The 28th

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Theme Paper

: Utilizing Smart Technologies to Enhance the Profitability of Overseas Construction

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The ICAK was established in 1976 as the nation's only promotion agency for the overseas construction industry. The main function of the ICAK is to facilitate Korean contractors' overseas business and to develop the industry as a whole.

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Table of Contents

Utilizing Smart Technologies to Enhance the Profitability of Overseas Construction[1]

The 28th Asia Construct Conference

International Contractors Association of Korea (Republic of Korea)

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Abstract

The construction industry's profitability remains among the lowest of major global sectors, prompting accelerated adoption of smart technologies to enhance efficiency, safety, and value creation. This study examines global policy trends, corporate strategies, and case applications of smart construction technologies—such as Building Information Modeling (BIM), Internet of Things (IoT), robotics, automation, and digital transformation—to identify their potential for improving profitability in overseas construction markets. Analysis covers policy frameworks in leading economies, including the United Kingdom, United States, Germany, and selected Asian countries, which increasingly mandate or incentivize smart technology integration. The paper also reviews applications by top global contractors and technology firms, highlighting productivity gains, cost reductions, and operational improvements. Korean companies' overseas initiatives are assessed, showcasing their deployment of BIM, drones, modular construction, and advanced robotics through both in-house development and international partnerships. Strategic integration of these capabilities is projected to help Korea achieve USD 50 billion in annual overseas construction orders and secure a position among the world's top four construction powers.

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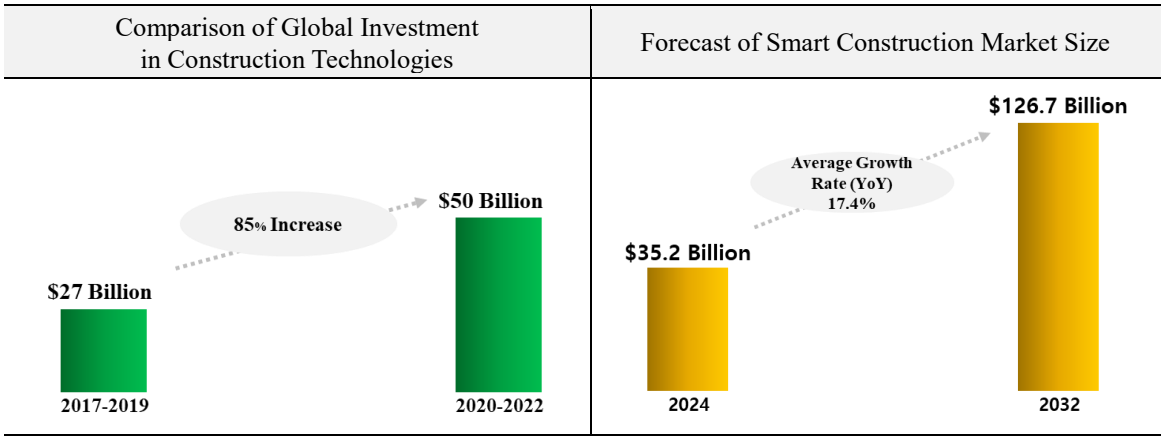
1. Introduction

According to the global consulting firm McKinsey, the profit margin of the construction industry stands at around 4.4%, ranking only 15th out of 17 major industries. In other words, the industry's profitability is significantly lower than that of advanced manufacturing and information and communication technology (ICT). In response, the construction sector has been making various innovative efforts to ensure survival, with a particular focus on actively adopting smart technologies.

This trend is also evident in the sharp increase in investment in smart technologies. Between 2020 and 2022, global investment in construction technologies reached USD 50 billion, an 85% increase compared to USD 27 billion in the 2017–2019 period. During the same period, the number of investment cases rose to 1,229, up 30% from the previous 944 cases. These figures suggest that the development and application of smart technologies aimed at improving profitability and productivity are expected to expand across the construction industry in the future.

Fig 1 | Comparison of Global Investment in Construction Technologies and Forecast of Smart Construction Market Size



Sources: Mckinsey(2023), Steve Rogerson(2024)

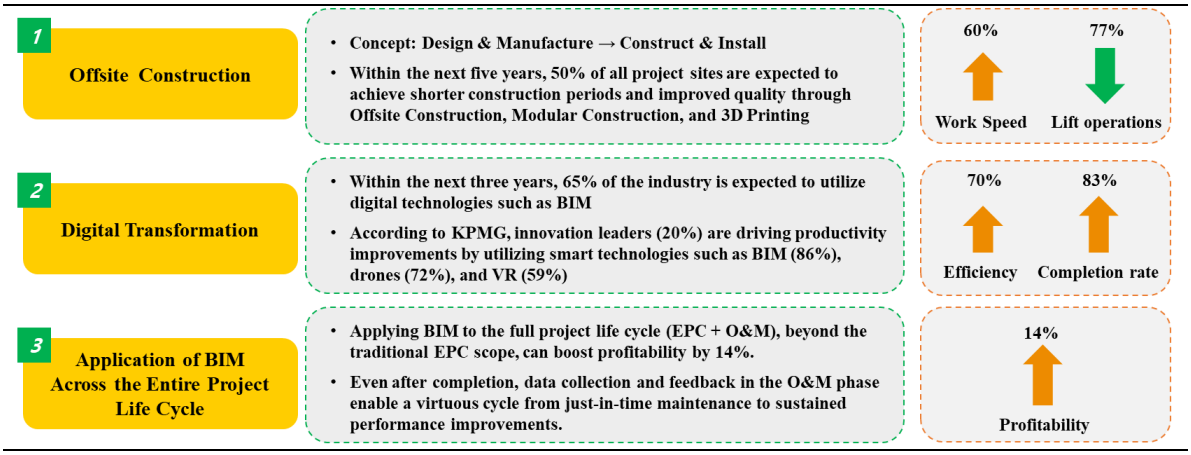
In particular, the smart construction market—integrating technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), Building Information Modeling (BIM), robotics, and automation into the construction industry—is projected to continue its steady growth. The market is expected to expand at an average annual growth rate of 17.4%, reaching USD 126.7 billion by 2032. This is anticipated to generate benefits for the construction industry, including cost reduction, shorter construction periods, and improved safety.

Amid these expectations, three major technology trends can be identified as key drivers for creating higher added value in the construction industry: 1) Offsite Construction (OSC); 2) Digital Transformation (DX); 3) the application of Building Information Modeling (BIM) across the entire project life cycle. What benefits, including profitability enhancement, can be expected from adopting these technologies?

First, Offsite Construction is a method that increases the proportion of components prefabricated in factories and assembled on-site. Compared to conventional methods, it is expected to improve work speed by 60% and reduce lift operations by 77%. Second, many leading global construction companies are integrating digital technologies such as drones and Virtual Reality (VR) into their sites, improving work efficiency and task completion rates by 70% and 83%, respectively, while also utilizing them for accident prevention.

Finally, expanding the application of BIM to cover the entire project life cycle, including Operation and Maintenance (O&M), is estimated to increase profitability by 14%. This approach enables a virtuous operational cycle—from just-in-time maintenance to sustained performance—through systematic data accumulation and feedback during the O&M phase after project completion.

Fig 2 | Key Technologies and Expected Benefits Driving High Value-Added Transformation in the Construction Industry



Sources: Prepared by the author based on ENR FutureTech (2022)

2. Expansion of Policies for Adopting Smart Construction Technologies in Major Countries

Major countries around the world are accelerating innovation and improving efficiency in the construction industry by adopting smart construction technologies. Governments are introducing diverse strategies and legislation to promote the use of such technologies, and this trend is steadily spreading to other nations.

The United Kingdom, through its Construction 2025 strategy, aims to boost construction productivity by 33% and halve carbon emissions by 2025, thereby accelerating the adoption of smart construction technologies. Since mandating BIM Level 2 for public construction projects in 2016, the UK has been working toward a transition to fully integrated BIM (Level 3) by 2025, targeting a 33% reduction in construction costs and a 50% reduction in project delivery times. In addition, technologies such as drones, AI, IoT, and automated equipment are being integrated with BIM to further enhance site management and decision-making efficiency.

The United States is expanding BIM adoption through the National BIM Standards and actively pursuing the Smart Cities Initiative to build smart urban infrastructure. Federal programs are also promoting research and development to apply AI and robotics in the construction sector, supporting automation at worksites. Following the U.S. General Services Administration's encouragement of BIM use, agencies such as the Department of Transportation and the Department of Defense have actively adopted BIM in design and construction, making it an essential element in large-scale infrastructure projects. While application standards vary by state, ICT integration for greater efficiency is steadily advancing across the U.S. construction market.

The European Union (EU) recommended BIM use in public procurement guidelines in 2014, and member states are gradually expanding its adoption. For example, France has encouraged BIM application in public housing projects since 2017. Germany is promoting the integration of smart construction technologies through its Industry 4.0 initiative, actively adopting robotics, IoT, and AI to enhance productivity and sustainability, and supporting green building through the Energiewende policy. Since 2020, Germany has implemented legislation mandating BIM use in public construction projects to accelerate digital construction. Nordic countries such as Norway, Finland, and Denmark are also

leading the digital transition by requiring BIM across all public projects.

In Asia, similar policies have been spreading and becoming more concrete, with governments increasingly recognizing the role of smart construction technologies in improving efficiency, productivity, and sustainability.

China has positioned smart construction and smart city development as key national strategies. Through the *Made in China 2025* policy, it is promoting the development of innovative technologies that apply robotics, AI, and big data to the construction industry, while actively introducing sustainable construction solutions that combine green building practices with smart technologies. Since 2021, China has mandated the use of BIM in national public construction projects, and, in connection with its "Smart City" policy, has been advancing smart construction that integrates advanced technologies such as AI, cloud computing, and IoT. As a result, BIM has become a mandatory element in large-scale public buildings and infrastructure projects, with active research and pilot projects underway.

In **Japan**, the Ministry of Land, Infrastructure, Transport and Tourism has been gradually mandating the adoption of BIM and CIM (Construction Information Modeling) since 2023, applying these systems to public infrastructure projects such as roads, bridges, and tunnels. CIM refers to the extension of the BIM concept to civil engineering infrastructure, using 3D models for information management in projects such as roads, bridges, tunnels, railways, and ports. Under the government-led *i-Construction* initiative, Japan is accelerating construction automation through the introduction of smart construction technologies.

Singapore has strengthened its policy support for smart construction, mandating digitalization in public construction projects through BIM and the *Integrated Digital Delivery (IDD)* program. The Building and Construction Authority (BCA) is leading industry innovation through policies that promote smart construction and is also playing a key role in smart city development.

Australia is promoting digitalization and sustainability in the construction industry through the *National Construction Code (NCC)*. In 2023, the federal government announced a roadmap for mandatory BIM adoption. Major state governments, including New South Wales (NSW) and Victoria (VIC), require BIM application in public projects such as roads and railways, thereby driving the sector's digital transformation.

In sum, governments around the world are expanding policies to promote the application

of various smart construction technologies—including BIM, robotics, AI, and IoT—which are expected to enhance real-time data management, predictive analytics, automation, and decision-support systems across the construction industry.

3. Cases and Impacts of Smart Technology Applications by Leading Overseas Construction Companies

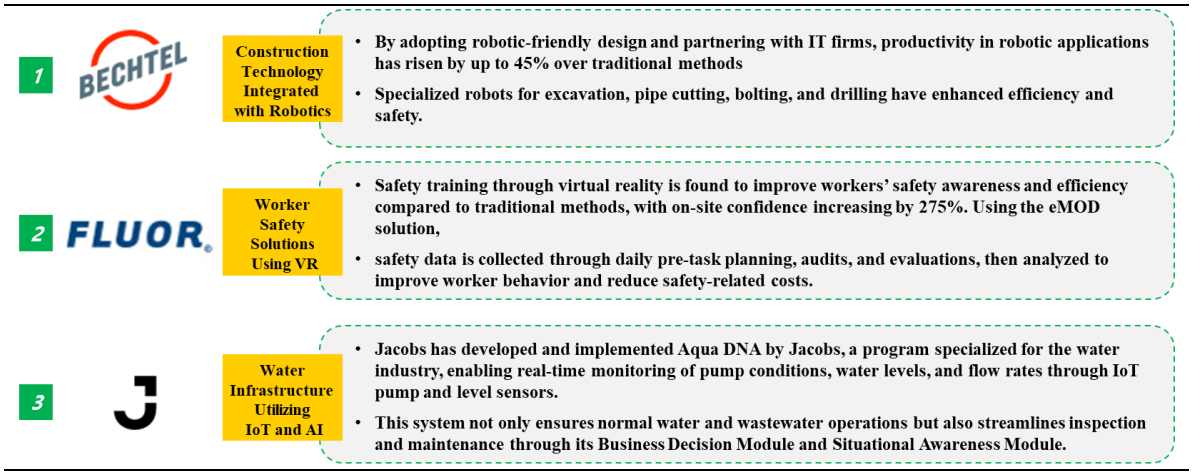
Leading global construction companies—including France's Vinci, the top-ranked firm in overseas construction revenue, U.S. firms Bechtel, Fluor, and Jacobs, and Japanese firms Kajima, Obayashi, and Penta-Ocean—are driving innovation in the construction industry through the development and application of smart technologies. These global players have been building expertise in smart technology within their domestic markets and are expanding its application to overseas projects.

Vinci, through its transport infrastructure subsidiary Eurovia, has developed *Smartvia Cyro* to advance the digital transformation of road projects. This system uses sensors to measure and transmit road temperature and load data in real time, enabling predictive maintenance and optimized road management. Another innovation, *Thermal Screen*, converts heat energy generated by vehicle movement and sunlight into electricity. Applied in the *Novatherm Demonstrator* project, it utilizes solar and geothermal energy to prevent road icing while supplying power to nearby infrastructure. In addition, Vinci actively engages in mergers and acquisitions (M&A) with ICT firms and operates a startup platform to enhance efficiency and data management for road, rail, and telecommunications projects. Since launching its startup platform *Leonard* in 2017, Vinci has developed 185 programs in areas such as low-carbon concrete, unmanned aerial vehicles, and smart grids, successfully commercializing various advanced technologies.

In the **United States**, major firms are breaking away from traditional construction methods by integrating smart technologies. **Bechtel** (ranked 22nd in overseas revenue) works with IT companies to continuously improve methods and maximize site efficiency through robot-friendly design. By applying robotics in construction, Bechtel has achieved up to a 45% increase in productivity in excavation, pipe cutting, and drilling compared to conventional approaches. **Fluor** (ranked 24th) applies smart technologies to enhance worker safety, introducing VR-based safety solutions for immersive training. Compared with traditional lectures and audiovisual training, this approach significantly boosts workers' confidence on site. Fluor also manages safety data through pre-task planning, safety audits, and evaluations, helping to prevent accidents and reduce related costs. **Jacobs** employs an aggressive M&A strategy to deliver customized solutions, acquiring companies such as FMHC to expand into wireless communication technology, design, network

development, and construction, and Federal Network Systems (a Verizon subsidiary) to provide system integration, IT, and data security solutions. It also acquired Van Dyke to strengthen its cybersecurity offerings.

Fig 3 | Cases of Smart Construction Technology Application by Leading U.S. Companies



Sources: Prepared by the author based on ENR FutureTech (2022)

In **Japan**, major construction companies are actively developing robot-assisted methods to address labor shortages. **Kajima** (ranked 28th) has created robots capable of steel frame welding and fireproof coating, as well as an indoor drone autonomous navigation system for site use. It also applies the *Automatic Uprising Construction By Advanced Technique (AMURAD)* method, which builds from the top down, delivering shorter construction periods, reduced labor costs, and less waste. Kajima's *A4CSEL* system enables remote operation of unmanned heavy equipment via tablets and is being piloted at sites in Fukuoka and Oita. **Obayashi** (ranked 35th) has developed Automated Guided Vehicles (AGVs) to transport materials along designated or free-moving paths using sensors, cameras, and radar. Other innovations include a remote-control system for existing heavy machinery without additional equipment, welding and ceiling installation robots, crack detection robots, and the Hybrid Assistive Limb (HAL), which detects faint bioelectric signals to support workers' muscle strength.

Shimizu (ranked 78th) has introduced the *Shimizu Smart Site*, a next-generation production system integrating BIM with autonomous robots and human workers. It features horizontal and vertical transport robots, including the adjustable horizontal slide crane *Exter*, the column welding robot *RoboWelder*, the multi-functional installation robot *Robo-*

Buddy, and the material transport robot *Robo-Carrier*. Equipped with AI and IoT, these robots receive task instructions via a centralized management system, autonomously navigate sites, identify targets, and transmit real-time operational data. **Penta-Ocean** (ranked 69th) has collaborated with robotics companies since 2018 to develop underwater robots for constructing and maintaining marine structures such as breakwaters, with potential applications in offshore wind farm construction.

Taisei (ranked 110th) has developed the *T-iROBO* series for site automation, including the *T-iROBO Cleaner* for site cleaning, the semi-autonomous *T-iROBO Slab Finisher*, and the *T-iROBO Rebar* for automatic rebar tying. Heavy equipment manufacturers closely linked to construction are also innovating. **Komatsu** developed the world's first semi-automatic excavator using GNSS-based location data and 3D design models. It has automated bulldozer blade control to improve operational efficiency and offers a range of smart construction solutions, including surveying and construction planning simulations.

The Japanese construction industry is also advancing smart technology development through inter-company collaboration and open innovation. **Kagoshima** and **Takenaka** co-founded the Construction RX project to jointly develop remote-control and transport management systems, leveraging each company's robotics expertise. **Taisei** collaborates with external firms and research institutions through *TOI Lab*, while **Shimizu** works with universities and public research bodies via its in-house research facilities.

Fig 4 | Shimizu's Smart Site System and Kajima's Unmanned Construction Equipment in Japan

Shimizu's Smart Site System	Kajima's Unmanned Construction Equipment
	

Sources: Shimizu website. https://www.shimz.co.jp (accessed April 17, 2025);
Kajima website. https://www.kajima.co.jp (accessed April 16, 2025).

4. Global Big Tech Companies' Moves to Enter the Smart Construction Market

The entry of major global tech companies and other non-construction firms into the smart construction market has been notable. **Siemens** is focusing heavily on advanced technologies related to climate change response and energy, with the goal of securing a leading position in smart city models. To this end, it operates a dedicated Infrastructure & Cities Sector and leverages its proprietary Green City Index to consolidate capabilities for driving urban development. Siemens continues to research and apply future-oriented technologies such as urban infrastructure automation, energy efficiency, and digital twins.

The **Boring Company**, founded by Elon Musk, is developing Loop Tunnels—underground transportation systems designed to address existing traffic congestion. In Las Vegas, the company has constructed a Loop system starting from the Las Vegas Convention Center to connect multiple areas, with some sections already in operation. In Chicago, it is developing a Loop system to link O'Hare International Airport with the downtown area.

Sidewalk Labs, formerly a subsidiary of Alphabet, once collaborated with the City of Toronto on the Sidewalk Toronto project. The initiative aimed to present a 21st-century smart city model by integrating modular construction methods, intelligent transportation systems, utility tunnels, and environmental information systems. However, due to various controversies, as well as technological and data privacy concerns, the project was scaled back or terminated in the early 2020s. Nevertheless, Alphabet has maintained an interest in the smart city sector, continuing to develop urban innovation technologies and pilot projects.

Amazon ventured into the construction sector in 2018 by investing in the modular housing company **Plant Prefab**. It is also developing a variety of smart home solutions centered on Alexa, incorporating AI and edge computing technologies. Other initiatives, such as Amazon Key and the smart doorbell Ring, aim to transform the consumer living environment. Although some services, such as Echo Look, have been discontinued or repurposed in response to market conditions, Amazon remains committed to building a smart home ecosystem.

In sum, global corporations are moving beyond their core businesses, applying innovative technologies and business models to smart construction. Through technological convergence, they are improving efficiency, safety, and sustainability, and will continue pursuing new opportunities and challenges in the industry.

5. Overseas Applications of Smart Technologies by Korean Companies

Hyundai Engineering & Construction (HDEC) became the first company in the world to apply *3D BIM* throughout the entire process of the Qatar National Museum project. Designed by world-renowned architect Jean Nouvel, the building takes inspiration from the "Desert Rose," resulting in a geometric form with virtually no straight lines or right angles. The project, tailored to meet the client's demand for creativity and artistic design, has been praised for successfully realizing its distinctive exterior—comprising 316 massive circular-plate structures.

During construction, a steel frame was erected in the shape of a desert rose, followed by the installation of more than 76,000 fiber reinforced concrete (FRC) panels fitted onto the circular plates. Each panel was labeled with a barcode, enabling real-time tracking and quality control by scanning to determine its exact position within the structure. The 3D BIM model allowed on-site staff to detect design errors in advance and prevent potential construction issues. To further minimize errors, a one-third scale mock-up of the building was created for quality inspections, enabling the prediction and resolution of technical and structural challenges before main construction began.

GS Engineering & Construction is targeting the overseas modular construction market through both in-house technology development and cross-border M&A. It acquired *Danwood*, a Polish company ranked fourth in Germany's modular housing market, securing expertise and market share in timber modular construction. Danwood operates with over 150 design variations and automated manufacturing processes, ensuring strong cost competitiveness in Europe. GS E&C also acquired *Elements Europe*, a U.K.-based steel-frame modular construction firm with a track record in high-rise modular buildings. In 2023, Elements Europe won the *Camp Hill* project in Birmingham, involving six buildings (3–26 stories) totaling 550 rental housing units and commercial facilities. The company designs over 1,100 modules, fabricates them in-house, and transports them to the site for assembly—reducing noise, pollution, and congestion, while also cutting material costs, shortening construction time, and lowering safety risks.

Ssangyong Engineering & Construction, recognized worldwide for its high-end building capabilities, has been applying BIM to various projects after initial theoretical and technical reviews of 3D BIM. Notable among its achievements is Singapore's *Woodlands*

Health Campus, where it operated a 50-member BIM team to model the complex hospital structure, minimizing design changes. Meetings with the client were conducted using tablets instead of printed drawings, enhancing efficiency. In Dubai, Ssangyong applied BIM to the *Atlantis The Royal* hotel, a project known for its graceful exterior with 33,000 streamlined facade panels and an 80-meter-high sky bridge connecting the hotel and residences. BIM enabled precise realization of the complex, non-standard design and helped preempt construction challenges, reducing both time and costs.

Fig 5 | Qatar National Museum and Atlantis The Royal, UAE

Qatar National Museum	Atlantis The Royal, UAE
	

Sources: Hyundai E&C blog. https://blog.naver.com/hdec_official (accessed April 15, 2025).;
Ssangyong E&C website. https://www.ssyenc.co.kr (accessed April 15, 2025).

In the plant sector, **Hyundai Engineering** applied modular design expertise to the *Al-Zour LNG Terminal* project in Kuwait. The project involved building regasification facilities with a capacity of 130,000 m^3/day, eight LNG storage tanks (225,000 m^3 each), and associated infrastructure. A critical success factor was timely completion of the 1.2 km marine jetty superstructure. Hyundai Engineering fabricated 500 meters of the superstructure as 12 modules in an off-site factory, transported them to the site, and installed them using marine cranes—shortening the schedule by more than six months.

Daewoo Engineering & Construction has been actively applying drone technology for surveying large-scale civil works. Using photos and videos taken from multiple angles, the company generates 3D terrain models for design review, constructability analysis, and earthwork volume calculation. Compared to traditional surveying, the drone method is significantly more accurate and cost-effective: work that previously required four people over 10–15 days can now be completed by two people in 4–5 days, reducing surveying time

by more than 50%.

At the *Haluo River Multi-Purpose Dam* project site in the Philippines, Daewoo maximized efficiency in site management and design by deploying innovative drone solutions. Drones captured high-resolution imagery of the site, generating realistic image-based drawings that were transmitted to design and construction teams in real time. This approach overcame limitations of conventional aerial surveying, such as weather-dependent workdays, cost inefficiencies, and logistical inconvenience. Notably, drone operation was managed remotely from Daewoo's drone control center in Korea—about 3,000 km away. The control center pre-programmed flight routes, enabling missions without on-site manual piloting, thus delivering real-time data while overcoming physical distance and time constraints. This system significantly improved operational efficiency and cost-effectiveness.

6. Conclusion

As examined above, to overcome the low profitability of the construction industry, governments in major countries are implementing policies that mandate or actively promote the adoption of smart construction technologies. In particular, the United Kingdom, the United States, and Germany have mandated the use of BIM, and this trend is expected to expand further, accelerating the digital transformation of the construction sector. Going forward, the ability of companies to rapidly secure smart technology capabilities in response to changes in national construction policies will likely become a key determinant of their competitiveness in winning contracts.

Reflecting this, leading companies in France, the United States, Japan, and other advanced economies have long been actively applying smart technologies, generating a range of positive outcomes such as improved profitability, increased productivity, and enhanced safety. Moreover, global big tech companies are also seeking to expand into the construction market, leveraging their technological competitiveness.

Amid intensifying competition in the global construction market, Korean companies are also deploying BIM, IoT, drones, robotics, and AI at overseas sites, while accelerating the creation of higher value-added construction through technology partnerships and M&A with leading international firms. However, the development and expanded application of smart technologies by individual companies can entail considerable trial and error and sunk costs. This underscores the need for government-level support, including initial funding for R&D projects and the strengthening of specialized training programs for smart construction technologies.

Encouragingly, the Korean government is laying the policy groundwork to promote smart construction. The Guidelines for the Promotion of Smart Construction Technologies were introduced and have been in effect since late 2021. In addition, legislative measures are underway to provide financial support and foster talent development, with the goal of accelerating the adoption and diffusion of smart construction technologies. By consolidating these capabilities, smart construction is expected to become a cornerstone for enabling Korea to achieve USD 50 billion in annual overseas construction orders and to secure its position among the world’s top four construction powers.

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