Design and Building Practice, Anti-Seismic Building Codes in Central European Carpathian Region, Hungary and Romania

Dr. Ing KEGYES Csaba and
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NEMZETI INNOVÁCIÓS HIVATAL

ANTI-SEISMIC BUILDING CODES IN THE CENTRAL EUROPEAN CARPATHIAN REGION, HUNGARY AND ROMANIA: DESIGN- AND BUILDING PRACTICE.

Dr. KEGYES Csaba (Hungary), Dr. GOBESZ F. Zsongor (Romania)

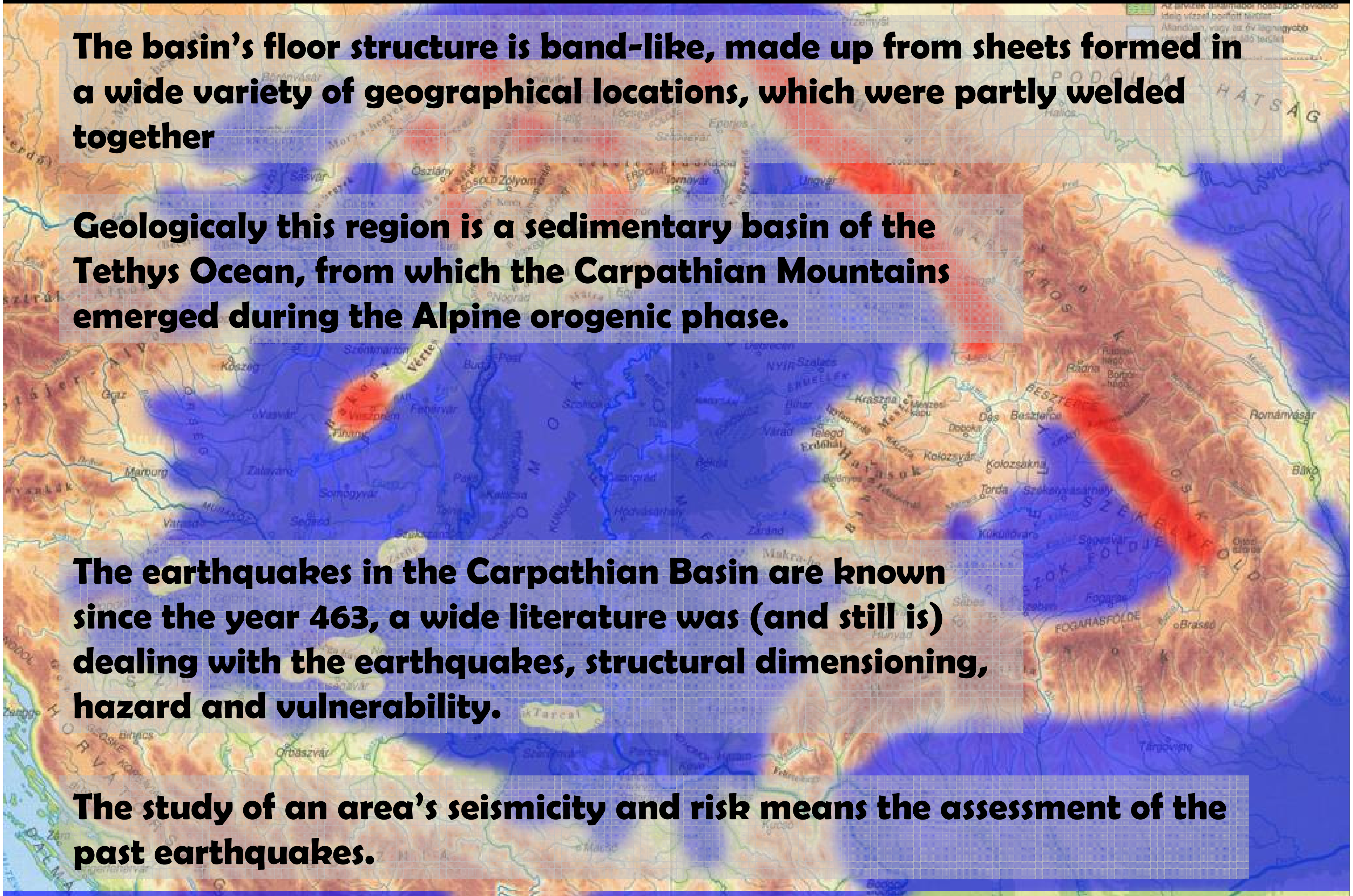
The Seismicity of the Carpathian Basin and of the Region

The basin's floor structure is band-like, made up from sheets formed in a wide variety of geographical locations, which were partly welded together

Geologicaly this region is a sedimentary basin of the Tethys Ocean, from which the Carpathian Mountains emerged during the Alpine orogenic phase.

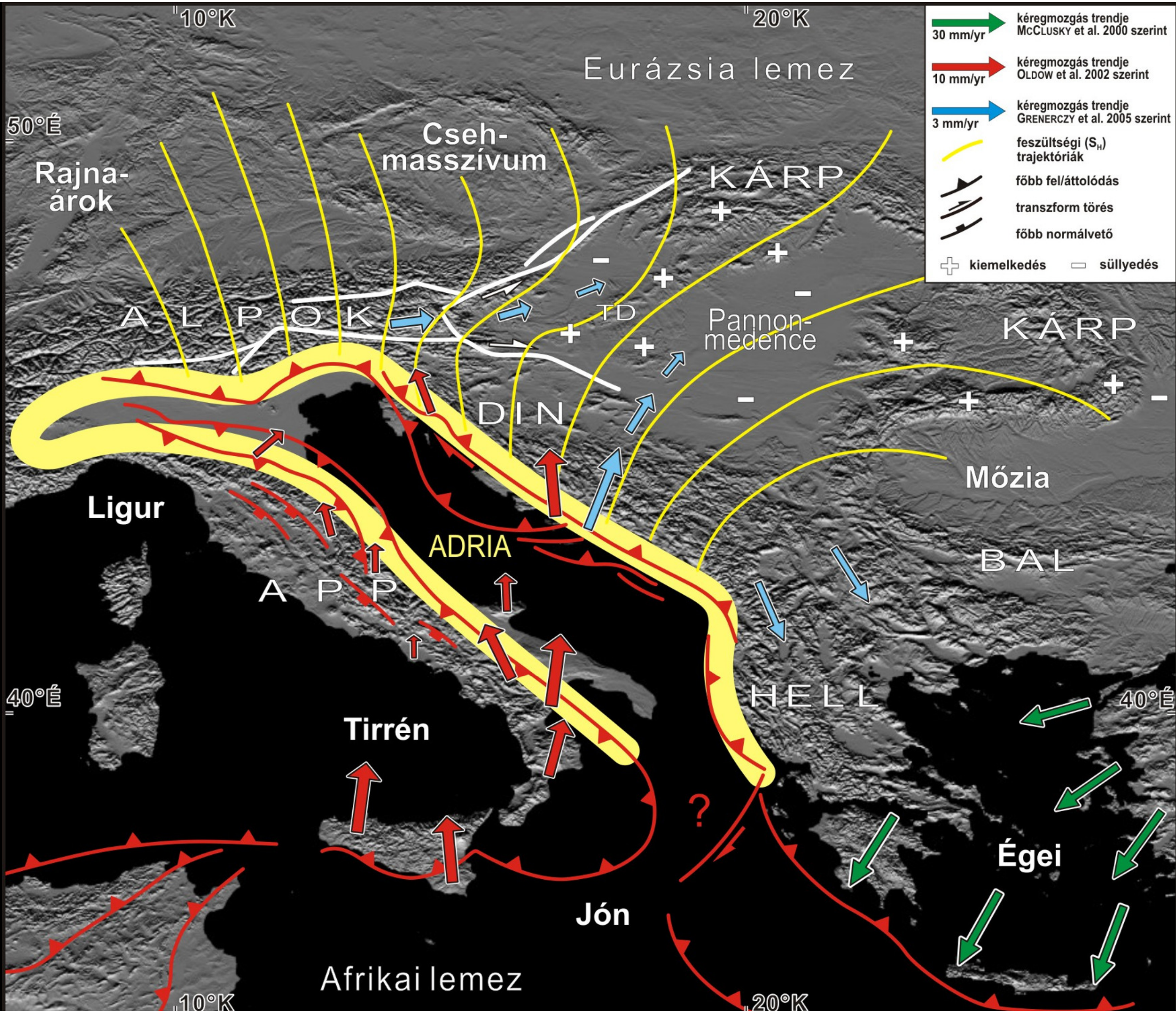
The earthquakes in the Carpathian Basin are known since the year 463, a wide literature was (and still is) dealing with the earthquakes, structural dimensioning, hazard and vulnerability.

The study of an area's seismicity and risk means the assessment of the past earthquakes.



The Pliocene Sea of the Carpathian Basin

The movement of the plates

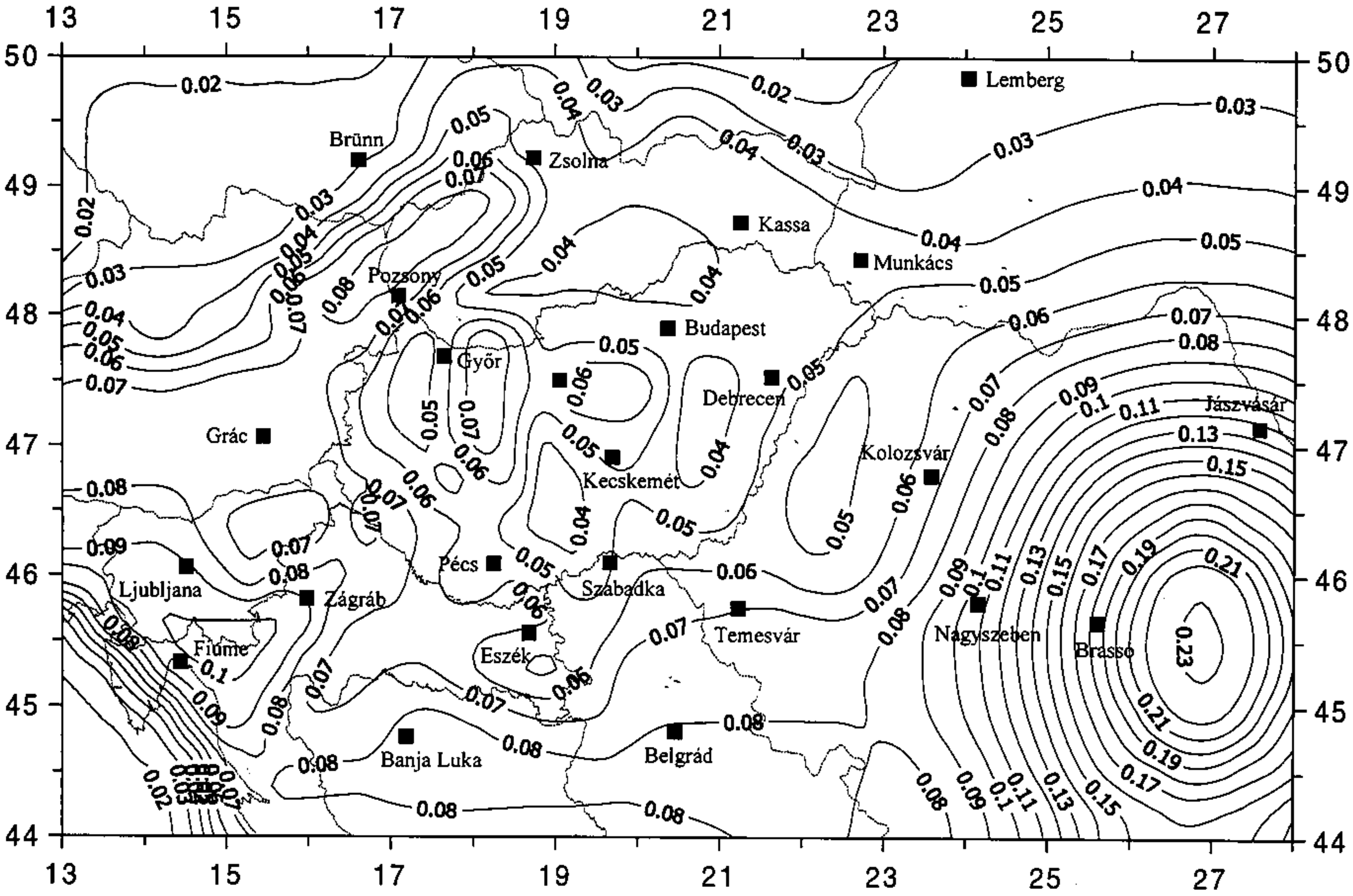


The seismicity can be displayed probably in the best way through the expected ground accelerations between two distant cities:

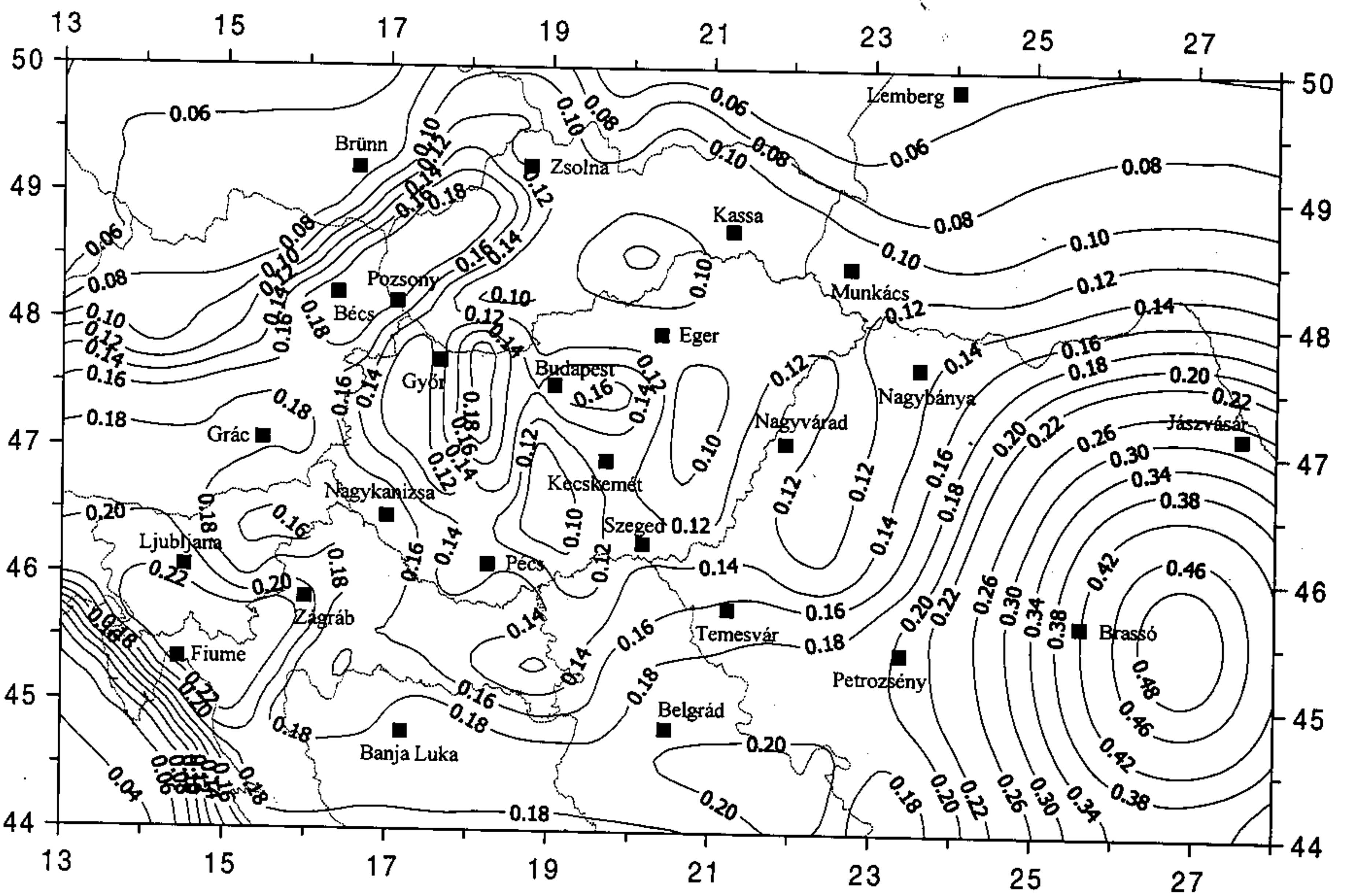
Cluj-Napoca, in the middle of the Transylvanian Basin, and

Győr, a major settlement in “Kisalföld” (Little Plane).

Period	Standard deviation (σ)	Probability	Peek acceleration (.ag [g]) Győr	Peek acceleration (.ag [g]) Cluj-Napoca
50 years	0.00	75%	0.05 – 0.06	0.06 – 0.07
100 years	0.00	75%	0.06 – 0.08	0.08
250 years	0.00	75%	0.08 – 0.10	0.08 – 0.10
50 years	0.50	75%	0.08	0.08 – 0.10
100 years	0.50	75%	0.10 – 0.12	0.10 – 0.12
250 years	0.50	75%	0.12	0.14 – 0.16



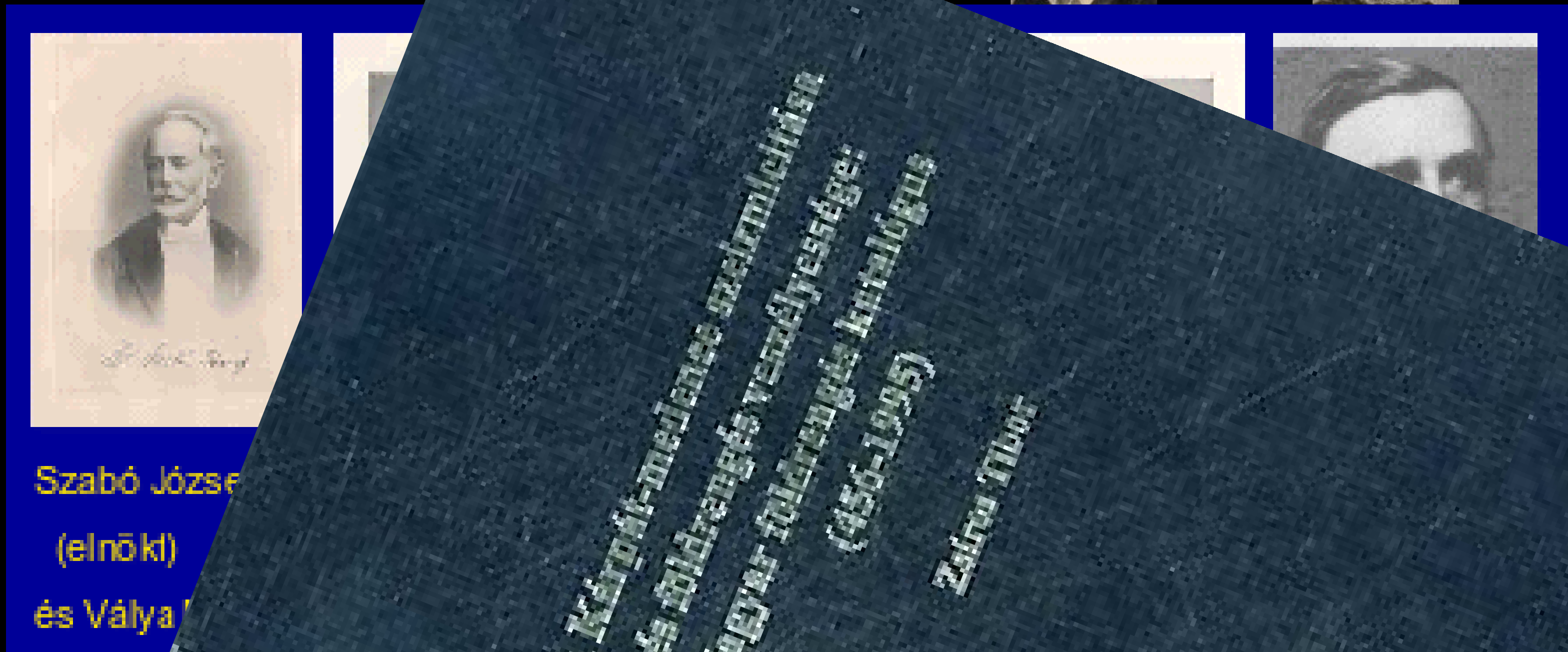
The horizontal peak acceleration values (g) with standard deviation σ = 0, considering 75% probability of no exeedance within 50 years, in the Carpathian Basin.



The horizontal peak acceleration values (g) with standard deviation σ = 0.5, considering 75% probability of no exeedance within 250 years, in the Carpathian Basin.

Historical Earthquakes in the Carpathian Basin

Studies:



314),

359),

1880 - 8

Measuring instruments p

rzik)

Earthquakes in the Carpathian Basin during

Réthly (1952): 455 – 1918, 1997 earthqua
Csomor and Király (1962): 1880 – 1956, 873 ear
Zsíros, Mónus and Tóth (1988): 5022 earthquakes,
Zsíros (2000): totally **20,478** earthquakes...

Historical Earthquakes in the Carpathian Basin

Date	Epicenter	.m	I0	Location
Major earthquakes during the years 456 – 1600:				
456.09.07	47.24N, 16.62E	6.3	9.0	Savaria / Szombathely (HU)
1107.02.12	45.70N, 26.60E	5.9	7.0	Vráncsaföld / Vrancea (RO)
1196.02.13	45.70N, 26.60E	6.4	8.0	Vráncsaföld / Vrancea (RO)
1599.08.04	45.70N, 26.60E	5.9	7.0	Háromszéki havasok / Vrancea Mountains (RO)
1599.10.01	47.76N, 18.12E	5.6	8.0	Komárom / Komarno (SK)
Major earthquakes during the years 1601 – 1700:				
1604.05.03	45.70N, 26.60E	6.4	8.0	Háromszéki havasok / Vrancea Mountains (RO)
1605.12.24	45.70N, 26.60E	6.4	8.0	Vráncsaföld / Vrancea (RO)
1660.02.08	45.70N, 26.60E	5.6	6.5	Vráncsaföld / Vrancea (RO)
1681.08.19	45.70N, 26.60E	6.4	8.0	Vráncsaföld / Vrancea (RO)
1681.11.24	45.60N, 26.00E	4.3	4.0	Barcaság / Burzenland (RO)
Major earthquakes during the years 1701 – 1800:				
1701.06.12	45.70N, 26.60E	6,2	7,5	Vráncsaföld / Vrancea (RO)
1703.07.28	48.86N, 20.93E	4,6	6,5	Gölnitz / Gelnica (SK)
1711.10.11	45.70N, 26.60E	5,9	7,0	Háromszéki havasok / Vrancea Mountains (RO)

.m – *measured magnitude;* I0 – *epicentral intensity*

Historical Earthquakes in the Carpathian Basin

Date	Epicenter	.m	I0	Location
Major earthquakes during the years 1801 – 1900:				
1802.10.26	45.70N, 26.60E	7.2	9.5	Háromszéki havasok / Vrancea Mountains (RO)
1802.11.07	45.70N, 26.60E	5.4	6.0	Háromszéki havasok / Vrancea Mountains (RO)
1900.01.29	46.01N, 21.13E	3.9	5.5	Vinga – Varjas / Vinga – Varias (RO)
Major earthquakes during the years 1901 – 1995:				
1901.04.02	45.51N, 20.64E	5.0	7.0	Nagytorák / Begejci (SRB)
1908.10.06	45.50N, 26.50E	6.8	8.0	Háromszéki havasok / Vrancea Mountains (RO)
1929.11.01	45.90N, 26.50E	6.2	6.5	Kézdivásárhely / Targu Secuiesc (RO)
1934.03.29	45.80N, 26.50E	6.6	8.0	Vráncsaföld / Vrancea (RO)
1940.10.22	45.76N, 26.42E	6.2	7.0	Komandó / Comandău (RO)
1940.11.10	45.77N, 26.73E	7.3	9.0	Háromszéki havasok / Vrancea Mountains (RO)
1977.03.04	45.77N, 26.76E	7.2	9.0	Vráncsaföld / Vrancea (RO)
1985.08.15	47.05N, 18.09E	4.9	7.0	Berhida (HU)
1986.08.30	45.54N, 26.31E	6.9	8.0	Háromszéki havasok / Vrancea Mountains (RO)
1990.05.30	45.85N, 26.66E	6.6	8.0	Háromszéki havasok / Vrancea Mountains (RO)
1991.12.02	45.47N, 21.18E	5.6	7.5	Vejte-Grád / Voiteg (RO)
1992.03.02	45.91N, 21.56E	4.6		Temesvár / Timisoara (RO)
1995.02.02	46.39N, 22.31E	4.3		Zaránd-hegység / Zărand Mountains (RO)
1995.08.25	45.36N, 17.69E	4.9	6.5	Pozsega / Požega (HR)

HUNGARIAN SEISMIC DESIGN SPECIFICATIONS

„**Conventional static calculus**" (late 1800's), considering 2 kinds of inertial forces:

- for long period oscillations: $S_1 = k_1 \cdot P$
- for short period oscillations: $S_2 = k_2 \cdot P$

(global coefficient multiplier: 1.50)

Coefficients	Intensity		
	7	8	9
k_1	1/40	1/20	1/10
k_2	1/8	¼	½
$c_1 = 1.50\ k_1$	0,0375	0,075	0,150
$c_2 = 1.50\ k_2$	0,1875	0,375	0,75

Dynamic design theory (mid 1900's):

$\beta = a_s / a_g$ → „modal analysis"

$$\eta_{ik} = \frac{x_{ik} \cdot \sum_{k=1}^{n} Q_k \cdot x_{ik}}{\sum_{k=1}^{n} Q_k \cdot x_{ik}^2}$$

ME 95-72 and ME 95-74 (technical specifications):

$S_{eq} \leq (S + P) \cdot 1.25$

$S_k = Q \cdot k \cdot \beta$ $\quad 0.8 \leq \beta = 1 / T \leq 0.3$

	5	6	7	8
k	0.005	0.01	0.025	0.05

self-oscillation approximation (n – nr. of storeys):

Subsoil	Solid, rocky, hard soil	Clay, sand, debris	Clay and sand, loose soil
T (s)	n / 15	n / 20	n / 30

more precise calculation sample:

$$T = \frac{2 \cdot \pi \cdot l^2}{3.52} \sqrt{\frac{m}{E \cdot I} \; \frac{1 + 2.25 \cdot e + 1.3 \cdot e^2}{\beta}}$$

MI-04-133-78 and MI-04-133-81 (technical guidelines):

$$S = Q \cdot k_g \cdot k_s \cdot k_t \cdot \beta_i \cdot \Psi_i \cdot \eta_{i,k} \qquad 0.8 \leq \beta = 1 / T_i \leq 0.3$$

except buldings with $H < 50$ m, where:

$$3 \cdot \left[\lg \frac{3 \cdot H(H+10)}{B \cdot \gamma(H+50)} + 1 \right] \geq I_{max}$$

Building protection (importance) classes:
- I (extremely important buildings and structures),
- II (very important buildings and structures),
- III (important buildings and structures),
- IV (less important structures),
- V (small significance buildings).

Earthquake intensity factor:

intensity	5	6	7	8	9
k_g	0.005	0.010	0.025	0.050	0.100

Building protection factor:

class	I	II	III	IV	V
k_s	1.60	1.40	1.00	0.70	0.50

Subsoil and foundation factor k_t:

Foundation type	Subsoil condition			
	Rocky soils, coarse gravel	Medium quality soils	Wet, less bearing soil	Water-logged soft soils
Spread footing	1.00	1.15	1.25	-
Pillar	0.90	1.15	1.25	-
Cup	0.80	1.00	1.15	-
Base plate	-	0.90	1.00	1.10
Support pile	-	1.00	1.15	1.30
Floating pile	-	1.10	1.30	-

Structure type	ψ
Reinforced concrete frames, steel frames, one-story industrial structures	1,00
Reinforced concrete structures with stiffening walls, core and frame combination concrete structures, bearing walls, masonry with bond beam	1,33
Very tall, slender objects (water towers, antennas, chimneys)	1,66
Very low flexible structures, simple load-bearing walls with bond beams	2,00

TS S-35 (1990): some novelty, but mostly repeating the guidelines of MI-04-133-81

MSZ ENV 1998-1-1 NAD (1998):

Based on the elastic response:

$$0 \le T \le T_B \quad S_d(T) = \alpha \cdot S \cdot \left[1 + \frac{T}{T_B} \cdot \left(\frac{\beta_o}{q} - 1\right)\right];$$

$$T_B \le T \le T_C \quad S_d(T) = \alpha \cdot S \cdot \frac{\beta_o}{q};$$

$$T_C \le T \le T_D \quad S_d(T) = \alpha \cdot S \cdot \frac{\beta_o}{q} \cdot \left[\frac{T_C}{T}\right]^{kd1} \ge [0{,}20] \cdot \alpha$$

$$T_D \le T \quad S_d(T) = \alpha \cdot S \cdot \frac{\beta_o}{q} \cdot \left[\frac{T_C}{T_D}\right]^{kd1} \cdot \left[\frac{T_D}{T}\right]^{kd2} \ge [0{,}20] \cdot \alpha$$

$$\eta = \sqrt{7/(2+\xi)} \ge 0{,}7 \qquad q = q_O \cdot k_D \cdot k_R \cdot k_W \ge 1{,}5$$

1st zone	ag = 0.04 g,
2nd zone	ag = 0.06 g,
3rd zone	ag = 0.08 g,
4th zone	ag = 0.10 g.

TT-TS 4 2003 – HSM: equivalent static method

$$S_{M,S} = \beta \cdot Q \cdot k_g \cdot k_s \cdot k_t / q \ge 0{,}2 \cdot Q \cdot k_g \cdot k_s \cdot k_t$$

$$\beta = \frac{1}{T_S} \le 2{,}5$$

empirical formulas:

- wall and masonry $T_S = N\,(1 \pm 0.5)/25$
- rc frame structure $T_S = N\,(1 \pm 0.5)/8$

Category of importance	k_s
1. Very important buiding (hospital, fire station)	1.4
2. High traffic building (train station, office building, theater)	1.2
3. Common residential and public building	1.0
4. Inferior buildings (agricultural and provisional buildings)	0.8

Soil quality	k_t
Rock, solid and dry gravel	1.0
Dry granular and cohesive soil	1.2
Granular and cohesive soil under water	1.4

design acceleration: 0.7· PGA(EC8)

or kg from the NA (EC8, ag zone value)

ROMANIAN SEISMIC DESIGN SPECIFICATIONS

Decision nr.84351 of the MLPC (1941): „*Provisional instructions to prevent damage to buildings due to earthquakes and restoration of degraded*” (9 pp)

Decision nr.60173 of the MLPC (1945): „*Instructions to prevent damage to buildings due to earthquakes*”, approved by the Superior Technical Council (in Journal nr.7/1945) (10 pp)

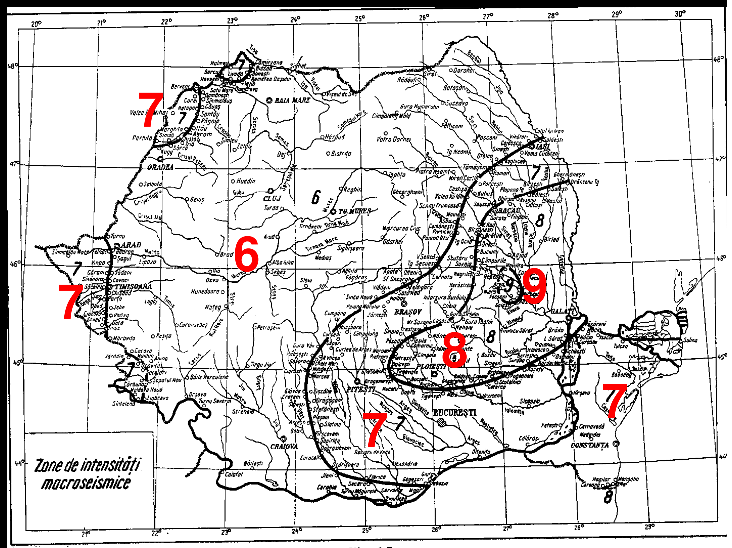
STAS 2923-58 (1958): „*General design specifications in seismic regions. Seismic Loads*”, by the Standardization Commission (Vol.1: 132 pp, Vol.2: 97 pp) – unapproved...

P.13-63 (1963): „*Conditioning Standard for the design of civil and industrial buidings in seismic regions* ”, approved by the CSCAS (39 pp)

Class	Characteristics	Zone intensity 7	8	9
I.	Monumental and very important building, structure	8	8	9
II.	Everything, except I, III, IV and V	7	8	9
III.	One-floor industrial, energetical building with more than 50 people capacity	7	7	8
IV.	One-floor house, public and commercial building	7	7	8
V.	Provisional building, less important structures	Calculation not required		

$$S = c \cdot Q = K_S \cdot \beta \cdot \varepsilon \cdot \psi \cdot Q = \sum_{i}^{n} S_k = c \cdot Q$$

$$c = K_S \cdot \beta \cdot \varepsilon \cdot \psi \triangleright 0{,}02$$



Zone intensity	K_S
7	0.025
8	0.050
9	0.100

Admissable stress on the foundation soil, [kg / cm²]:

$\sigma \geq 2$	$\sigma < 2$	Weaker, wet, loose soil
$0.6 \leq \beta = 0.9 / T \leq 3$	$\beta = 1.25 \cdot 0.9 / T \leq 3$	$\beta = 1.50 \cdot 0.9 / T \leq 3$

Equivalence coefficient (ε) with load factor:

$$\varepsilon = \frac{\left[\sum_{1}^{n} Q_k \cdot u_k\right]^2}{\left[\sum_{1}^{c} Q_k\right] \cdot \left[\sum_{1}^{n} Q_k \cdot u_k^2\right]}$$

Load type		Load factor
1 Dead load (machines, equipments too)		1.0
2 Snow		
3 Live load	Tan... elev...	
	Hou... cult...	
	Indu... exc...	

Base shear force (mass proportional distrtibution):

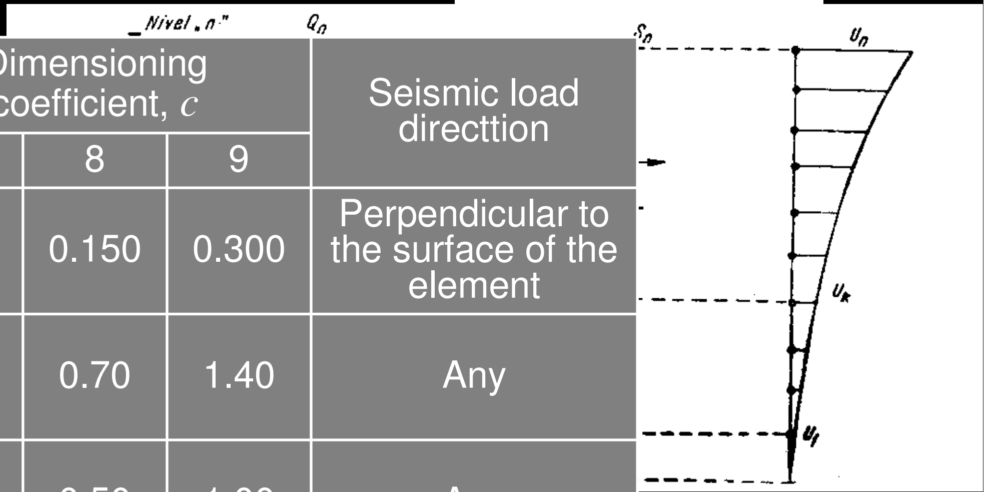
$$S_k = S \cdot \frac{Q_k \cdot u_k}{\sum_{1}^{n} Q_k \cdot u_k}$$

or

$$S_k = K_s \cdot \beta \cdot \psi \cdot \eta_k \cdot Q_k$$

$$\eta_k = u_k \cdot \frac{\sum Q_k \cdot u_k}{\sum_{1}^{n} Q_k \cdot u_k^2}$$

Initial condition for simplified calculation: $S = \sum_{i}^{n} S_k \geq 0{,}02 \cdot Q$



Non-structural parts: $S = c \cdot Q$	Dimensioning coefficient, c			Seismic load directtion
	7	8	9	
Exterior, interior wall	0.075	0.150	0.300	Perpendicular to the surface of the element
Railing, exterior / interior decoration, low chimneys and towers	0.35	0.70	1.40	Any
Balcony, gutter, industrial equipments on structural parts	0.25	0.50	1.00	Any

Damping factor (...

Structur...	...
1. All buildings, except 2 and 3	1.0
2. Rc frames, roof hinged to rc column	1.2
3. Tall, flexible structure, isolated chimney, water tower, communi-cation towers, towers	1.5

	... or stress	Increase factor %		
		7	8	9
Tensioned - compressed element	Axial load	25	50	100
Pillar-bearing beam	Pillar stresses	25	50	100
Very loaded console	Entire gravitational load on the console	25	50	100
Widespan console	Entire gravitational load on the console	12.5	25	50

P.13-70 (1970): „*Standard for the design of civil and industrial buidings in seismic regions* ”, approved by the MCI and the State Committee for Economy and Local Government (63 pp)

$$S = K_S \cdot \beta \cdot \varepsilon \cdot \psi \cdot \varphi \cdot Q = \sum_i^n S_k$$

$$0{,}60 \le \beta = \frac{0{,}8}{T} \le 2{,}00$$

Structure type	Ψ
Frame structure	1.0
Rc wall structure	1.2
Masonry wall structure	1.3
Tall, flexible structure, isolated chimney, tower or tower-like	1.8
Water tower	2.0
Anything else not above	1.2

Class	Building, structure	K_S / Seismic zone			
		6	7	8	9
I.	High priority building: monumental, artistic, cultural, primary importance by earthquake, economically major priority	0.03	0.05	0.08	0.12
II.	Everything else not in I, III, and IV	-	0.03	0.05	0.08
III.	One-floor housing, public, commercial or industrial building	-	0.02	0.03	0.05
IV.	Provisional building, lesser important structure	-	-	-	0.03

By the equivalence coefficient, higher modal shapes could be taken into account:

$$\varepsilon_i = \frac{\left[\sum_1^n Q_{k,i} \cdot \Phi_{k,i}\right]^2}{\left[\sum_1^c Q_k\right] \cdot \left[\sum_1^n Q_{k,i} \cdot \Phi_{k,i}^2\right]} \le 1{,}0$$

Condition by the first vibration mode:

$$F_1 = c_1 \cdot Q \ge 0{,}02 \cdot Q$$

Most positive aspect

- seismic gap calculation between side by side buildings [cm]:

$$\delta = 2 + 40 \cdot \left(c_1 \cdot T_1^2 \cdot \frac{H}{H_1} + c_2 \cdot T_2^2 \cdot \frac{H}{H_2} \right)$$

Foundation ground type	φ factor
Common, natural soil	1.0
Rock, compacted gravel, or other consolidated ground	0.8
Clayey soil, sandy clay, low consistency sand, higy humidity (w> 20%) loess, high groundwater level	1.5

The lessons learned from the 4th March, 1977, earthquake has led to a new intensity zone map and to new design specifications.

P.100-78 and P.100-81

$$S_r = K_S \cdot \beta_r \cdot \varepsilon \cdot \psi \cdot Q$$

Seismic zone i.	6	6½	7	7½	8	8½	9
K_S	0.06	0.09	0.12	0.16	0.20	0.26	0.32

0.07 (P.100-81)

Importance classes:

$0.75 \leq \beta_r = 3 / T_r \leq 2.00$

≤ 2.00

S

(b

co

m

$\delta =$

0

5

5

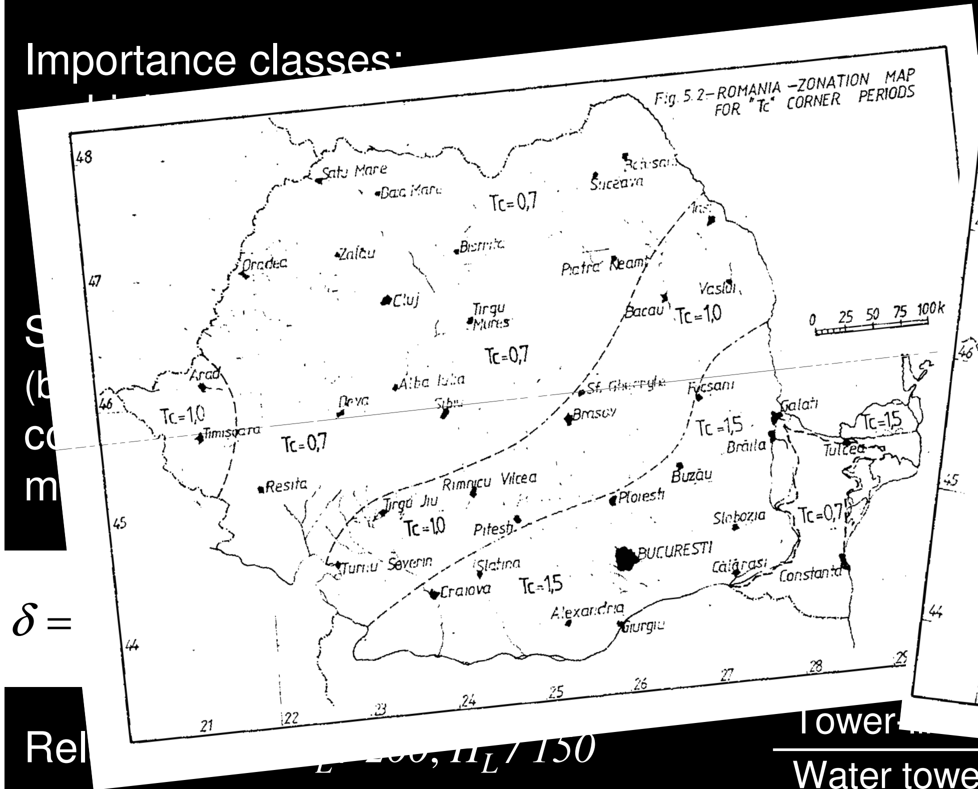
5

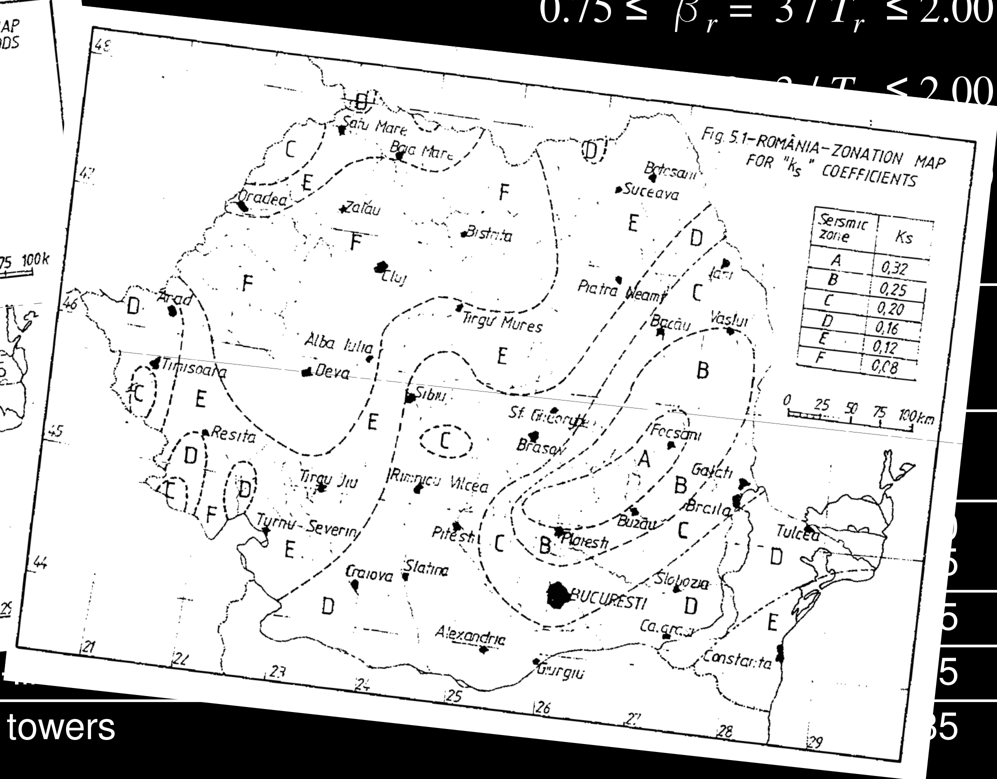
Rel $_L / 200$, $H_L / 150$

Tower-

Water towers

35





P.100-90 and P.100-92

2 maps:

- Tc (corner period),
- new protection zones

$$S_r = c_r \cdot G$$

$$c_r = \alpha \cdot K_S \cdot \beta_r \cdot \varepsilon_r \cdot \psi$$

I. - vital buildings (must function during and after earthquake).

II. - buildings playing role in damage limitation, after-effects liquidation.

III. - buildings not in other categories

IV. - less important, minor buildings

Macroseismic protection zone

	A	B	C	D	E	F
K_S	0,32	0,25	0,20	0,16	0,12	0,08

	I.	II.	III.	IV.
α	1,4	1,2	1,0	0,8

Dynamic coefficient:

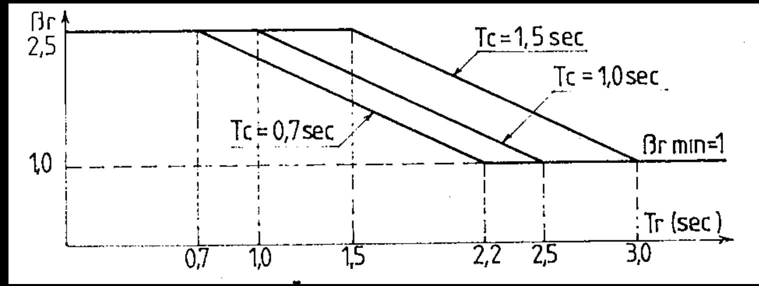
$\beta_r = 2.5 \qquad T_r \le T_c$

$\beta_r = 2.5 - (T_r - T_c) \ge 1 \qquad T_r > T_c$

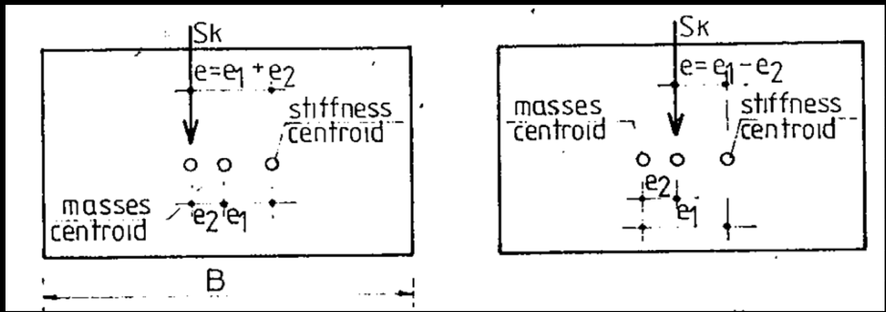
Form factor in relation to the mass and vibration mode:

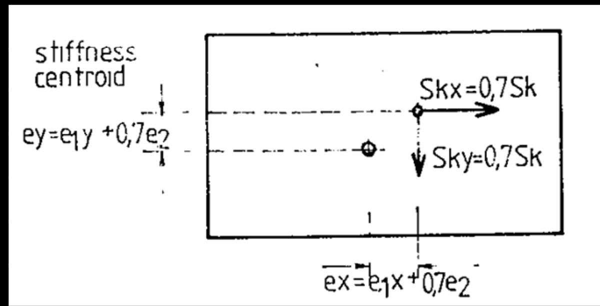
- changed shape:

$$\varepsilon_i = \frac{\left[\sum_{1}^{n} Q_{k,i} \cdot \Phi_{k,i}\right]^2}{\left[\sum_{1}^{c} Q_k\right] \cdot \left[\sum_{1}^{n} Q_{k,i} \cdot \Phi_{k,i}^2\right]}$$

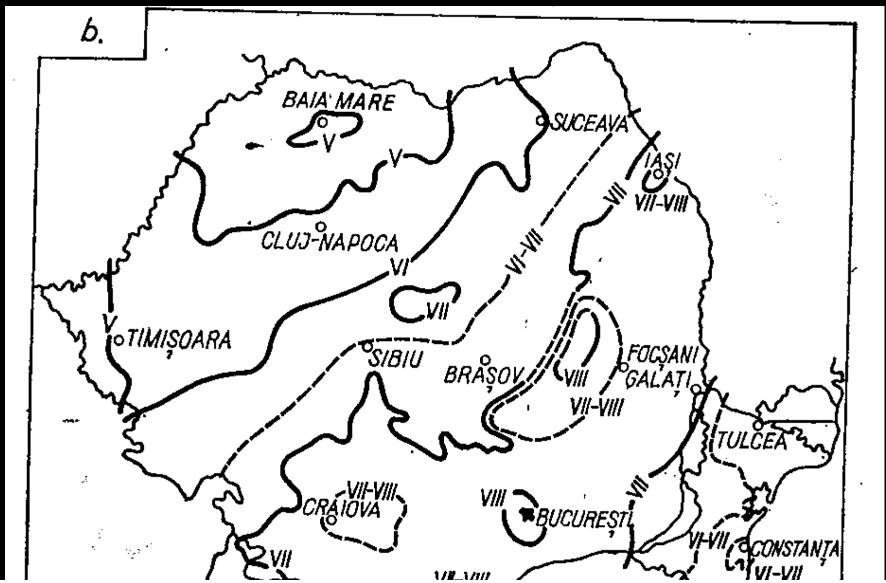


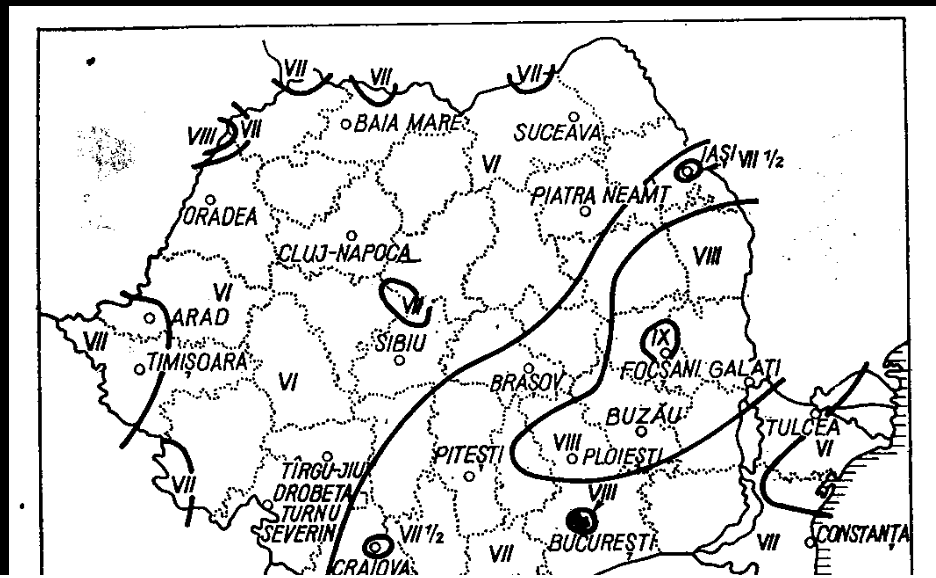
The stiffness and mass center → torsion $M = S \cdot e$; $e = e_1 \pm e_2$ → base shear force reduction





Studies of the 10.11.190 and 04.03.1977 earthquakes → isoseismal lines (**STAS 11100/1-77**)





Chapters 11 and 12 from P.100-92 were modified and extended in 1996 (by MLPAT)

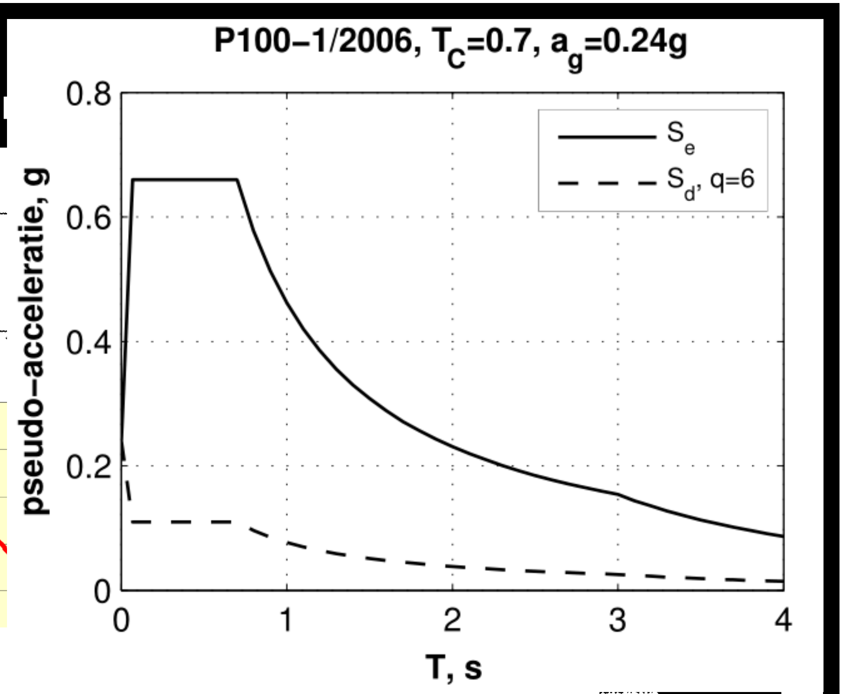
P 100-1-2006

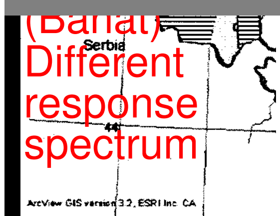
Reduction factor: $q = q_m \cdot q_S = q_m \cdot q_{Sd} \cdot q_R$

Design spectrum:

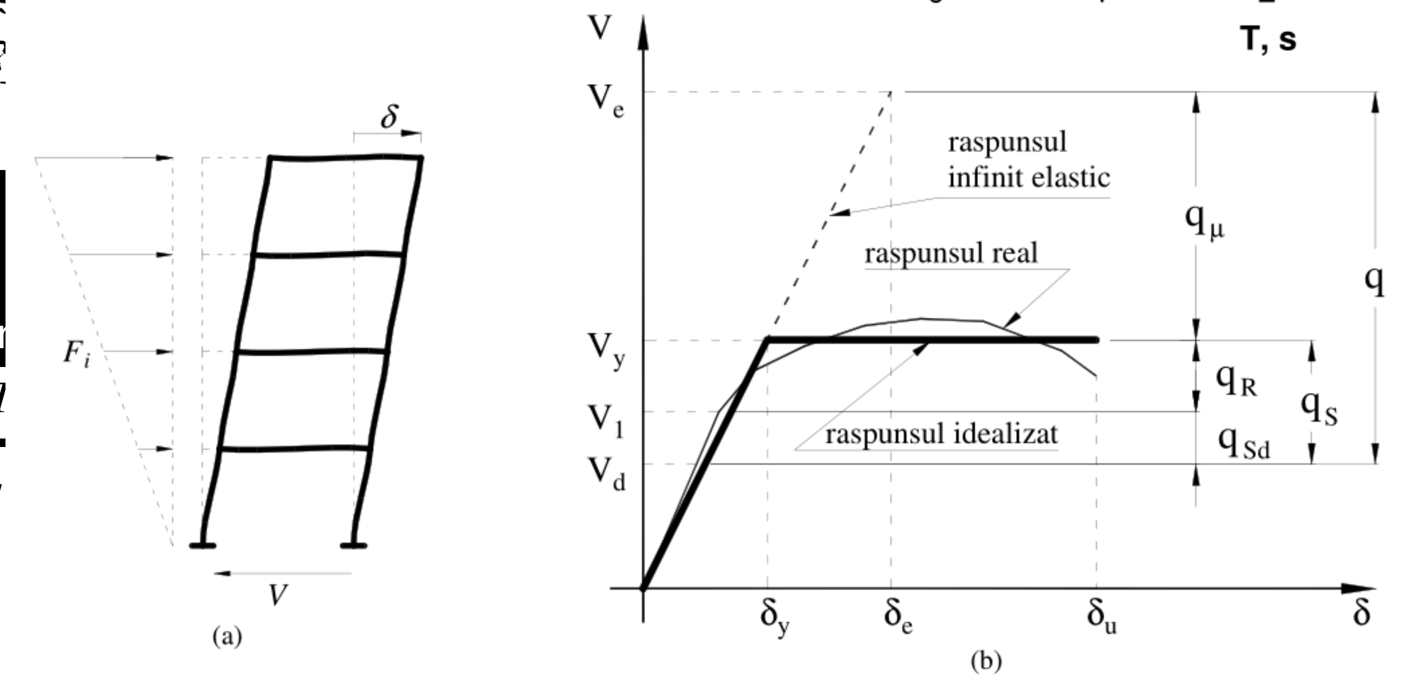
$$0 \le T \le T_B: \quad S_d(T) = a_g \left[1 + \frac{\frac{\beta_0}{q} - 1}{T_B} T \right]$$

$$T > T_B: \quad S_d(T) = a_g \frac{\beta(T)}{q}$$





(Banat)
Different response spectrum



(a) (b)

d values		
	Z2	Z3
	0,10	0,16
	1,0	1,6
	3	2

Elastic respor

$S_e(T$

$T \le T_B \qquad \beta(T$

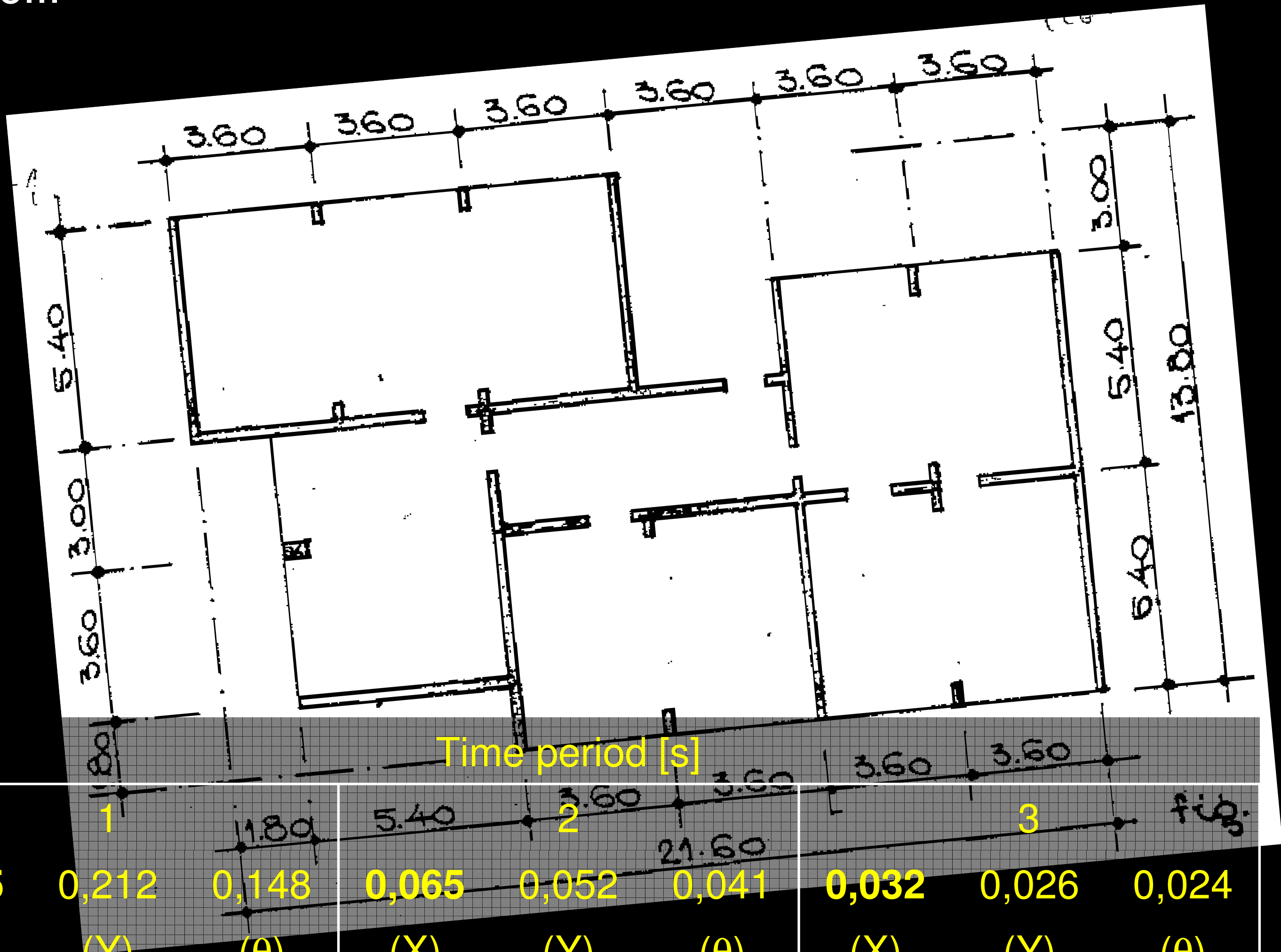
$T_B \le T \le T_C$

$T_C \le T \le T_D$

$T > T_D \qquad \beta(T) = \beta_0 \cdot \frac{T_C \cdot T_D}{T^2}$

Vertical oscillations: $T_{Bv} = 0.1\, T_{Cv} \quad T_{Cv} = 0.45\, T_C \quad T_{Dv} = T_D$

Sample structure...



	Time period [s]								
	1			2			3		
T [s]	**0,345**	0,212	0,148	**0,065**	0,052	0,041	**0,032**	0,026	0,024
	(X)	(Y)	(θ)	(X)	(Y)	(θ)	(X)	(Y)	(θ)

5-storey house with cell structure (2.75 m floor height), made from:
RC walls (15 cm thick) with frame structure (30 x 45 cm columns, 25 x 30 cm transverse beams, 20 x 30 cm precast facade beams), 12 cm thick precast slabs (on top with a 13 cm thick soundproof stratification).
15 cm thick AAC (Ytong) insulating masonry on the walls, 30 cm thick on the facade.

HUNGARY	[.g]	[m/s²]	ROMANIA	[.g]	[m/s²]
Makó	**0.12**	**1.1772**	**Sânnicolau Mare**	**0.224**	**2.1974**
Mezőhegyes	**0.12**	**1.1772**	**Nădlac**	**0.224**	**2.1974**
Battonya	**0.10**	**0.981**	**Arad**	**0.224**	**2.1974**
Gyula	**0.10**	**0.981**	**Chişineu Criş**	**0.116**	**1.1380**
Biharkeresztes	**0.12**	**1.1772**	**Oradea**	**0.174**	**1.7069**
Létavértes	**0.12**	**1.1772**	**Săcuieni**	**0.29**	**2.8449**
Vámospércs	**0.10**	**0.981**	**Valea lui Mihai**	**0.29**	**2.8449**
Nyírbátor	**0.10**	**0.981**	**Carei**	**0.29**	**2.8449**
Csenger	**0.10**	**0.981**	**Satu Mare**	**0.174**	**1.7069**
MSZ EN 1998-1:2008			**P100-1/2006; SR EN 1998-1:2004; NA:2006 * IMR = 100 years**		

P_{NCR} = 39% probability under 50 years in Romania, considering T_{NCR} = 100 years of return period.

	ag(30y) / ag(100y)	ag(50y) / ag(100y)	ag(225y) / ag(100y)	ag(475y) / ag(100y)	ag(95y) / ag(100y)
Vrancea	**0.4**	**0.7**	**1.2**	**1.5**	**2.0**
Banat	**0.6**	**0.75**	**1.2**	**1.4**	**1.65**
Transylvania	**0.5**	**0.73**	**1.2**	**1.45**	**1.83**

.η =0.8165	1.	2.	3.	Σ
T [s]	**0.345**	**0.065**	**0.032**	
Makó	0.129	0.098	0.047	0.169
Sânnicolau Mare	0.359	0.219	0.074	0.427
Mezőhegyes	0.108	0.098	0.039	0.169
Nădlac	0.359	0.219	0.074	0.427
Battonya	0.108	0.0842	0.039	0.141
Arad	0.359	0.219	0.074	0.427
Gyula	0.108	0.082	0.039	0.141
Chişineu Criş	0.190	0.074	0.041	0.207
Biharkeresztes	0.129	0.098	0.047	0.169
Oradea	0.284	0.110	0.062	0.311
Létavértes	0.129	0.098	0.047	0.169
Săcuieni	0.473	0.184	0.102	0.518
Vámospércs	0.108	0.082	0.039	0.141
Valea lui Mihai	0.473	0.184	0102	0.518
Nyírbátor	0.108	0.082	0.039	0.141
Carei	0.473	0.184	0102	0.518
Csenger	0.108	0.082	0.039	0.141
Satu Mare	0.2845	0.110	0.062	0.311

Global seismic coefficient comparison for the X direction elastic response spectrum

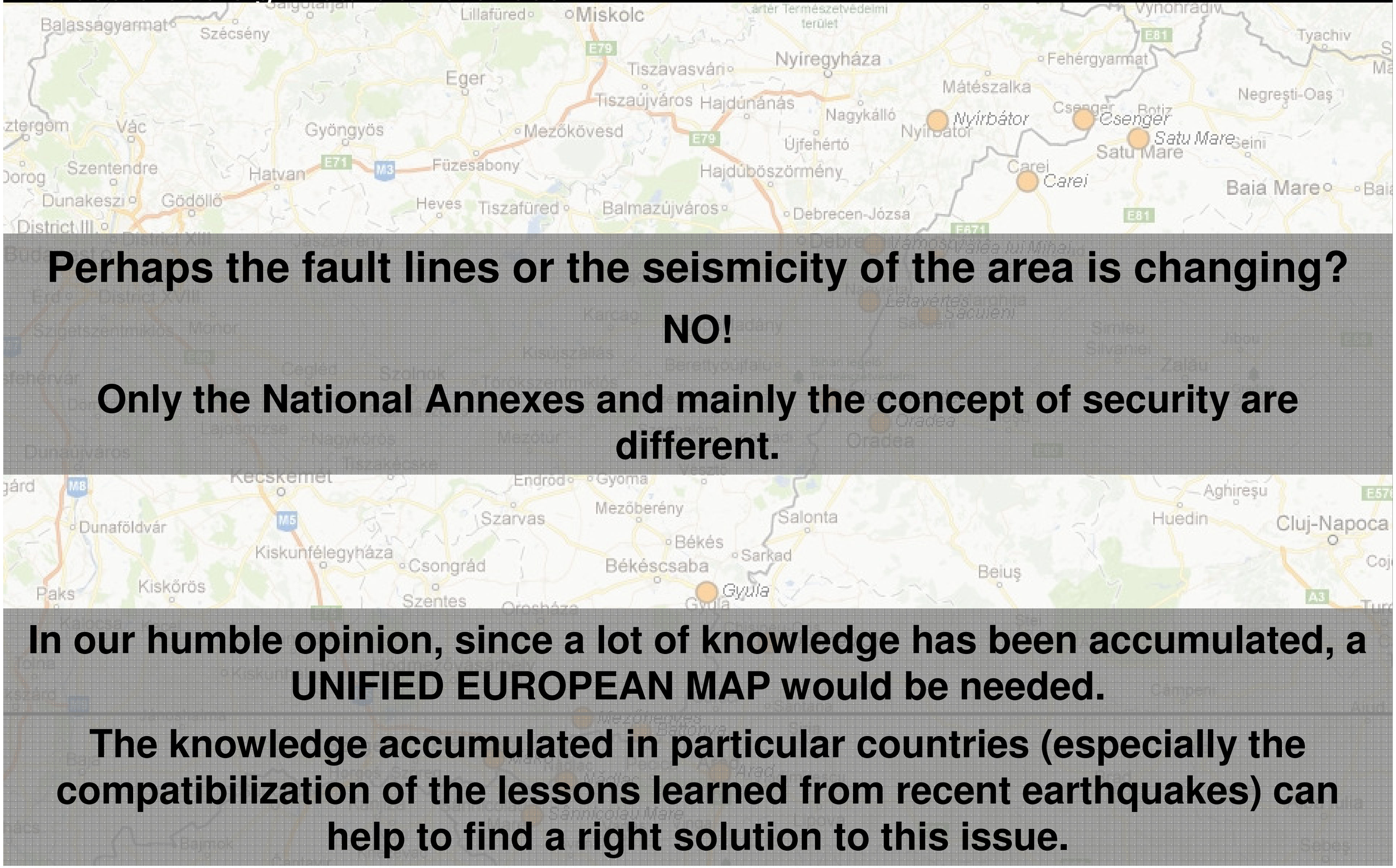
.q = 3,00	1.	2.	3.	Σ
T [s]	**0.345**	**0.065**	**0.032**	
Makó	0.054	0.054	0.026	0.080
Sânnicolau Mare	0.147	0.085	0.056	0.178
Mezőhegyes	0.053	0.054	0.026	0.080
Nădlac	0.147	0.085	0.056	0.178
Battonya	0.044	0.045	0.021	0.066
Arad	0.147	0.085	0.056	0.178
Gyula	0.044	0.045	0.021	0.066
Chişineu Criş	0.078	0.032	0.022	0.086
Biharkeresztes	0.053	0.054	0.026	0.080
Oradea	0.116	0.047	0.035	0.130
Létavértes	0.053	0.054	0.026	0.080
Săcuieni	0.193	0.078	0.054	0.215
Vámospércs	0.044	0.045	0.021	0.066
Valea lui Mihai	0.193	0.078	0.054	0.215
Nyírbátor	0.044	0.045	0.021	0.066
Carei	0.193	0.078	0.054	0.215
Csenger	0.044	0.045	0.021	0.066
Satu Mare	0.116	0.047	0.035	0.130

Global seismic coefficient comparison for the X direction design response spectrum

What is along the country border:

the answer to this question was illustrated by the previous tables.

Between the border's left and right side - although we started from the same EuroCode - we could see significant differences.



Perhaps the fault lines or the seismicity of the area is changing?

NO!

Only the National Annexes and mainly the concept of security are different.

In our humble opinion, since a lot of knowledge has been accumulated, a UNIFIED EUROPEAN MAP would be needed.

The knowledge accumulated in particular countries (especially the compatibilization of the lessons learned from recent earthquakes) can help to find a right solution to this issue.

CONCLUSIONS

- Earthquake-resistant structures, in the sense of fullfilling the required protection, can be built only trough correct structural composition.
- The data processing after the earthquakes observed in the Carpathian Basin are leading to the conclusion that it is not sufficient to dimension just for earthquakes, it is required to develop a protection concept based on structural behavior.
- The concept of safety is in fact a tehnologic and economical issue.
- Excessive risk-taking is uneconomical.
- The real behavior of the buildings and structures provides a sufficient basis to the reasonable development of the safety concept.

EC 8 (CEN) criteria:

- **ULS** (no-collapse requirement)
  MSZ EN 1998-1:2006, for T = 50y, P_{NCR} = 10%, T_{NCR} = 475y → ag (ULS) / ag (475) = 1.00
- **SLS** (damage limitation requirement).
  MSZ EN 1998-1:2006, for T = 92y, P_{NCR} = 10%, T_{NCR} = 95y → ag (SLS) / ag (475) = 0.53
- **LS NC** (no-collapse requirement)
  EN 1998-3:2004, for T = 50y, P_{NCR} = 2%, T_{NCR} = 2475y → ag (LS NC) / ag (475) = 1.75
- **LS SD** (damage limitation requirement)
  EN 1998-3:2004, for T = 50y, P_{NCR} = 10%, T_{NCR} = 475y → ag (LS SD) / ag (475) = 1.00
- **LS DL** (damage limitation requirement)
  EN 1998-3:2004, for T = 50y, P_{NCR} = 20%, T_{NCR} = 225y → ag (LS DL) / ag (475) = 0.75

The accelerations used in the assessment of existing buildings should be according to LS SD, LS DL and LS NC.

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in memoriam

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