

A research on trimming timber for sunjayoun and construction of Korean traditional Architecture

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ABSTRACT: 'Hanok' is very developed in its joint and align of vertical member and horizontal member as a wooden style of house architecture. These types of complex structure style could be developed since there were lack of metal goods in the past, and direct align between wood was more lasting than metals. However, these factors have rather become an obstacle of modernization and generalization of 'Hanok' because such a complex structure should pass through hands of craftsman after all. Recently, trimming timber of all sorts of members are handed down through experience of woodworkers. Therefore, there's a need down the cost of construction by making inquiries on manufacturing technique and modulation. 'sunjayoun' is trimmed and constructed on the spot, in the specific construction progress, different from other members because of its nature. Through modulation of member of 'sunjayoun', construction cost can be reduced by trimming mass of timber from factories or lumber mill, and it will also become able to improve or maintain quality of buildings.

Keywords: 'sunjayoun'(Fan-Fib Rafter), 'chunyeo' (Angle Rafter), Korean traditional Architecture, hipped and gabled Roof

1. INTRODUCTION

1.1 Background and Purpose of a Research

All Eaves line of 'Hanok' roof consists of 'an angle rafter & a square rafter' and 'Anheorigok'. These eaves lines have strongly the features of handcraft so much that they can be described as 'naturalness' or 'a line representing Korean traditional construction'.

Emphasizing the concern of 'Hanok', the necessity to supply 'Hanok' is also getting high. But, the actual situation is that it is rare to find the detail data and researches for the detail process and technique trimming timber and installing it as the purpose of

'sunjayoun' which forms eaves lines. In this research, to know these things, techniques of carpenters for trimming timer and assembling is investigated and summarized by visiting directly the working site of traditional construction, and a research report of full-sizing cultural properties is analyzed.

1.2 Review of Preceding Researches

The interpretation of preceding researches for an eaves line is mainly more ideal and nonobjective rather than numerical and quantitative. That is, the interpretation is mainly formed as metaphorical and natural description representing the curves of a mountain. On the other hand, there were some preceding researches expressed as a

numerical value using by proportional analysis which is a detail researching technique.

Div.(Writer)	Main Subject of a Research
Lee, Min-Sub Lim, Gyeong-Hun Kim, Deuk-Sun Chang, Seok-Ha Chang, Soon-Yong	Analyzing the decorative side of a roof
Oh, Hyun-Tak Cho, Jae-Young	Describing practically the slope of a roof : Investing and Analyzing the change of the slope and the external diameter angle for the curves of eaves
Kim, Young-Bae Park, Gang-Chul	Researching the features of roof curves, the cartography and the elements
Chang, Soon-Yong	Describing and explaining the processes of design such as from a plane design to a kind of a pillar, a beam and a grinder, how to arrange and the frame system
Sun, Myung-Sook Yoon, Hueng-Ro National Research Institute of Cultural Heritage(NRICH)	Researching a handcraft man(a master builder)
Bae, Ji-Min	Researching the process to decide the curve of a roof around the construction site of a palace

1.3 The Range of a Research

Firstly, the construction site was observed by visiting there in order to understand the works of carpenters and the construction record and the maintenance report were investigated. Now, a tourist home with the style of 'Hanok' has been constructed actively in Jeollanam-Do province. Park, Young-San, Gu, Ja-Youn and others who are master builders have take part in the project.

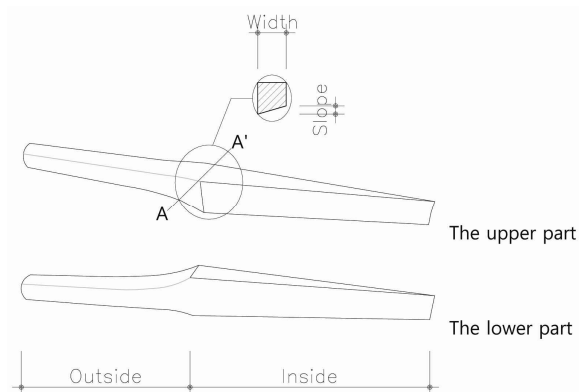
The writer of this research has investigated, recorded and arranged the processes of trimming timber and assembling it by visiting the construction site and interviewing with master builders from March of 2002 up to now.

A gambrel roof without an angle rafter has no a curve of the edge of the eaves, a

sharp slope and a weak curve of eaves in comparison with a gable roof and a roof with 4 angle rafters. Additionally, almost style of a roof on an attached building is consisted of a gambrel roof. Accordingly, this research investigated as a target of a gable roof which forms the curve of eaves due to an angle rafter. To find improvements of the data collected from the works of a main builder who has a lot of customary techniques, also, this research compared his customary techniques with general techniques of traditional architecture in the past, investigated current construction method to repair and maintain cultural properties and set up other construction sites within local area as the range of research.

2. THE RANGE OF A RESEARCH

2.1 The name of Each Rafter of 'sunjayoun' and the Features



Inside & Outside

It is good to calculate the length of each rafter in the plane and to leave a space at the end of header because the length of each rafter for 'sunjayoun' is different respectively. "Inside" means the length from 'Galmosanbang' to 'the crossing point of an angle rafter' inside a main beam, and "Outside" means the length from 'Galmosanbang' to 'the header of sunjayoun' outside a main beam.

A Curve

The curve of 'sunjayoun' is the length of the vertical segment from the segment between the bottom of laths installing a sunja rafter and a triangular gable tile of a middle beam to 'Galmosanbang', and it stands for the bending status of 'sunjayoun'.

Width

Width is gathered as a shape of folding fan from the top of 'Galmosanbang' of 'sunjayoun' to inside of a main beam. It is common that the side of width is the face connected with each 'sunjayoun' and it is cut in the plane and the non-disclosed side of width is left as the shape of raw timber as it is by omitting a finishing process. The bottom side of width is cut according to the slope of 'Galmosanbang'.

Slope

Slope means the height of the rafter cut in accordance with the slope of 'Galmosanbang' in width.

Hoisa

Hoisa is called as 'Dollim' and it means the length of the bottom side reaching to 'Galmosanbang'. It has bigger size than "Width" because the angle between the center line of 'sunjayoun' and 'Galmosanbang' is changed gradually as much as 45 ~90° from the first rafter to the last rafter on a plane.

2.2 The process of Construction

Trimming Timber of 'sunjayoun'

Like a plane rafter, 'joapangi' was used for traditional trimming timber of 'sunjayoun'. It is possible to work on a temporary facility in nowadays, so trimming timber is directly accomplished and fixed at the installation site on a roof unlike another member.

Selecting a curve of 'sunjayoun'

'sunjayoun' uses a wood which has bigger curve than a plane rafter. And the more it

goes from the first rafter to the last rafter, the more a curve is small and width is large. If it assumes that the height of 'Galmosanbang' is 1/2 of the curve of angle rafter, the curve of the first rafter of 'sunjayoun' should be 1/2 of an angle rafter curve and the curve of the last rafter should be same as the curve of a plane rafter or a little bit bigger than it.

Dividing 'sunja' (Selecting the number and an interval of 'sunjayoun')

In case of the arrangement of 'sunjayoun', the first rafter should be fixed attaching to an angle rafter after trimming timber and the center interval of the header of each rafter should be arranged to be 1 Korean foot. Because it is for making the interval between the widen 'sunjayoun' be same as the width of a vertical shingle. Though the last rafter is also 'sunjayoun', it is treated as 'pyungyoun' because it is similar to the shape of 'pyeongyoun' and it is in a line. The more the shape of header of 'sunjayoun' is the first rafter, the more it is shown as an oval. The reason why 'sunjayoun' is arranged at the same interval with one of a plane rafter is because there is an effect to show that the more it goes visually to an angle rafter, the more the interval of header is wide. By the reason of above, 'sunjayoun' supplements that the more it goes to the first rafter, the more the interval of header is wide by arranging the header of 'sunja' at interval of 1 Korean foot. So, it is regarded as experimental selection in order to pursue the rationality of time and space so that a shingle is installed without the joints on the top of softwood.

Designing 'Galmosanbang'

'Galmosanbang' can supplement a curve of 'sunjayoun' and can make an effect of a big curve by using a member of 'sunjayoun' with a small curve. The height of 'Galmosanbang' should be set up about 1/2 of the curve of an angle rafter at the first rafter. The height is getting lower gradually and even reaching at the last rafter, we can

see the end of a member. Also, the shape of 'Galmosanbang' slopes up to the inside. If extending the line connected between the outside and the inside of top of 'Galmosanbang', the line reaches at the top of a middle beam. That is, it means that the part between a main beam and a middle beam of 'sunjayoun' is paralleled with the bottom.

Installing 'sunjayoun'

If 'sunjayoun' is revealed as the shape of the ceiling inside of a house, it is gathered closely as the shape of a folding fan from the main beam to the triangular gable tile beam. If considering just one side, the header of 'sunjayoun' is attached to the bottom of laths, it is attached to the top of 'Galmosanbang' at the position of a main beam, and the back header of 'sunjayoun' is gathered at the top of a triangular gable tile on a middle beam. Ultimately, trimming timber and installing 'sunjayoun' mean that a raw timber(sunjayoun) which is an irregular and natural grooving member is tied together at three points such as the bottom of laths, the top of 'Galmosanbang' and the triangular gable tile of a middle beam. The 'sunjayoun' installed with above method adjusts a curve in order to be arranged according to the curve from the bottom of laths, it is closed to 'Galmosanbang' with slope and it is gathered at one point on a triangular gable tile of a middle beam.

2.3 Trimming timber and Assembling 'sunjayoun'

Selecting a material of 'sunjayoun'

For the strength of a wooden material, one of root is stronger than one of header. The strength of the curved part should be high because it has a role of cantilever toward the eaves. In case of a traditional method, it was also toward header. Even though this method has a structural advantage, it requires a lot of works such as cutting a good deal of woody tissue and shaving a wood in order to sharp the edge of thick softwood at the edge of eaves.

To produce a curve bending up lightly to the eaves, softwood material with suitable bending strength is selected. But, it is difficult to expect a regular bending shape because it is not industrial products. So, it is necessary for grouping the selected softwoods and trimming it in accordance with the shape and the condition. This grouping job is called as 'grading work', and it means a work to classify the bending strength of softwoods according to the installation position and the kind and to record it. Only, it is possible to use the softwood bent to one way but, it is difficult to use the softwood bent to two ways. Because it is difficult to do marking for the softwood bent to two ways and there could be occurred unexpected transformation or variation after installation. Especially, softwood with little bending 원구 has advantages to make a shape of bending up eave. In case of 'sunjayoun', it is required thicker wood in comparison with 'Pyeongyoun'.

Making a Trimming Timber Table

To practice trimming timber for 'sunjayoun', an actual size drawing should be made. It is principle to make a drawing at the ratio of 1:1 for an actual size drawing, but sometimes it may be made at the ratio of 1/5~1/10 according to the situation. If the actual size drawing is completed, a trimming timber table should be made and dimensions and the quantity for position of each sunja rafter should be filled up in the table. Commonly, the dimensions and the quantity may be modified at the course of installing 'sunjayoun'. Traditional trimming timer table is mainly classified as two kinds as follows. how to classify the table are i) how to understand dimensions of width, height, slope and cantilever and ii) how to understand dimensions of inside, outside, width, a curve, slop and Hoisa. These methods has little difference according to the genealogy of a carpenter.

Trimming 'sunjayoun'

Trimming 'sunjayoun' has an order of skinning - marking - trimming. The first step to trimming softwood is skinning. The bark of raw timber should be removed firstly because it is easy to live on bark for an insect. Generally, a sickle is used for skinning as a tool. Caution at the process of skinning is that the bark should be peeled off in the direction of growth. Likewise shaving, it is easy to do skinning for the forward wave of bark and it is difficult to do skinning for the reverse wave of bark because it is easy to dig into the raw timber for a skinning tool.

The second step to trimming 'sunjayoun' is cutting. The timber after completing skinning is cut off according to the required length. It is common that extra length of 1~2 Korean inch is left because the dimension is cut off exactly in the step of trimming.

The third step is drawing a line with Chinese ink. The bending direction of softwood is located upwardly, it is drawn with a main Chinese ink and then it is marked header using by a frame of header. The position of a beam is marked and Chinese ink line is drawn to express the crossing point of a folding fan frame inside a main beam.

The fourth, trimming is accomplished through 2 times such as 1st and 2nd. The outer length is cut off as much as the width of header of 'sunjayoun' and the inner length is cut off up to the top point of a middle beam next to an angle rafter in order to gather the back side by 1st trimming. After the 1st trimming, the cut softwood is shaven by a plane. The shaven wood is carried and kept on a footboard of the temporary facility installed in height of a beam. Through the 2nd trimming, the sunjayoun completing 1st trimming is cut off in detail width and slope according to Galmosanbang, laths and a middle beam. The 2nd trimming should be accomplished based on the target dimension by putting the sunjayoun into the actual installation space and adjusting the dimensions.

Fixing and Binding

The trimmed sunjayoun is fixed temporarily on Galmosanbang with a clamp and then the sides of sunjayoun are fixed orderly to an angle rafter with a nail. The number of a nail is needed over 3 according to the length of a sunja rafter and the nail is driven at regular intervals of middle 3~4 Korean foot. A rafter nail with long length which can be driven up to a beam is driven to Galmosanbang, too.

2.4 Analysis for a Configuration Element of sunjayoun

Dividing sunja

In the category that wide interval of the first piece is not opposed to the standard of decorative design and the change of the interval is increased or decreased regularly, it is economical to set up at interval to install a shingle of 1 Korean foot. It is different from the cast that lattice sticks is tied on the top of softwood and mud is plastered on the ceiling. But, actually it does not matter that the finishing work for the top of softwood is substitute for installing a board because a technique to cut a board when constructing 'Hanok' has been developed and the installation of lattice sticks has been not used due to high wages of labors. It is common that a board with width of 1 Korean foot is used in the viewpoint of materials according to the size of a house.

Change of the curve of laths and sunjayoun

The curve of laths on sunjayoun appears on Anheori and a bending angle rafter. This is shown as a curve both on plane and on projection, and it is a dimensional curve which is made by pulling the laths of a rectangle section down inside and the bottom of a building using a rope or a wire. To install sunjayoun, it should be matched with the triangle shape linking the three points of the bottom of laths, the top of a main beam and the top of a middle beam next to an angle rafter. Wooden construction

can accept an expected error of target dimensions or a mistake of trimming timber within a small range. If it is possible to perform the 2nd trimming for sunjayoun according to the actually measured dimension of the bending laths after installing them, that is to say, we can assume that sunjayoun is firstly installed after completing 1st and 2nd trimming simultaneously according to the target dimension calculated by geometrical logic and then the laths are bent and they are connected with the edge point of butt end.

The former is a traditional way and it has been used until now. If there is occurred a small gap for the bending strength due to unequal woody tissue of each lath, in this case, a part of timber trimmed according to the target dimension should be repaired.

In case of the latter, on the other hand, the edge point of sunjayoun trimmed by the target dimension calculated by geometrical logic should be connected with the laths by bending them. If any piece among from the 1st piece to the last piece of sunjayoun is escaped from a track of parabola, it causes the shape of projection to hamper.

The slope of Galmosanbang and sunjayoun

For the height of Galmosanbang, the height of the part approaching to an angle rafter is the highest and it is getting low gradually toward the last piece. The curve of Galmosanbang is changed closely to a straight line in comparison with one of laths, and it is favorable to make a shape of triangle by making the part touching with sunjayoun as a straight line when constructing. Also, Galmosanbang has the slope of vertical direction in the direction of a straight line connecting a main beam with a middle beam. The more it is toward inside, the more the slope is getting large so that sunjayoun is closed and supported. This slope is overlapped and paralleled with the segment drawing from any point on an outer segment of Galmosanbang(a right triangle) to the crossing point of a folding fan frame.

A round beam with a round section is mainly used for constructing Hanok. In this case, the bottom of Galmosanbang closing to a beam should be made roundly and concavely as the shape of a round beam and then it should be installed. In most cases, the center of Galmosanbang should be installed according to the center line of vertical pillar. By the way, softwood transferring the weight of a roof to a beam keeps the balance in the viewpoint of a whole building because it is installed with slope. But, local eccentric force is always affecting. Sometimes, so, some master builders considering the eccentric force install vertically Galmosanbang in front of softwood.

sunja / a Folding Fan Frame

Theoretically, the back end of sunjayoun is gathered to one point. The back end is sometimes broken or torn when handling it and it is possible to corrode easily after installation because it is so thin like a paper. The crossing point of sunjayoun is located at one point on the top of a middle beam. So it is necessary for cutting off excessive thin part of the back end or being blunt it by locating the crossing point at much inside.

3. ANALYSIS FOR CONSTRUCTION OF SUNJAYOUN

3.1 Analysis through EMP

EMP is the standard about the necessary price for unit quantity of a construction work based on a standard estimating system for unit manpower and materials. The EMP suggested in Table 3 follows the standard of Cultural Heritage Administration of Korea.

Name	Descriptions (Unit : Person)
Trimming sunyoun materials	Korean Carpenters 2.09, Korean Carpenters & Sculptors 0.62, Common Labors 0.41
Assembling	Korean Carpenters 0.73,

sunyoun materials	Korean Carpenters & Sculptors 0.36, Common Labors 0.36
Total (Trimming sunyoun materials)	Korean Carpenters 2.82, Korean Carpenters & Sculptors 0.98, Common Labors 0.77

* Summary for Standard Estimating System and Practical Work for Repairing Cultural Heritage, Cultural Heritage Administration of Korea, 1998

EMP is applied to calculate appropriate construction cost when designing and constructing a building, and it suggests the standard to be quantitative a work that it is difficult to measure. The writer of this research estimated the period of trimming sunjayoun and assembling process based on EMP and investigated the difference between actual period and the estimated period.

If a Korean carpenter who controls a sculptor and a labor and has a skill to make sunjayoun is established as a standard, daily working time of 8 hours can be set up 1(100% Participation). If EMP is reinterpreted, it is possible to assume that it will take about 3(2.82) days in order to trim and assemble 100 softwoods.

Bojanggak and Hyangrojeon which are a royal palaces of Bulgapsa has respectively a scale of 97.20 m² and 137.70 m² and the quantity of sunjayoun inside Bojanggak and Hyangrojeon is about 1,500 materials, and the quantity is similar with each other. According to the interpretation of EMP, it will take about 43(15x2.82=42.3) days in order to trim and assemble sunjayoun. If sunjayoun is constructed by carpenters of 2 groups, generally, the term of construction can be assumed as 21 days.

The term of 30 days was taken as the term of actual construction. Among 30 days, it took 19 days to trim timber and it took 11 days to assemble sunjayoun. Accordingly, there is difference of 9 days between the term of actual construction and the term estimated by EMP. Even though considering the transporting time and dummy after

trimming timber, there is difference of a week(7 days).

These differences can be reasonable result between estimation and actuality according to an ideal assumption. But the reason of these differences is because actuality is not matched with theoretical assumption that assembling will be started after completing trimming process. That is to say, it is difficult to expect exactly the term of construction due to complex variables such as different length & the height of curve of each piece of sunjayoun, laths of a parabola and the curve of Galmosanbang changing in a straight line. So, we can confirm that the main factor for extending the term of construction is the trimming works of 1st and 2nd round.

3.2 Analysis through Site Investigation

We compared the construction site of an arboretum in Wando with the site of Bulgapsa. According to Kim, Chang-Ho who was a master builder at the construction site of an arboretum in Wando, it took 18 days in trimming timber at the arboretum site and the period is similar to the trimming period of Bulgapsa. But, the assembling at the arboretum site was completed just in a day. The very remarkable assembling period was based on the genealogy and the experiences of the master builder. The difference from another construction site is that firstly trimming work is completed in the 1st round and it had noticeable effect that he used same trimming timber at 8 places with a careful plan. Therefore, he could save considerably a lot of time to carry the wood materials and to supplement the difference between the target dimensions and the foundation after the 1st trimming. That is, he worked same sunjayoun of 8 places using by several small teams at a time.

3.3 Shortening of a construction period and Improving of construction performance

A Term of Construction

The summary of above research is as follows. Manufacturing sunjayoun is very difficult process that it requires a complicate and difficult technique. This difficulty influences on the indefinite classification, and delay of construction period is caused derivatively for the reason. A term of construction can be saved by deciding exactly the target dimensions, simplifying the trimming process and working simultaneously simple and repeated processes.

A Problem of Construction

[Designing] A problem of the quantity to trim and assemble

The back end of a Folding Fan Frame is weak

The weight of Eccentric Force acting on Galmosanbang

Fixing sunjayoun by a soft chisel (a problem of reuse in disassembling)

Making many uniform curves of laths

4. CONCLUSION

The purpose of this paper is to understand the current constructing process of 'sunjayoun' forming the curve of eaves at a Korean traditional house(Hanok), to analyze it and to find out the improvement.

For this, the shape and the technique of 'sunjayoun' and the current construction practices were investigated and improvements were considered by referring to literatures. As the result of these investigations, the writer of this paper understood the ways to improve structurally a Korean traditional house(Hanok) and to plan durability in pursuing the typical curves of a roof, and could look at the possibility to adapt the know-how of a main builder having strongly customs to this modern industry and to accomplish mass-production and accuracy of processing. To improve the trimming timber of sunjayoun which is affected by the skills and sensibility of a

main builder, on the other hand, it is expected to open a new area by macroanalysis through making algorism and a computer application program in order.

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