Proposed Computational Design method for spatial steel structures - with engineering integration through design to production

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Abstract

In spatial steel structures, engineers are expected to design a structure not only to ensure its structural safety but to takes account of its desired architectural functions, as often the structure also composes the interior or exterior façade exposed to view. Steel is one of the most widely used materials to fulfill these functions.

Recent development of geometrical modeling software has been of a great assistance to establish more complex "freeform" structures. Three dimensional stress analyses and member designs are then carried out to ensure structural safety in terms of its overall behavior and member design level. In the meantime, full engineering on connections among multiple members taking account of constructability is put aside to later stage in some occasions. Consequently, un-constructability or misalignment among components (plates and / or shapes) are often recognized in shop drawing preparation stage, and it sometime causes revisit to the overall geometrical design, cost increase and even suspension of the project.

In the paper, the author will introduce a proposed comprehensive design method, namely "Computational Design", in which engineering process is automated and integrated from overall geometrical development to initial production stage of shop drawing preparation by establishing multiple software packages interlocking each other. The proposed design method includes the functions: -

(1) Overall geometrical development: In this function, an overall geometry is automatically and quickly developed so that quite a few numbers of case studies can be performed. To achieve this function, an algorithm is constructed in order to develop freeform shapes by just varying several parameters that control the overall geometry.

(2) Structural analyses and member designs: In this function, the optimum cross section can be searched based on the predetermined load conditions according to an applicable structural design code (such as the Japanese Building Code).

(3) Connection engineering: It enables immediate examination of connections taking account of constructability, by pre-mounted connection patterns in function of controlling parameters such as the angle between members.

(4) Shop drawing preparation: This function is realized by interlocking BIM software with aforementioned functions. Cross conversion among geometry, analysis program and BIM are made possible, contributing to drastically reducing works on the production side.

The proposed method helps architects and engineers design more complex spatial structures in the quickest and well-engineered manner. The paper will also report application results of the proposed design method to an actual project in which the intended effect is recognized.