

Hybridization of Western Timber Truss and Traditional Korean Roof Shape in the Early 20th Century

Jeonghyun Kim¹, Jihong Kim², BongHee Jeon^{3*}

ABSTRACT: During the Japanese colonial period of Korea(1910-1945), the Japanese colonial government built Korean style buildings using Western timber truss. Although these buildings look like traditional Korean pavilions in terms of exterior form, they have significantly different structural frames. The architectural features originated from Korean tradition, such as protruding eaves and curved roof shape, were achieved by different structural system and methods which were developed from late 19th to early 20th centuries in Japan. In this study, we analyzed the hybridized roof structure and how the prototypical methods and their variants were implemented.

KEYWORDS: Japanese colonial period of Korea, tradition, Western truss, eclectic roof structure, roof shape

1 Introduction

Every culture has their way of constructing a building, which is repeatedly used throughout its history. Wooden roof structures, composed of orthogonal columns, beams, purlins and inclined rafters, were one of the most conventional methods used in East Asian architectural tradition. As modernization came to East Asian countries, Western architecture was introduced. Governmental offices, hospitals and courthouses which symbolized new political and social order began to be built in Western styles such as Neoclassicism. Also, traditional-style buildings, whether they are newly built or renovated, were influenced by Western technologies such as truss structures and metal reinforcements.

Adoption of Western truss became the focus of architectural discourse in this time of transition. However, it was not an easy task to adopt Western truss directly to the traditional structural system. East Asian traditional buildings have curved roof profile which is different from linear roof profile generated by trussed structure. In addition, the roof shapes are not only relevant to the roof structures but also closely related to the entire structural system of a building.

While other East Asian countries underwent more complicated transition, Western truss was adopted by Japan during Meiji period after the devastating earthquake of 1891. During the Japanese colonial period of Korea(1910-1945), expositions were held in cities of Japan and Korea by Japanese colonial Authorities. To promote their colonial reign, they built Korean Pavilion, *Cho-seon-kwan*. (Kang, 2004) These buildings look like a Korean traditional pavilions in terms of exterior forms, they have significantly different roof structures. Architectural features from Korean tradition, such as protruding eaves and curved roof shapes, were

implemented while Western truss was adopted and hybridized to the roof structures. They have eclectic features which have not been addressed in East Asian Modern architectural studies.

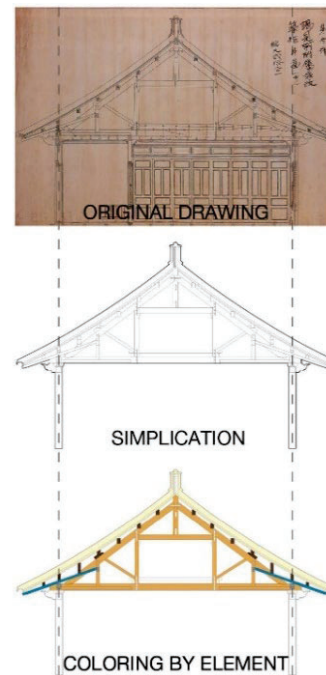


Fig.1. Making of Analytic Diagram

National archives of Korea, the depository of historical records of the country, have recently constructed digital

¹ Jeonghyun Kim, Hongik University, Republic of Korea, jekim@hongik.ac.kr

² Jihong Kim, Cultural Heritage Administration, Republic of Korea, jekim@hongik.ac.kr

^{3*} Contact Author: BongHee Jeon, Dept. of Architecture and Architectural Engineering · Institute of Construction and

Environmental Engineering · Institute of Engineering Research, Seoul National University, Republic of Korea, jeonpark@snu.ac.kr

data base of buildings built in Japanese colonial period. The data base contains schematic plans and detailed drawings of the buildings. It allowed us not only grasp a concept of the design principle, but also understand the structural frames and the concrete methods of construction. (National archives of Korea, 2008) For this study, we selected 22 cases which showed eclectic roof structure and Korean-style roof shape. The drawings include very detailed information so that we need to abstract them into diagrams. (Fig.1)

2 Adoption of Western Truss in Japan and Korea

1861 in Japan, Western wooden truss had been introduced to the Nagasaki steel plant. After a heavy earthquake had struck the Nobi province, the traditional wooden structure was questioned in terms of its safety. Japanese architects and scholars began to pay attention to Western truss and applied it to their projects. (Im, 2011)

Even in repair work for the traditional building, which is national monument, like Todai-ji, Western truss was applied. Daibusuden of Todai-ji had been through precarious situation since 19th century because of the structural defect. It had enormous size of roof which needed structural reinforcement. Although the problem had been addressed since 1880s, the repair work was not started until early 20th century. Architects and scholars who were educated in Western society led the repair work.

The repair work of Daibusuden of Todai-ji, had been continued from 1906 to 1913. According to the construction record, we could find out that the box truss structure had been used to reinforce the roof. (Fig.2) Central structure was replaced by truss and the principle of truss was widely used to replace wooden structural members. Wooden joints were reinforced by bolts and nuts. (Fig.3) Using Western roof tile reduced the roof load by 12%. (Coaldrake, 1994)

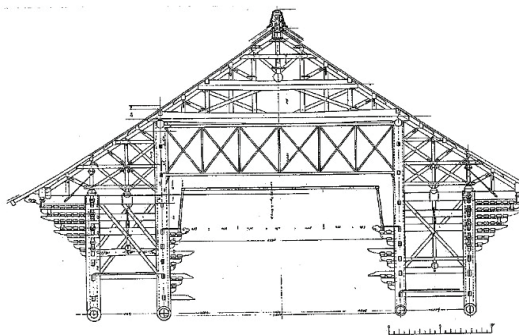


Fig.2. Daibusuden of Todai-ji: sectional detail of restored and rebuilt truss after Meiji restoration project (Coaldrake, 1994)

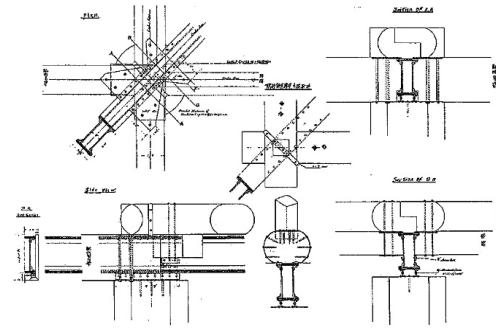


Fig.3. Daibusuden of Todai-ji: Iron pins and plates added to reinforce framing at the time of the Meiji restoration project (Coaldrake, 1994)

In Korea, figuring out the conditions of western influence on roof structure in this era is more complex because the modernization process was led by multiple political groups, the Korean government, Western and Japanese colonialists. In the late 19th century, the first building, *Beon-sa-chang*(1884) (Fig.4) which have a trussed roof was constructed by the Korean government. (Im, 2011)

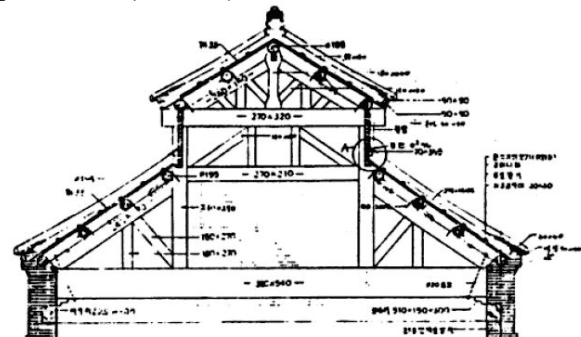


Fig.4. Section Drawing of *Beon-sa-chang* (Im, 2011)

Meanwhile, many other trussed structures were built by western people, mostly for religious purpose. Those buildings had totally western style roof both aesthetically and structurally. In prior studies, these eclectic roofs were classified into three groups, Korean style, Japanese style, and eclectic style. Although the classification is clear, it does not represent the eclectic feature embedded. For example, the eclectic style, according to the prior classification, includes too many different types of roofs. It should have been classified much more carefully. In this study, we suggest two points of view to investigate the eclectic roof structure. The first one includes the technic and design integrity of eclectic roof structure and the second one includes the historical origin of the technology. Through this study, we get to expand the scope of discussion about eclectic roof structure in that period.

3 Eclectic Features of Roof Structure

The roof of traditional Korean pavilions is characterized by protruding eaves, curved roof shape and wooden frame composed of rafters and purlins.

Rafters are supported by purlins and categorized into two kinds, short and long rafter. (Fig.5) In order to achieve a desired roof profile, each kind of rafters have different slope. By piling soil on the rafters, a smooth roof profile is achieved. Another noticeable feature of traditional Korean roof is that the long rafter acts like a cantilever to make protruding eaves.

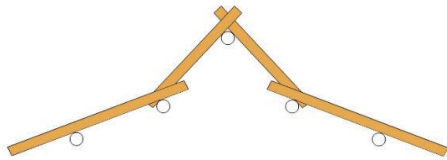


Fig.5. Roof structure of Korean traditional building

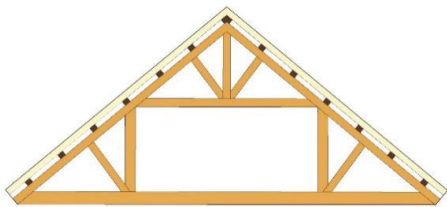


Fig.6. Structural diagram of Western truss (Queen truss)

Western Truss, on the other hand, consists of different set of building elements. The most significant difference is the use of diagonal members. (Fig.6) The diagonal part of a trussed roof is not composed of multiple building elements. Rather, the side part of the roof consists of a single long rafter and supporting columns. This structure does not have protruding eaves or curved roof shape.

The complexity in representing the traditional shape of roof emerges here. The typical Western truss itself does not allow for the traditional elements implemented. Several technological references published around 1910s-1930s suggest solutions to this problem. Fig.7 is a drawing from 'Improved Japanese House Structure(改良日本家屋構造)' which was published in 1919. The illustration shows how to adopt a truss structure having protruding eaves and curved roof shape. Based on this reference, we infer that using some additional building elements was a relatively ordinary method to represent a traditional shape of roof with truss structure.

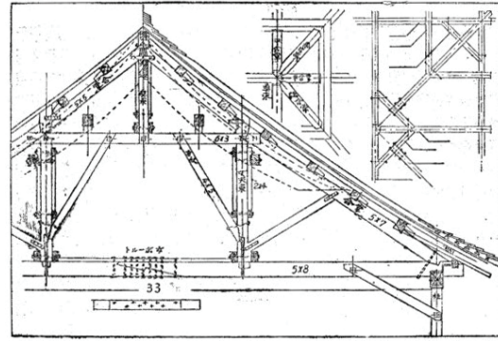


Fig.7. Roof structure of Korean traditional building (Tamotsu, 1919)

4 Structural Characteristics of Hybrid Roof

In this chapter, we will investigate roof structure of eclectic roofs and figure out what methods are specifically implemented. In doing so, we hope to answer the following questions: How are Korean and Japanese traditional timber frame structure and Western truss integrated in hybridized manner? How are the traditional shapes, such as roof curvature, protruding eaves, ornamental elements generated?

As shown in Fig 8, the use of Western truss is a remarkable attribute of the eclectic roofs. While King Truss and Queen Truss structure were widely used, there were several variations of structure which reveal the hybridized characteristic of the eclectic roofs. Case D and Case C show how the King and Queen Truss are implemented.

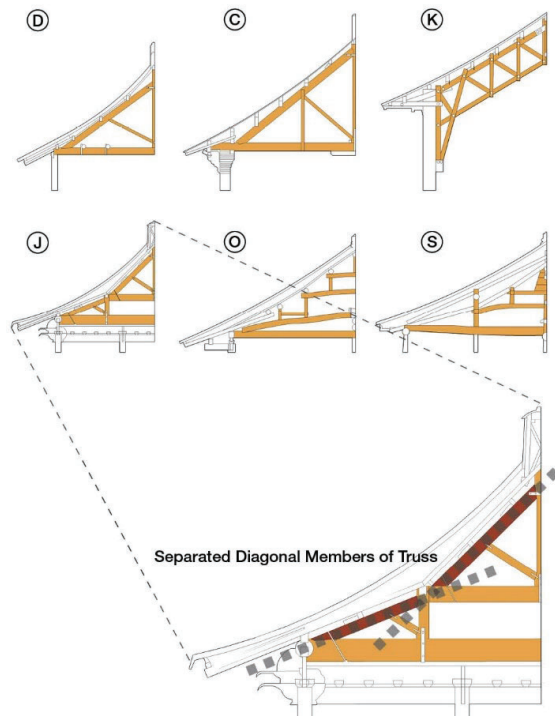
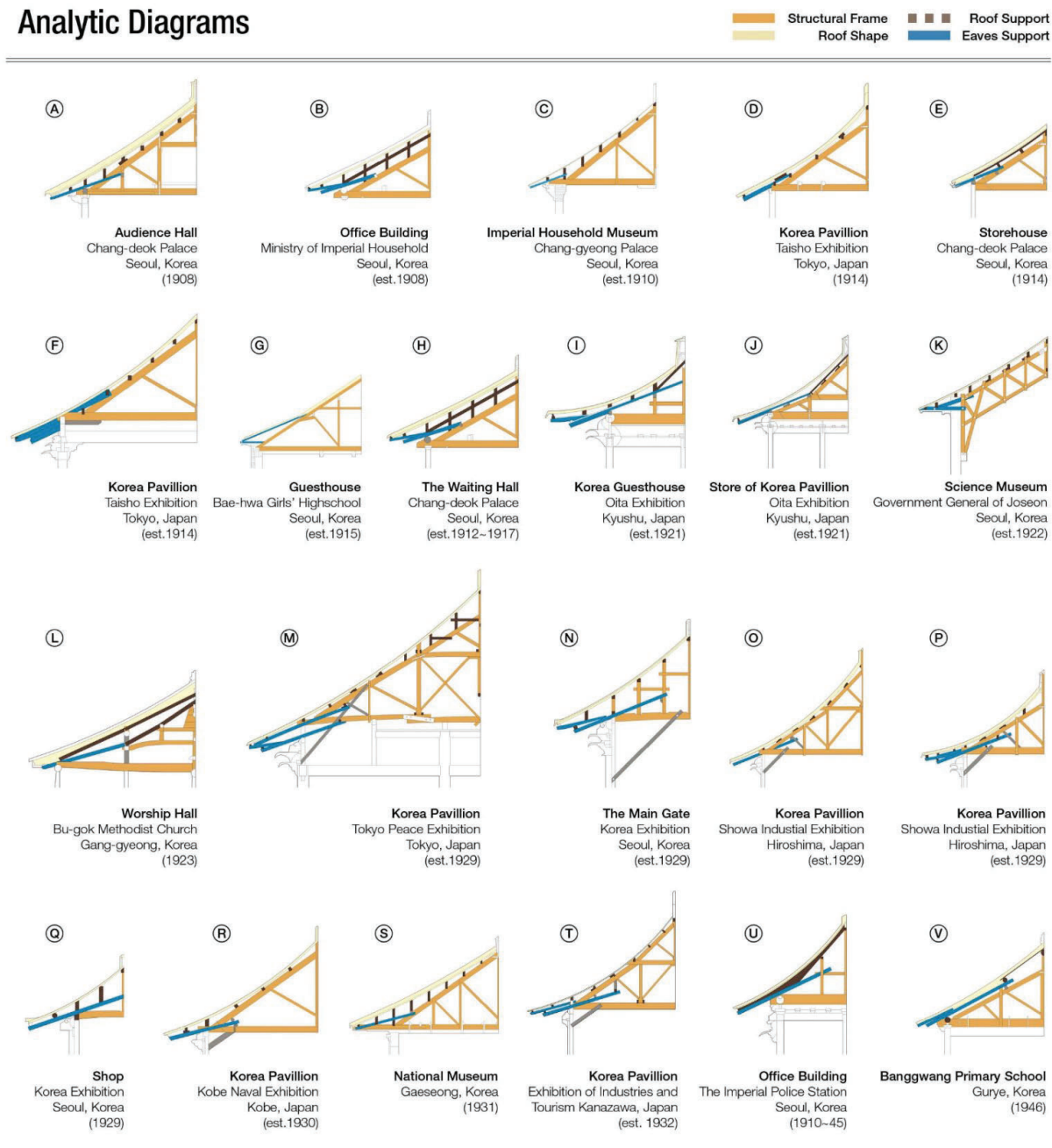


Fig.8. Roof structures hybridized with Western truss
In Case J, we note the separation of a diagonal member of truss structure. The upper and lower

diagonal members have different angles to make the curved roof profile. Case K shows a very unique roof structure which provides higher space for exhibition. In Case O and Case S, the features from traditional Japanese and Korean roof structures were still dominant over truss. However, both of them have double-layered roof structure to avoid piling soil.

Analytic Diagrams



In most cases, the ways of making a curved roof profile are similar. To generate a curved form, vertical supports are added on top of the diagonal member of the truss structure. This seems to be the most common method of making curved roof shape. (Fig.9) The significance of this method is that it reduces the load of the roof considerably by making double-layered roof structure instead of heavy soil.

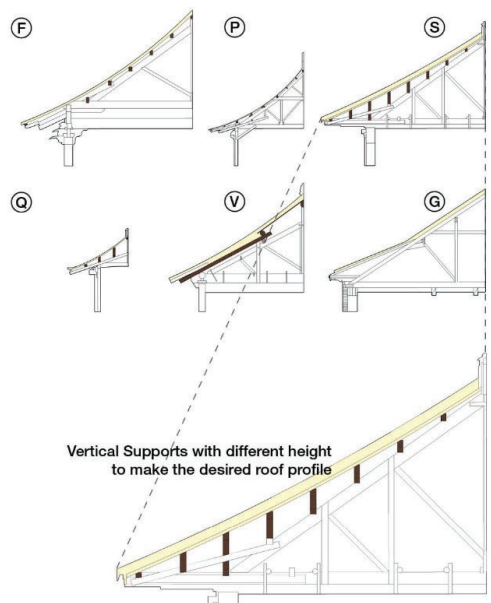


Fig.9. Roof profile generated by vertical supports on truss

Protruding eaves are an essential part for a roof structure because it prevents rain water from entering the enclosure. Unlike traditional protruding eaves, auxiliary rafters are added to the main trussed frame usually on a diagonal member. (Fig.10) Several kinds of auxiliary rafters are used case by case. The connections between auxiliary rafters and the main truss structure are usually located upon a diagonal member of truss structure.

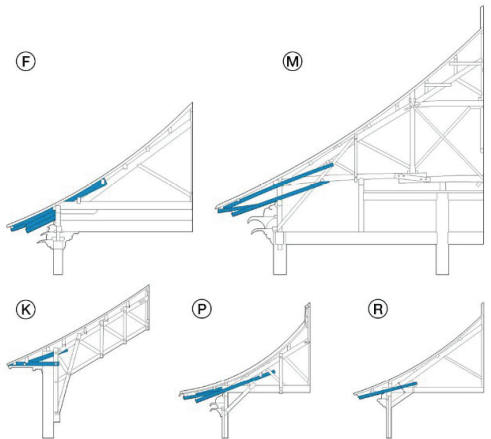


Fig.10. Protruding eaves generated by axillary rafters

We also found similar method of making protruding eaves in 'Improved Japanese House

Structure(改良日本家屋構造)' published in 1919. Four methods are illustrated in this book and the second one from the top shows the same method as our cases. (Fig.11) It is a noticeable fact that a particular building element called “桧木”(tied building element) was used. Fig.12 illustrates the positions and the intervals of rafters.

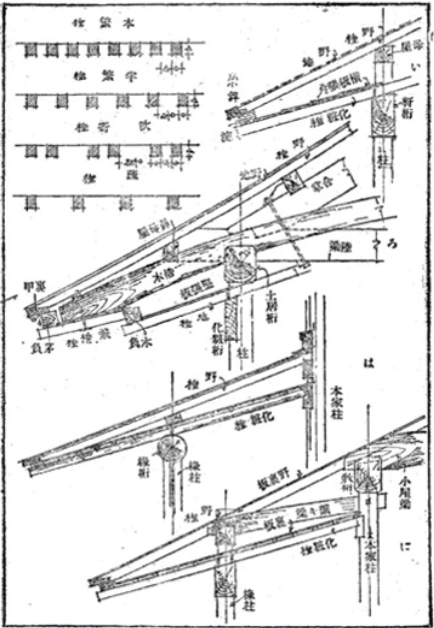


Fig.11. Protruding eaves (Tamotsu, 1919)

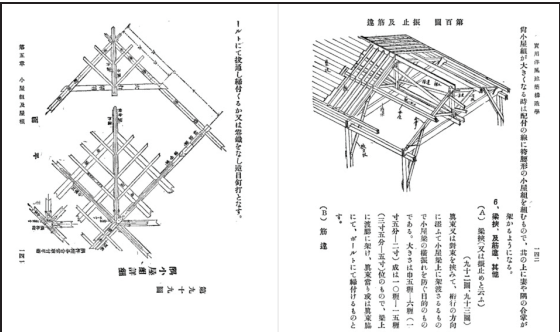


Fig.12. Rafters (Tamotsu, 1919)

While the main structural frame is replaced by truss, some specific parts of the traditional building elements still remain without structural function. They separated the ornamental part from the building elements and attached to the façade. For example, the end parts of a traditional beam maintain its sculptural shape even though the beam itself does not exist anymore. (Fig.13)

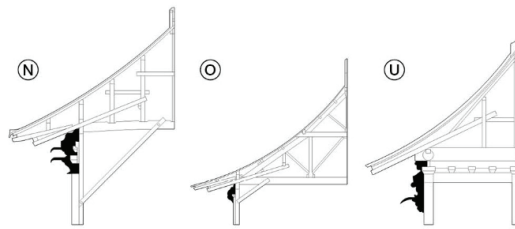


Fig.13. Ornaments from traditional building elements.

5 Conclusion

The cases from the Japanese colonial period of Korea clearly exhibit the eclectic features. Through this study, we found the prototypical method of construction of these buildings and the variations shown in each case. The eclectic features in these cases can be summarized in three points. For the structural frame, adopting the Western truss was a main issue. The cases have different degrees of hybridization as a result of integrating traditional roof structure and Western truss. While most cases clearly represent an embrace of Western truss, certain components and connections of them had been modified to generate traditional roof shapes. Architectural features from traditional Korean pavilion, such as protruding eaves and curved roof shape, were implemented through various new methods instead of traditional way. Roof curvature is implemented by using vertical support on top of truss and the protruding eaves are formed by auxiliary rafters. Ornaments from traditional building elements which lost their original function and lacked authenticity were selectively retained to mimic traditional roof shapes.

Through reviewing the eclectic roofs of the colonial period buildings in Korea, we found an underlying eclecticism between the intention to pursue traditional Korean roof shape and the actual implementation of adopted-technology during cultural exchanges in the early 20th century.

Acknowledgement

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2021R1F1A1062048)

This research was further developed after the abstract submission of WCTE 2023 and published in an academic journal (MDPI: Buildings), titled as 'Korea at the Exhibition: Making the Appearance of Korean Style with 'Hybrid Roof' in Early 20th Century'. This paper shows the initial stage of the research and includes a part of the findings in the published journal paper mentioned above.

REFERENCES

- 1) Crouch, D. and Johnson, J. (2001) *Traditions in Architecture*: Oxford
- 2) Im, J., Kim T. (2006) The receptiveness of Wooden Roof Truss in Modern Age of Korea: *Journal of Architectural Institute of Korea* v.24 n.8
- 3) Joo, S. (2010) *Characteristics of Building the Modern Facilities administrated by the Japanese Government General in Korea*: Seoul National University
- 4) Kang, S. (2004) *Adoption of architectural modernism in modern facilities during Japanese ruling era of Korea : focused on expo buildings, elementary schools and apartments*: Seoul National University
- 5) Lee, K. (2009) *The Building Principles and Typology of Roof Structure in the East Asian Wood Architecture*: Seoul National University
- 6) National archives of Korea. (2008) *A Bibliographical Introduction of Architectural Drawings in the Japanese Colonial Period vol.1*: National archives of Korea
- 7) National archives of Korea. (2009) *A Bibliographical Introduction of Architectural Drawings in the Japanese Colonial Period vol.2*: National archives of Korea
- 8) Park, C., Kim M and Kim T. (2008) *A Study on the Type and Characteristics of Wooden Roof Truss in Modern Age of Korea – Focused on the Survey Reports of Modern Architectural Properties*: *Journal of Architectural Institute of Korea* v.24 n.8
- 9) The Academy of Korean Studies. (2009) *Architectural drawing collection in modern period*: The Academy of Korean Studies,
- 10) Coaldrake, W. (1994) *Western technology transfer and the Japanese architectural heritage in the late nineteenth century*: *The Journal of The Society of Architectural Historians, Australia and New Zealand*
- 11) Tamotsu, Y. (1919) *Improved Japanese House Structure*: Japanese Industrial Society