The 2023 World Congress on
Advances in Structural Engineering and Mechanics (ASEM23)
GECE, Seoul, Korea, August 16-18, 2023

Experimental Investigation on Seismic Performance of Unreinforced Masonry Walls Strengthened with Lightweight Engineered Cementitious Composites

Chukwuwike Mike Ogwumeh[1)], Zhanbolat Artyk[2)], Beybaris Mauthan[3)], Dichuan Zhang[4)], Chang-Seon Shon[5)], and Jong Ryeol Kim[6)]

[1), 2), 3), 4), 5), 6)] *Department of Civil and Environmental Engineering, Nazarbayev University, Astana, Kazakhstan, 53 Kabanbay Batyr Ave., Astana, Kazakhstan, 010000*

[1)] *chukwuwike.ogwumeh@nu.edu.kz* [2)]*zhanbolat.artyk@.nu.edu.kz*
[3)]*beybaris.mauthan@nu.edu.kz* [4)]*dichuan.zhang@.nu.edu.kz* [5)]*chang.shon@nu.edu.kz*
[6)]*jong.kim@nu.edu.kz*

ABSTRACT

Engineered cementitious composites (ECC) have been studied for structural retrofitting applications, such as seismic retrofitting on unreinforced masonry (URM) walls because they exhibit a ductility strain hardening response under tension in contrast to conventional concrete. Literature shows that using normal-weight designed cementitious composite can significantly increase the strength of UMR under cyclic in-plane horizontal loads. However, it has limited improvement in the deformation capacity and ductility of the wall, which is also a critical criterion for seismic resistance. This restriction might be due to the incompatibility between the wall and the composite's strength and stiffness. It is theorized that lightweight engineered cementitious composites (LWECC), which have lower strength and stiffness and are more compatible with brick walls, can address the restriction.

Three URM walls with an aspect ratio of 0.55 were tested under cyclic in-plane loads. The walls were built to represent 1/3 of an interior prototype load-bearing wall segment of a typical non-earthquake-resistant three-story residential URM clay brick building built in Almaty region, Kazakhstan, within 1957 to 1967. One wall was a URM wall without retrofitting as a reference specimen, while the other two were retrofitted by troweling 15 mm thick layers of LWECC on both sides of the wall. The LWECC composites were chosen to have two different compressive strengths of 12 MPa and 27 MPa, exhibiting tensile strength and tensile strain capacities of 2.63 MPa (1.80%) and 3.75 MPa (1.48%), respectively. A constant vertical load was first applied to the specimen to mimic the gravity load, and then the cyclic lateral load with increasing displacement amplitudes was applied to the top of the wall until failure, defined by a 15% reduction from the peak load. Results from the in-plane wall testing showed that the URM walls retrofitted with the LWECC exhibits a slight increase in the lateral load-resistant capacity by average values of 10.14% for 12 MPa LWECC retrofitted wall and 7.21% for 27 MPa LWECC retrofitted wall. However, there were significant improvements in the ultimate displacement and wall ductility capacities. The wall retrofitted with 12 MPa LWECC had an average increase of 122.78% and 151.18% in its ultimate displacement and ductility capacities, respectively. The wall retrofitted with 27 MPa LWECC has an average increase of 58.44% and 151.91% in its ultimate displacement and wall ductility capacities, respectively. The findings show that the LWECC retrofitting method can significantly increase the ductility and displacement capacity of unreinforced masonry (URM) walls, resulting in a change from brittle failure to a more ductile mode of failure while maintaining wall integrity under significant lateral displacement.

Keywords: Masonry walls, Lightweight engineered cementitious composites (LWECC), Retrofitting, Cyclic loading, In-plane behavior.

REFERENCES

Choi, H.-K., Bae, B.-I., & Choi, C.-S. (2016). Lateral Resistance of Unreinforced Masonry Walls Strengthened With Engineered Cementitious Composite. *International Journal of Civil Engineering*, *14*(6), Article 6. https://doi.org/10.1007/s40999-016-0026-1

Deng, M., Dong, Z., & Ma, P. (2019). Cyclic loading tests of flexural-failure dominant URM walls strengthened with engineered cementitious composite. *Engineering Structures*, *194*, 173–182. https://doi.org/10.1016/j.engstruct.2019.05.073

Deng, M., & Yang, S. (2018). Cyclic testing of unreinforced masonry walls retrofitted with engineered cementitious composites. *Construction and Building Materials*, *177*, 395–408. https://doi.org/10.1016/j.conbuildmat.2018.05.132

Li, V. C. (2012). Tailoring ECC for Special Attributes: A Review. *International Journal of Concrete Structures and Materials*, *6*(3), Article 3. https://doi.org/10.1007/s40069-012-0018-8

Lin, V. W. J., Quek, S. T., Nguyen, M. P., & Maalej, M. (2010). Strengthening of Masonry Walls Using Hybrid-fiber Engineered Cementitious Composite. *Journal of Composite Materials*, *44*(8), Article 8. https://doi.org/10.1177/0021998309346186

Salmanpour, A. H., Mojsilović, N., & Schwartz, J. (2015). Displacement capacity of contemporary unreinforced masonry walls: An experimental study. *Engineering Structures*, *89*, 1–16. https://doi.org/10.1016/j.engstruct.2015.01.052

Tomaževič, M. (2009). Shear resistance of masonry walls and Eurocode 6: Shear versus tensile strength of masonry. *Materials and Structures*, *42*(7), 889–907. https://doi.org/10.1617/s11527-008-9430-6

Zhu, H., Wan, K. T., Satekenova, E., Zhang, D., Leung, C. K. Y., & Kim, J. (2018). Development of lightweight strain hardening cementitious composite for structural retrofit and energy efficiency improvement of unreinforced masonry housings. *Construction and Building Materials*, *167*, 791–812. https://doi.org/10.1016/j.conbuildmat.2018.02.033