Form Finding Analysis of Multi-Reciprocal Element (MRE) Space Structures

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Summary

A Multi-reciprocal element (MRE) space structure consists of a number of reciprocal frame systems, which are three dimensional structures and constructed by a closed circuit module of mutually dependent members. At each joint in a module, it is necessary for only two members to be connected to each other. When all of the members are connected properly, a complete circuit module can be formed. MRE space structures can span small or very large areas without intermediate vertical supports in an economic, aesthetic and convenient way.

If the individual members of a MRE structure have the same length and the members are placed appropriately, each member can support the others thus establishing the MRE structure. By using various types of members with different depth notched joints, a free-form shape can be constructed simply and systematically. However, in order to model or design this structure, it is necessary to control the complicated geometry and investigate the relationships between the geometry of each member and the internal forces by the self supported members.

In this presentation, a form finding analysis method of MRE is proposed. The members are modeled by Timoshenko beam elements which consider large increments of displacement and rotation. For modeling of the joint between two members, the distance from the bottom of the notch to the neutral axis of each member is constrained by using the Lagrange multiplier method.

This presentation is organized as follows. Firstly, the variational formulation is derived to minimize the total potential energy of beam elements with the constraint conditions for modeling the joint of the connected members. Then, the discretized nonlinear equations are solved by using the Newton-Raphson method. Finally several novel examples of MRE are demonstrated to validate the proposed method. This proposed method should be valid for understanding the behaviors of free-formed structures based on MRE in the field of structure design.

keywords: Form Finding, Multi-reciprocal element, Reciprocal Frame, Variational method

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