

Seismic Performance Assessment of Twin URM and Confined Masonry Buildings Using Nonlinear Static Analysis

Enio Deneko^{1*}[0009-0000-7236-5242], Altin Bidaj¹[0000-0002-1101-6310], Marjo Hysenlliu¹[0000-0002-0863-2112], Ksanti Hysenlliu²[0009-0002-0033-6412]

¹ Department of Mechanics of Structures, Polytechnic University of Tirana, Albania

² Department of Economics, Entrepreneurship and Finance, Marin Barleti University, Albania

*eniodeneko@hotmail.com

Abstract. This paper presents a comparative seismic performance assessment of two adjacent masonry buildings located in Kruja, Albania, both classified as damage state DS-4 following a recent earthquake. The buildings are identical in geometry, height, and mass distribution, but differ in structural system: one is an unreinforced masonry (URM) structure, while the other is a confined masonry (CM) structure with undersized and poorly detailed tie-columns. Nonlinear static (pushover) analyses were carried out using macro-element modelling, with material properties calibrated from laboratory testing. Capacity curves, performance points, inter-story drifts, and damage patterns were evaluated in accordance with Eurocode 8 performance levels. Pushover analyses reveal marginal improvements in the weakly confined masonry building: base shear capacity (V/W) increases by 45% (from 10.3% to 15.0%), while ductility improves by 30% ($\mu = 2.19$ vs. 1.68). The study highlights the critical role of proper confinement detailing and demonstrates that inadequate CM solutions may fail to provide the expected seismic benefits.

Keywords: Pushover analysis; Seismic assessment; Unreinforced masonry; Confined masonry; Performance levels; Eurocode 8.

DOI: <https://doi.org/10.15157/tultechbook.3.c14>

References

- [1]. Hysenlliu, M., Bidaj, A., Bilgin, H. Seismic performance assessment of existing masonry buildings using nonlinear static analysis. *Journal of Integrated Engineering and Applied Sciences*, 2024, 2(1), pp. 1–12.
- [2]. Orumiyehi, A.; Sullivan, T.J. Displacement-Based Seismic Assessment of the Likelihood of Failure of Reinforced Concrete Wall Buildings. *Buildings* 2021, 11, 295.
- [3]. Academy of Sciences of Albania. KTP-N.2-89: Technical Conditions for the Design of Anti-Seismic Constructions. Tirana, Albania, 1989.

- [4]. Lagomarsino, S., Penna, A. Seismic assessment of existing masonry buildings: displacement-based approach. *Bulletin of Earthquake Engineering*, 2009, 7(3), pp. 843–864.
- [5]. Lagomarsino, S., Galasco, A., Cattari, S., Penna, A. TREMURI program: an equivalent frame model for the nonlinear seismic analysis of masonry buildings. *Engineering Structures*, 2013, 56, pp. 1787–1799.
- [6]. Magenes, G. Masonry building design in seismic areas: recent experiences and prospects. *International Journal of Architectural Heritage*, 2008, 2(1), pp. 1–20.
- [7]. Dolce, M., Kappos, A., Masi, A., Penna, A., Vona, M. Vulnerability assessment and earthquake damage scenarios of masonry buildings. *Bulletin of Earthquake Engineering*, 2021, 19, pp. 299–328.
- [8]. Hysenlliu, M., Deneko, E. Capacity evaluation and spectral analysis of a damaged low-rise reinforced concrete building. *Journal of Transactions in Systems Engineering*, 1(3), 2023, pp. 120–130.
- [9]. Adhikari, R.K.; Parammal Vatter, A.; D'Ayala, D. Seismic Performance Assessment of Low-Rise Unreinforced and Confined Brick Masonry School Buildings Using the Applied Element Method. *Buildings* 2023, 13, 159.
- [10]. FEMA 356. *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*. Federal Emergency Management Agency, Washington, D.C., 2000.
- [11]. FEMA P-750. *NEHRP Recommended Provisions for New Buildings and Other Structures*. Federal Emergency Management Agency, Washington, D.C., 2009.
- [12]. CEN. EN 1998-1:2004. *Eurocode 8: Design of Structures for Earthquake Resistance – Part 1: General Rules, Seismic Actions and Rules for Buildings*. Brussels, 2004.
- [13]. CEN. EN 1996-1-1:2005. *Eurocode 6: Design of Masonry Structures – Part 1-1: General Rules for Reinforced and Unreinforced Masonry Structures*. Brussels, 2005.
- [14]. Tomazevic, M. *Earthquake-Resistant Design of Masonry Buildings*. Imperial College Press, London, 1999.
- [15]. Pardalopoulos, S.I.; Gkektsi, A.E.; Lekidis, V.A. Evaluation of an Approximate Seismic Assessment Procedure for Load-Bearing Masonry Buildings. *Infrastructures* 2025, 10, 118.
- [16]. Nikolić, Ž.; Runjić, L.; Ostojić Škomrlj, N.; Benvenuti, E. Seismic Vulnerability Assessment of Historical Masonry Buildings in Croatian Coastal Area. *Appl. Sci.* 2021, 11, 5997.
- [17]. Blagojević, P.; Brzev, S.; Cvetković, R. Simplified Seismic Assessment of Unreinforced Masonry Residential Buildings in the Balkans: The Case of Serbia. *Buildings* 2021, 11, 392.