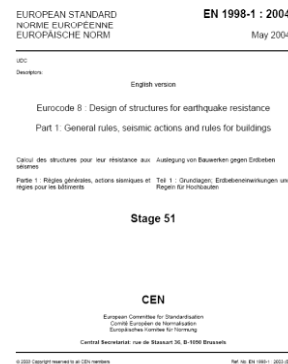
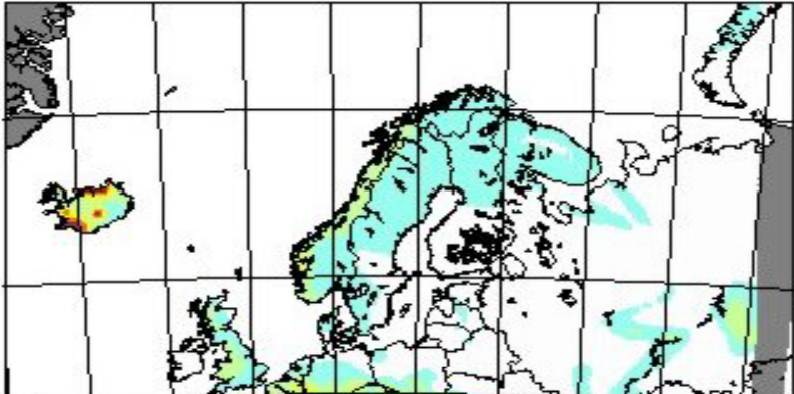


Design seismic actions and determination of action effects using appropriate computational tools

Anastasios Sextos
Lecturer

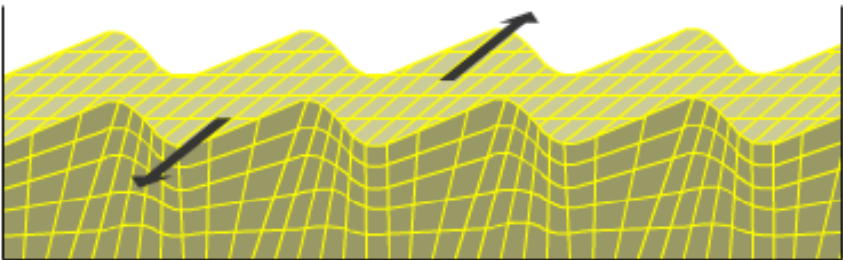


Seismicity, faults and earthquake generation



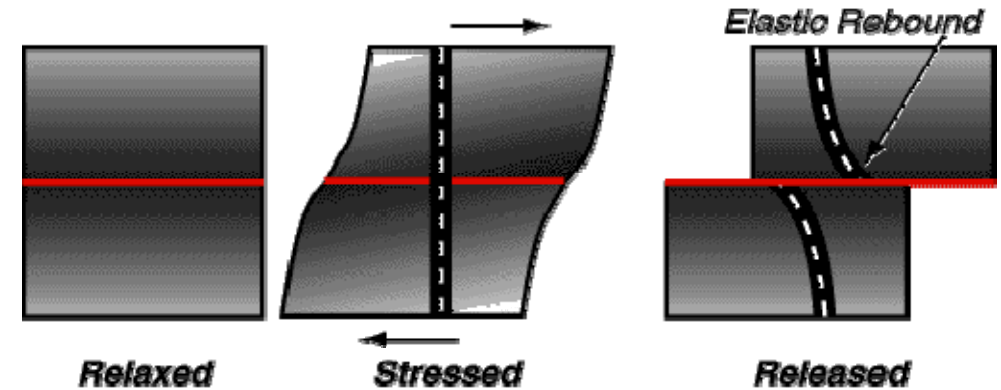
EARTHQUAKES ▶ RESTART

Love waves (named after mathematician A.E.H. Love) cause the ground to twist from side to side. These two types of surface wave cause great damage to buildings.



Direction of wave movement

▶ BACK 13 of 13 NEXT ▶

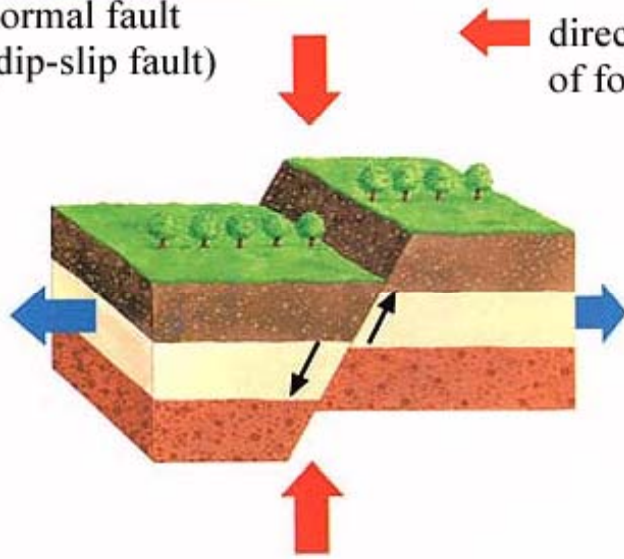


- Accumulation of stresses
- Fault zone
- Reverse, normal and strike slip
- Energy release
- Wave propagation



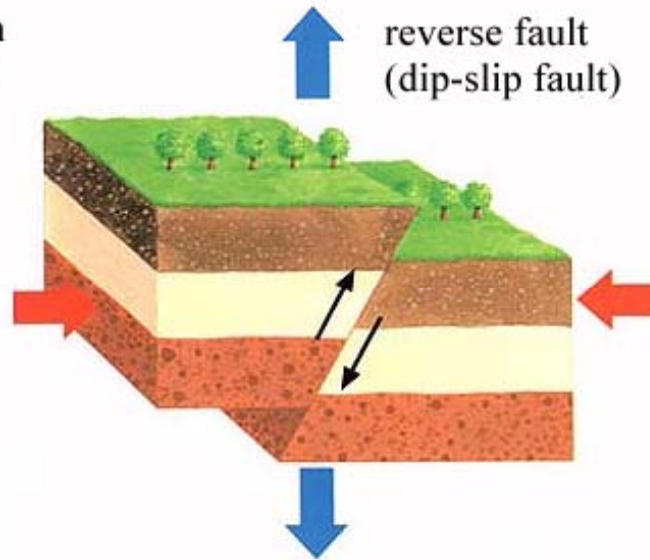
Seismicity, faults and earthquake generation

normal fault
(dip-slip fault)

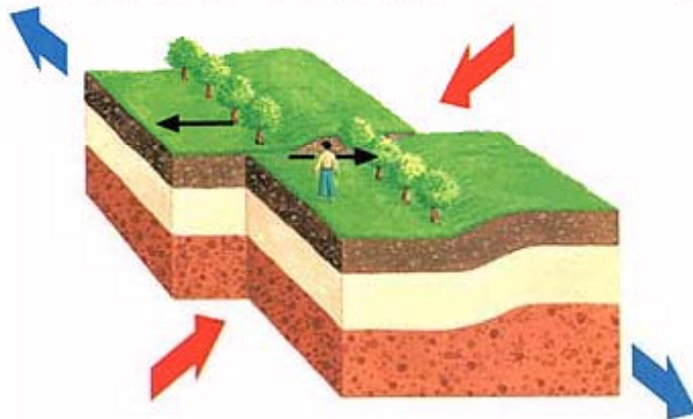


direction
of force

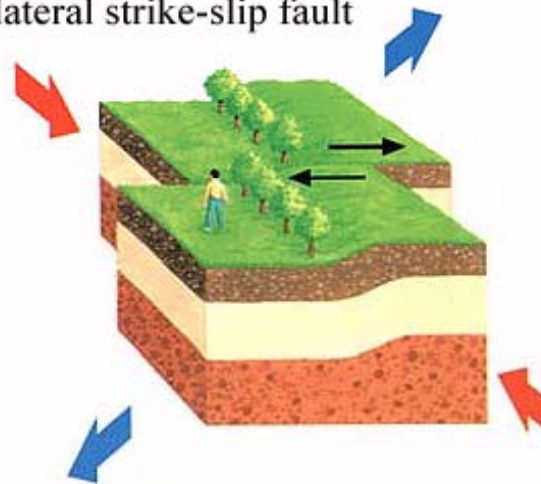
reverse fault
(dip-slip fault)



left-lateral strike-slip fault

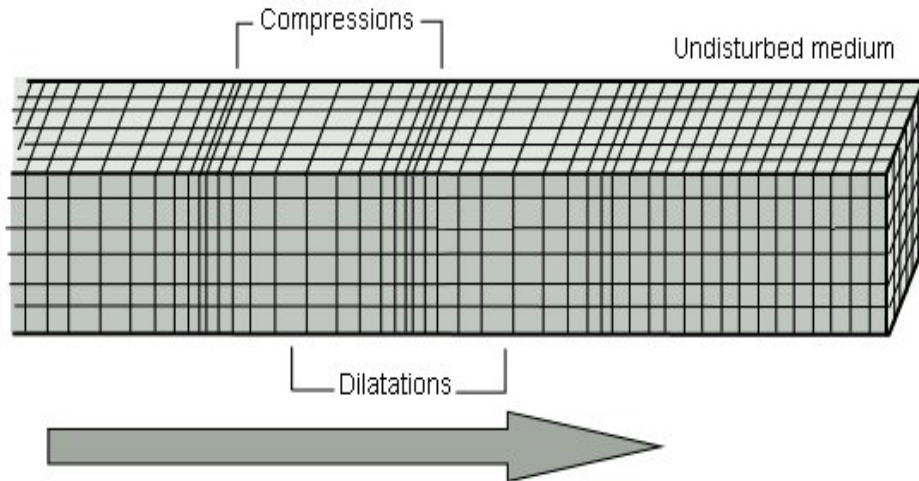


right-lateral strike-slip fault

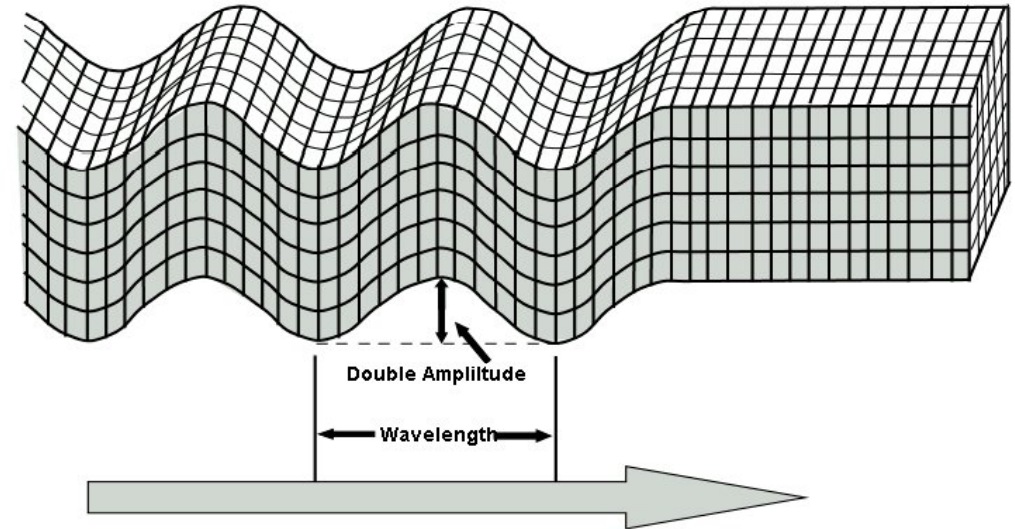


Seismicity, faults and earthquake generation

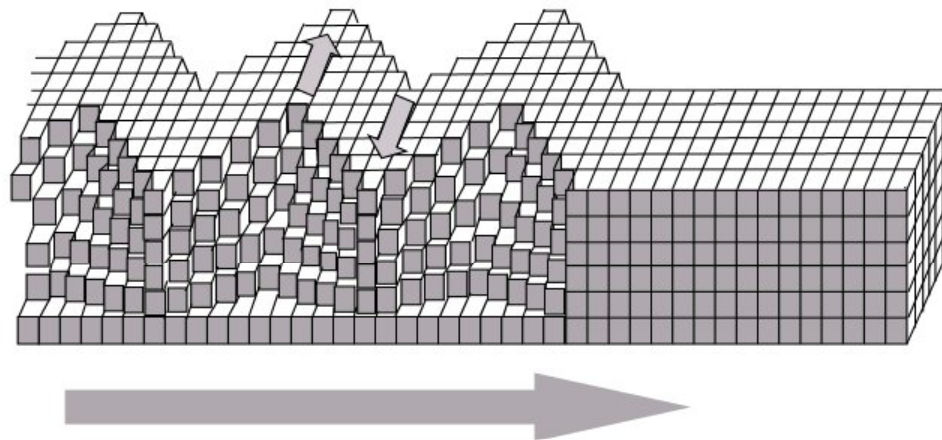
P Wave



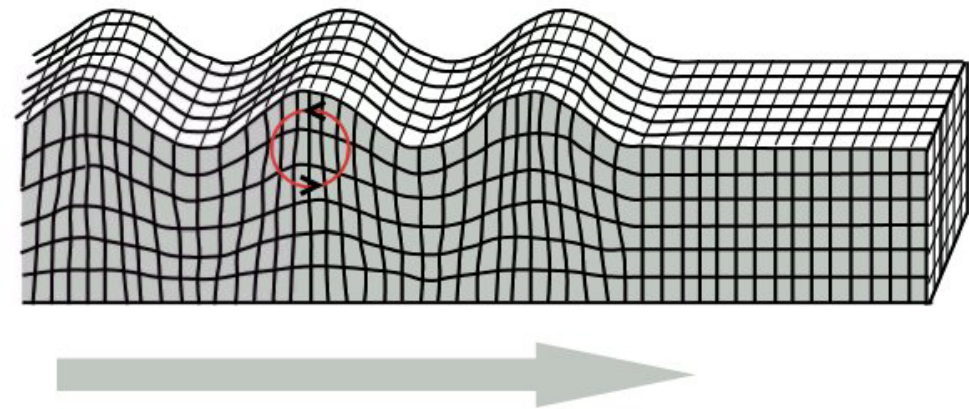
S Wave



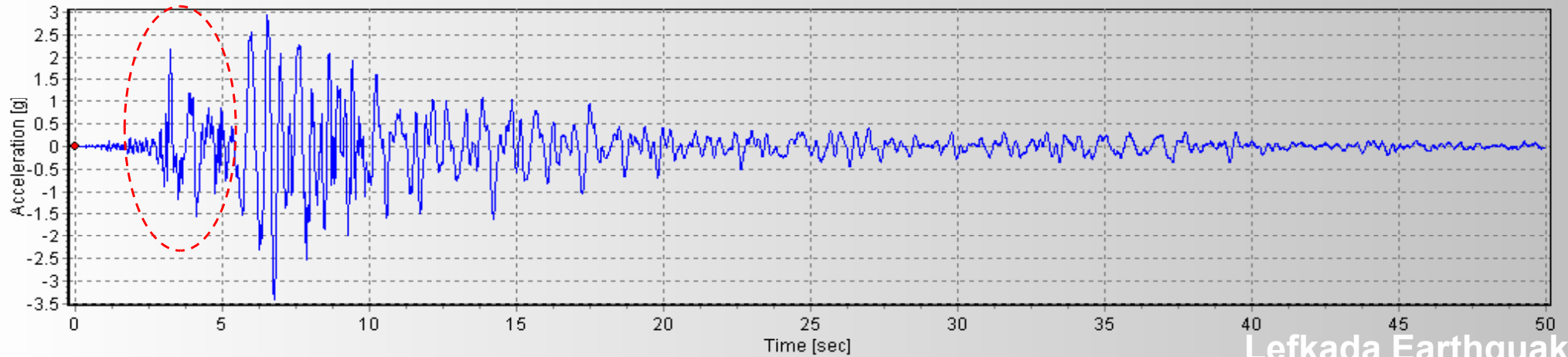
Love Wave



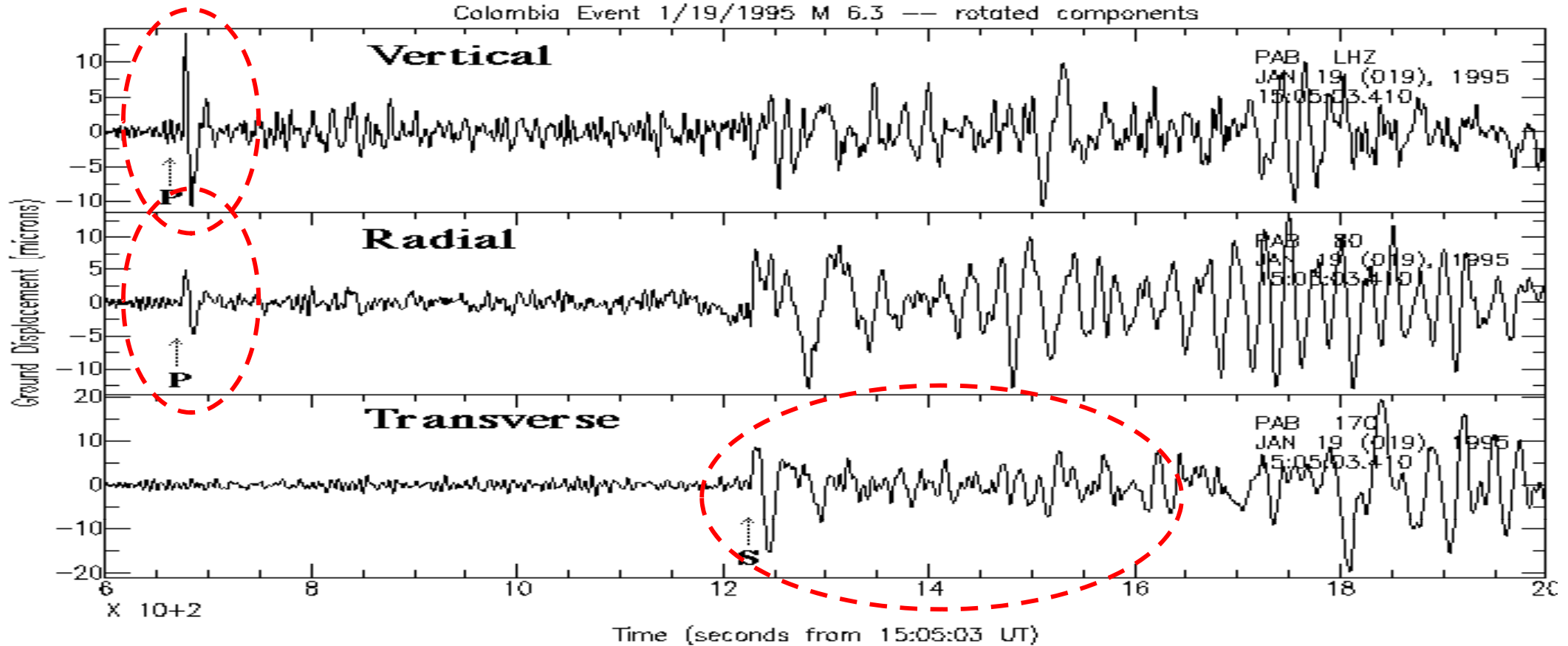
Rayleigh Wave



Seismicity, faults and earthquake generation



Colombia Event 1/19/1995 M 6.3 -- rotated components



Seismic hazard, vulnerability and seismic risk

Seismic Hazard (SH):

A property of an earthquake that can cause damage and loss. Probabilistic Seismic Hazard Analysis (PSHA) determines the frequency (i.e. the number of events per unit of time) with which a seismic hazard is expected to occur. Typically, the seismic hazard is calculated as a *frequency* that 'a ground motion amplitude is greater than a specified value'.

Vulnerability (V):

The 'sensitivity' of a given structure under a seismic event. The probability that a structure will exhibit a specific level of damage under a given level of seismic forces

Seismic Risk (SR):

A level of loss or damage related to a given set of structures that are exposed to a particular level of seismic hazard given their own vulnerability.

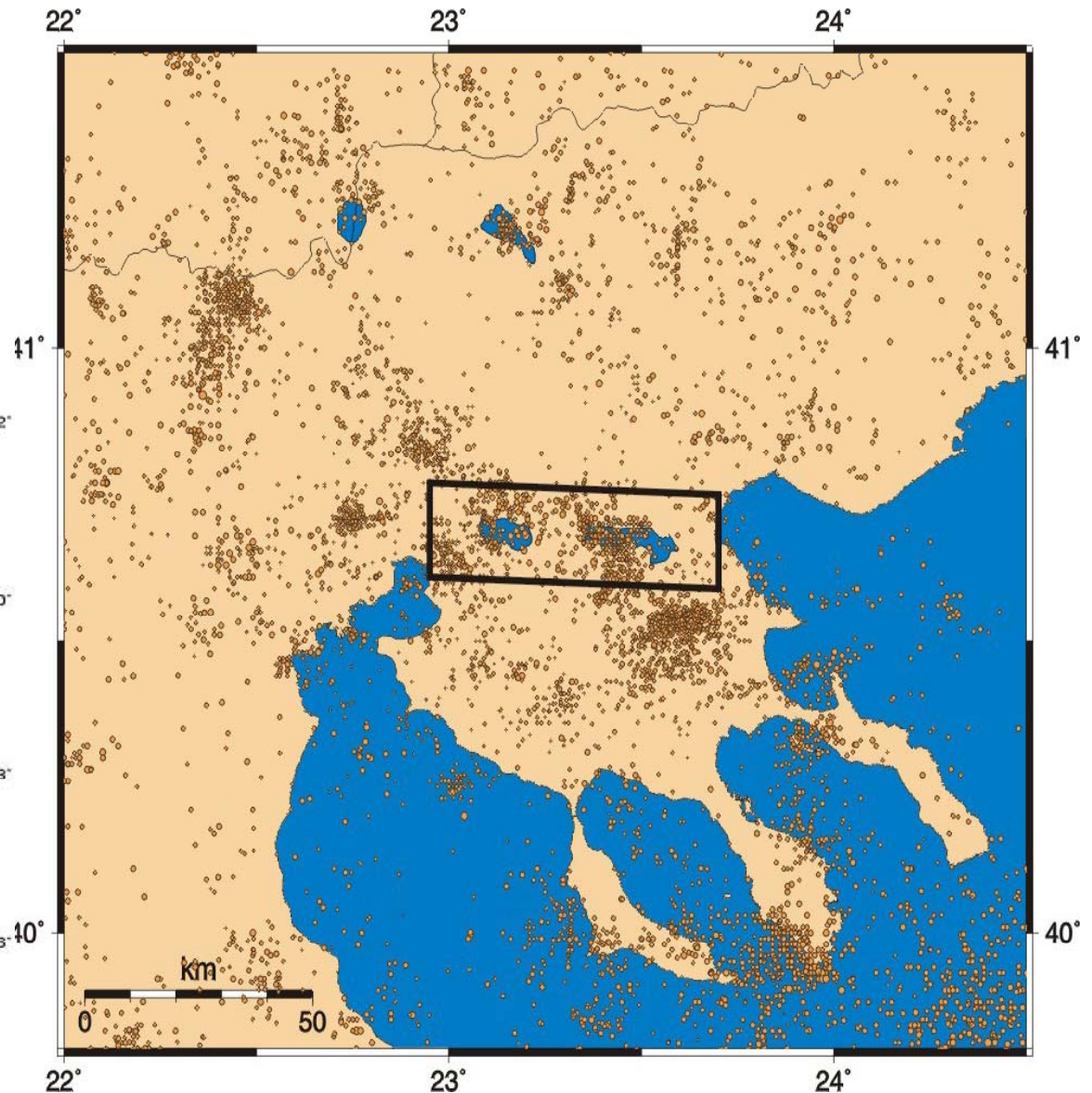
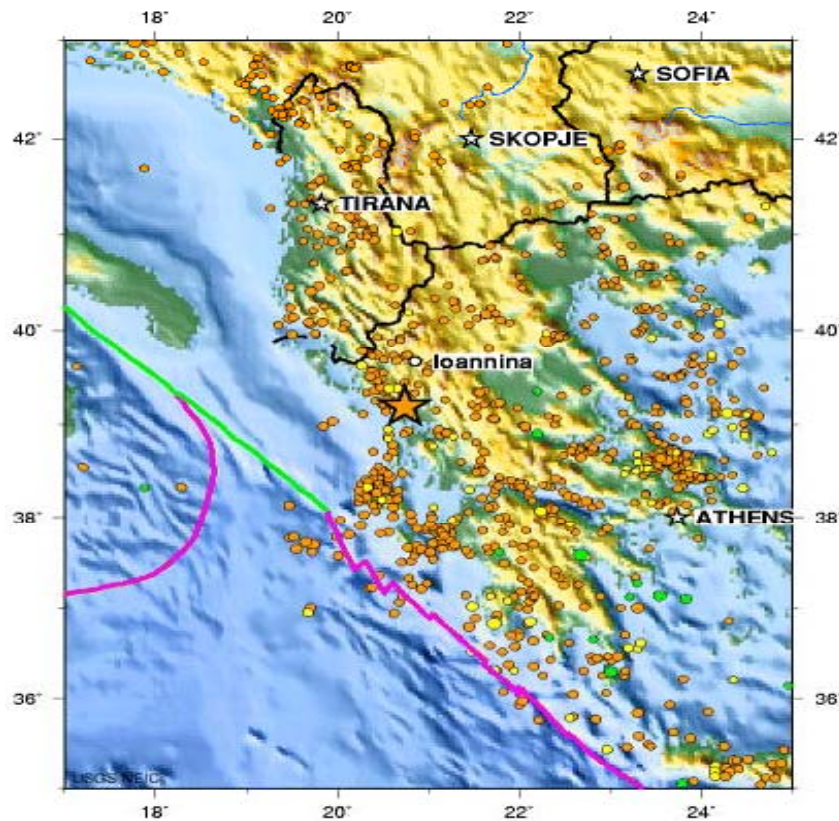
$$\text{Seismic Risk} = \text{Vulnerability} * \text{Seismic Hazard}$$



Seismicity, faults and earthquake generation

Seismicity

The seismic energy released in a given time window in a given area



Seismic hazard, vulnerability and seismic risk

Seismic Hazard (SH):

A property of an earthquake that can cause damage and loss. Probabilistic Seismic Hazard Analysis (PSHA) determines the frequency (i.e. the number of events per unit of time) with which a seismic hazard is expected to occur. Typically, the seismic hazard is calculated as a *frequency* that 'a ground motion amplitude is greater than a specified value'.

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A level of loss or damage related to a given set of structures that are exposed to a particular level of seismic hazard given their own vulnerability.

$$\text{Seismic Risk} = \text{Vulnerability} * \text{Seismic Hazard}$$



Design Seismic Actions

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1998-1 : 2004

May 2004

UDC

Descriptors:

English version

Eurocode 8 : Design of structures for earthquake resistance

Part 1: General rules, seismic actions and rules for buildings

Calcul des structures pour leur résistance aux séismes Auslegung von Bauwerken gegen Erdbeben

Partie 1 : Règles générales, actions sismiques et règles pour les bâtiments Teil 1 : Grundlagen; Erdbebeneinwirkungen und Regeln für Hochbauten

Stage 51

CEN

European Committee for Standardisation
Comité Européen de Normalisation
Europäisches Komitee für Normung

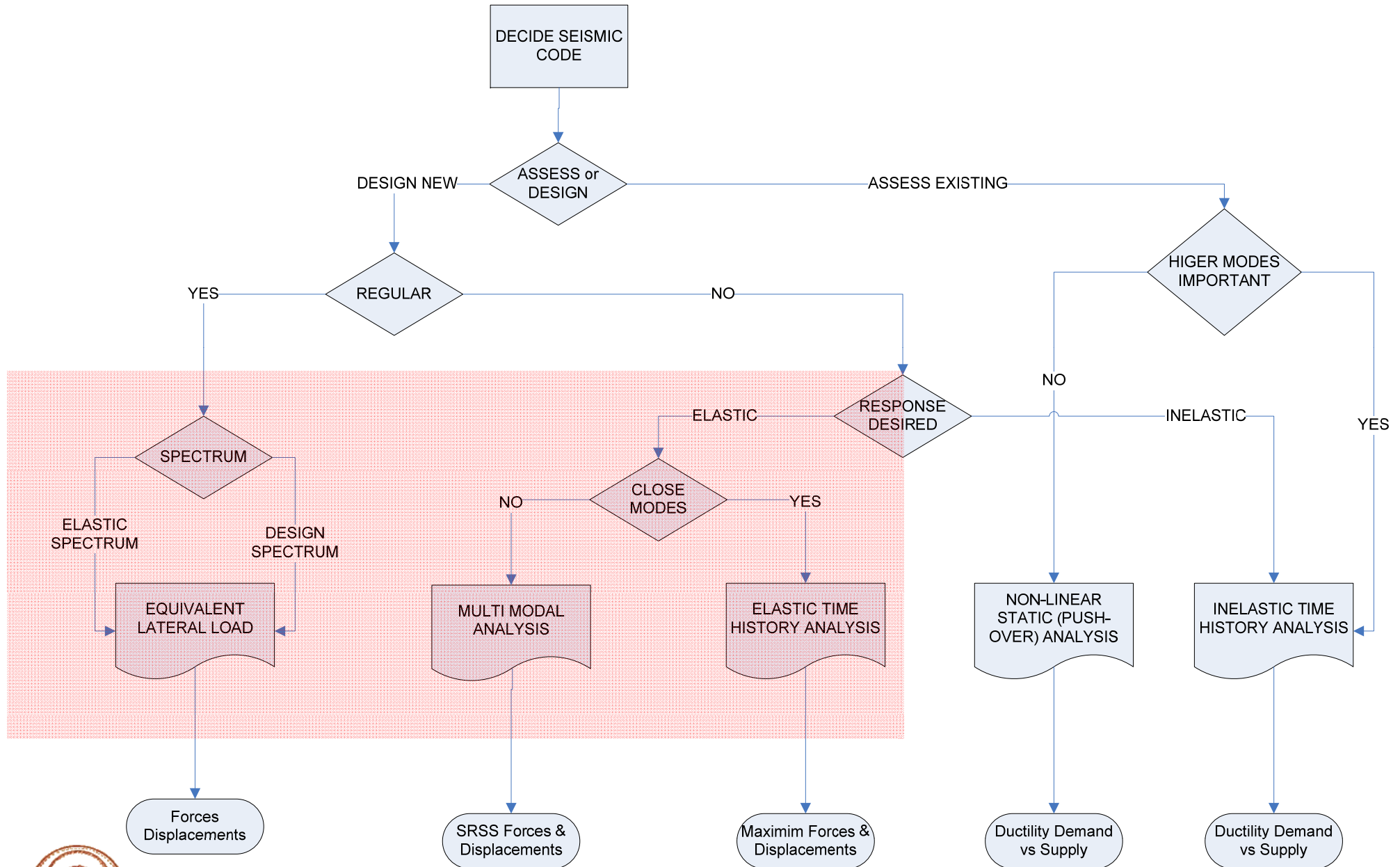
Central Secretariat: rue de Stassart 36, B-1050 Brussels

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Ref. No. EN 1998-1 : 2003 (E)



Seismic design & assessment flowchart



Eurocode 8 parts

Table 1: Eurocode 8 parts and key dates (achievement or expectation)

EC8 Part	Title	Approval by formal vote	Availability from CEN	National publication - National Annexes ⁽²⁾
1: EN1998-1	General rules, seismic actions, rules for buildings	Feb 04 ⁽¹⁾	Dec. 04 ⁽¹⁾	Dec. 06
2: EN1998-2	Bridges	June 05 ⁽¹⁾	Nov. 05 ⁽¹⁾	Nov. 07
3: EN1998-3	Assessment and retrofitting of buildings	Feb 05 ⁽¹⁾	June 05 ⁽¹⁾	June 07
4: EN1998-4	Silos, tanks, pipelines	April 06 ⁽¹⁾	July 06	July 08
5: EN1998-5	Foundations, retaining structures, geotechnical aspects	Feb 04 ⁽¹⁾	Nov. 04 ⁽¹⁾	Nov. 06
6: EN1998-6	Towers, masts, chimneys	March 05 ⁽¹⁾	June 05 ⁽¹⁾	June 07

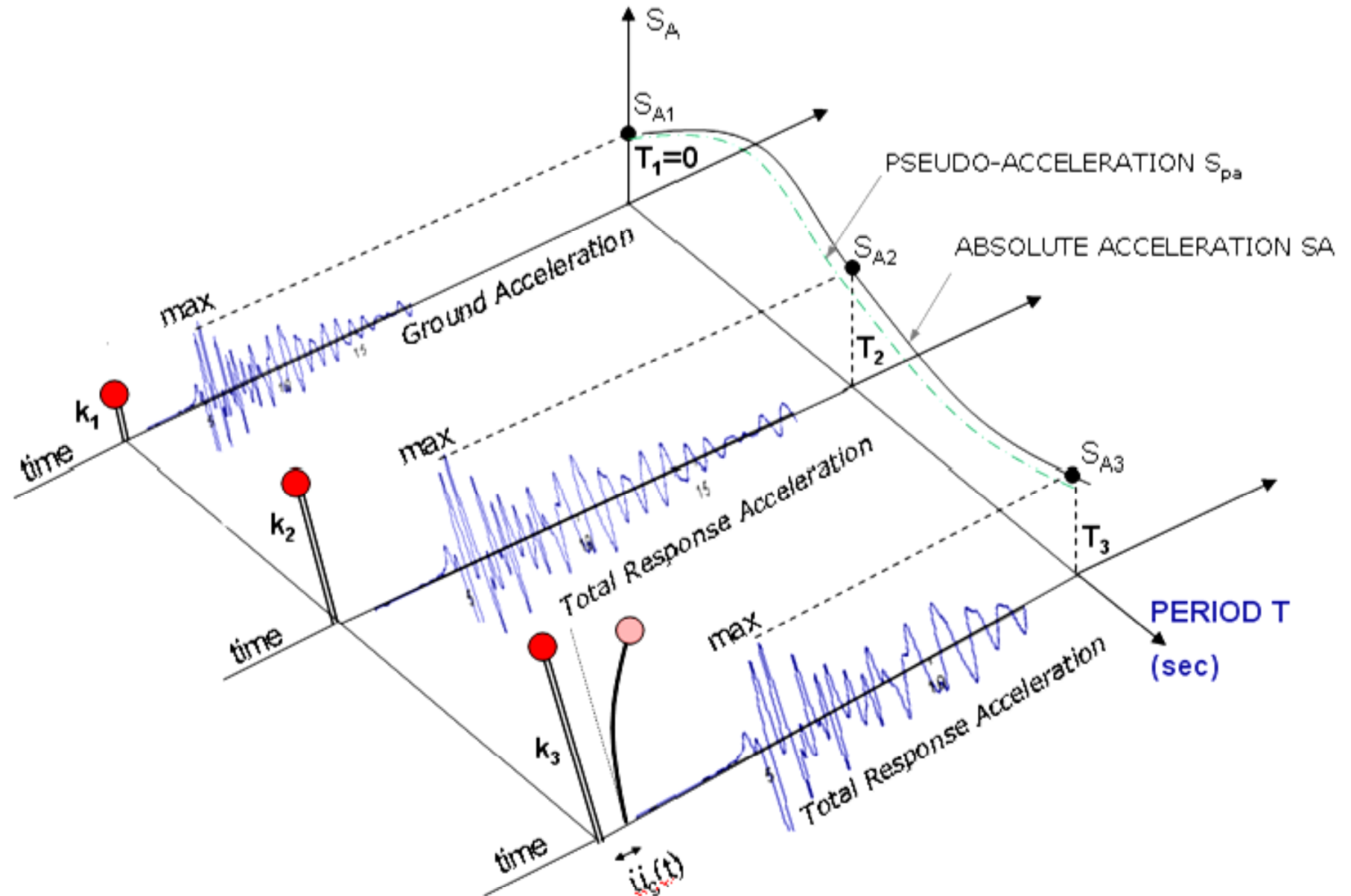
(1): Actual achievement date

(2): Expected date of publication by CEN member states of national (translated) version of EN, with National Annex and Nationally Determined Parameters; adaptation of national provisions to allow nationally the parallel use of the EN.

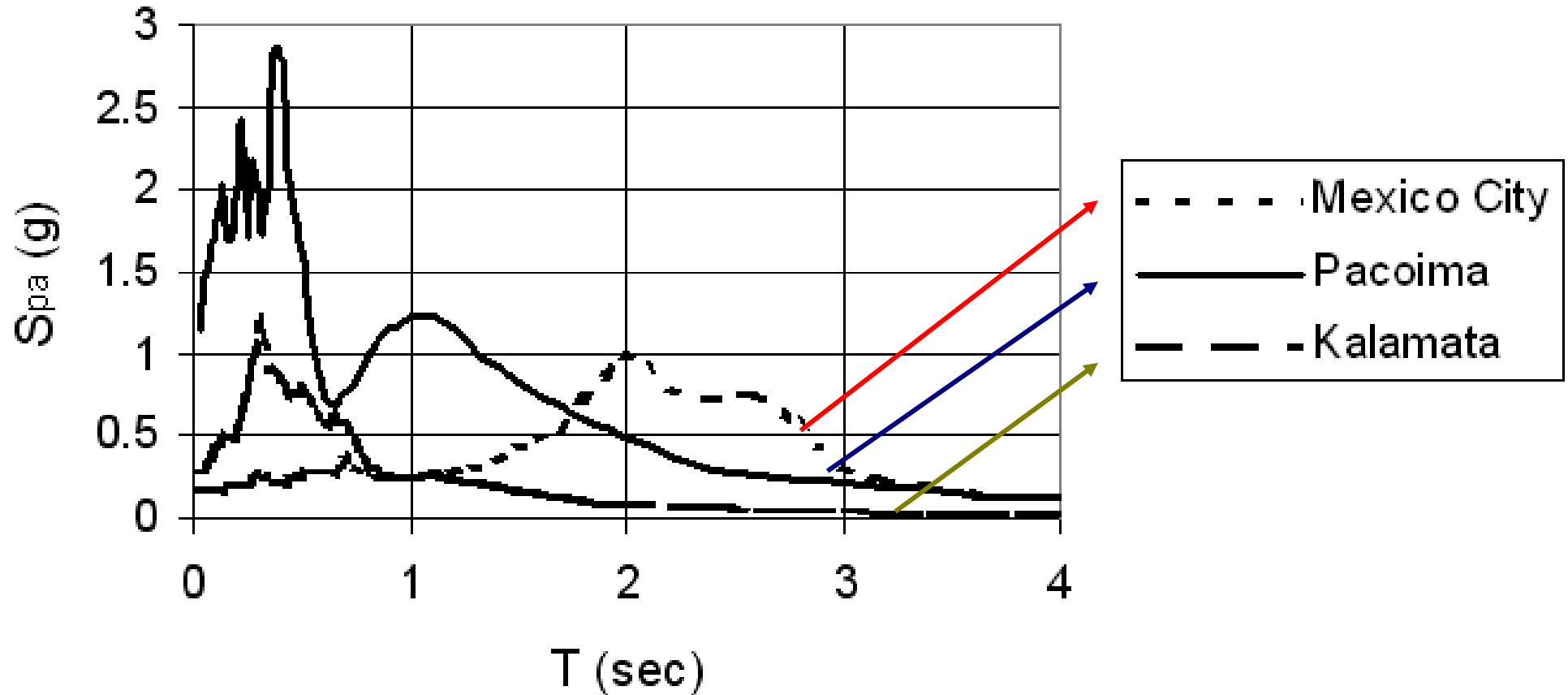
* M. Fardis (2006), 1st European Conf. on Earthq. Eng. and Seismology



Response spectra



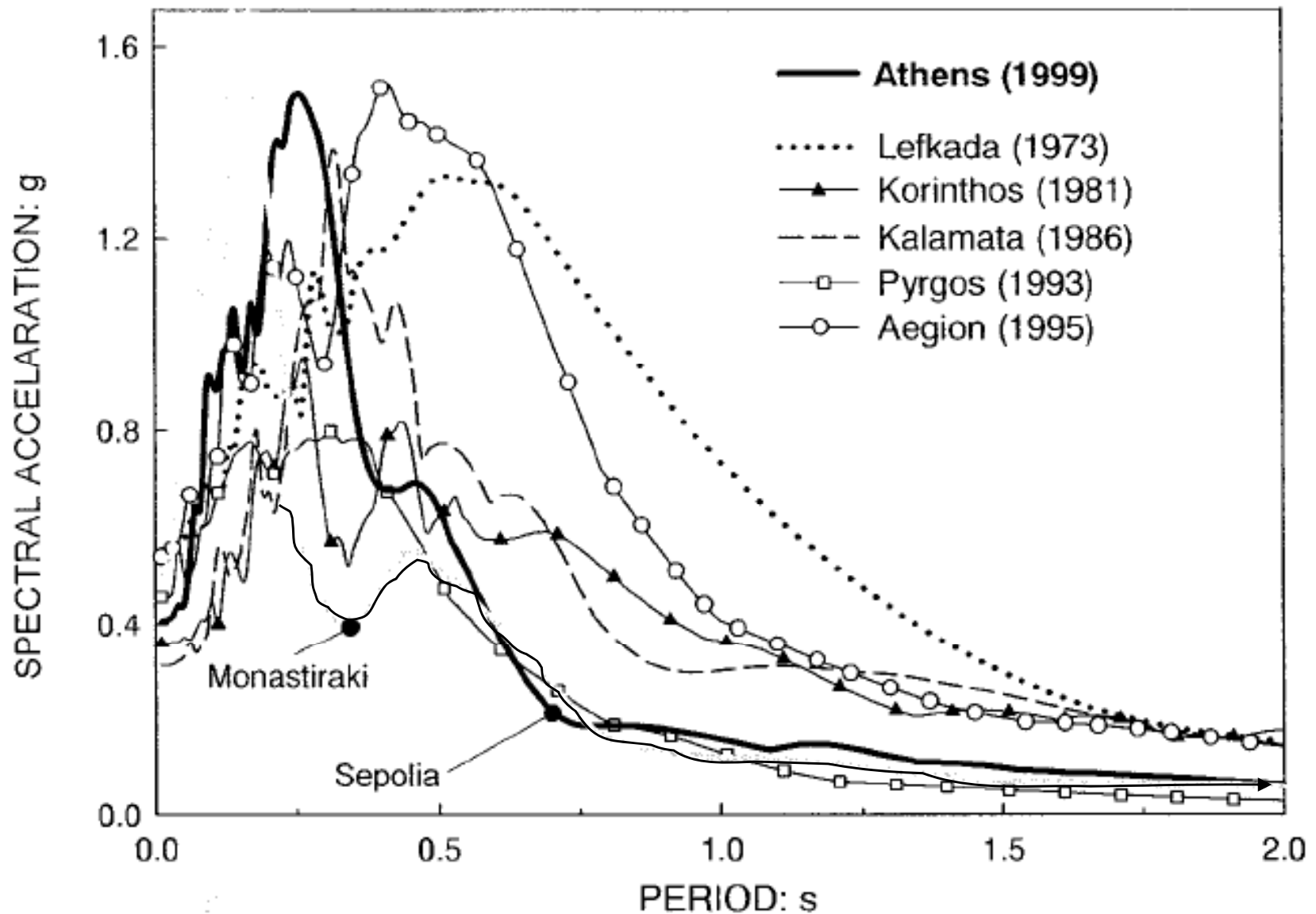
Response spectra



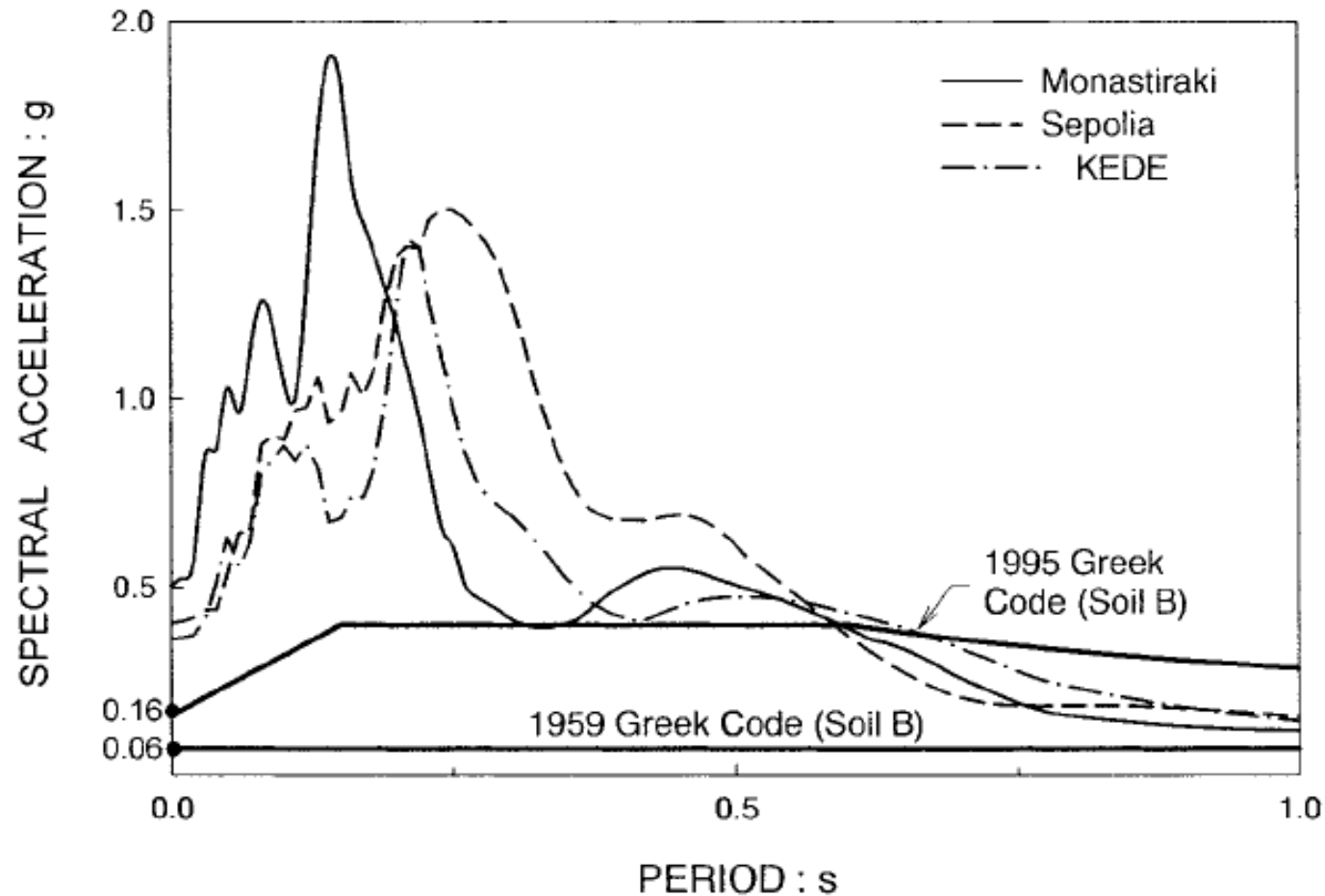
Depend on fault mechanism, epicentral distance, path and local site conditions



Response spectra



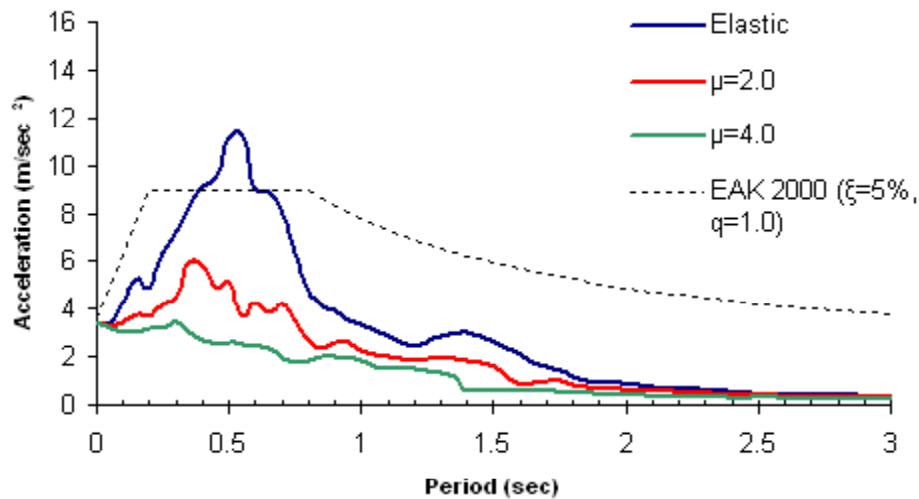
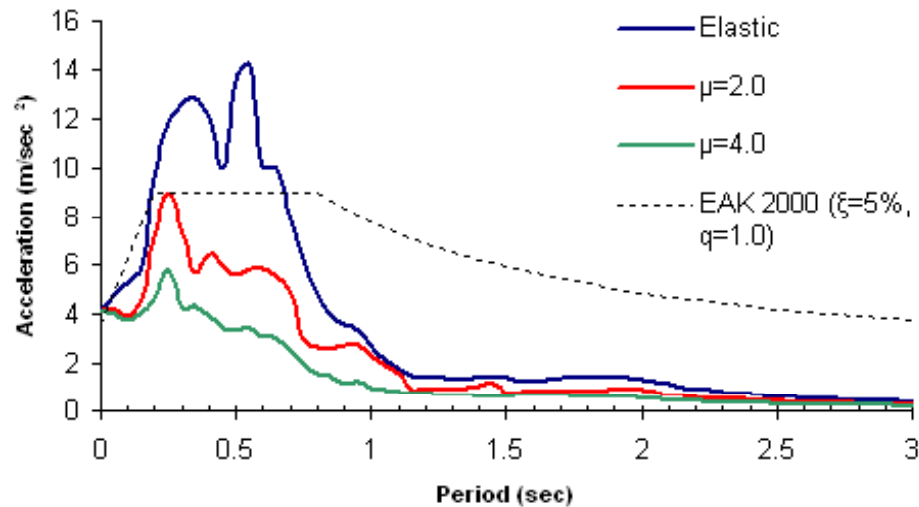
Response spectra



May well exceed seismic code prescribed spectra



Response spectra

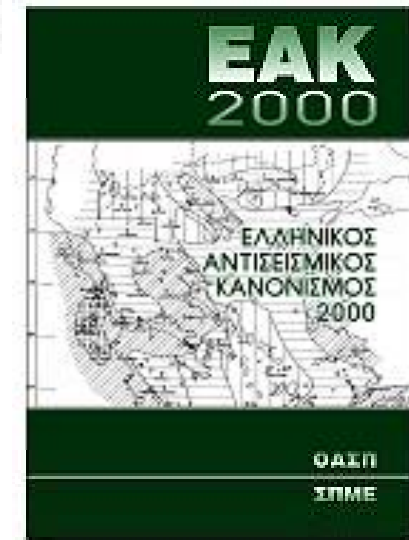
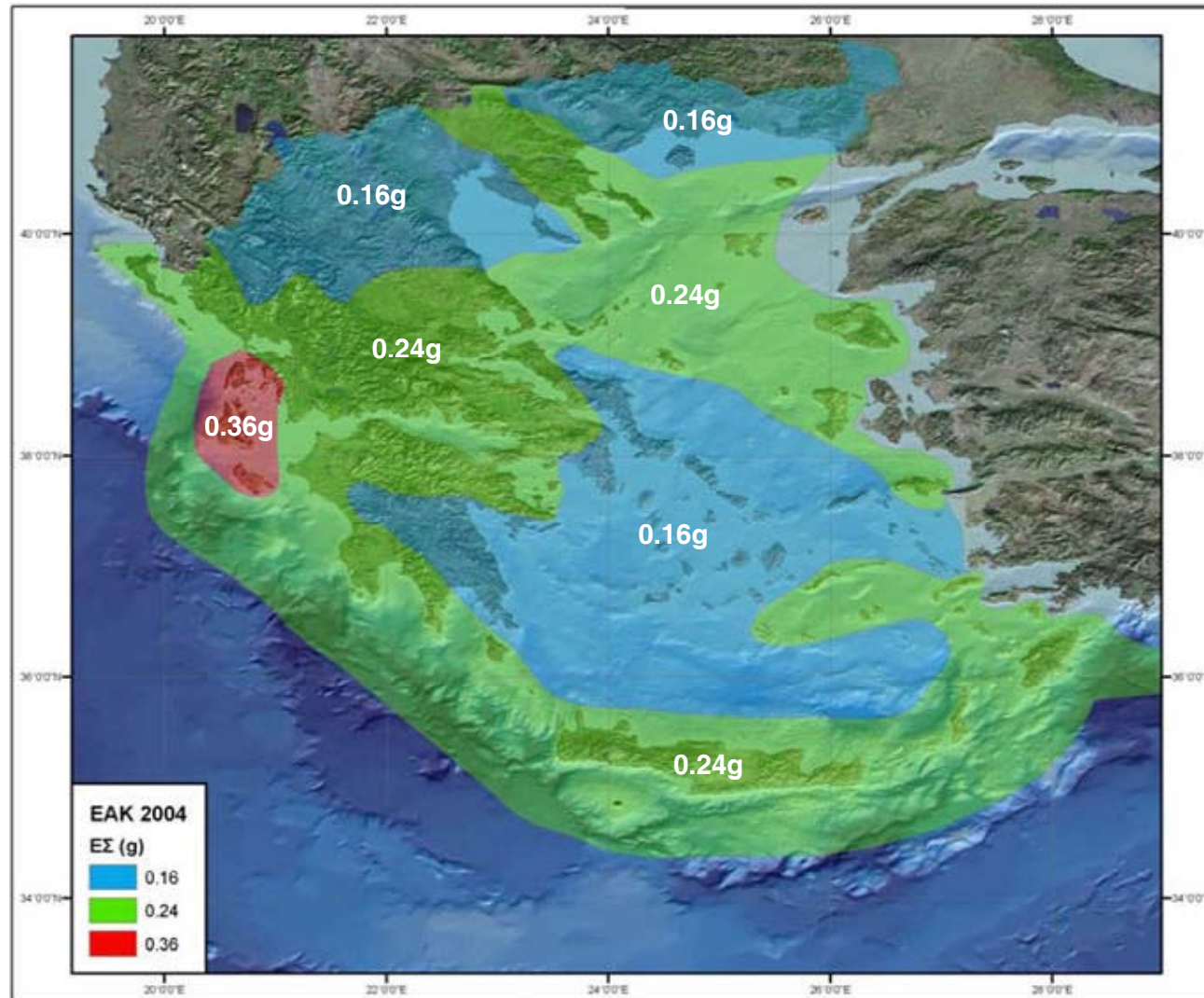


Inelastic spectra derived for ductility factors $\mu=2,3$ and 4 by the main shock response spectrum

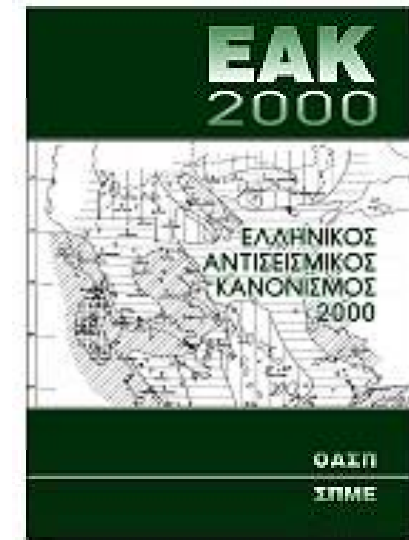
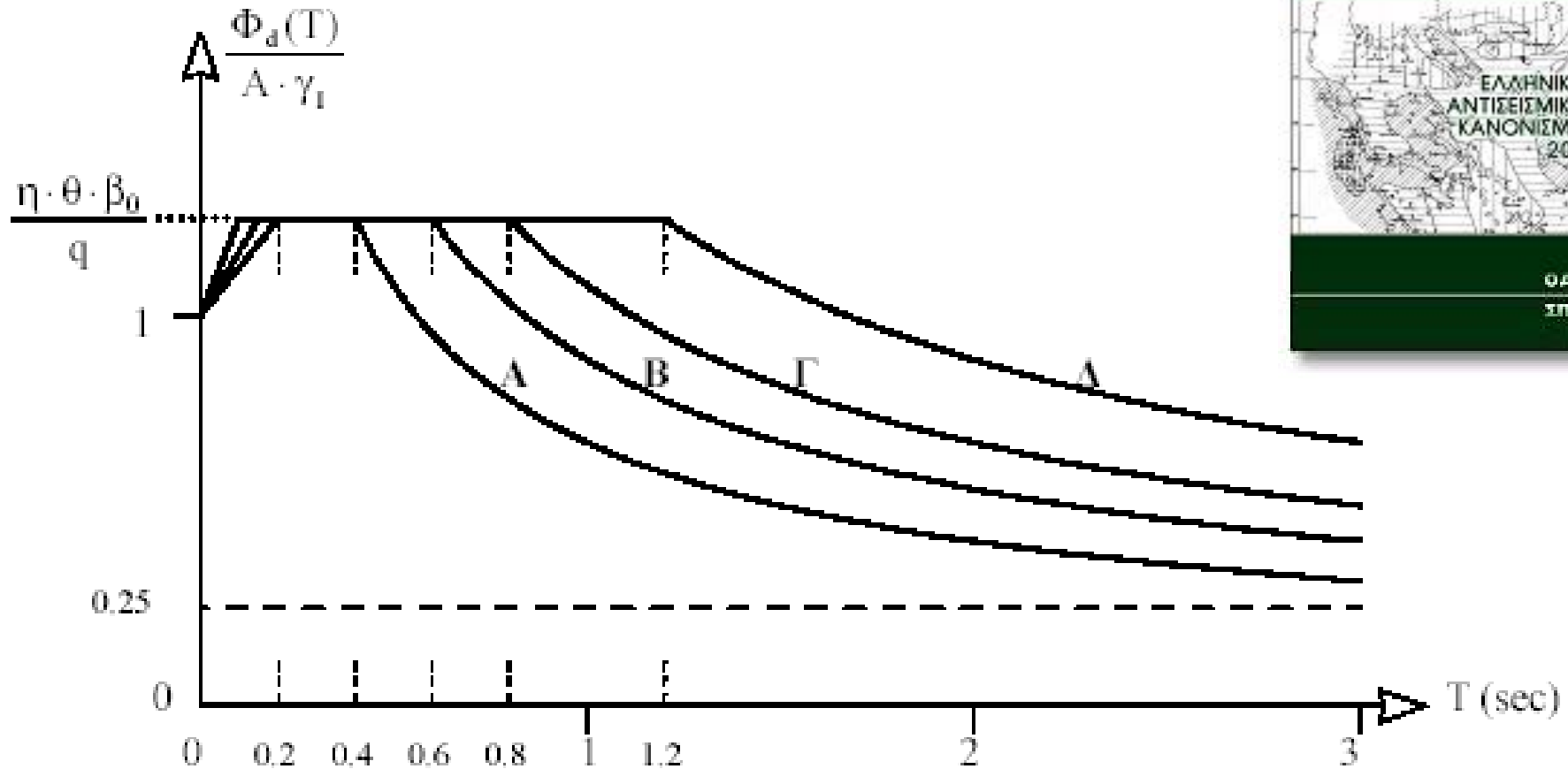


Hellenic Seismic Code

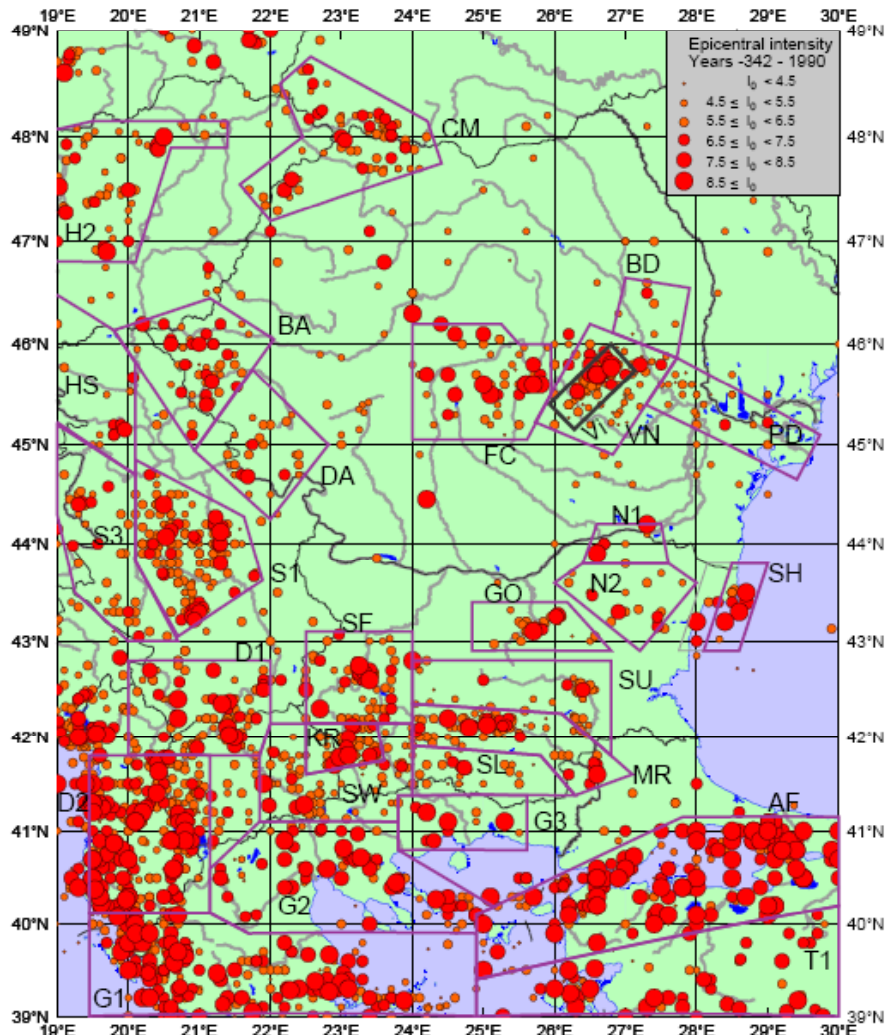
Seismic Zones for Greece (2004)



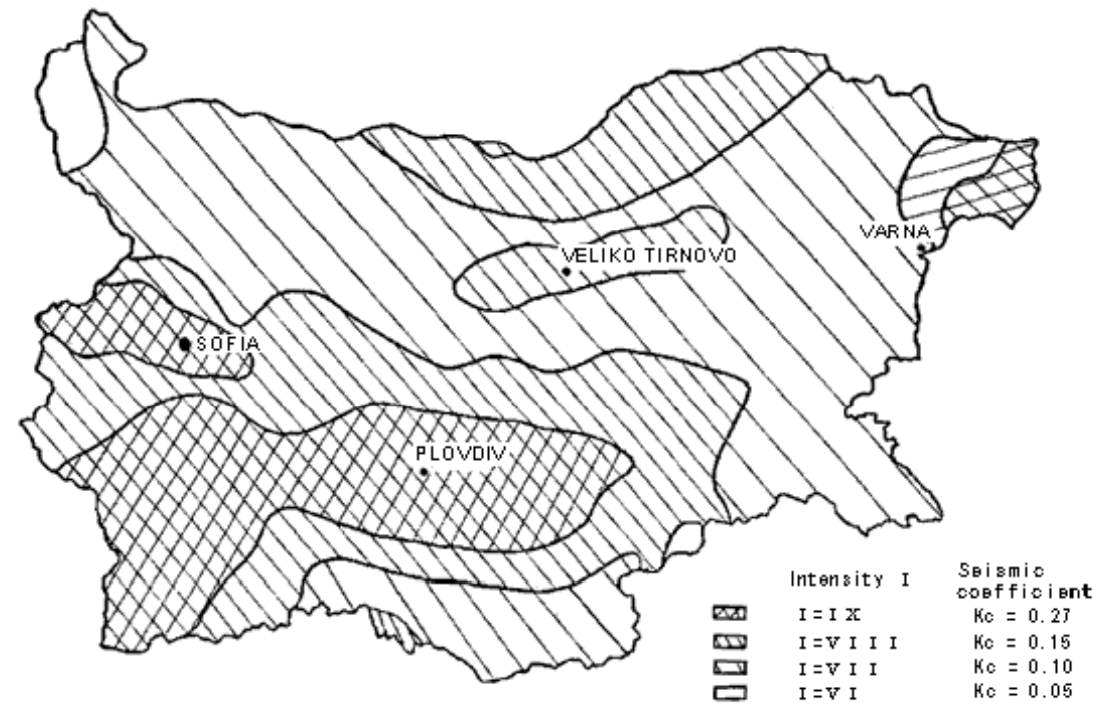
Hellenic Seismic Code



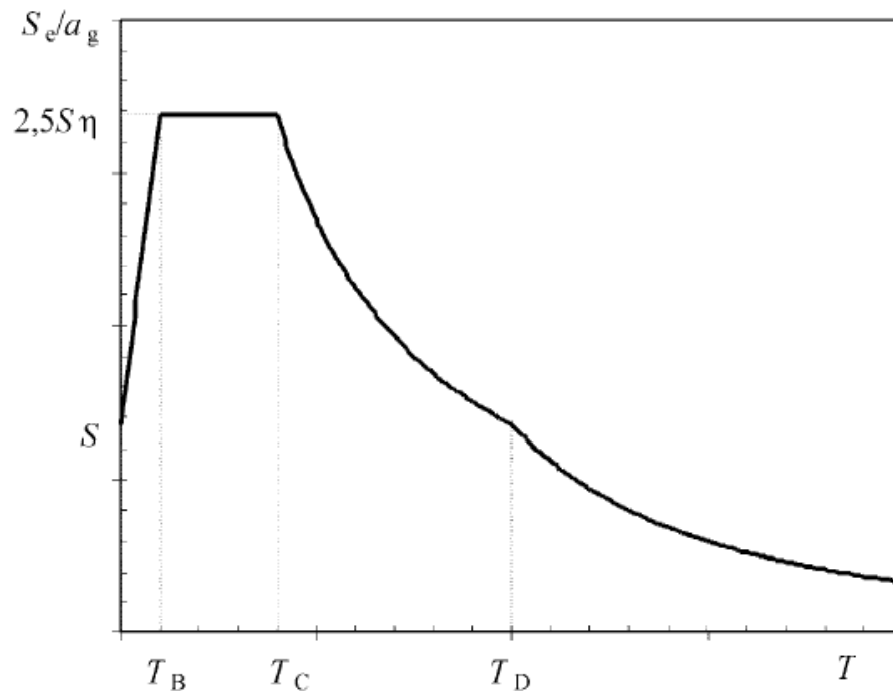
Bulgarian Seismic Code



Seismic Zones for Bulgaria



Eurocode 8 Elastic Response Spectrum



$$0 \leq T \leq T_B : S_e(T) = a_g \cdot S \cdot \left[1 + \frac{T}{T_B} \cdot (\eta \cdot 2,5 - 1) \right]$$

$$T_B \leq T \leq T_C : S_e(T) = a_g \cdot S \cdot \eta \cdot 2,5$$

$$T_C \leq T \leq T_D : S_e(T) = a_g \cdot S \cdot \eta \cdot 2,5 \left[\frac{T_C}{T} \right]$$

$$T_D \leq T \leq 4s : S_e(T) = a_g \cdot S \cdot \eta \cdot 2,5 \left[\frac{T_C T_D}{T^2} \right]$$

DAMPING η

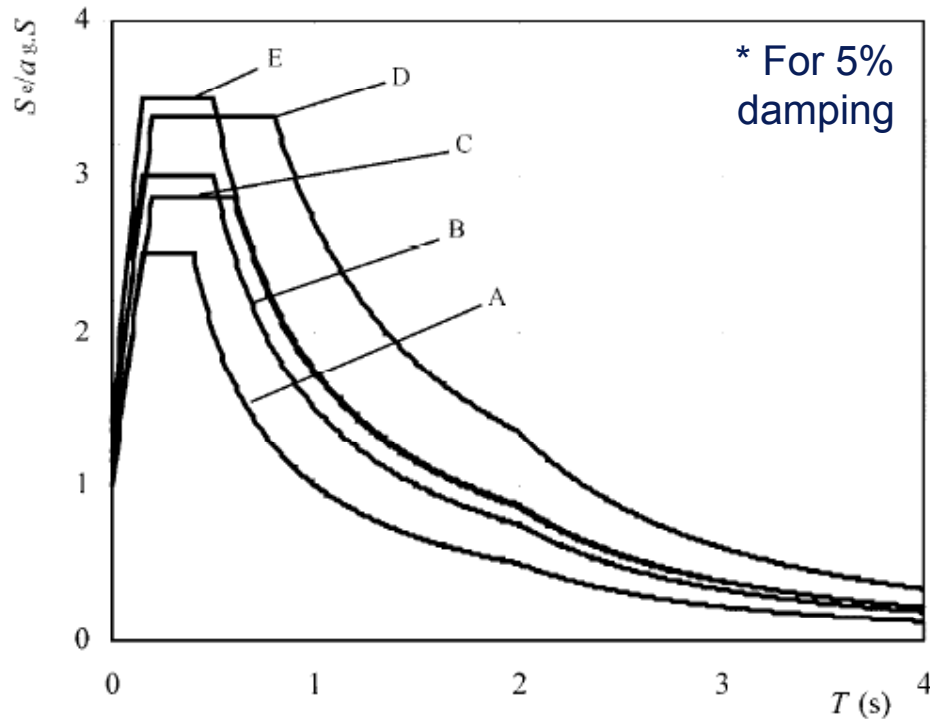
- Identical for both horizontal actions
- S = Soil factor
- α_g = design ground acceleration
- η = damping correction factor
- T_B, T_C, T_D = corner periods

• RC structures (uncracked)	0.7-1.0%
• RC Structures (fully cracked)	1.0-4.0%
• RC Structures (fully cracked no yielding)	5.0-8.0%
• Prestressed concrete (uncracked)	0.4-0.7%
• Lightly stressed concrete	0.8-1.2%
• Composite	2.0-3.0%
• Steel	1.0-2.0%



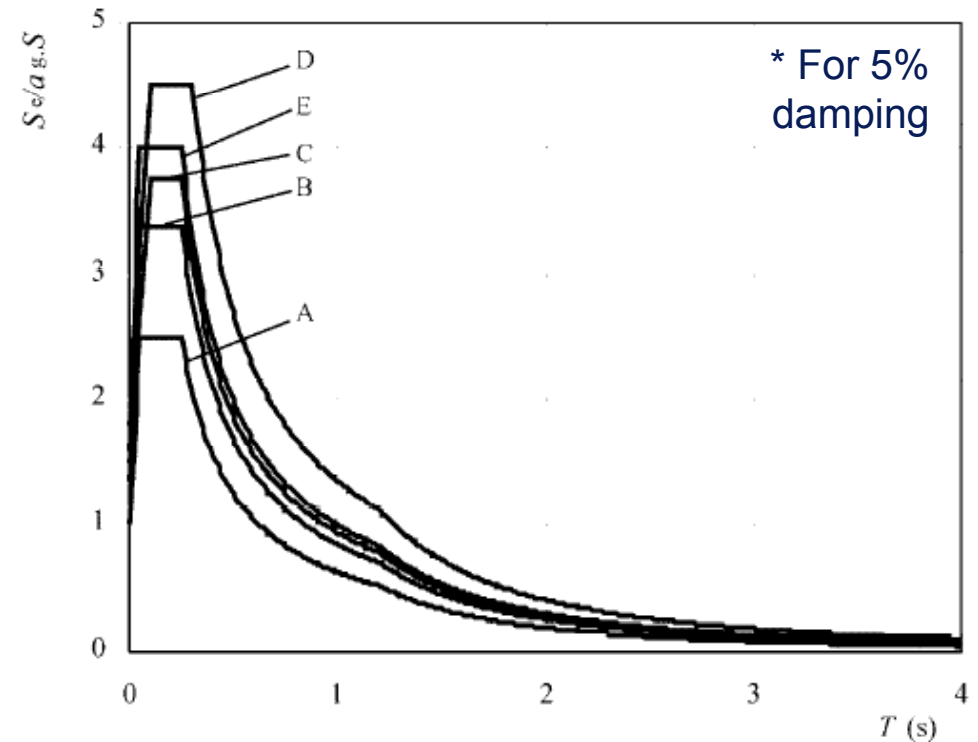
Eurocode 8 Elastic Response Spectrum: Two types of spectra

- **Type 1:** For areas exposed to earthquakes with expected surface wave magnitude $M_s > 5.5$



Ground type	S	T_B (s)	T_C (s)	T_D (s)
A	1,0	0,15	0,4	2,0
B	1,2	0,15	0,5	2,0
C	1,15	0,20	0,6	2,0
D	1,35	0,20	0,8	2,0
E	1,4	0,15	0,5	2,0

- **Type 2:** For areas exposed to earthquakes with expected surface wave magnitude $M_s \leq 5.5$



Ground type	S	T_B (s)	T_C (s)	T_D (s)
A	1,0	0,05	0,25	1,2
B	1,35	0,05	0,25	1,2
C	1,5	0,10	0,25	1,2
D	1,8	0,10	0,30	1,2
E	1,6	0,05	0,25	1,2

Eurocode 8 : Soil Classes, Im

Ground type	Description of stratigraphic profile	Parameters		
		$v_{s,30}$ (m/s)	N_{SPT} (blows/30cm)	c_u (kPa)
A	Rock or other rock-like geological formation, including at most 5 m of weaker material at the surface.	> 800	–	–
B	Deposits of very dense sand, gravel, or very stiff clay, at least several tens of metres in thickness, characterised by a gradual increase of mechanical properties with depth.	360 – 800	> 50	> 250

Structure type

Importance factor: γ_I

Buildings

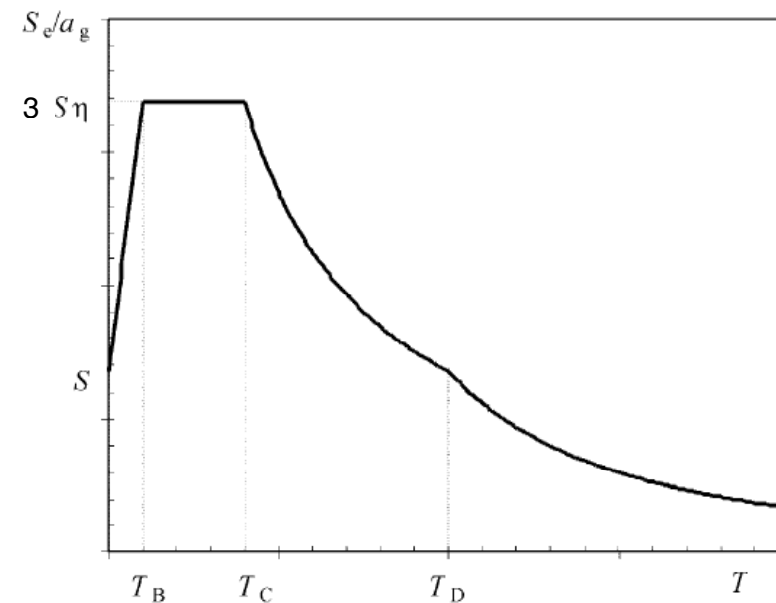
- Hospitals, fire stations, power plants, etc. 1.4
- Schools, assembly halls, stadia, museums, etc. 1.2
- Ordinary buildings 1.0
- Agricultural buildings 0.8

Bridges

- Critical to maintaining emergency communications. 1.3
- Average 1.0
- Not critical to maintaining emergency communications. 0.7

Eurocode 8 Elastic Vertical Response Spectrum

- shape retained
- again **Type 1** ($M_s > 5.5$) and **Type 2** ($M_s \leq 5.5$) distinction is made
- but shape is not changing depending on the spectrum type neither on the soil conditions
- vertical PGA is lower than horizontal PGA



$$0 \leq T \leq T_B : S_{ve}(T) = a_{vg} \cdot \left[1 + \frac{T}{T_B} \cdot (\eta \cdot 3,0 - 1) \right]$$

$$T_B \leq T \leq T_C : S_{ve}(T) = a_{vg} \cdot \eta \cdot 3,0$$

$$T_C \leq T \leq T_D : S_{ve}(T) = a_{vg} \cdot \eta \cdot 3,0 \left[\frac{T_C}{T} \right]$$

$$T_D \leq T \leq 4s : S_{ve}(T) = a_{vg} \cdot \eta \cdot 3,0 \left[\frac{T_C \cdot T_D}{T^2} \right]$$

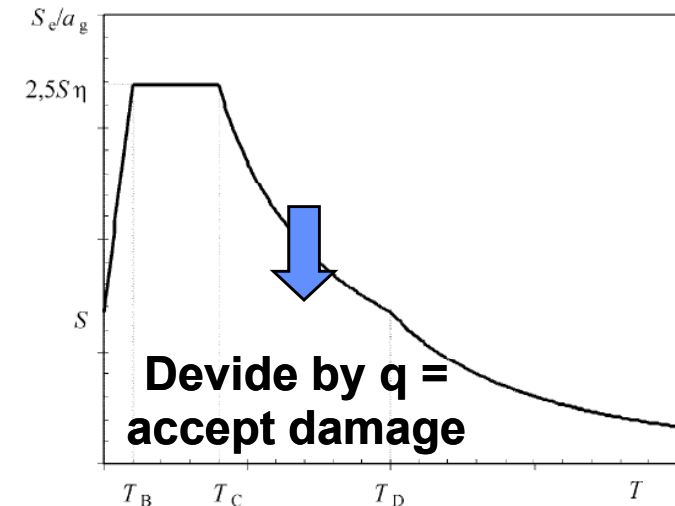
Spectrum	a_{vg}/a_g	T_B (s)	T_C (s)	T_D (s)
Type 1	0,90	0,05	0,15	1,0
Type 2	0,45	0,05	0,15	1,0



Eurocode 8 Design Spectrum for Elastic Analysis

EN1998-1:2004 §3.2.2.5

“To avoid explicit inelastic structural analysis in design, the capacity of the structure to dissipate energy, through mainly ductile behaviour of its elements and/or other mechanisms, is taken into account by **performing an elastic analysis** based on a **response spectrum reduced** with respect to the elastic one, hence forth called a **"design spectrum"**. This reduction is accomplished by introducing the **behaviour factor q** ”.



$$0 \leq T \leq T_B : S_d(T) = a_g \cdot S \cdot \left[\frac{2}{3} + \frac{T}{T_B} \cdot \left(\frac{2.5}{q} - \frac{2}{3} \right) \right]$$

$$T_C \leq T \leq T_D : S_d(T) \begin{cases} = a_g \cdot S \cdot \frac{2.5}{q} \cdot \left[\frac{T_C}{T} \right] \\ \geq \beta \cdot a_g \end{cases}$$

$$T_B \leq T \leq T_C : S_d(T) = a_g \cdot S \cdot \frac{2.5}{q}$$

$$T_D \leq T : S_d(T) \begin{cases} = a_g \cdot S \cdot \frac{2.5}{q} \cdot \left[\frac{T_C T_D}{T^2} \right] \\ \geq \beta \cdot a_g \end{cases}$$



Eurocode 8 Design Spectrum for Elastic Analysis

$$0 \leq T \leq T_B : S_d(T) = a_g \cdot S \cdot \left[\frac{2}{3} + \frac{T}{T_B} \cdot \left(\frac{2,5}{q} - \frac{2}{3} \right) \right]$$

$$T_B \leq T \leq T_C : S_d(T) = a_g \cdot S \cdot \frac{2,5}{q}$$

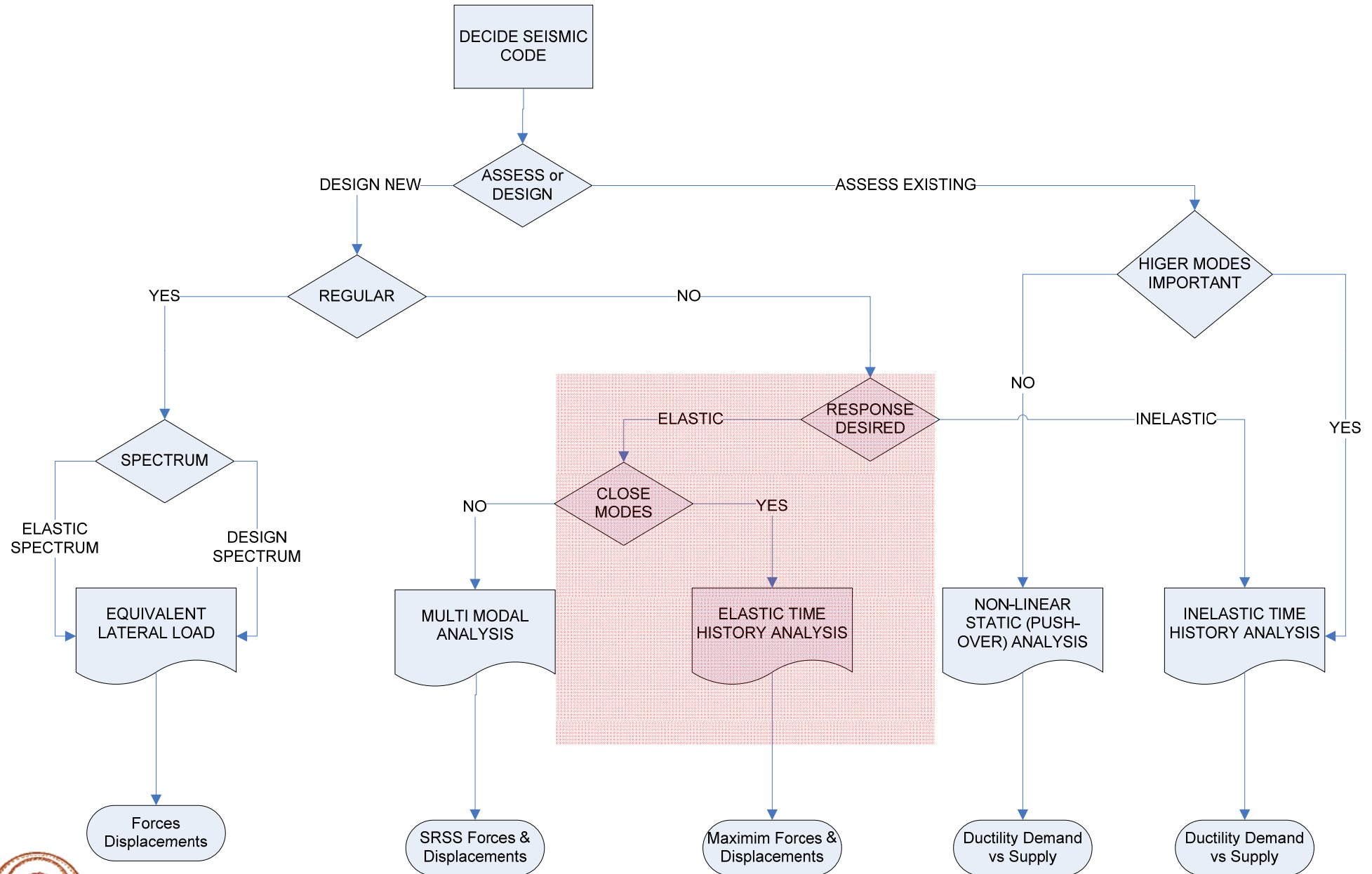
$$T_C \leq T \leq T_D : S_d(T) \begin{cases} = a_g \cdot S \cdot \frac{2,5}{q} \cdot \left[\frac{T_C}{T} \right] \\ \geq \beta \cdot a_g \end{cases}$$

$$T_D \leq T : S_d(T) \begin{cases} = a_g \cdot S \cdot \frac{2,5}{q} \cdot \left[\frac{T_C T_D}{T^2} \right] \\ \geq \beta \cdot a_g \end{cases}$$

Building type	Behaviour factor: q
Reinforced concrete	
• Frame system	5.0
• Dual system	4.5–5.0
• Wall system	4.0–5.0
• Core system	3.5
• Inverted pendulum system	2.0
Steel	
• Moment resisting frame	5.0–8.0
• Concentric braced frame	4.0
• Eccentric braced frame	5.0–8.0
• Cantilever structures	2.0
• Moment resisting frame with concrete/masonry infills	2.0



Seismic design & assessment flowchart



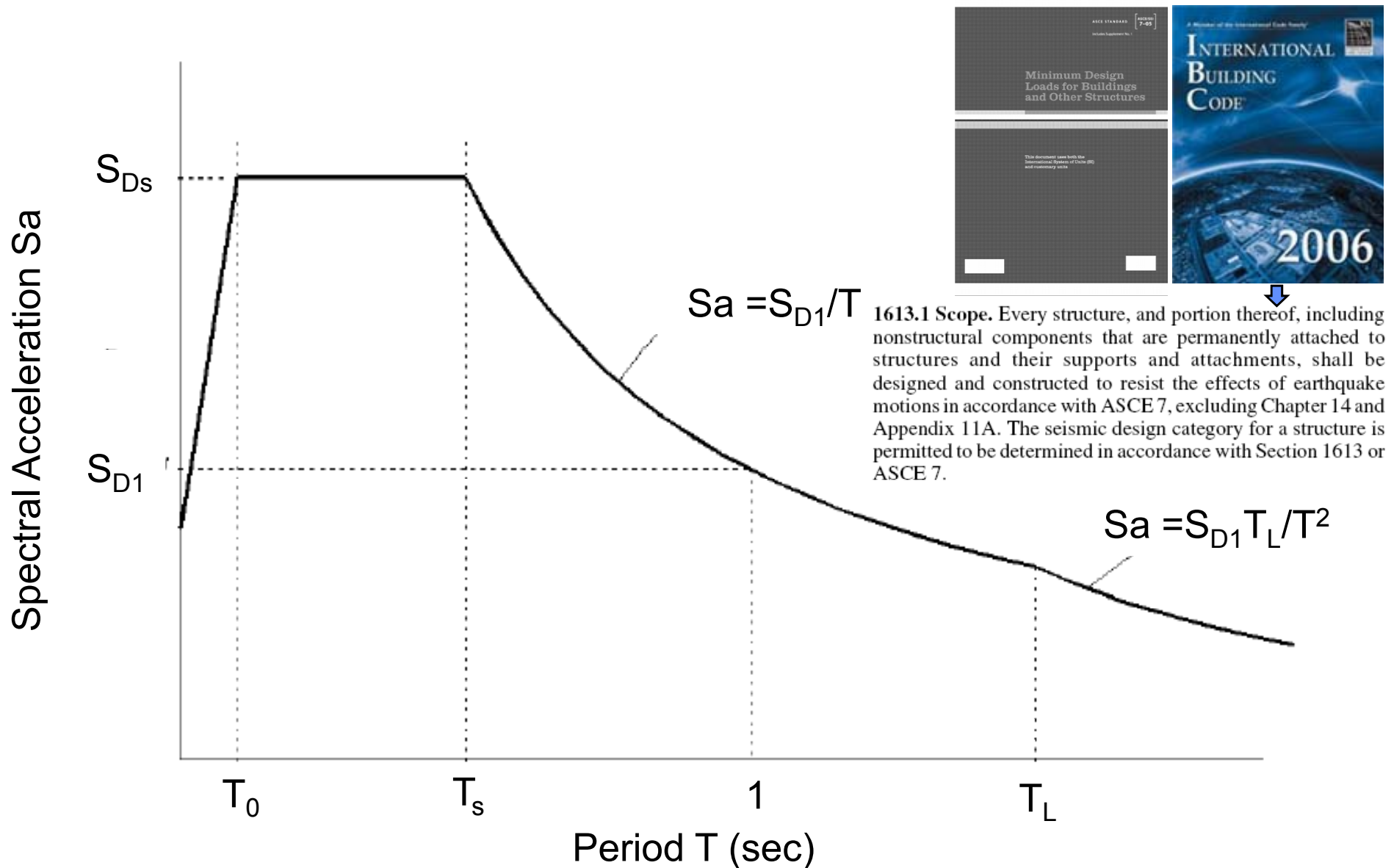
Eurocode 8 Alternative representation of Seismic Action

Time History representation

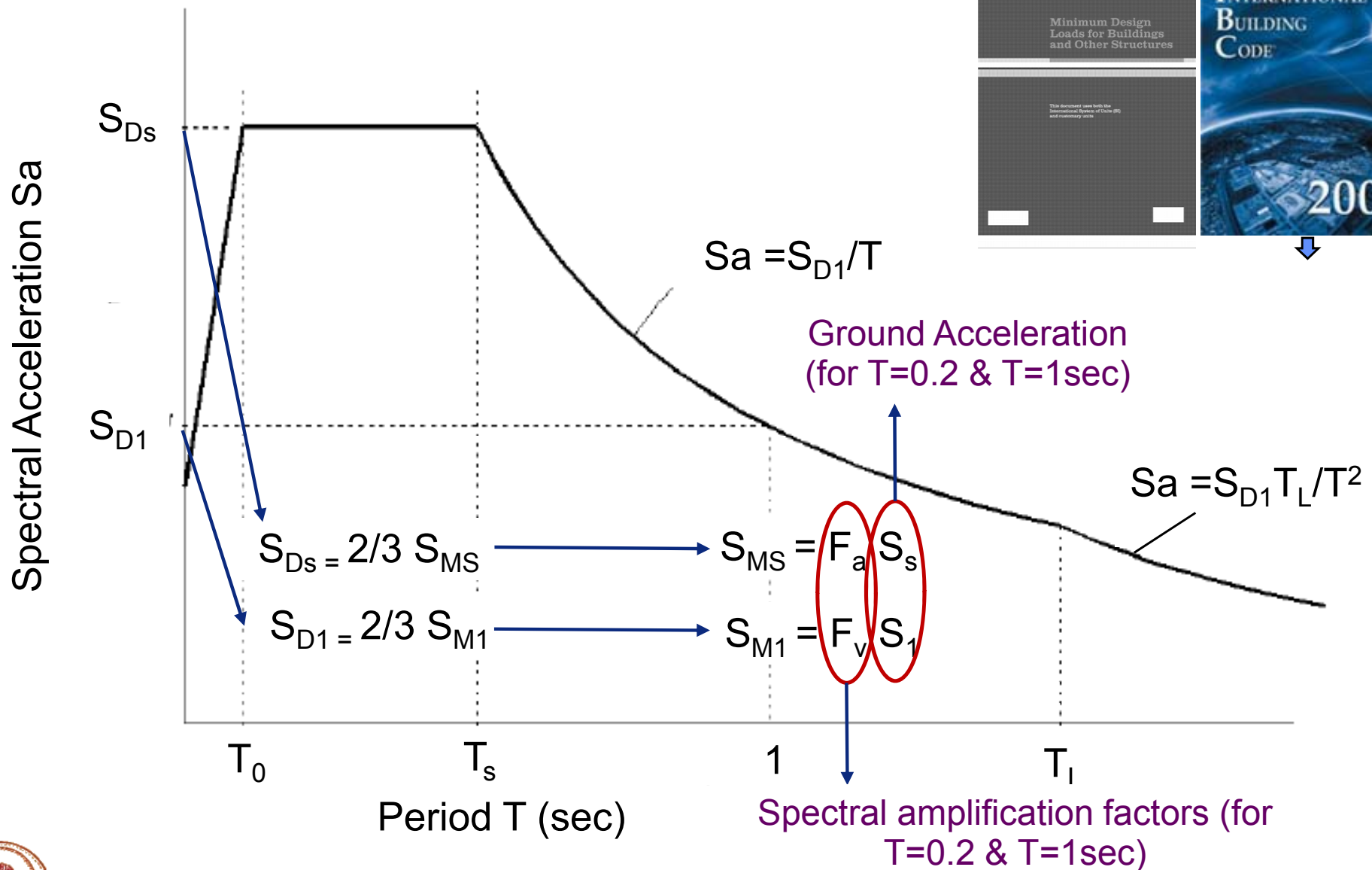
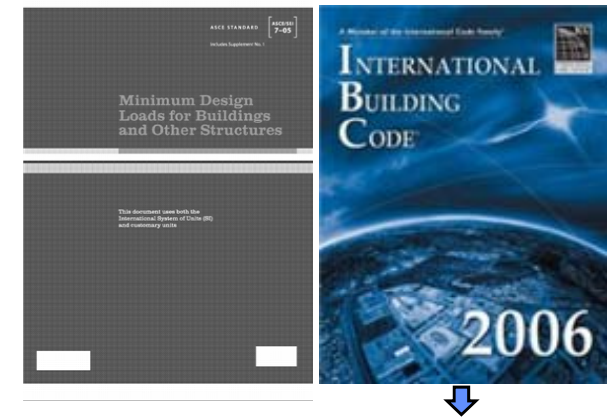
- Accelerograms may be **either artificial or recorded**
- The **three components** are necessary
- Same accelerogram cannot be used **simultaneously along both horizontal** directions
- **Duration should be consistent with the magnitude** of the earthquake (minimum duration is 10sec unless specific site response analysis is made)
- The suite of artificial accelerograms should observe the following rules:
 - (1) A **minimum of 3 records** is used
 - (2) The **mean of the zero period spectral** acceleration response (i.e. PGA) should not be less than $\alpha_g \cdot S$ for the specific site
 - (3) In the range of periods between **0.2T₁ and 2T₁**, where T₁ the fundamental period of the structure in the direction where the accelerogram will be applied: no value of the mean 5% damping elastic spectrum (as calculated by all time histories) should be **less than the 90%** of the corresponding value that would have been derived using the 5% damping elastic response spectrum



U.S. International Building Code (2006) - ASCE standard 7



U.S. International Building Code (2006) - ASCE standard 7



U.S. International Building Code (2006) σε συνδυασμό με ASCE standard 7



TABLE 1613.5.3(1)
VALUES OF SITE COEFFICIENT F_a ^a

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIOD				
	$S_s \leq 0.25$	$S_s = 0.50$	$S_s = 0.75$	$S_s = 1.00$	$S_s \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	Note b	Note b	Note b	Note b	Note b

Spectral Amplification Factors F_a & F_v (for $T=0.2$ & $T=1$ sec)
Function of soil condition and earthquake intensity

VALUES OF SITE COEFFICIENT F_v ^a

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT 1-SECOND PERIOD				
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \geq 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	Note b	Note b	Note b	Note b	Note b

- a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at 1-second period, S_1 .
b. Values shall be determined in accordance with Section 11.4.7 of ASCE 7.



U.S. International Building Code (2006) - ASCE standard 7

Soil categories

TABLE 1613.5.2
SITE CLASS DEFINITIONS

SITE CLASS	SOIL PROFILE NAME	AVERAGE PROPERTIES IN TOP 100 feet, SEE SECTION 1613.5.5		
		Soil shear wave velocity, \bar{v}_s , (ft/s)	Standard penetration resistance, \bar{N}	Soil undrained shear strength, \bar{s}_u , (psf)
A	Hard rock	$\bar{v}_s > 5,000$	N/A	N/A
B	Rock	$2,500 < \bar{v}_s \leq 5,000$	N/A	N/A
C	Very dense soil and soft rock	$1,200 < \bar{v}_s \leq 2,500$	$\bar{N} > 50$	$\bar{s}_u \geq 2,000$
D	Stiff soil profile	$600 \leq \bar{v}_s \leq 1,200$	$15 \leq \bar{N} \leq 50$	$1,000 \leq \bar{s}_u \leq 2,000$
E	Soft soil profile	$\bar{v}_s < 600$	$\bar{N} < 15$	$\bar{s}_u < 1,000$
E	—	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity index $PI > 20$, 2. Moisture content $w \geq 40\%$, and 3. Undrained shear strength $\bar{s}_u < 500$ psf		
F	—	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays ($H > 10$ feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays ($H > 25$ feet with plasticity index $PI > 75$) 4. Very thick soft/medium stiff clays ($H > 120$ feet)		

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m², 1 pound per square foot = 0.0479 kPa. N/A = Not applicable

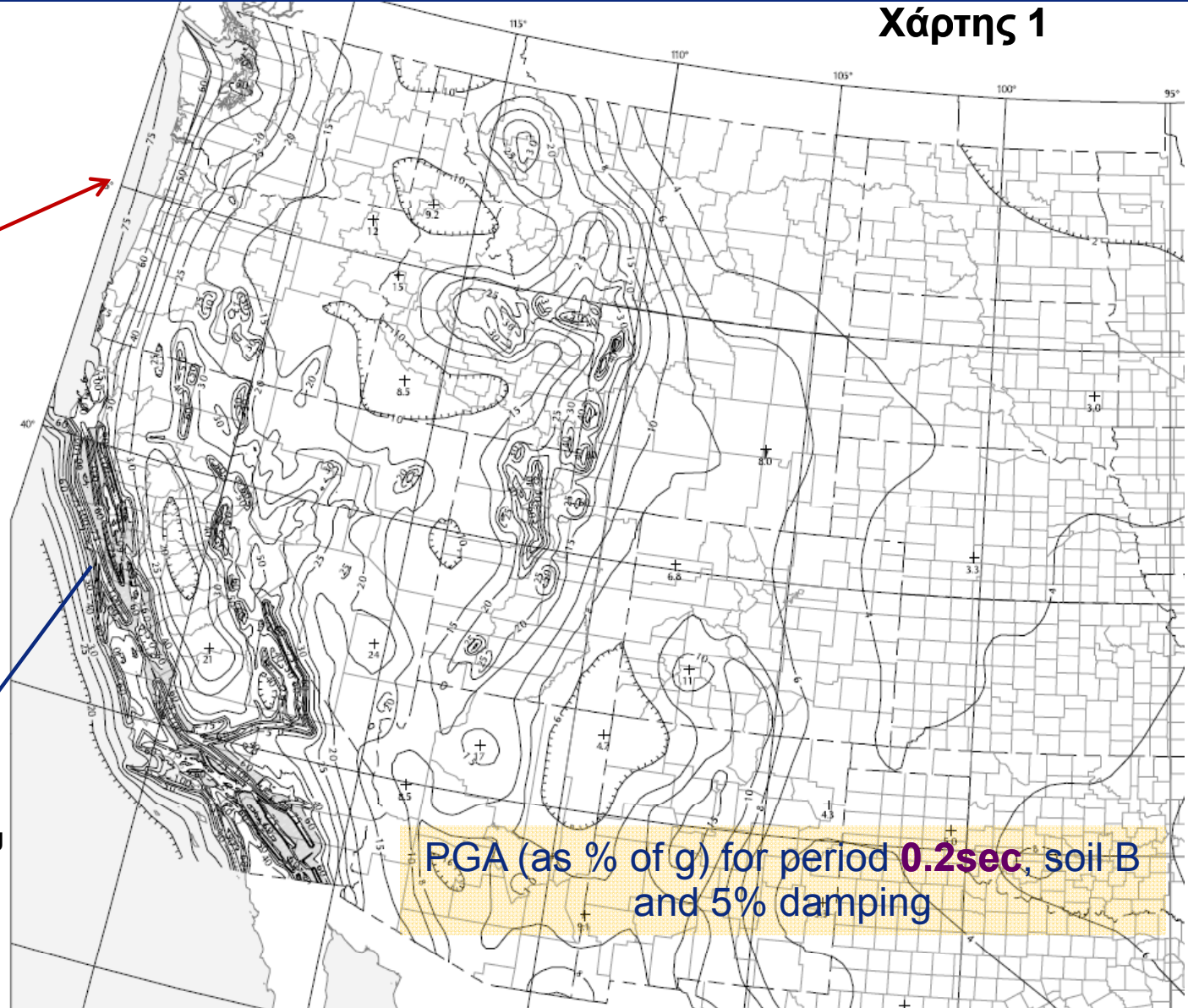
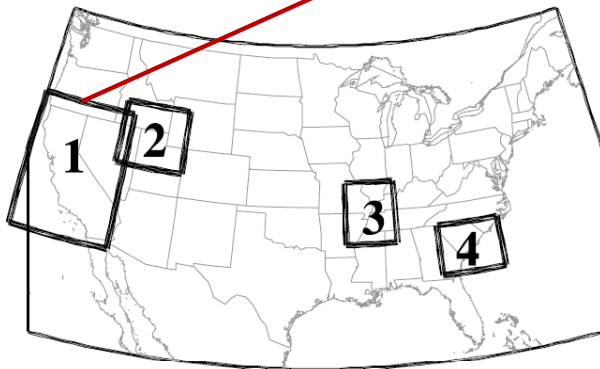


U.S. International Building Code (2006) σε συνδυασμό με ASCE standard 7



PGA (S_1 για $T=0.2\text{sec}$)

Χάρτης 1



Values up to 200% $g = 2g$

PGA (as % of g) for period **0.2sec**, soil B and 5% damping



U.S. Seismic Codes: FEMA 273

B_1 = damping Coefficient

S_{x1} = (Site Response Coefficient F_v depending on soil conditions and seismicity) * (ground acceleration S_1 at $T=1$ sec)

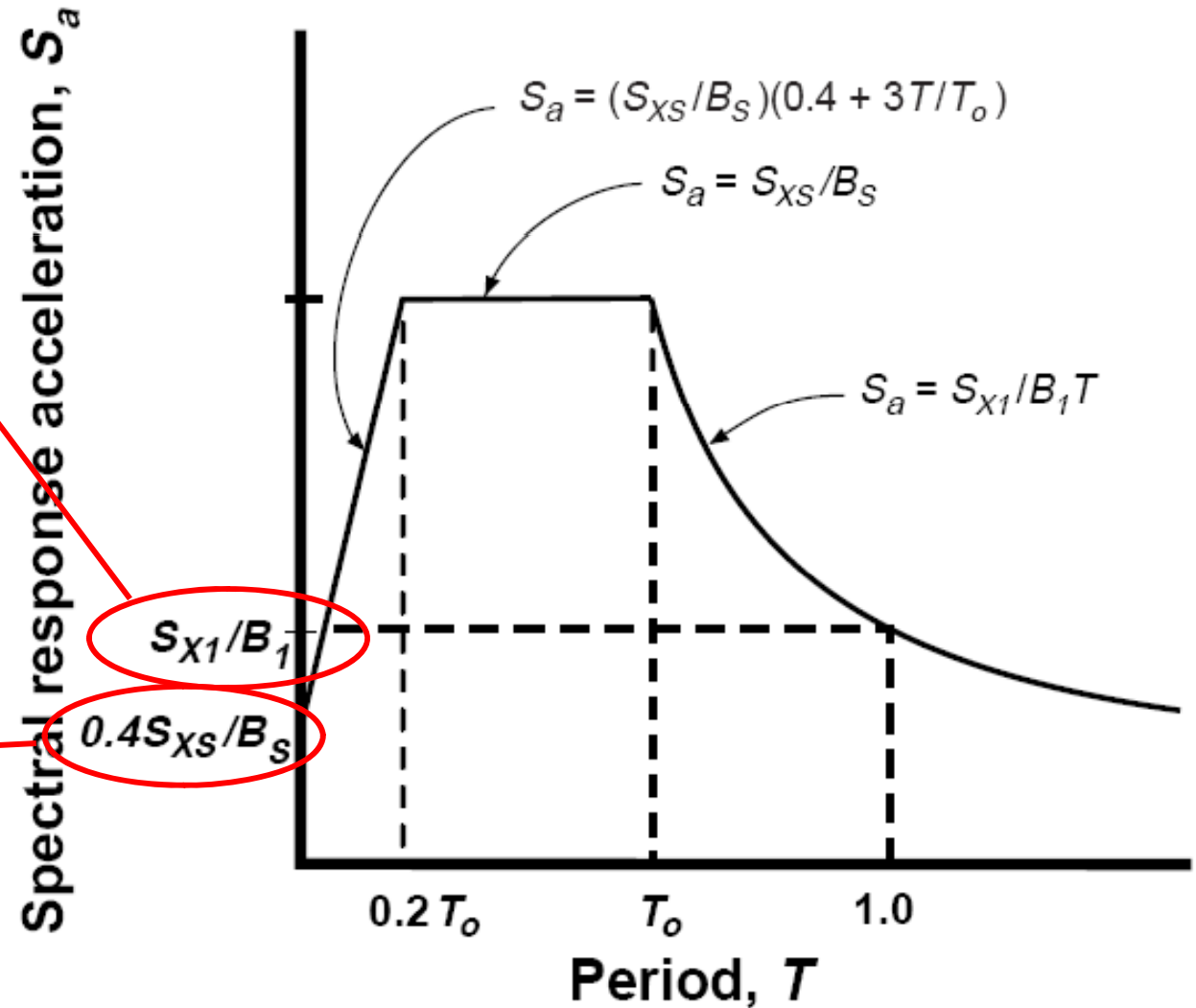
S_{xs} = (Site Response Coefficient F_a depending on soil conditions and seismicity) * (ground acceleration S_s at $T=0$ sec)

FEDERAL EMERGENCY MANAGEMENT AGENCY FEMA 273 / October 1997

NEHRP GUIDELINES FOR THE SEISMIC REHABILITATION OF BUILDINGS



Issued by FEMA in furtherance of the Decade for Natural Disaster Reduction



Again spectral acceleration is both Magnitude and Site dependent

U.S. Seismic Codes

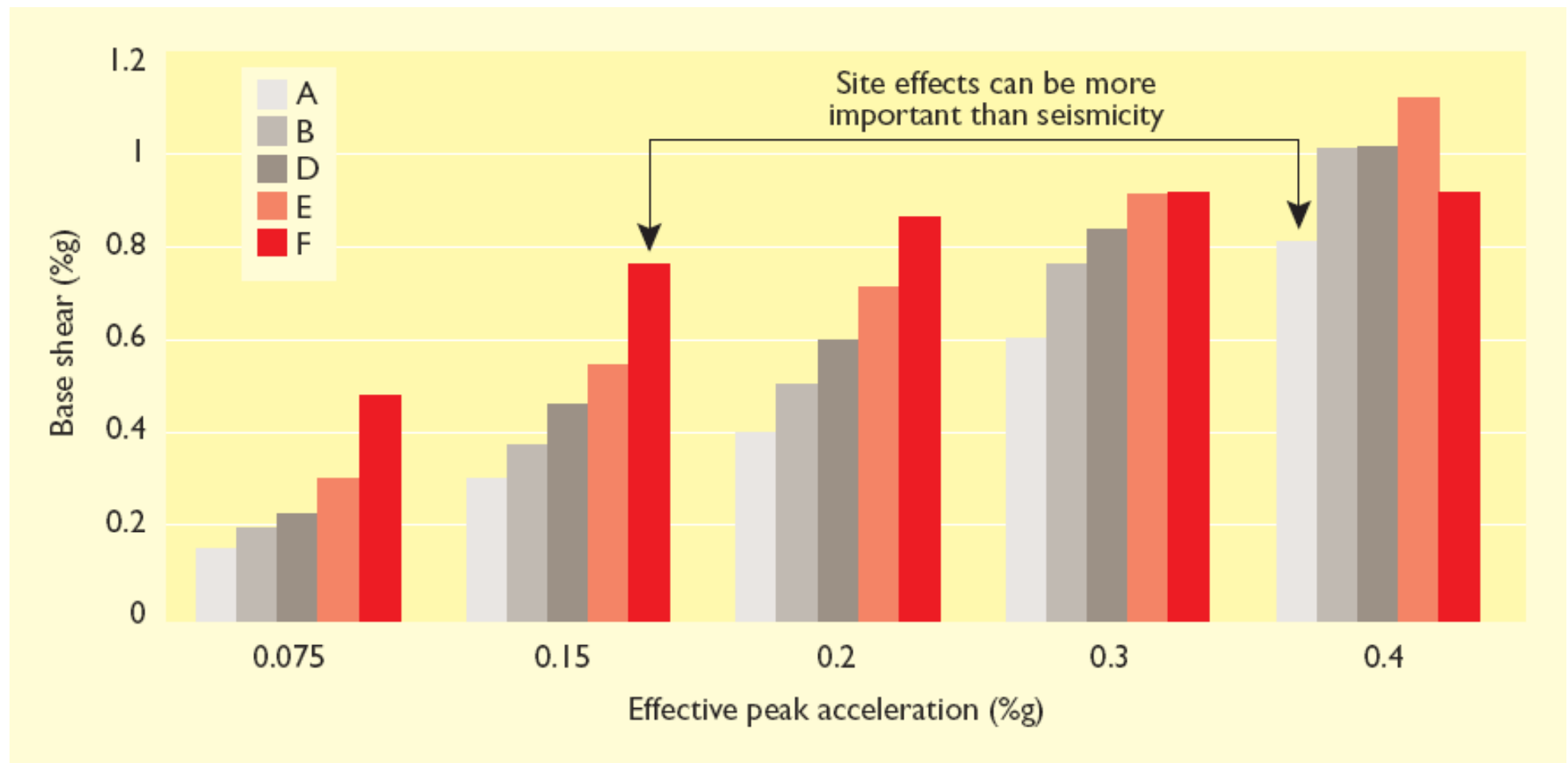


Fig. 3. US Uniform Building Code shows that horizontal earthquake force (base shear) in low seismic, soft-soil areas can be the same as high seismic, rock areas (see Table 1 for soil classes)—this ‘amplitude dependence’ is not accounted for in Eurocode 8



Comparative study of Seismic Codes

$V_{s,30}$ (m/sec)	180	360	760	1500
UBC/97 IBC/2000	S_E	S_D	S_C	S_B S_A
EAK2000	D - C	C	B	A
EC8 (ENV1998)	C	C	B	A
EC8 (prEN1998) (Draft4, 2001)	D	C	B	A
New Zealand, 2000 (Draft)	D ($T > 0.6s$ $\Rightarrow V_{s,30} < 200$)	C ($T < 0.6s$ $\Rightarrow V_{s,30} > 200$)	B	A
Japan, 1998 (Highway Bridges)	III ($T > 0.6s$ $\Rightarrow V_{s,30} < 200$)	II ($T = 0.2 - 0.6s \Rightarrow$ $V_{s,30} = 200 - 600$)	(I)	I ($T < 0.2s \Rightarrow V_{s,30} > 600$)
Turkey/98	Z₄ - Z₃	Z₃ - Z₂	Z₃ - Z₂ - Z₁	Z₁
AFPS/90	S₃ - S₂	S₃ - S₂ - S₁	S₁ - S₀	S₀

- Different PGA levels
- Different Site Amplification
- Different Force reduction (behaviour) factors



Uncertainties



Selection of the design earthquake

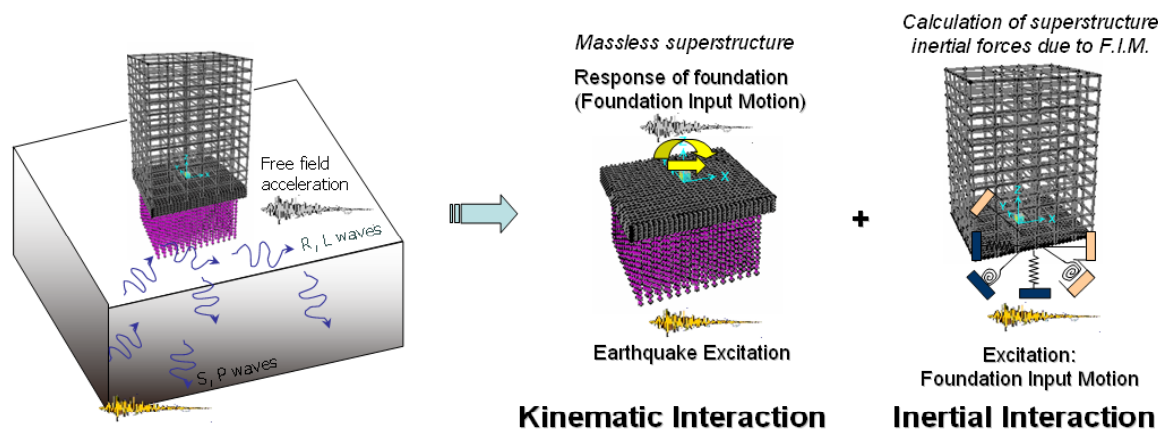
- Methods to select 'realistic' acceleration time histories for the analysis in the time domain?
- Possible sensitivity of the structure in the selection process?
- How many accelerograms?
- Scalling?
- Natural or artificial accelerograms?
- Duration της of earthquake input?
- Spatial variability of earthquake ground motion?



Dynamic characteristics of the structure?

For both spectral analysis and time history analysis the dynamic characteristics of the structure play an important role. However, they depend on:

Flexible soil and foundation (soil-structure interaction)



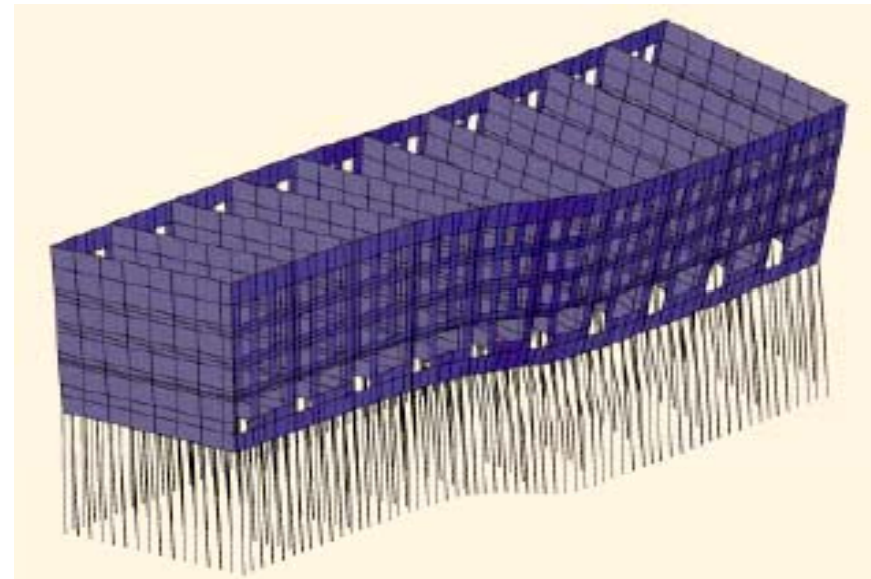
Yielding of R/C members and period elongation

- Fundamental period increases
- the modal participation factors are modified

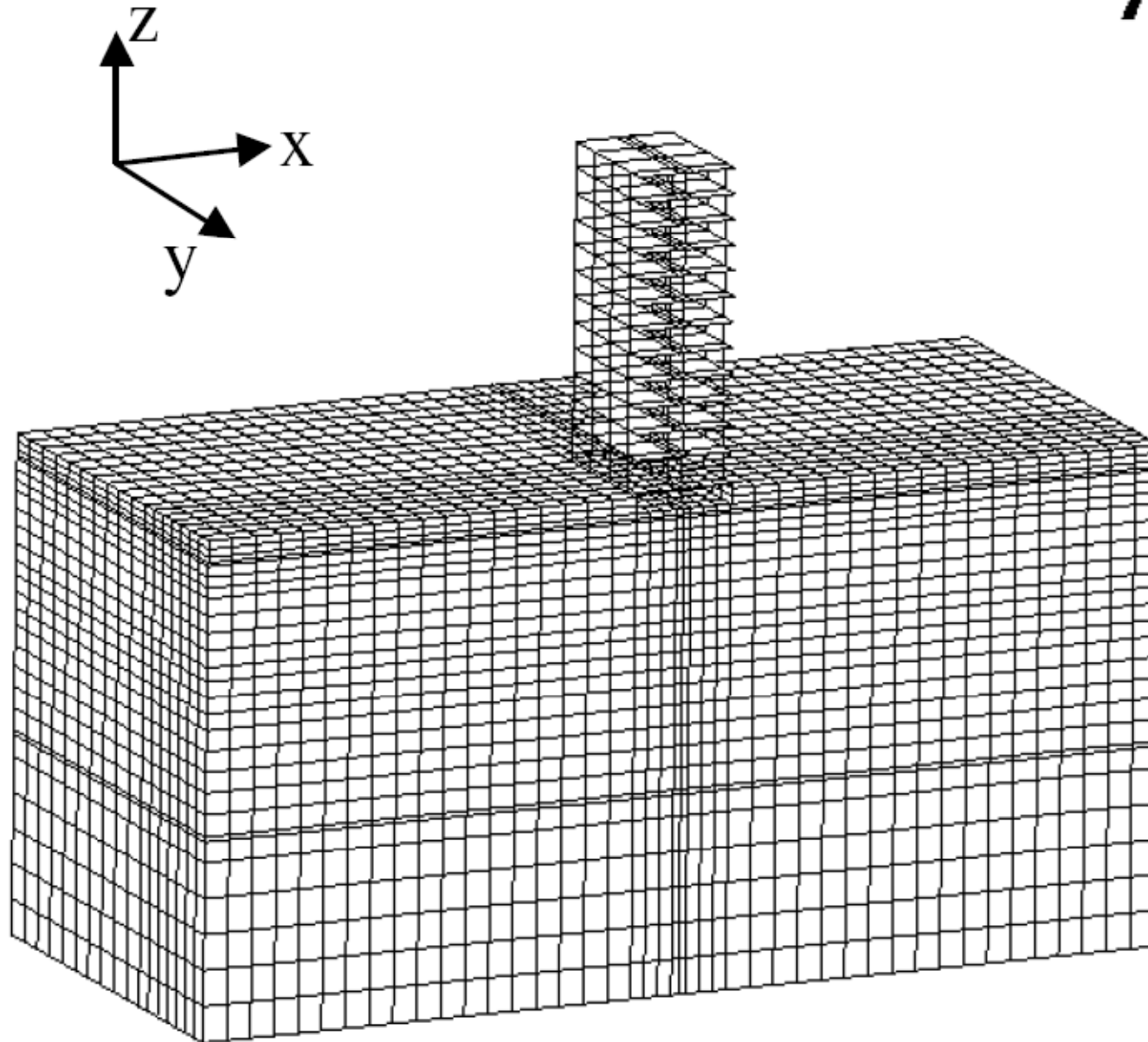
- the dynamic characteristics change in time



Soil-structure interaction



Soil-structure interaction

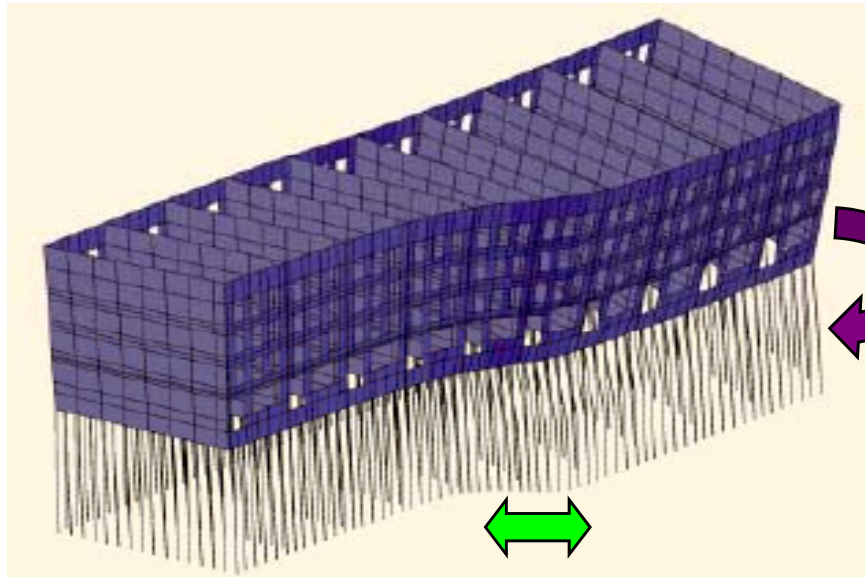


Soil-structure interaction

1. Motion exhibits a significant **rocking component**.
2. **Seismic excitation at the base** of a structure founded on soft soil is generally **different** than the free field vibration as seismic waves are reflected and refracted on the foundation hence, radiated back to the surrounding soil.
3. The **fundamental period** of the flexibly supported structure is expected to be **higher**
4. Once the structural period is shifted rightwards on the response spectrum the corresponding **spectral acceleration is different**.
5. **Eigenmodes** and **modal participation factors** are affected
6. An additional **damping** is introduced at the **structure-soil interface**.



Soil-structure interaction (EN 1998-5)



Inertia forces developed in the structure cause in turn displacements at the foundation relative to the free field (frequency dependent impedance – inertial interaction)

Foundation is not able to follow the imposed by soil displacement field, hence seismic motion at the base of the structure is different than that of the free field (kinematic interaction)

= Decoupling of kinematic & inertial interaction



Soil-structure interaction (EN 1998-5)

- (1)P The effects of dynamic soil-structure interaction shall be taken into account in:
- a) structures where P- δ (2nd order) effects play a significant role;
 - b) structures with massive or deep-seated foundations, such as bridge piers, offshore caissons, and silos;
 - c) slender tall structures, such as towers and chimneys, covered in EN 1998-6:200X;
 - d) structures supported on very soft soils, with average shear wave velocity $v_{s,max}$ (as defined in Table 4.1) less than 100 m/s, such as ground type S₁.

NOTE: For a better understanding of the general effects and significance of dynamic soil-structure interaction, Annex D provides relevant information.

- (2)P The effects of soil-structure interaction on piles shall be assessed according to 5.4.2 for all structures.



Soil-structure interaction (EN 1998-5)

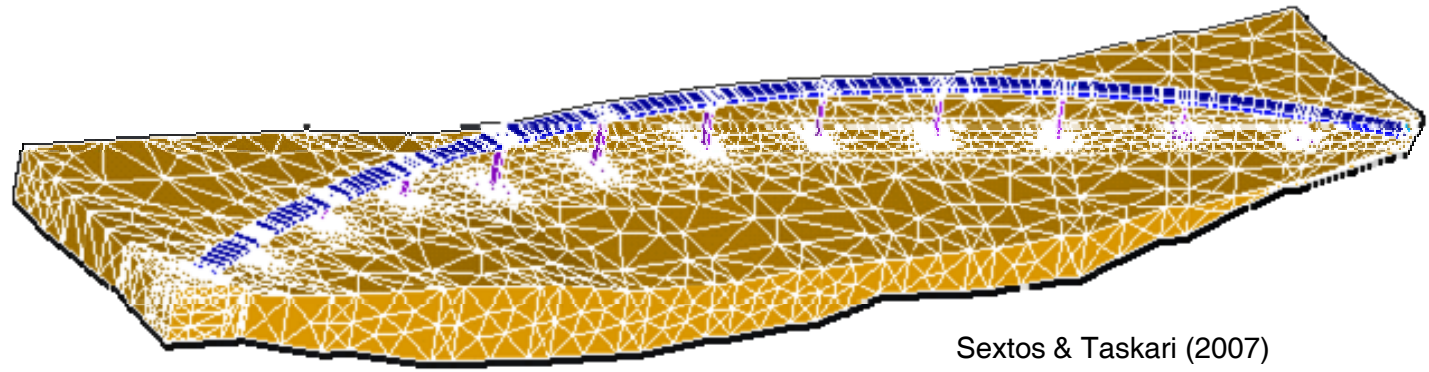
Table C1: Expressions for static stiffness of flexible piles embedded in three soil models

Soil model	$\frac{K_{HH}}{dE_s}$	$\frac{K_{MM}}{d^3E_s}$	$\frac{K_{HM}}{d^2E_s}$
$E = E_s \cdot z/d$	$0,60 \left(\frac{E_p}{E_s} \right)^{0,35}$	$0,14 \left(\frac{E_p}{E_s} \right)^{0,80}$	$-0,17 \left(\frac{E_p}{E_s} \right)^{0,60}$
$E = E_s \sqrt{z/d}$	$0,79 \left(\frac{E_p}{E_s} \right)^{0,28}$	$0,15 \left(\frac{E_p}{E_s} \right)^{0,77}$	$-0,24 \left(\frac{E_p}{E_s} \right)^{0,53}$
$E = E_s$	$1,08 \left(\frac{E_p}{E_s} \right)^{0,21}$	$0,16 \left(\frac{E_p}{E_s} \right)^{0,75}$	$-0,22 \left(\frac{E_p}{E_s} \right)^{0,50}$



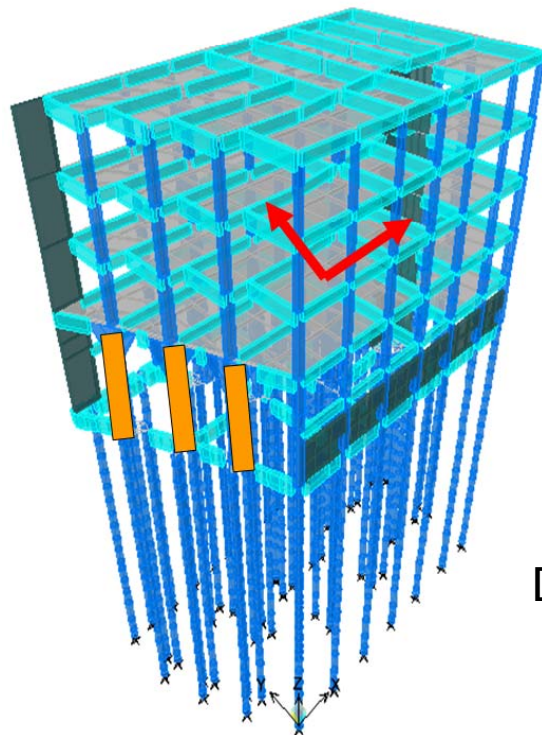
Angle of incidence? Which direction to excite along?

Which is the critical angle of earthquake excitation for curved bridges or irregular buildings?



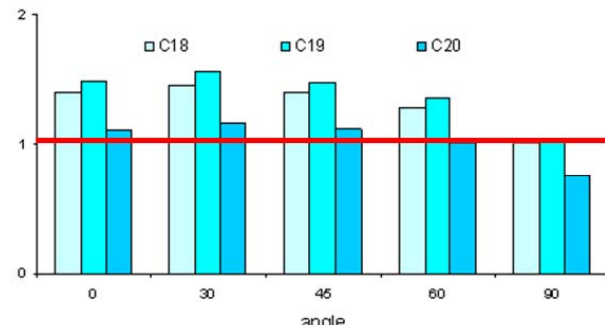
Sextos & Taskari (2007)

Sextos, Kappos & Mergos (2004)

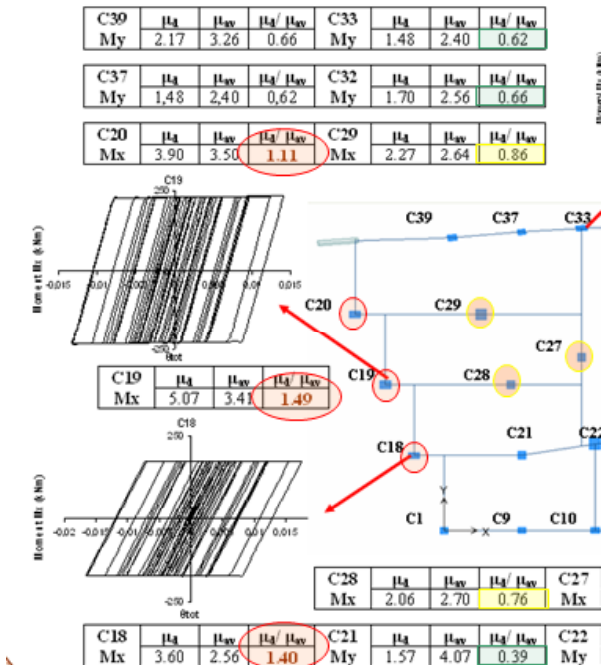


Sextos et al. (2005)

the most critical



Ductility demand changes as the angle changes



Computational tools



Strong Ground Motion Databases On-line



<http://www.isesd.cv.ic.ac.uk>

PEER Strong Motion Database

<http://peer.berkeley.edu/smcat/>



<http://www.k-net.bosai.go.jp/>



<http://db.cosmos-eq.org>



<http://folkworm.ceri.memphis.edu/>



Strong Ground Motion Translators On-line: www.civilengineering.gr

Μεταγλωσσιστής καταγραφών Pacific Earthquake Engineering Center - [PEER Strong Motion Database]

Αρχείο Εργαλεία Σχετικά

Channels: LHZ
TS (059), 2001 19:02:40.819

Channels: LHZ
TS (059), 2001 19:02:40.819

(100%) Installing PEER Database Manager

Installing PEER Database Manager
This may take several minutes. You can use your computer to do other tasks during the installation.

Name: **PEER Database Manager**
From: H:\PEERdeploy

Preparing Application...

Cancel

Ανάγνωση δεδομένων

Γενικά Στοιχεία Καταγραφής

PEER STRONG MOTION DATABASE RECORD. PROCESSING BY PACIFIC ENGINEERING.
SPITAK, ARMENIA 12/07/88 : , GUKASIAN, UP
ACCELERATION TIME HISTORY IN UNITS OF G. FILTER POINTS: HP=0.5 Hz LP=25.0 Hz
Number of Points = 1990 Time Step = 0.01 sec

.1059659E-03	.3569064E-03	.6500317E-03	.5820180E-03	.5303288E-03
.4842342E-03	.4385566E-03	.3933087E-03	.3483467E-03	.3038297E-03
.2599220E-03	.2165198E-03	.1736681E-03	.1315255E-03	.9012390E-04
.4952193E-04	.9724923E-05	-.2911628E-04	-.6715234E-04	-.1044440E-03
-.1402653E-03	-.1731018E-03	-.2005829E-03	-.2204817E-03	-.2317107E-03
-.2347910E-03	-.2321291E-03	-.2310917E-03	-.2539884E-03	-.3332152E-03
-.4789356E-03	-.6612200E-03	-.8101190E-03	-.8124184E-03	-.5947328E-03
-.2666784E-03	-.3572567E-04	.5385253E-04	.1124615E-03	.1871044E-03
.2393139E-03	.2692570E-03	.2913801E-03	.1456275E-03	.4875304E-03
-.1706241E-02	-.3173690E-02	-.4292730E-02	-.4405658E-02	-.3285434E-02
-.1777570E-02	-.1112322E-02	-.1388938E-02	-.1800770E-02	-.2023996E-02
.0001866E-03	.0001346E-03	.0003091E-03	.0007073E-03	.0001005E-03

Accel (m/sec²)

Time (sec)

PEER Strong Motion Database

Introduction Browse Search Documentation Providers Credits

1: Search earthquake or station characteristics and peak values

Earthquake Any

Mechanism Any

Magnitude (Range) - ML M MS Any

Distance (km) - Closest Hypocentral Projection of fault plane (JB distance)

Site Classification USGS Any (Compare to NEHRP classifications)

Geomatrix Any

Taiwan CWB Any

Mapped Local Geology Any

Instrument Housing Any

Data Source Any

PGA (g) - Range 0.001 ... 2.086

PGV (cm/sec) - Range 0.1 ... 263.1

Αρχείο προς επεξεργασία: C:\Documents and Settings\Αναστάσιος Σέξτος\Επιφάνεια εργασίας\GUK-UP.AT2



Signal Processing – Freeware on-line: www.seismosoft.com



SeismoSignal - C:\Program Files\SeismoSoft\SeismoSignal\Accelerograms\ChiChi_longt.dat

File Edit View Tools Help

Baseline Correction and Filtering | Time Series | Fourier and Power Spectra | Elastic/Inelastic Response Spectra | Ground Motion Parameters

Acceleration

Time [sec]	Acceleration [g]
0.	0.0001
0.01	0.0007
0.02	0.0007
0.03	0.0007
0.04	0.0007
0.05	0.0005
0.06	0.0001
0.07	-0.0005
0.08	-0.0007
0.09	0.

Velocity

Time [sec]	Velocity [cm/sec]
0.	0.
0.01	0.003924
0.02	0.010791
0.03	0.017658
0.04	0.024525
0.05	0.030411
0.06	0.033354
0.07	0.031392
0.08	0.025506
0.09	0.0220725

Displacement

Time [sec]	Displacement [cm]
0.	0.
0.01	1.4715000E-005
0.02	8.8290000E-005
0.03	0.00023054
0.04	0.00044145
0.05	0.00071777
0.06	0.00103986
0.07	0.0013685
0.08	0.00165462
0.09	0.00188679

Displacement | Velocity | Acceleration | Pseudo-Velocity | Pseudo-Acceleration | Graph

X-axis: Period, Frequency, Displacement
Y-axis: Displacement, Velocity, Acceleration, Pseudo-Velocity, Pseudo-Acceleration

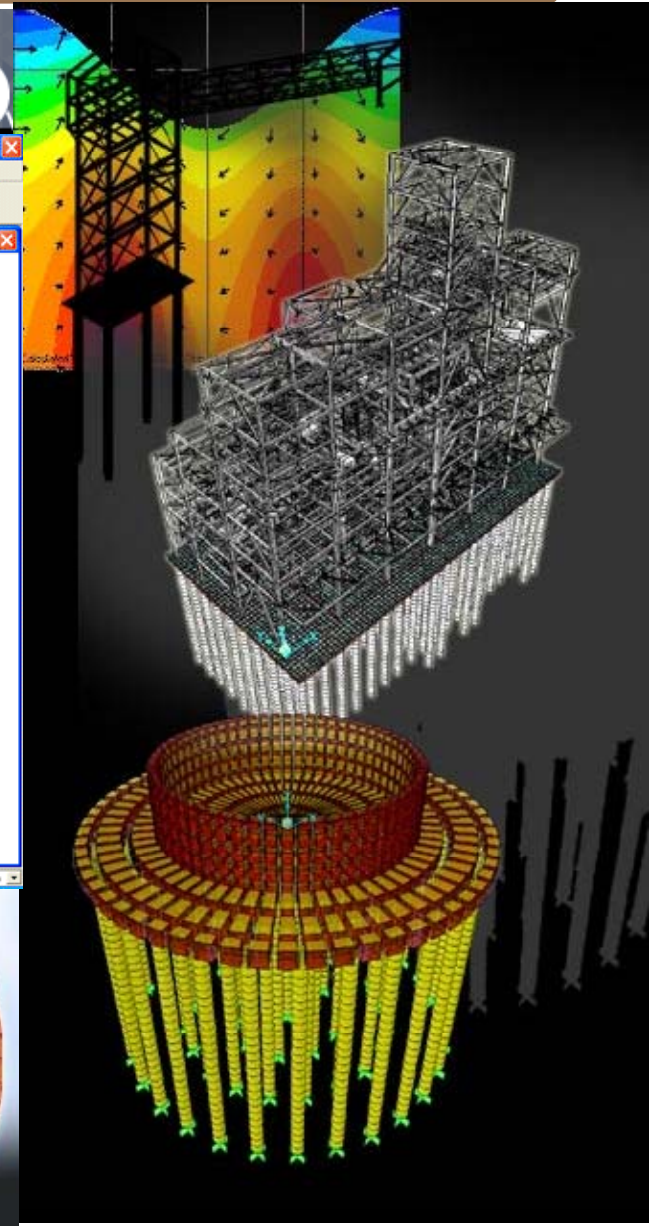
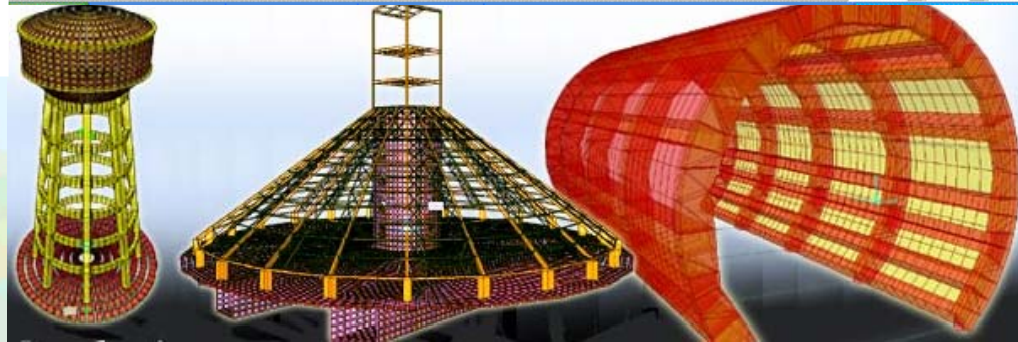
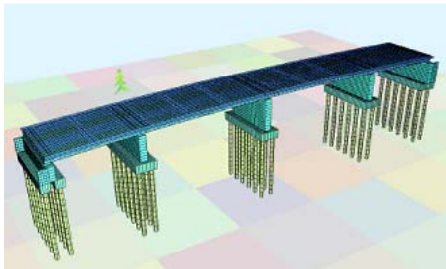
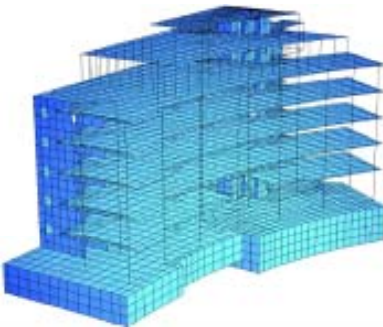
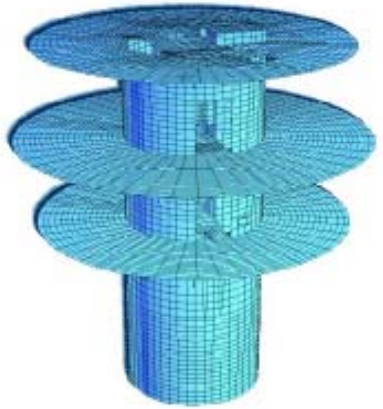
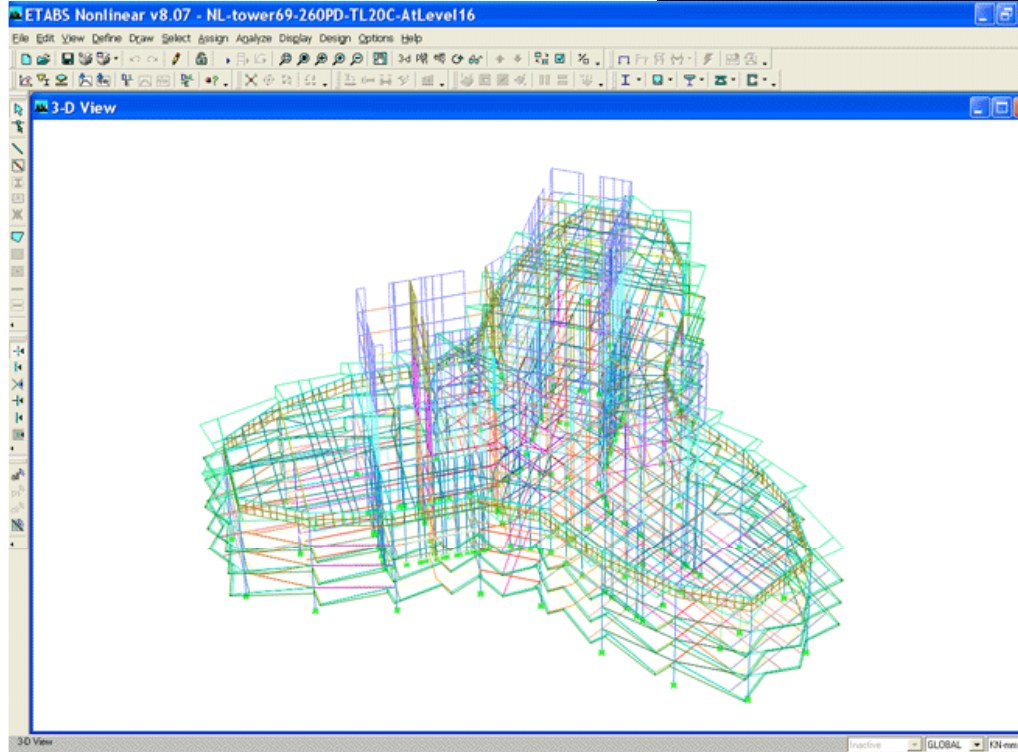
Finite Element software for the determination of action effects

SOFiSTiK

ETABS

e-tools
Lipens

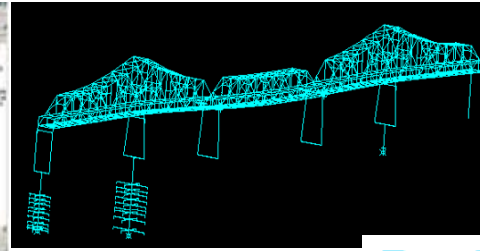
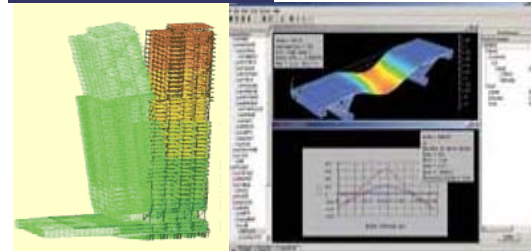
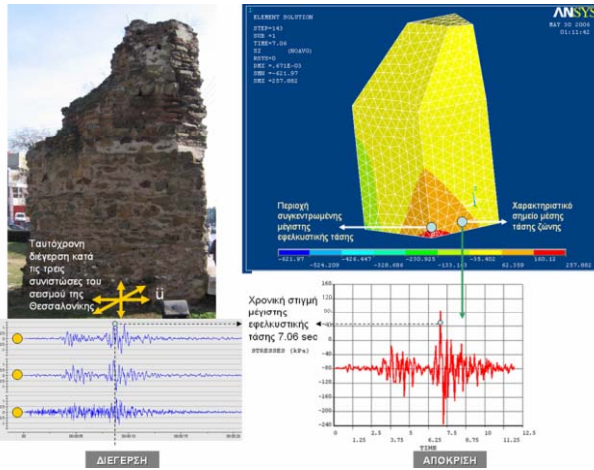
SAP2000



Finite Element software for the determination of action effects



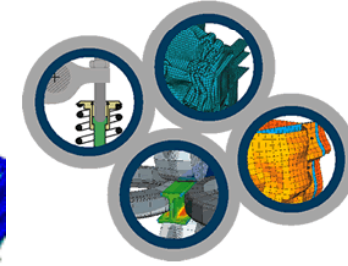
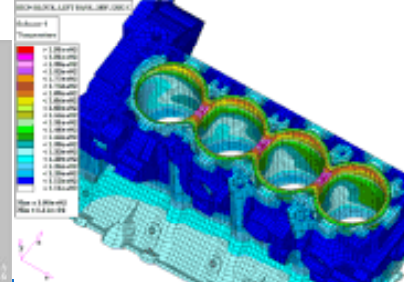
Finite Element software for the determination of action effects



A D I N A

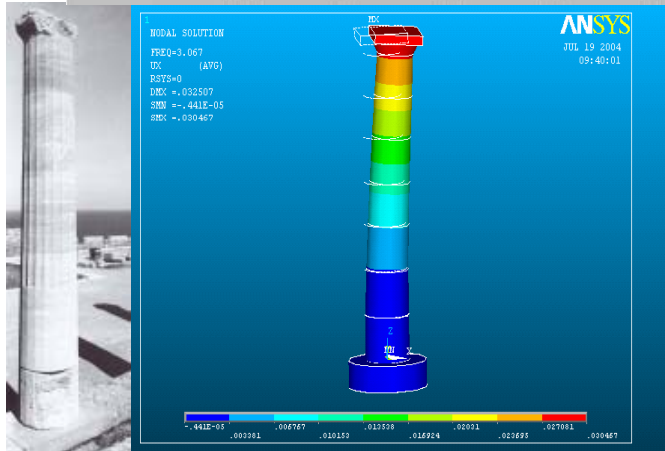
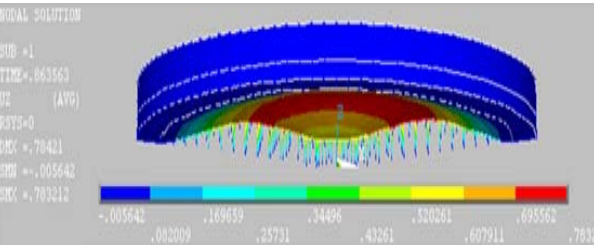
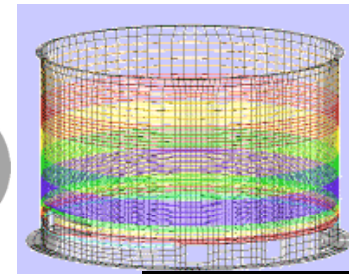
The Finite Element System for Structures, Heat Transfer, and CFD

ABAQUS

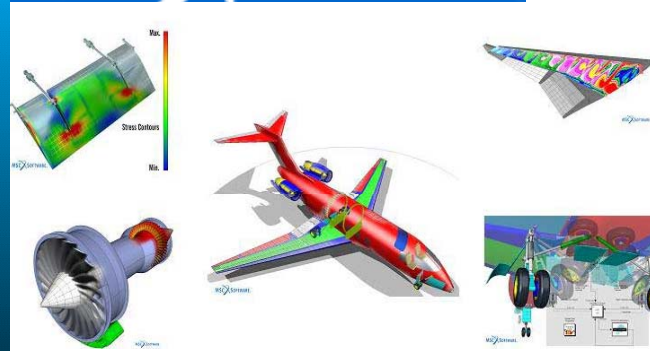


LUSAS

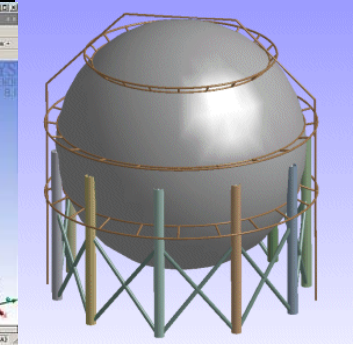
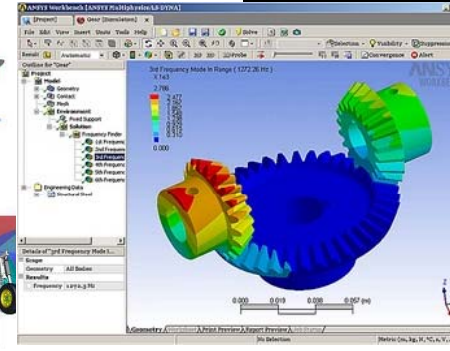
Civil & Structural



MSC SOFTWARE



ANSYS



A hybrid GIS/Mobile-Database Expert System for the assessment of buildings

MUNICIPALITY OF DUZCE
MARMARA EARTHQUAKE REHABILITATION PROGRAMME
Marmara Depremi Rehabilitasyon
POST-EARTHQUAKE QUICK INSPECTION FORM

Χρήστης: Admin
 Τετάρτη, 10
 Νοεμβρίου 2004
 17:47

STEP 0: Description | **STEP 1: General Inspection** | STEP 2 | STEP 3 | STEP 4 | STEP 5 | 1999 Earthquake Profile

MAP INFO GIS DATA

MAPINFO_ID	1
Type	
Mahale_no	0
Parcel_no	0
Ada_no	0
Number of Storeys	11
Number of Flats	0
Number of Dwelle	0
Height	0
Owner	

Damage observed:
 Column and beam failure. Extensive masonry wall cr

Type of intervention:
 RC column jacketing, masonry wall reconstruction

Intervention Cost: Intervention ID: 453423 Date of intervention: 23/5/1999

Engineer Name:
 Hakan Polat

Engineer Name:

Comments

BUILDING SCORE -0.8

(c) Aristotle University Thessaloniki, Dept. of Civil Engineering, Laboratory of Reinforced Concrete, 2004

Record: 1 of 17094

BUILDINGSTASOS, 1 of 17094

Tables: List Form Query

New [Icons]

HP iPAQ Pocket PC

NOKIA

Ranking Score

2 3

An Expert System for the assessment of Soil-Structure interaction in buildings

EXPERT SYSTEM

Αρχείο Επεξεργασία Βοήθεια

Αρχικά Δεδομένα FEMA 440 Υπολογισμός ελατηρίων και αποσβεστήρων επιφαν. θεμελίωσης Υπολογισμός ελατηρίων και αποσβεστήρων βαθιάς θεμελίωσης

Επιλογή μεθόδου ανάλυσης

- Ισοδύναμη στατική μέθοδος
- Δυναμική φασματική μέθοδος
- Ανελαστική στατική ανάλυση (Push-Over Analysis)
- Ελαστική δυναμική ανάλυση (Elastic Time History Analysis)
- Ανελαστική δυναμική ανάλυση (Anelastic Time History Analysis)

Εδαφοτεχνικά στοιχεία

Μέτρο Διάτμησης G (kN/m²) 80000

Πυκνότητα εδαφ. υλικού ρ (t/m³) 2

Λόγος Poisson ν 0.2

Μέγιστη εδαφική επιτάχυνση (g) 0.24

Θεμελιώδης ιδιοσυχνότητα του σεισμικού κραδασμού (Hz) 3

Συντελεστής απόσβεσης εδαφικού υλικού β (%) 5

Επιλογή κατάλληλου συστήματος εδάφους-θεμελίωσης

Ομογενής Ημιχώρος G, ν, ρ

Ομογενής Ημιχώρος G, ν, ρ

Υπολογισμός ελατηρίων και αποσβεστήρων

Γεωμετρία πεδίου

Μήκος πεδίου L (m) 2

Πλάτος πεδίου B (m) 2

Βάθος εγκαβωτισμού D (m) 1

Υπολογισμός ελατηρίων και αποσβεστήρων επιφαν. θεμελίωσης

Υπολογισμός ελατηρίων και αποσβεστήρων βαθιάς θεμελίωσης

Γενικά στοιχεία κτιρίου

Αριθμός ορόφων 2

Ποιότητα Σκυροδέματος C20/2

Εδαφοτεχνικά στοιχεία

Μέτρο Διάτμησης (kN/m²) 50000

Λόγος Poisson 0.2

Μέγιστη εδαφική επιτάχυνση (g) 0.24

Στοιχεία τυπικού ορόφου

Μήκος (m) 14

Πλάτος (m) 15

Ύψος (m) 3

Φορτίο ορόφου (kN/m²) 5

Στοιχεία τοιχωμάτων ανά κύρια διεύθυνση

Αριθμός διαφορετικών τοιχωμάτων (ομάδες κοινών τοιχωμάτων) 2

Ομάδα τοιχωμάτων 1η

Πλήθος τοιχωμάτων ομάδας 4

Μήκος τοιχώματος (m) 2

Πλάτος τοιχώματος (m) 0.2

Στοιχεία θεμελίωσης

Ομάδα πεδίων 1η

Μήκος πεδίου (m) 2.6

Πλάτος πεδίου (m) 0.8

Ύψος πεδίου (m) 0.6

Βάθος εγκαβωτισμού (m) 0.8

Έλεγχος για ανάγνωση συντελεστής ΔΑΕΚ.

Υπολογισμός ελατηρίων και αποσβεστήρων

Μεταφορική Ιδιομορφή (κατά τη διαμήκη διεύθ.)

Στατική δυσκαμψία (kN/m) []

Δυναμική δυσκαμψία (kN/m) 998725

Συντελεστής απόσβεσης (kN s/m) 11199

Λικνιστική Ιδιομορφή (περί τη διαμήκη διεύθ.)

Στατική δυσκαμψία (kNm/m) []

Δυναμική δυσκαμψία (kNm/m) 1244911

Συντελεστής απόσβεσης (kN m s) 8245

Μεταφορική Ιδιομορφή (κατά τη εγκάρσια διεύθ.)

Στατική δυσκαμψία (kN/m) []

Δυναμική δυσκαμψία (kN/m) 998725

Συντελεστής απόσβεσης (kN s/m) 9439

Λικνιστική Ιδιομορφή (περί τη εγκάρσια διεύθ.)

Στατική δυσκαμψία (kNm/m) []

Δυναμική δυσκαμψία (kNm/m) 1196824

Συντελεστής απόσβεσης (kN m s) 7990

Μεταφορική Ιδιομορφή (κατά την κατακόρυφη διεύθ.)

Στατική δυσκαμψία (kN/m) []

Δυναμική δυσκαμψία (kN/m) 0

Συντελεστής απόσβεσης (kN s/m) 3520

Στρεπτική Ιδιομορφή

Στατική δυσκαμψία (kNm/m) []

Δυναμική δυσκαμψία (kNm/m) 2507086

Συντελεστής απόσβεσης (kN m s) 13374

Sextos & Katsanos (2006)



Design Seismic Actions

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1998-1 : 2004

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UDC

Descriptors:

English version

Eurocode 8 : Design of structures for earthquake resistance

Part 1: General rules, seismic actions and rules for buildings

Calcul des structures pour leur résistance aux séismes Auslegung von Bauwerken gegen Erdbeben

Partie 1 : Règles générales, actions sismiques et règles pour les bâtiments Teil 1 : Grundlagen; Erdbebeneinwirkungen und Regeln für Hochbauten

Stage 51

CEN

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