How to Build Rationally and Beautifully -System and Detail of Hybrid Spatial Structures

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Summary

From the View point of the theme “Elegance in Structure”, not only the structural system but both the detail and constructional method should be focused. Hybrid tension spatial structures which has been designed by the author and experienced construction will be descrived.

Keywords: spatial structure, structural system, detail, construction, hybrid tension, string, initial tensioning, BSS, SKELSION, dome

1. Introduction

“Spatial Structure” is able to realize the architectural space with long-span rationally, It’s basic characteristic is the performance of form and axial resistance, and such tension members as cable and rod is most important to produce light-weight Hybrid string structures (HSS). HSS is conceptually opposed to pure tension structure like eablenct, and it aims at not only the structural rationality including cost performance due to sophisticated system, detail and construction, but also the attractive feature of structural expression with the sense of transparency and lightness.
“System and Detail”, one of the main themes of structural morphology in spatial structure, are characterized strongly in HSS. Furthermore, in this field, holistic design based on the total understanding that is “how to build rationally and beautifully” is strongly required. The concept of “Elegance in Structure” is should be confirmed through whole design process created by individual idea or human imagination.

2. Elegance in structural Realization

In general, one of the most important theme of architectural design is how to make fusion between the Imagination that is target of space and Technology that is realization ability of Structure. Recently, the Collaboration between architect and structural engineer is payed to attention.
There are two stages to realize the fusion of aesthetic and rationality in structural design. The one is how to realize the ideal image rationally, and the other is how to realize rational and innovative technology attractively. The concept of “Elegance in Structure” exists in dual vector which combine the Imaginetion and the Technology. By the recent development of IT, free space or organic shape can be drawn easily and quickly. It must be

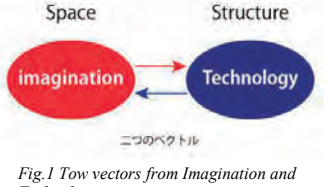

Fig.1 Tow vectors from Imagination and Technology

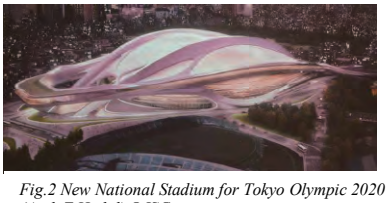

Fig.2 New National Stadium for Tokyo Olympic 2020 (Arch.Z.Hadid) ©JSC

emphasized that the endeavor to realize every expensive image without consideration is not only the role of structural engineer. In addion to calculate and design for getting safety and economy of structure, structural engineer should endeavor to create sophisticated system, detail and constructional method which may be unable by computer.
Considering the saving energy of the earth, “Less with More” is the significant theme of “Elegance in Structre”

3. Own Experience of Design and Construction

3.1 Temporary Space build by human power

Temporary-gazering space for the event or the disaster, not only attractive feature but special structural performance is required. Ultra light-weight structures which are able to built quickly and enjoyable by any persons will be shown. Here, pretensioning systems of the strings are interesting, and important.

Fig.3 String scissors for Nagoya EXPO.2005

3.2 Beam String Structure (BSS)

BSS is named for the hybrid structure in which stiff beam and flexible string are combined. It is characterized with productive rationality due to fabrication and construction, and structural rationality due to self balance and controlled ability of the behavior. By adopting various material and members, it has the advantage as for architectural expression and structural feature.

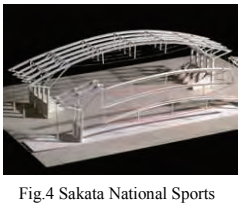

Fig.4 Sakata National Sports Memorial gymnasium (1991)

3.3 SKELSION

The term SKELSION means the combination of skeleton and tension string. For a portal frame with slight section, the hangar string is placed against vertical dead load and bracing strings are arranged against seismic and wind force. Both the pre-stressing force of the hanger and bracing strings balance each other. The most important detail is focused to the joint for introduction of pre- stressing of the strings

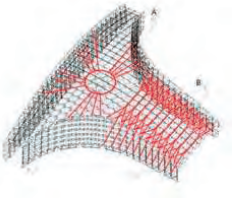

Fig.5 “Motenashi Dome” in Kanagawa (2004)

3.4 Metamorphoses in Dome structure

In the world of nature, so-called metamorphoses played by some insects give us surprise and inspiration to image how to construct the dome structure.
From the view point of dynamic change as for shape or behavior of structure, “Panta dome ” and jack down method are similar to this performance.
Several own experiences of drastic construction of which span are over 150m will be introduced as well as original system and detail.

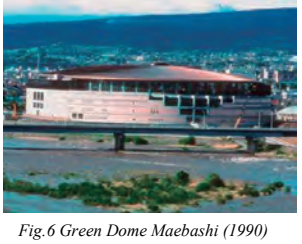

Fig.6 Green Dome Maebashi (1990)

Fig.7 Izumo Dome (1992)

Fig.8 Yamaguchi Kirara Dome