Complex Structure Combined with Timber BSS and Cantilever Trusses -Ariake Gymnastics Centre, Japan-

Kenichi KUME*, Masao SAITOH[a], Yoshisato ESAKA[b]
Takayuki NISHIYA*, Hatsutaro TANAKA*, Miho YAMASHITA*, Katsuhide MURAKAMI[b]

*Structural Engineer, Structural Design Department, Shimizu Corporation
2-16-1 Kyobashi, Chuo-ku, Tokyo 104-8370, Japan
k_kume@shimz.co.jp

[a] Emeritus Professor, Department of Architecture, Nihon University, Tokyo, Japan
[b] Structural Engineer, Engineering Department, Nikken Sekkei Ltd., Tokyo, Japan

Abstract

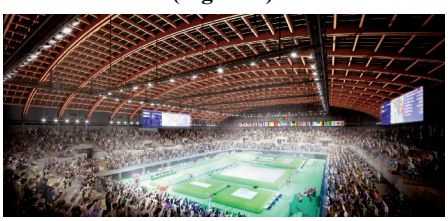
For the 2020 Tokyo Olympic and Paralympic Games, the construction of stadiums and arenas is proceeding across Japan. One of its major facilities, the Ariake Gymnastics Centre, will be used as a competition facility for gymnastics, rhythmic gymnastics, trampoline at the Olympic Games, and for Boccia at the Paralympic Games. After the Olympic and Paralympic Games, this facility will be used as an exhibition hall which is scheduled for temporary use for approximately 10 years. The most defining characteristic of the Ariake Gymnastics Centre is that long-spanning roof (approximately 90 m in span) which is primarily made from large laminated timber sections.

There are two main features of the facility's architectural design. The first is a low rise arch shape which provides an attractive feeling of lightness from an exterior view (Figure 1). The second is the timber roof which gives a feeling of warmth from the interior view (Figure 2). In order to harmonize this architectural design with structural mechanics and to ensure construction rationality, the proposed structural system is comprised of a Complex Structure combined with Cantilever Trusses and Beam Strings Structure (BSS). The space structure with a span of approximately 90 m is realized by cantilever trusses (9.6 m) composed of steel frames and laminated timber at both ends and by BSS (69.6 m), composed of laminated timber and cables (Figure 3).

BSS is a self-balanced structure combining a bending compression member (Beam), a tension member (String), and an axial compression member (Strut) to connect them. We proposed a lift-up method to take advantage of this self-balanced characteristic of the BSS. This system doesn't generate thrust caused by the weight of the roof (Dead Load). And, after lift-up, it becomes a structural system which behaves like an arch against loads. Furthermore, considering the various loading scenarios, we proposed sub-strings (Sub-cables) in order to heighten stiffness and ensure strength.

This paper introduce "Architectural design and Structural system", "Structural design of the roof" and "Construction" of the Ariake Gymnastics Centre.

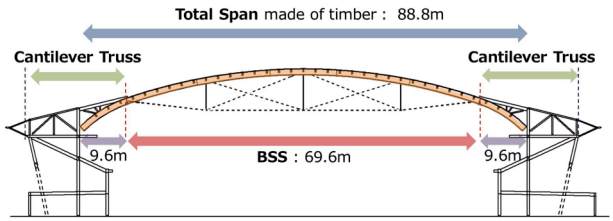
(Figure 1) *



(Figure 2) *

References

[1] Masao Saitoh, *Principle of Beam String Structures*, Proceedings of International Conference of IASS (Madrid), pp.17-38, 1979, 9



(Figure 3)

(*Courtesy of The Tokyo Organizing Committee of the Olympic and Paralympic Games, Completion image as of November 2017)