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Steel Cover Structures for the Renovation of Large Temples

Structures métalliques pour la restauration de grands édifices en bois

Stahlrüstung für die Renovierung eines großen Holzbaues

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SUMMARY
There are very many large Shinto and Buddhism temples built of timber in Japan. Reconstruction or repair of such buildings, when required, is made by placing a large cover structure which covers them up entirely. In conventional practice, it used to be fabricated by the use of wooden logs and manpower. In the recent large scale repair of the Todaiji Temple in Nara, a rationally designed steel structure was used utilizing steel scaffold materials also used for repair of the Zaodo Temple on Mt.Kinbusan.

RÉSUMÉ
Il existe au Japon de nombreux temples shintoistes et bouddhistes construits en bois. La reconstruction partielle ou la réparation de ces bâtiments, lorsqu 'elle s'avère nécessaire, est réalisée après que les temples ont été entièrement recouverts d'une structure provisoire. Au cours des réparations importantes qui ont été effectuées sur le temple de Todaiji à Nara, une telle structure métallique a été conçue tandis qu'une application faisant appel à un échafaudage en acier a été réalisée pour la réparation du temple Zaodo sur le Mont Kinbunsan.

ZUSAMMENFASSUNG
In Japan gibt es eine große Anzahl aus Holz gebauter shintoistischer und buddhistischer Tempel. Die Rekonstruktion oder Reparatur solcher Gebäude erfolgt nach der Errichtung einer Hüllstruktur, die den Tempel vollständig einschließt. Bei konventionellen Verfahren wurde die Hüllstruktur aus Holz von Hand errichtet. Bei der letzten Großreparatur des Todaiji Tempels in Nara gelangte eine rationell konstruierte Stahlstruktur zum Einsatz. Auch für die Reparatur des Zaodo Tempels auf dem Berg Mt. Kinbusan wurde eine ähnliche Struktur mit Stahlgerüst verwendet.

1. PREFACE

Traditionally in Japan, the very large temporary protective shelter known as SUYANE has been used for new construction, restoration or extensive renovation of large scale wooden religeous buildings such as Buddhist temples or Shinto shrines. The SUYANE is large enough to contain the overall subject, to protect rain at the stage of replacing the roofing, and protect moisture at the stage of repairing timber frames and plastering walls, for normally, total work at an event will take more than 10 years, long enough to damage them without proper isolation from exposure to the atmosphere.

For long years, SUYANE have been constructed with timber logs, each weighing about 25kg, which can be handled by one man without any machinery, and can be performed even at the top of a mountain.

As the system depends on experience, its structural durability is not always perfect. It often suffered from typhoon and snow.

Modern rationalized structural design construction methods were required for large span renovation works.

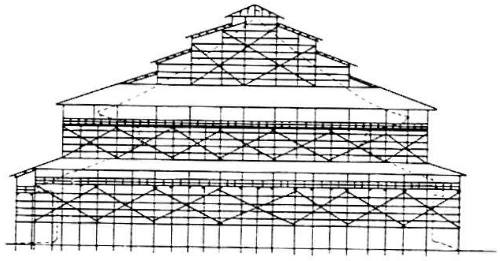

Fig. 1, Traditional SUYANE with logs at Higashi-Honganji temple, Kyoto

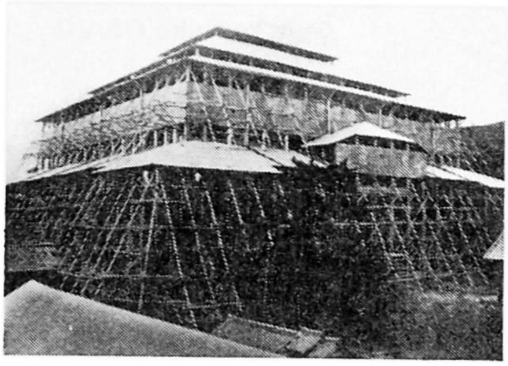

Fig. 2, Traditional SUYANE with logs

2. CASE STUDIES

2.1 Case 1: Todaiji temple. Extensive repair work (1974-1979)

Todaiji temple is a wooden building for setting up a large Buddhist image that is about 25 m tall, and was constructed in 751. The building was burned twice during wars. And the one that we can see at the present time was reconstructed in 1709. This scale is 57 m width, 50.5 m depth, and 46.8 m height.

The work condition was severe as worshippers were allowed to visit the temple at any time, and no leakage of rain fall was allowed during roof replacement, therefore SUYANE was essential for the work.

The temple is the largest wooden structure in the World; (57 m x 50.5 m, and 46.8 m height.) And no doubt, SUYANE should be larger than the temple. Steel structure was adopted and structurally it should be completely independent from the temple at any detail.

The construction was subject to difficulties because of the samll working space around the temple, which did not allow a large mobile crane to access it. A very special portal crane was examined, again working space was too small. And the expences for special crane was subject to the economy for the work. In addition, no piling was allowed at the site because

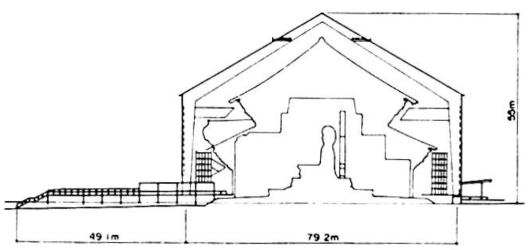

Fig. 3, Todaiji temple SUYANE Cross section

of the anticipated historical remains in the ground.
Under such conditions, the following method was planned;

1) Provide a temporary fabrication yard behind the temple.
2) Erect two spans of SUYANE at the fabrication yard.
3) Slide the fabricated element to the final position to cover the temple.
4) Erect further elements of SUYANE to slide to connect to the first element.
5) Repeat the process to complete the total SUYAEN.

According to the plan, new soil was placed to cover the working area, and temporary concrete foundations with the rails for slide were provided on the new soil, without damaging the original ground.

Data, Total steel component; 2,300 tons
Maximum sliding component; 720 tons.

To cope with various possible difficulties, the following methods were adopted to secure the work:

*For slide; steel rollers were adopted.
*For pushing; hydraulic jacks were adopted.
*For the prevention of deflection of an element during slide; temporary steel members were provided to reinforce the element.
*For tightening and untightening the steel bolts; a newly developed high strength bolt, called "Slope detection bolt" was adopted, which was by joint development between Kawasaki Steel Corp. and Mitsubishi Electric Corp.

The work was performed along the plan, and achieved successful results.

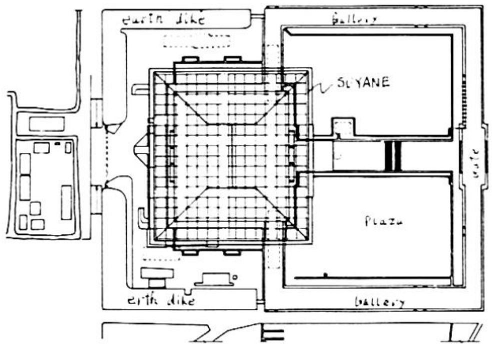

Fig. 4, Todaiji temple SUYANE Layout

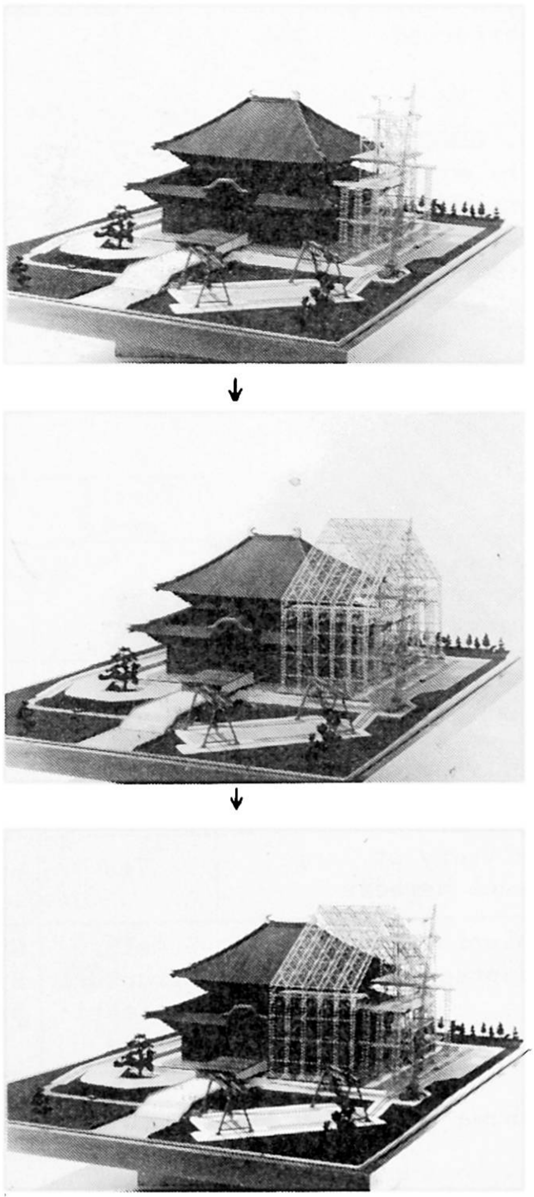

Fig. 5, SUYANE fabricate beside the temple was to moved over the building by rollers

2.2 Case 2: Kimpusanji temple Zaodo. Roof replacement;

It is told that Kimpusanji Zaodo was constructed in about 660, and was burned seveal times. And present building was reconstructed in 1591, its scale is 35 m width, 37 m depth, and 29 m height, and its scale is next of Todaiji temple
The work condition were as follows;
The temple stood at an isolated location enclsoed by three sides with cliffs. Only a narrow access road existed at the front, which did not allow a large crane and large SUYANE elements to access it.
Once a timber structure was considered for SUYANE, but the economical disadvantages,

mainly for adopting expensive timber, caused this plan to be abandoned.
Alternation to adopt steel scaffolding pipes was examined and realized.
In Japan, 48.6 mm dia., 2.5 mm thickness steel pipe was widely used for temporary scaffolding for civil construction.

Various difficulties were overcome as follows to perform the work successfully;
*For the prevention of deflection of the large span SUYANE, provision of the temporary suports from the temple structure at a certain interval.
*For the lack of structural section of a single pipe, bundled plural pipes to be used as a single structural member.
With those practices, the work was sufficiently performed.

3. CONCLUSION

The author believes each scheme adopted at each project was the most practical and inevitable solution, having amassed the possible technologies to meet with each work condition to reach satisfaction for all people concerned.

The adopted SUYANE schemes for the work conditions of the two projects are shown in the table below.

	Todaiji temple	Kimpusanji temple
Allowing worshippers to visit the temple during renovation	Yes	Yes
Support from temple structure	No	Yes/No
Delivery of large equipment to site	Yes	No
Delivery of large steel members	Yes	No
Solution; Adopted SUYANE	Steel structure Prefabrication	Group use of Scaffolding pipes

Scheme of SUYANE adopted to meet the conditions

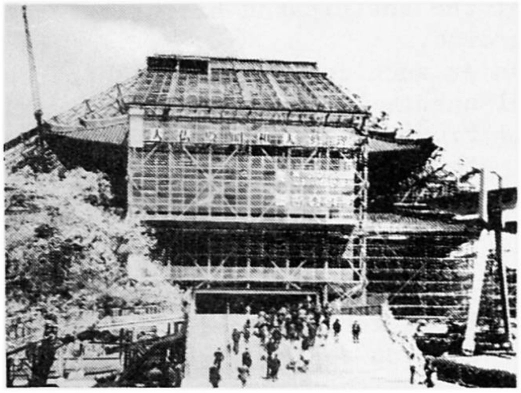

Fig. 6, Todaiji temple SUYANE
Under construction

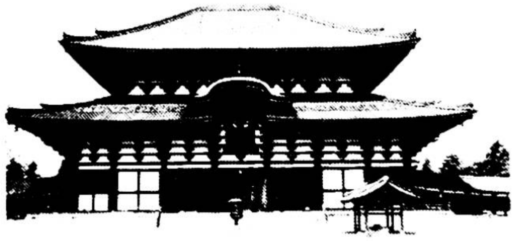

Fig. 7, Todaiji temple
External view after renovation

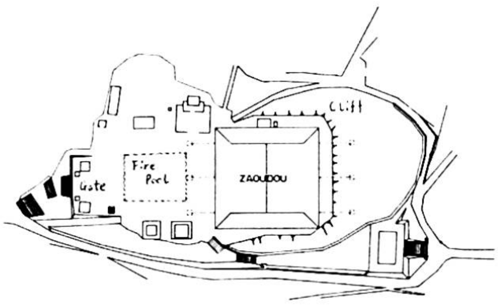

Fig. 8, Kimpusanji temple, Zaodo
Layout

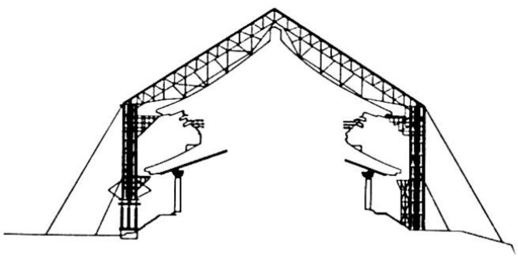

Fig. 9, Kimpusanji temple, Zaodo
SUYANE Section

	Todaiji temple	Kimpusanji temple
Erection & dis-mantlement by mobile crane	No	No
Erection & dis-mantlement by portal crane	No	No
Erection & dis-mantlement by fixed crane	No	No
Erection & dis-mantlement by sliding method	Yes	No
Erection & dis-mantlement by workers	No	Yes

Construction method adopted to meet each condition

The author expects this report to encourage engineers to successfully confront similar work in the future.

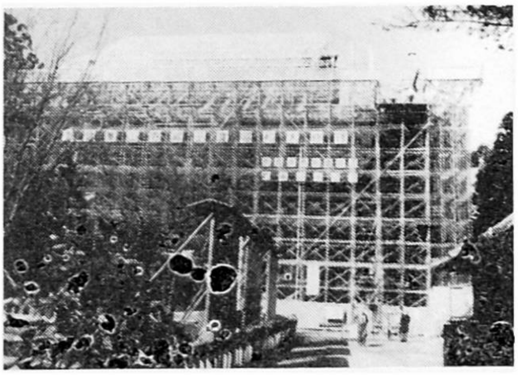

Fig.10, Kimpusanji temple, Zaodo SUYANE Under construction

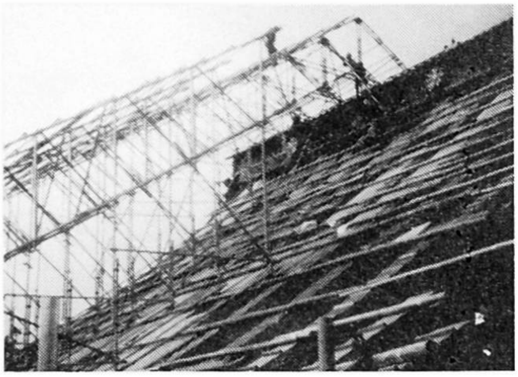

Fig.11, Kimpusanji temple, Zaodo Manual removal of roof

Fig.12, Kimpusanji temple, Zaodo SUYANE Plural pipes bundles

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