DESIGN AND FABRICATION OF MODERN GER UTILIZING SELF-ASCENDING PANTADOME SYSTEM

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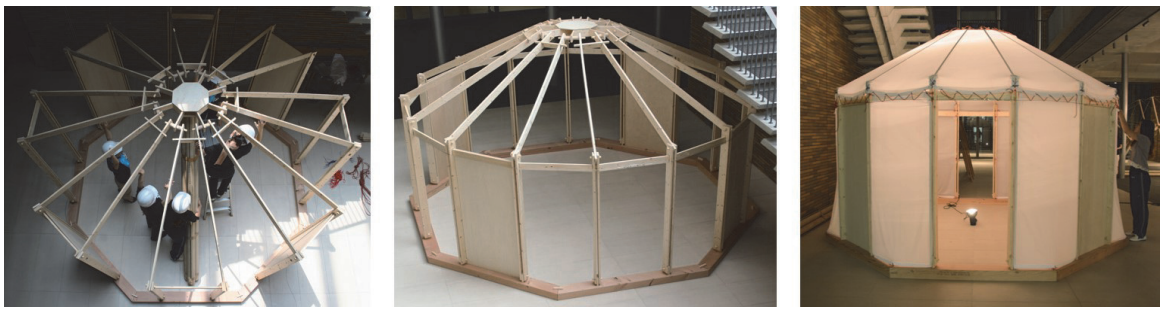
Introduction

Each semester in the architectural design class at Mukogawa Women's University, graduate students are assigned to design and fabricate full-scale architecture [1]. In the first semester of 2013, a ger such as that shown in Figure 1, was designed and fabricated. A traditional ger is a portable, round tent covered with skins or felt that is used as a dwelling by nomads in the steppes of Central Asia. The ger in Figure 1 is modern, utilizing the Pantadome system [2], [3], which was conceived by one of the authors and has been applied to many long-span roof structures [2], [3]. A 1:5 scaled model demonstrating the Pantadome mechanism is shown in Figure 2. In the second semester of 2015, a more advanced ger was designed and fabricated, utilizing a "self-ascending" Pantadome system [3], [4], which was first applied to the roof structure of a bullring in Xàtiva, Spain [3], [4]. In this paper, the design and fabrication processes used to construct a modern ger with a self-ascending Pantadome system, referred to as self-ascending Panta-ger in this paper, is described.



(a) Construction (lifting the roof) (b) Wooden framing (c) Final structure

Fig. 1: Ger utilizing Pantadome system in 2013

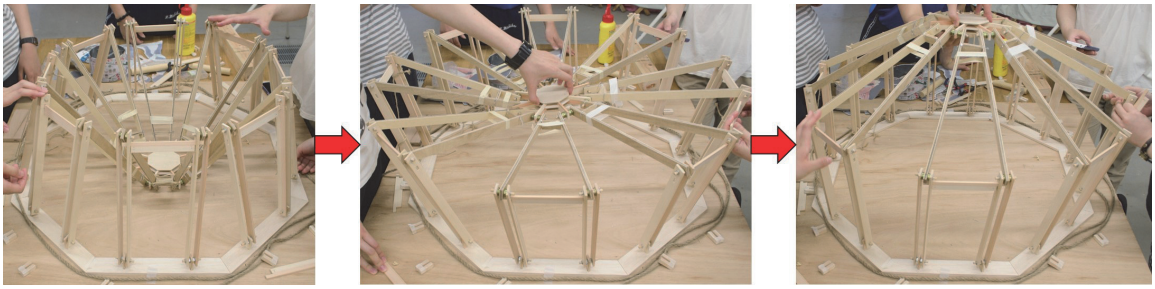


Fig. 2: Demonstration of the Pantadome mechanism using a 1:5 scaled model

Design and Fabrication Process

This ger was designed to be used for performances by students of the architectural department at a costume festival held every year at Mukogawa Women's University. To fulfill this purpose, the ger required quick construction using human power of several students pushing from a platform. Simple models such as that in Figure 4 were created to illustrate the self-ascending Pantadome mechanism, in which the roof is raised by shortening the distance between A (the lower vertex of a girder) and B (the lower chord of an inner ring) as shown in Figure 3. To shorten the distance between A and B, strings were fixed to A at and passed through a pulley at B and C (the head of a column), and pulled from the outside the structure.

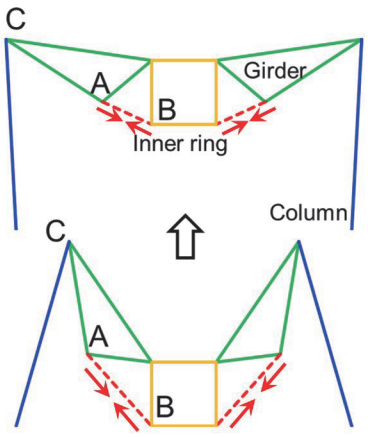
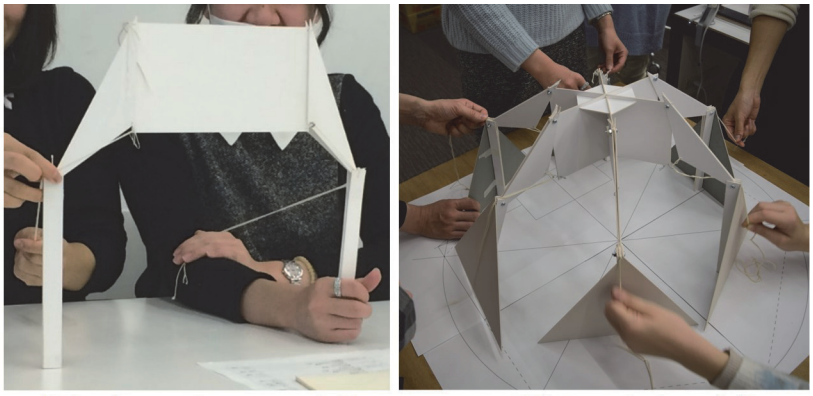


Fig. 3: Mechanism of self-ascending Pantadome



[Simple one-frame model] [1/20-scaled model]

Fig. 4: Scaled models for study

Structural aspects such as the stability of the Panta-ger were investigated by fabricating partial full-scale models and conducting experiments as shown in Figures 5(a) and 5(b). Through this, several aspects requiring improvement were identified, which are as follows: 1) the inner ring made of a wooden pole did not provide enough stability, and required replacement with an assembly of wooden plates as shown in Figure 5(c); 2) the columns were subjected to large compression forces and horizontal shaking when pulling the strings, thereby requiring that they be strengthened with bracing; and 3) the self-weight of the a plywood plate was excessive and required replacement with a wooden truss frame.

(a) One-frame model (b) Two-frame model (c) Inner-ring

Fig. 5: Experiments using partial full-scale models

The roof and walls were comprised of folded bellows of paper as shown in Figure 6. As the roof frame was lifted by pulling the strings from outside the structure, the bellows of paper

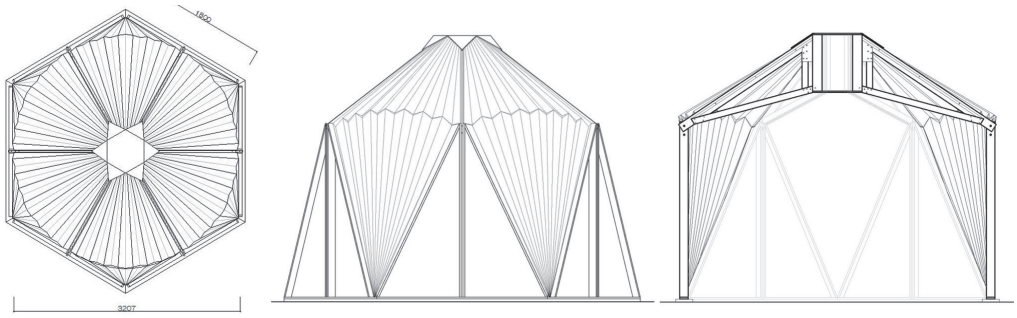
unfolded, creating the final Panta-ger structure. Partial full-scale and entire full-scale models were used to ensure full roof and wall coverage of the paper bellows given the movement of the wooden framing, as shown in Figures 6(a), 6(b), and 6(c).

(a) 1:10 scaled model (b) Partial full-scale model (c) Entire full-scale model

Fig. 6: Follow-up investigation of folded bellows to ensure full covering of the roof and walls

Final Product of Self-ascending Panta-ger

Design drawings of the final product of the self-ascending Panta-ger in its fully deployed stage are shown in Figure 7. Configurations were selected such that the columns were vertical upon completion. The deployment process of the self-ascending Panta-ger is shown in Figure 8. The major difference between this self-ascending Panta-ger and the previous one is that the roof was lifted externally through means of a pulley system as opposed to internally through means of manual pushing from below (Figure 1(a)).



(a) Roof Plan (b) Elevation (c) Sectional View

Fig. 7: Drawings of the fully deployed self-ascending Panta-ger

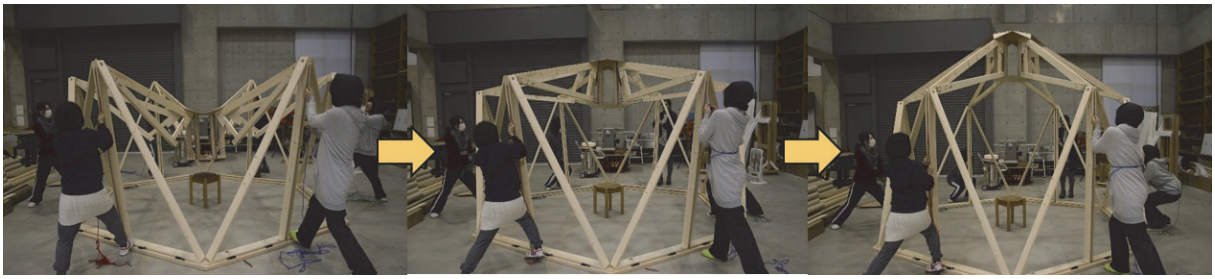


Fig. 8: Deployment process of self-ascending Panta-ger

The pictures of the final product are shown in Figure 9. Folded bellows of paper exist in harmony with wooden framing, creating an elegant aesthetic. At night, the ger may be lit up like a huge lantern using lighting equipment installed inside the ger as shown in Figure 9(c).

(a) Outside (b) Inside (c) lighted up at night

Fig. 9: Final product of self-ascending Panta-ger

Future Improvements

Future improvements for the self-ascending Panta-ger include: 1) removal of central columns since the truss frame bracing is substantially stiff and strong; 2) inclusion of an axis rod to wind strings Ⓐ and reduce the distance between the lower vertex of the girder and the lower chord of the inner ring, by pulling strings Ⓑ as shown in Figure 10. This would eliminate the need to pull the strings with exactly equal forces in order to lift the roof evenly as required by the current design.

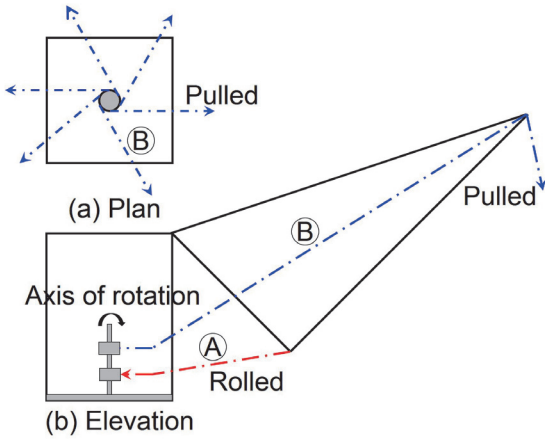


Fig. 10: Axis rod to wind strings Ⓐ, rotated by strings Ⓑ

Conclusions

The modern ger utilizing a “self-ascending” Pantadome system was designed and fabricated by graduate students in the architectural design class at Mukogawa Women’s University. The final product of the “self-ascending” ger is elegant, especially when lit up at night like a huge lantern.

References

[1] http://www.mukogawa-u.ac.jp/~arch/education/major/major00.html

[2] Kawaguchi, M. Application of pantadome system to long-span roof structures, *IABSE reports,* Vol. 71, pp.91–100, 1994.

[3] Kawaguchi, M. Kouzo to Kansei, Kouzo Dezain no Genri to Shuhou, *Kajima publishing*, 2015. (Japanese)

[4] Làzaro, C., Domingo A. Detailing and construction of the pantadome roof structure for a bullring in Xàtiva (Spain). *International Journal of Space Structure*s, Vol. 25, No.4, pp.229–241, 2010.