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IZIIS' seismic assessment protocol for existing building structures

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Abstract

The unexpected misbehavior of buildings during the recent frequent earthquakes in Mediterranean region resulted in significant loss of human lives, injuries and economic losses due to the poor capacity of their structural systems and built-in materials to sustain seismic load. Among the lessons learned from recent earthquake in southeastern Europe is that identifying existing buildings' vulnerability and thus reconsidering and improving their seismic safety, should become one of the top priorities for both, state and local government in seismic prone regions.

Key words: seismic safety assessment, protocol, existing buildings, rapid visual screening, in-depth analysis

The unexpected misbehavior of buildings during the recent frequent earthquakes in Mediterranean region resulted in significant loss of human lives, injuries and economic losses due to the poor capacity of their structural systems and built-in materials to sustain seismic load. Among the lessons learned from recent earthquake in southeastern Europe is that identifying existing buildings' vulnerability and thus reconsidering and improving their seismic safety, should become one of the top priorities for both, state and local government in seismic prone regions.

The goal of the presented work, realized at IZIIS as internal scientific project, is defining and implementing seismic safety assessment Protocol for existing buildings in North Macedonia, which also could be applicable in whole southeastern Europe. The proposed Protocol is meant to be a practical tool for reliable quantitative and qualitative assessment of the buildings' vulnerability in regions with various seismic hazard levels. The Protocol's structure follows the modern methodological approaches worldwide, including pre-defined conditions and step procedures for identification of vulnerable buildings. It contains three levels of assessment: (1) rapid visual screening (RVS) procedure, (2) simplified and (3) rigorous (in-depth) seismic analysis of buildings. The assessment procedure is meant to take a major role in establishing a seismic safety rating system in North Macedonia - a "Seismic Certificate" for a specific building. The algorithm for each phase of the Protocol depends on the "knowledge level" of the relevant parameters (site seismicity, local soil conditions, type and regularity of the structural system, importance class, construction period, design and construction regulations at the time, control of the construction process, history of conversion and changes in the structural system, previous exposure to other hazards etc.). Such evaluation, if made for a significant number of buildings, would provide a clearer picture of the seismic resistance of the existing building stock in the country.

The emphasis is on the first – the RVS procedure for buildings' seismic safety estimation. It is applicable for recording a larger number of buildings in a short period of time. The accomplishing RVS process involves filling out a form for the basic relevant building attributes, based on external and internal visual inspection and the available data on the seismicity of the location and the building itself. Providing a specific information from the initial review significantly affects the need for the second and each subsequent step for seismic safety estimation for as many buildings as possible. In that way, it is possible for the seismically safe buildings to obtain a seismic certificate with a procedure that is relatively fast and easily applicable and without significant financial costs for the users, the local government unit, or any other person, company or institution that needs it. The proposed RVS procedure potentially saves time and avoids expensive experts' engagements where it is not necessary.

The RVS procedure applies basic scores and their modifiers for two the most present structural systems in the region, and their subclasses. The list of all features that affect the observed buildings' final score, are shown in the Table 1.

Table 1. Required building score modifiers information by structural system

Score modifiers	Reinforced concrete structures	Masonry structures
Basic score	Seismic zone and building type	Seismic zone
Construction period	Before 1964	
	1964-1981	
	1982-1990	
	1991-2008	
	2009-2013	
	After 2013	
	Bearing capacity knowledge level	
Vertical irregularity	Sloping site	Soft story
	Moderately weaker storey than the one above	Vertical misalignment of openings
	Highly weaker storey than the one above	Abrupt wall thickness change
	Column setback	Number of stories
	Short columns	Lower neighbouring buildings
	Split level	No basement levels
	Any other obvious irregularity	Any other obvious irregularity
Plan irregularity	Flat slabs above ground level	High length/width ratio (3 or higher)
	Torsional irregularity	"L" shaped in plan
	Out-of-plane offsets of beams	Low lat. bearing capacity in one dir.
	Discontinued lateral bearing systems	Large openings
	Non-orthogonal lateral bearing systems	No horizontal belt courses
	Large diaphragm openings	Flexible floor and roof diaphragms
	Flat slab cantilevers (3.0 m or longer)	Horizontal misalignment of openings
	Any other obvious irregularity	Any other obvious irregularity
Foundation issues	Poor soil	
Redundancy	3 or more bays in both directions	2 or more bays in both directions
		Nearly equal plan length and width
		Only one story above ground
		Wall thickness > 50 cm
Post-construction modifications	Repaired and strengthened	
	Additional stories (without project)	
Other score modifiers	Visible deformations and structural damages	Visible deformations and structural damages
	Structural brick wall infills	Vertical belt courses on critical joints

The proposed RVS scoring system is based on the most recent experiences of the structural engineering societies worldwide, mostly the FEMA 154 and FEMA P-154 handbooks [1, 2], adjusted to the local building stock, seismicity of the region, local design codes for earthquake resistance and the history of the local structural design and construction practice.

References

[1] FEMA (2002): Rapid Visual Screening of Buildings for Potential Seismic Hazards: *A Handbook, Second Edition*, FEMA 154, prepared by the Applied Technology Council for the Federal Emergency Management Agency, Washington, D.C.

[1] FEMA (2015): Rapid Visual Screening of Buildings for Potential Seismic Hazards: *A Handbook, Third Edition*, FEMA P-154, prepared by the Applied Technology Council for the Federal Emergency Management Agency, Washington, D.C.