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A Study on the Smart Architecture Industrialization Model and its Institutional Basis

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SUMMARY

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1. Study Results

This study arose from the need to respond to the paradigm shift in domestic and foreign industrial production and management based on ICT combined with Fourth Industrial Revolution technology, and to improve production methods in the existing construction industry, which is labor-intensive and harsh on the environment, while improving building performance and service provision. As a strategy to achieve this purpose, the study was conducted for the purpose of preparing a smart architecture industrialization model and system expansion plan. To this end, the current status of the domestic construction industry and tasks to respond to changes in the omnidirectional industrial paradigm were reviewed, and smart architecture was defined in connection with various concepts corresponding to smart architecture. In addition, the requirements and strategies of smart industrialization were investigated based on other industries, and implications were revealed to present a smart industrialization model of architecture. Finally, the institutional means required for the

implementation of this model were examined. The main results of this study are as follows.

☐ Changes in the Domestic and Overseas Industrial Environment and the Focus of the Construction Industry

Referring to domestic and overseas major industry forecast reports, in the 1990s, as the need for discussions on the knowledge-based economy rapidly emerged in Korea and overseas, a consensus was formed on the importance of securing new technologies. In the 2000s, discussions on the reorganization of the global value chain took place, and innovation-related policies for the development and application of digital technologies were promoted. In particular, recent industrial policies are focused on the modernization of existing industries and fostering new industries, and lack clear boundaries between manufacturing, the service sector, and different industries.

In the construction industry, changes in production management methods to improve design and construction efficiency are emerging. The rapid shift in the industrial paradigm based on the digital economy and digital capital have given rise to the need for innovation of production methods in the design and construction processes in the construction industry. By utilizing a digital data-based target site analysis program, BIM, 3D printing, digital twin, etc., standardization, modularization, and productization are also being implemented to streamline labor and site-oriented design and work in the construction phase, and to facilitate linkage with a wide range of industries.

The introduction of new technology is expected to not only improve productivity in the construction industry, but it is also expected to enable the creation of new business models incorporating the technology. In addition to this, there is an increasing demand for improving socioeconomic functions and the value of buildings created by implementing new industrial technologies. Improvement of the value of the external environment surrounding buildings has also become an important consideration in addition to convenience and cost reduction for facility users, and improvement of physical performance such as energy and safety.

☐ Current Challenges in the Construction Industry Resulting from Changes in the Industrial Environment

According to industry statistics published by Statistics Korea, the construction industry accounts for a very high proportion of the total economic activity in Korea, and its significance continues to grow. In fact, the number of businesses and employees in the construction industry has been continuously increasing over the past five years, and the scale of revenue has also been steadily increasing, resulting in an increasingly growing industrial scale. In addition, when looking at building permits, construction start, building status, etc., there is a continuous demand for construction, and there is a high level of potential for employment and added value in the industry, and a potentially high impact on other industries.

At the same time, however, productivity in the construction industry is relatively low. The labor productivity of the manufacturing industry and the information and communication industry has improved over the past five years, while the labor productivity of the construction industry has decreased. Compared to the manufacturing industry's labor productivity of 112.7 in 2020, the construction industry recorded only 104.0 and the construction service industry only 89.8, indicating that the construction industry still relies heavily on the labor force. In addition to productivity, objectivity is lacking in decision-making systems in the design and construction processes, resulting in changes in design, delays in construction period, and numerous disputes.

In particular, in the construction process, workers have a high risk of falling victim to industrial accidents and consume a lot of resources, so it takes a lot of money to manage and control risk factors, while the amount of waste and energy used during production is also significantly higher than in other industries. Ultimately, such problems can only be considered in connection with the problems or limitations of the production structure and methods of the existing construction industry.

Based on these points, four major challenges faced by the construction

industry are presented. First, there is an urgent need to transition to smart architecture through the commercialization and diffusion of more efficient and productive smart technology, and data collection and analysis are required for this purpose. Second, it is necessary to promote the convergence of multi-sector industries by utilizing smart technology, improve the building production process and quality, and improve the level of service. Third, in order to build a digital-based industrial innovation market, it is necessary to discover new business models and cultivate human resources who can respond to market demands. Finally, it is necessary to expand the role of governments, such as in active R&D and corporate promotion, to expand the market for new industries.

□ Definition of Smart Architecture

By referring to the current challenges of the construction industry, examples of architecture and other fields applying smart concepts, and the results of surveying/analyzing smart architecture cognizance and requirements, the concept of "smart architecture" is broadly interpreted, and it has been defined as a more expanded and flexible concept, including services related to the production, distribution, and consumption process of architecture as a product for industrial activities. The values that smart architecture should have are mainly divided into five categories as derived from the research process.

First off, the definition of smart architecture, which was narrowly interpreted in previous studies as 'buildings', which is the final product of the construction industry, has been expanded to the 'act of building' as an industrial activity covering all stages of production, distribution, and use of buildings. Second, a collaborative network of ICT-based smart technology companies is needed in the physical environment of the existing construction industry. Third, a physical and digital environment in which automatic data analysis of buildings is possible must be created, and fourth, using smart technology, it is possible to create manufacturing buildings and economic and environmental values.

Finally, smart technology is converged and connected with buildings to improve the quality and service of buildings, and to improve the quality of life of users and enhance the level of urban space.

Reflecting these points, smart architecture has been defined as the "planning/design/construction and maintenance of buildings by combining ICT and digital information-based smart technology to improve the efficiency, productivity, and economic feasibility of architectural design and construction, and to improve the function and user service quality of buildings".

☐ Direction and Tasks to Create a Smart Architecture Industrialization Model

Industrialization models in other fields largely consist of public support for industrialization, institutional devices, and activity systems of actual stakeholders in the industry. The characteristics and implications of these models can be largely divided into five categories. First, the target of smartization must be converted into a form that converges not only the production process but also related services. Second, as a policy, it is necessary to induce a self-sustaining smart industry ecosystem by supporting the front and rear industries linked to the relevant industry. Third, an open cooperative network between SMEs should stimulate corporate innovation. Fourth, by building an open Big Data platform, it is necessary to activate the development of products and services using industry-related Big Data. Fifth, institutional devices essential for smart industrialization should be operated together. A support system for promoting smartization should be prepared along with the provision of systems for areas that are not in accordance with the current law.

When referring to the current challenges, concepts and requirements of the domestic construction industry, and examples of smart industrialization in other fields, the industrialization model for industrial revitalization of smart architecture can be set based on four main aspects. First, the objectives of the

smart architecture industrialization model and the target market should be determined. This means that it is necessary to set the targets that can be applied for smart construction that introduces smart technology to the production methods of the existing construction industry and to set the objectives to be achieved.

Moreover, in addition to existing traditional architectural services such as architectural design and construction as the main industrial activities of construction companies, it is possible to induce the participation of specialized companies that can develop and utilize smart technology for each construction phase, establish an industrial ecosystem where various industry stakeholders can converge/collaborate, and establish an open platform for exchanging and communicating technical information. Finally, the scope of public policy and institutional support is determined. In the initial stage, it is necessary to support technology development and demonstration through R&D projects, etc., continue to promote policies for fostering manpower and specialized companies, and reorganize related laws and regulations.

In this regard, the vision and objective of revitalizing the smart architecture industry can be discussed in connection with the shift in the industrial paradigm identified during the smart building concept setting process and the task of responding to the immediate challenges of the domestic construction industry. The key here is ‘production method innovation through digitalization and standardization’, 'sustainable production' based on this, and 'improving building quality and service use' and 'quality of life' as a result of this. This is the vision and practical objective of the smart architecture industrialization model. Based on this, establishing an industrial ecosystem capable of convergence of the existing construction industry and smart technology; establishing an industrial ecosystem network and user service provision platform; and securing an institutional support system, were set as sub-strategies, and the detailed tasks are presented.

☐ Role of Each Subject in the Smart Architecture Industry

The client of the smart architecture industrialization model plans and promotes the business and provides funds. The demand for smart architecture is expected to occur in industrial facilities, educational welfare facilities (medical facilities, schools, etc.), and residential facilities, and this can be presumed to be due to the need to install and manage sophisticated facilities. The client's business plan leads to the provision of new businesses and jobs in the market. It is necessary to plan and place orders so that various participating entities in the new industry can develop business models and create economic ripple effects due to the shift in the industrial paradigm.

Business planning and ordering induces the participation of experts and companies in related fields. Since smart architecture uses a much higher proportion of ICT and software than existing construction industry activities, the participation of the relevant experts in the design phase is essential. In particular, in the design process, the requirements and potential of all buildings should be checked and optimal alternatives should be identified. When considering facilities requiring smart architecture (industrial facilities, medical facilities, etc.), the use of a computer program capable of simulating numbers in a wide range of scenarios due to the complexity of the construction performance level makes it possible to enable more accurate design, which in turn leads to maintenance methods in production, construction, and use of the product. Therefore, in cooperative processes, more efficient and functional construction alternatives can be identified and can be used as a stepping stone for the establishment of various industrial ecosystems.

Public institutions operate smart technology platforms and systems. The role of the public sector is to provide various smart solutions to stakeholders in the smart architecture industry by creating new jobs through nurturing companies that make up the smart industry ecosystem and participating in direct ordering; managing the quality of smart architecture by evaluating performance and providing incentives in the smart construction process; and building/operating

a smart architecture technology and service platform like in other industries. In addition, data on building production and use data are collected from industry officials and building users, and these can be linked to the collection of Big Data for re-creation of new information.

Users provide the demand for smart service and provide information on the use of buildings. Building users receive services in such areas as safety, convenience, and comfort from buildings created based on smart architecture in a more technologically advanced way. In addition, the users themselves can control the environment of the spaces they use by using smartphones or ICT devices, and relevant information can be provided to the interworking system of the smart technology and service platform. Meanwhile, smart architecture can record and collect data about the environment surrounding the building regardless of the user's intentions, and likewise, it is possible to provide related materials to the technology and solution platform automatically. The data provided in this way can be converted into Big Data through a smart platform and a linked platform and can be used again as data for the production of new information on the construction industry.

☐ Proposal of System Expansion Plan for the Smart Architecture Industrialization Model

Based on the policies on the legal system related to smart architecture presented above, four institutional alternatives were suggested for the operation of the industrialization model. First, referring to the existing building certification/special case system, a smart architecture certification system that reflects the characteristics of smart architecture is introduced. Smart architecture, which can measure and evaluate digital information-based performance, is linked and utilized as a certification system, and it allows users to determine the level of smart architecture for each building environment, and as a result, provides a foothold for gradually spreading the industrialization model in the construction market. By referring to the special

provisions for remodeling under the current Building Act and the special regulations applied to buildings in special building zones, executive power can be enhanced by linking with incentives that can be provided upon acquisition of smart architecture certification.

Second, the standards of existing building and construction laws related to smart architecture are revised. It is necessary to actively introduce 'smart architecture' regulations into building/construction-related laws such as the Building Act, Framework Act on Building, Act on the Promotion of the Building Service Industry, and the Framework Act on the Construction Industry. In the Building Act, the concept of smart construction should be defined, and measures to activate smart construction design techniques and technologies, smart construction technologies, and convergence construction technologies should be prepared based on the Framework Act on Building and the Framework Act on the Construction Industry. In addition, so that the safety of buildings is not threatened by smart architecture, building standards for structure, fire, and evacuation safety set forth in the Building Act and subordinate statutes should be added. In the Act on the Promotion of the Building Service Industry and the Framework Act on the Construction Industry, related technology, performance management, and professional human resources development should also be revised.

Third, policy pilot projects for the diversification and expansion of the smart architecture industrialization model should be promoted. To this end, it is necessary to secure an organizational system that can establish and implement comprehensive policies that can be linked to other fields by establishing a 'Smart Architecture (tentative name) Committee' within the Fourth Industrial Revolution Committee established and operated by the government. In addition, it is necessary to develop and reorganize the smart city and smart building certification standards together to enable smart city linkage projects described in the Act on the Promotion of Smart City Development and Industry currently in effect. Finally, it is necessary to first apply the smart architecture

industrialization model in the public sector. In other words, the public sector applies the smart architecture model first and integrates the relevant certification system in phases to promote a policy for establishing an evaluation operation system that encompasses related planning and management.

2. Future Tasks

□ Development of Smart Architecture Performance Measurement and Evaluation System

In this study, the introduction of the smart architecture certification system was proposed as a short-term strategy for implementing the smart architecture industrialization model; however, detailed regulations on evaluation indices, grading, and evaluation methods for certification were not presented. When a smart architecture business model is decided on in the future, it will be necessary to prepare concrete plans for the operation of the evaluation system and certification system for each type. Just as the intelligent architecture certification system divides facilities into residential and non-residential facilities, or assigns grades according to detailed items and evaluation criteria for each planned field, the evaluation system of the smart architecture certification system should also be configured differently depending on the purpose of the building. In this case, the system can be divided into the common requirements of the unique characteristics of the architecture, that is, performance, manufacturing, and commerciality, and the requirements for each type of architecture. In terms of smart service production, it is predicted that the proportion of spatial and structural planning will be greater than the current intelligent architecture evaluation standard.

☐ Smart Architecture Business Model Development by Building Type

In this study, smart schools were briefly used as an example among the types of construction projects that can be implemented based on the smart architecture industrialization model. When considering the spatial characteristics of unit modules or facility conditions that require cutting-edge educational equipment, smart schools have many advantages as a smart architecture business model. In particular, in the recent situation in which the proportion of remote education has been increasing, smart schools can be a suitable test bed. Facilities with similar conditions include hospitals, apartment houses, and hotels, and other commercial and business facilities can be commercialized as smart Architecture by level. In addition to the use of smart architecture, the entities involved in projects must also be determined, and smart architecture requires the participation of experts in smart technology. In the current building laws, the roles of architects and construction engineers are limited in construction projects, so it is necessary to prepare standards for the establishment of a collaborative network for each type of smart building project, and to define roles, responsibilities, and authority.

☐ Research for the Enactment of Special Laws for the Revitalization of the Smart Architecture Industry

In the policy proposals of this study, the enactment of individual laws specific to smart architecture is presented as a mid- to long-term strategy for revitalizing the smart architecture industry. As shown by previous studies, the construction industry accounts for 4.5% of the country's GDP, and is an industry with high economic impact in terms of scale. In addition, it is directly related to the quality and safety of people's lives, and it is a symbol of social/national identity. Considering the omnidirectional changes in the architectural environment, the proportion of smart architecture is expected to expand gradually. Therefore, based on the phased progress of the smart architecture industrialization strategy in the future, as a more comprehensive and comprehensive mid- to long-term industry revitalization

strategy, a study on the ‘enactment of a special law for the promotion of the smart architecture industry (tentative name)’ is also required.

Keywords

Smart Architecture, Smart Architecture Platform, Smart Technology, Industrialization Model, Industrial Ecosystem