EUROPEAN CENTRE FOR VULNERABILITY OF INDUSTRIAL AND LIFELINE SYSTEMS

ECILS

NORTH MACEDONIA

EUR-OPA MAJOR HAZARDS AGREEMENT
ACCORD EUR-OPA RISQUES MAJEURS

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EUROPEAN AND MEDITERRANEAN MAJOR HAZARD AGREEMENT (EUR-OPA)

JOINT MEETING OF THE COMMITTEE OD PERMANENT CORRESPONDENTS AND DIRECTORS OF SPECIALIZED CENTRES

3-4 NOVEMBER 2020

HARMONIZATION OF SEISMIC VULNERABILITY ASSESSMENT OF URBAN CULTURAL HERITAGE

ACTIVITIES IN 2020

EUR-OPA
Joint meeting of the Committee of Permanent Correspondents and Directors od Specialized Centres, 3-4 November 2020

Dr. Veronika SHENDOVA
Director
European Centre for Vulnerability of Industrial and Lifeline Systems, ECILS

Project information

- Priority for action plan: Using scientific and technological knowledge to better assess evolving risks and adapt accordingly the resilience strategies
- Name of the Centre: ECILS, Skopje, North Macedonia
- Represented by: Prof. d-r Veronika Shendova, Prof. d-r Vlatko Sheshov
- Title of the Project: Harmonization of Seismic Vulnerability Assessment of Urban Cultural Heritage
- Implementation period: from 1st February to 1st November 2020
- Grant by Council of Europe: 1000 EURO (*desk study fees = 10 days x 100 Euro*)
- Contribution by ECILS: computer, working space, local transport
- Activities:
  - ✓ Review of the literature on disaster risk mitigation of urban historic centers
  - ✓ Review of the experience in protection of urban historic centers at national level
  - ✓ Set up of "vulnerability index" method, harmonized with the specific characteristics of urban historic centers in North Macedonia

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Cultural Heritage

IMPORTANCE

- key element for history and identity of the society, contributing to its well-being
- deserve special attention due to their value
- when damage of CH is considered, the reason does not play a primary role
- earthquakes - one of the most frightening, destructive and deadliest natural disaster

URBAN HISTORIC CENTRES, UHC

- important cultural-historic, economic and touristic centers
- most common building material - stone and brick masonry – seismically vulnerable
- often renovated in too superficial or too intrusive way, with little respect to existent materials and construction techniques, (demolishing, enlarging, upgrading)
- upmost importance - to assess the actual seismic response of historic centres

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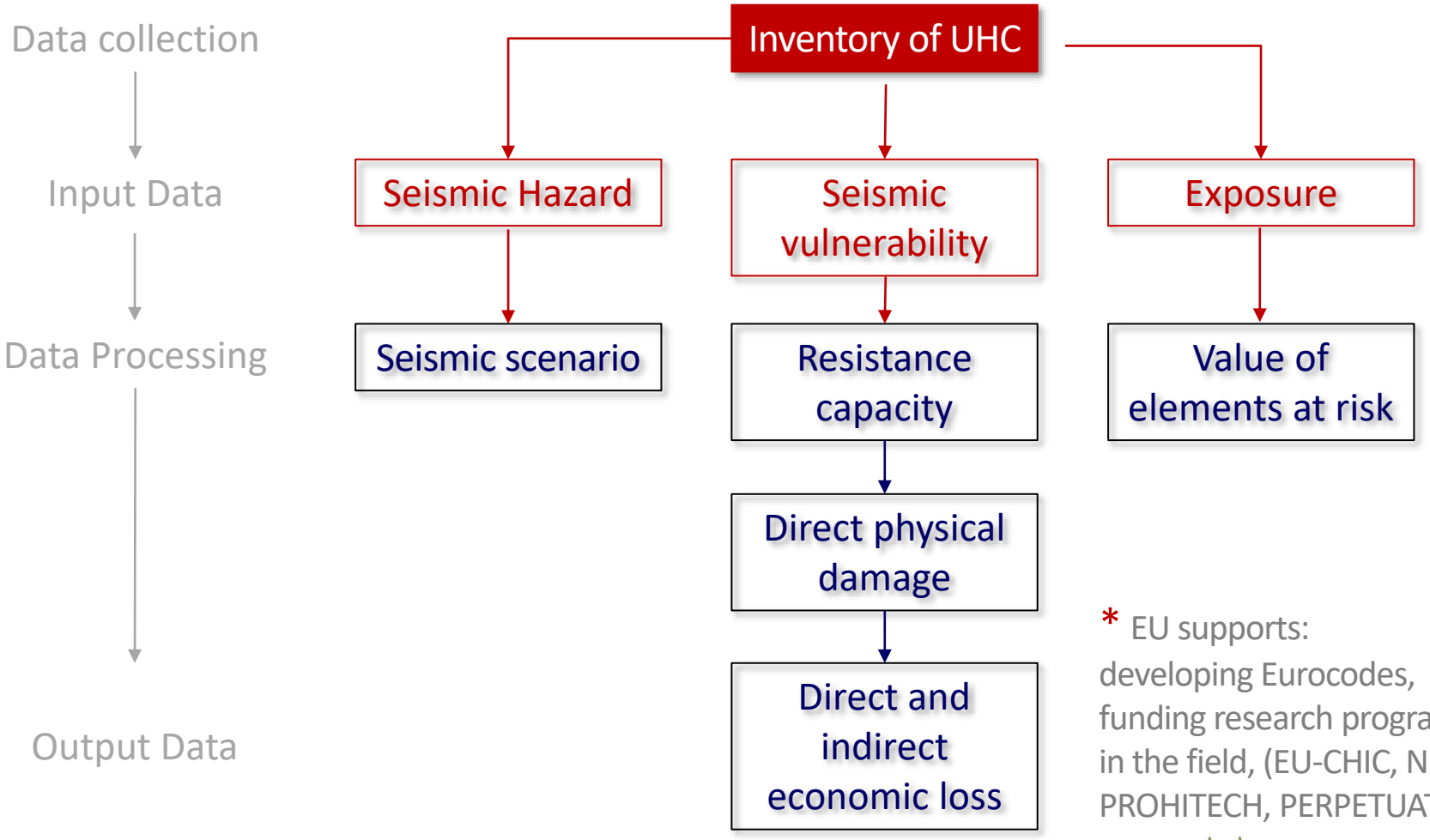
Earthquake Risk Mitigation of UHC



* EU supports: developing Eurocodes, funding research programs in the field, (EU-CHIC, NIKE, PROHITECH, PERPETUATE)

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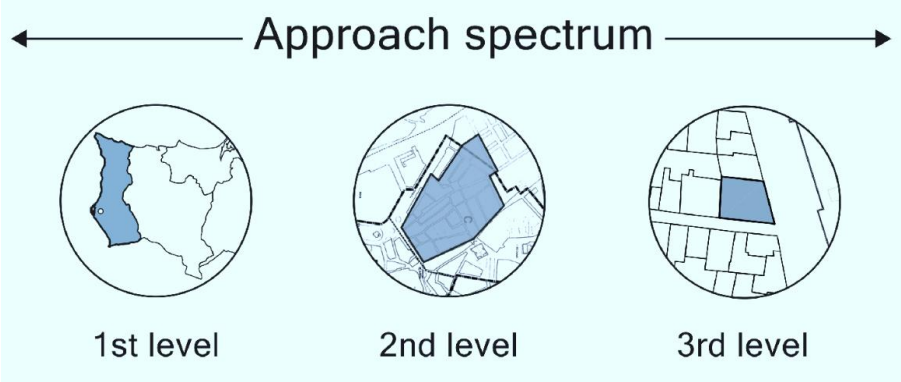
Seismic Vulnerability Assessment of UHC

1st level - large-scale assessments, including methodologies that resort to a large amount of data (usually of qualitative nature, provided either by the census, municipalities' archives, or through "in-situ" survey and inspections)



2nd level - based on mechanical models that rely on a higher quality of data (geometrical and structural features)

3rd level - involve the use of sophisticated numerical models that require a complete survey of individual buildings and a thorough knowledge of geometry and materials' properties

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Vulnerability Index Method

seismic risk assessment by using simplified scoring methods:

- proposed by Benedetti and Petrini (1984)
- adapted by Vicente (2008), applied to several historic centres in Portugal
- calibrated by Ferreira et al, (2017) using post-earthquake damage data derived from the 1998 earthquake of Azores

- vulnerability index I_V^* is obtained by the calculation of a score for each building, as the weighted sum of 14 parameters

$$I_V^* = \sum_{i=1}^{14} c_{Vi} p_i$$

- each parameter covers one aspect related to the building's seismic response and is distributed into 4 vulnerability classes c_{Vi} of growing vulnerability: *A, B, C, D*
- Weights p_i range from 0.50 for the less important parameters (in terms of structural vulnerability) to 2.5 for the most important

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Vulnerability Index Method

Parameter		Class, c_{vi}				Weight, p_i	
		A	B	C	D	ORIGINAL	CALIBRATED
1. Structural building system							
P1	Type of resisting system	0	5	20	50	0.75	2.50
P2	Quality of resisting system	0	5	20	50	1.00	2.50
P3	Conventional strength	0	5	20	50	1.50	1.00
P4	Maximum distance between walls	0	5	20	50	0.50	0.50
P5	Number of floors	0	5	20	50	1.50	0.50
P6	Location and soil condition	0	5	20	50	0.75	0.50
2. Irregularities and interactions							
P7	Aggregate position and interaction	0	5	20	50	1.50	1.50
P8	Irregularity in plan	0	5	20	50	0.75	0.50
P9	Irregularity in height	0	5	20	50	0.75	0.50
3. Floor slabs and roofs							
P10	Alignment of openings	0	5	20	50	0.50	0.50
P11	Horizontal diaphragms	0	5	20	50	1.00	0.75
P12	Roof systems	0	5	20	50	1.00	0.50
4. Conservation status and other elements							
P13	Fragilities and conservation status	0	5	20	50	1.00	1.00
P14	Non-structural elements	0	5	20	50	0.50	0.75

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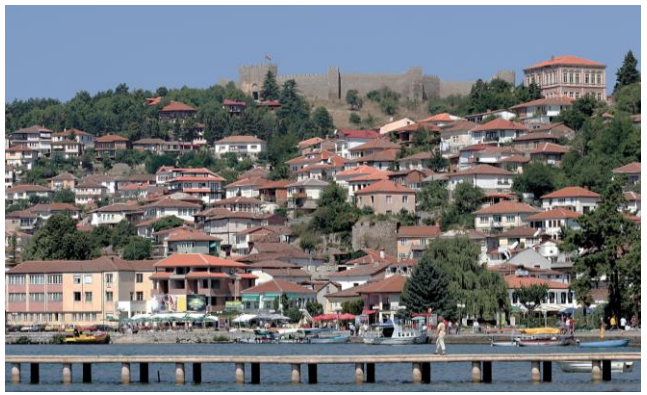
UHC in North Macedonia

Skopje Old Bazaar - one of the oldest and largest marketplaces in the Balkans; Skopje's trade and commerce centre since at least XII century, thirty mosques, numerous inns and hammams, among other buildings and monuments

Old City of Ohrid - formed between the VII and XIX centuries on the shores of Lake Ohrid, developed on archaeological remains dated back from the Bronze Age to the Middle Ages, listed as a UNESCO natural and cultural heritage site for its unique heritage values



Old City of Bitola - founded as *Heraclea* in the middle of IV century BC, known since the Ottoman period as "The City of The Consuls", important junction connecting the south of the Adriatic Sea region with the Aegean Sea and Central Europe; administrative, cultural, industrial, commercial, and educational centre

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Skopje Old Bazaar

- brick/stone/adobe plain masonry buildings, predominant Ottoman, remains from Byzantine, elements of modern architecture
- damages: 1555 earthquake, 1689 burning of the city, 1963 earthquake, during I and II World Wars, 2016 earthquake
- various rebuilding following these events

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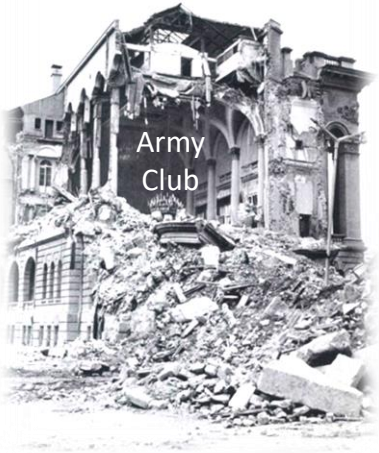
1963 Earthquake effect on Architectural Heritage

- entire monument fund was more or less damaged
- failure of individual structural parts
- large structural cracks
- inclination and deformations of structural elements
- part of it was completely destroyed


Mustafa Pasha mosque


Chifte Hammam


Kurshumli Inn


Army Club


Suli Inn

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Post-earthquake Repair and Seismic Strengthening

- immediate structural consolidation
- repair & strengthening during renovation process
- involving RC bearing structure, columns and belt courses incorporated into the existing masonry

after 1963 earthquake

after reconstruction (RC elements)

Sulli Inn

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Harmonized Vulnerability Index Method

- raising interest to make Bazaar a touristic attraction
- 2008 - law recognizing the Old Bazaar as cultural heritage of particular importance
- 2011 - Government's project for revitalization, including restoration of several building for further economic and cultural development

- intention to propose to the authorities - seismic vulnerability assessment by
- Vulnerability Index Method – harmonized with the specific characteristics of historic centers in North Macedonia
  - ✓ setting the most important and independent parameters P1, P2 (P3, P13), P4, P5, P6, P7, P8, P9, P10, P11(P12), P14
  - ✓ prescribing the vulnerability levels A, B, C, D for each of the independent parameters

Parameter	
1. Structural building system	
P1	Type of resisting system
P2	Quality of resisting system
P3	Conventional strength
P4	Maximum distance between walls
P5	Number of floors
P6	Location and soil condition
2. Irregularities and interactions	
P7	Aggregate position and interaction
P8	Irregularity in plan
P9	Irregularity in height
3. Floor slabs and roofs	
P10	Alignment of openings
P11	Horizontal diaphragms
P12	Roof systems
4. Conservation status and other elements	
P13	Fragilities and conservation status
P14	Non-structural elements

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Guideline for pre-earthquake vulnerability assessment

- prescribing the growing vulnerability levels A B C D for each of the parameters

Type of resisting system P1, Quality of resisting system P2 (P3,P13)

Class C_{vi}	P1 Resisting system	P2, Quality of resisting system						P3, P13 Cracked stiffness
		mortar	w kN/m^3	fc kPa	ft kPa	E MPa	G MPa	
A	confined masonry	cement	22	800	40	4200	1400	1.00
B	brick/stone masonry	lime/cement	20	600	30	3300	1100	0.83
C	brick/stone masonry	lime	19	400	20	2100	700	0.67
D	adobe masonry	Adobe mud	18	100	5	450	150	0.50

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Guideline for pre-earthquake vulnerability assessment

- prescribing the growing vulnerability levels A B C D for each of the parameters

Distance between walls P4, Number of floors, P5, Location and soil type P6

Class C_{vi}	P4 Maximum distance between walls (l/d,h_o/d) wall thickness:	P5 Number of floors	P6 Location and soil condition (according EN 1998-1)
A	0.60 m	1	A
B	0.50 m	2	B
C	0.40 m	3	C
D	0.30 m	enlarging/ upgrading	D, E

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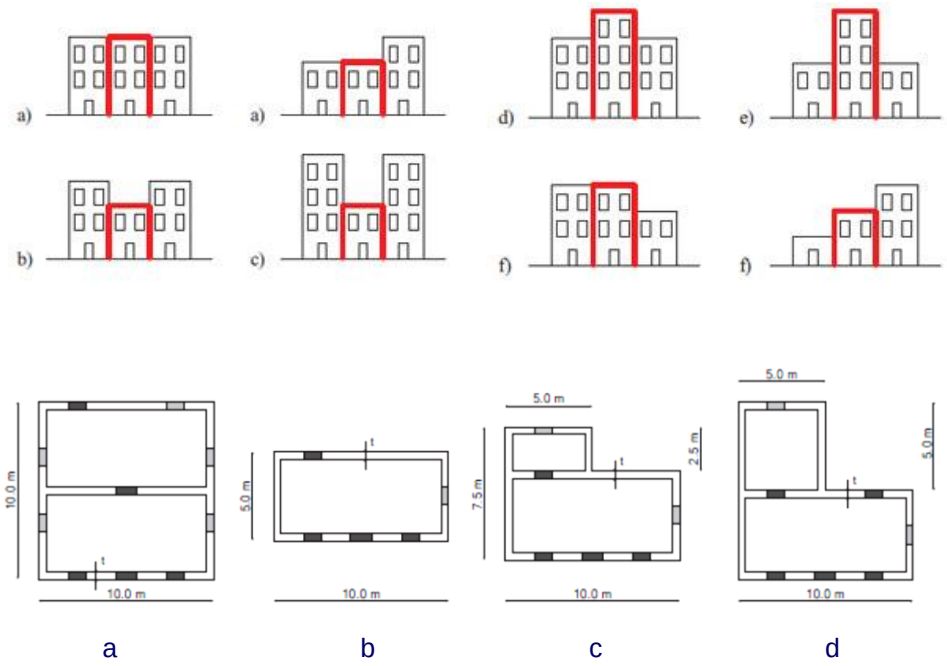
Guideline for pre-earthquake vulnerability assessment

- prescribing the growing vulnerability levels A B C D for each of the parameters

Position & interaction P7, Irregularity in plan P8, Irregularity in height P9



Class C_{vi}	P7	P8	P9 change in vertical elements' geometry
A	a	a	0%
B	b	b	up to 10%
C	c, d	c	(10 -20) %
D	e, f	d	(20 – 30) %

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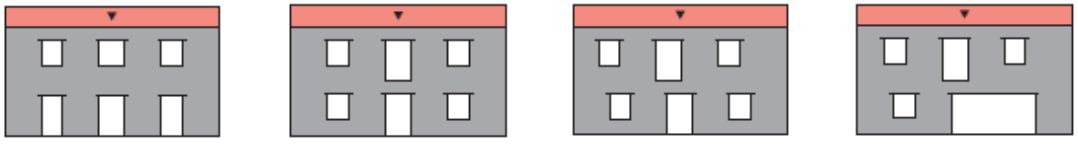
Guideline for pre-earthquake vulnerability assessment

- prescribing the growing vulnerability levels A B C D for each of the parameters

Alignment of openings P10, Horizontal diaphragms P11, (Roof structure P12)



Class C_{vi}	P10 Alignment of openings	P11, P12 Horizontal diaphragms (Roof structures)
A	a, regular and aligned	rigid and well connected
B	b, horizontal misalignment	flexible and well connected
C	c, horizontal and vertical misalignment	rigid and poorly connected
D	d, large openings in ground floor	flexible and poorly connected

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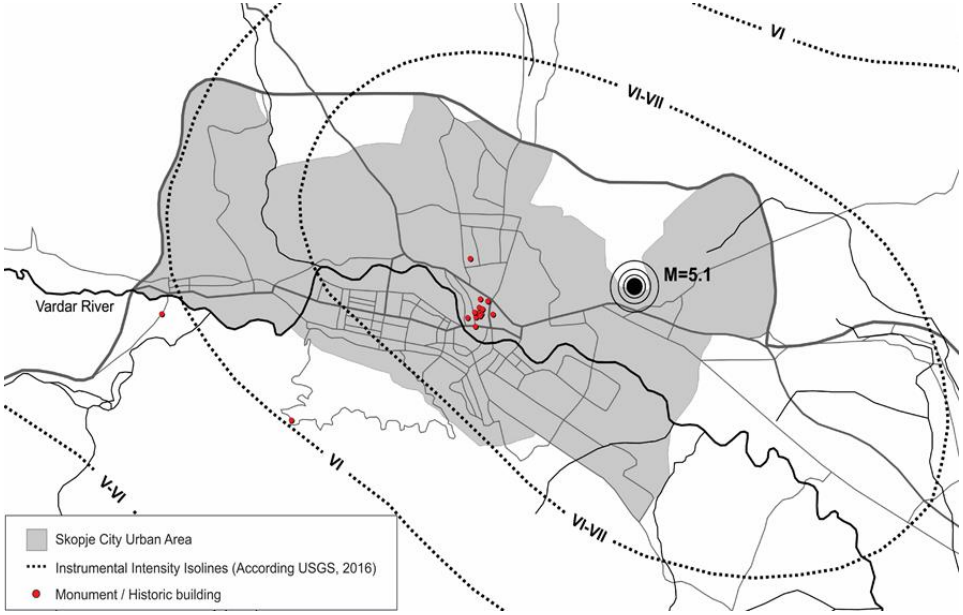
Proposal for next activities

1. application of harmonized vulnerability index method on 15 screened buildings
2. calibration of p_i (weight coefficient) using data from post-earthquake RVS
3. Seismic vulnerability assessment of the buildings in Skopje Old Bazaar, using harmonized, calibrated vulnerability index method

Skopje 2016 Earthquake, M=5.1 : damage to heritage



- Rapid visual screening of 15 cultural historic buildings and monuments (XII–XIX century)
- Damage varies from slight nonstructural one to very localized or negligible structural

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North Macedonia

European and Mediterranean Major Hazard Agreement (EUR-OPA)
Joint meeting of the Committee od Permanent Correspondents and Directors of Specialized Centres

3-4 November 2020

THANK YOU FOR YOUR ATTENTION !

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