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Material Cost Variations depending on the Forms and Dimensions of Timber Frame in Hanok Buildings

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In spite of various efforts to expand demands for Hanok, construction of the Hanok is not actively performed. According to the result of survey investigating people's recognitions for Hanok and the characteristics of demands(Auri, 2013), the purchasing cost, one of most important factors considered in purchasing Hanok, is still high(47.5%). The high price of Hanok is primarily caused by high construction cost. Therefore, the goal of Hanok technology development prioritizes reduction of the construction cost. The Hanok technology development advanced by Ministry of Land, Infrastructure and Transportation since 2009 has resulted new model for Hanok construction that costs under 7 million won per 3.3㎡. However, the majority of Hanok construction still depends on traditional technology, and the estimation of construction cost and formation of customer price are not transparent.

This study analyzed the carpentry works cost which pays more than 30% of the total cost for Hanok construction. This study focused on the analysis of material cost which mainly composes the total construction cost with labor cost due to the labor cost proportionally follows the material cost. Particularly, on the basis of Kan(間), a spatial cube module of Hanok, we investigated trends of the timber cost that varies in roof types and space changes of Hanok. This study estimated the material cost of Hanok that could change for various forms and dimensions of Hanok timber frame and,

as such, explored the approach to reduce the timber construction cost that is a dominant charge for the total construction cost of Hanok.

The species of timbers for Hanok construction were categorized into domestic and imported timbers. The pine tree and larch were main species of domestic timbers for Hanok construction, and the Douglas-per and Hemlock were major species of imported timbers. The larch tree was cheap and difficult to process due to it became too hard after drying, having lot of resin and crack. Generally, the pine tree was preferred. However, it was expensive and the supply and demand were not smooth, and thus the imported Douglas-per was frequently used.

The result of price comparison between domestic pine tree and imported Douglas-per showed price differences by the timber size − different prices by cross section diameter and length of timber in the domestic case; different prices by the diameter regardless of length for the imported timber. Therefore, when the diameter of timber's cross section was over 30cm, the prices of Douglas-per and Hemlock were cheaper than the pine tree; but the price of pine tree was cheaper when the diameter was less than 30cm. That is, the domestic pine trees had price competitiveness when the Hanok buildings was constructed in using of trees with small diameter.

In calculation of the construction cost, the unit cost was generally calculated in accordance with Pyeong or ㎡ but the standard unit of Hanok was generally 'module unit(間)'. The module unit was the unit of design as well as construction so that the cost was favorably calculated by size and type of the module unit. Thus, this study examined the quantity of domestic pine trees used for the module unit. The unit to calculate the quantity of timbers was defined by Jae(才) − volume with section of 3cm(1寸) of length and width and 3.6m(12尺) of height.

The quantity of timbers used in Hanok was determined particularly by the quantity of purlin on the upper part. It was examined that the basic scale was 3 Ryangga with 3 purlins and 5 Ryangga with 5 purlins and it was divided by basic unit, end, and Hoecheom part; the quantity of timbers added according to installation of wooden floor, closet, Soro, and etc. to utilize the space was calculated.

It was assumed that the sizes of 1 Kan were 9 Ja(2,700㎜), 10 Ja(3,000㎜), 13 Ja(3,900㎜) and etc. to calculate the quantity of timbers; total 1,196.3 Jae was used for Kan of 2,700㎜×2,700㎜(7.3㎡ =approximately 2.21 Pyeong), 1,304.5 Jae for 3,000㎜×3,000㎜(9㎡ =approximately 2.72 Pyeong), and 2,426.8 Jae for 3,900㎜×3,900㎜(15.2㎡ =approximately 4.60 Pyeong). To convert it into the quantity of timbers per unit area(㎡), the quantity of timbers used for Kan of 10 Ja was the lowest. When the timber common in market was used, the unwanted part of tree was the smallest. Therefore, the most economic size of module unit was 10 Ja under calculation with the quantity of timbers.

The construction of such Hanok structure as 3 Ryangga with 10 Ja width of a Kan used total 1304.5 Jae for following structural parts: square column, lower · middle · top lintel, Jusimdori, Jongdori, Jusimjangyeo, Jongjangyeo, girder, truss post, rafter, roof board, architrave, and Boaji. The gable roof construction used additional 201 Jae (15.41% increase) for building both ends of the roof with rafter, gable, flying rafter on gable board, and Mokgiyeongaepan; and the hipped-and-gable roof construction spent additional 950.3 Jae(72.85% increase) for Chunyu, Sunjayon, Galmosanbang, Hapgakbakgong · Mokgiyeon · Yeonmok · Gaepan, and Umiryang in camber beam. If the floor form of Hanok was planned to be ‘ㄱ’ or ‘ㄷ’ shape instead of ‘ㅡ’ shape, additional 507.2 Jae(38.88% increase) were calculated due to the installation of Hoecheom part where the roof was bent that added Chunyu, Golchunyu, Sunjayon, Glmosanbang, and Umiryang to roof structure; and the reduced amounts of some rafters.

The construction of Hanok by 5 Ryangga with 10 Ja width of a Kan typically generated Toigan in the roof structure adding 871

Jae(66.77% increase) for building Toibo, Jungbo, Goju, Jungdori, Jungjangyeo, Danyeon, Yeongolgaepan, Boaji, top · lower lintel, architrave, and Dongjadaegong in truss post. The gable roof construction used additional 1,169.9 Jae(89.68% increase) for building both ends of the roof; the hipped-and-gable roof construction spend additional 1,911.7 Jae(146.55% increase); and the Hoecheom part construction required additional 1,368.3 Jae(104.89%).

The installation of Wumul-maru in the floor added 157.5 Jae (12.07% increase) for Jangguytle, Dongguytle, and Marupan; the Toenmaru installation used additional 65 Jae (4.98% increase) for Toijangguytle, Toidongguytle, and Toenmarupan; the installation of wardrobe added 64 Jae (4.91% increase) for wooden wardrobe; and the Soro installation used additional 111 Jae (8.51% increase) for Ikgongboaji, Judu, Soro, Sorobangmak, and Changbang.

This study found that the construction cost could be reduced in the planning stage of Hanok as the calculation results of the quantity of timbers for constructing wood structure of Hanok that varied by the dimensions of Kan, types of roof and floor plan, and structural system of Hanok. For example, 1 Kan of Hanok should be planned less than 3m, not to be over the general unit of timber; when the scale was expanded, the front · rear Toigan could be favorably installed instead of expansion of the length of Kan; and the type of roof should be thoroughly considered since the hipped-and-gable roof required 1.3~1.5 times of quantity of timbers than the gable roof.

This study also estimated the carpentry construction costs of Hanok buildings utilizing above results. Considering with the popular housing construction cases of 40㎡ for tiny Hanok, around 50㎡ for samll size Hanok and around 70㎡ for mid size Hanok, we calculated the quantity of timbers for Hanok as well as approximate construction costs based on the proportion of unit and labor costs.