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Influencing Variables and Keywords of Technology Strategy for Modernized Hanok Research

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Abstract: As eco-friendly and sustainable architecture is becoming more popular, the interest in Korean traditional wooden buildings (Hanok) has also been increasing. The building technologies of the wooden construction have been actively developed in all over the world through the diversification of new materials and construction methods. On the other hand, the growth rate of wooden construction market is still slow in Korea. In an attempt to promote the Korean traditional wooden buildings, a comprehensive research project has been conducted. This R&D project is developing standard designs, new materials, and methods for modernized Hanok including houses, public buildings, long-span structures, and even high-rise buildings. To this end, the purpose of this study is to formulate a technological strategy for popularization of modernized Hanok. Influencing variables and issues are analyzed and defined first. At the same time, the five keywords have examined in the perspective of dissemination of modernized Hanok technology. Finally, a technology road map for strategic development of modernized Hanok is proposed through casual diagrams.

Key words: Hanok, modernized hanok, influencing variables, keywords of technology strategy

1. INTRODUCTION

As eco-friendly and sustainable architecture is becoming more popular, the effort to develop Korean traditional wooden buildings (Hanok) has also been increasing in Korea. However, while the wooden construction market has been increasing along with the development of wooden building technology globally, the growth rate of domestic wooden construction market is still slow. As a part of effort to improve this problems, the government has been conducting a comprehensive research project on the development of modernized Hanok building technology [1]. At the same time, the issues related to technology development have examined in the perspective of dissemination and popularization of modernized Hanok technology.

The purpose of this study is to propose a technological roadmap that is essential for long-term technological development in the perspective of industry level. The research methodology is to analyze and define the influencing variables and keywords of modernized Hanok technology.

Finally, based on these analysis, this research analyzes the fundamental technical support methods and suggests a strategic direction.

2. MODERNIZED HANOK

2.1. Characteristics of Hanok

The development of Korean traditional wooden building technology has continued reflecting both the values of tradition and characteristics of contemporary life. However, there are some obstacles such as the technical difficulty, higher construction cost compared with other countries' wooden building and low residential performance, etc. [2]. Therefore, it makes it difficult to popularization the Hanok building and its technology.

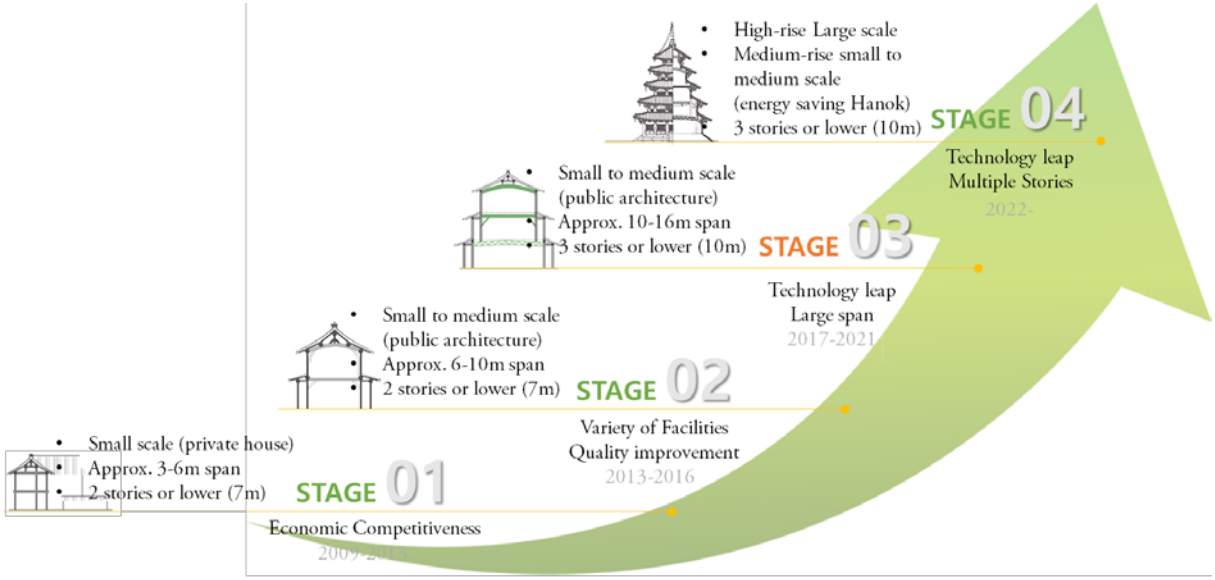

Figure 1. Long term plan for development of modernized Hanok technology [3]

Therefore, the government has been conducting a research on the advancement of modernized Hanok technology to settle these difficulties and improve economic efficiency through the development of new materials and building methods [1].

2.2. R&D project

The research on the "Development of modernized Hanok technology" has been conducted in four stages since 2010 (Figure 1). It includes a wide range of size, height and facility (e.g. from small-scale to large-scale, from low-rise to high-rise and from house to public building). This R&D project also includes the dissemination policy, architectural design, new material, building methods, construction management and information management system.

Especially, this study has focused on the reduction of construction cost and improvement of construction productivity. In addition, the applicability has been examined through six test-bed projects [2].

3. DEFINITION AND ANALYSIS OF INFLUENCING VARIABLES

In this chapter, the influencing variables of modernized Hanok technology are defined and analyzed (Figure 2). In addition, major issues are proposed for dissemination of modernized Hanok technology. Influencing variables includes timber frame type, architectural style, facility type, building size.

3.1. Timber frame type

Timber frame type is a major variable because these are related to the member size, distribution method and building methods. It can be classified into three types: light-frame wooden structure, heavy-frame wooden structure and cross-laminated timber (CLT).

Traditional Hanok has been developed into heavy-frame wooden structure with traditional and unique wood-frame method. Thus, it was limited to specific areas of building methods, design and facilities.

However, as the facilities type is diversified and the size of building is larger, to realize this, diversification of timber frame type and building methods for wooden structure is necessary. In addition, in terms of constructability and economic efficiency, it is necessary to expand the application of CLT and other wooden structures in future.

3.2. Architectural style

The architectural style can be classified by the period, materials, and structural type, etc. In this study, based on these criterions, it is categorized into three types: traditional Hanok, modern Hanok and Modernized Hanok.

Although the components of traditional Hanok have unique aesthetic aspects, complicated timber processing and joint method have been obstacles to the dissemination of Hanok to public due to technical difficulty and construction productivity.

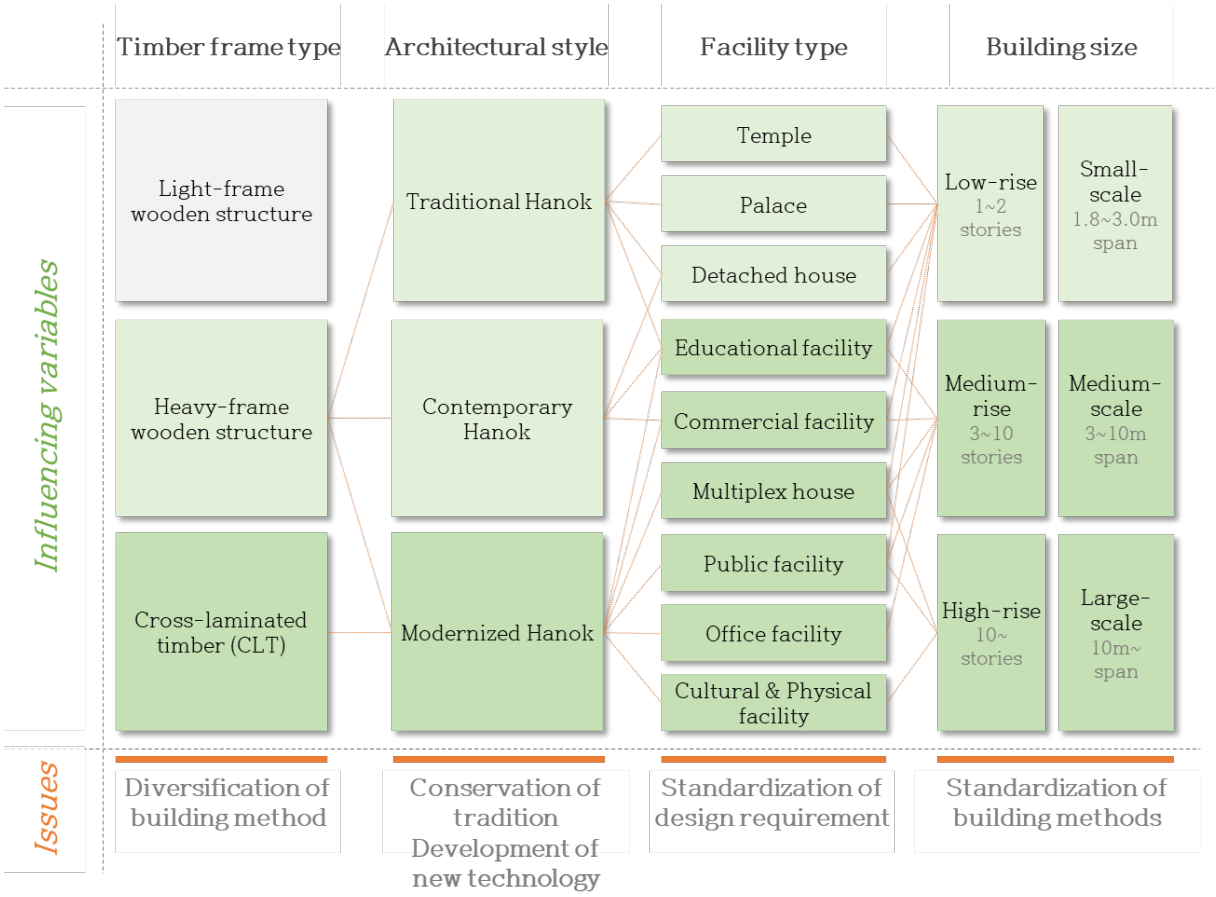

Figure 2. Influencing variables and Issues of modernized Hanok technology

In the research of modernized Hanok, various structural methods have also been attempted by changing the roof frame structure and use the joint metal instead of the traditional joint method (mortise and tenon joint). However, these alterations have been discussed as to how much can be included in the value of the tradition of Hanok. Therefore, the specific standards should be examined in terms of the conservation of tradition and application of new technology.

3.3. Facility type

Facility types are categorized according to building use and building law and consist of detached house, multiplex house, commercial and public facilities. Although the scope of traditional Hanok facility was limited to small residence, it has gradually been being expanded to multiplex house or public facilities since the modernized Hanok technology was developed.

In addition, the classification of these facilities was closely related to the building law in regards to the design standards, facilities and safety. Furthermore, it can serve as a major practical requirement for design work of the modernized Hanok.

Therefore, it is necessary to define the design requirements for each facilities and the standardization of design should be developed.

3.4. Building size

As the size of buildings becomes more diverse according to the facilities, the structure and wooden construction technology for high-rise and large-scale are required. The building size classification of Hanok is divided into low-rise, medium-rise and high-rise according to its height of the building and small-scale, medium-scale and large-scale according to the length of the beam.

Currently, there are technical difficulties to build a large-scale Hanok, so research on various structural technologies, building methods and also its application are required. In addition, the standard specifications that propose detailed descriptions of new building methods should be established and disseminated.

4. KEYWORDS OF TECHNOLOGY STRATEGY

Based on the influencing variables, the keywords of technology strategy for development and popularization of modernized Hanok were proposed (Figure 3). These five keywords include 'standard supply chain protocols, prefabrication & OSC, industry standard classification, knowledge repository & standard performance, automated life-cycle'.

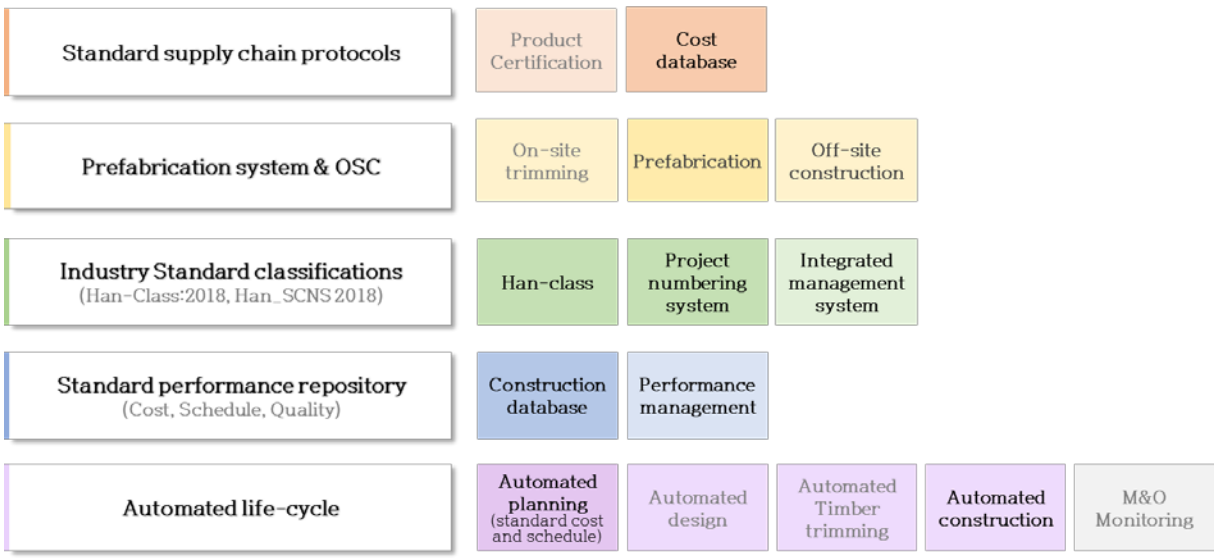

Figure 3. Keywords of technology strategy

4.1. Standard supply chain protocols

The production of standardized components and supply chain are very important in mass production and industrialization. However, the standard size and standard performance of materials used in modernized Hanok have not yet been established and the supply chain has not been organized systematically.

Therefore, there has been a continuous discussion in this study for standardization of the member size, certification of materials and establishment of efficient supply chain system. As first step to establish the supply chain for efficient procurement, the web-based construction cost catalog was developed to provide price information to general users. Also, the ways to be integrated and managed together with the standard of estimate for modernized Hanok construction was examined in the previous study.

Based on these efforts, if the historical database is accumulated more, it will be able to secure a supply chain systematically.

4.2. Prefabrication & OSC

The production method of components is a key factor that has a great influence on labor cost, time, quality, etc. Traditional Hanok applied a method of trimming timber on construction site because of its mortise and tenon joint method. However, most of the projects have currently applied the manufacturing method, and it has also been converted to prefabrication method and modularization [4]. In particular, in order to reduce labor cost, which is a big part of the Hanok construction project, the pre-fabrication should be applied actively. Furthermore, if the standard of materials and supply chain system are well established, the off-site construction (OSC) system will can be systematically applied to shorten the construction time, improve productivity and quality of Hanok.

4.3. Industry standard classification

The establishment of standard provides efficient measures for practical implementation at the industrial level and builds the base of industrialization system. It is also the most basic thing in order to share the information of each project participant. In this study, the classification reflecting the characteristics of Hanok (HanClass: 2018) was developed, and it has been continuously updated in order to be used to any modernized Hanok construction project.

In addition, based on these standard classifications, project numbering systems (PNS: work breakdown structure, cost breakdown structure, physical breakdown structure, geometry breakdown structure, etc.) was developed for automated data collection and analysis.

It also provides standard statement and schedule which can be universally available for all Hanok projects. Furthermore, the 5D-CAD integrated management system developed based on geometry breakdown structure (GBS) facilitate efficiency for project management. In order to continue the integrated data management for automation of project management, it is necessary to continuously develop and update these standard [5].

4.4. Knowledge repository & Standard performance

The actual construction data in the relational database based on HanClass (2018) enables to manage project schedule, cost and performance and also it is actively used for research through the automated analysis. For example, the previous researches include the following subjects: the productivity analysis by work section of modernized Hanok according to changes in building methods and materials [6], cost and duration analysis according to development of building method [7] and influencing factor of variation of building method and cost [8].

In addition, the guideline can be suggested based on construction database, which can lead to systematic performance management with 5D-CAD.

4.5. Automated life-cycle

The research on the automation in entire throughout the project life-cycle has been performed to improve productivity and reduce cost. In the planning phase, an automated program was developed to make a standard statement and an initial schedule easily depending on the project information. Also, in the design phase, the BIM library, algorithm [9], and the structural design software [10] was developed to provide the general public with design tools that help them to design Hanok more easily.

In construction phase, a rafter machining process was invented that could easily produce members of Hanok using laser scanning technology to reduce the labor costs [11]. In addition, a preliminary study on mobile application using augmented reality technology and 5D-CAD was conducted for improvement of workability and schedule management on Hanok construction site. Likewise, the construction robot manipulator for automation on the construction site should be introduced more actively to reduce the cost of the Hanok project. These studies have identified the possibility of comprehensive management throughout the life-cycle based on a 5D-CAD system. In addition, if automation in the M&O phase are further studied, it is expected that integrated project management in the entire life cycle will be possible in the future.

5. CASUAL DIAGRAM

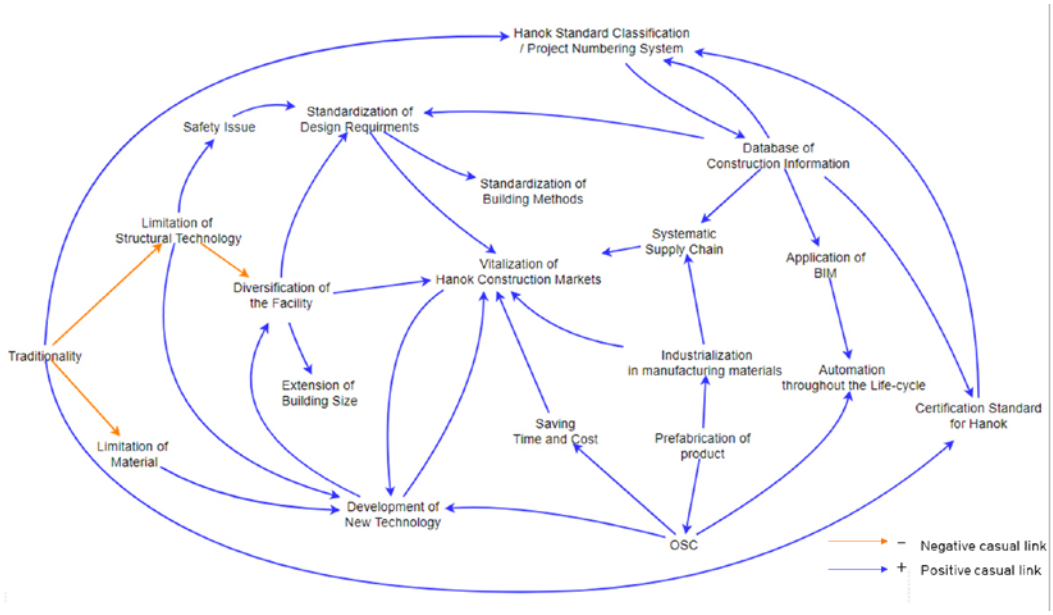

Figure 4. Casual diagram of modernized Hanok research project

In the previous chapter, four types of influencing variables related issues and the five technical strategies were discussed. In this chapter, based on the factors described above, the overall context of modernized Hanok research is reviewed and comprehensive technology strategies are summarized through casual diagrams that can identify causal relationships with each factor (Figure 3).

The traditional value of Hanok is very important, but, due to its material and structural technology limitations, it is difficult to diversify facilities and popularize Hanok architecture. Therefore, it is necessary to resolve these problems by developing various technologies within the scope of maintaining its traditional uniqueness. Thus, the classification that reflects the characteristics of the Hanok should be used to create and manage the certification standard of Hanok.

In addition, as Hanok project takes more time and cost than other wooden building, it is needed to be applied more actively the prefabrication technology and OSC method, which should utilize standard supply chain, BIM and automation technology based on accumulated database and PNS.

To this end, for the long-term technological development of Hanok, standardization of design standards and building methods based on abundant databases will be a way to utilize and popularize hanok technology more efficiently while keeping the value of Hanok well.

5. CONCLUSION

There has been an effort to popularize the development of technology for hanok wooden buildings as the interest in hanok has been increasing. To this end, the purpose of this paper was to identify influencing factors and issues of Hanok technology first and then suggest technology strategies of Hanok.

The influencing factors are defined as ‘timber frame type’, ‘architectural style’, ‘facility type’, and ‘building size’ and their issues are analyzed as ‘diversification of building method’, ‘conservation of tradition & development of new technology’, ‘standardization of design requirement’ and ‘standardization of building methods’.

Based on the influencing variables, the five keywords of technology were proposed as ‘standard supply chain protocols’, ‘prefabrication & OSC’, ‘industry standard classification’, ‘knowledge repository & standard performance’ and automated life-cycle’.

Finally, the overall context of modernized Hanok research is reviewed and comprehensive technology strategies are summarized through casual diagrams. More actual data shall be accumulated based on the Hanok classification and automation technology, prefabrication and OSC method should be applied more actively. In addition, standard design requirements and building methods including new materials and technology of Hanok can be proposed to promote popularization of Hanok technology.

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