

March 4, 1977 (M=7.2)

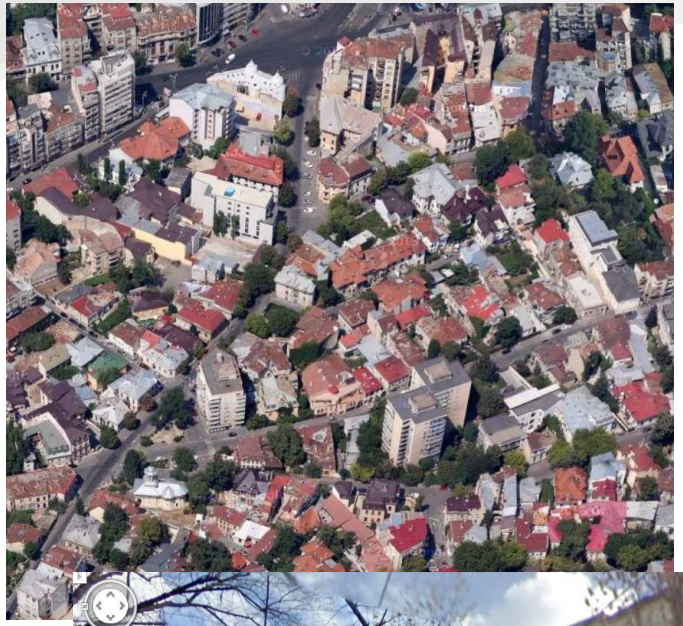
Other strong Vrancea earthquakes that caused severe damage and live losses, in Romania and in neighboring countries:

- **November 10, 1940 (M=7.4)**
- **August 30, 1986 (M=7.0)**

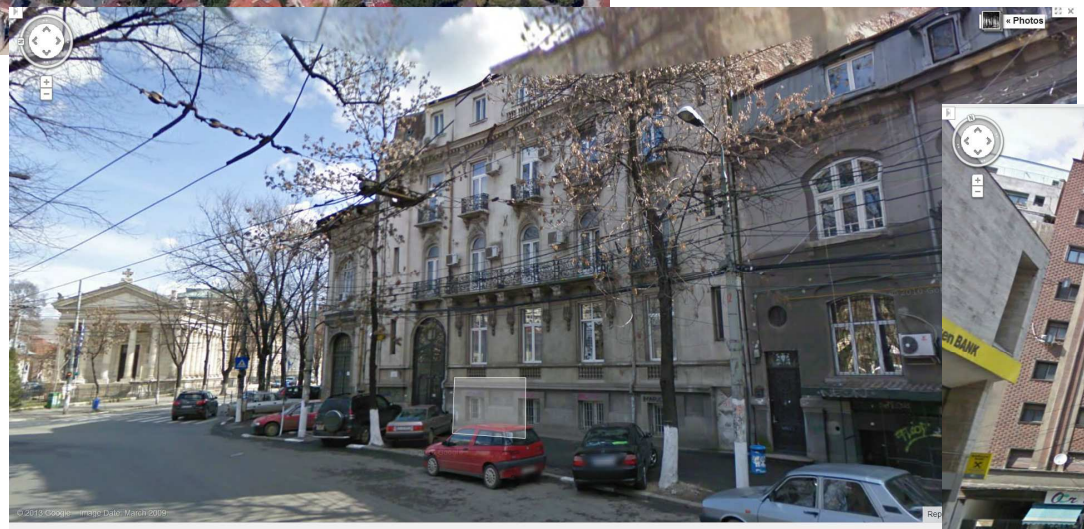
Background: Vulnerability of existing buildings



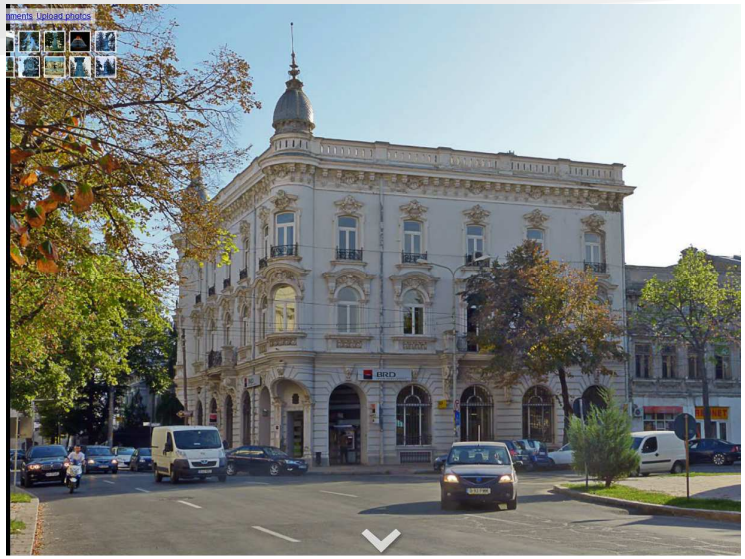
Background: Seismic assessment and rehabilitation programs

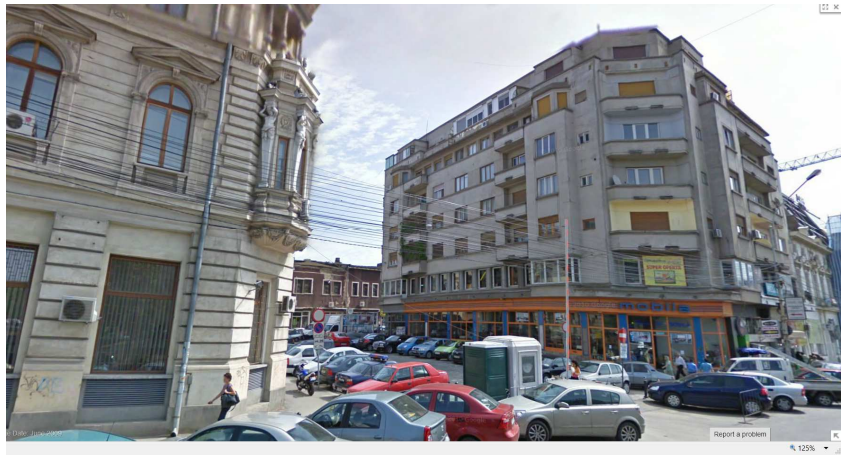


- In the early 90s, the Romanian government initiated a program of seismic assessment of buildings at risk, entirely financed from public funds (i.e. totally free for owners)
- In case structural intervention would have been necessary, owners would have had to pay one-third of the cost of seismic rehabilitation, 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 <u>all</u> 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

01.04.2013

LISTA IMOBILELOR EXPERTIZATE TEHNIC DIN PUNCT DE VEDERE AL RISCULUI SEISMIC CONSOLIDATE

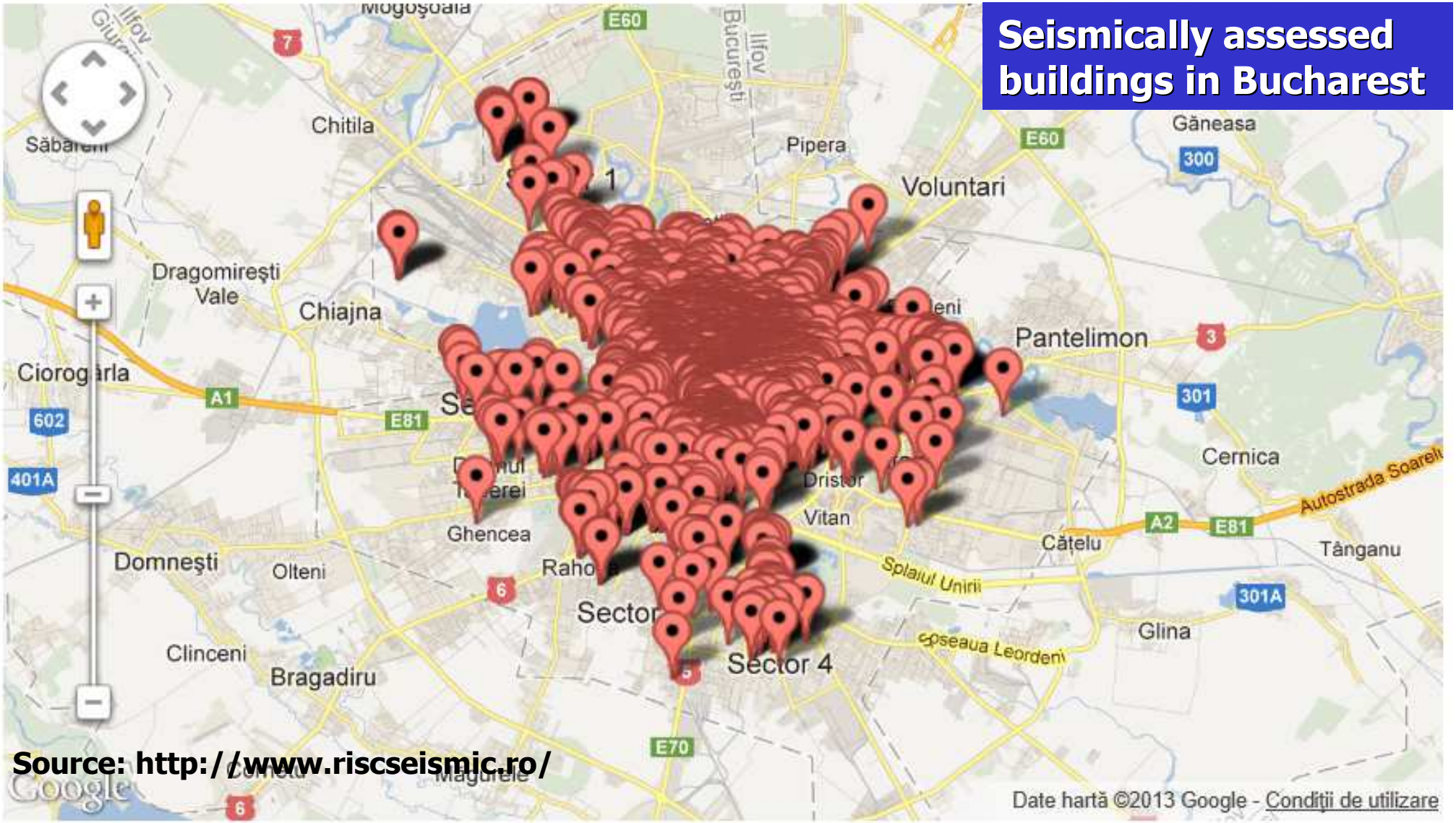
Detalii si informatii pot fi obtinute de la P.M.B. - Directia Generala de Dezvoltare, Investitii si Planificare Urbana - Directia de Investitii - Serviciul Consolidari
Splaiul Independentei nr. 291-293, sector 6. Telefon: 021-305.55.55 interior 1502

actualizat la 01.04.2013

Nr crt	Adresa imobilului			An construire	Regim inaltime	Nr. apart.	Arie desfasurata	An expertiza	Expert atestat	Obs.
	Adresa	Nr	Sector							
1	Strada BARBU MUMULEANU	11	2	1934	Ds+P+2E+M	5	431	1996	URSACHESCU E. MIHAI: U3 1996	Consolidat: PVRTL 65177/25.09.2009
2	Strada C.A. ROSETTI	25	2	1933	S+P+8	36	4,013	1993	PR. BUC. - S. CARAMAN; D. BADEA	PVRTL 438/22.05.2007
3	Strada CA ROSETTI	44	2	1933	S+P+3E+Ma	10	1,030	1993	PROIECT BUC. - A. SIMION	PVRTL 7875/05.03.2004
4	Strada COLTEI	44	3	1908	S+P+2E+Ma	17	1,775	1993	MIRONESCUT. MIRCEA	PVRCTL 867900/26.10.2009; AC 55/782742/12.11.2008
5	Strada COVACI	1	3	1880	S+P+1E+Ma	5	911	1993	GEROM - I. VARSA	
6	Strada GHEORGHE MANEA	15	3	1936	S+P+2E	5	672	1993	PROGRESEANU AL. ALEXANDRU	PVRTL 233/09.05.2007
7	Bulevardul GHEORGHE MARINESCU	3	5	1940	S+P+6	20	1,750	1997	A. CAZACLIU	PVRTL nr. 1 / 05.04.2004
8	Strada IENACHITA VACARESCU	36	4	1885	S+P+1E	3	580	1993	BALAN I. CRISTIAN	PVRTL 1112533/17.10.2012; AC 472/01.08.2011; AC 687/24.09.2012
9	Strada ION FLORESCU - Corp A+B	13	3	1918	S+P+2E; S+P+3E	14	1,744	1993		PVRTL 6097/19.12.1996; AC 7F/25.04.1994 / PMB; PROIECT 2460/93 / SC CENTR ISTORIC SA
10	Strada ION BREZOIANU	44	1	1937	P+9	28	2,532	1997	MIRALEX - A. PRETORIAN - ICI 1999	PVRTL 4349/5081/24.10.2007
11	Strada IULIU BARASCH	12	3	1936	S+P+6+M	15	1,640	1994	D. STANCI	
12	Strada JEAN LOUIS CALDERON	59	2	1935	S+P+M+7	19	3,706	1993	MIDA - TIT.	
13	Bulevardul LASCAR CATARGIU	15A	1	1934	S+P+5+Pd	17	2,351	1998	MIDA - M.	
14	Bulevardul LASCAR CATARGIU	48	1	1880	S+P+1E+Ma	7	716	1993	D. POPES	
15	Strada LOUIS PASTEUR	30	5	1936	S+P+3E+Ma	8	1,283	1997	MIDA - E. T	
16	Strada MIHAI EMINESCU	17	1	1937	S+P+7+M	40	6,050	1995	PROCEMA	
17	Bulevardul NICOLAE BALCESCU	25	1	1928	2S+P+11E	98	12,318	1994	PR. BUC. -	
18	Bulevardul NICOLAE BALCESCU	24	1	1928	S+P+12	119	12,031	1995	METROU -	
19	Strada SFANTUL ELEFTERIE	11	5	1936	P+4+M	10	1,295	1997	G. ARSENI	
20	Strada PALEOLOGU	3	2	1936	P+5	20	3,414	1993	CONCEPT	
21	Strada PETRE CRETU	68	1	1936	S+P+1E+Ma	3	651	1993	NAVODAR 1995	
22	Strada PLANTELOR	45 CORP B	2	1895	S+P+1E+Ma	3	147	1993	IPCT - M. U	
23	Strada RADU CALOMFIRESCU	13	3	1891	S+P+1E	5	823	1993	REMON - L	
24	Strada SALCAMILOR	12	2	1936	S+P+4+M	10	2,396	1993	ORION - M	

- **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**

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)

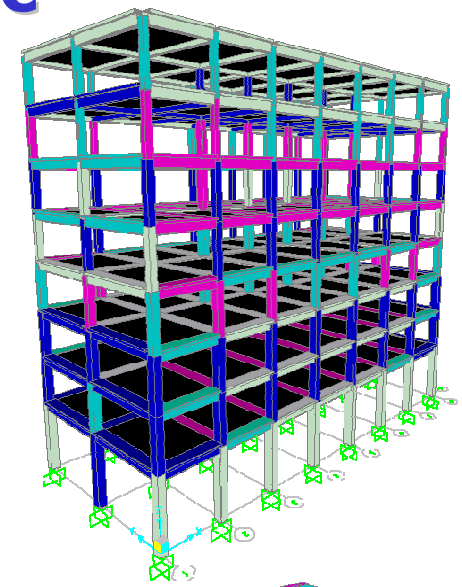
- **2006** – First Romanian seismic code harmonized with EN 1998-1:2004 (**P100-1/2006**)
- **~ 2004…2010** – Translation and adoption of Eurocodes as National Standards (**SR EN**); enforcement of National Annexes
- **2009** – Enforcement of the Romanian code for the seismic assessment of existing buildings (**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

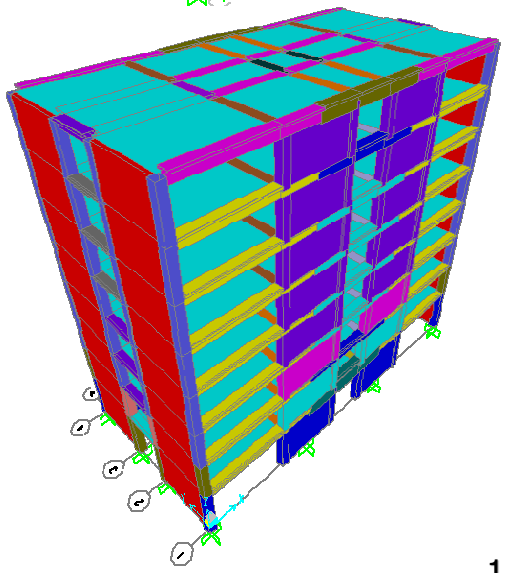
Synthetic Table

Features	EN 1998:3-2005	SR EN 1998:3-2005 & NA for Romania	P100-3/2008 - Evaluation	ASCE/SEI 31-03	IEBC 2009
Performance-based assessment	**YES** ▪ State of damage in the structure - defined based on limit states ▪ Seismic hazard levels - defined based on the mean recurrence interval (MRI) and on the corresponding probabilities of exceedance EC8-3 Section 2.1	**≡ EN 1998:3-2005**	**YES** ▪ Performance objectives ▪ 3 performance levels for specified seismic hazard levels	**YES**	**YES**
Limit states	1. *Near Collapse* (NC) 2. *Significant Damage* (SD) 3. *Damage Limitation* (DL)	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	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	1. *Life Safety*, 3-C 2. *Immediate Occupancy*, 1-B	1. *Life Safety* 2. *Immediate Occupancy* 3. *Collapse Prevention*
Distinction between ductile and fragile structural elements	**YES** + *Primary seismic* and *secondary seismic* elements, according to EN 1998-1:2004 EC8-3 clause 2.2.1.6(P)	**≡ EN 1998:3-2005**	**YES**	**YES** Deformation/Force-controlled elements ("ductile" / "brittle") + *Primary seismic* and *secondary seismic* elements	**≡ ASCE/SEI 31-03 & 41-06**

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
- **P100-3/2008, EN 1998-3:2005 & NA, ASCE 31-03, ASCE 41-06**
- 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



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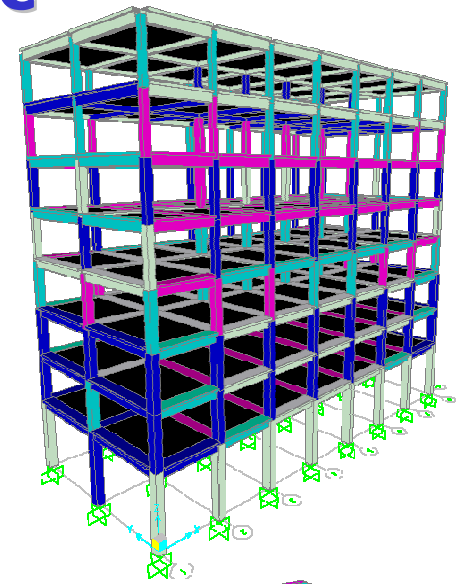
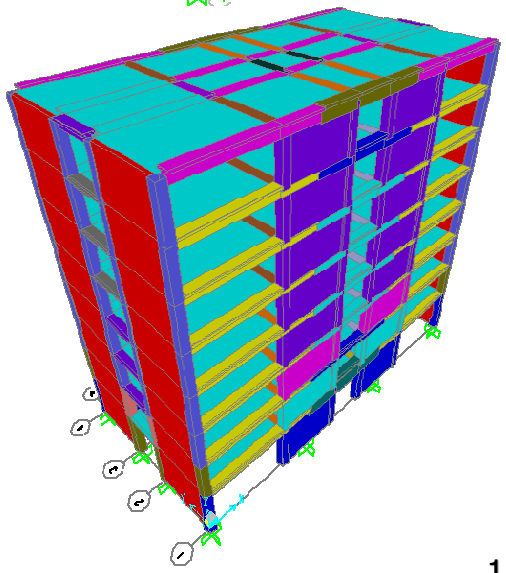


- Buildings chosen for poor seismic performance: post-elastic incursions in most structural elements, damage in 1st floor columns, story mechanisms in upper levels

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)



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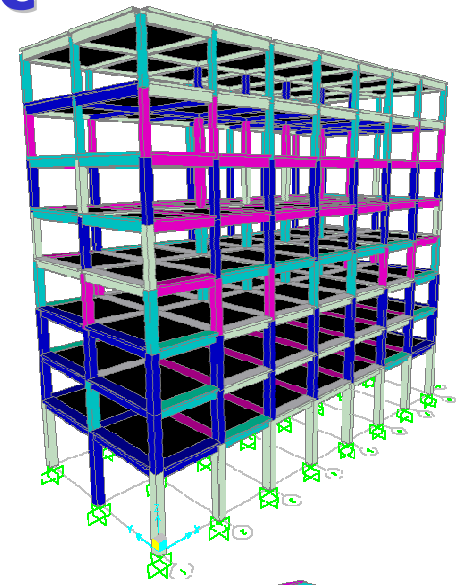
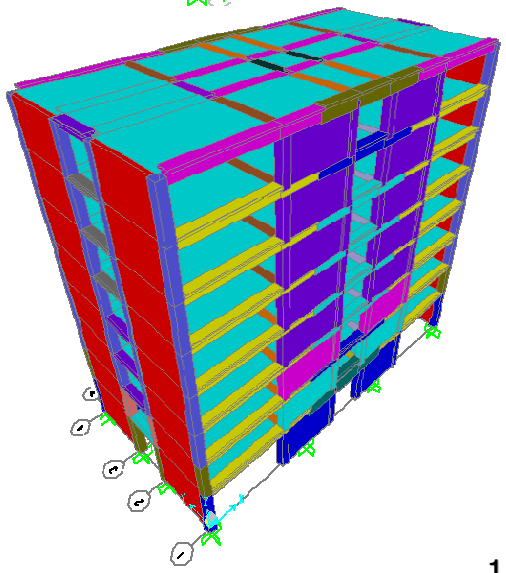


EN 1998-3:2005 & NA

- 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



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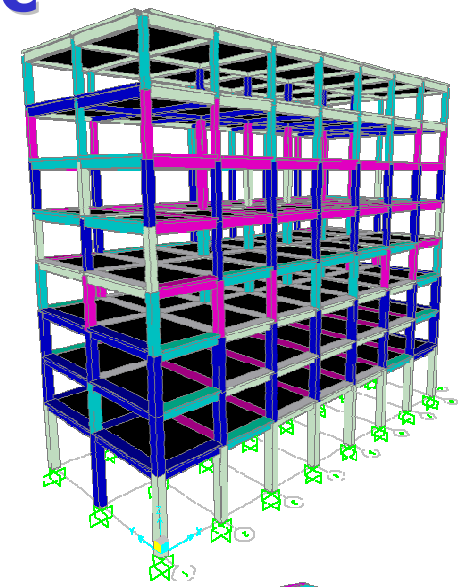
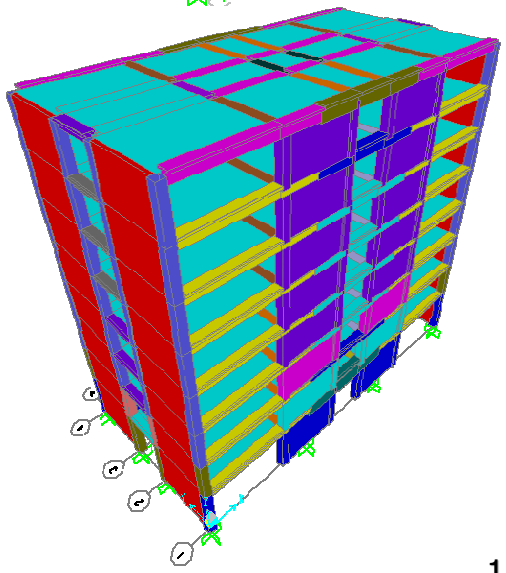


ASCE/SEI 31-03

- 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



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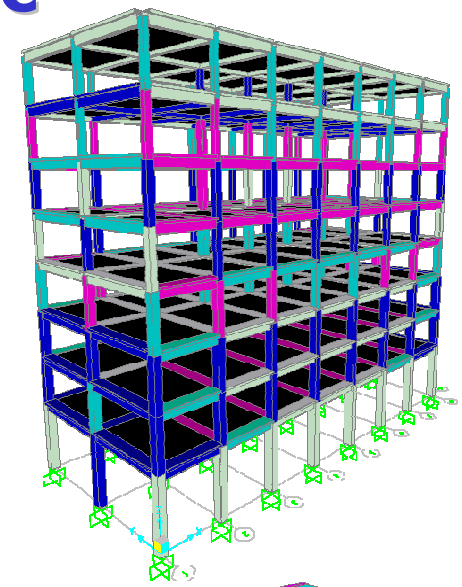
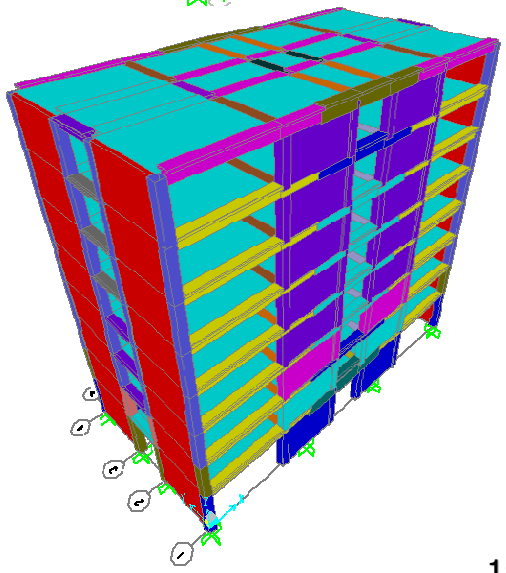


ASCE/SEI 41-06

- 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



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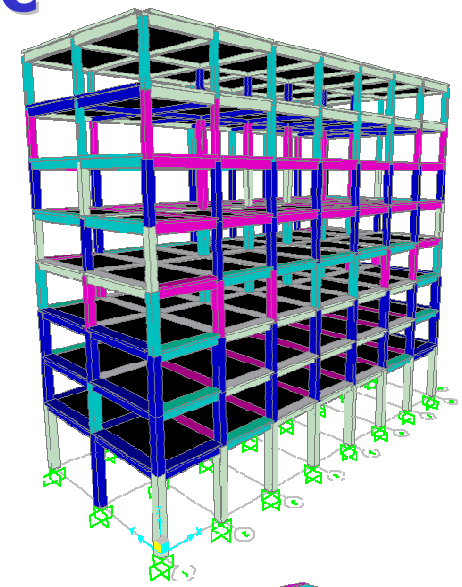
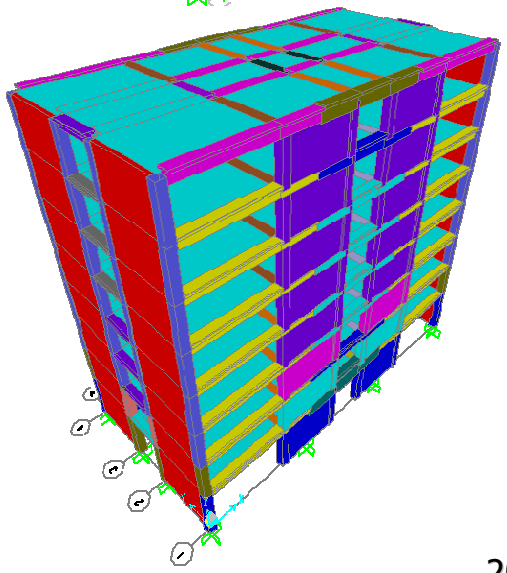


Conclusions of the study

- 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!