



MODIFICATION OF ROOF STRUCTURE OF THE TRADITIONAL WOOD HOUSES IN THE URBAN AREA OF DAEGU, KOREA DURING MID TWENTIETH CENTURY

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ABSTRACT: This study focuses on the roof structure modification of hanok, the traditional Korean timber frame house, in the central urban area of Daegu city, Korea during mid twentieth century. It is based on the 2 years survey of 10,753 cases of hanok architectures in this city. The urban sprawl and population growth gave an impetus to house builders developing new residential areas with modifying traditional plan and structure of hanok.

Instead of traditional way, the wood house builders of this period choose simpler and cheaper roof structure for housing in the dense urban area. They wanted to make the familiar and popular image of tile-roofed traditional wood house using heavy timber frame with cheaper cost and shorter construction time for adapting to housing market. New method using sparsely arranged small square cross-section rafters was in fashion. Other roof type with short and asymmetric eaves was used at small sites. Some special houses have newly designed structure for long span, too.

These modified wood houses shows that there were diverse needs at the housing market. But after this period wood house lost the popularity in the market as modern house building technology, and reinforced concrete construction was widely utilized.

KEYWORDS: Roof structure, thin rafter, Asymmetric eave, Korean timber frame house hanok, housing market

1 INTRODUCTION

This article focuses on the roof structure of hanok in Daegu that is one of the biggest cities in Korea. Hanok is the traditional wood house of Korea made of heavy timber frame structure. The roof structure is usually composed with heavy crossbeam, purlins and circular cross-sectional cantilever rafters supporting eaves covered with roof tiles on the amount of soil.

At the period of mid-twentieth century, there was heavy urban sprawl and population growth at the major cities in Korea. Many citizens wanted cheaper house near central city and the house builders needed to develop new residential areas for them. In the newly developed residential area, the builders made almost same mass houses to reduce construction time with less cost.

This study is based on the 2 years survey of 10,753 cases of hanok architectures in this city. The survey was carried out by Kyungpook National University (2012) and Keimyung University (2013) supported by AURI National Hanok Center. It was the first complete metropolitan council scale enumeration survey for hanok architecture.

The focus of this article is to understand new methodology of roof structure of hanok in Daegu. There were diverse roof structural types for responding market demand. In this article, two major types and one unique case will be presented.

Before this study, there were several researches about hanok architecture of Daegu. J. M. Ha's one was on the typology of the urban traditional housing focused on hanok in Daegu area [1], and J. W. Yoon surveyed the architectural composition of them [2].

2 PREPARATORY STUDY ON KOREAN WOOD HOUSE

2.1 HOUSING MARKET OF MID TWENTIETH CENTURY IN DAEGU

Daegu had been the main administrative city of southeast part of Korea, Gyeongsangdo province, since the beginning of the seventeenth century and is fourth biggest city with about 2.5 million population now.

Since the end of nineteenth century the cities of Korean peninsula has been getting bigger very fast. Busan, Incheon and Wonsan opened ports to foreign trade and the nationwide trunk railway network was built. Among them, Gyeongbuseon railway from Seoul to Busan was one of the main route and Daegu station was the main point for trade. More and more people including both native Korean and the people from other countries mainly Japanese came to this city for industry employment or commercial business during Japanese colonial period of early twentieth century. The central area old town where had been in the city wall before demolish at 1906 was very crowded with population increase. During Korean War,

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Daegu was in the marginal front of the UN forces, so there was not serious damage at the central area.

More people from north area of peninsula gathered to this city, so the city needed big amount of housing construction for incoming population. For example, the housing problem of Daegu was most serious among big metropolises of Korea at the year of 1970. According to the news on 16 May, 1970 of The Dong-a Ilbo newspaper, while the shortages of house in Seoul was 50.6% and Busan was 56%, Daegu's house shortages was about 60% then.

In the Korean Peninsula, people's house had been only traditional wood structure of hanok, but at the beginning of the twentieth century the new building structures came from foreign countries. Brick wall structure of China or simple and light wood structure of Japan were increasing in the construction field. Also concrete structure was emerging even in the people's housing field. These new structures could make higher and wider building. Moreover the material price of wood building had increased more sharply than other materials.

In this situation, traditional hanok technology met several matter to solve.

- (1) For price competitiveness, the construction cost of hanok must be down.
- (2) In the urban site condition for housing, the composition of hanok must be more compact in the small site.
- (3) To get good marketability, hanok must meet the needs and the sense of beauty of the ordinary people.
- (4) Also, for some needs of larger inner living space adapting contemporary life, the traditional method of hanok structure must be changed to make span of column free space longer than before.

For these, the hanok builders had to develop their technology traditionally used for long time.

2.2 TRADITIONAL ROOF STRUCTURE OF KOREAN WOOD HOUSE

The traditional roof of hanok is a kind of cantilever structure. The timber cross beam is put on the columns of front and rear side and short vertical column (daegong) is supporting purlin on it. If roof need more height, the second beam is used between daegong and top purlin. The purlins located at peak of roof slope and on the front / rear columns make triangle of roof shape and supporting rafters. The rafters make surface for roof slope with soil and rood tiles. This traditional method is similar to other countries like Chinese and Japanese wood structure, so it can be regarded as East Asian ancient wood structure shared in wide area.

In the research field of Chinese ancient architecture, there were 3 major types for making roof structure. For the biggest building, they used big girder and purlins; for smaller buildings such as local residence house, they used more thin columns and purlins without girder, otherwise, horizontally layered timbers are used like log house for small storage; but it is not so commonplace.

The traditional hanok is belong to the first type above even if it is not so big building. So hanok structure is very heavy not only because the girder has usually big cross sectional area but also the roof itself is heavy. The construction cost is also high. If the builders want light structure with cheap cost, they have to make newly modified structure instead of using traditional method.

Additionally, the roof of hanok has about 1 meter's eaves protruding for protect wood timbers and soil wall against rain fall from eaves' end. The cantilever rafters can make it. But in the small site, this outer space under eaves surrounding building mass should be located between the border line of lot and outer wall of building. It is not so effective land use method because there remains narrow and useless space behind the building.

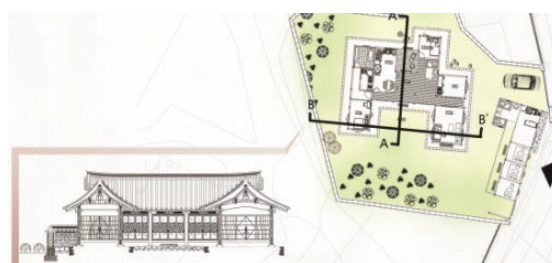


Figure 1: traditional style hanok in Daegu

3 GENERAL FEATURE OF WOOD HOUSE IN DAEGU

3.1 INTRODUCTION OF SURVEY

According to the survey, there remained 10,753 hanok architectures in the metropolitan Daegu city. This study is based on the survey the carried out for two years of 2012 and 2013 as mentioned above. Hanok is the typical architecture in Korea so the sizable of wood houses are belong to this type, but there are other types of wood structure such as Japanese or western style wood architecture. [3]

In the building register of Korea, the typology of structure is assorted like masonry structure (brick, block, stone and etc.), concrete, steel, wood, panel and so forth. In the category of wood structure, general timber structure, log house, and others are included; there is not specific tag of hanok or Korean traditional timber structure.

Before this survey there was not the official list of hanok, so the list of whole wood architecture including other types like Japanese, Chinese or western style wood buildings had to be listed up out of the whole building register. So the survey team had to define what makes hanok distinguished from other wood structure. Secondly, the investigators checked on each spot and confirmed 10,753 hanok buildings among 15,344 wood architectures in the list by on-site confirmation.

The ratio of hanok in the whole wood buildings was about 70% average; 35% at the central city (Jung-gu) whereas 87% at outskirts suburban area (Dalseong-gun). Hanok had been normally constructed wherever in the central area or outskirts, but after 1950 most cases were pointed at the

central city. It shows the population growth and urban centralization need more houses in the central city. By district in detail, Dalseong-gun, the southwest suburban area, has 2,420 hanok and Juon-gu, central urban district, has 1,788 ones. The cases of Dalseong-gun where is the rural area with the largest district and lowest population density are traditional and dilapidated hanok houses while the cases of Jung-gu, the smallest district with high density are newly designed ones built from early to mid-twentieth century. The outskirts area surrounding central district has mass constructed hanok houses against housing requirements with population growth of 1960-1970s period. About 93% hanok (10,015 cases) are used for dwelling and others for commercial, religious, public use and empty houses.

Table 1: distribution by year and district of hanok in Daegu

District	~50	50s	60s	70s	80s	90~	null
Jung	552	283	261	208	190	1	256
Dong	491	199	232	313	146	44	35
Seo	235	260	316	191	561	1	4
Nam	46	164	415	300	148	6	27
Buk	165	143	303	278	198	6	4
Suseong	88	189	279	228	161	18	33
Dalseo	58	25	53	107	81	29	2
Dalseong	1,028	608	253	212	118	78	123

3.2 TYPOLOGY OF ARCHITECTURAL PLAN AND ROOF

The investigating items are as follows; shape of plan and roof, materials of roof, rafters, columns, door & window's frame, outer wall, main gate, fence and the pavement of access alley. The major type of plan is I-shape in rural area and L-shape in central area while hanok with both wings is majority in Seoul. [4]

Table 2: roof shape of hanok in Daegu

Type	Number(case)	Ratio(%)
Gambrel roof	7,082	65.9
Hipped roof	1,917	17.8
Gable roof	1,085	10.1
Others	65	0.6
Unidentified	604	5.6
Total	10,753	100.0

In the whole city, L-shape and I-shape's ratio is 45.2% and 43.0% each. Even though L-shape is more difficult to build than linear shape hanok, L-shape of same building area could be built in smaller site. So, it is more efficient in the dense central area.

For the roof shape, 65.9% of hanok used the gambrel roof regarded as quality type. But the roof surface material was not so good. Traditional roof tile made of baked soil had only 5.2% whereas thin cement roof tile occupied 61.7%. Most of surveyed hanok cases were built at mid twentieth century when the fast construction with cheap cost house was needed. Wood house was commensurate with this kind of social need at the first time. But other materials that were supplied to the construction site like bricks,

concrete and steel made change to the housing market. So, hanok builders had to develop or modify their traditional technique and construction method.



Figure 2: examples of urban hanok Residential Areas composed with gambrel roofed L-shape hanok housing (Samdeok-dong 2ga and Namsan-dong 4ga, Jung-gu district)

4 METHODS OF ROOF STRUCTURE MODIFICATION

4.1 LIFTED SQUARE SECTION RAFTERS

The major roof shape of hanok in Daegu is gambrel type; it means normally people like that roof shape and it has good marketability. But gambrel roof needs more expensive construction cost than other roof types. For both of price competitiveness and marketability, the roof structure had to be changed. Otherwise, the wood architecture of Korea uses timbers not only as structure but also as finishing materials itself. If the structural method is changed, the shape of the house also has the possibility to be changed. So structural modification also should be limited in the range of the similar shape of traditional hanok.

The house builders of that period wanted to make the familiar and popular image of tile-roofed traditional wood house using heavy timber frames with less cost in shorter construction time for adapting to housing market. Some of the builders chose the new simple method using sparsely arranged small square cross-section rafters affected by foreign architectural technology.

In detail, the structural elements from ground level to the purlins on the outer columns supporting rafters are designed like traditional ones while the cross sectional area of members such as columns, cross beams and purlins is smaller than traditional method. On the outer purlins, they put short vertical lumbers to lift up extra purlins with square sectional wood bar. On these new purlins, simple lumber rafters are put to make roof surficial structure. Also on the center of cross beam they put the lifter (daegong) to make roof triangle.

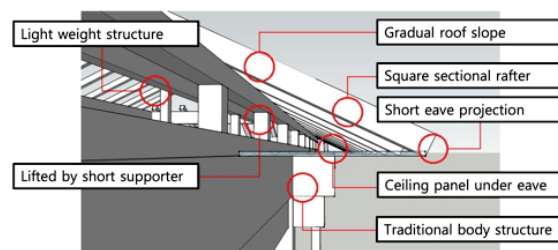


Figure 3: Lifted square cross section rafters roof structure

This newly modified roof structure is more simple and light in weight than traditional one, also the construction cost is cheaper.

Especially square sectional rafter is cheaper to make than traditional circular one. But the exterior of the house could not be qualified. So, they added ceiling panel under eave hiding small square sectional rafters lifted with short supporter on the purlin.

Though the roof structure had been changed, the main body and roof of the house has traditional image of hanok only except under eaves partially. So it looks like traditional hanok at the first glance. It can be called as hybrid wood structure. [5]

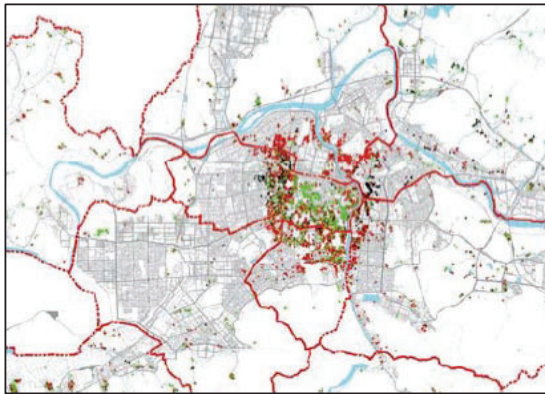


Figure 4: spatial distribution of 'no rafter type' (red dots)

In the survey, this kind of hanok is categorized as 'no (traditional) rafter type'. The number of cases is 4,633 and it is about 43.1% cases. These houses are located at the surrounding areas of Jung-gu district and most of them were built during 1960-1970s when the economic condition of the city was not so good. Most of them were built at very small site, so the courtyard is smaller than cases of other decades.

4.2 GAMBREL ROOF OF ASYMMETRIC EAVES

Other method for the urban hanok is making eaves asymmetric. The cases using this kind of eaves were distributed over all urban area of Daegu city, too.

For example, the case of 2504 Namsan-dong, Jung-gu hankok block can be focused where hanok on a similar type were regularly arranged on also typical lots. Actually this urban area was unified one lot of farmland located at the suburban area on the cadastral map of 1911. It belonged to one person named Sihoo Kim and was changed to building site by land readjustment project during 1960s. It was divided into more than 20 small lots of about 136-145 square meters at 1972-1973 and transferred its ownership to each other person right after land dividing. Every 4 or 5 lots were arranged into a line from south to north and 2 meters wide alley was put between each line of lots. This method of land readjustment work was normally applied whole urban area surrounding old central area. But 136-145 square meters' lot is not enough size to build traditional hanok. [6]



Figure 5: case of urban hanok area of 2504 Namsan-dong, Jung-gu (now destroyed)

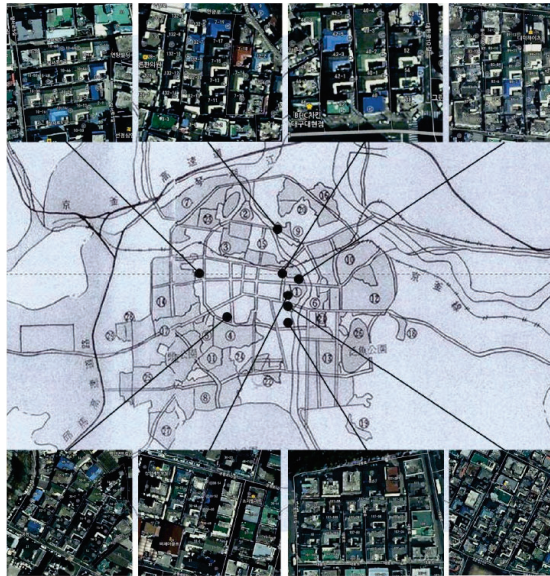


Figure 6: hanok block made by land readjustment project

On each lot, the house builder made typical L-shape plan house similar to each other. On the north part there was master bedroom, living room and 2 more bedrooms from west to east and kitchen and 1 more bedroom were at the west wing with courtyard on the southern east part of lot. This type of L-shape hanok was typical shape in Daegu city.

Usually hanok has 1,000~1,200mm projected eaves from outer wall. It is for shading inner space and preventing rain drop into the house. If the roof is gambrel or hipped roof, the eaves are surrounding the main body while gable roof has only 2 side eaves of the house.

People wanted the gambrel roof house, but it needs larger site area. House builders had to modify gambrel roof that could be built in the small area.

The normal eave projection length of more than 1,000mm is used at only 2 concave faces of L-shape plan house toward inner courtyard. Other faces have short eaves of about 400mm projected that is not enough for shading or preventing rain drops. From the structural viewpoint, this asymmetric eave roof is not good for balancing because angle rafter cannot be put on the exact position forming an angle of 45 degrees. But it is more attractive to housing market.

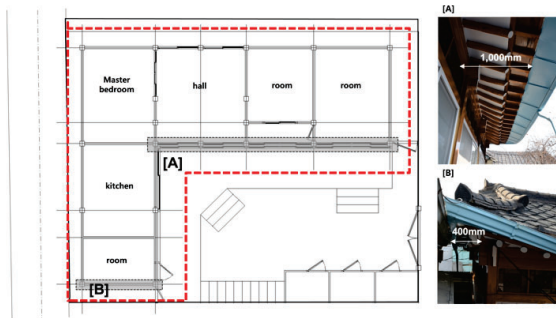


Figure 7: Gambrel roof with asymmetric eaves

4.3 NEWLY DEVELOPED ROOF STRUCTURE FOR LONG SPAN HALL

Using the lifted square sectional rafters and asymmetric eaves aims cheaper construction cost of hanok architecture for adaptation housing market's condition. But someone wanted to make bigger hanok with affordable cost. Usually residential hanok's longitudinal span is about 3.6m including 2.4-2.7m's room span and 0.9-1.2m width corridor. If the span is bigger, the cross beam has to more depth for supporting roof weight. But it needs more cost, too.

The case of 66-5, Jong-ro 2ga is the noteworthy one. It is located at the narrow long alley of Jin-golmok where is southern east part of central old quarter used to be inside of Daegu city wall of Joseon Dynasty (1392-1910). Land near Jin-golmok belonged to Dalseong Seo family's ownership. This rich and famous family made diverse style houses such as Western villa (now Dr.Jeong's children hospital), 2-story brick house (now Daegu Korean Chinese Association building) and several hanok houses designed by each architect or house builder. It means 66-5 hanok was also designed not for mass housing even though there is no documental evidence.



Figure 8: changing of the site of Byeongwon Seo's mansion (1911, 1938, 1949, 1957 and 1977)

66-5 hanok was the part of Byeongwon Seo's mansion and had been used as restaurant (Jin-golmok Sikdang, now closed) recently. His mansion was composed more than four buildings of family's residential part, reception and living part and 2 more attached buildings of servant's quarters. Buildings of Seo's mansion were built during 1920s. These three parts are used for each commercial function of restaurant on each lot, now. On the first a land registration map of 1911, there was large lot including all buildings of the mansion. It is very deferent from the case of 2504, Namsan-dong. [7]

66-5 hanok was the reception and living part of the mansion. This reception room needed bigger space than

traditional hanok so the designer had to make new structural method for it. This 66-5 hanok is also L-shape but the longitudinal span of the north wing is about half as large again as normal hanok.



Figure 9: plan of Byeongwon Seo's mansion and structure of 66-5 hanok

The 66-5 building is composed with 2 narrow wings of 3-purlins span and they made L-shape structural frame. Additionally wider 2-purlins span is added forward courtyard side for making 5-purlins span. For this wider span, this building has two more cross beams orthogonal direction to the main cross beam. It is so abnormal case among hanok structure. In this way, the builder could make long span with only small sectional timbers.

The rafter is traditional one but thin and sparsely laid. And they didn't put ceiling hiding roof structure. If the builder used the light weight roof structure of lifted square sectional rafters, ceiling had to hide the roof structure and could not make the traditional image of hanok.



Figure 10: worm's eye view of 66-5, Jong-ro 2ga, Jung-gu

5 CONCLUSIONS

Daegu's housing market of mid twentieth century was diversified so fast. Hanok builders had to develop their own technique to catch up with the new market trend struggling against other emerging house types. They had to build hanok with low cost in short time. Modified roof

structures such as using lifted square section rafter or asymmetric eaves were their strategy to survive in the market. And the case of 66-5 hanok shows that the traditional technique also could make wider span than before. These modified wood houses shows that there were diverse needs at the housing market.

But after this period wood house lost the popularity in the market as modern house building technology, and reinforced concrete construction was widely utilized.

Traditional carpenters were replaced not only in the housing market but also wood construction field. New wood architecture technology such as lightweight wood frame house was imported and nowadays most of wood houses are built with 2x4 style engineered lumber hided in the wall panel. The traditional carpenter's technology is also used for new hanok with high cost; it is still popular partially. Recently, so called 'neo-hanok' is developed using BIM based automatic design technology, precut with CNC, engineered lumber, metal joint and others.

But it shows possibility and tendency of the evolution of hanok.

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