Inside of Konjikido of Chusonji Temple at Hiraizumi

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The Conservation of the Golden Hall (Konjikido) of Chusonji Temple at Hiraizumi

Abstract

The Golden Hall (Konjikido) of Chusonji Temple located at Hiraizumi, Iwate Prefecture, was built between 1109 and 1124 by Fujiwara Kiyohira as a mausoleum for himself and as an Amida Hall. It was named Konjikido, because it is covered with gold leaf. Konjikido is sheltered in a room and separated from the visitors' area by a large glass showcase. The showcase was replaced in 1989, because the inside had become humid (more than 70 % RH through a year). After the improvement, the climate inside has been kept at almost 65 % RH. But cracks occurred on the urushi coating. Researches were conducted since 1992 to study the reasons for these cracks by monitoring temperature, humidity, moisture content and displacement of wooden boards, and strains within the urushi coating. The results showed that a gap between two wooden boards changed about 0.2 mm in a year due to seasonal temperature changes and that the gap had broadened about 0.4 mm in these seven years. Based on this calculation, the total increase of the gap after the improvement would be more than 1 mm, probably enough to cause cracking on the surface of the urushi coating. It has taken the wooden boards a long time to dry after the improvement, because they are coated with urushi which inhibits the passage of moisture. The wood shrinkage seems to have come to an end in recent years. But a careful observation is still required, because there is some strain at the cracks of the urushi coating.

1. Introduction

Chusonji Temple, located at Hiraizumi/Iwate Prefecture, was founded in 1105 by Fujiwara Kiyohira, governor of the northern province. He intended Hiraizumi to be the northern capital, a new Kyoto, so that the culture of Hiraizumi (or Chusonji) has often been called the 'mirror of Kyoto'. Although the twelfth century was a period of wars, and the samurai class was beginning to replace the old aristocracy, the culture of Hiraizumi flourished under Fujiwara, because Hiraizumi is far from Kyoto.

The golden hall (Konjikido), a small wooden building, was built between 1109 and 1124 by Kiyohira as a mausoleum for himself and as an Amida Hall. Konjikido, gorgeously covered in gold leaf, was also a symbol of the prosperity of Hiraizumi culture. In the twelfth century, Chusonji had about 340 buildings and several hundreds of people – monks and aristocrats – lived there. But many of the buildings were burned down or laid waste by war in the fourteenth century. Fortunately, Konjikido remained over the centuries. The remains of Kiyohira, his son and grandson are still mummified beneath the three altars of the golden hall. Konjikido now receives about a million visitors a year as one of the most famous historic sites in Japan (colour plate XVII).

2. Conservation facilities for Konjikido

Konjikido is a one storey, 5.5 m long, 5.5 m wide and 8.0 m high building. In order to protect it, a wooden shelter was built in 1288.

From 1962–1968 a reinforced concrete shelter was constructed and restoration was carried out on its entire exterior and interior (figs. 1, 2). Due to this restoration, it regained its glitter of gold as we see it now.

Konjikido is settled in a large glass showcase to avoid unexpected damages, which means it is separated from the visitors' area by glass screens.

After the construction of the concrete shelter, the humidity inside the glass showcase increased and many dewdrops were observed on the glass screens particularly in early summer (fig. 3). So the following countermeasures were proposed[1] and improvement was made between 1986 and 1990.

a. The reason for the high humidity inside was moisture that had risen from the ground into the glass showcase. A dehumidifier and a moisture barrier under the floor were necessary.

b. The reason for the many dewdrops on the glass screens facing the outside was assumed to be the chilled inside air due to the delay of about one month in the change of ground temperature following that of outside temperature. The dewdrops occurred whenever the surface temperature was lower than the dew point of the outside air. Heat insulation of the ground and air-conditioning of the shelter were necessary.

The glass showcase was also replaced in the campaign of 1986–1990. The new glass showcase was designed to have sufficient air-tightness and to keep the relative humidity inside stable. A moisture barrier and insulation layers were laid under the gravel on the ground. All gaps in the glass showcase were sealed thoroughly with silicon rubber. Inorganic moisture-buffering material was used for the back and side walls of the showcase to prevent a rapid RH change while the dehumidifier was working.

Four electric dehumidifiers were used in place of the former air-conditioning unit. They were set in an antechamber open to the glass showcase. They were controlled individually; that is, each dehumidifier had its own humidity sensor. The four humidity sensors were fixed at the four corners of the veranda of Konjikido. The temperature within the showcase was not controlled, because daily temperature change was estimated small enough due to air-conditioning of the shelter (fig. 4).

Because of the improvement of the conservation facilities, rising moisture from the ground and dewdrops on the glass screen were completely controlled. The dehumidifiers kept a stable level of relative humidity inside (about 65 % RH) through a year.[2] But torsion of the boards and cracks of the urushi coating occurred so that researches were conducted since 1992 to study the reasons.

3. Measurements

Temperature, humidity, moisture content and displacement of wooden boards, and strain of the urushi coating were measured.[3] All data were stored in data loggers (Hakusan Corporation, LT2001 or HLS-200) and transferred occasionally to a personal computer for analysis.

a. The temperature was measured below the left (south) veranda every hour (24 times/day) by a Pt resistance thermometer since July 1992.

b. The humidity was measured at the same point by an electric resistance hygrometer since July 1992.

c. The moisture content was measured at a wooden board (31 mm wide, 84 mm thick and 1.160 mm long) of the left (south) veranda every hour (24 times/day) by an electric resistance wood moisture meter (Kett, MT-8S) since August 1993.

d. The shrinkage of wood was measured by monitoring the width of a gap between two boards of the left (south) veranda every hour (24 times/day) by an inductance displacement transducer (Kyowa, DT-10F) since July 1992.

e. Strain was measured at a crack of the urushi coating on the back (west) wall every 12 hours (2 times/day) by a foil strain gauge (Showa Measuring Instruments, N11-FA-5-120-11-VM3T) from December 1995. Control data were also taken at a sound urushi surface nearby.

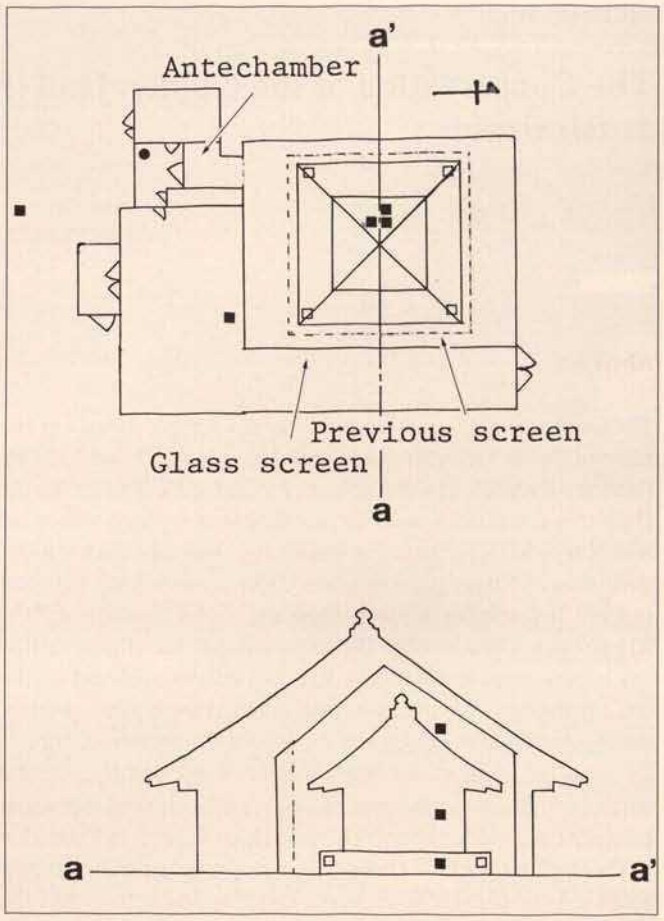

Fig. 2. Plan of the present shelter

Fig. 1. View of the present shelter

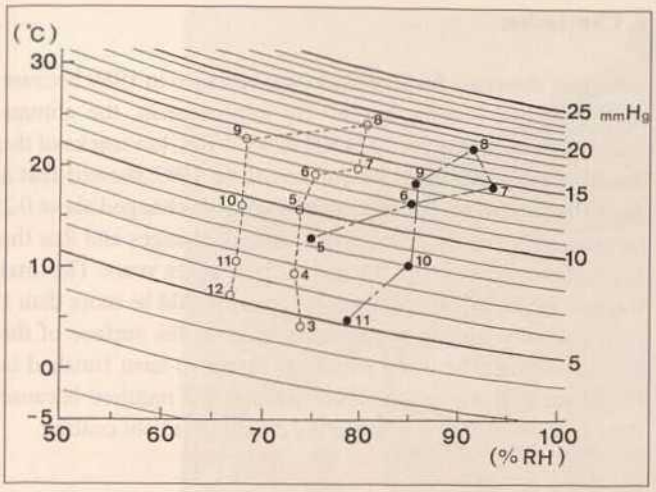

Fig. 3. Climate of Konjikido (1986, before improvement) 3 △
○ inside the glass showcase
• outdoors

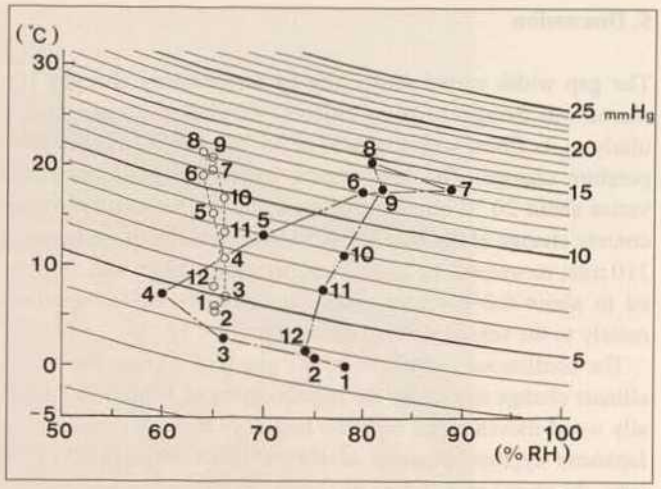

Fig. 4. Climate of Konjikido (1993, after improvement) 4 △
○ inside the glass showcase
• outdoors

4. Results

Figures 5–8 show the results indicating evident trends in spite of some missing data. The gap width became larger with seasonal changes of about 0.2 mm (fig. 7). The output of a moisture content meter is showed as the vertical axis of fig. 6, because the relation between the output and the real moisture content of the wooden board was not calibrated. But the manual of the moisture meter says that the output range 0–10 mV usually corresponds to a moisture content of 0–30 %. The strain gauge measuring the gap width seemed to be broken because it expanded too much (fig. 8).

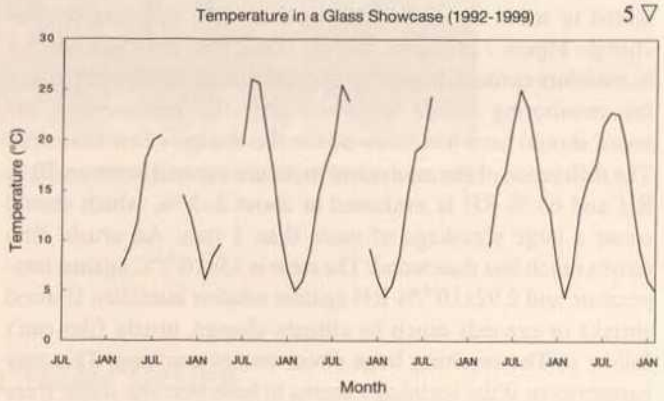

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Fig. 5. Temperature inside the glass showcase from July 1992 to January 1999

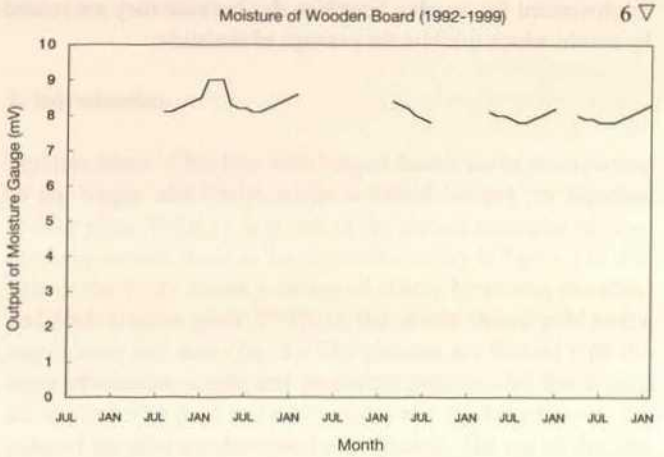

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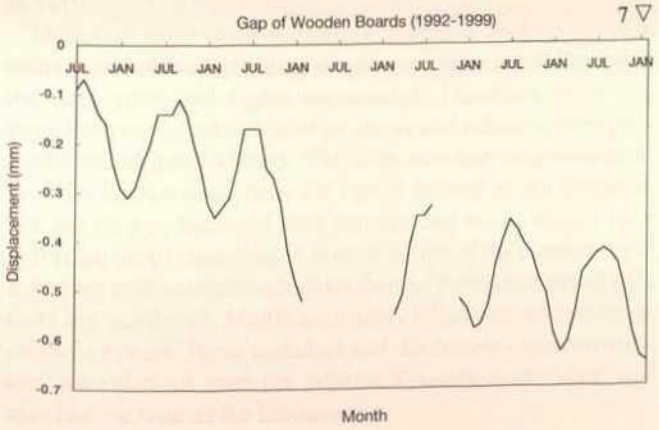
Fig. 6. Moisture content of a wooden board from August 1993 to January 1999

Fig. 7. Gap width between two wooden boards from July 1992 to January 1999

Fig. 8. Strain of the urushi coating from December 1995 to January 1999 large change: measured at a crack
small change: at a sound urushi surface nearby



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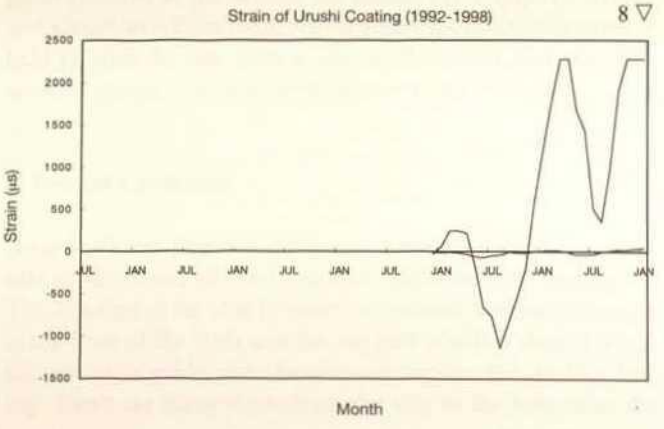

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5. Discussion

The gap width varied seasonally by temperature change. The reason was thought to be as follows. Wood expands perpendicularly to its fibers with the ratio of 35–60x10^{-6}/°C against temperature change. The temperature inside the glass showcase varies about 20 °C annually, also raising the seasonal moisture content change of the board (fig. 6). As the width of the board is 310 mm, movement by annual temperature change was estimated to about 0.2–0.4 mm. This figure corresponded approximately to the seasonal variation of fig. 7.

The continuous expansion of the gap (fig. 6) was due to the climate change caused by the improvement of 1986–1990. Usually wood moves much more by humidity than by temperature. Japanese cypress expands or shrinks with ratios of 0.12 % (straight grain) and of 0.23 % (cross grain) against 1 % change of moisture content. Using these figures, the boards were estimated to move about 0.6 mm against 1 % moisture content change. Figure 7 indicates that the board may have lost about 1 % moisture content during the observation of 1992–1999. Since this monitoring started two years after the improvement, the board should have lost more due to the change of environment. The difference of the equivalent moisture content between 70 % RH and 65 % RH is evaluated at about 2–3 %, which should cause a large shrinkage of more than 1 mm. An urushi film moves much less than wood. The ratio is 15x10^{-6}/°C against temperature and 2.92x10^{-4}/% RH against relative humidity. If wood shrinks or expands much by climate change, urushi film can't follow it. The resulting large stress causes cracking. This may happen even if the shrinkage seems to have become stable from 1998, because strain is found still remaining between urushi film and wood (fig. 8). This means that it takes a long time after improvement for wooden boards to dry because they are coated by urushi which inhibits the passage of moisture.

6. Conclusion

The glass showcase for Konjikido was replaced in 1989 because the inside had become humid. By improvement, the climate changed from more than 70 % RH to 65 % RH, but cracks of the urushi coating occurred. Researches since 1992 showed that a gap between two wooden boards of a veranda changed about 0.2 mm in a year due to seasonal temperature changes and that the gap had broadened about 0.4 mm in these seven years. The total increase of the gap after the improvement would be more than 1 mm, probably enough to cause cracking on the surface of the urushi coating. The wood shrinkage seems to have finished in recent years. But a careful observation is still required because there is strain still remaining at the cracks of urushi coating.

Acknowledgement

The author thanks Mr. Haseki of Chusonji, Mr. Kobayashi of Hakusan Corporation and Mrs. Matsubara of Tokyo National Research Institute of Cultural Properties for their help.

Notes

1 Sadatoshi Miura: 'Temperature and humidity in a large glass showcase for a temple hall', *Preprints for the 8th Triennial Meeting of ICOM-CC*, (1987, Sydney), pp. 897–900.
2 Sadatoshi Miura: 'Temperature and humidity in a large glass showcase for a temple hall', Part 2, *Preprints for the 9th Triennial Meeting of ICOM-CC* (1990, Dresden), pp. 592–595.
3 Sadatoshi Miura and T. Ogawa: 'Study on the relation between the occurrence of cracks of Urushi coating and a climate change after the improvement of shelter for Golden Hall of Chusonji', *Conservation Science*, 38, 1999, pp. 31–38 (in Japanese).

Photo Credits

Figs. 1–8 by the author
Colour plate XVII: Chusonji Temple, Hiraizumi