ICCEPM 2024 https://dx.doi.org/10.6106/ICCEPM.2024.0033
The 10th International Conference on Construction Engineering and Project Management
Jul. 29-Aug.1, 2024, Sapporo

Survey-based User Perception Analysis for Off-site Construction in Institutional Building

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Abstract: Off-site construction (OSC) is an architectural approach involving the prefabrication of building structures, components, parts, and equipment in a factory, followed by transportation to the construction site for assembly and installation. This method is particularly suitable for buildings with simple, repetitive structures and straightforward processes, such as hospitals, hotels, and schools. However, the inherent prefabrication characteristic has led to a widespread negative perception among the general public, resulting in significant resistance, especially from parents, concerning educational buildings utilizing OSC. In response, this study targeted users currently employing OSC in institutional buildings to analyze critical perception factors and derive avenues for enhancing the activation of OSC methods. The survey, categorized into seven factors, revealed that safety factors received the most positive responses, while social factors were identified as the most negatively perceived. The analysis of improvement requirements for OSC indicated that addressing issues related to hazardous material exposure and improving air quality are crucial in the equipment and eco-friendly aspects. In terms of design and usability improvement, maintaining harmony with the surrounding environment was identified as essential. Ultimately, this study anticipates the activation of OSC through the analysis of user perceptions and improvement suggestions for each OSC factor.

Key words: Off-Site Construction, Institutional Building, Survey, User Perception

1. INTRODUCTION

Amid various issues such as declining productivity, deteriorating building quality, and increasing safety concerns in the recent construction industry, Off-Site Construction (OSC) has been suggested as an alternative solution [1]. OSC is a construction method where building elements, components, pre-assembled parts, and modular units are produced off-site and transported to the construction site for assembly and installation, differing from traditional on-site construction methods [1]. In contrast to traditional on-site construction, OSC entails the prefabrication of architectural components in a factory, facilitating standardized processes and heightened quality.

OSC is gaining global attention for its ability to simultaneously enhance construction project speed, cost-efficiency, and overall building quality. According to a report by Allied Market Research (2021), the global OSC market is estimated at $130.4 billion as of 2020 and is expected to grow to $235.46 billion by 2030 (with a CAGR of 5.9%) [2].

Leveraging the advantages of OSC buildings, there is a growing interest in applying them to public buildings, especially schools. In response to overcrowded classrooms, the Korean Ministry of Education has proposed a comprehensive plan for educational recovery, suggesting the inclusion of modular classrooms in new and expanded schools and placing modular classrooms in schools facing temporary overcrowding issues [3]. However, the application of such innovative construction methods has sparked negative perceptions and concerns among some users, particularly in institutional construction centered around educational facilities. The introduction of OSC in public building construction, especially in educational institutions, has faced significant opposition from parents and education stakeholders.

Therefore, it is necessary to draw conclusions based on objectively collected data from real users of OSC public buildings, comparing public perceptions and addressing negative concerns. Hence, this study aims to investigate users' perceptions based on the impact factors of OSC buildings through a survey and derive improvement measures.

2 LITERATURE REVIEW

In the midst of revolutionary changes in the construction industry, there is a burgeoning research focus on the activation of buildings using innovative OSC methods. A preceding study [4] defined project characteristics influencing construction difficulty based on the selection of OSC methods through prior research surveys. Expert consultation was employed to calculate construction difficulty indices for each method. Subsequently, a decision-making system capable of selecting the optimal construction method based on project characteristics and cost considerations was developed. Virtual data input simulations were conducted to validate the utility of the decision-making system. In specific construction methods, a case study [5] delved into detailed indicators and methodologies for analyzing the cost-effectiveness of OSC implementation in on-site activities, particularly in the context of Precast Concrete (PC) methods, drawing from existing literature and prior research. Furthermore, another study [6] conducted an IPA survey on the core success factors of OSC, deriving key improvement factors to enhance the adoption and utility of OSC in South Korea. However, it is notable that these studies primarily targeted OSC industry experts through surveys, leaving a gap in research focusing on actual users who may not be experts in the field.

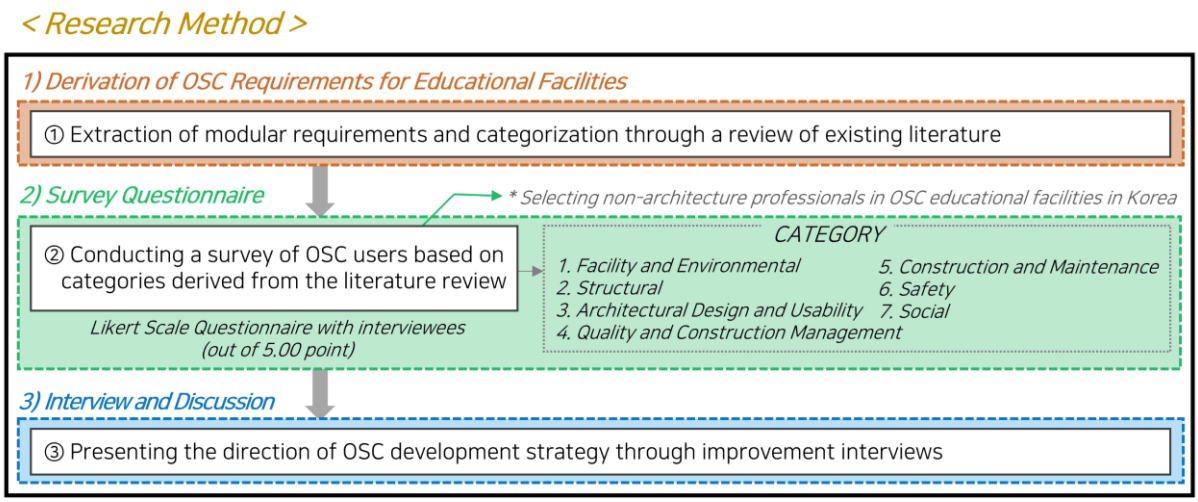
Therefore, this study aims to analyze key perception factors of OSC buildings by actual users who are experiencing OSC buildings, hindered by negative perceptions from the general public. Through a survey, the study intends to derive strategies to promote the activation of OSC methodologies.

3. RESEARCH OBJECTIVE AND METODOLOGY

The main objective of this study is to examine whether users of OSC buildings perceive a negative perception similar to that of the general public. The goal is to identify modular improvement suggestions from the perspective of users. To achieve this, a survey and interviews are planned with non-architecture professionals working in OSC educational facilities. To facilitate smooth execution, the study has been limited to Korea, where negative perceptions of the introduction of OSC buildings are assumed.

The research consists of three phases, as illustrated in Figure 1. First, existing literature will be reviewed to derive modular requirements for OSC methods, school construction, and public facility construction. Subsequently, the identified factors will be categorized, and survey questions will be formulated in a way that non-experts can understand. Responses to the questions will be quantitatively assessed using a Likert Scale, with answers rated on a scale of 'Strongly Disagree' 1 point, 'Disagree' 2 points, 'Neutral' 3 points, 'Agree' 4 points, and 'Strongly Agree' 5 points. Positive responses, including 'Strongly Agree' and 'Agree,' will be classified as positive, while negative responses, including 'Strongly Disagree' and 'Disagree,' will be categorized as negative for analysis. Finally, interviews will be conducted to collect improvement suggestions and consolidate opinions.

Figure 1. Methodology of the research



4. FACTORS BASED ON THE REQUIREMENTS OF OSC BUILDINGS

We gathered 25 prior studies focused on the OSC industry, public facility construction, and school construction [7-31]. Extracting and categorizing the requirements of OSC buildings resulted in a total of seven factors, as summarized in Table 1: facility and environmental factors, structural factors, architectural design and usability factors, quality and construction/management factors, construction and maintenance factors, safety factors, and social factors.

Table 1. OSC building factor-specific requirements and significance

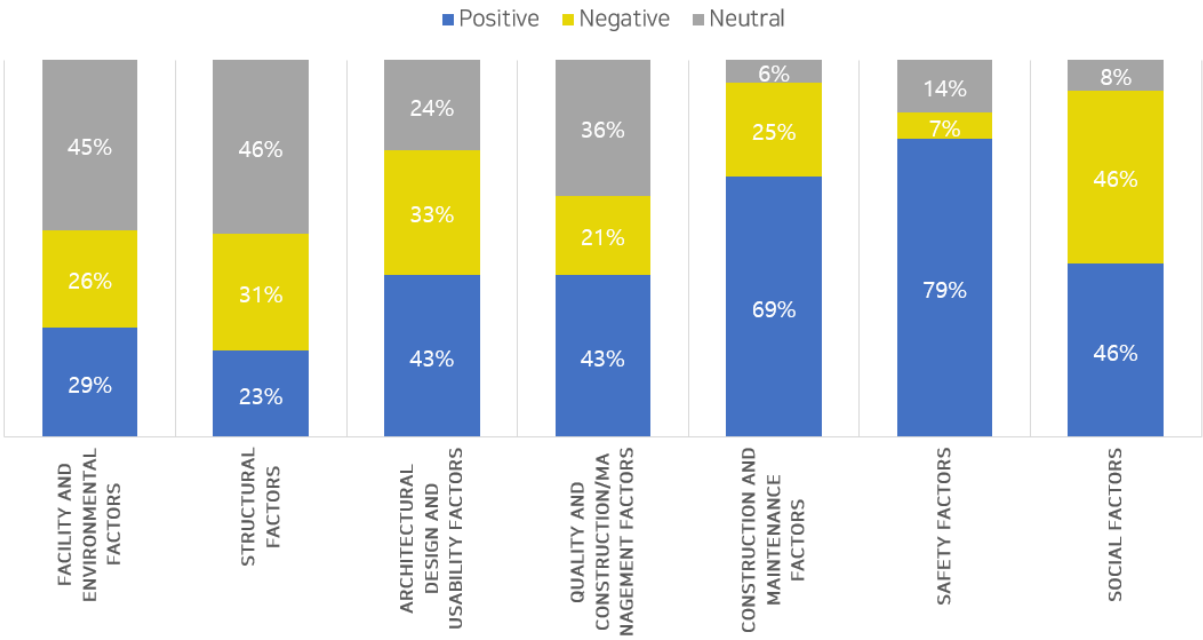
Division	Requirements	Significance
1. Facility and Environmental	The Presence of Environmental Friendliness in OSC Buildings	Is environmental friendliness necessary for eco-friendly school construction?
		Can greenhouse gas reduction be effectively achieved?
	Reduction Degree of Waste in OSC Buildings	Is waste reduction possible through OSC construction?
	Degradation Level of Indoor Air Quality in OSC Buildings	Is improvement needed for indoor air quality degradation?
	Existence of Sustainability in OSC Buildings	Is OSC construction sustainable?
	Degree of Lighting and Illumination Adequacy in OSC Buildings	Is effort required for ensuring adequate lighting and illumination?
2. Structural	Existence of Performance Standards in OSC Buildings	Are specific performance criteria established?
	Degree of Structural Design in OSC Buildings	Can the floor plan be designed in various shapes?
		Is remodeling and spatial change of the structure facilitated?
	Selection of Appropriate Structure in OSC Buildings	Can a structure be selected according to specific situations?
	Stability of PC Component Junction - Stable or Unstable	Does the PC structure meet the required structural performance?
3. Architectural Design and Usability	Harmony with Surrounding Buildings in OSC Buildings	Is it aesthetically harmonious with the surrounding environment?
	Feasibility of Applying Design to OSC Buildings	Is the application of universal design feasible?
	Occurrence of Vibration in OSC Buildings - Present or Absent	Vibration measurement. Does the evaluation comply with ISO10137 residential standards?
	Assurance of Quality in OSC Buildings	Does the design meet the required quality level?
	Possibility of Noise Generation in OSC Buildings	Does the design comply with quality evaluation criteria?
		Does the soundproofing performance of OSC construction meet the standards?
		For remodeling projects, is there a need for pre- and post-measures for factors that may cause complaints?

4. Quality and Construction Management	Presence of Inspection for OSC Components	Is there a need for quality inspection of PC components?
	Performance Level of Waterproofing Method for OSC Components	Does the waterproofing performance of OSC construction meet the standards?
5. Construction and Maintenance	Feasibility of Progress Management in OSC Construction	Is it possible to achieve air reduction through the use of progress management in public construction projects?
	Potential for Cost Reduction in OSC Construction	Can cost-saving effects be obtained by utilizing factory-produced modular components?
	Existence of Facility Management Plan for OSC Buildings	Is there a need for facility management processes for PC structures?
	Ease of Maintenance for PC Components	Can maintenance of PC components be made easy?
	Potential for Reduction of Fine Dust in OSC Buildings	Is it possible to reduce fine dust through remodeling?
6. Safety	Ensuring Fire Safety in OSC Buildings	Is the stability of the fire safety of modular buildings secured?
	Existence of Specialized Planning for OSC Construction	Is there a plan for the transportation of PC components, considering the balance and movement?
	Methods to Ensure Durability of OSC Buildings	Are standards established for the cover thickness of reinforcing bars and the quality of concrete?
	Availability of Seismic Safety Management Manual for OSC Buildings	Is the seismic stability of OSC school buildings secured?
	Possibility of Traffic Accidents in OSC Construction	Is the safety of students and workers considered during the transportation of PC components?
	Reduction in Occupational Safety Accidents in OSC Construction	Is it possible to reduce risk factors for the health and stability of construction workers through OSC construction?
7. Social	Recognition of Container Usage in OSC Buildings	Is it possible to change the negative perception of the traditional modular method, such as containers?
	Existence of Legislation for OSC Construction	Can housing regulations be relaxed specifically for OSC buildings?
	Presence of Contractual Systems in OSC Construction	Is a new contract system needed different from existing buildings?
	Decrease in Specialized Construction Workforce	Will there be a decrease in specialized construction personnel when OSC construction becomes more prevalent?
	Distinction of Responsibilities in OSC Construction	Can responsibilities be defined between material producers and constructors in case of defects?
	Possibility of Profit Reduction in OSC Construction	Can the reduction in the role of constructors lead to a decrease in construction profits?

5. RESULTS OF THE SURVEY

The total number of respondents is 13, and the survey targets professors and administrative staff currently working in modular school facilities. The survey was conducted remotely through a distributed link. The first part of the survey assessed the perceptions of OSC users regarding the seven influencing factors extracted from the requirements of OSC buildings (facility and environmental factors, structural factors, architectural design and usability factors, quality and construction/management factors, construction and maintenance factors, safety factors, and social factors). The results are presented in Figure 2.

Figure 2. Perception survey on OSC factors



Facility and environmental factors were generally perceived in a neutral manner, with 29% positive responses, 45% neutral responses, and 26% negative responses. Areas for improvement were identified, including air quality enhancement (40%), reduction of hazardous material exposure (40%), and enhancement of lighting and illumination (20%).

5.1. Facility and Environmental Factors

To assess perceptions regarding facilities and environmental factors, respondents were asked, "Do you think modular school buildings are more environmentally friendly compared to traditional school buildings?" The responses indicated a generally neutral stance, with 29% positive, 45% neutral, and 26% negative opinions. Identified areas for improvement included air quality enhancement (40%), reduction of hazardous material exposure (40%), and improvement of lighting and illumination (20%).

5.2. Structural Factors

The evaluation of structural factors involved the question, "Does the classroom area, size, and height of the modular school building meet the requirements for the learning environment?" Structural factors were perceived neutrally, with 23% positive, 46% neutral, and 31% negative opinions.

5.3. Architectural Design and Usability Factors

To gauge perceptions of the design and usability of modular buildings, respondents were asked, "Are you satisfied with the quality of modular school buildings in terms of usability and design?" The architectural design and usability factors received predominantly positive responses, with 43% positive, 24% neutral, and 33% negative opinions. Reasons for considering the quality (usability, design) as not excellent were identified, including harmony with the surrounding environment (60%), individualization of design (20%), and others (20%).

5.4. Quality and Construction Management Factors

To ascertain users' perception of quality and construction management factors, the question was posed, "Are you satisfied with the waterproof performance of the modular school building?" Quality and construction management factors demonstrated largely positive opinions, with 43% positive, 36% neutral, and 21% negative opinions.

5.5. Construction and Maintenance Factors

The investigation of thoughts on construction and maintenance factors involved the question, "Do you think the facility management of modular school buildings is well-executed?" Construction and maintenance factors received predominantly positive responses, with 69% positive, 6% neutral, and 25% negative opinions.

5.6. Safety Factors

To assess perceptions of safety factors, respondents were asked, "Do you think the safety of modular buildings is ensured against fire and earthquakes?" Safety factors were overwhelmingly positive, with 79% positive, 14% neutral, and 7% negative opinions. This contrasts with the negative perceptions of the general public, who express concerns about safety issues such as building collapse.

5.7. Social Factors

Through the question, "What is the perception of surrounding parents, students, and teachers regarding modular school buildings?" social factors showed minimal differences, with 46% positive, 8% neutral, and 46% negative opinions.

6. DISCUSSION

Free opinions regarding the improvement and suggestions for modular buildings were collected. The interview results generally revealed concerns about facilities and environmental factors. Specific improvement suggestions included the need for air conditioning in the hallways due to inadequate insulation, especially in vulnerability to summer heat, and the necessity for special waterproofing treatments to enable water cleaning on restroom floors. Additionally, it was suggested that electrical wiring should not be arranged in the restroom. These insights suggest that integrating considerations for facilities and environmental factors into future technological advancements for modular buildings could improve users' perceptions and foster widespread adoption.

7. CONCLUSION

This study conducted a survey targeting users actively engaged with modular school buildings, which have faced significant opposition from parents of students expected to utilize such structures. Through a comprehensive review of prior research, seven categories of modular requirements for OSC methods, school construction, and public facility construction were derived. The identified categories include facility and environmental factors, structural factors, architectural design and usability factors, quality and construction/management factors, construction and maintenance factors, safety factors, and social factors. A questionnaire was developed based on these categories to assess perceptions. In contrast to the negative views from the general public, it was found that the overall perception was positive, with a 41% positive response rate.

This study is constrained by a relatively small sample size of 19 participants and its focus on a specific geographical area, namely Korea. The analysis primarily involves determining positive or negative response ratios, lacking an in-depth exploration of participants' specific opinions. Future research endeavors to address these limitations by expanding the sample size, conducting detailed analyses of responses, exploring various aspects comprehensively, and considering cross-national comparisons to broaden the study's scope and enhance the reliability of its findings.

The main objective of this study is to investigate the perceptions of users regarding modular school buildings and derive improvement suggestions based on their perspectives. The research aims to listen to the viewpoints of educational facility users who may hold negative perceptions about the introduction of OSC buildings, ultimately contributing to garnering positive support for modular school architecture. As a result, this study is expected to provide systematic and valuable insights for the future adoption

and management of OSC school buildings, aiding decision-making processes in educational facility construction.

ACKNOWLEGEMENTS

This work was supported by the Korea Institute of Energy Technology Evaluation and Planning(KETEP) grant funded by the Korea government(MOTIE) (RS-2023-00266248)

REFERENCES

[1] J. Son, J. Lee, “Off-Site Construction: Innovation of construction production system”, Construction Engineering and Management, vol. 20, no. 5, pp. 3-7, 2019.

[2] Allied Market Research, "Offsite Construction Market by Material, Construction Type and Application: Global Opportunity Analysis and Industry Forecast, 2021-2030", 2021.

[3] Ministry of Education, “Comprehensive Plan for Education Recovery(교육회복 종합방안)”

[4] S. Lee, H. Cha, B. Son, “A Study of the Decision Making System in adopting Off-Site Construction Method in the Initial Stage Considering the Building Project Characteristics -Focused on Structure Work of Apartment Housing-”, Construction Engineering and Management, vol. 23, no. 1, pp. 89-97, 2022.

[5] W. Yun, B, Bae, E. Shin, T, Kang, “Development of Economic Analysis Indicators and Case Scenario Analysis for Decision-making support for Off-Site Construction Utilization of Apartment Houses”, Construction Engineering and Management, vol. 24, no. 6, pp. 24-35, 2023.

[6] S. Jung, J. Yu, “A Study on Critical Success Factors of Off-Site Construction -By Importance Performance Analysis-”, Construction Engineering and Management, vol. 24, no. 2, pp. 24-36, 2023.

[7] Y. Choi, “Prior and post action to minimize complaints during renovation in occupied complex building”, Hanyang University Master's Thesis, 2016.

[8] H. Han, “Analysis of Characteristics and Construction Case of Prefabricated Modular Buildings in Disaster Environment”, Design Convergence Study, vol. 17, no. 5, pp. 17-31, 2018.

[9] Y. Heo, H. Lim, I, Jung, K. Lee, “Structural Performance Evaluation of Rooftop Modular Structure Connected with Unit Blocks”, Journal of Korean Society of Steel Construction, vol. 35, no. 2, pp. 81-90, 2023.

[10] K. Jung, “Improvement of Old School Facility Management Process based on Economic Analysis”, University of Seoul Master's Thesis, 2018.

[11] M. Jung, S. Lee, Y. Chang, S. Kwon, “Smart quality inspection technology for on-site PC members based on Off-Site Construction (OSC)”, Spring Annual Conference of Architectural Institute of Korea, Jeju, Korea, pp. 745-746, 2021.

[12] J. Kim, “Problems and Improvements of Waterproofing Method of Domestic Container-type Modular Housing”, Chung-Ang University Master's Thesis, 2017.

[13] H. Kim, Y. Yoo, J. Lee, B. Cho, H. Kim, “The Full Scale Fire Test of Medical Modular Block for the Fire Resistance Performance Evaluation”, Proceeding of annual Conference of the Architectural Institute of Korea, Jinju, Korea, pp. 329-332, 2008.

[14] D. Kim, “Improvement of Window plan of School building with a view of Environmental-friendly Aspects”, Chungbuk National University Master's Thesis, 2013.

[15] J. Kim, “A study on measures to improve earthquake-related school disaster management: Focusing on the case of the Pohang earthquake”, Korea National University of Education Master's Thesis, 2022.

[16] M. Kim, S. Park, Y. Ahn, “Adoption and Improvement Direction of Modular Construction Method for Public Health Facilities -Focused on Public Health Centers of Buk-do and Jawol-do in Ongjin-gun-”, Autumn Annual Conference of Architectural Institute of Korea, Incheon, Korea, pp. 610-613, 2020.

[17] J. Lee, J. No, S. Kwon, S. Kim, “Flexible Unit Floor Plan of Off-Site Construction Housing Considering Long-Lasting Housing Certification System”, Land and Housing Review, vol. 12, no. 4, pp. 103-117, 2021.

[18] E. Lee, M. Lee, C. Hyun, “Evaluations of Dynamic Characteristics and Floor Vibration Serviceability for Stacked Modular House”, Journal of Korean Institute of Architectural Sustainable Environment and Building Systems, vol. 13, no. 6, pp. 473-480, 2019.

[19] H. Lee, C. Cho, “A Study on Developing the Design Quality Indicators(DQI) for School Building - Using Delphi Survey Method and Analytical Hierarchical Process(AHP)”, Journal of the Architectural Institute of Korea Planning & Design, vol. 28, no. 5, pp. 69-77, 2012.

[20] J. Lee, O. Jang, J. Kim, “Study on Recognition and Satisfaction of Modular Housing through the Post Occupancy Evaluation”, Journal of the Korean Housing Association, vol. 25, no. 5, pp. 63-71, 2014.

[21] J. Lee, “Development of floor unit cost statement for management of progress rate in public construction”, University of Seoul Master’s Thesis, 2017.

[22] W. Lee, H. Shin, Y. Um, D. Kang, “Analysis of Indoor Particle Reduction in a Remodeled Elementary School Classroom”, Spring Annual Conference of Architectural Institute of Korea, Jeju, Korea, pp. 781, 2021.

[23] J. Moon, B. Lee, “OSC in Terms of Structural Design Standards”, Review of Architecture and Building Science, vol. 66, no. 7, pp. 34-38, 2022.

[24] S. Moon, H. Shin, S. Yoo, J. Lee, “Basic research for deriving the Sustainability evaluation Factors of Off-Site Construction -Focused on the evaluation items GSEED, BREEAM and LEED-”, Autumn Annual Conference of Architectural Institute of Korea, Jeju, Korea, pp. 1236-1239, 2022.

[25] S. Nam, “A Decision Support Model for Factory Production Process through

Prefabricated Components in Modular Buildings”, Ajou University Doctoral Thesis, 2019.

[26] S. Park, S. Ryu, H. Kim, “A Study on the Revitalization of OSC Industry through the Perception Survey Analysis on the Modular School Building Installation - Focusing on the Seoul Green-Smart Future School Remodeling Project”, Autumn Annual Conference of Architectural Institute of Korea, Yeosu, Korea, pp. 583-584, 2021.

[27] S. Park, “A study on the construction management counterplan for protection learning environment”, Chonnam National University Doctoral Thesis, 2016.

[28] S. Son, “School Building for the Credit-System”, Review of Architecture and Building Science, vol. 62, no. 1, pp. 30-34, 2017.

[29] S. Yoon, “4th Industrial Revolution & Future School Facility”, Journal of the Korean Institute of Educational Facilities, vol. 24, no. 3, pp. 4-5, 2017.

[30] Y. Yang, J. Song, J. Hong, S. Kwon, “Object Detection and Remote Sensing-Based Smart Safety Management Technology for Construction of Off-site Construction(OSC)”, Autumn Annual Conference of Architectural Institute of Korea, Jeju, Korea, pp. 749-750, 2022.

[31] I. Yu, “Vitalization of the OSC industry and changes and development directions in the specialized construction industry(OSC 산업 활성화와 전문건설업의 변화 및 발전방향)”, Construction Engineering and Management, vol. 20, no. 5, pp. 12-18, 2019.