Shape and topology optimization of shear wall consisting of latticed blocks for seismic retrofit of existing building and its prototype model using additive manufacturing

Toshiaki KIMURA* and Makoto OHSAKI†

* Department of Architecture and Architectural Engineering
Kyoto University
Kyoto daigaku-Katsura, Nishikyo-ku, Kyoto 615-8540, Japan
e-mail: kimura@archi.kyoto-u.ac.jp

† Department of Architecture and Architectural Engineering
Kyoto University
Kyoto daigaku-Katsura, Nishikyo-ku, Kyoto 615-8540, Japan
Email: ohsaki@ archi.kyoto-u.ac.jp

ABSTRACT

Among various methods for seismic retrofit of existing building, installation of shear wall consisting of light weight blocks is one of the most effective approach in a view of reduction of construction cost. Because the blocks are connected to the existing frame mainly with contact, the shear wall resists the story shear force by only compression, and complex anchoring or welding is not necessary. Owing to this simple connection, reduction of construction cost can be achieved. However, shape of blocks in practical design tends to be regular in view of simplicity in manufacturing process and constructability.

The second author developed a method of shape optimization of latticed blocks based on ground structure approach. In the previous study [1], it is reported that very thin lattice members exist in the optimal solutions obtained by a nonlinear programming approach. To prevent this difficulty, a combinatorial method has been presented for layout optimization of blocks with given patterns [2]. In both studies, locations of the nodes are fixed, and the latticed block is discretized with beam element. We developed a new method of shape optimization of a shear wall consisting of latticed blocks using Simulated Annealing (SA) [3]. The lattice members are discretized with plane stress elements, and the locations of nodes and the widths of lattice members are adopted as design variables. The proposed method consists of two phases for optimizing the topology and member size, respectively. Design problem in each phase is formulated to maximize the lateral reaction force for specified inter-story drift angle.

In this study, we present a prototype model of the optimized shear wall fabricated by Additive Manufacturing (AM). Structural performance is tested by attaching the shear wall (300mm × 500mm) to a frame with steel column and beam (both are 20mm × 50mm) representing the existing structure. Verogrey, which is a kind of hard resin, is used for structural material of shear wall to be fabricated by a 3D-printer. Numerical examples of optimization, fabrication process by AM and results of structural performance test are shown to demonstrate effectiveness of application of optimization.

REFERENCES

[1] T.Mikami, M. Ohsaki, K. Fukushima, Shape optimization of latticed blocks for seismic retrofit of building frames, Proceedings of IABSE Confrence Nara , pp.1-6, 2015

[2] K.Fukushima, M. Ohsaki, T.Mikami, T. Miyazu, Combinatorial optimization of latticed blocks composed of various unit shapes for seismic retrofit, J.Struct. Constr. Eng., AIJ, Vol. 81, No.728, pp.1657-1664, 2016 (in Japanese)

[3] T. Kimura, M. Ohsaki and Y. Yamaoka, Shape and topology optimization of shear wall considering of latticed blocks, Proc. IASS Symposium 2018, Boston, USA, Int. Assoc. Shell and Spatial Struct., Paper No. 234, 2018.