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Research on Major Trends of Smart Technologies in the Construction Sector Analyzed Through Big Data: Focusing on Government-led Initiatives

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Abstract

In this paper, we analyzed new smart construction technologies based on the data registered from 2020 to July 2024 and identified a total of 21 technologies certified as smart construction technologies, which accounted for 21.6% of the total 167 new construction technologies. In addition, we analyzed the distribution by field and confirmed that 17 smart construction technologies (13.5%) were included in the civil engineering technology field, 3 in the architectural technology field (2.4%), and 3 in the mechanical equipment technology field (2.4%). After selecting 12 major keywords of smart construction technologies for TF-IDF analysis, we analyzed whether these keywords were included in the designated technical documents and found that the most frequently mentioned keyword among the 21 certified smart construction technologies was "data & artificial intelligence." This study is useful for understanding the current status of smart construction technologies and the utilization of important keywords in the construction technology field. Through this, it can be used as data to suggest the development direction of smart construction technologies and evaluate the technology demand and applicability in specific fields.

Keywords*: New Construction Technology, Smart Construction Technology, TF-IDF, Machine Learning, AI*

1. INTRODUCTION

In 2018, the Korean government and the Ministry of Land, Infrastructure and Transport, referred to hereafter as MOLIT, defined key technologies with high utilization in the construction industry as 'smart construction technology' and established activation measures and a roadmap to effectively introduce them to the industry. Smart construction technology refers to the application of cutting-edge technologies such as Information and Communication Technology (ICT) to traditional construction technology to increase productivity, safety, and quality of construction work, with the goal of shortening the construction period, reducing manpower input, and increasing on-site safety. This technology includes methods, equipment, and systems developed to promote the development of the construction industry, such as digitalizing, automating, and manufacturing all

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stages of construction work in factories [1].

In 2019, the Construction Technology Promotion Act was revised to stipulate the mandatory introduction of smart safety equipment, and in 2021, the MOLIT announced guidelines for the on-site application of smart construction technology. In 2022, with the announcement of a plan to activate smart construction, the government is continuously promoting research and development (R&D) for the development of core technologies, and is commercializing technologies that have been developed and promoting technology transfer to the private sector. The government and the are proposing BIM in a cloud environment, virtual reality (VR) and augmented reality (AR), the Internet of Things (IoT) and sensors, drones, big data and artificial intelligence (AI), simulation, robots, intelligent construction equipment, modular construction methods, and 3D printing technology as major smart construction technologies [2].

Looking at each stage of construction lifecycle phase, the life cycle, the design stage presents BIM, drones, big data and artificial intelligence, virtual reality, and simulation as the main smart construction technologies. The construction stage presents a plan for effectively applying most smart construction technologies to the field, and the maintenance stage presents BIM, big data and artificial intelligence, robots, the Internet of Things, and sensors as the main technologies. TF–IDF, or term frequency–inverse document frequency, is a statistical measure used in information retrieval to evaluate the significance of a word in relation to a document within a collection or corpus. It helps to identify words that are particularly characteristic of a document by considering two key factors [3]. The TF–IDF score is calculated by multiplying the TF and IDF scores for a word. A high TF–IDF score suggests that the term is frequent within the document and relatively rare across other documents, marking it as particularly significant in identifying or categorizing the document within the collection. This approach is widely used in search engines, document similarity analysis, and various natural language processing tasks.

TF–IDF has historically served as a weighting factor in applications such as information retrieval, text mining, and user modeling. Its effectiveness in highlighting important words within documents has made it invaluable for search engines and similar tools to rank or retrieve relevant information [4]. In fact, a 2015 survey revealed that 83% of text-based recommender systems in digital libraries relied on TF–IDF. This high usage indicates its popularity and effectiveness in aiding systems to suggest relevant texts by analyzing the significance of terms within documents. The widespread adoption in digital libraries and recommender systems illustrates TF–IDF's utility in contexts where understanding and extracting meaningful content from large text corpora is essential [5].

TF-IDF is an analysis method that evaluates the importance of a specific word in a specific document in a text group consisting of multiple documents. This method can be used to extract keywords in a document or to identify similarities between multiple documents. The analysis values from TF-IDF are calculated from the following formula [6]:

$$TF - IDF = \frac{n_{i,j}}{\sum_k n_{k,j}} \times \log\left(\frac{|D|}{|\{d_j : t_i \in d_j\}|}\right) \quad (1)$$

In Eq. (1), $n_{i,j}$ is the frequency of term t_i in document d_j, $\sum_k n_{k,j}$ is the total number of terms in the document d_j, $|D|$ is the total number of documents in the corpus, and $|\{d_j : t_i \in d_j\}|$ is the number of documents in which term t_j appears.

1. **Term Frequency (TF)**:
   This component measures how often a word appears in a specific document. A higher frequency means that the word is more representative of that document. However, common words (e.g., "the," "is," "and") that appear frequently across many documents are less meaningful in distinguishing individual documents. Here, TF (Term Frequency) refers to the frequency with which a specific word appears in a document, and a higher TF value indicates that the word plays an important role in the document. Document Frequency (DF) is a frequency measure that indicates how often a specific word is used in multiple documents. A high DF value means that the word is a word that is commonly used in multiple documents, and therefore may be less important in indicating the unique characteristics of a specific document [7].

2. **Inverse Document Frequency (IDF)**:
   This adjusts the term frequency by considering how common or rare the word is across all documents in the corpus. If a word appears in many documents, it receives a lower IDF score, as it is likely not particularly unique or informative for identifying specific documents. Conversely, words that appear in fewer documents receive a higher IDF score, indicating a higher potential to distinguish the document they appear in. IDF(Inverse Document Frequency) is the inverse of DF, and measures how important a specific word is in the entire document. The larger the IDF value, the more likely it is that the word will play a relatively important role in a specific document. Based on the weights derived from TF-IDF analysis, LDA(Latent Dirichlet Allocation) topic modeling is performed to find keywords. LDA analyzes which topics exist in a given text as a probabilistic model, and can infer the distribution of words related to each topic in the document and the distribution of which topics each document consists of [8]

In this study, we investigate the current status of smart construction technologies designated by the government and analyze the importance of key keywords applied to smart construction technologies using TF-IDF, one of the machine learning statistical techniques.

2. RESEARCH METHODOLOGY

The MOLIT is promoting various policies and research and development (R&D) projects to promote the development and on-site application of smart construction technology. Smart construction technology aims to improve productivity, safety, and quality by incorporating information and communication technology (ICT) into the entire construction process. The main areas of smart construction technology are as follows:

1. **BIM (Building Information Modeling):**
   Manages the entire construction process from design to maintenance with a 3D model to increase efficiency.

2. **Drone and sensor technology:**
   Provides accurate information through on-site monitoring and data collection.

3. Big data and artificial intelligence (AI):
Analyzes large-scale data to support decision-making and optimize process management.

4. Virtual reality (VR) and augmented reality (AR):
Uses for design review and education to improve understanding.

5. Modular construction:
Shortens construction periods and improves quality by assembling factory-made modules on-site.

The MOLT has established a 'Smart Construction Technology Roadmap' and is providing related guidelines to promote the on-site application of these technologies. In addition, it certifies new smart construction technologies and discloses related information through the Korea Agency for Infrastructure Technology Advancement (KAIA).

The introduction of smart construction technology offers various benefits, such as shortening construction periods, reducing costs, and reducing safety accidents, and is leading to innovation in the construction industry. Considering that the Ministry of Land, Infrastructure and Transport's policy promotion of new smart construction technologies began in 2020, this study conducted an analysis based on data registered from 2020 to July 2024. Using the concept of smart construction technology and examples of smart technology utilization in the construction field presented in the MOLT's "Guidelines for Field Application of Smart Construction Technology (March 2021)", new technologies applied for and registered by companies and institutions were classified based on terms related to smart construction technology.

3. RESEARCH RESULTS

The MOLT and the "Korea Agency for Infrastructure Technology Advancement (KAIA)" are promoting a new construction technology designation system in the field of land, infrastructure and transport certification/evaluation in order to encourage the development desire of technology developers (individuals or corporations) and promote the development of domestic construction technology and strengthen national competitiveness. New construction technology refers to construction technology that is first developed domestically or has been improved after being introduced from abroad, and is judged to be novel, progressive, and applicable to the field in Korea. If there is a request from the developer for such technology, it is designated as a new technology if it is deemed necessary to disseminate the technology. The new technology designation certificate is initially granted a protection period of 8 years, and can be extended once within the range of 3 to 7 years.

As shown in Table 1, a total of 995 new technologies have been certified from 1990 to July 2024 based on the e-Government website database (DB). Of these, 21 technologies are certified as smart construction technologies. When the government set the starting point for the policy to activate smart construction technology as 2018, the proportion of smart construction technologies among the certified new construction technologies was 21 out of a total of 167 new technologies, accounting for 21.6% of the total. Looking at the distribution of registration years for new smart construction certification technologies, 3 were registered in 2020, 2 in 2021, 4 in 2022, 8 in 2023, and 4 as of July 2024.

Table 1. Smart Construction Technologies and Keywords in New Construction Technologies (2018 to July 2024)

Reg. Nos.	Smart Construction Technologies	Keywords	Reg. Yrs.
996	Painting Method Using a Remote-Controlled Road Surface Marking Device (R-BOT Method)	Pavement marking, Automation, Remote control, Painting robot, Unmanned automation	'24
991	Non-contact, Target-free Bridge Displacement Measurement Technology Using Laser and Camera-based Image Processing	Metrology, Retest, Safety Diagnostics, Maintenance, Displacement	
990	the Autonomous Drone System with Digital Twin Technology and AI Algorithm for Concrete Structure Exterior Inspection	Autonomous Drones, Artificial Intelligence, Digital Twin	
988	Air Shower System Technology Utilizing Counter Flow Air Currents to Reduce the Inflow of Fine Contaminants at Entryways	Entry and Exit Dust Reduction, Counter Flow, Bar Type Module Structure	
981	Thin Overlay Continuous Reinforced Concrete Pavement Method (UT-CRCP) Using Super Absorbent Polymer (SAP) Concrete with Enhanced Internal Curing Effect and an Integrated Automated Paver for Reinforcement Placement	UT-CRP, Internal Curing, Super Absorbent Resin, Overlaid, Integrated Automatic Paver	'23
978	Field Survey and Analysis Techniques for Cut Slopes Using Real-Time Kinematic Global Navigation Satellite System (RTK-GNSS) and Photogrammetry	Real-time positioning device, Photo organizing system, Excavated slope field survey, Analysis system	
973	Performance Evaluation Technology for Elastic Pads in Concrete Tracks Using a Wireless-Portable System	Safety Inspection, Railroad Track, Facility Maintenance, Track Construction, Track Performance Evaluation	
971	Offsite Construction Technique for Inserting Box-Type Infill Modules from the Top of U-Shaped Wall Precast Concrete Structures	Modular, U-shaped, Wall construction, Precast concrete modules, Box infill modules, Plug-in installation, Off-site	
960	Bridge Dynamic Characteristics and Deflection Estimation Technology Based on Spatiotemporal Decomposition Using Continuous Vibration	Time-division algorithm, Constant vibration, Dynamics, Sag, IoT	
959	Wireless Measurement System for Vertical Displacement of Bridges Based on Acceleration and Strain	Strain, Acceleration, Wireless, Data fusion, Serial displacement	
957	Precision Inspection Technology for Safety Assessment of Underwater Structures Using a Combined Underwater Drone Survey System	Safety Assessment, Facility Maintenance, Underwater Structures	

954	Smart Monitoring Technology with IoT Sensor for Real-Time Tipping Hazard Alerts	Real-time alarm, Smart sensor, IoT, Construction safety, Safety solutions	
949	Trenchless Full Repair and Reinforcement Method for Sewage Pipes Using UV Light Exposure Robots and Automatic Curing Systems	UV light curing, Smart automated curing system, Non-excavation total repair and reinforcement, Rapid curing	‘22
933	AI-Based Thermal Imaging and Vision Fusion Measurement System for Coating Condition Assessment of Steel Structures	Artificial intelligence, Film thickness, Thermal imaging, Steel bridge, Thermal detection	
925	Natural lighting system using sun-tracking collectors, floodlights and diffusers	Solar collectors, Natural lighting system, Relay lens, Long distance Light transmission, Renewable energy	
924	Damage analysis technology for concrete bridge structures using high-resolution automated image acquisition system and masked region-based convolutional neural network	Bridge, Visual inspection, Imaging H/W, Operation S/W, Damage analysis and evaluation S/W, Mask R-CNN, Concrete damage (Cracks, Efflorescence, Spalling, Rebar Exposure, Breakage)	
920	Composite construction with end-reinforced precast double walls	Double Wall, Precast Concrete, Composite, End Reinforcement	‘21
918	Automated analysis of asphalt pavement hazards using AI	Road Pavement Maintenance, Artificial Intelligence (AI), Automatic Analysis, Analysis Time Reduction, Smart Construction Technology	
902	Supporting technology for condition assessment using Portable Electronic Device for safety & maintenance for regular safety inspection of Type 3 bridge facilities	ICT, PED, Bridge Facilities, Safety Inspection & Diagnostics, Condition Assessment	‘20
898	High-resolution imaging equipment for road tunnel maintenance and crack detection technology for lining surfaces based on artificial intelligence algorithms	Safety Inspection, Tunnel, AI, Crack Detection, Condition Assessment	
883	How to re-test a bridge with LTE radios and a floor-mounted weighted displacement measurement device	Bridge, Wireless, Re-testing	

Table 2 shows the ratio of smart construction technology by technology field of new construction technology from 2018 to July 2024. This allows us to confirm the proportion of smart construction technology in each technology field. There are a total of 126 new construction technologies certified and registered in the civil engineering field, of which 17 technologies are classified as smart construction technologies, accounting for

13.5% of the total. In the field of architectural technology, out of a total of 56 new construction technologies, 3 are smart construction technologies, accounting for 2.4% of the total. In addition, in the field of mechanical equipment technology, out of a total of 8, 3 are certified and registered as smart construction technologies, accounting for 2.4% of the total.

Table 2. Percentage of smart construction technologies by new construction technology sector

Technical areas	Smart construction technologies (cases, %)		
	Not applicable	Applicable	Percentage
Civil Engineering	109	17	13.5
Construction	53	3	2.4
Machinery-equipment	5	3	2.4
Total	167	23	13.8

Note: Data includes duplicate technologies from 2018 to July 2024.

Table 3 shows the certification registration designation numbers for 21 smart construction technology fields. The certification registration designation numbers of 21 smart construction technologies by technology field are organized in the table . The reason the number of registrations by technology field is 23 is because there were cases where two technologies were registered repeatedly. "Painting method using a remote-controlled road marking painting device (R-BOT Method, designation number 996)" was registered simultaneously in the civil engineering and mechanical equipment fields. Additionally, the "Autonomous Drone System Utilizing Digital Twin Technology and AI Algorithm for Visual Inspection of Concrete Structures (Designation Number 990)" employs digital twin and artificial intelligence technologies to inspect the appearance of concrete structures and is registered in both the civil engineering and architectural fields.

Table 3. Smart construction technology designation numbers by technical fields

Technical areas	Smart construction technologies Registration Nos.
Civil engineering	996*, 991, 990*, 981, 978, 973, 960, 959, 957, 954, 949, 933, 924, 918, 902, 898, 883
Construction	990*, 971, 920
Machinery-equipment	996*, 988, 925

Note: The asterisks (*) indicate technologies that were duplicated between 2018 and July 2024.

According to the Smart Construction Technology Roadmap for Construction Productivity Innovation and Safety Enhancement (MOLIT, October 2018), smart construction technologies that can be applied to each stage of construction exist in the following four stages: planning survey, design, construction, and maintenance.

Table 4 provides a summary of the smart technologies applied at each stage of construction projects, as specified in the MOLIT roadmap (2018). Key keywords were selected to perform a TF-IDF analysis, aiming

to identify the smart technologies applicable across various construction project stages.
The technologies used in each stage can be applied in various ways throughout the construction industry, and these stage-by-stage application technologies are presented . By utilizing these smart construction technologies as the main keywords of TF-IDF analysis, it can contribute to analyzing which technologies are important in each stage of construction and deriving the value of the corresponding technologies.

Table 4. Smart technology by construction stages (MOLIT, October 2018)

Construction Phase	Smart Technologies
Planning Research	Drones, 3D scanning, Digital map
Design	BIM, VR&AR, Big Data & Artificial Intelligence, 3D Scanning, Digital Twin
Construction	Big Data & Artificial Intelligence, Internet of Things, Freefab, Robotics, Autonomous Vehicles
Maintenance	Drones, Big Data & Artificial Intelligence, Internet of Things, Mobile Technology, Robotics
Safety Management	Drones, Mobile Technology, Robotics

TF-IDF (Term Frequency-Inverse Document Frequency) is a technique used to assess the importance of key terms in a specific document. This method primarily operates based on two principles: Term Frequency (TF) and Inverse Document Frequency (IDF).Based on how frequently a term appears in the entire document set, it assigns a higher weight to a term that appears less frequently. In other words, the more frequently a specific term appears in a specific document but rarely in other documents, the higher the weight it has. Through this, the weight of common words that appear commonly between documents (e.g., 'and', 'also', etc.) is lowered, and key terms unique to a document are evaluated as relatively more important. The main keywords for smart construction technology for TF-IDF analysis were set as BIM, drone, VR&AR, big data & artificial intelligence, 3D scanning, Internet of Things (IoT), digital twin, prefab, mobile technology, robotics, digital map, and autonomous driving. The main keywords set for TF-IDF analysis of smart construction technology are as follows:

BIM (Building Information Modeling), Drones, VR & AR (Virtual Reality & Augmented Reality)
Big Data & Artificial Intelligence, 3D Scanning, IoT (Internet of Things), Digital Twin
Prefab, Mobile Technology, Robotics, Digital Mapping, and Autonomous Driving

The Internet of Things (IoT) refers to devices equipped with sensors, computing power, software, and various technologies that enable them to connect to and share data with other devices and systems via the Internet or other communication networks [9]. The Internet of Things (IoT) spans fields like communication, electronics, and computer science engineering. The term "Internet of Things" is sometimes regarded as a misnomer since devices do not necessarily have to connect to the public Internet; they only need to be networked and individually addressable [10] These keywords play an important role in analyzing the use of smart technology in each construction stage, and TF-IDF analysis can be used to evaluate the importance of each term and confirm the relative value of the technology. This keyword is based on the keywords of examples of smart construction technologies by construction stage presented in the “Ministry of Land, Infrastructure and Transport’s Guidelines for Applying Smart Construction Technology on Site (March 2021).” A total of 12 smart technologies are applied by construction stage, and can be classified according to the construction stage to which each smart technology is applied, as shown in Table 5.

Table 5. TF-IDF of Construction stages by keywords

TF-IDF Keywords	Utilization of Smart Technology in Construction Fields
BIM	Design
Drons	Planning research, Maintenance, Safety management
VR & AR	Design
Big Data & AI	Design, Construction, Maintenance
3D Scanning	Planning research, Design
IoT	Construction, Maintenance
Digital Twin	Design
Freefab	Construction
Mobile Technology	Maintenance, Safety management
Robotics	Construction, Maintenance, Safety management
Digital map	Planning research
Autonomous Driving	Construction

The 12 smart construction technology keywords were selected as the main core factors of construction technology new technology certification, and TF-IDF analysis was performed on them. Through this analysis, we evaluated how important each keyword is in the document and how rarely it appears in other documents, and identified the relative importance of each technology as a new technology certification factor. Through this process, we quantitatively measured the differential importance of each of BIM, drones, VR&AR, big data &AI, 3D scanning, IoT, digital twin, prefab, mobile technology, robotics, digital map, and autonomous driving within the context of the construction phase and document. Through this, we can objectively analyze how specific technologies are highlighted in the criteria for new technology certification.

Table 6 shows how many of the 12 keywords set in the 21 certified smart construction technologies were included after the preprocessing process for TF-IDF analysis for the technical documents submitted by each organization.

Table 6. TF-IDF preprocessing for certification-designated smart construction technology names

Reg. Nos.	BIM	Drons	VR & AR	Big Data & AI	3D Scanning	IoT	Digital Twin	Freefab	Mobile Tech	Robotics	Digital Map	Autonomous Diving
996	0	0	0	0	0	1	0	0	0	1	0	0
991	0	0	0	1	1	0	0	0	0	0	0	0
990	0	1	0	1	1	0	1	0	0	0	0	1
988	0	0	0	0	0	1	0	0	0	0	0	0
981	0	0	0	0	0	1	0	0	0	1	0	0
978	0	0	0	1	0	0	0	0	1	0	0	0
973	0	0	0	1	0	1	0	0	0	0	0	0
971	0	0	0	0	0	0	0	1	0	0	0	0

960	0	0	0	1	0	1	0	0	0	0	0	0
959	0	0	0	1	0	0	0	0	1	0	0	0
957	0	1	0	1	1	0	0	0	0	0	0	0
954	0	0	0	0	0	1	0	0	1	0	0	0
949	0	0	0	1	0	1	0	0	0	1	0	0
933	0	0	0	1	1	0	0	0	0	0	0	0
925	0	0	0	1	0	1	0	0	0	0	0	0
924	0	0	0	1	1	0	0	0	0	0	0	0
920	0	0	0	0	0	0	0	1	0	0	0	0
918	0	0	0	1	1	0	0	0	0	0	0	0
902	0	0	0	1	0	1	0	0	1	0	0	0
898	0	0	0	1	1	1	0	0	0	0	0	0
883	0	0	0	1	0	1	0	0	0	0	0	0

As a result of analyzing this table, the frequency of use of each keyword is as follows:

1. The most frequently included keyword is “Data & AI”, which was used in 15 out of 21 new technologies.

2. The second most frequently included keyword is “Internet of Things (IoT)”, which was used in 11 new technologies.

3. On the other hand, keywords with a frequency of use of 0 include “BIM”, “VR & AR”, and “Digital Map”.

This shows that Data & AI and IoT are key technologies that are mainly used in smart construction technology certification, while BIM, VR & AR, and digital maps are relatively less frequently used or are not applied under certain conditions. This analysis will provide useful information for strengthening the certification criteria for smart construction technologies or re-evaluating the importance of specific technologies.

Among the certified smart construction technologies, the technology with the most keywords is “Autonomous driving drone system using digital twin technology and concrete structure exterior inspection technology using artificial intelligence algorithm” with designation number 990. This technology contains the following five main keywords: Drone, Data & AI, 3D scanning, Digital twin, and Autonomous driving.
Through this TF-IDF preprocessing process, it can be evaluated that technologies containing a large number of keywords have high importance and value, and through this analysis, the characteristics and certification requirements of each smart construction technology were identified in detail. This confirms that technology No. 990 is a complex solution that integrates particularly important technological elements in the smart construction field. Keyword analysis is centered on the frequency of specific words, which can be expressed as ‘term frequency’ (TF), which checks how frequently the word appears in the corresponding document.

A high TF value does not necessarily mean that it is a major keyword. This is because if a specific word is a common word that appears frequently throughout the document, its word frequency (TF) will inevitably be high in that document. That is, words with a high DF (Document Frequency) value are often derived as keywords or subject terms. TF-IDF is proposed to supplement these results. TF-IDF stands for ‘Term

Frequency-Inverse Document Frequency' and it resets the frequency of word appearance based on the probability of word appearance rather than the simple frequency of the word. TF-IDF is a value that multiplies TF by IDF, which can be expressed as the importance of a word in relation to the entire document. The higher the frequency of a word appearing in a specific word, and the fewer documents containing that word among the entire documents, the larger the value [11].

The values shown in the preprocessing process in Table 6 can be interpreted as the importance of the corresponding keywords, which do not simply indicate the frequency, but rather the components of the smart technologies included in the technical literature. These values show how closely each smart technology is related to a specific keyword, and allow us to determine whether the corresponding keyword is emphasized in the technical literature or utilized as a key element that constitutes the characteristics of the corresponding technology. The values obtained during the preprocessing stage in Table 6 were used to represent the significance of each keyword. In other words, rather than simply indicating frequency, these values reflect the components of smart technologies included in the technical documentation.

Table 7 shows the results of analyzing the TF-IDF of certified smart construction technologies for the main keywords of smart construction technologies.

Table 7. TF-IDF for certification-designated smart construction technology names

Reg. Nos.	BIM	Drons	VR & AR	Big Data & AI	3D Scanning	IoT	Digital Twin	Freefab	Mobile Tech	Robotics	Digital Map	Autonomous Diving
996	0	0	0	0	0	0.15051	0	0	0	0.43265	0	0
991	0	0	0	0.08317	0.24866	0	0	0	0	0	0	0
990	0	0.20828	0	0.03327	0.09946	0	0.26848	0	0	0	0	0.26848
988	0	0	0	0	0	0.30103	0	0	0	0	0	0
981	0	0	0	0	0	0.15051	0	0	0	0.43265	0	0
978	0	0	0	0.08317	0	0	0	0	0.37018	0	0	0
973	0	0	0	0.08317	0	0.15051	0	0	0	0	0	0
971	0	0	0	0	0	0	0	1.04139	0	0	0	0
960	0	0	0	0.08317	0	0.15051	0	0	0	0	0	0
959	0	0	0	0.08317	0	0	0	0	0.37018	0	0	0
957	0	0.34713	0	0.05544	0.16577	0	0	0	0	0	0	0

954	0	0	0	0	0	0.15051	0	0	0.37018	0	0	0
949	0	0	0	0.05544	0	0.10034	0	0	0	0.28843	0	0
933	0	0	0	0.08317	0.24866	0	0	0	0	0	0	0
925	0	0	0	0.08317	0	0.15051	0	0	0	0	0	0
924	0	0	0	0.08317	0.24866	0	0	0	0	0	0	0
920	0	0	0	0	0	0	0	1.04139	0	0	0	0
918	0	0	0	0.08317	0.24866	0	0	0	0	0	0	0
902	0	0	0	0.05544	0	0.10034	0	0	0.24679	0	0	0
898	0	0	0	0.05544	0.16577	0.10034	0	0	0	0	0	0
883	0	0	0	0.08317	0	0.15051	0	0	0	0	0	0

In the case of smart construction technology with designation number 996, the keyword “digital map” shows the highest TF-IDF value of 0.4327, which suggests that “digital map” is a very important element in the technology. In designation number 990, “drone” and “digital twin” show relatively high TF-IDF values of 0.2083 and 0.2685, respectively, suggesting that the two technologies play relatively more important roles in this smart construction technology. For the designation number 971, the keyword “digital twin” has the highest TF-IDF value of 1.0414, which is the highest value among all rows. This value shows that “digital twin” plays a very important role in the content of the technology. On the other hand, a value of 0 can be interpreted to indicate that the term is not included in the technology or is not sufficiently important compared to other technologies.

4. DISSCUSION AND SUGGESTION

The construction new technology designation system, one of the certification and evaluation fields of the Ministry of Land, Infrastructure and Transport, is being implemented to promote the development of domestic construction technology and strengthen national competitiveness, in the fields of civil engineering, architecture, and mechanical equipment. As of July 2024, smart construction technology accounts for 13.8% of certified new construction technologies, and the number of certification applications and selections has been continuously increasing since 2020. However, the field application of smart construction technology is highest in the civil engineering field at 13.5%, but the overall utilization and application stage is still insufficient.

The government is currently promoting a roadmap for the promotion of smart construction technology with the goal of innovation in construction productivity and strengthening safety, but it is necessary to establish a feedback system that can analyze the reasons for the somewhat passive application in construction and building sites. To this end, it is necessary to provide specific cases and various examples for the planning investigation, design, construction, maintenance, and safety management stages presented in the roadmap. Smart construction technology can start with big data management. It is necessary to apply machine learning and artificial intelligence technologies such as TF-IDF through the use of various big data to achieve innovation in construction productivity and strengthen safety, thereby improving the country's external competitiveness [12].

5. CONCLUSION

In this paper, we analyzed the data registered from 2020 to July 2024 and found that 21 technologies certified as new smart construction technologies account for 21.6% of all new construction technologies. By field, 17 smart construction technologies (13.5%) were certified in the civil engineering field, and 3 technologies (2.4%) were certified in the architecture and mechanical equipment fields, respectively. We selected 12 main keywords to perform TF-IDF analysis based on the Ministry of Land, Infrastructure and Transport's smart construction technology field application guidelines, and analyzed the frequency of occurrence of keywords included in each technical document. As a result, the keyword "data & artificial intelligence" was found to be most frequently mentioned in 15 of the 21 smart construction technologies, while "BIM," "VR & AR," and "digital map" had an inclusion frequency of 0, suggesting that the field application environment has not yet been sufficiently developed. This study systematically identifies the current status of smart construction technology and the utilization of important keywords in the construction field, providing useful data for evaluating the future development direction of smart construction technology and its applicability according to field-specific demands.

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