Proposal of design method of natural and rational tree-structure based on computational hanging upside-down simulation

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Abstract

In our previous study [1], a physical hanging upside-down model was created to obtain structurally rational configuration of a tree-structure supporting a free-surface shell roof, which was still close to the designer's image. Then, simulation of computational hanging upside-down model of unstable truss structure was conducted to correct nodal coordinates slightly so that the equilibrium holds at each joint due to axial member forces only. However, trunks and branches obtained were all straight lines, similar to most existing tree-structures, which gave artificial rather than natural impression. In this study, a design method to obtain "natural" and "rational" tree-structure based on hanging upside-down simulation is proposed. First, a shape of a tree-structure is obtained using physical model similar to actual trees as shown in Figure 1. The 3D geometric data is computed through photogrammetric processing and the finite element model is created as shown in Figure 2. Computational simulation of the hanging upside-down model is conducted applying the dynamic relaxation as shown in Figure 3. Bending stress values before and after the hanging upside-down simulation is evaluated. Finally, architectural design of a natural and rational tree-structure, which has slightly curved trunks and branches but still has bending stress within admissible level, is proposed as illustrated in Figure 4.

Figure 1: Physical model

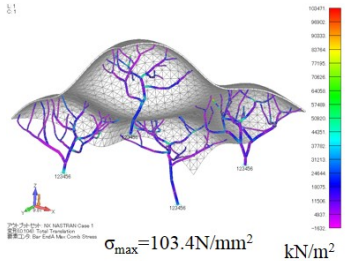

Figure 2: Finite elemenet model

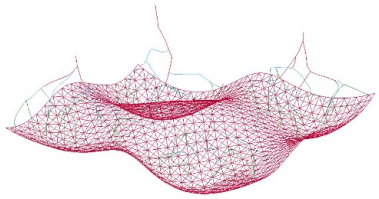

Figure 3: Computational hanging model

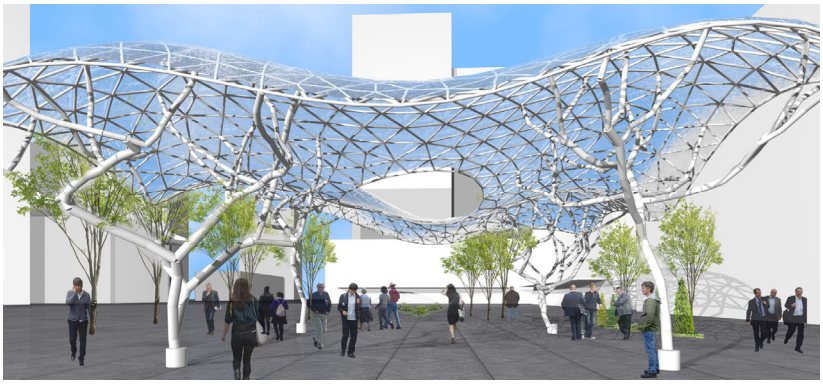

Figure 4: Architectural design

References

[1] C. Eguchi, N. Sugiura and H. Tagawa, "Architectural and Structural Design of Tree-structure supporting Free-surface Shell Roof using Hanging Upside-down Model", Proceedings of the IASS Symposium 2018, Creativity in Structural Design, July 16-20, 2018, MIT, Boton, USA