Tree-Ring Dating for Sinmu-mun, the North Gate of Kyungbok Palace in Seoul

PARK Won-Kyu [1], LEE Jin-Ho [2], KIM Yo-Jung [3], WAZNY Tomasz [4]

[1,2,3]School of Forest Resources, Chungbuk National University, Cheongju 361-763, Korea
043-261-2543 FAX 043-273-2241 treering@chungbuk.ac.kr
[4]Faculty of Conservation and Restoration, Academy of Fine Arts, 00-379 Warsaw, Poland

Abstract

The cutting dates of 10 wood elements (beams and corner rafters) of Sinmu-mun (神武門), the north gate of Kyungbok Palace (慶福宮), were determined by the dendrochronological 'crossdating' method. Crossdating method employs graphic comparison of the master patterns (ring-width chronologies of known dates) of living trees with those of the sample chronologies of unknown dates. The living trees for the masters used for this study were *Pinus densiflora* S. et Z. (sonamu or Japanese red pine 赤松), a major species for Korean buildings. By the comparison of Sinmu-mun (神武門) samples with the masters, the Sinmu-mun samples produced the cutting dates mostly as A.D 1869, 1870 and 1871. Surprisingly, these dates are 4 to 6 year later than the known date (A.D 1865) of Sinmu-mun reconstruction. It was recorded in a historical document 'Ilsungrok (日省錄)', the King's official diary. Since we raised the question about the Sinmu-mun construction date, another record was found in the 1872 April issue of Ilsungrok, which indicated the rebuilding (改建) of Sinmu-mun during 1871-1872. It proofs that tree-ring dating is a precise dating method and it can be applied to the Korean architectures.

Keywords: dendrochronology, cutting date, architectural history, Korea palace buildings

Introduction

The annual rings of many tree species can be used to date old buildings and archeological sites by using dendrochronological methods (Stokes & Smiley 1968, Baillie 1984). Some species reported to have been growing for several centuries in Korean forests provide unique opportunities to develop long tree-ring chronologies for dating buildings in this region (Park 1994, Park et al. 2001). *Pinus densiflora* Sieb. et Zucc. (Japanese red pine 赤松), also known as 'sonamu' in Korean common parlance, occurs naturally in Korea and Japan, although rarely in Manchuria, covering a wide ecological spectrum (Yoshioka 1958). This species is one of the most favorite building materials in Korea. Here, we report dendrochronological applications of *Pinus densiflora* in South Korea (Republic of Korea) to the dating for the Sinmu-mun(神武門), a 19th century structure at Kyungbok Palace (慶福宮) in Seoul.

Sinmu-mun is the north gate of Kyungbok Palace, one of four existing palaces in Seoul, which

Figure 1. Sinmu-mun in 1920s.

was the capital city for over 500 years during the Chosun Dynasty (朝鮮 A.D. 1392-1910). Kyungbok Palace was constructed at the beginning of the Chosun Dynasty during the late 14th century, but was completely destroyed during the Korea-Japan war (Imjin-weran, 1592-1599) (Lee 1998).

Kyungbok Palace was reconstructed during the 1860s when Daewongun (大院君), the father of King Kojong (高宗), tried to reinforce royal authority. 'Ilsungrok (日省錄) ', the Kings' diary of the Chosun Dynasty, records that the reconstruction of the Sinmu-mun gate was finished in 1865 (Jang 1963).

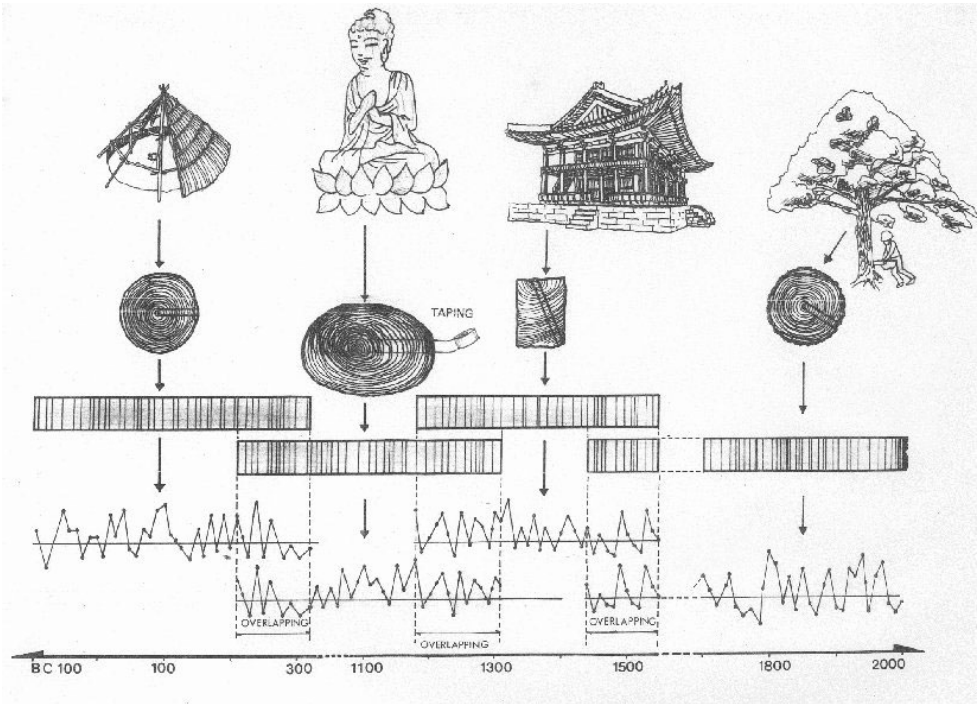

Fig. 2. Scheme of tree-ring dating: unique ring patterns exist in certain periods.

Methods and Materials

During the roof repairing of Sinmu-mun (神武門) in 1999-2000, 10 elements (beams and corner rafters) of woods were collected for dating by the authors. All sampled woods were made from the woods of Japanese red pine (*Pinus densiflora*).

The wood discs (about 2 cm thick) were cut from the beams and corner rafters which had been replaced due to the rotten parts. After sanding the surfaces of the sampled discs, ring widths were measured to the nearest 0.01mm by using a Velmex measuring system. Ring-width plots of individual samples were produced by using the TSAP program (Rinn 1996). These plots were used for visual comparison on a light table to crossdate each other by synchronizing the patterns. Figure 3 shows the plots of the samples after synchronizing. We made a site or master chronology by averaging all sample plots.

The final dating process was performed by graphic comparison between ring-width plots of old wood collected from the building 'Sinmu-mun (神武門)' and those of living pine trees in several

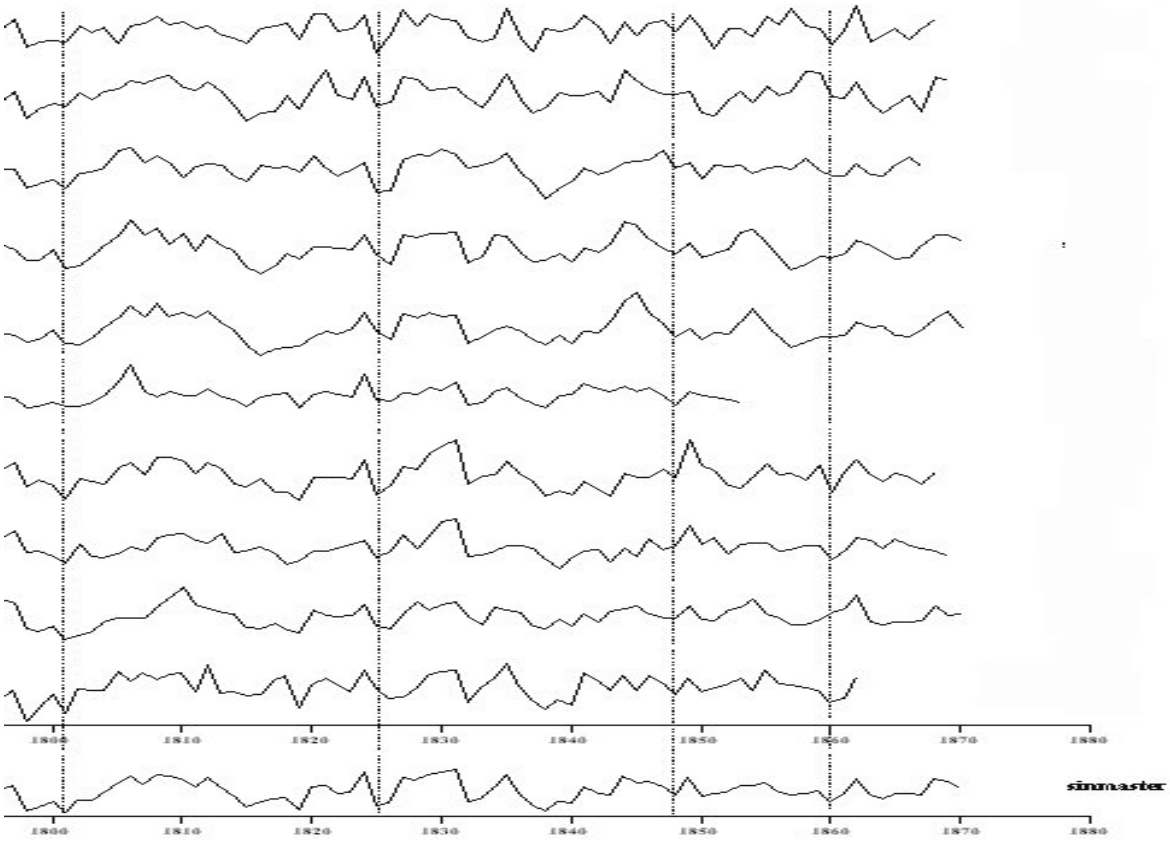

Fig. 3. Building the site mean chronology (lowest one) by synchronizing the ring-width patterns of Sinmu-mun samples (the inner parts of the plots are not given)

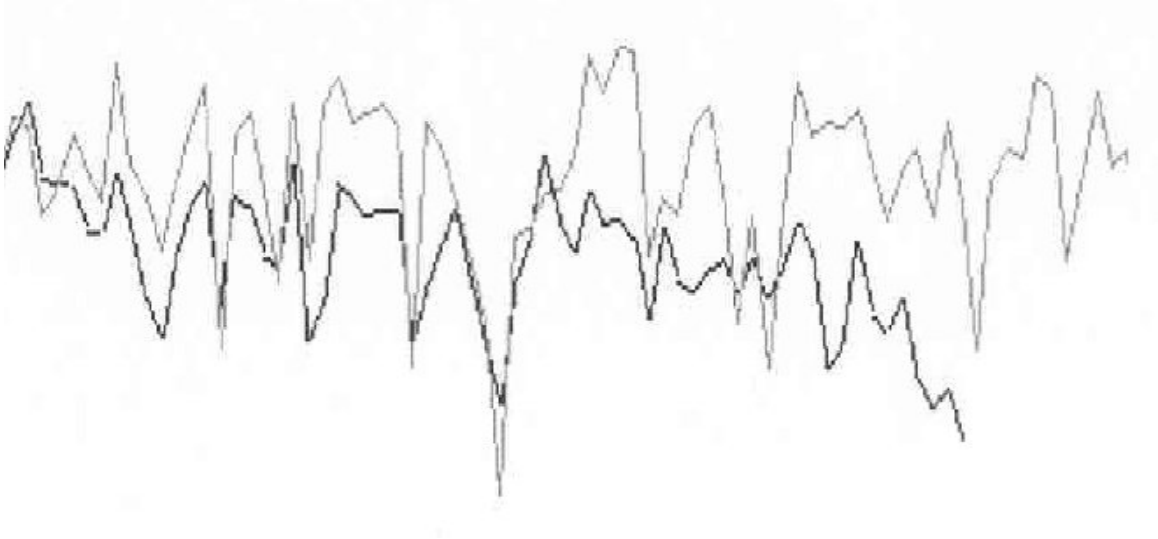

Fig. 4. Crossdating by matching the ring-width patterns of living trees (light lines: known dates) and old wood samples of buildings (dark line: unknown dates)

regions in South Korea, whose rings were assigned to the specific calendar years (Fig. 4). The dating quality was also evaluated by statistical methods (t-test and G sign test)(Baillie 1982). The calendar year of the outmost ring just beneath to the bark in the sample results the cutting date of the logs from which the sampled woods were made.

Results

The site (mean) chronology of the Sinmu-mun was well cross-dated with four of the seven red-pine site chronologies of Mt. Sorak (雪嶽山). The four chronologies were the west-slope sites at the higher elevation. Those sites at a lower elevation and the east-slope sites of Mt. Sorak as well as any other pre-existing red pine chronologies of Mts. Worak. Songni. Dukyoo, and Chiri in South Korea, could not be well cross-dated with the Sinmu-mun chronology. The Hangaerung chronology possessed the highest correlations with that of Sinmu-mun (t value; 10.6 and G value; 81% with 132-year overlap). This high t and G-value (sign agreement) suggest that the origin of Sinmu-mun logs (woods) might be near to the western slope of Hangaerung, a pass in Mt. Sorak. The western slope of Hangaerung is close to the upper stream of the Han River, along which the logs could be transported to Seoul by rafting. Rafting was one of the major transport methods for logs in Korea during the pre-industrial period (Jang 1963).

The cutting dates of individual Sinmu-mun samples are given in Table 1. In aids of springwood/ summerwood formation in the last ring with the bark, the cutting season as well as cutting year could be estimated (Figure 5 and Table 1).

Table 1. The results of crossdating for the Sinmu-mun samples

Sample No.	Years of Rings (Tissue)	Bark	Cutting Date & Season
SINMU01	1741-1868 (Summerwood)	Yes	1868 Fall to 1869 Spring
SINMU02	1771-1870 (Springwood)	Yes	1870 Summer
SINMU03	1761-1868 (Springwood)	Yes	1868 Summer
SINMU07	1751-1870 (Summerwood)	Yes	1870 Fall to 1871 Spring
SINMU08	1751-1870 (Summerwood)	Yes	1870 Fall to 1871 Spring
SINMU09	1739-1853 (Not available)	No	After 1853 ?
SINMU11	1776-1869 (Springwood)	Yes	1869 Summer
SINMU13	1700-1869 (Summerwood)	Yes	1869 Fall to 1870 Spring
SINMU14	1743-1870 (Summerwood)	Yes	1870 Fall to 1871 Spring
SINMU16	1758-1862 (Not available)	No	After 1862 ?

The cutting periods for the logs were A.D. 1868-1871 (Table 1). Surprisingly, these dates are 4 to 6 year later than the reconstruction of Sinmu-mun in 1865, which was known from a historical document 'Ilsungrok (日省錄)', the King's official diary. One and a half year after we had raised the question about the Sinmu-mun construction date by the above dendrochronology dating (Korea Culture Properties Adm. 2000), another record was found in the 1872 April issue of Ilsungrok, which indicated the rebuilding of Sinmu-mun in 1872. The original content is as follows; '命神武門改建 惠廳錢三萬兩 戶曹錢一萬兩 兵曹錢一萬兩 劃送斯速竣役 議政府啓言 神武門 今方改建 都監財力 乏 難以繼用云 惠廳儲 庫錢三萬兩 戶曹儲 庫錢一萬兩 兵曹錢一萬兩 劃送請以爲斯速竣役'. It said that the budgets should be supplied to complete the reconstruction(改建) of Sinmu-mun. The record suggests that the Sinmu-mun was being reconstructed before April 1872. The tree-ring evidence indicated that the reconstruction started after 1871 spring.

Conclusions

Using the red-pine tree-ring chronologies, we were able to date the Sinmu-mun Gate at Kyungbok Palace in Seoul. The chronologies of old woods were well cross-dated with the red-pine chronologies of the eastern part of Sorak, suggesting a cutting date in the period 1868-1870/1871. These dates are 4 to 6 year later than the known reconstruction of Sinmu-mun in 1865. It indicates that the rebuilding or large-scale repair of Sinmu-mun was done just 5-6 years after the reconstruction because this cutting dates were obtained from major load-bearing elements such as corner rafters and beams. The reasons of rebuilding or repair are not known yet. The dendro (i.e., tree-ring) dates was confirmed by a newly found record by the royal document 'Ilsungrok'. In other word, this document proofs that tree-ring dating is a precise dating method and it can be applied to the Korean architectures. Successful dating of a 19th century building enabled also to extend the chronologies of pine woods extend back to the early 1700s.

Fig. 5. Determining the seasons of log cutting by examining the tissue of last ring. Springwood of red pines in Korea is formed during May-July and summerwood during August-September. No tissue is formed during October-next April.

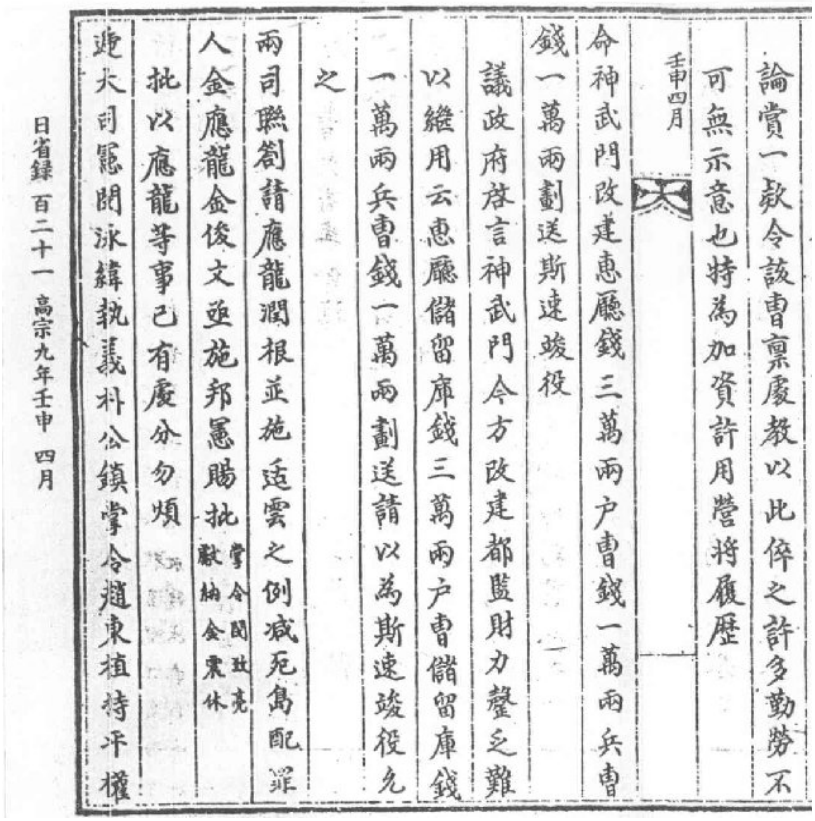

Fig. 5. The article describing the rebuilding of Sinmu-mun in Ilsungrok on April 27 in the ninth year of King Kojong (A.D. 1872).

ACKNOWLEDGMENTS

This work was supported by grant no. R01-2000-000-00393-0 from the Research Program of the Korea Science and Engineering Foundation. We thank Mr. Wang-Hee Park (Korea Cultural Properties Administrations), Mr. Chun-Shik Jung (Yurim Construction Co.), and Dr. Dong-Heub Lee (Forestry Research Institute, Korea) for their support in carrying out the sampling and survey.

REFERENCES

1. BAILLIE,M.G.L.(1984), *Tree-Ring Dating and Archaeology*, Croom Helm, London, Chapter 3.

2. JANG, Daewon (1963), "A note about the reconstruction of Kyungbok Palace", *Hyangto Seoul*, Vol. 16, No.7 pp. 7-58.

3. Korea Cultural Properties Administrations (2000), *The Repair and Detailed Survey Report of Kyunghoe-ru*, Uri Architects Co., pp. 326-332.

4. LEE, Kanggeun (1998), *Kyungbok Palace*, Daewonsa, Seoul, Chapter 1.

5. PARK, Won-Kyu (1994), "Tree-ring networks for detecting global warming in Korea", *J. Korea Forestry Energy*, Vol. 14, pp.80-87.

6. PARK, Won-Kyu, Yojung KIM, Jinho LEE and Jeongwook SEO (2001), "Development of tree-ring chronologies of *Pinus densiflora* from Mt. Sorak and dating the year of construction of the Kyunghoe-ru pavilion in Seoul", *J. Korean Physical Soc*. Vol. 39, No. 4, pp. 790-795.

7. RINN, F. (1996*), TSAP version 2.4-Reference Manual*, Heidelberg, Germany, pp. 118.

8. STOKES, M. A. and T. L. SMILEY (1968), *An Introduction to Tree-Ring Dating*, University of Chicago Press, Chicago, Chapter 2.

9. YOSHIOKA, K. (1958), *Ecological Studies on Pine Forests in Japan*, Norin Shupan Co., Tokyo, Japan, Chapter 1.