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Two Case Studies of Measuring Historic Wooden Buildings in Japan Using Digital Technology for Preservation – Eiheiji Temple and Ohtaki Shrine

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Abstract
This paper introduces two case studies of measuring historic wooden buildings in Japan using digital technology. One is Eiheiji Temple, the head temple of Zen Buddhism, and the other is Ohtaki Shrine, the only shrine dedicated to a deity of paper in Japan featuring a complex roof structure. The key point is that having skilled traditional carpenters perform measurements using digital technology, it becomes possible to obtain clear and accurate data.

Keywords
Eiheiji Temple (Head Temple of the Zen Buddhism, Soto Sect), Ohtaki Shrine (God of washi paper: traditional Japanese paper), measurements by master carpenters, Fukui Prefecture

1. Purpose of the Study

The purpose of this study is to introduce two case studies of measuring historic wooden buildings using digital technology for preservation. As representative examples, two cases are introduced, one is Eiheiji Temple (head temple of Zen Buddhism, Soto Sect) and the other is Ohtaki Shurine (God of Washi, traditional Japanese paper).

Recently, methods for surveying cultural properties such as historic buildings using digital technology have been established, and concrete efforts to create documentation are underway. This paper aims to introduce two examples from Japan and provide reference materials for the application of these methods in other countries.

2. Case 1 - Survey of Eiheiji Temple

Eiheiji Temple is the head temple of the Zen Buddhism, Soto Sect and is located in the mountains of Fukui Prefecture, Japan. It was founded in 1246 by Zen Master Dogen. Buddhism was introduced to Japan in 538, brought from India via China.

The Zen Buddhism, Soto sect of Eiheiji Temple is known for its rigorous training, which focuses solely on Zazen meditation and achieving enlightenment through Zazen.

Eiheiji Temple is located in the mountains of Fukui Prefecture, northwest of Tokyo, and covers a total area of approximately 33 hectares.

Within the temple grounds are 19 buildings, Figure 1, designated as Important Cultural Properties, Figures 2-6, (Buddha Hall, Dharma Hall, Main Gate, Middle Gate, Monks' Hall, Great Storehouse, Great Light Storehouse, the Monks' Quarters, and five corridors (east of the Mountain Gate, west of the Mountain Gate, east of the Middle Sparrow Gate, west of the Middle Sparrow Gate, east of the Buddha Hall), the Main Hall and Worship Hall of the Shōyō Hall, the Shōyō Gate, the Sutra Hall, the Gate of the Matsudaira Family Mausoleum, the Relic Hall and Shrine Hall, and the Imperial Envoy's Gate. Additionally, there are over 70 other structures that are not designated as cultural properties.

Currently, related technologies are being tested at the National Institute of Cultural Properties, Nara (Nara, an ancient capital founded in 710) and the National Institute of Advanced Industrial Science and Technology, with results published online in 2022.

T&I Co. Ltd.'s current technology was developed in collaboration with Shimizu Corporation to create 19 buildings designated as Important Cultural Properties, including the Buddha Hall, from 2023 to 2024.

On-site measurements: June–October, 2023 (80 working days), Editing, processing, and output: November, 2023–February, 2024. However, there were days when work was not possible due to temple events, so the period was long, but the actual working hours were standard.

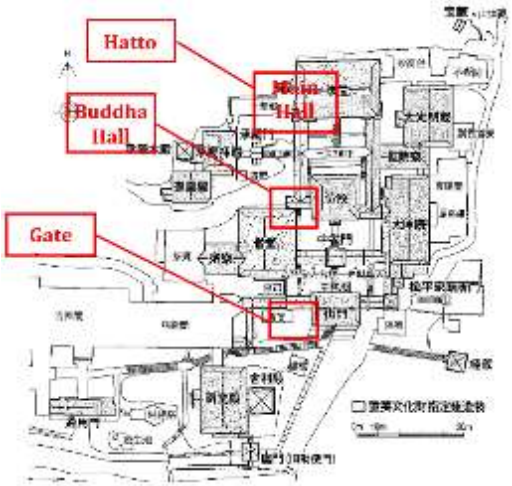

Fig. 1. Complex Layout of Eiheiji Temple
Source: Eiheiji guidebook, Sep. 2024

Fig. 2. Main Hall of Eiheiji Temple
Source: T&I Co. Ltd.

Fig. 3. Inner Sanctuary
Source: T&I Co. Ltd.

Fig. 4. Eiheiji Temple, Longitudinal section
Source: Shimizu Co. Lt., T&I Co. Ltd.

Fig. 5. Eiheiji Temple, Cross section
Source: Shimizu Co. Ltd., T&I Co. Ltd.

Fig. 6. Eiheiji Temple, Sculpture
Source: Shimizu Co. Lt., T&I Co. Ltd.

1 Eiheiji Temple, Buddha Hall, 18.4 m in length, 17.2 m in width, 18.0 m in height, Single-story, with a gabled roof, main roof tiles.

Surveyors: 4 people, equipment: 3 units, days: 5, editing and output: 8 days.

2 Eiheiji Temple, Main Gate, 16.6 m in length, 9.1 m in width, 19.6 m in height.
Five bays, three doors, two-story double gate, gabled roof, copper-clad.
Surveyors: 4 people, equipment: 3 units, days: 7, editing output: 10 days.

3 Eiheiji Temple, Main Hall, 32.3m in length, 23.3m in depth, 21.0m in height, gabled roof, tile-clad with some copper-clad sections.
Surveyors: 4 people, equipment: 3 units, days: 6.5, editing output: 9 days.

3. Case 2 - Survey of Ohtaki Shrine

Ohtaki Shrine (Figures 7 – 16) is located in Echizen City, Fukui Prefecture, and is designated as an Important Cultural Property of Japan. The shrine was founded around 500 AD, and the current main hall was reconstructed in 1843. Its intricate construction exudes a sense of grandeur. Particularly notable is the roof structure, which features an irimoya-style roof (Note 1) with a chidori-style gable (Note 2), a karahafu-style gable (Note 3), and another irimoya-style roof with a karahafu-style gable layered on top – a design unique in Japan. The distinctive feature of Ohtaki Shrine is its complex roof structure, which is the most intricate among Japanese shrine architecture. The roof is covered with cypress bark, and the walls are adorned with carved decorations, giving it a Baroque-like appearance.

The main hall measures 4.23 meters in width, 3.64 meters in depth, and 10.45 meters in height, and worship hall measures 3.83 meters in width, 3.84 meters in depth, 7.27 meters in height with a total floor area of 54 square meters.

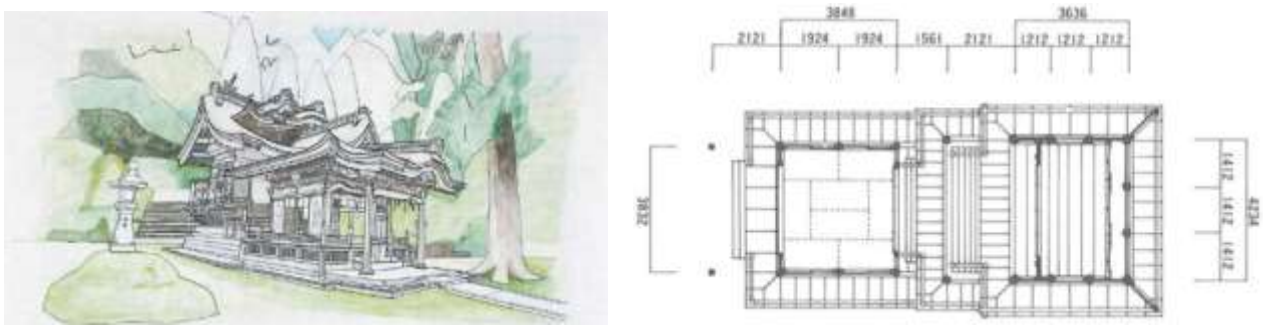

Fig. 7. Whole View + Floor Plan
Sketch: Source: Keimi Harada
Floor Plan: Source: History of Fukui Prefecture, No.14, Architecture, Printings, Sculpture, July 31, 1989, Fukui Prefecture Government

Fig. 8. Façade, Source: T&I Co. Ltd

Ohtaki Shrine is the only shrine in Japan that worships “paper”. In ancient and medieval times, paper was a valuable commodity, and as Japan's political system became more established, the demand for paper increased.

Additionally, the spread of Buddhism led to a surge in demand for paper for copying sutras. Large quantities of paper were also required for household registration records. The paper produced in this region was of high quality and highly valued.

The first paper money in Japan was also created by the feudal lord who ruled this area. The technology used in today's paper money was also developed here.

Famous painters have used paper produced in this area.

Fig. 9. Left side Elevation, Source: T&I Co. Ltd.

Fig. 10. Left side Section, Source: T&I Co. Ltd.

Fig. 11. Ceiling Plan, Source: T&I Co. Ltd

Fig. 12. Sculpture Dragon of Kohai
Source: T&I Co. Ltd.

Fig. 13. Sculpture Left side Wall Panel
Source: T&I Co. Ltd.

Ohtaki Shrine: Main hall, 4.23m in length, 3.636 m in depth, 10.45m in height; Worship hall, 3.832 m in length, 3.848 in depth, 7.27 in height, approximately 54 m^2, cypress bark roof, gabled roof with a hipped gable.

Surveyors: 4 people, equipment: 4 units, days: 5, editing output: 10 days.

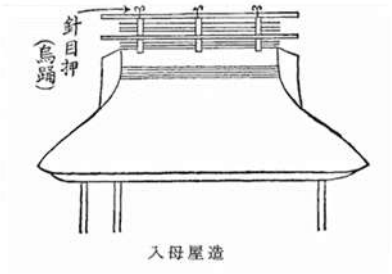

Fig. 14. Note 1: Irimoya style roof

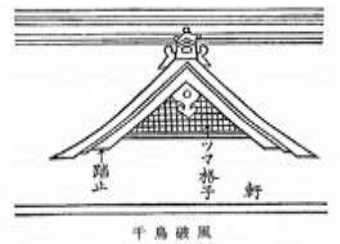

Fig. 15. Note 2: Chidori style gable

Fig. 16. Note 3: Karahafu Style gable

Source: (Note 1, Note 2, Note3) 'Tatsutaro Nakamura, Japanese Architecture Dictionary, October 2011, Chuo-Koron Art Publishing Co.

4. Work-Load

Regarding the time required for the survey, the average man-hours and survey time per unit area are proportional to the amount and volume of wood used. For approximately 100 cubic meters, it takes about one day with three pieces of equipment and 2–3 people.

If digital technology is not used and surveyors measure on-site and create drawings, the estimated time based on experience is as follows:

In the case of the Hatto Hall (Main Hall) at Eiheiji Temple, digital surveying requires 4 surveyors with three units of equipment for 6.5 days plus nine days for editing and output, while manual surveying requires 3-4 surveyors for 40-50 days (approximately 10-12 times that amount).

Additionally, scaffolding is required for field measurements, which incurs additional costs. Scaffolding costs vary depending on height and construction period but are estimated to be approximately 10% of the total construction cost. 3D scanning eliminates the need for scaffolding, reducing costs and minimizing the client's burden, while also providing greater accuracy than manual measurements.

A particular advantage of having temple carpenters conduct surveys is their familiarity with the structure of temples and shrines and their understanding of survey techniques [4].

5. Issues

The followings are the issues and prospects for the future.

The measurement technology for traditional wooden buildings utilizing digital technology in Japan is expected to be utilized in other countries and regions in the future. However, in order to develop this technology further, it is necessary to understand the differences in characteristics between regions and construction methods.

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