4ο ΕΠΙΣΤΗΜΟΝΙΚΟ FORUM ΓΙΑ ΤΗ ΜΕΙΩΣΗ ΤΗΣ
ΔΙΑΚΙΝΔΥΝΕΥΣΗΣ ΑΠΟ ΚΑΤΑΣΤΡΟΦΕΣ
ΣΤΗΝ ΕΛΛΑΔΑ
4th SCIENTIFIC FORUM FOR
DISASTER RISK REDUCTION
IN GREECE

Σεισμική διακινδύνευση σχολικών κτιρίων

Άννα Καρατζέτζου, Εύη Ρήγα, Στεφανία Αποστολάκη, Κυριαζής Πιτιλάκης

19 Μαρτίου 2021

SDGEE
Research Unit of Soil Dynamics and Geotechnical Earthquake Engineering

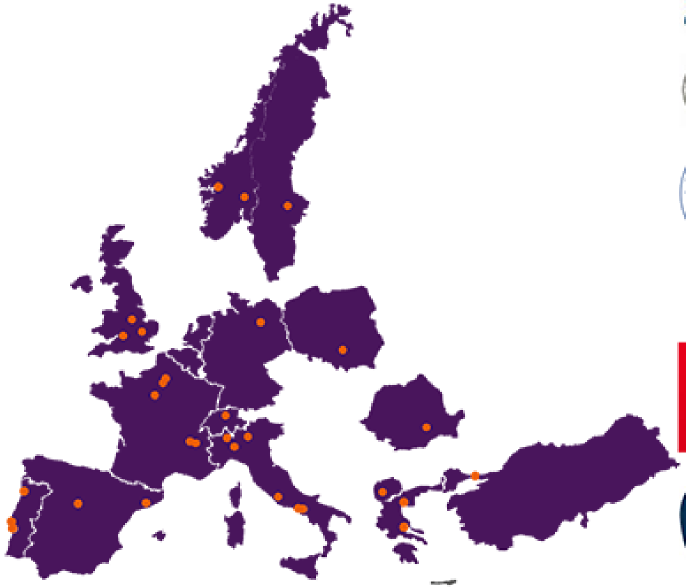
Tyrnavos – Larissa earthquake, 2021

Outline

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

SERA Integrated Risk Model for Europe

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



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Koninklijk Nederlands Meteorologisch Instituut
LNEC Laboratório Nacional de Engenharia Civil
NERC Science of the Environment
NOA
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SERA Integrated Risk Model for Europe

Objectives:

- Local (e.g. city), national and continental scale integrated seismic risk assessment framework.
- Build upon research efforts and data collected in previous European projects (SHARE, NERA, SYNER-G, LESSLOSS.....RISK-UE)
- Produce an integrated assessment of seismic risk across all countries in Europe and share models and results through the EFEHR web platform and GEM's OpenQuake platform.

Seismic Damage Assessment Methodology

Exposure × ***Hazard*** × ***Fragility*** = ***Seismic Damage***

Exposure

Building Schools

Hazard

- PGA
- Sa (0.3s)
- Sa(0.6s)
- Sa(1s)

Fragility

Fragility Curves per Typology:

a) P(=NO)=1-(P>Slight)

b) P(=Slight)=(P>Slight)-(P>Mod.)

c) P(=Mod.)=(P>Mod.)-(P>Ext.)

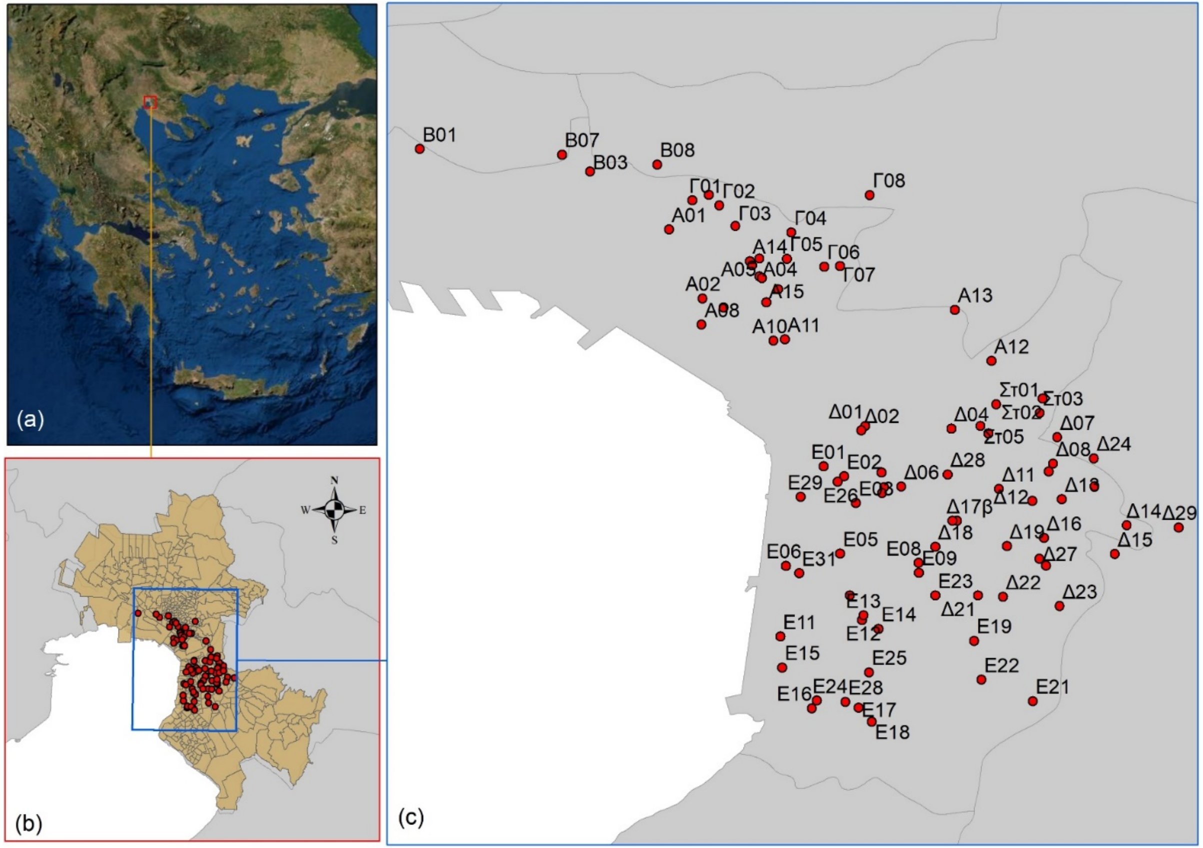
d) P(=Ext.)=(P>Ext)-(P>Complete)

e) P(=Complete)=(P≥ Complete)

Seismic Damage

Distribution of the expected damages in school buildings in the various building typologies

Step 1: Mapping and classification of the school buildings (*Exposure*)



Step 1: Mapping and classification of the school buildings (*Exposure*)

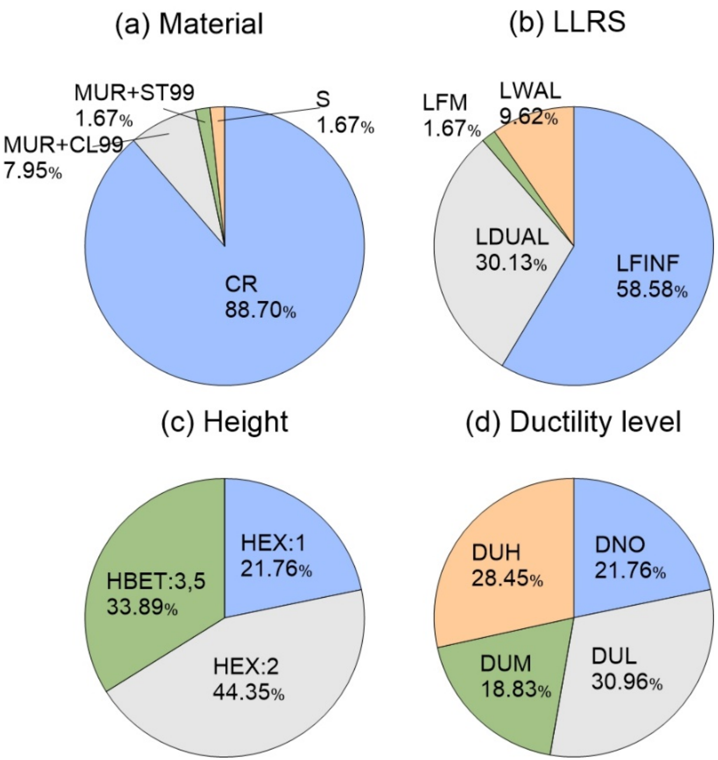
Definition of building classes using selected attributes of GEM Building Taxonomy

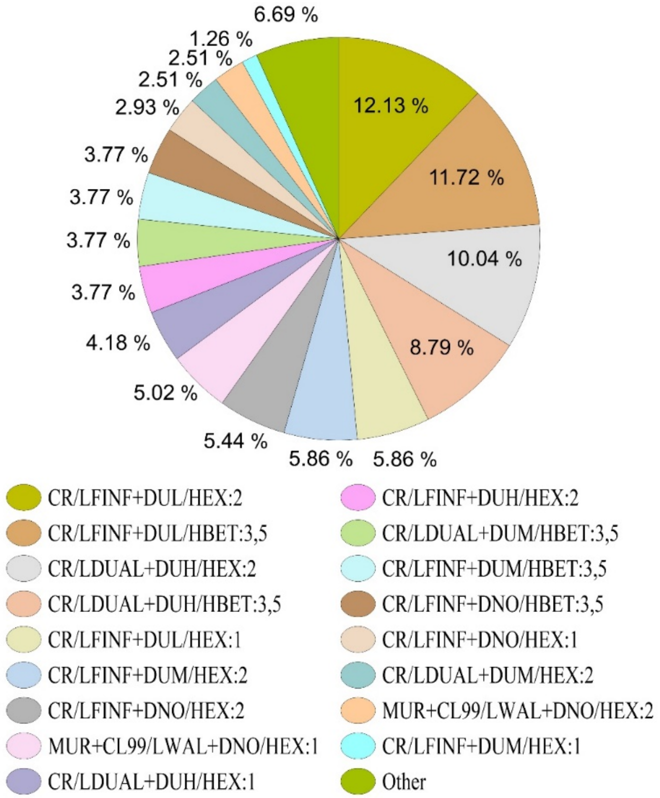
- Main construction material
- Lateral load resisting system
- Number of storeys
- Seismic design/ductility level

Step 1: Mapping and classification of the school buildings (*Exposure*)

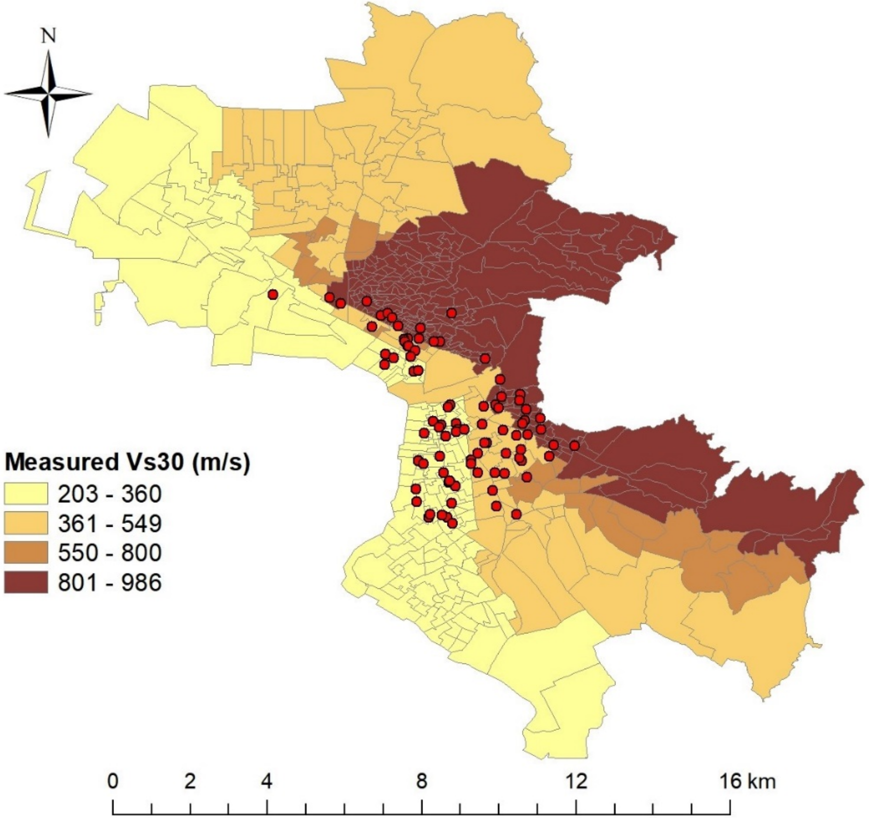
ATTRIBUTE	ELEMENT CODE	LEVEL 1 VALUE	ELEMENT CODE	LEVEL 2 VALUE
MATERIAL	CR	Concrete, reinforced	PC	Precast concrete
	MUR	Masonry, unreinforced	CL	Fired clay unit, unknown type
	MR	Masonry, reinforced	ST	Stone, unknown technology
	MCF	Masonry, confined	ADO	Adobe blocks
	MATO	Material, other	CB	Concrete blocks, unknown type
	W	Wood		
	S	Steel		
LATERAL LOAD-RESISTING SYSTEM (LLRS)	LWAL	Wall	DUL	Ductile, low
	LDUAL	Dual frame-wall	DUM	Ductile, medium
	LFM	Moment frame	DUH	Ductile, high
	LFINF	Infilled frame	DNO	Non-ductile
HEIGHT	H	Number of storeys above ground	HBET	Range of number of storeys above ground
			H	Exact number of storeys above ground
	SOS	Soft Storey Buildings		
DUCTILITY LEVEL	DUH	Period of construction: 1996-present		
	DUCM	Period of construction: 1986-1995		
	DUCL	Period of construction: 1960-1985		
	DNO	Period of construction: before 1959		

Step 1: Mapping and classification of the school buildings (*Exposure*)

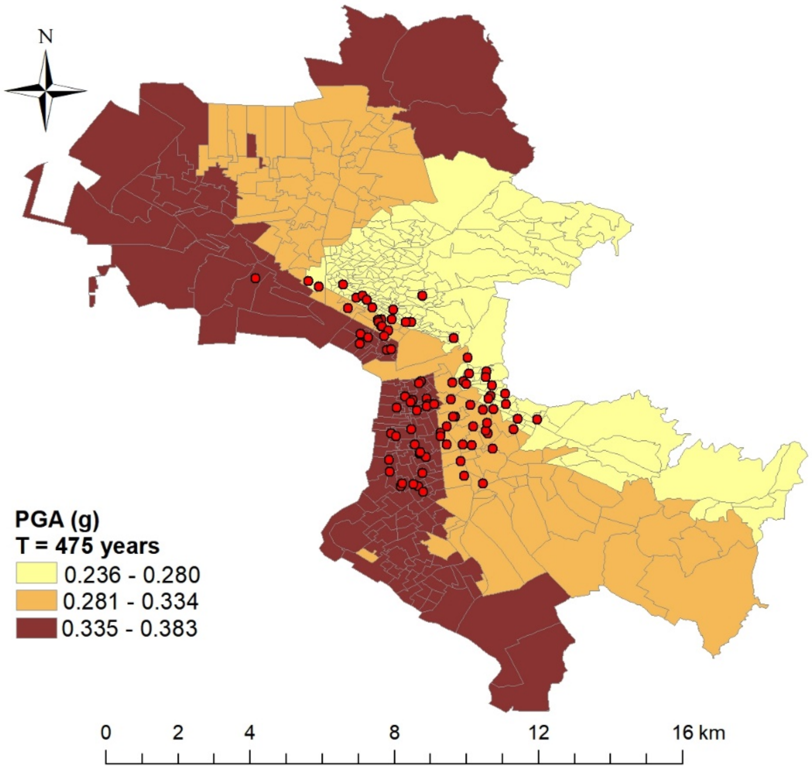




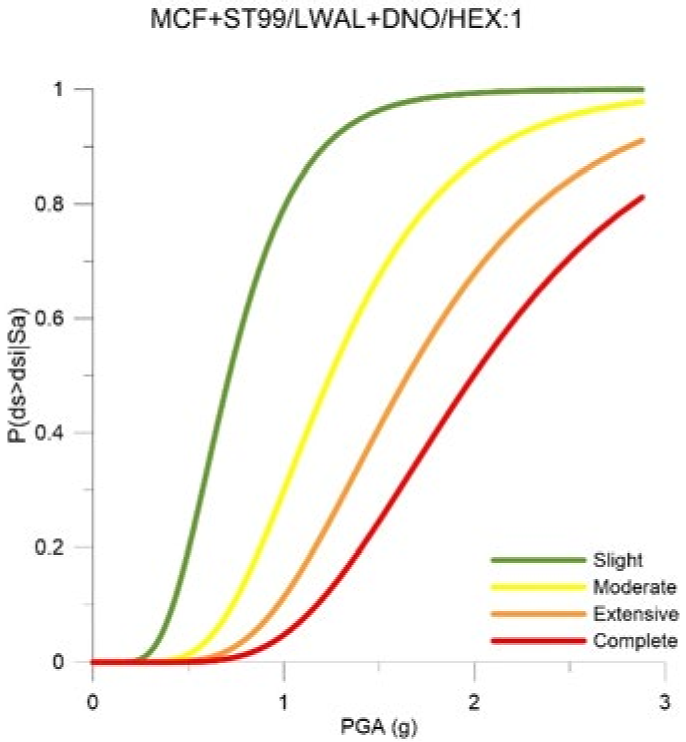
Step 2: Seismic hazard model

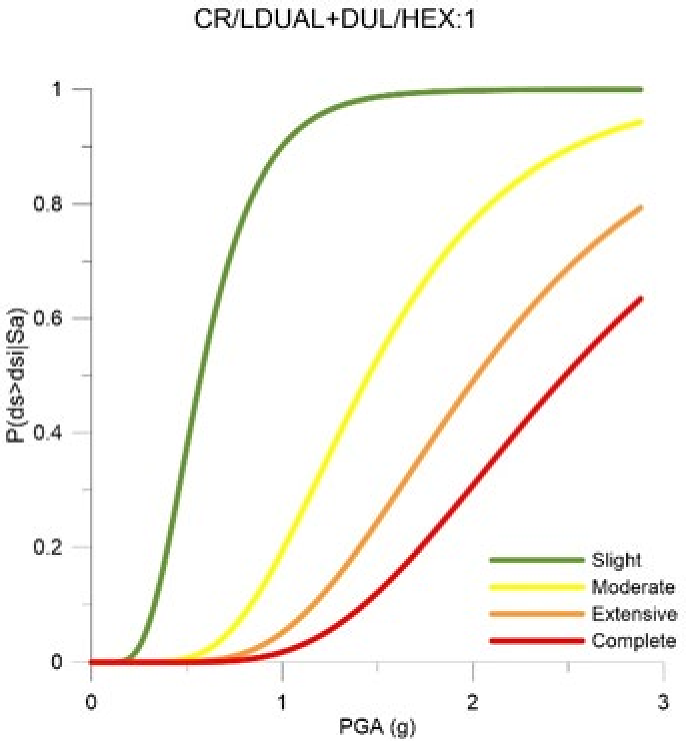


Step 2: Seismic hazard model



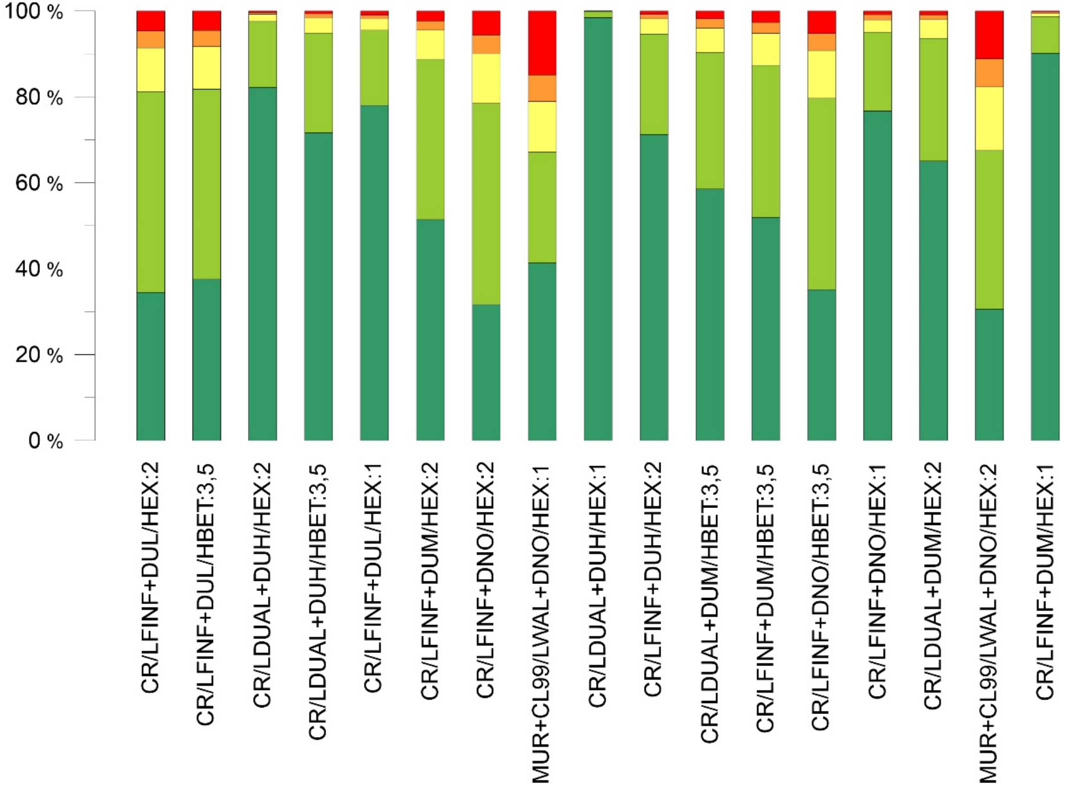
Fragility Model





(Martins and Silva, 2020)

Assessment of seismic damages



<u>Event Based 475 years:</u> Damage distribution to the 5 DS

green: No damages

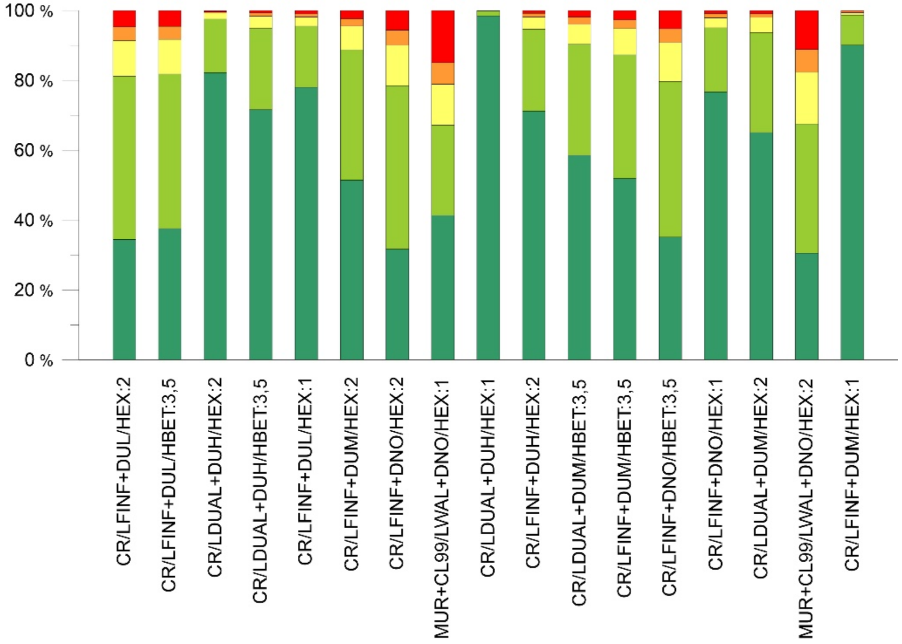
light green: Slight damages

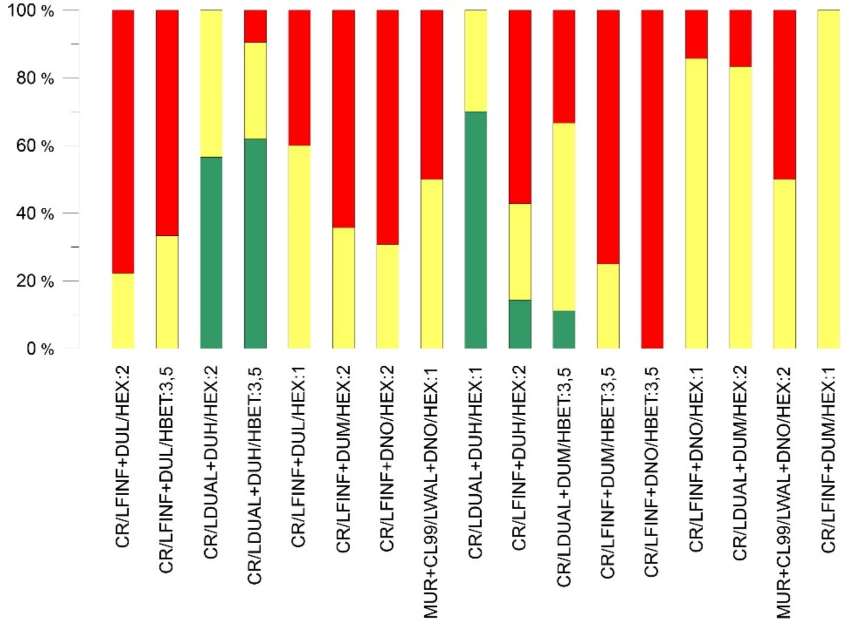
yellow: Moderate damages

orange: Extensive damages

red: Complete

Assessment of seismic damages





Concluding Remarks

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

...There is long way to go, but we are on good track

Recent publications…(01)

H. Crowley, V. Despotaki, V. Silva, X. Romão, J. Daniell, E. Veliu, H. Bilgin, C. Adam, M. Deyanova, N. Ademović, J. Atalic, C. Nievas, G. Weatherill, E. Riga, **A. Karatzetzou**, B. Bessason, V. Sendova, D. Toma-Danila, Z. Zugic, M. Belen Benito, S. Akkar, U. Hancilar (2020). Model of Seismic Design Lateral Force Levels for the Existing European Building Stock. (submitted for publication in Bulletin of Earthquake Engineering) (Impact Factor: 2.819).

E. Riga, **A. Karatzetzou**, S. Apostolaki, H. Crowley, K. Pitilakis (2020). Verification of seismic risk models using observed damages from past earthquake events. (submitted for publication in Bulletin of Earthquake Engineering). (Impact Factor: 2.819).

Crowley H, Despotaki V , Rodrigues D, Silva V, Toma Danila D, Riga E, **Karatzetzou A**, Fotopoulou S, Zugic Z, Sousa L, Ozcebe S, Gamba P (2020). Exposure Model for European Seismic Risk Assessment. Earthquake Spectra. https://doi.org/10.1177/8755293020919429 (Impact Factor: 2.079).

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Recent publications…(02)

Pitilakis K., Riga E, **Karatzetzou A**, Apostolaki S, A. Kiratzi (2020). Towards the development of a uniform seismic vulnerability and risk model in Europe. The cases of Athens and Thessaloniki, Greece. 17th World Conference on Earthquake Engineering, 17WCEE. Sendai, Japan - September 13th to 18th 2020.

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

Riga E, **Karatzetzou A**, Apostolaki S, Pitilakis K. (2019). Παραμετρική εκτίμηση της σεισμικής επικινδυνότητας στο πολεοδομικό συγκρότημα της Θεσσαλονίκης. 8ο Πανελλήνιο Συνέδριο Γεωτεχνικής Μηχανικής, Αθήνα, Ελλάδα, 6-8 Νοεμβρίου 2019.

Riga E, **Karatzetzou A**, Fotopoulou S, Apostolaki S, Dafloukas K, Pitilakis K. (2019). Urban seismic risk model for resilient cities. The case of Thessaloniki. Sustainability in the built environment for climate change mitigation, 23-25 October 2019, Thessaloniki, Greece

Karatzetzou, E. Riga, K. Pitilakis (2018). Urban-scale assessment of soil-structure interaction effects: the case of Thessaloniki city, Greece. 16th European Conference on Earthquake Engineering (16ECEE), 18-21 June 2018, Thessaloniki, Greece.

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Ευχαριστώ πολύ!

Thank you!

email: akaratze@civil.auth.gr

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